SOUVENIR

10th Convention

of

Indian Dairy Engineers Association (IDEA)

and

National Seminar

on

Engineering for Innovative Dairy Products and Process Development

September 29-30, 2016

: Organised by :

Sheth M. C. College of Dairy Science, Anand

Anand Agricultural University, Anand

&

Indian Dairy Engineers Association (IDEA)

Venue : **Sheth M. C. College of Dairy Science**, AAU, Anand-388110

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SOUVENIR

Chief Editor

Dr. J. B. Upadhyay

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Mr. A. D. Patel

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Mr. Y. V. Vekariya

Published by

SMC College of Dairy Science

Anand Agricultural University

Anand-388 001 (GUJARAT)

सत्यमेव जयते

प्रधान मंत्री
Prime Minister

MESSAGE

I am happy to learn that the SMC College of Dairy Science, Anand Agricultural University, Anand, in collaboration with the Indian Dairy Engineers Association, is organizing the 10th National Convention of Dairy Engineers, and National Seminar on "Engineering for Innovative Dairy Products and Process Development" on 29th and 30th September, 2016, in Anand.

On this occasion, I extend my best wishes to the organizers and participants.

(Narendra Modi)

06 September, 2016
New Delhi

Dr. N. C. Patel

VICE CHANCELLOR
Anand Agricultural University
Anand-388 110

MESSAGE

I am happy to note that SMC College of Dairy Science, Anand in collaboration with Indian Dairy Engineers Association (IDEA) is organizing 10th National convention and National Seminar on "Engineering for Innovative Dairy Products and Process Development" during 29-30th September, 2016 at Anand.

Novel or innovative technologies are the alternative paths to save energy for processing huge amount of milk and milk products, maintaining their nutritional values as well as quality attributes. Numbers of traditional dairy product are very popular in different regions of the country. But, mechanization of these traditional dairy product is required for the Dairy and Food Industries to standardize the process and improve the quality and safety of the products. Low cost innovative technology should be developed and commercialized by the Industry for producing high quality traditional dairy products and market it effectively throughout the world. Renewable energy or solar power system can be encouraged to generate the power for the Energy efficient dairy machineries.

In this context, the theme of the present seminar is very relevant. I am sure that the deliberations of the seminar will be useful in bringing out new strategies in this direction. This seminar will provide a common platform for Dairy Engineers fraternity where they could exchange their ideas, share their views and experiences for the betterment of Dairy and Food Industry.

I congratulate the organizers of the seminar and wish the seminar a grand success.

Date : 06/09/2016

(N.C.Patel)

Dr. K. B. Kathiria

Director of Research and Dean
PG Studies
Anand Agricultural University
Anand

MESSAGE

I am happy to know that SMC College of Dairy Science, Anand in alliance with Indian Dairy Engineers Association (IDEA) is organizing 10th National convention and National Seminar on "Engineering for Innovative Dairy Products and Process Development" during 29-30thSeptember 2016 at Anand.

Extensive research in science and technologies has born many novel and alternate technologies in present era. To satisfy the modern consumers' appetite for quality and more nutritious products, various new technologies and novel products are invented by numerous researchers and industries. Low cost processing and novel products help to milk producers, processing industries and most importantly the consumers. With increasing application of innovative technologies explores several new areas for policy makers, too.

In this Context, the present theme provides a common platform for industries, milk producers, research scholars, scientists, educationalists and policy makers to exchange their views and ideas for better upliftment of the dairy and food product processors.

I congratulate the organizers of the seminar and the office beerier of the Indian Dairy Engineers Association. I wish the seminar a grand success.

Date : 29/09/2016

(K. B. Kathiria)

Er. S. C. Aggarwal
Ex . Addl. Managing Director
MILKFED Pb.

PRESIDENT
Indian Dairy Engineering Association
Chandigarh

MESSAGE

It gives me immense pleasure that SMC College of Dairy science Anand, Anand Agriculture University in collaboration of Indian Dairy Engineering Association are organizing 10th National convention and National Seminar during 29-30th Sept. 2016 at Anand.

Dairying in India has grown at incredible pace with India emerging as the largest producer of milk in the world. The per capita availability of Milk is now at very satisfactory levels which is largely due to Operation Flood Program conceived and successfully implemented by Father of Dairying of India, Dr V. Kurien, Ex. Chairman NDDB Anand. Restrictions on manufacture of dairy products imposed by the Govt. have become things of past. Now we do have surplus milk which can be converted into value added products. Having said so, our role of Dairy Technocrats and Engineers become more responsive to match our skills and knowledge to meet requirements of World standards of hygiene and manufacturing .

Dairy engineers have also to take care of Energy Conservation and to implement green technologies wherever possible keeping in mind cost reductions so that Dairy can match the International prices of milk commodities.

I do take opportunity to extend my thanks to Dr N. C. Patel, Hon. Vice Chancellor Anand Agriculture University who has very kindly accepted my request made during the occasion of 9th Convention which was held at NDRI Karnal, to hold this 10th National Convention at AAU Anand .

I extend my Best Wishes for the success of the National Convention and Seminar

Date : 29/09/2016

(S. C. Aggarwal)

Dr. J.B. Prajapati

Principal & Dean
SMC COLLEGE OF DAIRY SCIENCE
Anand Agricultural University
Anand – 388 110 (Gujarat) India

MESSAGE

Graduate program in Dairy Technology in India involves about 50% courses related to Engineering subjects and hence it becomes very important for all Dairy Science Colleges in the country to pay attention to it. In this context, the present seminar focused on "Engineering for Innovative Dairy Products and Process Development" is most pertinent. I am sure that this seminar and souvenir will give Engineering solutions to the problems of Dairy Industry and infuse news ideas for process and product development with engineering skills. Specifically, Indian Dairy Industry needs engineers to design and develop machines and lines for Indigenous dairy products, as these products has great a huge domestic and international market and hence has potential to earn more revenue for our milk producers.

I thank and congratulate Indian Dairy Engineers Association for organizing and hosting the seminar at SMC College of Dairy Science. I am sure all the participants of the seminar and readers of this souvenir will be benefitted. I wish the program a grand success.

Date : 29/09/2016

(J.B. Prajapati)

INDIAN DAIRY ENGINEERS ASSOCIATION (IDEA)

CITATION

LIFE TIME ACHIEVEMENT AWARD

DR. AMRUTLAL G. BHADANIA

Dr. Amrutlal G. Bhadania has been chosen by the IDEA for conferring this honour on him during the 10th IDEA convention (2016), in recognition of his professional excellence in the field of Dairy Engineering.

Dr. Amrutlal G. Bhadania obtained B.Sc. (Dairy Technology) degree from SMC College of Dairy Science, Anand in the year 1978 with first class and joined Sabar Dairy, Himatnagar as Technical Officer. After working for about one year in the dairy plant, he joined as Assistant Professor, Department of Dairy Engineering, SMC College of Dairy Science, Anand. He obtained Masters and Ph.D. degree with distinction in the field of Dairy Engineering from Gujarat Agricultural University. He has enthusiastically worked at various capacities and became head of Dairy Engineering Department, SMC College of Dairy Science, AAU, Anand from September, 2006. During his academic career, Dr. Bhadania has published 102 research and technical papers, attended 60 seminars/workshops/conventions, presented 20 papers in seminars/conventions, guided 11 M. Tech. and 3 Ph.D. (Dairy Engineering) students and won 8 best research paper/poster awards. An articulate teaching of Dr. Bhadania is loved by UG and PG students. Dr. Bhadania is recipient of Best Teacher Award of Faculty of Dairy Science, Anand Agricultural University, Anand for the year 2015. He has contributed significantly in different research projects including e-course development for B.Tech. (Dairy Technology) Degree Programme. His research area of interest is on development of equipment for the manufacture of indigenous dairy products and energy conservation in dairy processing operations. He is a member of Executive Committee of Indian Dairy Engineers Association (IDEA) and successfully organized 4th convention of IDEA & National Seminar. Dr. Bhadania has also made remarkable contribution as secretary and president of Alumni Association of the college.

In recognition of his meritorious service to the Dairy Engineering Profession, organizing committee of the convention & seminar and IDEA take pride to honour Dr. Amrutlal G. Bhadania by presenting this citation on the occasion of 10th IDEA convention & seminar.

Date: 29-09-2016

President
Indian Dairy Engineers Association

INDIAN DAIRY ENGINEERS ASSOCIATION (IDEA)

CITATION

LIFE TIME ACHIEVEMENT AWARD

SHRI CHANDRAVADAN SHAH

Shri Chandravadan M. Shah has been chosen by the IDEA for conferring this honour on him during the 10th IDEA convention (2016), in recognition of his professional excellence in the field of Dairy Engineering.

Shri Shah obtained his bachelor degree in electrical engineering from M. S. university of Baroda in the year 1961 with second class. He joined textile mill as an engineering supervisor at Ahmadabad for eight months. He joined as a lecturer in Dairy Engineering Department at Dairy Science College, Anand in June 1962.

Shri Shah was the pioneer faculty in the college. He was the instrumental in the installation of Dairy machinery at student's training Dairy (Anubhav Dairy) as well as the development of different Dairy Engineering laboratories at the newly constructed college building.

Shri Chandravadan shah had taught different dairy engineering subjects at diploma, under graduate and post graduate level. He was promoted to the post of assistant professor in the year 1964. Mr. shah was deputed for master degree in dairy Engineering at National Dairy Research institute, Karnal in the year 1975 and he secured first class with first position. He was awarded silver medal by Kurushetra University.

Shri Chandravadan shah was promoted to the post of associate professor in Dairy Engineering in the year 1982. He was recognized for teaching post graduate students in the year 1977.

Shri Chandravadan shah attended Dairy Teacher's workshop at Bangalore and Mumbai. He was also deputed to attend Dairy industry conference at Jaipur and Ludhiana. He guided four students for master degree in Dairy Engineering. He published five popular articles in Indian Dairy man.

Shri Chandravadan was appointed as advisor in student's representative council. He was appointed as assistant rector and rector of college hostel. Shri Chandravadan shah retired from active service in June 1998 after putting 36 year of service at the Dairy Science College, Anand.

In recognition of his pioneering active service in Dairy Engineering field, the organizing committee of the convention & seminar and EC members of IDEA feel happy to honour him on the occasion of 10th IDEA convention.

Date: 29-09-2016

President
Indian Dairy Engineers Association

INDIAN DAIRY ENGINEERS ASSOCIATION (IDEA)

CITATION

LIFE TIME ACHIEVEMENT AWARD

Dr. ISH KUMAR SAWHNEY

Dr. Ish Kumar Sawhney has been chosen by the IDEA for conferring this honour on him during the 10th convention (2016), in recognition of his professional excellence in the field of Dairy Engineering.

Dr. Sawhney is Ph.D. (Food Engineering & Technology) from S.L.I.E.T. Longowal, M.Tech. (Agricultural Structures & Process Engineering), B.Tech. (Agricultural Engineering) from P.A.U. Ludhiana and has obtained advanced training in Dairy Process Engineering at University of Illinois, Urbana-Champaign, USA & Management Development Programme at IIM, Ahmedabad. He is a Dairy Engineer with 40 years of R&D experience in process equipment design, teaching/training/skill development and techno-economic consultancy on dairy processing projects.

He joined Agricultural Research Service in 1976 as Scientist S-1 at National Dairy Research Institute, Karnal and has rendered services at the Institute at several important positions that include Head, Dairy Engineering Division, Member, Institute Technology Management Committee (I.T.M.C.), Nodal Officer (Patents), Controller of Examination & Member Academic Council of NDRI (Deemed University) and Member Governing Board of SINED-TBI. He superannuated from ICAR service on 31.10.2015 but acknowledging his distinguished services, the ICAR has awarded him Emeritus Scientist position for a period of another two years.

Dr. Sawhney has conducted extensive research on generation and accumulation of engineering design data on traditional Indian dairy products for R&D applications. His accomplishments include: in-line mechanized system for production of Indian dairy products, equipment for continuous cooling of khoa, multipurpose conical process vat for viscous dairy products, conveyor system for continuous processing of paneer and chhana, a butter melting system employing static tube with heated extended surface fins, a village level improved khoa pan, cream separation attachment for mixies and food processors and shelf life prediction software for moisture sensitive dairy products. He is the co-inventor to the two Indian Patents on technologies development.

He has 61 publications in the scientific journals of national and international repute. He has participated in 32 National and International conference / seminars / symposia and has been invited to deliver guest lectures on specialized research topics by several universities and dairy processing industries. He is renowned academician and is the major research advisor to 3 Ph.D. and 16 M.Tech. Dissertations in Dairy Engineering. He is the author of an e-learning course material on "Instrumentation & Process Control" for B.Tech. Dairy Technology and is the co-author of Self-Learning Material for I.G.N.O.U. for the Diploma (Dairy Technology).

Dr. Sawhney is recipient of FAO / UNDP Fellow, National Academy of Dairy Science (India) Fellow, Certificate of Merit / best paper awards by Institution of Engineers (India), AFSTI, IDA, DTSI, IDEA. He is Vice-President of 'Indian Dairy Engineers Association (IDEA) and Executive Member, Dairy Technology Society of India (DTSI). He was the Convener of 5th & 9th National Conventions of Indian Dairy Engineers Association, held at NDRI Karnal in 2005 and 2014 respectively.

In recognition of his meritorious service to the Dairy Engineering Profession, organizing committee of the convention & seminar and IDEA take pride to honour Dr. Ish Kumar Sawhney by presenting this citation on the occasion of 10th IDEA convention & seminar.

Date: 29-09-2016

President
Indian Dairy Engineers Association

INDIAN DAIRY ENGINEERS ASSOCIATION (IDEA)

CITATION

LIFE TIME ACHIEVEMENT AWARD

SHREE SUMER CHAND AGGARWAL

Shree Sumer Chand Aggarwal has been chosen by the IDEA for conferring this honour on him during the 10th convention (2016), in recognition of his professional excellence in the field of Dairy Engineering.

Mr Aggarwal did his schooling from a small town School, Hindu A. S. High School Sadhaura with State Merit with Distinction in the year 1967. He then graduated with B.Sc. Engg. (Mech.) with Honours from Punjab Engg. College Chandigarh in the year 1973. He did General Management Program from IRMA Anand in the year 1991. He is Fellow of Institution of Engineers India.

Mr Aggarwal started his career with Haryana Tanneries as Mechanical Engineer and later joined dairy industry as Jr. Dairy Engineer in Haryana Dairy Chandigarh in 1976. Later on he shifted to Punjab Dairy Cooperative Federation in 1981. After have worked on many important assignments in capacity of Manager Engineering, General Manager in headquarter and in various Dairy plants, he superannuated from this organisation as Additional Managing Director. Mr Aggarwal has been instrumental in planning and installation of number of dairy plants in Haryana and Punjab. He has also been instrumental in introducing number of new dairy products in Milkfed Punjab, such as, Verka Sweet Lassi, Verka Mango Drink, Verka Kheer etc. After his superannuation, he also served as Technical Advisor to Milkfed Punjab for about 6 years.

Mr Aggarwal has always been keen to share his technical knowledge with his colleagues and has taken associated organizations to new heights with the help of his team. It is vital to say that he is a self made man, who from his school days till becoming Additional Managing Director believed in his hard work and solicited team work from all to achieve many goals whether it was project execution, maintenance or management of dairy plants. He carried out turnaround of virtually three sick dairy plants of Milkfed Punjab as General Manager of these units and completed turnaround of two plants in less than one year. This was achieved by profit maximization process with introduction of new products, better planning of product mix and with introduction of Waste Management, Energy Management, Quality control measures and above all personnel discipline and good leadership.

In recognition of his meritorious service to the Dairy Engineering Profession, organizing committee of the convention & seminar and IDEA take pride to honour Shri Sumer Chand Aggarwal by presenting this citation on the occasion of 10th IDEA convention & seminar.

Date: 29-09-2016

President
Indian Dairy Engineers Association

INDIAN DAIRY ENGINEERS ASSOCIATION (IDEA)

CITATION

LIFE TIME ACHIEVEMENT AWARD

MR. VIMAL CHADHA

MR. Vimal Chadha has been chosen by the IDEA for conferring this honour on him during the 10th IDEA convention (2016), in recognition of his professional excellence in the field of Dairy Engineering.

MR. Vimal Chadha obtained B.Sc. (Dairy Technology) degree from NDRI Karnal in the year 1979 with first class and Msc. Dairy Engineering from NDRI Karnal inyear 1982. There after he joined Kwality Ice cream at Kolkata in projects. As Project Engineer. After working for about four years in Kwality, he joined as Senior project Engineer with APV Texmaco , Kolkata.. He has enthusiastically worked at APV and did many projects and also did Milk food ice cream and Aseptic Yoghurt project in Gurgaon.

He started his own business in year 1989 and completed many projects with Pepsi , Coke and Dairy Industry for process systems. Finaly he started his Co. in the name of Ved Engineering at B-38, Sector-60, Noida in year 1992 and has been successfully running as on today cattering to Dairy plants private and all the Milk co operatives for supply of Dairy equipment , milk plants . Also he expanded his activity to Beverage , Juice , Pharma and Food processing industry in the coming years and worked for Britania, Dabur , Emami, Gopaljee, and many more

In recognition of his meritorious service to the Dairy Engineering Profession, organizing committee of the convention & seminar and IDEA take pride to honour Mr. Vimal Chadha by presenting this citation on the occasion of 10th IDEA convention & seminar.

Date: 29-09-2016

President
Indian Dairy Engineers Association

PROLOGUE

We are all directly connected with the dairy industry, and as you know, our industry is the most vibrant and dynamic. Dairy sector contributes to 21% of our GDP. Market gurus state that dairy sector is growing at the rate of 1.7 % in the world and 4-5 % in India. At this juncture when India has established itself as the largest milk producer in the World, it has a potential to become a major contributor to the global export market of milk products. The novel foods and innovative process have assumed paramount significance and are crucial in international trade.

The success of the dairy industry is due to the innovative approaches being applied by dairy engineers and technocrats in various areas. Indian dairy industry demands some special innovations, which may be uncommon for western dairy sector. We also need to innovate as the competition in the market increases. Our innovations start from milk procurement system and innovative dairy products and process development. These include all the advancements in the area of equipment design, safety, quality and energy efficiency aspects to suit the requirement of all the types and levels of dairy professionals.

The present seminar is therefore highly relevant, which provides a platform for us to share our experiences and ideas. I feel elated to present the souvenir, which is a magnanimous compilation and luminous result of all those intellectual discussions, deliberations and exchanges in the form of technical papers forming an integral parts of the our National Seminar entitled **"Engineering for Innovative Dairy Products and Process Development."** organized during 29-30 September, 2016 at the milk capital of India. The Indian Dairy Engineers Association readily came forward for supporting such initiative. These ponderings would certainly bring out strategies required to achieve the targeted goals. In publishing this souvenir, a plethora of dairy professionals, equipment manufacturer, academicians and consultants, besides District Milk Unions and allied organizations contributed generously either through articles or through fiscal means by way of advertisements and by sponsoring the delegates as well as other amenities of the seminar. Specific mention must be made of the faculty of the college, who put in every effort with the sole target that their Alma master succeeds in endeavor.

During the seminar we are also going to honour the dairy professionals with **Life Time Achievement Award** for their outstanding contributions to the dairy engineering field and the **Best Thesis Award** to the M. Tech. dairy engineering students. I congratulate all of them on this occasion.

I take this opportunity to thank all contributors who have given the papers for their invited talks, oral and poster presentations, industry presentations as well as invited technical articles for this souvenir. I am thankful to Dr. J.B.Prajapati Principal & Dean of the college for his motivation and careful guidance. I thank my publication team of dedicated youngsters, Er. Istiyak Chauhan, Er. Ashish Patel, Er. Yogesh Vekariya and Dr. Subrota Hati for their sincere efforts and hard work to make this souvenir available to you in time. I also thank our former Principal and Dean Dr. B.P. Shah for his keen interest and moral support for the success of seminar.

I thank our silver sponsors IDMC Ltd., NABARD and Food & Bio Tech. Engineers (I) Pvt. Ltd. and our co-sponsors GCMMF Ltd., Gayatri Dairy Products Pvt. Ltd., Cipriani Harrison valves corp., Thermowave Engg. Pvt. Ltd., Milk Fed Panjab for the financial support at this juncture.

I profusely thank one and all who stood by me at this moment of pride and glory, and for your continued support throughout.

Dr. J.B.Upadhyay
Organizing Secretary
10th IDEA Convention and National Seminar

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Dr. I. K. Sawhney, Vice - President (IDEA) and Emeritus Scientist, Dairy Engineering Division, ICAR-NDRI, Karnal
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	Mr. S. I. Patel	

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Dr. K. D. Aparnathi (Convener)
Ms. Komal Patel

INVITED SPEAKERS

Sr. No.	Topic	Name of the speaker
Day - 1 (29-09-2016)		
Session – 1: Engineering for emerging milk processing technologies (11.30 to 13.00)		
1	An Emerging Method of Cleaning-in-Place: Ice Pigging	Dr. A. K. Agrawal
2	Developments in emerging dairy product formulations	Dr. A. K. Singh
3	Sub-Baric Thermal Processor	Dr. Mahesh Kumar
4	Dairy Products of the Future	Dr. Atanu Jana
5	Advances in milk drying technologies.	Mr. R. P. Singh
Session – 2: Advances in dairy equipment development (14.00 to 15.30)		
1	Energy optimization and use of non-conventional energy in dairy industry	Dr. B. Velmurugan
2	Advances in mechanized production of traditional Indian dairy products	Dr. Sunil M Patel
3	Waste management system in dairy plants	Mr. Sameer Saxena
4	Developments in packaging of milk & milk products	Dr. M. J. Solanki
Session – 3: Industrial Forum (16.00 to 17.30)		
1	Opportunities for entrepreneurship & start ups in dairy sectors	Er. R. K. Chugh
2	Skill assessment of Dairy Engineering professionals for global competence	Dr Gopal Sankhala
3	Advanced Mixing Solutions: An Overview	Mr. G. Ramesh Babu
Day - 2 (30-09-2016)		
Morning Session: (8:00 to 9:30)		
1	Characterization of engineering properties of paneer for varying pressing duration of automated press	Dr. Chitranayak
2	Minimization of refrigeration energy consumption in a dairy plant	Dr. J. K. Dabas
3	Optimizing the Proportion of Exothermic Reactants and Water for Cooking of Noodles in Self-Heating Container	Mr. A V Dhotre
4	Printpack: Solution of Modern Packaging Technology for Dairy and Food Industry	Mr. Sumit Saha
Session – 4: Recent Developments in dairy engineering sector (10:00 to 11:30)		
1	Advances in Instrumentation & Automation in Dairy Industry	Er. Amit Vyas
2	Dairy Engineering Education present status and future scenario	Dr. Rekha Menon
3	Advances in dairy processing equipment	Mr. V. K. Ghoda
4	Insights into automation and digitalisation of dairy industry.	Sh. A. K. Jain
5	Hygenic design of the food processing equipments	Dr. R. K. Shah

PROGRAM

Day 1: 29/09/2016, Thursday	
Time	**Program**
8:30 – 9:30	Registration
9:30 - 11:00	Inaugural Session
11:00	Inauguration of Poster Session
11:00 - 11:30	High Tea Break
11:30 - 13:00	Technical Session 1: Engineering for Emerging Milk Processing Technologies
13:00 – 14:00	Lunch Break
14:00 - 15:30	Technical Session 2: Advances in Dairy Equipment Development
15:30 - 16:00	Tea Break
16:00 - 17:30	Technical Session 3: Industrial Forum
18:00 - 19:00	General Body Meeting of IDEA
19:00 - 20:30	Cultural Program
20:30 - 21:30	Dinner

Day 2: 30/09/2016, Friday	
Time	**Program**
7:30 - 8:00	Break Fast
8:00 - 9:30	Special Technical Session
9:30 - 10:00	Tea Break
10:00 - 11:30	Technical Session 4: Recent Developments in Dairy Engineering Research & Education sector
11:30 - 12:00	Tea Break
12:00 - 13:00	Valedictory Function
13:00 - 14:00	Lunch

CONTENT

An Emerging Method of Cleaning-in-Place: Ice Pigging

A.K. Agrawal, T. Aravind, B. Prasanth, Geetesh Sinha and K.K. Sandey

Department of Dairy Engineering, College of Dairy Science and Food Technology, Raipur (C.G.)

Introduction

In modern milk processing, cleaning is the primary treatment and this should be carried out immediately after processing work is over. It is a precondition, for the production of hygienically satisfactory and high quality products, that milk and milk product processing plant is scrupulously clean. Now a day, in almost all dairy plants, CIP (Cleaning in Place) is used i.e. the plant is cleaned by circulation or by a once thorough mechanical cleaning process without dismantling. The removal of soil depends on the kind of soil and its state, nature of support of soil (surface finish) and mechanical action depending on the velocity of flow, presence of foam etc (Anantakrishnan and Simha, 1987). The effectiveness of cleaning is dependent on 'physical action' or 'force applied' by a cleaning solution. Therefore, high turbulent systems are desired for efficient cleaning. Adequate physical action can be ensured by the selection and utilization of proper pumps to provide sufficient turbulence of the cleaning solution through the pipelines and equipment to achieve maximum efficiency (Ahmad, 2006). For obtaining 'physical action' at fouled surfaces and smooth flow at normal surfaces, some smart material is required that acts like a fluid squeezing through complex geometries but behaves as 'tough' as it is a solid scraper which cleans the fouled surfaces. Further, this smart material should be such that it never gets stuck in the surface geometry it cleans. The 'crushed ice in water' or 'ice pig' is able to achieve many of the desirable characteristics of the smart material. The ice pig can traverse through very complex topologies for cleaning and can recover and separate products. Further, it does not get stuck, and even if it did, it will be melt into water, which can then be easily drained (Quarini, 2002).

Peculiarities of Ice Pigging

Pushing a piston like object through a pipe to clean the pipe walls is known as pigging. In ice pigging, the 'pig' consists of crushed ice in water with a freezing point depressant. The void fraction is carefully controlled so that the ice/water mix move like a solid plug in free flow areas, but is able to flow like a fluid in constricted areas (Quarini, 2002). The ice pig is capable of being injected through a small diameter inlet and expanding to fill a pipe, which can be up to 200 times larger in area. This results in minimum engineering work required on existing pipelines to accommodate ice pigging as a fouling removal solution (Ainslie *et al.*, 2009)

It offers to be innovative de-fouling technology. The non-Newtonian behavior of ice pig gives it a special flow characteristics; it appears to achieve plug flow whenever it can. Close analysis of videos suggests that the ice pigs are slipping at the solid surfaces. Plug flow means that there is little mixing through the ice pig. It is therefore able to act as a good product recovery device and as a product separator. The ice slurry acts in a manner of displacing material downstream of it by applying shear and hence mechanical cleaning of all surfaces comes into its contact (Ainslie *et al.*, 2009).

Places where Ice Pigging can be used

Ice pigging is a process for the removal of fouling, deposition, dirt particles etc. from the pipes, ducts, narrow spaces in a pipe or network of pipes. Ice pig can navigate obstructions such as bends, T's, valves, partially closed valves, pumps, and contractions/ expansions by realigning aggregate's shapes to fit the shape of equipment.

This process involves the pumping the ice slurry (mixture of ice and brine solution) through the pipes, ducts for cleaning. Ice pigs are capable to pass through the smaller diameter inlet and expanding to fill a pipe. There is no need to change lay out of pipe lines for ice pigging. Ice pigs can easily pass through large diameter pipes, bends, valves sockets etc. Only limiting thing is that ice slurry produces higher pressure drop in the pipes when compared to cleaning or disinfecting solutions at the same velocity.

Properties of Ice Slurry

The main factors in ice pigging intended for cleaning process are ice fraction, ice particle size and freezing point depressant concentration. Ice fraction can be estimated by measuring the temperature of the ice slurry solution and initial concentration of freezing point depressant (Melinder and Granyard, 2005). The size of ice particle mainly depends upon the method employed for its storage and length of time since its formation. The particle size increases with time elapsed (Pronk *et al.*, 2005). The ice fraction and particle size, both contribute to the rheological properties of slurry. The higher the ice fraction, the more the pig behaves like a solid, thus exerting larger cleaning forces on the pipe wall and generating larger pressure drops per unit length. However, there is also the risk of blocking the pipe work with larger ice fractions (Shire *et al.*, 2008).

Performance of Ice Pigging

Several trials are performed in food industries where the ice pigging process provided not only cleaning of pipes but also resulted in efficient product recovery (Quarini, 2002). In some investigating trials, the ice pigging has achieved up to 90% recovery for a viscous product at ambient temperature pipe line. These trials were carried out over a range of pipe diameters and lengths 1 cm to 10 cm and up to 100 m in length. It has demonstrated its ability to pass and clean various process equipment i.e. inline mixers, extruder, lobe pumps, dosing units and mono pumps (Ainslie *et al.*, 2009)

In their experiment on ice pigging, (Ainslie *et al.,* 2009) used four-way manifold to demonstrate the ice pig's ability to flow through diameter changes and multiple paths and successfully scoured fine grain sand, representative of loose small particulate fouling. It has been reported that the largest volume of fouling material approximately 160 kg removed by using the 4.5 Tons of ice slurry. These processes have also been tested on several different pipe materials like cast iron, PVC and stain less steel.

In a study, satisfactory cleaning properties of ice slurry was reported on different industrial heating units namely plate heat exchanger (Model: C6-SR, Make: Tetraplex) and tube in tube heat exchanger (Model: MTC70/W-3, Make: Tetra Spirflo) (Shire, *et al.,* 2008).

Modeling of Ice Pigging

For cleaning process, Evan *et al.,* (2008) developed a model for predicting the flow and melting behavior of ice slurry passing through stainless steel pipelines. However, in a study carried out of using ice pigs in a plate heat exchanger and tube heat exchanger, it was reported that pressure drop increased exponentially with ice fraction and with the square of the velocity (Shire e*t al.*, 2008).

Freezing point depressant

The Freezing Point Depressants (FPD) is added in order to maintain the slurry condition, preventing the ice particle from fusing together and forming a solid block of ice. Typically, sodium chloride is used due to low cost, minimal health and safety implications and small concentrations required. Other FPD's are also used which includes sugar, sorbitol, hydrochloric acid, sodium hydroxide, sodium nitrate and poly ethylene glycol.

The selection of freezing point depressant mainly depends on the ideal solution or product which is already present in pipeline. The chemicals such as acids, alkali, anti-corrosion and pacifiers agents are added as part of freezing point depressant. This is particularly important for materials such as "yoghurt or curd" where cleanliness and hygiene are important in determine the safety and product stability.

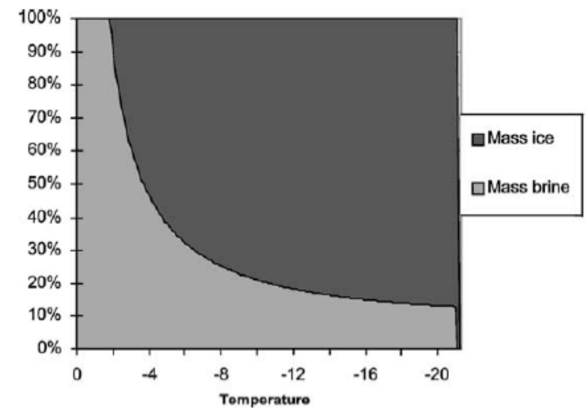

Fig. 1 Variation of ice to brine proportion with temperature (3% $NaCl_2$).

The principal effect of the depressant is to produce an ice-water mixture which is stable over a range of temperatures. The above figure explains the percentage of ice to brine variation with temperature for a 3% sodium chloride ($NaCl_2$) solution (Quarini, 2002).

Purpose of adding freezing point depressant

It decreases the viscosity while thermal conductivity of the fluid phase increases. It replaces corrosive behavior of acid/alkali solutions used in CIP with gentle effect on adjacent metal surfaces. FPD's prevents agglomeration of ice crystals used in CIP by ice pigging.

Ice slurry, Ice particle size and manufacturing

Ice slurry is nothing but fine–crystalline ice particles with an average characteristic diameter, which is equal or smaller than 1 mm (Egolf and Kauffeld, 2005). Now a days, mostly ice slurries produced by mechanical scraped type generators, which produces ice particles of approximately 200 µm size.

However, the particle sizes were approximately one to four millimeters before growth occurred. The effect of this crystal growth behavior is that physical properties are time dependent. Storage and mixing of ice slurry lead to a decrease of the rheological parameters (the viscosity and the critical shear stress) up to 60%.

In simple terms the ice slurry from being pumpable and conforming to different topographies like a liquid, and yet behaves in pipe as a solid, providing an enhance shear stress on the pipe walls and therefore more efficient cleaning of the pipe walls.

Controlling and maintaining the ice slurry consistency is important. A good quality of ice is subject to Ostwalds ripening where by ice crystals tend to stick together and form a solid mass as the ice ages. To overcome these problems a freezing point depressant and mechanical agitation is used.

The ice pigging technology requires an ice making facility (Scraped Surface Heat Exchanger), flow analysis unit, storage tank, and delivery pump, conductivity meters etc. The ice is generated with portable water, a freezing point depressant, table salt etc.

Mechanical type Ice slurry generator

In mechanical – scraper type ice slurry generator, the refrigerent evaporates in a double – wall cylinder. Through the inside space, bounded by the inner cylinder, the water or brine solution flows. In their experiment (Ainslie *et al.*, 2009) generated ice pig by circulation of 5% sodium chloride brine solution through a rotating screw, scraped surface ice generator and stored in a 700 liter stirred tank. Depending upon the ice fraction required, the ice machine was turned off when a set temperature was reached.

Fig. 2 Mechanical scraped surface ice generator

Measurement of ice fraction

Ice fraction is more important in behavior of the ice slurry. It affects flow behavior and rheological properties of ice slurry (Hansen *et al.,* 2002). A simple and repeatable method is used with a standard coffee press (a container with mesh plunger). The ice slurry is fully filled in this container and then mesh plunger is slowly inserted. Finally, the plunger is pushed slowly downwards, until no more travel can be achieved. The ice fraction was calculated as ratio of volume of water to the total volume of coffee press.

Thermo – physical properties of ice slurry

i. Density

The ice slurry contains ice with a density lower than the liquid phase, the difference between densities gives a buoyancy force to ice particles. Due to this phenomenon, the density cause stratification of the fluid in the pipes and in storage tanks ducts. We need to agitate continuously for preventing the stratification more significant with ice slurry for lower temperature applications because the lower freezing point requires a higher concentrations of additives or FPD's, which increases the density difference between the liquid phase and the ice particles, except for alcohols and ammonia (Hagg, 2005).

The density of ice slurry can derived as follows:

$$\rho = m/ V_i + V_w + V_a$$

Where,

ρ = density of ice slurry (kg/m^3)

V_i = volume of ice (m^3)

V_w = volume of water (m^3)

V_a = volume of additive (m^3)

ii. Viscosity

In cleaning by ice pigging, the shear force on the pipe wall is generally carried out through the use of an effective viscosity. A number of experiments show that ice slurry behaves as a Newtonian fluid at low ice fractions, and as a non-Newtonian fluid at high ice fractions. Many relationships between the ice fraction and effective viscosity have been developed (Thomas, 1965). Theoretically, this effective viscosity could be used to predict the desired ice friction for fouling with a known adhesion to the pipe wall.

$$\mu_e = \mu L (1+2.5 C + 10.005 C^2 + 0.0027 \times 10^{16.6 C})$$

Where:

μ_e = effective viscosity of ice slurry i.e. ice water mix (Pa.s)

μ = viscosity of water (Pa.s)

L = volume of water (fraction)

C = volume of ice (fraction)

iii. Thermal properties: low viscosity, high ability to transport energy by at least 20% of ice at -35°C with a freezing point of -25°C (Hagg, 2005).

- **iv. Chemical characteristics:** pH 7 – 9.5
- **v. Environmental impacts:** non-toxic, non-polluting, without use of any chemical
- **vi. Material compatibility:** chemically stable, non-corrosive, compatible with iron, copper, aluminium, stainless steel and polymers.
- **vii. Freezing point:** -2°C to -20°C.

Cleaning efficiency

The cleaning ability of the ice pig was measured on a straight 20 mm diameter length of glass pipe (Quarini, 2002). Different materials were smeared on the inside wall of the pipe. The ambient water (20°C) and then ice pig was circulated throughout the pipe at constant mass flow rates. The fluids were pumped through the solid pipe until the pipe appeared clean. Cleaning factor was defined as follow:

Cleaning factor = Time taken to clean with 20°C water/Time taken to clean with ice plug

Table 1: Comparison of cleaning factors

S. No.	Fouling materials	Cleaning factor for ice pigging	Cleaning factor for hot water
1	Jam	10	3
2	Salad cream	5	4
3	Margarine	15	10
4	Toothpaste	15	–

The above table represents the result of the experiments with jam, salad cream, margarine and toothpaste smeared on the pipe walls. The higher the cleaning factor value, the better the system is at cleaning the fouling material off the walls. The ice pig or ice slurry is better at cleaning soil of the tube wall than an equivalent volume of hot water and much better than cold water.

Ice pigging to plate heat heat excahngers

In an experiment (Quarini, 2002) the ice pig was pumped through very complex geometries including a plate heat exchanger, with an average gap width of 3 mm between the corrugated plates. With smaller ice particles, beside a set of plates, the other geometries included 90° bend, T-junction and orifice plate with area ratios of 12:1 (contraction), 1:9 (expansion).

a – Jam fouling before water flow

b – Jam fouling after water flow

c – Jam fouling shortly after ice pig entery

d – Jam fouling at the end of the ice pig

Fig. 3 The ice pig successfully passed through PHE

The ice pig was found successfully scouring through these complex topologies and appeared to do so as a plug. Even the most complex geometries appears to generate very little disruptions or mixing in the ice; the ice would flow like a fluid where it had to but would quickly knit itself together and then move as though it were a solid plug when it was allowed to do so.

After the arranging of the plates in plate heat exchanger, initially mains water at 15 °C was circulated through the heat exchanger at 0.11m/sec velocity, it removes small amount attached jam from plate surfaces. After the circulation of water the ice pig or ice slurry 20 – 30% volume to the total circulated geometry volume, it removes the majority of the reaming fouling of jam. This circulation is continues for several times for efficient cleaning, with the ice slurry contains ice fraction ($_{i}$ is 50% by coffee press.

The ice pig was cleaned to superior level, when compared to water, with no change in flow velocity or the volume of fluid used. This is due to the effective viscosity of the ice slurry increasing with ice fraction. The gap between the plates in plate heat exchangers is 3 mm. it was found that best results were obtained when the ice particle sizes were optimized.

Advantages of ice pigging:

Ice pigging can be considered as an alternative to traditional flushing. Ice pigging provides the following benefits:

1. Ice pigging is more suitable technology than other cleaning methods because it uses significantly less water during the cleaning process (Friedman *et al.,* 2012).
2. The waste can be easily collected and dispensed of eliminating contamination of nearby steams or ponds.
3. It is more effective than flushing for removing sediment and biofilm.
4. It is possible to add treatment materials (chemicals such as acids, alkali, anti–corrosion, and pacifier agents) as part of the freezing point depressant.
5. It is able to achieve better cleaning per unit volume than water and therefore it is very attractive in processes where effluent waste presents special problems.
6. Increase in product recovery within the processing lines.
7. Reduction in down time required for cleaning.
8. Low operational risk and easy implementation.
9. Use less water than flushing
10. Efficient removal of loose material at slow speeds (high wall shear).
11. Easy introduction and removal.
12. In expensive, "single use" and reduce man – time.
13. It is environmental friendly as it reduces the need of expensive and potentially hazardous cleaning chemicals.
14. Reduction in cleaning water and effluent processing costs.

Benefits *vs.* other cleaning techniques:

Ice pigging can be considered as an alternative to traditional flushing, uni – directional and CIP. Compared to these alternatives ice pigging provides the following benefits:

1. More effective than flushing for removing sediment and biofilms.
2. Ice pigging can easily and efficiently remove 'soft' fouling; using a volume of ice pig less than one tenth of the volume of water.
3. Can be used in locations where flushing is not practical or possible.
4. Can navigate obstructions such as bends, partially closed valves, butterfly valves, and changes in pipe diameter.
5. No need of chemicals usage as in CIP.

Conclusion

In some investigations ice pigging technology has proved to be successful in food processing operations. Based on their findings, food industry is also using ice pigging technology for CIP purposes. Looking to the similarity with food processes, ice pigging has a great potential in dairy processing also. This would result in lower material cost, lower operational cost but require other infrastructure for manufacture of ice pigs in dairy processing plant itself.

Dairy Products of the Future

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Introduction

Global milk consumption is growing, with demand by 2050 projected to increase by 50 %. The Food and Agriculture Organization (FAO) of the United Nations projects that the global milk demand in 2050 will exceed 1 billion metric tonnes (MT). Milk and dairy products are considered high-quality protein sources that provide the full package of essential amino acids needed for muscle function and maintenance; plus nine essential nutrients supporting bone health, and heart and nerve function. Milk and dairy products, therefore, make a vital contribution to supporting healthy people and healthy communities.

Food security – a massive challenge

Food security in India can be achieved by paying higher attention to issues such as climate change, integrated water management, agricultural pricing and crop insurance; dairying has to be given prime importance too. The schematic diagram to achieve food security is shown in Fig. 1.

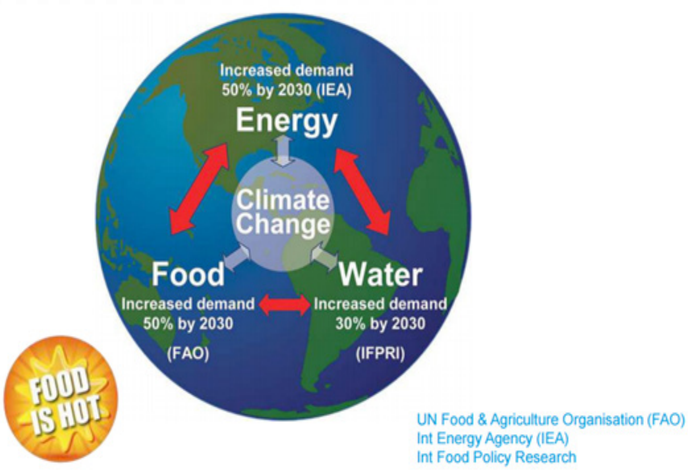

Fig. 1 Methods to achieve food security

Nutrient contribution from dairy products

Milk contains numerous nutrients (fat, protein, lactose) and it makes a significant contribution to meeting the body's needs for calcium, magnesium, selenium, riboflavin, vitamin B_{12} and pantothenic acid (vitamin B_5). However, milk does not contain enough iron and folate to meet the needs of growing infants. The contribution of dairy to nutrient intake is shown in Fig. 2.

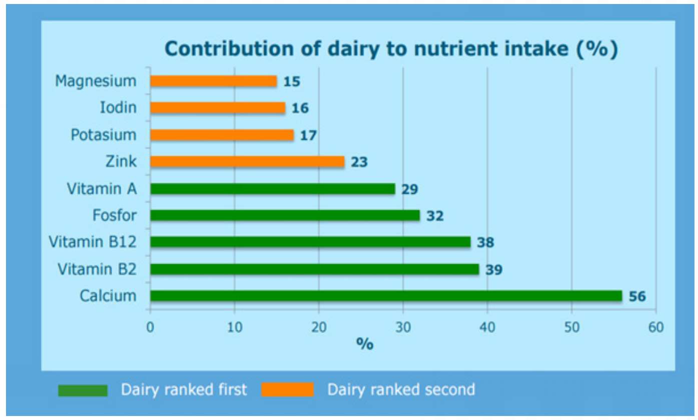

Fig. 2 Contribution of dairy to nutrient intake in NL (% of intake)

Milk/cheese components with putative functional properties

Recently, several oligosaccharides have been categorized in milk and have been suggested as potentially bioactive ingredients. More than 70 fully annotated oligosaccharides have been identified in human milk and ~40 in bovine milk, of which 24 contains sialic acid. Oligosaccharides are composed of a lactose core bound to lactose-amine units via β1–3 or β1–6 links and carrying fucose or sialic acid in their terminal position. These molecules are abundant in human milk and have been proposed as important for child development. Neutral oligosaccharides—namely the monomer *N*-acetylglucosamine and fucoseare essential to the development of the microbiota of breast-fed neonates because of their immunomodulating actions. Conversely, acidic oligosaccharides help to prevent the adhesion of pathogens to the intestinal mucosa. Bovine milk also contains these oligosaccharides, which are abundant in colostrum.

Milk is also often fortified, e.g., with vitamin D or Omega-3 FAs, because it provides an excellent vehicle for fat-soluble molecules and can be marketed to target population groups after appropriate regulatory evaluation.

Some kinds of cheeses, namely those inoculated with *Penicillium* such as Roquefort, Stilton, or Gorgonzola, exhibit high concentrations of andrastins A–D, which are potent inhibitors of farnesyltransferase, a key enzyme in cholesterol synthesis. Other peptides formed during ripening-induced proteolysis might further contribute healthful properties that would possibly contribute to the low incidence of Cardio-Vascular Diseases (CVD) in high-cheese-consumption countries.

Trends in dairy processing and products anticipated

In near future, the following trends in dairy industry is envisaged

Type of milk: Over and above use of Cow and Buffalo milk, focus will be laid also on Camel milk and Goat/Sheep milk.

Globally, cow milk accounts for 83 % of global. In addition to cow milk, only buffalo milk makes a substantial contribution at the global level accounting for 13 % of global production and 24 % of developing country production. The contribution of milk from goats (2.4 %), sheep (1.4 %) and camels (0.3 %) is limited at the global level and only slightly higher among the developing countries as a group.

Health foods – dairy foods fortified with nutrients, vitamins, minerals; dietetic foods – diabetic (sugar-free), anti-hypertensive, zero-cholesterol dairy products, etc.

Functional foods including fermented dairy foods

The recently extended range of functional foods include probiotic, prebiotics and symbiotic (i.e. prebiotic + probiotic) foods. In addition, foods enriched with antioxidants, isoflavones, phytosterols, anthocyanins; and fat and sugar reducing foods are considered as functional foods. It is estimated that probiotic functional foods comprise 60-80% of total functional foods. The probiotic dairy products have a special role among functional foodsProbiotic dairy products contain lactic acid bacteria (LAB – i.e. *L. casei*, *L. plantarum*, *L. brevis*) or Bifidobacterium spp. Otherdairy products are enriched with prebiotics, fiber, calcium, omega-3, acethanol and bioactive peptides from LAB. Probiotics are involved in the treatment of diseases such as diarrhea in children, osteoporosis, some types of allergies, of diarrhea caused by antibodies, and constipation. Consumption of fermented yogurt with Lactobacillus strains can reduce the level of blood cholesterol

Cheese is one of the most successful probiotic dairy products that have high potential to carry bacteria. The number of probiotic bacteria in cheese can exceed 10 million/g and cheese have more protective effects on probiotic bacteria in comparison to yogurt because of its chemical and physical properties such as low pH, high buffering capacity, high nutrients and high fat levels. Survival of *Lactobacillus plantarum*, *Lactobacillus bulgaricus*, *Bifidobacterium animalis* and *B. angulatum* in white cheese during ripening led to bacterial population exceeding 10^8cfu/g.

Dairy foods for different segments i.e. such as for children, for adults, for geriatrics, for women, etc. Age-specific marketing is best employed by targeting niche groups within broad age segments.

Intake of dairy products is low, especially among females. In one survey, only 9% of females aged 14-18 and 25% of females aged 9-13 met the 'Healthy Eating Index' (HEI) target.

The consumers (aged 50+) not only benefit from the increased muscle mass, bone density, and strength, and reduced body fat mass, that whey proteins and milk minerals provide, but senior shoppers also have the buying power to purchase products like high-protein food and drinks. Food formulators should aim to tailor high-protein goods specifically to senior shoppers.

New product development – Formulated dairy foods, convenience dairy foods, dairy based sports drink.

Organic dairy products

Organic milk comes from cows that are not given any hormones, antibiotics, or pesticides. They haveaccess to open pastures and are fed 100 % organic feed, grown in fields that are chemical-free for at least 3 years. Organic milk must be handled separately from conventional milk and never intermixed. Organic milk and milk products must be processed, either on-farm or off-farm, in a certified organic plant.

The growing demand for organic dairy products is driven primarily by consumers' belief in the higher quality and safety of these products, and their awareness of the positive environmental, animal welfare, and ethical impacts of organic agricultural practices. Many are concerned about the use of antibiotics and of rBST (recombinant bovine somatotropin), a genetically engineered Bovine Growth Hormone that is injected into an estimated 30 % of lactating cows in conventional dairies. Hence, the modern consumers prefer to choose organic dairy products despite higher prices.

Blend of dairy with non-dairy food ingredients – Soybased, Cereal based, adding Fruit and Vegetables, Oats, etc. Several dairy products are being modified by including vegetables, fruits, vegetable proteins, etc. such as blended cow milk with soy milk, cheese analogues made using dairy proteins and vegetable fats/oil, malted milk powder, etc.

Snacking, convenience– driving force of future

A recent survey by Technomic opined that snacking is so prevalent that it's starting to replace regular meals. The snacking trend is alive and well in the dairy category as well. And, as in other sectors, snacking and convenience go hand in hand.Consumers are looking for convenience, ready-to-eat and value-priced foods.

- Food processors are creating more snack packs that include cheese as well as items such as nuts, pretzels, and fruit.
- Drinkable yogurt products are outpacing spoonable products in growth.
- On-the-go packaging continues to be a hit across all dairy categories.

The theme of convenience based dairy product manufacture will have to focus onspreadability of butter/Fat spreads, Soft scoop ice cream, Cheese powder, cheese flavourings, drinkable yoghurt products, Instant milk powders, formulated dry mixes for reconstitution.

Type of milks

Camel milk: Camel milk is three times as rich in Vitamin C as cow's milk; rich in Iron, Unsaturated fatty acids (USFA) and B vitamins.Hurdle being yield of milk is reasonable i.e. 5 l./day is reasonably good yield for camel milk. However, camel milk is not compatible with UHT processing.

FAO developed first Camel milk cheese in 1992. Camelbert cheese in 1993 - in Mauritania. Then came Camel chocolate from powdered camel milk – Vienna based Chocolatier. Camel milk ice cream was introduced in 1999 by Israeli scientist. Date flavoured camel milk hits the Middle East (no added sugar, naturally probiotic).

Camel milk has more lucrative market in the Middle East and West.Emirates Industry for Camel Milk and Products (EICMPs) – Camelicious product, rolled out in United Arab Emirates (UAE).

Goat milk: Goat milk has high level of Medium Chain Triglycerides (MCTs) and easily accessible proteins. Goat's milk contains more calcium, less lactose, less cholesterol and fewer allergens. Daniscohas developed new ice cream based on goat's milk. Low fat goat milk plus Creamodan and Litesse ingredients provides 'smooth and rich body'.

Novel processing of milk

UV processing of milk: Photopurification which uses UV light to inactivate pathogens could outstrip pasteurization of dairy products in future (SurePure – developer). Such method uses radiation at a germicidal wavelength of 254 nm which inactivates pathogens, including virus. In South Africa, such treatment has provided big energy saving, since heat is not required. Such photopurification treatment has been used in South Africa and approved for use in India. UV treatment of fruit juice has been approved by FDA in the US.In countries where pasteurization of milk is mandatory, photopurification is used in conjunction with pasteurization to increase its shelf life.

Photopurification has also been attempted in the production of Cheddar cheese; food safety standards have been reached. SurePure treatment did not inactivate enzymes responsible for cheese texture and flavor development.

Membrane processing of milk: Reverse Osmosis (RO), Nanofiltration (NF), Ultrafiltration (UF) and Microfiltration (MF) processes have been in use in the dairy industry for several decades. The phenomenal growth in the application of membrane separation technology in the dairy processing brought into focus the need for novel membranes and processes that enable production of new dairy based ingredients. Now-a-days wide pore UF process is used to develop α-lactalbumin enriched protein products, loose NF process is used to recover and purify oligosaccharides, high pressure UF process is used to replace the conventional NF process used for concentrating dairy product streams. There has been increased interest in use of MF in production of micellar casein concentrate (MCC). MCC is obtained from MF of skim milk during which most of serum protein and non protein nitrogen components are removed into permeate thereby increasing the ratio of casein/total protein and casein/true protein. The retentate obtained is a concentrated colloidal suspension containing casein in micellar form, lactose, minerals and some serum proteins. MCC has potential uses in cheese making, process cheese (as rennet casein replacer), nutritional meal replacements, whipped toppings, coffee whiteners, etc

Lactose free dairy products

The incidence of lactose intolerance – caused by the inability to digest the milk sugar lactose – is genetically determined and varies greatly between different populations as well as also age groups. In order to cut down on bloating and the embarrassment caused by the build-up of intestinal gas, consumers are resorting to specialist products. Globally, lactose-free dairy and ice cream both achieved 10% value gains in 2015. The US is the largest market for lactose-free food, accounting for 29% of global sales in 2015. Lactose-free dairy and ice cream continue to experience appreciable dynamism, considering the relative maturity of the market, enjoying value growth rates of 15% and 16%, respectively, over the previous year.

A study carried out in 2015 by the Sanjay Gandhi Post Graduate Institute of Medical Sciences in Lucknow, UP, found that nearly three quarters of the Indian population was suffering from some degree of lactose intolerance. In late 2015, Gujarat Co-operative Milk Marketing Federation (GCMMF) Ltd. announced that it was the first dairy company to introduce a 'lactose-free milk' product in India under Amul brand.

Dairy alternatives

Legume like soyabean has been the favoured ingredient to prepare 'vegetable milk'. Nuts and cereals may serve to produce a "milk" substitute. This diversity is a fundamental part of the category's appeal, since it caters for a wide range of preferences regarding personal taste, food intolerances and also environmental and ethical concerns. Some consumers may be allergic to one type of nut or cereal but not another, e.g, some may object to soya products on environmental grounds.

Value added dairy products

While margins in the liquid milk space stood at 4-5 %, those for Value added dairy products (VADPs) ranged from 12-18 %. According to estimates, the share of VADPs in the milk and milk derivatives segment is growing at about 25 % every year, and it is expected this pace would be maintained till 2019-20. Curd, ghee and ice cream has greater scope.According to Parag Milk Foods, VADPs accounted for about 80 % of its turnover.

Futuristic demand for milk

Organization for Economic Co-operation and Development- Food and Agricultural Organization (OECD-FAO) outlook estimates that Asian milk demand will touch almost 320 million tonnes by 2020 and that means the region will need to increase milk availability by another 40 million tonnes during the next 6 years. At an aggregate level, by 2020 the world will consume 60 billion litres more milk than in 2012 and more than half of this increase will be in Asia.

"Modified foods" were traditionally developed to be eaten by those who had special dietary requirements, usually for medical reasons. Over the past few years an upsurge in consumer interest in "healthy eating" has encouraged food manufacturers and retailers to introduce "healthier" product versions to their existing ranges.

Invited Articles

Potential applications of renewable energy in dairy sector

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Introduction

Increased demand for milk and milk products has led to tremendous growth of dairy industries in the world. Around 500 modern dairy plants, spread throughout the country, process around 300 lakh litres of milk every day and produce packed liquid milk of different grades and a wide variety of dairy products. A conservative estimate of 1: 0.8-1.3 itself produces large quantities of effluents in the organized sector during milk processing every day. Around 155 million tonnes of milk has been produced daily during April 2016 and its requirement increases rapidly day to day with the production of cattle dung which has been mostly not well attended. As per an estimate approximately 3 million tonnes of cattle dung will be available by 2022. Other than the economic considerations, both the dairy industry and cattle dung are responsible for the release of green house gases into the atmosphere. Hence, a holistic approach need to be considered for collection and utilization of cattle dung as it has been implemented for the procurement of milk. The cattle dung produced in dairy farms is being used as fuel (dry cakes) and/or composted for use as manure. Besides, the production of renewable energy in the form of biogas, the anaerobic digestion of cattle dung considerably reduces production of foul odour as compared to their aerobic composting. As a whole, cattle dung digestion to produce biogas increases the income as well as reduction in heat energy requirements leads to a better and hygienic environment to the farmer in the form of quantity of milk produced and quality of milk can be improved by biogas production and its usage for sterilization.

There is a rapid growth globally in use of renewable energy especially biogas. Biogas is produced in anaerobic conditions, i.e. in the absence of oxygen by fermentation of organic substrates including manure, sewerage, household waste, industrial wastewater etc. Biogas mainly contains methane, carbon dioxide and traces of hydrogen sulphide, ammonia, hydrogen and moisture. Biogas calorific value is around 21 MJ/m^3, which contains methane, can be used in thermal as well as electrical applications.

Sunlight is a renewable source of clean and sustainable energy that is potentially harnessed to produce electricity and heat useful for numerous domestic and industrial applications. Dairy is one such industry that requires energy intensive processes like process heating, refrigeration cooling and electricity loads to meet the ever growing demand globally. Washing, cleaning, chilling, pasteurisation, sterilisation, evaporation, chemical processes and spray drying are a few examples of the energy requiring processes in dairy industry. From among all the processes chilling/cold storage required for product preservation alone accounts for ~20% of energy consumption. The cold storages uses compression based refrigeration technology requiring high grade energy supplied through grid electricity and is very expensive. An alternative could be solar photovoltaic that can be used to generate electricity which can then subsequently be used to run the refrigerator as conventional. Though promising, solar photovoltaic technology requires large battery bank for storage and hence are expensive. Vapour absorption based refrigeration technology on the other hand requires low grade energy such as waste heat for operation and therefore promises to be a cost effective alternative to the compression based technology. Similarly, low and high temperature requirement and power of the dairy sector can be replaced by solar based thermal and power generation system.

SPRERI's intervention on application of renewable energy in dairy sector

In dairy effluent treatment plant, effluents generated from various sections of the production facilities are first received in a collection tank. Before mixing in an equalisation tank, the effluents are passed through a fat trap unit. The low density semi-solids, which float in the tank contain fats, proteins, packing materials etc. are called as 'dairy effluent scum' are removed manually. After removing the dairy effluent scum (top layer), the effluents are further treated in aerobic or anaerobic conditions. The characteristics of dairy effluent scum vary with the products being produced in the plant and their relative proportion and the methods of the operation used. The schematics of the source of dairy effluent scum generation in a dairy effluent treatment system have been shown in Fig. 1.

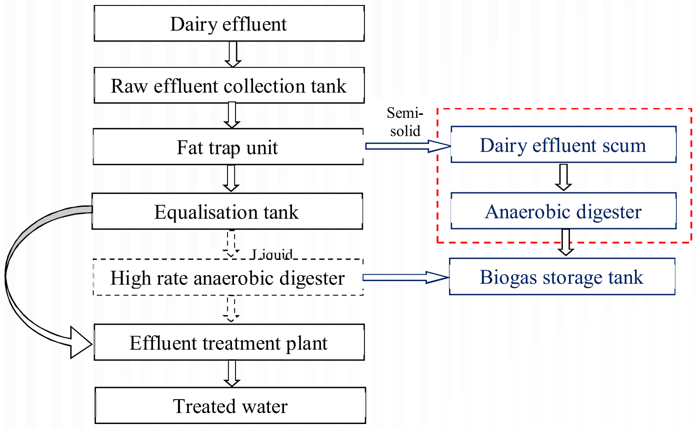


Fig.1. Schematics of the dairy effluent treatment system

Dairy effluent based biomethanation plant

Conventionally, extended aeration type activated sludge process is used for the treatment of dairy effluents. The process is highly energy intensive, expensive and requires large investments in infrastructure. During treatment, an offensive odour is produced, which creates unhealthy conditions near the treatment plant. In comparison, an anaerobic treatment option is not only attractive from low energy consumption point of view, but also from several other aspects such as the process accepts higher organic loading, produces methane as a useful by product and no offensive odour associated with it.

In a dairy, many processes are involved in handling and product making. Effluent from some of the sections in dairy like casein, cheese, paneer, ghee and butter carry medium has high organic load (COD of 10000-80000 mg/L) and if the streams coming from these sections are separated and treated anerobically, more organic matter could be removed using relatively very small reactor volume. In additions, the load on existing aerobic system can also be reduced drastically. SPRERI has carried out extensive research on anaerobic treatment of dairy effluents and developed a low cost up flow anaerobic hybrid reactor that only treats dairy effluents efficiently, but also produces biogas in substantial quantities as a by product, which can be used as fuel. The technology reduces pollution load, produces energy and does not require aeration, thus saves electricity. SPRERI has also installed a few such plants in the dairies and their performance has been found satisfactory.

Vidya Dairy, Anand is a unique and pioneering organization of its kind in the country, which imparts one-year on-hand experiences in dairy plant operation and management to B.Tech (Dairy Technology) students of Gujarat Agricultural University, Anand. The dairy has a capacity to handle 100000 L of milk per day. On an average, it produces around 12000 L of effluents daily entirely from cheese production unit. Since there is a vast scope of reducing the load on existing system by treating cheese whey separately using high rate anaerobic digestion system, it was operated with 12000 L of effluent (10500 L combined effluent + 1500 L of cheese whey) having aggregate COD load of 27700 mg/L. Biogas produced has 76% methane it is used to produce electricity using biogas engine-generator set. Performance data of anaerobic filter has been shown in Table 1.

Table 1. Performance of anaerobic filter at Vidya Dairy

Feed (L/d)	12000	16000
COD in (mg/L)	2300	4000
COD out (mg/L)	300	450
COD removal (%)	87	89
Inlet pH	7.0	6.7
Outlet pH	7.2	7.0
Biogas production (m^3/d)	11	25
Biogas yield (m3 m/kg COD fed)	0.4	0.4

Dairy effluent scum based biomethanation plant

Dairy effluent scum was collected from a dairy industry at Anand (Gujarat) processing liquid milk, ice-cream, ghee and cheese etc. Rich organic content of the scum indicated its suitability as a feed stock for biomethanation. The laboratory scale followed by pilot scale studies for biomethanation have been carried out at SPRERI using the dairy effluent scum as the substrate in daily fed reactors for 10% total solids concentration and 40 days hydraulic retention time. A very high biogas yield of 45-50 L/kg of fresh dairy effluent scum and 462 L/kg of total solids was obtained. The methane content of the biogas was found to be 70-72% as compared to 50-60% for the cattle dung. The methane production potential of the dairy scum was found to be 3.8 times that of the cattle dung. The hydrogen sulphide content of the biogas was very low (around 10-30 ppm). As such the biogas can directly be used for thermal applications and as well as power generation.

Based on the studies carried out at SPRERI, a demonstration plant for biomethanation of 500 kg/d dairy effluent scum has been set-up at M/s Vidya Dairy, Anand (Fig. 2). The floating drum type biogas plant having effective volume of 20 cu m consisting of inlet chamber, digester, gas holder and outlet was designed and constructed. For commissioning of the plant, the digester was charged with digested cattle slurry taken from a large cattle dung based biogas plant in normal operation. An average biogas production of around 12-15 cu m per day with a methane content of 71% was obtained. The biogas produced is being used for in-house thermal applications.

Fig. 2 Dairy effluent scum based biogas plant at M/s Vidya Dairy, Anand

Large capacity fixed dome biogas plants using cattle dung

A very large fraction of biogas plants are fixed dome type – Deenbandhu design (1-6 m^3 capacity) and Janta design (upto 10 m^3 capacity). The fixed dome type biogas plants are constructed on-site using common materials like bricks, cement, sand, gravel etc. but, in general, no steel. The common all brick masonry fixed dome type biogas plant designs i.e. Deenbandhu and Janta of 1 to 10 m^3 capacity have been successfully modified under All India Coordinated Research Programme on Renewable Energy Sources (AICRP on RES) for digestion of cattle dung in solid-state (TSC upto 15%). Reinforced cement concrete is not used for construction of either the digester or the dome of the plant. The design is suitable for all regions of the country where average weekly minimum ambient temperature is 10°C or higher. As such, the design is, in general, not suitable for hilly terrains. The plant may be designed for any rated capacity between 10 to 500 m^3 of biogas per day or higher and for the hydraulic retention period of 40 days or more depending upon TSC of the influent slurry. The commercially available 30 cm internal diameter PVC pipe is used for feeding the substrate. The pipe is laid at an angle of 75°C with horizontal. The lower end of the pipe is kept at a height of at least 90 cm above the bottom of the digester (Fig. 3). Normally cattle dung mixed with equal quantity of water is used as feed for the plant (TSC 9 to 10%). The plant may also work satisfactorily for higher TSC of up to 12%. This means water consumption may be cut by upto 50% depending upon season and physical status of the cattle dung used at the time of feeding. Construction of the plant requires materials and equipment which are used for routine construction work in the country. Whereas, construction of KVIC plants requires fabrication of the gas drum in an established workshop and special infrastructure for transportation and installation of the gas drum at the construction site. Maintenance requirements of all brick masonry plants are far lesser than the floating drum biogas plants. Cost of the plant is also upto 30 - 40% less than the cost of KVIC plant of the same capacity. More than 200 demonstration plants of the modified designs have been set up at selected rural sites throughout the country, except hilly terrain, under the guidance of various cooperating centers of AICRP on RES. All those plants are working satisfactorily, a few of those for as long as 7 years.

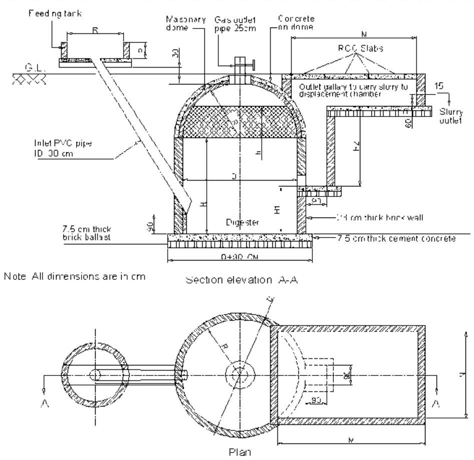


Fig. 3 Layout of large capacity biogas plant

Upgradation of biogas to natural gas equivalent fuel

One of the hot topics in bioenergy industries is the upgradation technology of biogas to biomethane due to rise in price of oil and natural gas. The biogas cleaning and upgradation process increases the calorific value and removes the undesirable gases like H_2S, carbon dioxide and moisture which will be more harmful to the system to be utilized. Sabarkantha District Co-operative Milk Producer's Union Limited (Sabar Dairy), Himmatnagar, Gujarat has been utilizing natural gas for its thermal applications in day to day milk processing operations. The dairy effluent generated from its milk processing site has been anaerobically treated in a high rate anaerobic reactor to produce biogas. Since the biogas produced have potential to replace a part of its natural gas utilization in boilers and canteen for cooking after upgradation and also reduces its cost of expenditure on natural gas. M/s Sabar Dairy seeks out help from M/s Gujarat Knowledge Application and Facilitation Centre (A centre of excellence by CII, Government of Gujarat and Gujarat NRE), Ahmedabad for implementing a suitable biogas upgradation technology. As a technical network partner to Gujarat Knowledge Application and Facilitation Centre, SPRERI has been approached for technical guidance to erect and commission a biogas purification plant at M/s Sabar Dairy. A 100 m^3/h low pressure Vapour Swing Adsorption (VSA) technology has been employed for purification of biogas at Sabar Dairy. The composition of biogas before and after purification using VSA system has been shown in Table 2.

Table 2. Composition of biogas before and after purification

Parameter	Before purification	After purification
CH_4 (%)	60 – 66	90 – 94
CO_2 (%)	30 – 35	4 – 5
H_2S (ppm)	2000 – 2500	1 – 2

The total amount of purified biogas with 90% methane content for the period of 16 months i.e. from February 2015 to May 2016 has been completely utilized in their existing boiler replacing the same quantity of natural gas obtained from government sources.

Solar thermal system

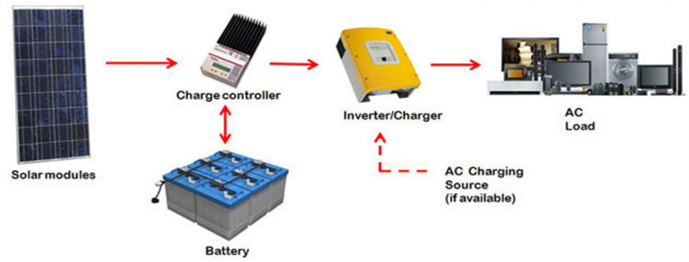
In Solar thermal systems the collector will absorb the energy falling from the sun and converts to heat energy .This heat energy will be used in many applications such as heating, cooling, drying, cooking, power generation etc. There are two types of solar thermal systems , one is stationary collectors such as flat plate collectors, evacuated tube collectors etc absorbs the solar radiation and converts it in to heat energy which is used for low temperature applications (< 100 °C), these collectors does not require tracking and second one is non- stationary collectors or concentrators such as parabolic troughs, parabolic concentrators, fresnel reflectors etc. which will reflects the light energy falling on it and concentrate it in smaller area which results in increased heat flux and temperatures, these type of concentrators require tracking mechanism, used in high temperature applications (>100 °C).

Low temperature processes <80°C	High temperature processes >100°C
Such as: • Bottle washing 60 °C • Pasteurization 70 °C • Yogurt maturation 40-45 °C • CIP (Cleaning-in-Place) 70-80 °C	Such as: • Bottles sterilization • UHT treatment (milk sterilisation) • Multiple stage evaporation • Spray drying

Solar thermal systems can greatly contribute to energy savings during the production processes in the dairy sector, which demand water temperatures of <250 °C. Solar thermal may be utilized for following dairy processes

Solar power generation system

A solar photovoltaic system converts sunlight into electricity. A photovoltaic cell consists of two or more thin layers of semi-conducting material most commonly silicon which is encased between sheets of glass or plastic. When the silicon is exposed to light, electrical charges are generated and this can be conducted away by metal contacts as direct current (DC). This DC is converted in to alternating current (AC) by inverters. The power output from the inverter is connected to the load (ac appliances). The systems include storage by introducing the battery banks for backup during night hours as well as during the cloudy weather. Solar photovoltaic system mainly consists of solar panels, charge controller, inverter, battery and load. The typical solar photovoltaic system is shown in the figure below.



In dairy sector most of the electrical load is from the equipments like light, fan, cooling applications, running of machineries, cold storage, air conditioning, office equipments, pumps etc. Rooftop solar PV system for power genration will contribute electrical energy savings in diary sector; diary industry may easily adopt the system for power generation as it is simple, reliable and clean energy.

Conclusion

Renewable energy resources such as solar and biogas has a huge potential to replace fossil fuels in dairy sector which have not been fully exploited and it have a vast scope for improvement. Renewable energy usage will help the dairy sector to create new jobs thereby improving the economy of the nation as well as reduce the carbon foot prints. Biogas production from dairy manure as well as waste to energy from dairy industries for captive use and solar based refrigeration system reduces the waste generation and shows the potential production of renewable energy for thermal/ cooling or electrical applications in commercial level. There are also many opportunities for applications of solar thermal and solar photovoltaic technology in dairy processing plant. It can greatly add to energy savings during the production processes in the dairy sector.

Advances In Mechanized Production of Traditional Indian Dairy Products

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Introduction:

India is number one producer of milk in the world, with an average production of 142 Million Tones per annum in 2015; out of this about 50-55% of the total milk production is converted into traditional milk products, which is mainly confined to the cottage scale in the non-organized sector. With the rapid growth of dairy industry in our country, the technology and design of process equipment has also undergone needed changes and equipment for making indigenous products are no exception. The small-scale technology for the preparation of indigenous products cannot be exploited for industrial production.

India has made substantial growth of urban and semi-urban areas. As a result, increasing number of persons in the cities is desirous of purchasing quality milk products and milk-based sweets. The small scale techniques used at present for the preparation of value added Traditional Indian Dairy Products (TIDP) can not be adopted for industrial production. The current method for the manufacture of indigenous dairy products are based on the techniques that remained unchanged over ages. Regardless of the volume of the production, they are manufactured primarily in jacketed kettles, which inherently suffers from several disadvantages, where possibilities to control and optimize heat treatment processes are very limited. The equipment employed at the cottage level is enlarged for the industrial level of operation. Consequently inefficient use of energy, poor hygiene, sanitation and non-uniform product quality associated with rural scale operation crept into large-scale manufacture due to the non-existence of processing equipment based on advanced techniques of production and sound engineering principles. This has necessitated the need for innovations in designing of equipment for the manufacture of value added dairy products. It is high time that concerned efforts are made by the experts and scientists to formulate value added dairy products with engineering interventions of innovative design of equipment to produce hygienic products with economy of processing. The commercial large scale production of Value added dairy products with very good hygienic and sensory properties has necessitated sincere efforts for innovations in the designing of equipment for the manufacture of Value Added Dairy Products.

With the rapid growth of dairy industry in our country, the technology and design of process equipment is also undergoing changes. The small-scale technology for the preparation of indigenous products cannot be exploited for industrial production, therefore innovations in the designing of equipment for the manufacture of value added dairy products is the need to have premium prices for the locally produced high quality value added dairy products. One of the strategies to enhance our presence in world dairy market is to promote R & D of value added quality dairy products besides improving the traditional dairy products by innovative techniques, designing of equipment and mechanization for the manufacture of value added dairy products. India also needs to develop innovative dairy products and modernize manufacturing of traditional dairy products. The value addition of milk is an important aspect to be looked into by the dairy engineers, scientists and technologists. India has developed various innovative indigenous technologies over the centuries, to preserve milk in the form of value added products. India can be a lead player to command the value added dairy products in the global market by introducing innovations in the designing of equipment for manufacture of value added dairy products. It also helps in opening new frontiers for indigenous dairy products through mechanization and innovations in designing of equipment to have exciting opportunities for development of the rural economy of India.

Traditional Indian Dairy Products:

A variety of traditional milk products are manufactured in India with most of them are region specific. The making of traditional milk products has essentially been a cottage scale enterprise within the basic process of their production, variations exist from one unit to another that give products their distinctive touch, taste and flavour. Now, technologies for mechanized production of these products on industrial scale are being standardized. The classification of traditional dairy products based on the principle of manufacture is given below:

Table 1 Classification and uses of Traditional Milk Products of India

S. No.	Principle of Manufacture	Products	Uses
1.	Heat Desiccation	*Khoa*	*Khoa* based sweets (*Burfi, Peda, Gilabjamun, Kalakand, Milk Cake, Kunda etc*)
		Rabri	Direct consumption
		Basundi	Direct Consumption
		Thabdi	Direct Consumption
		Halwas	*Gajar Halwas, Dudhi Halwas, Chiku Halwas etc.* for Direct Consumption
		Halwasan	Direct Consumption
2.	Heat & acid coagulation	*Chhana*	*Channa* based sweets (*Rasogolla, Sandesh, Rasmalai, Chhana Murki, Chum-chum etc.*)
		Paneer	Culinary dishes, Direct consumption
3.	Fermentation	*Dahi*	Culinary dishes, Direct consumption
		Chakka	*Shrikhand, Shrikhand vadi*
		Misti Dahi	Direct consumption
4.	Fat concentration	Makhhan	Direct consumption, *Ghee* making
		Ghee	Culinary dishes, Direct consumption
5.	Frozen	*Indian Kulfi*	Direct consumption
6.	Addition of cereals and desiccation	*Kheer, Payasam, Dhudh pak*	Direct consumption

Mechanized Manufacture of Traditional Milk Products

Conventional methods of manufacture of Traditional Indian Dairy Products has inherent disadvantages such as inefficient use of energy, poor hygiene, fatigue on the operator, non-uniform product quality etc. In order to overcome these inherent disadvantages, attempt have been made for mechanization of the process to develop batch, semi-continuous, and continuous equipments for manufacture of these products on large and commercial scale.

Mechanized Production of Khoa:

Khoa is an indigenous milk product prepared by concentration of milk and is widely used in India and in neighboring countries as a base material for preparation of numerous sweets like *penda, burfi, gulabjamun, kalakand*, etc. Generally three main types of khoa namely pindi, dhap and danedar are recognized which differ mainly in body and texture characteristics and are required for specific types of sweets.

Processing of khoa mainly takes place in pans/kettles, where the possibilities of controlling operating variables and optimizing heat treatment are generally very much limited. Increased demand for efficient and labour saving processes in dairy industry favours the use of mechanized system. The heat sensitivity of khoa adds to severe fouling on heating surfaces. At higher consistencies the wettability of heating surfaces further reduces and causes a reduction in thermal efficiencies for khoa processing. Under such conditions conventional heat exchangers do not provide satisfactory solution and therefore, the efforts are being made towards mechanizing the process of khoa making.

Batch type Khoa making Machine

Rajorhia (1971) attempted a semi-commercial process of khoa making using jacketed steam heated stainless steel kettle with built-in-stirrer.

Khoa making unit suitable for village level operation has been developed by Sawhney *et al.*(1980) to overcome some of the problems faced in traditional method of khoa making. The unit consists of a hemi-spherical pan joined to a cylindrical water jacket with dead weight safety valve to control steam-water pressure. The pan has an easy operating rotary scraping mechanism. It can convert five litres of milk into khoa within 10 to 12 minutes when operated at 30 psig (206.85 Kpa) water- steam pressure. The milk in the pan is heated through water in the jacket by placing the equipment over a specially designed furnace. Anap and Kumar (1980) developed a rice husk or mixture of rice husk and dungcake heated, village level milk processing unit which can be modified for khoa making.

More (1983) developed a prototype khoa making machine working on the principle of SSHE and it has been claimed to perform satisfactorily on small and medium scale production. Agrawala *et al.* (1987) developed a conical process vat which consists of a steam jacketed S.S. conical vat with a cone angle of 60 degree. The steam jacket is partitioned into four segments to provide variable heating area for efficient use of thermal energy. The rotary scrapers have been designed to offer a uniform centrifugal force of scraping at all points on heat transfer surfaces. The scraping assembly is coupled to a variable speed drive unit for control of speed at different stages of khoa preparation, desired to obtain a better texture of the product.

More (1987) developed an equipment which consists of a stationary jacketed drum having steam inlet, condensate outlet through steam trap and pressure gauge. The jacketed drum is also provided with an opening at the top for entry of milk, exhaust of vapour and for observation of on going process. The unit is also provided with a water inlet with control valve for cooling the product at the end of the process and power operated spring loaded scraper assembly. Optimum operating conditions were reported to be a temperature of 121°C and scraper speed of about 28 r.p.m. The equipment was used to treat four kg of milk per batch.

A prototype khoa making machine of mild steel working on the principle of SSHE has been successfully developed by Christie and Shah (1988). Subsequently in their follow-up study an improved version of S.S. machine having capacity to convert 50 kg of milk into khoa per hour per batch was developed by Christie and Shah (1990). Sunil Patel (1990) has studied heat transfer performance of scraped surface heat exchanger during khoa making. The unit consists of steam jacket divided into three compartments for better control of heating process as the content reduces during later part of khoa making. The scraper blades are spring loaded on the assembly which is arranged in such a way that the whole surface is efficiently scraped. This khoa making machine was successfully used by Upadhyay *et el*(1993) for preparation of khoa based sweets like *penda*, *halwa* and other concentrated food products by altering the operating variables of the machine.

Continuous khoa making process

In order to overcome drawbacks of traditional method of khoa making, such as limited capacity, lot of time and labour requirement and necessity to clean pan between batches, Banerjee *et al.* (1968) designed and developed an equipment for continuous khoa making. It consists of a steam jacketed drum heater, open steam jacketed pans and power driven scrapers. In this equipment, milk at the rate of 50 litre per hour is gradually concentrated by heating it in a steam jacketed drum heater operated at 3 kg/cm^2 (294.3 Kpa) steam pressure followed by further heating and concentrating it in open steam jacketed pans. Since the unit was made of mild steel, the product was prone to oxidation and discoloration (Rizvi *et al.*, 1987) and the plant did not work effectively owing to the lack of controls for regulated supply of milk (Boghra,1979). The method for production of khoa with this machine was standardized by De and Singh (1970). Rajorhia and Srinivasan (1975) made improvements in the design of this plant by replacing mild steel with stainless steel.

Punjrath *et al.* (1990) have developed an inclined scraped surface heat exchanger for continuous khoa making. The unit comprises a feed balance tank, positive displacement pump and S.S. inclined scraped surface heat exchanger (ISSHE). The inner cylinder of ISSHE is surrounded by a three - compartment insulated steam jacket and equipped with a rotor that acts as both a scraper and a conveyor.

Dodeja *et al.* (1990) have described a continuous khoa making equipment operating on the principle of thin film scraped surface heat exchanger. The product quality was acceptable when the equipment was operated under standardized conditions (144 to 158°C temperature and 100 to 150 r.p.m of rotor). Higher rotor speed had adverse effect on flavour and texture of khoa.

Christie and Shah (1992) studied the feasibility of manufacturing khoa using scraped surface heat exchanger.

Dodeja *et al.* (1992) developed a continuous khoa making system which consists of two SSHE equipped with scraper assembly.

Bhadania (1998) has developed three stage continuous khoa making machine based on principle of scraped surface heat exchanger and has studied heat transfer performance of the machine.

Use of roller dryer for manufacture of khoa

In order to find an alternative method of khoa making for mass production, Bhadania *et al.* (1986) studied the feasibility of using roller dryer for the manufacture of khoa. The concentrated milk of 50-55% TS prepared in a jacketed steam pan was used in the laboratory scale roller dryer. The unit was operated at 3 r.p.m. and between 1.5 and 1.8 kg/cm^2 (147.15 and 176.58 Kpa) steam pressure. Organoleptic evaluation of the product showed that colour, body and texture were comparable to khoa made by the conventional method. The flavour and appearance score of the khoa were less than the control product. It has been reported that proper working of scraped material from the roller was an essential factor to get uniform body and texture of the product.

Mechanized Production of Heat Desiccated Milk Products:

Since long, various efforts have been made in mechanization of heat desiccated milk products like, *Halwas, Burfi, Gulabjamun, Rabri, Kheer, Peda, Basundi, Halwasan etc.*

Halwas

Mechanization of manufacture of khoa based sweets like *penda, halwa(Gajar Halwa, Dudhi Halwa)* is tried using Batch type Stainless Steel Version of SSHE developed at SMC College of Dairy Science, Anand Agricultural University, Anand. The process parameters are optimized for and the product was compared favourably with products made by conventional method in the sensory and rheological profile, with better score and colour (Upadhyay et. Al, 1993). Jain (2010) manufactured *'Lauki Halwa' & 'Carrot Halwa'* using batch type multi purpose SSHE developed at SMC College of Dairy Science, AAU, Anand, and studied its heat transfer performance.

Burfi

With a view to overcome the limitations of small scale batch method of *Burfi* making, a mechanized method of manufacture of burfi was developed by Palit and Pal (2005) adopting existing units such as scraped surface heat exchanger (SSHE) and Stephen processing kettle. It improved continuous manufacture of khoa using two stages thin film SSHE developed by Dodeja *et al* (1992), addition of sugar @ 30% is recommended by Reddy (1985); proper blending and kneading of khoa with sugar in Stephen processing kettle. Directly from Stephen processing kettle, Burfi was hot filled (at about 60 °C) into previously cleaned and sterilized polystyrene containers of 250 g capacity and covered with plastic lids. Khojare and Kumar (2003) standardized the parameters for *Burfi* making in CPV from Khoa. Pre-weight khoa obtained from Thin Film SSHE was loaded in the CPV.

Gulabjamun

A mechanized semi-continuos system is adopted for the manufacture of gulabjamun from khoa at Sugam Dairy, Baroda (Banerjee, 1997). The process involves mixing of khoa (60-70%TS) with 19-20% refined wheat flour and leavening agent (baking powder) in a planetary mixer. The dough is divided into 8 g portions and transported to the ball forming machine. Then the balls are shaped like a cylinder and are carried to afrying system containing oil at a temperature of 140 °C. After frying, the balls are soaked in 62.5 % sugar syrup solution. The gulabjamuns swell and weight about 16 g each. The gulabjamuns are packed in plastic containers and an appropriate amount of hot syrup is added. Lids are applied on the cups and subsequently sealed. Packaged gulabjamuns are stored under refrigerated conditions. Canned gulabjamuns are stored at room temperature (Aneja, *et. al*, 2002).

Rabri

Efforts have been made to develop a commercial method for manufacture of Rabri employing SSHE for concentration of buffalo milk, and addition of shredded chhana/paneer in place of clotted cream to provide the desirable texture to the final product (Gayen and Pal, 1991 b). Pal, *et. Al* (2005) successfully developed a technology for the large scale production of Rabri using thin film scraped surface heat exchanger (TSSHE). It involved standardization of buffalo milk to 6% fat, addition of sugar @ 6% to preheated (85-90 °C) milk and concentrating in TSSHE upto 50% solids, addition of shredded paneer and packaging in hot condition (80 °C) and immediately cooling.

Kheer

Jain (2010) manufactured *'Kheer'* using batch type multi purpose SSHE, and studied its heat transfer performance.

Peda

The Industrial mechanized method of converting khoa into *Kesar Peda* had been developed at National Dairy Development Board (NDDB), Anand. It has been subsequently adopted later by Sugam Dairy, Baroda. It involves heating of khoa at 60 °C and adding sugar, flavour and other ingredients in planetary mixer. The peda mass thus obtained was cooled to 5 °C by transferring into a cold room and fed to peda shaping machine followed by packing and storing under refrigerated conditions (Banerjee, 1997).

Basundi

Bandyopadhyay and Mathur (1987) reported use of a steam jacketed kettle for desiccating milk in the preparation of concentrated milk products. Patel *et al.* (2005) made *Basundi* by open pan concentration using steam jacketed kettle and products were evaluated for their proximate composition, physico-chemical properties and sensory attributes. Three pilot models viz. cylindrical type, conical type, and *Karahi* type were developed for *Basundi* making on the principle of scraped surface heat exchanger (SSHE). All the models were tested for *Basundi* making and their heat transfer behaviour at different operating conditions. Heat transfer and energy consumption were estimated for design optimization and to generate information for optimum operating conditions of the machine (Rajasekhar, 2001). Heat utilization in *Basundi* making was evaluated using cylindrical type, conical type and karahi type scraped surface heat exchangers (SSHEs). The heat utilization in these heat exchangers was evaluated with and without induced draught on milk surface (Shah, *et al.;* 2002). Mechanization of manufacture of *Basundi* is tried using Batch type Stainless Steel Version of SSHE developed at SMC

College of Dairy Science, Anand Agricultural University, Anand. The process parameters are optimized for and the product was compared favourably with products made by conventional method in the sensory and rheological profile, with better score and colour (Patel, 2006). Manufacture of '*Basundi*' was tried at NDRI, Karnal, using conical process vat and two-stage thin film SSHE with standardized buffalo milk. '*Basundi*' prepared in conical process vat, was good in body, texture, appearance and overall acceptability for processing time between 80 to 100 min. (Agrawala *et al.*, 1987a, More, 1987, Ranjeet, 2003, Dodeja *et al.*, 2004). Patel *et al,* (2007) developed a mechanized system for Continuous *Basundi* Machine (CBM) based on the principle of thin film SSHE. It consists of concentration unit of three SSHEs with specially designed scrapers, variable frequency drive (VFD) to facilitate variation of speed of scrapers, resistance temperature detector (RTD) sensors and other controls to optimize processing parameters. The design of CBM machine, based on the principle of TFSSHE, is claimed to be energy efficient and produces better quality product as compared to traditional product. It consists of concentration unit of three SSHEs and chilling units of two SSHEs, with specially designed scrapers, variable frequency drive (VFD) to facilitate variation of speed of scrapers, resistance temperature detector (RTD) sensors and other controls to optimize processing parameters which resulted in better quality product in terms of sensory and rheological attributes is done for attaining a product of uniform standard and assured quality.

Halwasan

'Batch type *Halwasan* makimg Machine (BHM)' is designed at SMC College of Dairy Science, Anand Agricultural University, Anand, with funding support of 'Business Planning and Development Unit-Anand Agricultural University. Standardization of mechanized production of *'Halwasan'* in terms of manufacturing techniques, sensory profiles, and compositional and physico-chemical attributes is done for attaining a product of uniform standard and assured quality. *Halwasan* prepared by using Batch type of *Halwasan* making Machine (BHM), is very good in hygienic quality as well as rheological attributes, having average sensory score of 92/100 as compared to sensory score 88/100 of *Halwasan* made by traditional/conventional method.

Mechanized Production of Heat and Acid Coagulated Products:

Panner and Chhana are two prominent traditional heat and acid coagulated milk products of India. Mechanized processes for industrial production of these products has been developed. Significant R&D at National Dairy Development Board (NDDB), National Dairy Research Institute (NDRI) and several agricultural universities has resulted in to optimization of processing variable for mechanized production.

Paneer

Batch production of paneer at a small scale employing the traditional process often results in an inconsistent product. A continuous *paneer*-making system was developed at NDRI, Karnal by Agrawala *et al.* (2001). In this system, the unit operations involved in *paneer* making have been mechanized. The continuous *paneer* making machine is designed to manufacture 80 kg *paneer* per hour by employing twin-flanged apron conveyor cum filtering system for obtaining the desired moisture content and texture attributes.

Chhana

Attempts were made by different workers to mechanize the *chhana*-making process. Aneja (1998) reported a prototype for continuous *chhana*-making, capable of producing 40 kg/hr of *chhana*. Recently, workers at Indian Institute of Technology, Kharagpur developed a continuous chhana-making unit of 60 L/h of milk capacity (Sahu and Das, 2007). The unit has a duplex plunger pump and a helical coil heat exchanger for dosing of milk and acid and heating the milk prior to acid coagulation respectively. It also consists of a vertical column that gives residence time for the separation of milk solids to *chhana*. In this unit, the chhana-whey mixture, after being discharged from the top of the column, is moved over an inclined strainer through which the whey is removed.

Chhana based Confections

Bengali sweets are chhana based, like, *Rasogolla, Rasomalai, Rajabhog, Khirmohan, Sandesh etc.* They are popular world over for their delicacy.

Rasogolla

Different workers made successful attempts to mechanize the production process of *rasogolla*. Choudhury *et al.* (2002) developed a prototype mechanized unit for kneading of *chhana* and *chhana* ball-forming in a continuous manner. It was reported that such unit can handle 15–20 kg of *chhana* per hour and convert it continuously into *chhana* balls (approximately 6 g) as the final product. Recently, Karunanithy *et al.* (2007a,b & c) also tried to mechanize these unit operations in *rasogolla* making for its continuous production. The authors claimed that the resulting product from the developed continuous *rasogolla* making machine was comparable in quality with the control and market products.

Sandesh

Kumar and Das (2003) optimized the processing parameters viz. mixing, kneading and cooking of *chhana* and sugar mixture for the mechanized production of *sandesh* from cow milk. But, it was observed that the desired homogeneity after the initial mixing was lacking in the product. With a view to overcome this, Kumar and Das (2007) subsequently developed a single-screw vented extruder for cooking of *chhana* and sugar mixture that can be integrated with the mechanized method for the continuous production of *sandesh* from cow milk. With necessary modifications, this technology may also be adapted to continuous production of *sandesh* from buffalo milk.

Mechanized Production of Fermented Milk Products

Fermented milk constitutes a vital component of human diet in many regions of the world. In the Indian sub-continent also, fermented milk products such as dahi (curd), lassi and butter milk figure prominently in people's diet.

Dahi

Many organized dairies are now preparing *dahi* adopting mechanized and standardized method (Singh, 2005). In this method, fresh, good quality milk is pre-heated and subjected to filtration and clarification. The milk is standardized to 4 to 5% fat and 10 to 12% SNF, homogenized and heat treated followed by cooling to incubation temperature and inoculated with specific *dahi* starter culture. It is then filled in suitable containers (plastic cups) of the appropriate size and incubated at 40–42°C for 3–4 hours. When a firm curd is formed and the acidity reaches to about 0.7%, *dahi* cups are transferred to cold room maintained at about 4–5°C and stored at that temperature till consumption. Kumar and Pal (1994b) studied the suitability of reverse osmosis (RO) concentrates for the manufacture of *dahi* and reported that the quality of *dahi* made from 1.5-fold RO concentrates was highly satisfactory.

Misti Dahi

The technology for the manufacture of *misti dahi* in an organized manner was developed by Ghosh and Rajorhia (1990). The process involves standardization of buffalo milk (5% fat and 13% SNF) followed by homogenization at 5.49 MPa pressure at 65°C, sweetening with cane sugar (14%) and heating mix to 85°C for 10 min. Then cooling the mix to incubation temperature and inoculating with suitable starter culture and incubating the mix to obtain a firm curd. The firm curd is transferred to cold storage (4°C) and served chilled. Now, the organized dairies for example, Mother Dairy, Delhi; Mother Dairy Gandhinagar is manufacturing and marketing *misti dahi* at large scale.

Lassi

Industrial process with mechanization is developed for manufacture of *Lassi*. Extension of shelf life of *lassi* is achieved by ultra high temperature (UHT) processing of product after fermentation and packaging it aseptically. Aneja *et al.* (1989) developed a method for manufacture of long-life lassi that does not settle down over extended storage in aseptic packs. Now, UHT-processed *lassi* and spiced buttermilk are commercially manufactured and marketed by different dairies in India. Kumar (2000) developed *lassi* for calorie-conscious and diabetic people using an artificial sweetener and reported that aspartame at a rate of 0.08% on curd basis was the most acceptable level to prepare low calorie *lassi*. Recently, Khurana (2006) developed suitable technologies for the manufacture of mango, banana and pineapple *lassi* along with their low-calorie counterparts using artificial sweeteners.

Shrikhand

A fully mechanized/continuous process has also been developed for industrial production of *Shrikhand* (Aneja and Vyas, 1983). In this process, *Chakka* is prepared by separating the whey from skim milk dahi employing 28" dia. Basket centrifuge at 1100 rpm. The resultant *Chakka,* sugar and plastic cream are then mixed in a planetary mixer. Dhotre (2006) developed and studied the performance of SSHE for continuous thermization of *Shrikhand. Shrikhand* was thermized at different operating conditions like temperature, scraper speed, and TS level in *Chakka*.

Mechanized Production of Fat Rich Dairy Products

In the traditional Indian dietary regimen, milk fat in the form of malai (cream), Makkhan (fresh-churned butter) and ghee contributes significantly towards nourishment of the people of all age groups. Many scientists has made attempt to mechanize production of these products on industrial scale.

Cream

The various types of cream separators are developed for mechanized separation of cream from milk and sour milk are, (i) Warm milk separator (ii) Cold milk separator(iii) Power driven separator (iv) Hand driven separator (v) Open bowl or gravity fed separator (vi) Semi enclosed separator (vii) Hermetically sealed separator/ air tight/ pressure fed/ foam less separator (viii) Sour milk separator

Makkan

Makkan is freshly churned butter without salt. Mechanized methods of production of white butter of industrial scale are available in batch and continuous process.

Ghee

Punjrath (1974) developed a prototype continuous ghee making plant of 100 kg/h capacity on the principle of flash evaporation using butter as base material. In another process Abichandani *et al.,* (1995) a thin film scraped surface heat exchanger (TFSSHE) attached with a butter melter for continuous manufacture of *ghee*. The organoleptic and chemical quality of ghee prepared by this continuous mechanized method did not differ from that prepared by batch process. Recently, Patel *et al.* (2006) developed an industrial method of ghee making with an aim to reduce fat and SNF losses by inclusion of serum separator and a spiroheater. It was claimed by the authors that the new method offers more commercial benefits than the existing methods. NDRI has perfected continuous equipment for manufacture of 500 kg ghee per hour (Abhichandani, 1997). This equipment is integrated with an efficient butter melter developed at NDRI.

Design and development of equipments for value added Traditional Indian Dairy Products at SMC College of Dairy Science, AAU, Anand:

SMC College of Dairy science, Anand Agricultural University, Anand has designed and developed several equipments for mechanized production of value added Traditional Indian Dairy Products (TIDP), like *Basundi, Kulfi mix, Kheer, Khoa, Peda, Thabdi, Burfi, Gajar Halwa, Dudhi Halwa*, *Halwasan* etc. with better hygienic, rheological qualities and improved shelf-life at lower cost of processing. The mechanized production of value added dairy products will give the following advantageslike (i) Economic production (ii) Uniform quality of the product (iii) Hygienic production and better keeping quality (iv) Scale-up production (v) Less laborious process (vi) Less energy consumption (vii) Better control over the process parameters to maintain rheological and sensory attribute (viii) Promotes export of traditional Indian products like *Basundi, Kulfi mix, Kheer, Khoa, Peda, Thabdi, Burfi, Gajar Halwa, Dudhi Halwa, Halwasan etc.* through small and medium entrepreneurs. These innovations in designing of equipment for the manufacture of value added TIDP will help in commercialization and to promote small entrepreneurship through Public Private Partnership (PPP), for the benefit of the society to get hygienic and best quality value added dairy products.

Developments in Packaging of Milk and Milk Products

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Packaging plays an indispensable role in modern society. Packaging is considered as 5^{th} "P" of management. The 7 "P" of management are 1. Protection 2. Preservation 3. Presentation 4. Promotion 5. Packaging 6. Portability and 7. Pollution free. Packaging is an all-embracing term and covers the operation of cleaning, giving protective coating, weighing and filling, closing, labeling, surface designing, printing, cartooning and bracing, containerizing, marketing and may also include material handling. Packaging is also described as a complex, dynamic, scientific, artistic and controversial segment of business. It is certainly dynamic and constantly changing. New materials need new methods, a new methods demand new machinery, new machinery results in better quality and better quality opens up new markets which require changes in packaging. The cycle is repeating. Product and packaging material are becoming so interdependent that we cannot separate/consider one without the other. They are made from each other. Most foods spend the greatest part of their lives in some form of package. Once the product is packaged, the overall quality of the product is controlled by the package. This signifies the importance of packaging. Even some foods are recognized by their packaging materials.

Objectives of Packaging

1. *To contain the product: (A prime objective)*
   a. Adequate size and shape (Parle-G biscuit package, Surf Excel tubs, Milk powder)
   b. Proper constructional features. No leakage, spillage, diffusion, i.e. loss prevention.
   c. Package: Contain commodity in natural form (Little Heart biscuits Pillow pack, prevent damage
   d. No subsequent damage after packaging (during handling transportation and storage).
   e. Thus package must be strong enough to contain the commodity as it is.
   f. Optimum compatibility (nontoxic, non soluble with product… No physical, chemical or biochemical changes/alteration… i.e. inert to the product.
2. *To protect the product :*
   Against damages which may be due to different forces viz. (a) Mechanical, (b) Environmental (c) Microbial and Biochemical hazard. (d) Social Hazards.

Sr. No	Storage	Hazard	Damage	Protection
I	Handling and transportation	Drop, shunting, shocks, vibrations, stack load, compression etc.	Breakage loss of shape dusting seepage	Cushioning blocking.
II	Storage	Stack load, compression Attack by rodents and insects	Crushing, distortion sticking Spillage, contamination spoilage	Adequate compression Strength of package. Resistance and Repulsiveness to Insects
III	Environment during storage transportation and distribution	Biological or otherwise	Contamination	Toughness of packaging material (to resist penetration).
		High/low humidity moisture/ water.	Physical, chemical and biological deterioration due to loss/ gain of moisture	Efficiency of closure. Water vapour barrier properties.
		O_2	Oxidative Rancidity Vitamin Destruction Off flavour development	O_2 BARRIER VACUUM – O_2 N_2/CO_2 flushing packaging in impermeable package
		Light U.V. Rays (> 300 Ft Candles or Lumen / Ft^2 = 3229 Lux	Acceleration of oxidative rancidity Bleaching of pigments.	Use of opaque or colour (Yellow, red, brown, etc. packaging)
	Storage	Temperature	-Change of state -Increase of moisture ingress (entrapped) -Increased rate of deterioration	Protection -Heat insulation -Use of poor conductor -Use of reflective insulation
		Time	Gradual and slow changes accumulate and staling and other deteriorative changes	-Early / immediate marketing (FIFO) -Proper schedule of dispatching order product -Heat insulation -Barrier material

3. *To help in selling product or legal or information reasons:*
   a. Give description, introduction and use of product…Governed by features viz. clean and smooth surface, good printing and feel…. Design; shape must be favourable for dispensing and reclosures and for disposability, reuse etc.
   b. Name of the product : Manufacturer's name / packager's name, address …net weight…Batch No…. Code No…Mfg. Date…30-40% area of the label.
   c. Almost 60% space for product information; Recipe/contents, method of use, dosage etc.
   d. Legal requirements: Stating recipe, ingredients, Date of manufacture…Expiry date…Location of manufacturer/or address (for return or complaints), Weight/Volume, Name of products, Veg/ Nonveg Logo etc.
4. *To help selling product: (Marketing reasons)*

   Providing advertising features…Reminder for future purchase…Visual attraction…Emphasize benefits…*Samrat Namkeens.*
5. *Quantity reasons. guarantee reasons:*

   Assurance/guarantee for quality, ingredients, identification and follow-up. (Amul: The Taste of India)
6. *For technical reasons:*

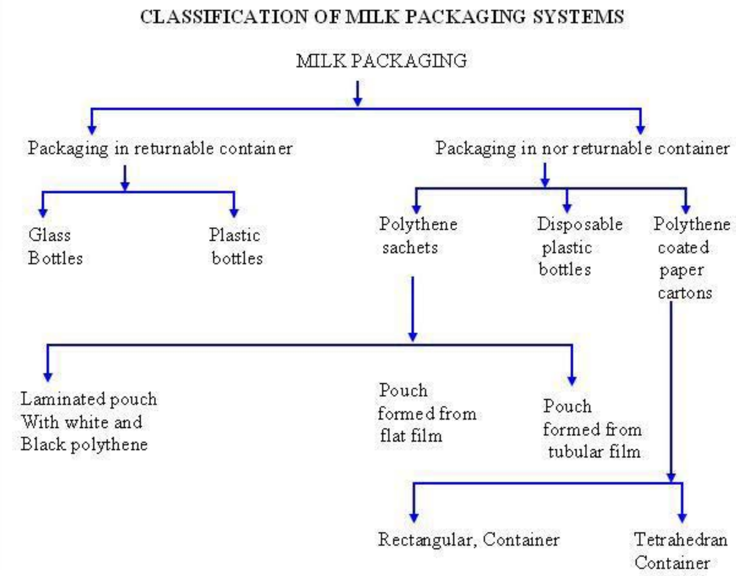
   Marking to ensure accurate registration of design on each package…marking to identify the product.
7. *To provide ease of transportation and handling and storage….*

1 Packaging- not merely to contain product but it is a process of getting goods from the source to the point of use in the most beneficial manner. This involves all aspects of handling, storage, preservation, distribution, advertising, sales promotion, display, dispensability, preparation and various other fact of industry.

There is ever increasing list of objectives. These are:

a. See through properties b. COF c. Self standing d. Reusability e. Reclosure f. Prevent damage and finally Economical (!!!!).

Criteria for Selection of Milk Packaging Material



Milk is productand hence exremely perishable and sensitive, hence need exact packaging material in order to preserve its innate cracteristics and quality for some span of time. The necessary characteristics of the packaging material are:

1. Innert : Free from off flavours and do not impart any taste or flavour to milk.
2. Prevent bacterial contamination.
3. Resistant to UV light.
4. Prevent physiological effects on the product.
5. Good/required mechanical properties.
6. Tamperproof.
7. Good Oxygen barrier properties.

Materials used:

i. Glass
ii. Plasics: Now a days LD:LLDPE (50;50) is popularly and widely used. Coextruded multilayer films with anouter opaque layer is employed in India. To prevent especially light, inner/sandwitched black (carbon black) layer films can also be used.

Classification of milk packaging systems.

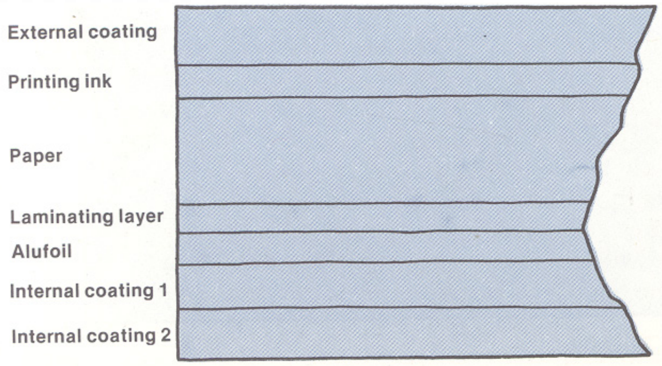
4Other packaging materials are Glass bottles with aluminium foil lid/snap-on plastic lid. Plastic bottles of HDPE or PP can also be used. Considering severe solid wate disposal, reusable polycarbonate bottles (can take 300 trips aganst glass wbottles which can take 30 trips) with leak proof screw cap are now becoming popular. These bottles are unbreakable and are much lower in weight (1/6 th that of glass bottle). PET bottles can also be used.

Properties required in laminates for aseptic packaging:

Table : Properties sought in laminate for Aseptic Packaging

No.	Properties	Example of suitable material
1	Tear resistance	PVC, PVDC/PVC, PE, PP
2	Stiffness	Paper, PS
3	Puncture resistance	Ionomer, PET
4	Printability	Paper, Al-foil, PS, PE, PET
5	Folding	Al-foil, paper
6	Heat sealing	LDPE/LDPE
7	Light barrier	Al-foil paper metallized film
8	H_2O vapour barrier	Al-foil PE, PVDC
9	O_2 barrier	Al-foil, PET, PVDC, PVA, EVA i.e. EVOH

The lamnate now a days used in India foe Tetra bricks contai the following layers:



Tetra Pak Aseptic packaging material

In India, the external and internal coat of LDPE are ued. In paper layer Kraft paper is employed to improve the mechanical strength.

Multi layer plasic bottles containig barrier material are also used in developed countries. Flxible multilayer film containing sandwitched barrier layer can also be employed. For sterilized milks, glass bottles, multi layer flexible films can be used.

Packaging of Fat Rich Dairy Products

The main characteristics required for packaging materials are:

1. Prevent light
2. Prevent moistue loss.
3. Prevent oxygen transmission.

Cream:

In the early 20^{th} century wax coated paper board cartons were used for cream. Newer cream packaging concepts include thermoformed packs made from LLDPE, PS or PP. Tin plate (lacquered) containers have also been used for larger sizes. Whipped/whipping creams are sold in aerosol container/cans. PE/ PP tubs are also used. Sterilized cream is packed in similar lines to that of UHT milk.

Butter:

The requirements of packaging material are:

1. Non toxic, not harmful to the health of consumers.
2. Grease and moisture proof.
3. Barrier for oxygen.
4. Low metallic content.
5. 2Prevent light transmission.

In India, butter is packed in bulk as well as in retail packages. For bulk packaging, generally PE bags (not copacible), moisture-proof or waxed paper along with corrugated/wooden boxes are used.

For retail packs, flexible packaging materials like vegetable parchment paper or grease proof paper, aluminium foil along with paper board cartons/boxes are more commonly used. Aluminium (Al) film (0.09 mm thick, lacquered and), Al foil/parchment paper or grease proof paper (40-42 gsm) , PVC or PP tubs and card board boxes with parchment insert can also be used. HIPS, PE, PP, P VDC and EVOH singly or in combination have also been used for butter. Recently shallow 1-2 mil thick Al foil trays with heat sealable PVDC-Cellophane or other suitable barrier material are used.

Ghee:

The packaging materials of ghee must have

1. Good fat resistance.
2. Barrier properties against oxygen and moisture
3. Temper proof

A major portion of ghee is packed in lacquered tin plate conainers of capacity ranging from 250 gm to 15 kg, providing almost no air gap. This can give ghee keeping quality of about one year. Glass bottles and jars are also used. Alternate packages which are plastic based are now replacing costly tin containers. For shorter shelf life, 200gm, 500gm and one kg pouches made from multilayer coextruded films of LD/HDPE are used which are economical. Al foil laminates or PET/PP stand-by pouches provided with screw cap have also entered Indian market. Laminated PET/PET pouches, bag in boxes and Al/PE lined paper board cartons are also employed. Nylon/PS based laminates, in combination of barrier material like EVOH are also being experimented as these materials can provide a fairly high strength and shelf life.

Packaging of concentrated and Dried Milks

The packaging materials for these products must confirm to certain special characteristics which are:

1. Protection against moisture, light, air, dust, microbes, foreign odour, rodents etc.
2. Adequate material strength to with stand damage during storage, handling and marketing.
3. Resistant to climatic hazards.
4. Proper shape, size and appearance to promote marketing.
5. Inert.
6. Convenient closure.
7. Economical

Packaging materials for these products

1. Glass: Bottles, barrels, jars etc.
2. Metal: Lacquered Tin Cans, Barrels, drums, bins etc.
3. Wood: Drums, bins, barrels etc.
4. Paper board derivatives.
5. Al foil laminates.
6. Thermoplastics and their derivatives.
7. Composite films:
   a. Copolymer films
   b. Coated films
   c. Coextruded films
   d. Laminates

Flexibles for powder

1. Paper board cartons lined with Al foil/PE or bag inside the paper board cartons, Lacquered tin cans (Vacuum treatment followed by nitrogen gasing to reduce oxygen content to $< 3\%$).
2. Long storage: Lacquer/Print/Al foil(10 gsm)/ Adhesive coated paper(40 gsm)/PE (30 gsm) multi- layers. PET/ Metallized (Met.) PET flexible are also used.
3. Shorter keeping quality: Only paper board cartons with PE/PET bag inside or even paper board coated with PVDC or other barrier material. HDPE based plastic bottles are also used.
4. Bulk packaging: Sacks made from Kraft paper laminate, parchment, LDPE, cellophane, bitumen and wax. Even cast films are recently used:
   a. WMP: Laminates of paper, LDPE, Al foil or metallized, BOPP/PE or PET.
   b. SMP: HDPE flexible film or bottles, laminates containing HDPE/LD or LLDPE/ Nylon, Saran, EVA. PE bag in box.

The sacks for bulk packaging:

a. White paper as outer coating followed by no. of Kraft paper layers (3-6 for 25 kg bag).
b. Outer Kraft paper bag (70 gsm), second Kraft paper bag with PE liner.
c. WMP: 4-6 ply Kraft paper with 3mm LDPE liner. Even now cross woven oriented LDPE strip is used as inside liner to improve the mechanical strength. Bitumen is employed as an adhesive for paper layers.
d. SMP: 2-4 ply Kraft paper/2mm LDPE.
e. Separate LDPE liner/bag

Retail packages:

1. Thick laminated paper (45 gsm)- Al foil (9 u)- LDPE (25 u) having very low WVTR & GTR.
2. PET (12.5 u)/Al foil/Al foil (9 u)/PE (64 u), The Form-Fill-Seal film containing PET (17 u)/PE (9 u)/Al foil (9 u)/LDPE (70 u). Metallized film can also be used in place of Al foil.
3. Lined card board/Adhesive/coating of PVDC or Met. PET/PE Packs.

Multi-wall Sacks: Layer of bituminized paper, often the outer white paper with 4-5 inner Kraft paper layers, containing powder bag in side.

Perfect closure is required;

a. Metal is completely impervious but closure is a weak point.
b. Sacks are sealed by sewing thread which makes holes and therefore it is covered by water proof tap (Usually BOPP).
c. By a mixture of nitrogen and hydrogen (Palladium as a catalyst) can have up to one year of storage.

WMP/Baby foods are packed in lacquered tin cans subjected to vacuum followed by nitrogen gas packaging. WMP/ malted foods are packed in flexible like:

1. 50/100 gm: PET (12 u)/Met.PET (12 u)/LDPE (38 u)
2. 500 gm: PET (12 u)/Met.PET (20/12 u)/LDPE (50/60 u)
3. 1 kg: PET (12 u)/Met. PET (12 u)/LDPE (65 u)

Ice cream

The chief requirements of packaging material are:

1. Protection against contamination.
2. Attractiveness.
3. Protection against moisture loss.
4. Ease of opening and reclosure.
5. With stand temperature fluctuations.

Packaging materials used in India:

1. Waxed paper cups/tubs with paper lid
2. HIPS cups/tubs are the most used packaging material with coated paper/PS or PVC or PP lid.
3. Rigid PVC containers offer clarity and excellent graphical design are widely used in Europe.
4. Bars: Wax coated paper wrapper, Met. BOPP/PE, PE laminates, Met. PET-Paper, Met. PET-paper-PE.
5. In developed counties openable cartons of bleached sulphite board coated with wax or lined with lacquered Al foil are used. Al foil laminate cartons are very effective. Al is barrier to light and radiant energy. When there is break of cold chain, light is reflected and rise in temperature is slower. It requires longer time to thaw and have attractive appearance.
6. PP or HDPE pots or tubs, cylindrical containers (250 or 500 ml) made from wax coated paper board are also used.

Indigenous Product

Now some development in packaging of traditional indigenous products in India can be seen.

Paneer: The materials employed popularly used in India arePET, PET/PE, Met. PET/PE flexible films. Butter papers, PE liners, retortable tin-cans (For sterilized product), Cryovac films containing PET/EVOH/PE can also be used.

Peda/Burfi: Paper board boxes coated with PE or PP are widely used in India. LLDPE liners are popularly used in India Though glassine is much superior to LLDPE liner in providing oil resistance. Packaging materials employed for chocolate and candy packaging lines, LD/HDPE or Sran/Cellophane/saran/PE can also be used.

Sandesh: Paneer line, PS, HDPE bags, Nylon (bulk packs) tin cans, folding paper board boxes, earthen pots and leaves of banana- het pressed to give shape can be employed.

Dahi: Milk pouch material, HIPS or PP or HDPE cups or tubs are popularly used in India. Glass jars, PVC lined HDPE can also be used.

Lassi: Packaging line for pasteurized milk, Tetra bricks, PET or PP bottles are employed in India.

Shrikhand: HDPE or HIPS or PP cups/tubs with coated Al liners are employed.

Rassogolla: Tin cans provided with sulphur resistant lacquer. SO_2 is employed for improving shelf life. Shrikhand line can also be used.

Cheese

Many ways of packaging cheese have been used throughout the centuries and these have varied according to the type of cheese and on the material available.

Broadly speaking, there are two main types of packaging requirement, viz. The long term wrap for factory packaging and the short term wrap for retail sale.

For the former, waxed cellulose and nylon films and cellulose – polyfilm, cellulose polythene, polyfilm polythene, and polythene polyester laminates have found favour, for the latter, polyfilm, cryovac, saran, polyvinyl are suitable.

Any material used for packaging of cheese should have –

Afford general protection

Prevent moisture loss

Improve appearance

Protect against microorganisms

Prevent oxygen transmission

PACKAGING MATERIALS FOR CHEESE IN BROAD CATEGORY

CHEESE	TRANSPORT PACK	CONSUMER/UNIT PACKAG-ING
HARD CHEESE	boxes and frames of wood /plywood	waxed or plastic coated , smear proof paper
SEMI SOFT CHEESE	wooden boxes of frame with Al coated laminate , wax paper ,cardboard boxes	smear proof paper , laminated Al foil or plastic foil, compound or shrink – wrap laminate
SOFT CHEESE	wooden boxes, transport boxes made of card-board	packaged individually into the laminated Al foil or plastic foil placed cardboard boxes
FRESH CHEESE	wooden box or card-board box made of cor-rugated paper , plastic or foils	plastic cups for quarg and lay-ered cheese , in laminated foil placed , in clear plastic bags
PRO-CESSED CHEESE	cardboard box	Al foil , lacquered and heat seal capable plastic laminate, plastic cups or tubes

DIFFERENT PACKAGING MATERIAL USED

Wax: wax was used first time in U.K. Before the first world war.

Advantages-

Obvious, simple and cheap treatment for cheese coats.

More useful and harmless way of protecting cheese against pets and other types of damage.

Disadvantages-

it was difficult, moreover, to get an even coating of wax over the whole cheese the treatment usually cost money.

Application of the film/bag consisting of PET/EVOH or other barrier material/PE or Inomer, Cryovac liners during ripening of bulk of cheeses have saved millions of rupees in dairy industry.

Roquefort has been successfully packaged in aluminum foil with cellulose varnish on the outside and paraffin wax on the inside.

NEW AND COMPETITIVE PACKAGING MATERIALS THE ECONOMICAL AND ENVIRONMENTAL BENEFITS

According to the centre for advanced food studies in Denmark, The new biopolymers may be based on proteins like casein, on carbohydrates like starch, cellulose ,on lipids, and also on polymers from surplus monomers produced in agriculture such as polylactate (pla), and finally, on bacterial produced polymers from microorganisms grown on waste, like poly 3-hydroxy-butyrate (phb).

They expect to increase the hard cheese shelf-life from 2-3 months to nine months.

Camembert, Coulommier, brie etc., are soft variety ripened cheese.

After packaging the ripening process will continue until the cheese is consumed.

It is therefore necessary that the packaging film for soft cheeses should be sufficiently permeable to oxygen and carbon dioxide to allow the ripening process.

THE MATERIALS MOST COMMONLY USED

Waxed paper: most economical

Perforated cellulose

Multi-layered laminates such as cellulose films/waxed paper, super coated paper/wax paper, aluminum/ glassine paper/waxed paper.

Cellulose film/waxed paper laminates

Better results with respect to the conservation, refining and appearance of the packaged product.

The waxed paper is placed in contact with the cheese and permits absorption of a part of the water from the cheese and desorption through the outside cellulose film

UNCOATED CELLULOSE FILM:

Sufficiently permeable to oxygen and carbon dioxide to permit ripening of soft cheeses

CELLULOSE FILM COATED WITH A NITROCELLULOSE FILM:

Only the nitrocellulose varnish films are sufficiently permeable to water vapor to be usable in packaging soft cheeses.

However, the commercially available nitrocellulose coated films are generally characterized by too high a water permeability.

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ALUMINIUM AND TIN FOIL

The glassine – lined aluminum and tin foil were found the best for cream cheese.

Transparent film wrapping always has an advantage that the product can be inspected on sight.

CARTONS (TREATED PAPER, COATED PAPER AND PLASTICS)

They are suitable for packaging high moisture soft cheese that have no characteristics form .

Cartons may be made of a plastic material such as polystyrene. They are then stronger and have superior prosperities in respect of resistance to fat absorption; etc.

MODERN MATERIALS FOR PACKAGING OF CHEESE

Traditional ones are expensive, largely on account of labour cost. Modern packages are convenient to use, attractive

GLASS JARS

The most serious disadvantages are fragility and weight.

UNLINED METAL CONTAINERS

A packs 60 lb cottage cheese with brine into a plastic liner in a metal can which are then closed by an aluminum clip, and the whole kept at below 0°c. A keeping quality of 5 months is claimed.

LAMINATES :

The best way of overcoming the defects of a single material is to bond or laminate two or more thin films of different material together

Thick film of a cheap material of poor specific quality may serve as a foundation for thin film of an expensive material having excellent specific qualities

Plastic film packaging of cheese is applicable to all varieties except such extreme type as cottage (very high moisture, no form, and rapidly consumed) and may not be necessary for such type as parmesan (very low moisture, hard, and resistant to microbiological faults).

The main types of film (polymer) used for cheese packaging are as follows-Polythene-very resistant and tough material. It is impervious to moisture but allows oxygen and co2 to penetrate

PVC- and PVDC polymers are the most popular for cheese.

Cellulose (modified) is not a plastic but is extremely used as a laminate with polythene.

In India about 20 million lit. milk is packaged every day, which can contribute about 40 million empty pouches every day. Considering critical sold waste disposal problems, the time has ripened to consider Biodegradable packaging materials, especially milk packaging. The ASTM (American Society of Testing and Materials) defines '*Biodegradable' as: "Capable of undergoing decomposition into carbon dioxide, methane, water, inorganic compounds, or biomass in which the predominant mechanism is the enzymatic action of microorganisms, that can be measured by standardized tests, in a specified period of time, reflecting available disposal condition*.

Certain Applications

Dairy	Products Biobased Packaging	Yoghurt Butter Margarine Soft Cheese	Mechanical protection Moisture barrier Light barrier Grease barrier Gas barrier	Cardboard + biobased plastic, PLA; 10% PLA+ 90% copolyesters; 10% PLA + 90% co-polyamide; 10% PLA+ 90% starch; 10% PLA + 90% PCL; Cellophane
Biobased Packaging	Milk Hard Cheese Yoghurt, feta cheese, sour cream, quarg, cottage cheese	High moisture, light (and gas) barrier High mechanical strength, light and gas barrier (O2 and CO2) High mechanical strength, high gas barrier (O2, CO2, and light)	Moisture and oxygen barrier Higher CO2 permeability compared to O2 permeability Mechanical strength and moisture barrier	PLA-bottles; PHB/V-bottles; Paperboard cartons coated with PLA and/or PHB/V. PLA and other biobased/ biodegradable material with high CO2 to O2 permeability. Cardboard coated with a mixture of biobased/ iodegrada ble materials, PLA Beverage Biobased

PLA: Poly lactic acid PLB: polyhydroxybutyrate V: valerate

There is good scope of applying Active packaging materials for Traditional Indian dairy products. Active packaging is one which performs some additional desirable role other than providing inert barrier to external packaging viz. moisture absorbance, Oxygen scavenger etc.

Skill assessment of Dairy Engineering Professionals for global competence

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Introduction :

The global dairy industry is expected to reach USD 505 billion by 2017, at a compound annual growth rate (CAGR) of 5 per cent (Anonymous, 2012). It is also expected that milk volumes in the period will more or less grow at the same rate. Milk, cheese, and yogurt are major segments of the global dairy market, and will account for a major share of the dairy produce. The cheese and yogurt segment is touted to grow at a slightly faster pace than the traditional categories, primarily due to the increased demand from emerging markets. The developed markets of USA and Western Europe hold the largest share of the global dairy market, while Brazil and the APAC countries considered as emerging dairy markets – have the highest market growth rate in the coming years. These emerging markets are the major drivers for dairy market expansion. The demand for dairy products in these markets will continue to grow, driven by population growth, rising income levels, urbanization, and change in dietary patterns, especially in developing countries such as China and India. However, milk supply in China and India, as well as countries within South East Asia and Africa, is not keeping pace with the growing demand. Bridging this gap between supply and demand is a compelling opportunity for global dairy companies.

Dairy Technology deals with all methods of handling milk from production and consumption and includes processing, packaging, storage, transport and physical distribution. Various skills required for dairy engineer-Dairy Development, Communication Skills, Engineering Graphics, Fluid Mechanics, Thermodynamics, Economics and Statistics (focusing on dairy sector), refrigeration and air conditioning, instrumentation and control processes, quality assurance, Dairy Engineering, Food Engineering, Dairy Machinery, dairy plant design and development, dairy plant operations and management, entrepreneurship skills, packing and distribution of dairy products.

Dairy engineers provide the dairy industry with the multidisciplinary engineering skills and knowledge that is needed to work independently while designing and maintaining milk harvesting, farm water and/or farm dairy effluent systems. As engineers, your role could include design, installation and maintenance of the entire system. Skill building can be viewed as an instrument to improve the effectiveness and contribution of professionals to the overall production. It is as an important ingredient to push the production possibility frontier outward and to take growth rate of the sector to a higher trajectory. Skill building could also be seen as an instrument to empower the individual and improve his/her social acceptance or value. But insufficient supply of quality skills is one of the main impediments to further growth in this sector.

According to Business Dictionary, skill defined as an ability and capacity acquired through deliberate, systematic, and sustained effort to smoothly and adaptively carryout complex activities or job functions involving ideas (cognitive skills), things (technical skills), and/or people (interpersonal skills).

Career Opportunities

The establishment in 1965 of the National Dairy Development Board (NDDB) and the promotion of the "Operation Flood" scheme by it, gave a great fillip to the dairy industry in India. The spectacular growth of the dairy industry in the last two decades had created various demands for indigenous production of dairy equipment, increased quality standards and production of varieties of milk products. This has resulted in the progressive development of dairy equipment manufacturing industry and technical consultancy organizations and has also given impetus to research and teaching. Such notable expansion of the dairy processing and related industries has opened up vast career opportunities for dairy technologists and engineers.

There are now more than 400 dairy plants in the country making various types of milk products. They need good qualified and well trained personnel to run the plants efficiently. The growth of the dairy processing industry has also encouraged the indigenization of dairy equipment. Most requirements of the dairy industry are now met indigenously. Presently, there are over 170 dairy equipment manufacturers. Many of them undertake turnkey jobs. The industry has two distinct kinds of jobs: (1) equipment design and fabrication and plant design; and (2) project execution. These jobs can be performed by a dairy technologist with an aptitude in engineering.

The dairy technologists can also undertake consultancy work. A successful consultant, however, needs several years of working experience in dairy firms to understand the nitty gritty of the work. Besides opportunities for teaching and research, dairy technologists can start their own enterprises such as small-scale milk plants, creamery, and ice-cream units.

Training of dairy industry engineers:

A well-trained, well-managed team of engineers is vital to the running of a milk plant. If training or management is lacking then the equipment will break down or not work effectively. With short life products such as milk, shortage, stoppages or ineffective machinery can mean disaster.

In an ideal world the engineers would be required to be a well-organized, methodical, highly-condensed team devoted to in-depth planned maintenance. However, in reality what is in fact often required is a highly reactive force that can respond quickly to the unknown with the minimum of delay.

Dairy product training

It is often not appreciated that an engineer working in a dairy produce environment needs to understand the nature of the products or the processes being applied. That he can repair any individual item of plant is not sufficient. A lack of knowledge in the dairy produce and processing field leads to misunderstanding of the importance of hygiene and clean working practices, usually a major criticism of the engineer by production staff. This can manifest itself in the deposit of foreign matter into produce, e.g. grease streaks in butter, nuts and bolts in cheese blocks and even, more important, it may lead to dangerous practices such as welding in areas where dry milk powder is present. The engineer, who has no knowledge of the processes involved, cannot assist the production staff in trouble shooting process problems and will be at a disadvantage in locating possible defects in modern complex equipment.

Knowledge of the dairy produce and the processing methods will already exist on site and the use of production staff in this type of training is to be encouraged, being both cost-effective and valuable in assisting the development of good relations between productions and engineering departments. The areas that need to be covered are milk and its treatments, pasteurization, separation and effects of mishandling, and a brief explanation of test procedure and the microbiological implications would be useful. Butter making and cheese making processes should be treated in the same way in their basic make-up, outline of the process involved and problem areas. Engineers should also have a good knowledge of packaging, with emphasis of the effects of poor packaging on the product and any legal demands. The production departments may well organize training of this type for their own operators. If so, this would be an excellent opportunity to combine forces.

The analysis as explained will require a considerable amount of time, but will in the end save time by ensuring that during recruitment an excellent picture will be formed of what is required. By having the training objectives built in, training plans and scheduling will be easier to control and monitor. This will also provide an excellent vehicle through which to judge when and where the training inputs have been effective. By doing such an analysis it will be possible to foresee problem areas and provide a basis for a planned maintenance schedule.

Recruitment: It is essential to establish a centre core of highly-skilled trouble shooters at an early stage both in the mechanical and electrical areas. The ability to fault-find is not present in all engineers; it is however a skill that can be learnt. This is time-consuming and needs good examples to follow. In demonstrating effective fault-finding skills simple logic is not all that is required. Good fault-finders need to be happy with the theoretical as well as the practical aspects of systems, and demonstrations of this will be required.

Management: The person specification when recruiting Management should include, apart from a good technical background and dairy industry experience, some ostensible indication of high motivation, organizational skills, good communicative ability, a strong training background and a high awareness of production needs and attitudes. It is the human-relations skills rather than the engineering qualifications that should be considered. The Engineering Manager must be consulted when recruiting other engineering management staff. Disharmony within the engineering structure is to be avoided. Also the engineering team must be able to cooperate effectively with other management teams within the unit.

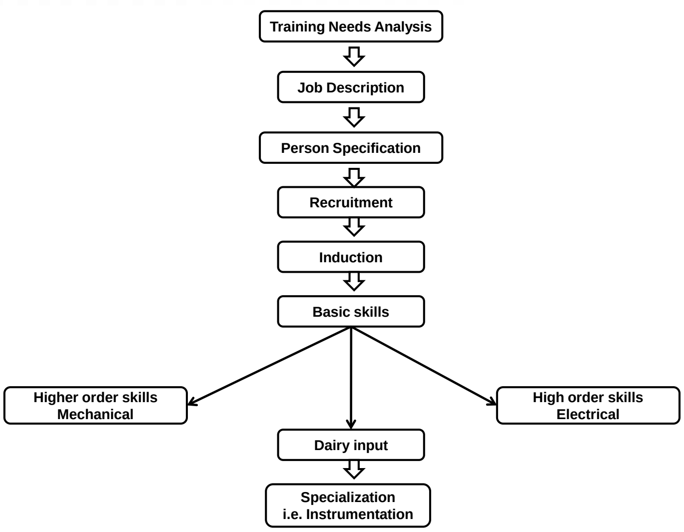
Engineering staff: When recruiting engineers, reference should be made to the skills requirement as defined in the Training Need Analysis. Reliability and the ability to work unsupervised once directed are important factors, as many jobs will require the engineer to work on his own initiative away from the workshop. If recruiting raw beginners such as apprentices, tests for numeracy, spatial ability and mechanical comprehension are very valuable.

Providing training expertise: The training of engineers is time-consuming and requires a large input of skill. This may be available on site. However, time could well be a problem, so training must be carefully planned and use made of all the available resources.

These are likely to be:

- Own skilled staff on site
- Local college or skill centre
- Local college operating on site
- Specialist training organizations
- Own specialist trainers

Skills training



Source: http://www.fao.org/docrep/003/X6548E/X6548E02.htm /Accessed on 02/09/2016

The best means of ensuring that the basic skills content of any training programme is complete in detail is to use, as a guide, such publications as the modular practices published by the engineering industry. Skill specification would include on completion of training that the individual should be capable of the following:

- Applying statutory and safety regulations.
- The safe and efficient use of both hand and portable power tools.
- The safe and efficient use of test and measuring equipment.
- The use of factory recording procedures associated with maintenance and breakdowns.
- Working to sketches, engineering drawings.
- The cutting, bending and joining of piping and tubing.
- Installing, servicing, testing and replacement of factory services pipe work and ancillaries.
- Applying various methods of securing and fixing components.

Performance evidence

Performance evidence will be the main form of evidence used to assess the competence of apprentices in the workplace.

The qualification specification sets out the assessment methods that may be used to produce sufficient evidence to demonstrate competence. This will include:

- Observation of the apprentice carrying out their role the workplace by an assessor.
- Products of the apprentice's work.
- Workplace or witness testimony.
- Documentary evidence such as photographs of work, completed maintenance reports and records, minutes of meetings.

The competence units within this qualification must be assessed in the apprentice's workplace, and evidence must be derived from the activities that they undertake as part of their normal food and drink engineering maintenance role.

The only exceptions to the requirements for demonstrating competence in the workplace will be to allow a minimum amount of evidence to be derived from simulation of activities which may cover:

- Dealing with emergency situations (i.e. fire procedures, or accidents)
- Work activities which do not arise regularly in the workplace (i.e. dealing with one-off new installations, resolving problems with colleagues at work).

Core technical skills

- Perform first line routine mechanical maintenance, including removing and replacing components, cleaning, lubrication, inspection and fault finding.
- Apply 'best practice' techniques e.g. condition monitoring and proactive maintenance.
- Produce replacement components, using manual and machine processes.
- Weld stainless steel and other materials used in food production equipment.

Core knowledge

- Food processing/manufacturing and product knowledge (to meet company requirements e.g. Dairy/Confectionery/Meat processing).
- Understanding of how to comply with regulations, including food safety and HACCP (Hazard Analysis and Critical Control Points).
- The impact of customer requirements and demands on the food supply chain.
- Materials science, including the key features of raw materials, their uses in food production and types of equipment used to process them.
- Principles of electrical systems, including their uses, safety and legislation.
- Services and utilities knowledge, including the importance and impact of energy management and pollution control in food production.

Paranto and Kelker (1999) analyzed employers' satisfaction with job skills of business college graduates in a regional university in the US. They examined which skills employers perceived important when hiring business graduates. 346 employers were identified for the survey by the University's placement office. They are mostly in rural areas in the upper Midwest of the US, and hired business graduates during the 1990-94 period. 136 employers responded (39% response rates). By using factor analysis, 18 variables (skills) were reduced to four major factors, namely specific skills, core skills, personal characteristics, and communication skills (Table 1).

Table 1: Skills under Four Factors

Specific Skills	Core Skills	Personal Characteristics	Communication Skills
Database knowledge	Self confidence	Business ethics	Listening skills
Spreadsheet knowledge	Critical thinking	Professionalism	Speaking skills
Word processing knowledge	Creative thinking		Written communication
Ability to adapt to changing technology	Interpersonal skills		
Technical skills	Leadership skills		
Mathematical skills	Experience with real world problems		

Hill and Petty (1995) conducted a similar analysis but focused on occupational work ethics. By using factor analysis, forty eight skills were grouped into four factors: interpersonal skills, initiative, being dependable, and "reversed items on instrument" (Table 2). The last factor was interpreted as negative perceptions, in which there are (lack of) skills such as *irresponsible*, *careless*, *selfish*, etc. The study recommended that school curriculum should address the four factors to make student skills more relevant to the workplace.

Factor 1: Interpersonal Skills	Factor 2: Initiative	Factor 3: Being Dependable	Factor 4: Reversed Items
Courteous	perceptive	following directions	hostile
Friendly	productive	following regulations	rude
Cheerful	resourceful	dependable	selfish
Considerate	initiating	reliable	devious
Pleasant	ambitious	careful	irresponsible
Cooperative	efficient	honest	careless
Helpful	effective	punctual	negligent
Likeable	enthusiastic		depressed
Devoted	dedicated		tardy
Loyal	persistent		apathetic
Well groomed	accurate		
Patient	conscientious		
Appreciative	independent		
Hard working	adaptable		
Modest	persevering		
Emotionally stable	orderly		
stubborn			

The engineering department needs to contain three teams: engineers, electricians and support team. Each team should be independent in structure but capable of inter-dependence with the other enquiry teams and other working groups within the milk plant. Assessment plan sets out the requirements for the food and drink engineering maintenance standard for two roles: mechanical maintenance engineer and multi-skilled maintenance engineer. For the first time the Standard combines the unique blend of engineering maintenance skills and knowledge, with food safety, compliance and food processing skills and knowledge, required by the dairy industry.

References

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Advanced Mixing Solutions: An Overview

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Introduction :

In dairy and food industry ; mixing of 2 different liquids , mixing of solid in a liquid is very common process. In India, various types of conventional stirrers, agitators or blenders are being used for this purpose. However effective mixing is a challenge to dairy/ food technologists. Effective mixing improves the texture, quality, decreases the time and saves energy. Also the end product will be homogenious. A small article is prepared on two different mixing solutions (techniques/systems) (i.e.) (1) Powder wetting and dispersing machine, (2) Jet stream mixer developed by the technocrats in europe in the field of dairy, food, pharma and other related industries.

(1) Powder wetting and dispersing machine:

(a) Processing of activated carbon:

Activated carbon is a very fine highly porous pure carbon powder which is used for the adsorption and the removal of unwanted organic substances and unpleasant smells and malodour out of liquids.

Main fields of application are the treatment and purification of drinking water, waste water and leachate water from landfills. On the other hand, Activated carbon is also being used in the production of filter materials (e.g. out of PUR-foam), to separate caffeine and for the clarification of sugar solutions.

Activated Carbon powder (PAC) is very dusty. The dust is nasty and contaminates all the environment.The powder is very light and for this reason it tends to float and agglomerate on top of liquid surfaces.

To develop the proporties of the powder, it must be completely wetted, dispersed and homogeneously distributed in the liquid.

Simple pouring or transporting onto the surface of the liquid is no longer acceptable.

Activated Carbon dust is combustable. Handling must be carried out with dust-ex-protected equipment.

With the Powder wetting and dispersing machine , Activated Carbon is being inducted dust-free from any bag, Big Bag or powder container directly into the liquid.

In a nutshell, following are the advantages of Powder wetting and dispersing machine over conventional stirrers.

- No lifting up of paper bags!
- No pouring!
- No dust, neither during the induction from a bag nor on top of the liquid!
- No agglomerates, no crusts, no layers of partially wetted dust!
- Complete wetting, intensive dispersing and homogeneous distribution of the Activated Carbon in the liquid.
- After the induction, the machine is switched to low speed and may be used as a perfect mixer or for additional dispersing and pumping out.
- Concentrations up to approx. 28% are possible without any problem. Higher concentrations might get viscous like a gel.
- All the inner area of the machine in dust-ex protected execution(acc. To Atex or other national regulations). Outside of the machine there is no need for an dust-Ex-zone classification, this means installation in a non-hazardous area is possible.

Following is the approximate Induction Rate for an Powder wetting and dispersing machine.

Power (kW)	Induction Rate (kg/min) from Bag	Induction Rate(kg/min) from Big Bag
15-18.5	10 - 15	18 - 24
37	20 – 30	30 - 40
37 – 45	25 - 40	33 – 50

The induction rates given in the above chart are based on water and normal conditions for the installation. Induction machines may be used to induct over a long distance, in this case the induction rate will slightly drop.

The size of the Powder wetting and dispersing machine is based on the size of the vessel for the liquid. It is independent from the size of the batch.

Processing system based on a Powder wetting and dispersing machine in combination with a vessel for liquids:

The Activated Carbon is inducted dust-free directly from a Big Bag. For an exact dosing of the liquid and the powder , the vessel is installed on load cells.

With such a system it is possible to produce highly concentrated basic suspensions , which are continuously and automatically dosed into a stream of water.

The size of the vessel may be determined in such a way , that the suspension is produced only once a day and then it is automatically dosed over a period of 24 hours without any problem and fail-safe into the liquid stream.

An Powder wetting and dispersing machine may be connected to more than only one vessel as well.In large water treatment plants the vessels for liquids may be executed e.g. as 30 concentrate tanks.

(b) Applications in Food industry:

Milk Products, Desserts, Stirred Yoghurt:

- Fast and perfect powder induction and dispersion
- Definitely less air, less foam, less product loss(residue in the tank) . this saves some thousands of rupees per year.
- No texture loss, better than any other system for powder induction
- Better particle dispersion
- Powder wetting and dispersing machine is 40% faster than Blender
- 30% higher viscosity
- Thickner and protein content reduction
- Induction of sticky proteins, stabilisers and thickners without problems
- Reduction of thickner concentration(amortisation time just about 1 year)
- No fat agglomeration (buttering)
- Very important: Jet stream mixer in the tank

Topping Creams:

- Typical Dispermix
- Addition and Dispersion of stabilisers and thickners

Curds:

- Addition of Stabilisers and Thickners
- Typically into a premix

Baby Food, Infant Food:

- As well for spray dry emulsions, for liquid baby food or for baby mash, pap etc.
- Clean,safe,hygienic, fast and perfect powder induction and dispersion
- Definitely less air
- Induction of sticky proteins and thickners without problems
- Higher concentrations and finer drop sizes for spray dry suspensions
- No high pressure homogeniser required
- Better homogenity with jet stream mixer
- Mixing and dispersion with dispermix
- Clean powder addition with Powder wetting and dispersing machine
- Separate lines or CIP Cleaning when changing between e.g. Gluten containing and Gluten free

Fruit Preparation for Yoghurt or Ice cream:

- Inducting and dissolving of different thickners and combinations of thickners into water, syrup or fruit concentrates
- Pectin concentrations up to 13%
- Temperatures up to 95°C

Marmalade, Jam etc.

- Similar application with lower concentrations
- Inductions of pectines in water at about 60 to 70° C
- Other thickners possible

Flavour Emulsions, Liquid Flavours, Spray Dry Emulsions:

- Thickner and oil can be dispersed with the same machine
- Drop size distributions down to 1µm possible
- New thickners (OSA starches) without problems
- CIP for optimum cleaning_

Beverages

- As well liquid and spray dried concentrates
- Main problem: sticky, foaming, difficult thickners (very difficult new modified starches, arabic gums, acacia gums)

- Inducted witha special powder inlet
- Induction rate up to 50 kg/min
- Additional emulsion of the oil
- Drop-sizes under 1μm without high pressure homogeniser

Instant coffee

- has to be inducted into hot water
- foams terribly below 60°C (140°F)
- looses aroma above 60°C
- inducts with minimum foam and no loss of aroma

Juice

- induction of stabilisers
- arabic gum,pectines,modified starches etc...
- rapid homogenous and agglomerate free distribution
- very often inducted in glucose or juice concentrates
- high power consumption because of the rheological (Non newtonian fluids) properties of these liquids

(2) Jet stream mixer:

It creates liquid jet.Because of collision of jet with bottom of the vessel, a kind of circular motion gets formed. Hence complete vertical mixing takes place.

Micro and macro mixing effect:

"Micro mixing" is considered as a mixing principle that mixes smallest particles in a small volume and creates a completely homogeneous medium

"Macro mixing" is considered as a mixing of the complete volume in the vessel without any dead zones.

Only the combination of micro and macro mixing achieves a good homogeneous system in the vessel. It is possible only with Jet stream mixer.

Advantages compared to conventional stirrers:

- Complete and homogeneous mixing of all areas in the vessel
- No rotation of the mixture
- Baffles, which are needed with conventional stirrers are not required
- Easy cleaning of the vessel
- Absolutely no sedimentation on the bottom
- Complete vertical mixing – also for liquids with different specific weight
- No forming of Vortex – no air induction by the rotating vortex
- Mixing shaft runs inside a stator tube – no air induction
- Reduced mixing time caused by a continuous and uniform mixing effect when dissolving solids into a liquid.
- No open rotor system for increased working safety.
- Easily to be installed into vessels with non-standard dimensions
- For high vessels side entry possible.
- In a nutshell; higher product quality, reduced production time, improved working safety, processing advantages.

Conventional Mixer Vs Jetstream Mixer:

Conventional mixer:

- Slow running propeller
- Poor macro and micro mixing
- Additional foot bearing required
- Difficult to suspend heavy materials
- Extreme peripheral forces
- Baffles and other means are required to create turbulence
- Moving parts with-in reachable distance
- Air is incorporated into the product by a Vortex

Jetstream mixer:

- Easy installation onto existing flange
- Good micro mixing in the mixing head
- Good macro mixing because of the vertical flow of the liquid
- All peripheral forces are kept with-in the mixing head
- No Vortex is formed
- No foot bearing required
- Installation as side entry for high vessels
- No moving parts with-in reachable distance

Conclusion: By switching over from the conventional stirrers, agitators, blenders into Powder wetting and dispersing machine / Jet stream mixers; quality of the mixing / texture can be improved. Time, man power, energy can be saved. Energy saved is energy produced.

Characterization of Engineering Properties of Paneer for Varying Pressing Duration of Automated Press

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Introduction

Paneer is highly nutritious heat–acid coagulated indigenous milk product, which occupies an important place in Indian diet. It is of great value in diet because it is a rich source of high quality protein, fat, minerals and vitamins. Paneer is used as a base material for the preparation of large number of culinary dishes and it is a popular food product at the common household level (Prince *et al*, 2007). According to the FSSAI rules, chhana or paneer is defined as a milk product obtained by precipitating a part of milk solids by boiling whole milk of cow and or buffalo or a combination thereof by addition of lactic acid, citric acid or any other suitable coagulating agent and subsequent drainage of whey (FSSAI, 2006).

For production of chhana, milk is heated to near boiling temperature, followed by cooling and coagulation at 80–85ºC by using 1– 2% citric acid or sour whey. Free whey is drained off to obtain the coagulum, which is a casein– whey protein complex with entrapped fat. About 90% fat and protein, 10% lactose and 50–60% minerals of original milk are recovered in chhana (De, 1980a). Recovery of total milk solids varies between 63% and 67% (Chandan, 2007). When hot coagulum is pressed, matting of the coagulum takes place due to change in visco-elastic properties of casein under pressure. Pressed blocks are immersed in chilled water at 4–6°C for 2–3 h. The product obtained is called as paneer (Pal and Agrawala, 2007). Traditionally, paneer is made by applying static pressure to hot mass of chhana. Quality of chhana is affected by the heat treatment given to milk prior to its acidification, pH of milk-acid mixture at the time of coagulation and residence time of the coagulum prior to separation of milk solids, besides the type of milk and its initial composition. The heat treatment of milk before acidification is characterized by the temperature to which milk is heated, the rate of heating, the temperature to which the milk is cooled and the rate of cooling (Choudhary *et al*. 1998). Heating causes denaturation of whey proteins and they get associated with casein micelles. The degree of denatured whey proteins depends on the time-temperature combination given to milk and is mainly determined by the maximum temperature to which milk is heated (Singh, 2004). De (1980b) reported that chhana is a rich source of fat and protein. In general paneer contains 55-70 percent moisture, 22-27 percent fat, 17-18 percent protein, 2.0-2.5 percent lactose, and 1.5- 2.0 percent minerals (Kanawjia *et al,* 1990). Paneer texture is the most sought after sensory attribute for its acceptability by the consumer and to establish an efficient, economic and profitable system for their industrial scale production, a proper understanding of this product's texture profile and sensory profile is essential (Desai *et al*. (1991)) studied the textural properties of paneer procured from six different sources in Karnal. Instron Universal testing machine fitted with a 100 N load cell was used for the study. They observed that the hardness, gumminess and chewiness of raw paneer varied significantly, whereas cohesiveness and springiness did not differ among the market paneer samples. They concluded that the hardness was inversely related to the moisture content and directly related to the calcium content of paneer. It was reviewed that texture and rheological properties of most of the coagulated dairy products is based on their structure. The microstructure of these products consists of a continuous protein matrix and a loose and open structure with space occupied by the fat globules dispersed through the protein network. Hardness is the most commonly evaluated characteristic in determining the texture of paneer. It may be defined as the force necessary to attain a given deformation. It was seen that the hardness of soy paneer increased as the coagulation temperature increased from 80-90ºC. Cohesiveness is an important textural property of soy paneer. It is defined as the extent to which a material can be deformed before it ruptures. It depends on the nature of the protein matrix. Cohesiveness increased with coagulation temperature up to 90ºC and with further increase in the coagulation temperature it decreased. Springiness is the rate and extent to which a deformed material returns to its original condition after the force is removed. Springiness depends on factors such as heat treatment, protein interaction, flexibility and degree of unfolding of protein. Pressing conditions are very important in obtaining paneer with desirable textural properties. Kulshreshtha et al. (1987) conducted a study on a laboratory-scale paneer press to correlate final paneer quality with pressing conditions. Pressing at pressures of around 98.1 k Pa gave a uniform quality product. Higher pressures yield hard paneer and decrease the yield due to more whey expression, whereas lower pressures yield softer paneer, but enhanced yield. In the present study, changes in physical properties of paneer including textural are being reported as affected by pressing conditions.

Materials and Methods

The physical and engineering properties of paneer prepared in a small hoop by applying various combinations of pressure and time of press were evaluated and an optimization of pressure and time of pressing of paneer preparation in small scale was carried out. The raw milk was procured from the cattle yard of ICAR-NDRI, Southern Regional Station, Bangalore. Fat and SNF content of the milk samples were standardized to 3.8 per cent and 8.7 per cent respectively.

Paneer preparation

The standard process was adopted for the preparation of paneer. Five litres of standardised cow milk was collected and heated in a steam kettle up to 90ºC (no holding). Stirring was done for some time and the citric acid solution was slowly added for coagulation at the rate of 2.0 g per litre at about 80 ºC. After the coagulation, the mixture was allowed for 5-10 minutes for settling of the coagulated mass. Whey was drained out using muslin cloth and the coagulum was covered well by the cloth and transferred to wooden hoop (9.59.512 cm) for pressing purpose. The various pressure and time of press combinations used were: 7.6 k Pa, 10.8 k Pa and 14.13 k Pa for 20 and 30 minutes. After pressing was over the coagulum was dipped in chilled water at 4-5ºC for about 2 h. The paneer block taken out from chilled water was drained for about two minutes, cut into 2 cm cubes and packaged in LDPE pouches for further analysis.

Evaluation and Analysis of Moisture content, porosity and bulk density

The moisture content of paneer was determined by standard gravimetric method. Porosity was determined by the following method: Paneer cubes of size 1.5 1.5 1.5 cm (V_0= 3.375 cm^3) were taken and their initial weights (M_0) were noted down. Then the weighed sample cubes were soaked in distilled water (1:20 ratio by volume) overnight in the refrigerator. After wiping the surface water, the weight of the samples was taken (M_1). Then the % porosity was evaluated as,

$$Porosity = \frac{M_1 - M_0}{V_0 \rho} \times 100$$

Bulk density was calculated by using the standard equation,

$$Bulk\ Density = \frac{M_0}{V_0}$$

Where, ρ is the density of water = 1 g/cc.

Texture Profile Analysis (TPA) of paneer

TPA tests were performed using Texture Analyzer of Stable Micro Systems (U.K.) equipped with 5 -kg load cell. The analyzer was linked to a computer that recorded the data via a software program texture exponent 32. Experiments were carried out by compression test that generated plot of force (g) vs. time (s), from which textural values were obtained. An aluminium cylindrical probe (P/75) was used to compress 2 × 2× 2 cm paneer samples. The speed of the probe was fixed at 5 mm/s during the compression of the samples. During the testing, the samples were held manually against the base plate. The typical texture profile (force-time) curve obtained with one complete run is presented in the Figure 1.

The data obtained in the compression test were used for determination of the following textural parameters:

Hardness: It is defined as the value of the peak force of the first compression of the product.

Hardness (N) = Maximum force of the first compression

(The values obtained in 'g' were converted into 'N' by 1000 g f = 9.81 N)

Cohesiveness: It is the extent to which a material can be deformed before it ruptures depending on the strength of internal bonds.

$$\text{Cohesiveness} = \frac{Area\ under\ 2nd\ compression\ (Area\ 2)}{\text{Area under 1st compression (Area 1)}}$$

Springiness: It is the extent to which a product physically springs back after deformation during the first compression.

$$\text{Springiness} = \frac{Length\ 2}{Length\ 1}$$

Chewiness: It is the energy required in masticating a solid food product to make it ready for swallowing.

Chewiness (N) = *Hardness Cohesiveness Springiness*

$$\text{Resilience} = \frac{Area\ 5}{Area\ 4}$$

Gumminess = Hardness Cohesiveness

Sensory evaluation of paneer

The sensory attributes of paneer were evaluated by using score card on nine point hedonic scale i.e.

colour and appearance, body and texture, flavour and overall acceptability. The nine – point Hedonic scale was used because the ultimate objective was to optimize the pressing time combinations based on the sensory acceptance of final product. The score cards were given to the expert panel members and their scores and remarks were recorded.

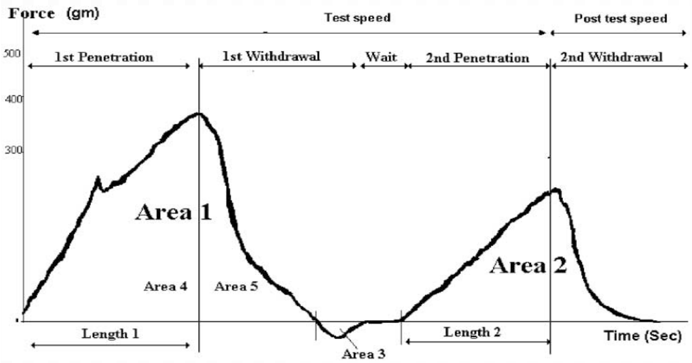

Fig.1: Typical texture profile (force-time) curve for one complete run in a TPA test

Results and Discussion

Pressure and time of press are the two major factors that affect the quality of the paneer. The effect of pressure applied and time of press on quality of paneer in terms of moisture content, porosity, bulk density and textural properties was studied, and the results are described and discussed.

Effect of pressure and time of pressing on moisture content of paneer

The moisture content data were obtained by analysing the different paneer samples. Applying and releasing pressure, time and rate of pressing were controlled automatically by automatic control unit. The dentist type air compressor was used to supply the required pressure. Pressure was applied over the coagulum through FRL unit, solenoid valve and finally by the pneumatic cylinder, with which the piston and the pressing circular plate was mounted. During the preliminary trials of paneer making different levels of pressure and pressing duration ranging from 2 to 6 kg/cm^2 and from 10 to 20 min respectively were applied for paneer pressing. In these initial trials it was found that the pressure below 1.5 kg/cm^2 was not sufficient to produce good quality paneer. Textural profile of the paneer prepared were evaluated by using the Texture Profile Analyzer and moisture content, bulk density and porosity were evaluated by the standard methods. The duration of pressure applied over the paneer hoop has found to have significant effect on the moisture content, which was reduced from 61.56 to 51.25 percent when time of pressing was changed from 10 to 20 minutes. Improvement in bulk density from 1.034 to 1.088 g/cc and decrement in porosity value from 18.01 to 12.24 percent were observed as the time of pressing was increased from 10 to 20 minutes. Significant improvement was also observed on the textural parameters of the paneer for the increased pressing time. An increment in the hardness value was observed from 18.22 N to 21.17 N as the time of pressing the coagulum was increased from 10 to 20 min.

Conclusions

The duration of pressure applied over the paneer hoop was found to have significant effect on the moisture content since the highest moisture content was observed for the lower value of pressure applied for 10 minutes duration and the lowest value of moisture content was observed for higher pressure applied for longer duration i.e. 20 minutes. An increment in the value of bulk density was observed as the time of pressing the coagulum was increased from 10 to 20 minutes and the pressure was increased. The results of the porosity show that, the highest value of porosity (%) was observed when little lower, about 1.5 – 2.5 kg/cm^2 pressure was applied for 10 minutes, whereas the lowest value of porosity (%) was observed when higher pressure was applied for 20 minutes duration. Sensory evaluation has got the highest score for overall acceptability for higher pressure-low pressing duration combination Significant improvement was also observed on the textural parameters of the paneer for the increased pressing time.

Acknowledgement

The authors acknowledge Dr. A.K. Srivastava, Vice-Chancellor and Director, ICAR-National Dairy Research Institute, Karnal-132001 and Head, Dairy Engineering Division, ICAR-NDRI for the continuous encouragement, support as well as providing the financial assistance and infrastructure to carry out the research work.

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Minimization of Refrigeration Energy Consumption in a Dairy Plant

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Introduction

Refrigeration is one of the most important sections of a Dairy Plant. A centralized Ammonia Refrigeration plant is usually used to meet different types of cooling requirements during processing and storage of milk and milk products. It has been estimated that in a typical multi-product dairy processing unit, 50 to 60% of the total energy consumption is contributed only by the refrigeration section. Yet in many cases, refrigeration plant technologies being used are from '70s and '80s. These refrigeration plants are major energy guzzlers of a processing industry and have a large scope of cost saving in terms of minimization of their energy consumption. It is a well known fact that the judicious and effective use of energy is mandatory to minimize cost (maximize profits) and enhance competitive position of a process industry. The effective use of energy is targeted to minimize energy costs without affecting production and quality. It is also well concerned to the minimization of environmental effects. Thus with the increasing cost of fuel and energy and in the presence of more and more strict norms/ regulations towards environmental effects of energy consumption, the investment in power savings is really a good idea.

Energy Saving Opportunities

An Ammonia refrigeration plant usually used in a dairy/ food processing and storage industry already has higher cycle efficiency as compared to synthetic refrigerants. Also Ammonia is an environmentally benign refrigerant. But still the scope of energy saving always remains by adopting energy saving technologies, using benchmarking, energy auditing and becoming more and more vigilant towards energy saving. The cost saving in terms of energy saving of a refrigeration plant can broadly be classified in three different categories as:

- Maximizing the refrigeration plant energy efficiency
- Minimization of direct loss of cooling produced by the plant i.e. effective cooling management
- Adopting partial or full use of the alternate refrigeration technologies which are either more efficient or which are capable of using cheaper energy sources.

The first and second are easily implementable in every size of a dairy processing unit. However the third one depends on the major breakthroughs of new technologies in the market. These can be adopted however at the time of new installations by large dairy industries but in general find a lethargic opinion from the decision makers primarily due to the fear of high initial cost, less know-how available, less faith regarding the ready availability of plant etc. So the first two categories of improvisation in energy consumption practices have been primarily discussed here.

Optimization of Refrigeration Plant Energy Efficiency:

The major areas of concern in improving the energy efficiency of a refrigeration plant have been recognised by Bellstedt (2012) as

- Variable head pressure control
- Compressor control
- Remote control optimisation
- Heat recovery
- Defrost management
- Variable cold store temperatures
- Variable evaporator fan speeds
- Condensate sub-cooling
- Design review
- Maintenance review

It has been observed that by introducing improvement and effective control measures in above areas of concern, as much as 45 % energy can be saved in a poorly designed and maintained plant and upto 18% can be saved in an already well designed plant.

Refrigeration Plant stability – First priority: Only the stable operation can be called an efficient operation. Instabilities are caused by On/off condenser fan operation, simple level control mechanism on vessels, compressor cycling in response to load changes and the poor control strategies. Hence achieving STABLE plant operation is generally a pre-requisite to effective reduction of energy use.

Using VFDs (Variable frequency Drives) for the condenser and evaporator fans have a large potential of saving power directly and indirectly. The direct power saving is in terms of the fan power saved as compared to step loading. The indirect power saved is in terms of better control on the head pressure and so less power consumption of the compressors. For example, the evaporator fans speed can be reduced intermittently when the cold store doors are closed and during the night which cause considerable energy saving.

Variable head pressure control with ambient sensor can save a lot of compressor power as the compressor power reduces 2-3% per 1^{0}C reduction in condensing temperature. Hence instead of running the plant on a constant head pressure in all weathers it is an efficient way of reducing energy by allowing the drop in head pressure in case of lower ambient temperature.

Compressor control: Screw Compressor capacity can be better controlled by using VFD as compared to sliding vane control. Variable capacity by variable speed also results in very low noise and high efficiency at part loads.

Efficient loading and unloading of Multi Compressors Plant: Part load efficiency of the compressors is always poor, so it is better to run one compressor on full load as compared to two or more at part load. Thus with the increasing load, first one compressor should be loaded to its peak and then the loading of second should be started. In the same way compressors can be unloaded.

Remote Optimization: The challenges to effective plant control are varying operating conditions due to summer/winter ambient conditions, production changes, seasonal production and day/night/weekend operation. Normally the plant is controlled through PLC which contains standard site programming. For optimised control however remote optimization can be used through a server on site commanded by a remote work station. The optimised settings override the PLC settings.

Heat Recovery: Heat recovery from the ammonia refrigeration plant can be done from three sources given in the order of increasing temperature as the lower discharge, the higher discharge and the oil cooler. This heat can either be directly used or can be upgraded by using a heat pump for higher temperature applications. For heating application above 50-55 °C, generally a heat pump is required, but the additional cost of a heat pump sometimes restricts the heat recovery. However, the proper use of heat pumps in a processing industry like dairy plant, where so many heating and cooling operations take place simultaneously, has a tremendous scope towards energy saving. A proper analysis and thermo-economic optimization is generally required to find the best solution for each site.

Condensate Sub-cooling by using feed water through a separate sub-cooler or by using an economized sub-cooler always has a positive effect on the COP of a refrigeration plant. Sub-cooling of refrigerant especially being supplied to lower temperature evaporator reduces the power consumption and saves a lot of energy and annual operating cost of the plant by increasing its overall COP upto 4-5%. Therefore a design review must be done on an existing refrigeration plant to explore the full extent of performance enhancement through condensate sub-cooling.

Suction splitting: Splitting of suction lines to run higher temperature loads at higher suction pressure is already used in modern plants. For example the suction lines from blast freezers and holding freezers should be separate from that of chiller rooms and processing rooms. In actual, whatever refrigerant vapours generate between the stages of expansion or before the evaporator should be trapped by separate suction lines working at comparatively higher suction pressure. Higher suction pressure naturally means less power consumption.

Replacement of liquid oil cooling with water oil-cooling in case of a screw compressor saves energy in terms of cooling effect of the refrigerant and must be preferred where there is no strict requirement from manufacturer's side.

Non-Condensable Control by replacement of Manual Air-Purging with Auto Air-Purging: An air purger is an essential component of the refrigeration plant and purging of air and other non-condensables from the higher pressure side is a routine activity. The presence of non condensable gases on the high pressure side increases the head pressure and so increases the power consumption. In the manual purging there may be the wastage of refrigerant and the process is also less efficient and irregular. Use of an autopurger is the best solution.

Removal of Water accumulation: Water enters with air, but accumulates in the system on the low temperature side, generally in accumulator/surge vessels. It reduces suction pressure required to achieve setpoint evaporation temperature and hence increases the energy consumption. So a water purger is required in the systems susceptible of water accumulation.

Oil feed to screw compressors: The monitoring and control of oil feed rate to a screw compressor is necessary in an energy efficient refrigeration plant. Insufficient oil flow causes poor compression efficiency and the excessive oil flow can cause overcompression or even hydraulic locking. Generally compressor discharge temperature is used to adjust oil flow rates and any incorrect adjustment can cause significant inefficiencies.

Typical Bottlenecks: There may be many other bottlenecks in the design and operation of the plant which decrease energy efficiency and these must be removed. For example the undersized suction/ discharge lines and unnecessary line obstructions reduces suction and increases discharge pressure at compressor. Undersized evaporators/condensers decreases suction and increases condensing temperature. Direct expansion evaporators limits variable head pressure control options. Excessively long wet/dry suction lines reduces suction pressure at compressor. Poorly designed wet suction risers reduces suction pressure at compressor. Redundant suction regulation valves reduces suction pressure at compressor.

Good preventive maintenance practices: The best maintenance system should result in high operating efficiency as well as high availability of the plant. Preventive maintenance is always a very cost effective apporoach as it provides energy savings, reduced maintenance cost and reduction in downtime. Before going for design review and adopting measures for improving energy efficiency, the scheduled maintenance plan of the plant should be reviewed first as only this has a large potential of improving energy efficiency without making any costly changes in the plant. The preventive maintenance schedule of each of the mechanical/ electric components should be sincerely followed.

In this way there are many energy saving measures which may be less effective or more effective, which may be cheap or costly and may be easier or difficult to adopt. What is required is a thermoeconomic design review and optimization on site using the tools of energy auditing and energy benchmarking. It depends upon the size of plant, cost involved feasibility of required changes, general accepatability and other factors but to go for maximum energy efficiency of the refrigeration plant is must for a growing dairy industry to become competitive and sustainable.

Effective Management of the Cooling Produced:

As we know "the energy saved is energy produced", likewise "the energy lost is energy spent". We may have a well designed and maintained energy efficient plant producing a given amount of refrigeration at the least possible cost but it will go waste if we are not using this cooling in an efficient and effective manner. So the energy conservation is as much necessary as producing it efficiently. For that a maintenance review is required to block all the possible losses of cooling. Some of the major points to be noted in this regard are given below:

- Quick maintenance of leakage as soon as possible.
- Cold storage should not be left open unattended even for a small time. Door should open in vestibule only. Air curtains should always be in working condition.
- The chilled water pipeline should be monitored regularly for any leakage and damage of insulation.
- Keep insure about the leakage of refrigerant.
- Selection of right temperature for storage of products. Unnecessarily lower temperature is a direct loss of cooling.
- Train and educate the manpower, handling the operation of cold storage and freezer about their proper use and prevention of any sort of cooling loss.
- The chilled water recirculation pumps should be efficiently controlled depending on the return temperature. Higher flow rate and lesser return temperature of chilled water indicates a direct loss.

Use of Alternate Refrigeration Technologies:

The aim of alternate refrigeration technologies is reduction in operating cost by more efficient operation or by contributing partly in the refrigeration load by utilising free or cheaper sources of energy and also be safe to environment. Some of these are:

- Using vapour sorption refrigeration systems for utilising waste heat of flue gases from the power generation/ boiler section. These systems can also be designed to run on solar heat energy.
- Ejector Refrigeration System which utilises steam as the input energy for compression of vapours. These are simple in design and run on heat energy which is cheaper than electric energy. The solar thermal energy can also be used in conjunction with boiler for preheating of feed water.
- Solar Electrical Cooling by using Photovoltaic (PV) vapour compression system or Photovoltaic

Peltier System.
- Solar powered dessicant cooling

Conclusions and Recommendations

- Analyse your plant for energy savings opportunities – there are many!
- Opportunities not feasible a few years ago are now viable due to higher power costs
- Many opportunities are available at relatively minor cost, or require controls upgrade only
- Implement viable opportunities now.
- Give most attention to the proper maintenance of refrigeration plant. Efficiency go down heavily in a poorly maintained plant
- Regular energy audit and benchmarking is a key to the control and reduction of running cost of the plant

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Invited Articles

Optimizing the Proportion of Exothermic Reactants and Water for Cooking of Noodles in Self-Heating Container

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Introduction

Noodles are one of the most popular foods in the Indian market. According to the Economic Times (2011), estimated market of noodles sector in the India is around Rs. 1,300 and it is growing at annual rate of 20 % in India (Subrata Ray, 2012). Noodles, need short but inevitable cooking before consumption, which too is inconvenient or impossible in certain situations. Hence, present study was planned to test the feasibility of embedding cooking facility in the package itself so that the cooking can be done as and when required. It was planned to provide exothermic reactants in a double sectional container whose heat of reaction would cook up the noodles placed in other section.

During the literature survey no published report of previous work on the same topic was found in India. However, in international research arena, there are reported applications using electrical resistance heating powered by external source or internal battery (Patent US6222160, Kroskey 2001, Patent: US6267045) and inductive heating (US6279470). Applications using mixture of acidic salt with a basic anhydride (Bell et al., 2001, Patent: US6248257, US6178963), dry mixture of magnesium, iron and calcium nitrate (Thomas, 2010) and combination of calcium oxide with water (Patent :US6289889) have been reported.

Material and Methods

Standardization of process parameters for cooking Noodles: A well laid cooking process with identified decisive cooking parameter is prerequisite for in container cooking and designing the self-heating container. Hence, following parameters were decided.

Dry noodles to cooking water ratio: The ratio of dry noodles to the cooking water to be taken for the study was determined through preliminary trials followed by the sensory evaluation for the overall acceptability. Several proportions of *Dry noodle: Cooking water* viz., 1:1, 1:1.5, 1:2.0, 1:2.5 and 1:3.0 as shown quantitatively in Table 3.1 were tried.

Table 3.1 Proportion of dry noodles to cooking water

Proportion No	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Dry noodles (gm)	40	40	40	40	40	60	60	60	60	60	80	80	80	80	80
Cooking water (ml)	40	60	80	100	120	60	90	120	150	180	80	120	160	200	240

Cooking temperature: Preliminary trials were conducted to decide the optimum cooking temperature for the noodles. Cooking at 5 different temperatures in the water bath followed by sensory evaluation was done to arrive at the optimum cooking temperature.

Cooking heat requirement: The cooking heat requirement i.e. the heat required for the cooking of noodles, as crucial for estimating the quantities of exothermic reactants, was determined analytically from the composition of the noodles and required cooking temperatures.

Heat requirement for the cooking of the experimental sample was calculated as follows:

$$Q_{total} = Q_{Water} + Q_{Product}$$
$$= \{M_w \times C_{pw}(T_{Cooking} - T_{initial})\} + \{M_n \times C_{pn}(T_{Cooking} - T_{initial})\}$$

Where; M_w is the mass of cooking water, C_{pw} is the specific heat of cooking water, $T_{cooking}$ is the cooking temperature, $T_{initial}$ is the initial temperature, M_n is the mass of noodles, and C_{pn} is the specific heat of noodles.

The value of the specific heat for noodles C_{pn} was estimated using Choi and Okos model (1983) under:

$$C_{pn} = \sum_{i=1}^{5} X_i \times C_{pi}$$

Where; X_i represent mass fractions of Water, Protein, Fat, Carbohydrate and Ash contents and the $C_{pi,}$ represent respective values of specific heats. Specific heats of individual constituents as functions of temperature were calculated using the following relations.

$$C_{pw} = 4.1762 - 9.0864 \times 10^{-5}T + 5.4731 \times 10^{-6}T^2$$
$$C_{pc} = 1.5488 + 1.9625 \times 10^{-3}T - 5.9399 \times 10^{-6}T^2$$
$$C_{pp} = 2.0082 + 1.2089 \times 10^{-3}T - 1.3129 \times 10^{-6}T^2$$
$$C_{pf} = 1.9842 + 1.4733 \times 10^{-3}T - 4.8008 \times 10^{-6}T^2$$
$$C_{pa} = 1.0926 + 1.8896 \times 10^{-3}T - 3.6817 \times 10^{-6}T^2$$

The empirical cooking heat requirement was also determined through preliminary trials. The mixture of dry noodles and cooking water was cooked in a metal container in water bath maintained at 100 °C along with another identical container filled with water taken as reference. Assuming the heat gained by both containers as same, it was found using following equation,

∴ Actual cooking heat requirement =

$$\{M_w \times C_{pw}(T_{final} - T_{initial})\} + \{M_v \times h_{fg}\}$$

Selection of reactants for heat generation

From the literature studied for various means of heat generations and exothermic reactants the Calcium Oxide and Water were selected as they are easily available, non toxic, GRAS status, cost effective.

Designing the self-heating container

Four different designs that could satisfactorily fulfill the requirements towards containing the product, containing the reactants, enable and sustain the heat transfer, etc. were worked out. Two of which were discarded on the basis of observations made during preliminary trials (out of the scope of this paper).

Optimization of the reactants (CaO and H_2O)

To optimize their proportion for efficiently heating 60 gm dry noodles along with 120 ml water following combinations of Calcium Oxide and Water were studied.

Table 3.5: Treatment combinations for Design

Treatment	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13
Cao (g)	50	50	75	75	100	100	100	125	125	125	150	150	150
H_2O (ml)	25	50	37	75	50	75	100	75	100	125	75	100	150

Statistical Analysis of the Experimental Data

Table 4.2 : Average Composition of the noodles	
Constituent	Mean ± Std Dev
Carbohydrate	61.74 (0.908)
Protein	9.24 (0.776)
Fat	14.50 (0.704)
Ash	1.53 (0.147)
Water	1.88 (1.096)
n=5	

The data which was to be used for primary screening of the selected variables was analyzed using the measures of variation. The data obtained during the final screening and the proportion optimization was analyzed using the Completely Randomized Block Design to know the best combination.

Results and Discussion

Composition of the noodles: Average composition noodles obtained on chemical analysis is shown in table 4.1.

Dry noodles to cooking water ratio: Noodles cooked with different proportions of dry noodles and cooking water were subjected to sensory evaluation by the judges for overall acceptability on hedonic scale. The results obtained are tabulated in Table 4.2.

Table 4.2: Sensory scores for various Dry noodles to cooking water ratio.

Dry Noodle (g)	Cooking water (ml)	Mean ± Std. Dev.
40	40	4.00 ± 0.632
	60	4.80 ± 0.748
	80	**7.80 ± 0.748**
	100	6.80 ± 0.400
	120	5.60 ± 0.800
60	60	3.20 ± 0.748
	90	4.60 ± 1.020
	120	**7.60 ± 0.800**
	150	6.80 ± 0.748
	180	4.20 ± 0.748
80	80	4.00 ± 1.095
	120	5.00 ± 0.632
	160	**7.60 ± 0.490**
	200	6.80 ± 0.400
	240	5.80 ± 0.748

As appears in the Table 4.2, the ratio 1:2 scored highest among other proportions i.e. cooking water in the proportion of twice the quantity of the dry noodles was adjudged best irrespective of the quantity of the dry noodles. The noodles prepared with the 1:1 proportion showed dry surface and some fragments adhering to the container surface were observed. The softness was lacking with clear indication of insufficient cooking water availability. In case of 1:1.5 proportion, the softness was improved with no sign of product adherence to the vessel but the dryness still persisted. The proportion 1:2.5, showed soft free strands of the product with some sings of free water at the bottom. The amount of free water further increased in case of 1:3 proportion to greater extent and product tasted flat. It may because of the taste maker remained in the free water as sediment.

Consequently, the proportions 1:2 and 1:2.5 were retained for further study. The analytical and actual heat requirements for cooking were studied for these proportions only.

4.3 Cooking temperature: Among the five cooking temperatures, the preliminary trials followed by sensory evaluation indicated that a temperature of about 85 °C was essential for satisfactory cooking of the noodles. (The temperature about 90 °C was found the best but it had the problem of vaporization).

4.4 Cooking heat requirement: Initial temperature for the mixture was set 30 °C and final cooking temperature was 85 °C, the value of specific heats calculated for average temperature of 57.5 °C were 2.0608 kJ/kg°C for noodles and 4.1889 kJ/kg°C for water. The results on analytical heat requirement and actual heat requirement for cooking different mixtures of dry noodles and cooking water are tabulated in Table 4.3 and Table 4.4 respectively.

Table 4.3: The values for analytical heat requirement (kJ) for cooking

Noodles (g)	Cooking water (g)	*Sp. heat of dry noodles	*Sp. heat of water	Initial Temp (°C)	Final Temp, (°C)	Analytical Heat Reqd (kJ)
40	80	2.0608	4.1889	30	85	22.964
	100	2.0608	4.1889	30	85	27.646
60	120	2.0608	4.1889	30	85	34.447
	150	2.0608	4.1889	30	85	34.558
80	160	2.0608	4.1889	30	85	45.929
	200	2.0608	4.1889	30	85	46.077

Data represented as mean (n=5). *At average temperature of 57.7 °C.

Table 4.4: The values for actual heat requirement (kJ) for cooking

Noodle (g)	Cooking Water (ml)	Water in reference, (g)	Initial Temp. (°C)	Final Temp. (°C)	Final weight, (g)	Water evaporated (g)	Actual Heat (kJ)	Actual Heat per gram (kJ/g)
40	80	120	30	95	111	9	52.99	0.442
40	100	140	30	97	124	16	75.40	0.539
60	120	180	30	95	165	15	82.87	0.460
60	150	210	30	96	186	24	112.23	0.534
80	160	240	30	94	221	19	107.22	0.447
80	200	280	30	97	232	48	186.92	0.668

Data represented as mean (n=3).

Rate of rise in cooking temperature in container

In the container of selected design that is product bowl atop the container, the cooking process was monitored in terms of rise in temperature of the contents after the reaction has been triggered. Peak temperature achieved in the product bowl and rate of temperature rise were noted with all the 11 combinations of CaO and H_2O (treatments). The data obtained is represented in Table 4.5. It can be seen from the Table 4.5 that rates of heat generation (i.e. temperature rise) were different in different combinations from the first minute. The temperatures received with all the treatments were significantly different than each other. The temperatures received in some of the treatments were more than twice of that received with other treatments.

During the first minute, T11 produced highest temperature (86.66°C) among all the treatments; it was followed by T8 with 81.00°C. Though second highest, the temperature produced by T8 was significantly lower that produced by T11. It was the only treatment that could surpass the standard cooking temperature of 85 °C (as identified in the preliminary trails) within 1 minute. Similar trend was observed for temperatures achieved in the second minute. T11 recorded highest temperature of 91.00°C which was significantly higher than next highest temperature of 87.66 °C recorded by T8. Thus, the T8 qualified the cooking temperature in second minute.

In third minute, temperature of T8 and T11 were almost same i.e. 88.333 °C and 88.666 °C respectively. Beside these T9 also produced an average temperature of 87.00 °C. The treatments T8, T9 and T11 were at par in the third minute. It indicated that if the cooking time is of 3 minutes, the T8, T9 and T11 would give statistically similar effects. Temperatures produced by both of them were at par and both were above the desirable cooking temperature of 85 °C. During fourth minute T11 recorded highest temperature of 87.00 °C which was significantly different than all other treatments including T8, which gave a temperature of 82.66 °C. From this point onward continuous fall was recorded in the temperature produced by T8. From the fifth and sixth minutes the temperatures given by all the treatments decreased. It indicated that the rates of heat generation and/or transfer to the products decreased. It may be due to the reason that concentration of the reactants decreased while the losses through escape of vapour from reactant space, convection and radiation to atmosphere remained persistent.

The highest temperature of the array was recorded by T11 followed by T8 with statistically insignificant difference. Hence, both the combinations can be adjudged the best to accomplish cooking within

2 minutes. Considering 3 minutes cooking, the T9 would be an additional option. The T8 would still be most preferable as it weighs 25 g less than T9 and T11 reducing overall weight of the container without any compromise in the cooking temperatures.

Table 4.5: Average rise in temperature in the product space over time

Treat	1 min	2 min	3 min	4 min	5 min	6 min
T1	35.000±0.00^{k}	37.666±0.57^{k}	39.666±0.57^{i}	41.000±1.00^{h}	40.666±0.57^{g}	39.666±0.57^{g}
T2	33.333±0.57^{l}	36.000±1.00^{k}	38.000±1.00^{i}	39.666±1.15^{h}	40.333±0.57^{g}	39.333±0.57^{g}
T3	34.333±1.15^{kl}	41.333±1.15^{j}	44.666±0.57^{h}	48.000±1.00^{g}	50.666±0.57^{f}	53.000±1.00^{f}
T4	40.666±0.57^{j}	48.333±0.57^{i}	53.000±1.00^{g}	59.333±1.15^{f}	61.666±0.57^{e}	63.666±0.57^{e}
T5	43.666±0.57^{i}	52.666±0.57^{h}	57.333±0.57^{f}	60.000±1.00^{f}	62.000±1.00^{e}	65.666±0.57^{d}
T6	55.333±1.52^{h}	64.333±2.08^{g}	70.000±1.00^{e}	74.333±0.57^{d}	77.333±0.57^{b}	80.000±1.00^{a}
T7	59.000±1.00^{g}	66.333±1.15^{f}	72.333±0.08^{d}	77.333±1.15^{c}	76.333±1.15^{b}	75.333±0.57^{b}
T8	81.000±1.00^{b}	87.666±0.57^{b}	88.333±0.57^{a}	82.666±0.57^{b}	76.666±1.52^{b}	74.333±1.15^{b}
T9	71.333±1.15^{e}	81.666±0.57^{d}	87.000±1.00^{a}	81.000±2.64^{b}	76.333±1.15^{b}	74.000±1.00^{b}
T10	69.666±0.57^{f}	79.333±0.57^{e}	77.33±1.52^{c}	74.666±0.57^{d}	72.666±0.57^{c}	70.333±0.57^{c}
T11	86.666±0.57^{a}	91.000±1.00^{a}	88.666±1.15^{a}	87.000±1.73^{a}	81.333±1.15^{a}	80.000±1.00^{a}
T12	79.333±1.15^{c}	84.666±1.52^{c}	83.666±1.15^{b}	77.666±1.15^{c}	73.333±1.52^{c}	70.333±1.52^{c}
T13	74.333±1.15^{d}	80.000±1.00^{de}	76.666±1.52^{c}	72.000±1.00^{e}	69.333±1.15^{d}	65.000±1.00^{de}

Data represented as Mean ± Standard Deviation. Each observation is Mean of three replications (n=3)
Means bearing similar superscript within the column do not differ significantly ($p < 0.05$)

A graphical representation comparing T8 and T11 is given in Fig 4.1.

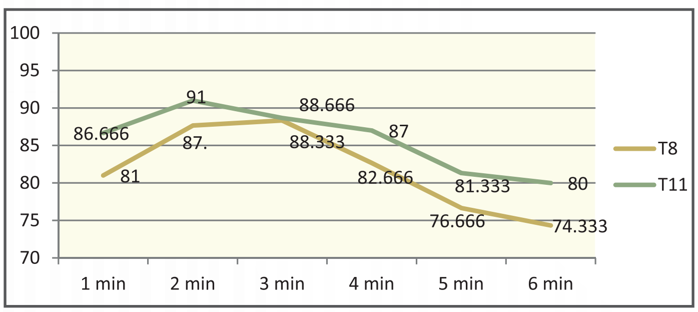

Fig 4.1: Comparision of the combination of reactant T8 (125:75) and T11 (150:75)

Heat generation, transfer and recovery

The actual heat generation and heat transfer to the product space was evaluated using the heat uptake equation for all the treatments. The results indicated very less heat recovery. The highest heat recovery of 31.21 ± 0.85 % was noted for T8, while the lowest value of 11.27 ± 2.21 % was noted for T2. The possible reasons for low heat recovery may be (i) formation and leakage of vapours (ii) poor thermal conductivity of the CaO that might form layer on heat transfer surface and restricting the movement of water molecules. It was also observed that though the heat recovery for T11 was lower than T8, the heat received in the product space was almost the same. There is fair possibility of less heat generation than the theoretical heat of reaction due to many factors like purity of reactants, rate of hydration, incomplete hydration, etc.

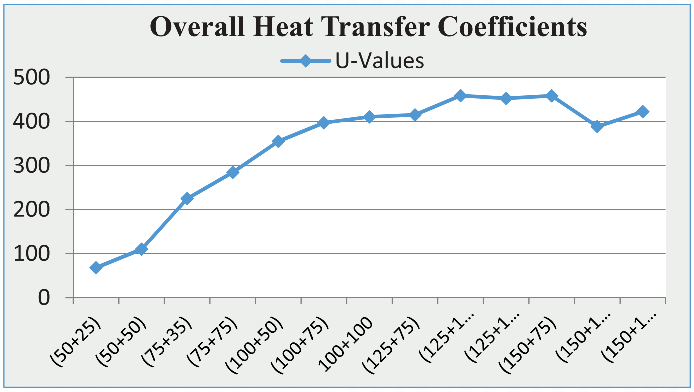

Fig 4.2: Overall Heat Transfer Coefficients, W/m^{2}K

Overall heat transfer coefficients

The overall heat transfer coefficients obtained in the study are displayed in Fig 4.2. Over the complete range of the various combinations of CaO and H2O, the U-values ranged from a lowest of 68.15 ± 8.24 W/m2K to the highest of 458.37± 64.69 W/m2K. The highest and lowest U-values were obtained with T9 and T1 respectively. The U-value obtained in case of T8 was almost equal to the highest value, which was remarkable factor.

Sensory Evaluation of the product

Table 4.7: Sensory evaluation of noodles cooked in self-heating container.

Sensory attributes	TO (Control)	T8	T11
Color	7.75 ± 0.45 ^{a}	4.58 ± 0.51^{c}	6.66 ± 0.65 ^{b}
Flavor	7.66 ± 0.49^{a}	4.58 ± 0.51^{b}	7.41 ± 0.66^{a}
Body and texture	7.83 ±0.38^{a}	4.25 ± 0.45^{c}	7.00 ± 0.85^{b}
Appearance	7.73 ± 0.38^{a}	4.41 ± 0.51^{c}	7.16 ± 0.57^{b}
Overall acceptability	7.91 ± 0.28^{a}	4.16 ± 0.38^{c}	6.91 ± 0.51^{b}

Data represented as mean ± standard deviation. Each observation is Mean of three replications (n=3), Means with different superscripts within a column differ significantly at ($P<0.05$)

The sensory characteristics of the noodles cooked in the self-heating container using the combinations T8 and T11 were evaluated using conventionally cooked noodles as control. From the results shown in Table 4.7, it is seen that all the scores of control for all the sensory attributes were significantly higher than the experimental products. Treatment T11 scored significantly higher than T8 and its flavour score was at par with that of control at 5 % level of significance. Although scored less it was acceptable.

Conclusion

The mixture of 150 g Cao + 75 g Water is most suitable to heat up 60 g of noodles with 120 ml water within 2 minutes without any agitation. Both the reactants as well as bye products of the reaction are inexpensive, readily available and possess GRAS status. Hence, the food safety is also ensured. However, there is scope to improve heat recovery and reduce the weight of container by using proper insulation.

The cost of the container comes approximately 10 times that of the product, which needs to be reduced for commercial viability (mass production). The weight of the package is more than double that of the conventional package.

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5. US6248257: Portable heat source.
6. US6267045: Cooking device with energy storage and extraction system.
7. US6279470: Portable and self-contained system for maintaining prepared foods in a cool state and reheating them.

Printpack: Solution of Modern Packaging Technology for Dairy and Food Industry

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Demographic background of India: According to 2011 census, 56% households in urban India now have four or less members.47.1% of rural households has now four or less members compared to a decade ago. The face of the consumer is changing with middle class explosion, aging population, women in the workplace, urbanization, rich becoming richer, shrinking household sizes. The implication of these changes from the value perspective of a pioneering packaging material firm like Printpack is to make shelf-stable portion pack packaging solutions with greater nutrition retention properties along-with convenience and consumer experience. We segment dairy and food processing in the following technology platforms:

Modified Atmosphere process and packaging: Ready meals, dry fruits, nuts, low water activity dairy and nondairy sweets, nutrition powders, instant mix, savory products are value added with this process.

The product is filled, package is exposed to UV then MAP sealed followed by UV exposure. Barrier cups or trays suitable for UV and MAP are used.

Hot fill sterilization: High acid foods with less than 4.0 pH without particulates are suitable for this process. Fruit pulp, purees, juices, salsa dips and acidified cheese dips are value added with this process to increase their shelf life. Sterilization is achieved by filling the product in high temperature in the range of 85-90 deg C. High barrier containers which can withstand high temperatures along with having high barrier properties adds value to the process by fulfilling its objective of getting higher shelf life.

Hot water sterilization process: High acid fruits with or without particulates (Dried fruits and acidified vegetables) with pH less than 4.00 are suitable for this process.

The product is filled; package is sealed and then sterilized in hot water bath at 85-90 deg C. High barrier cups with high temperature withstand properties adds value to the intended users of the process.

Retort sterilization Process: Low acid foods with pH greater than 4.6 example meats, vegetables, RTE meals, soup and dairy etc are suitable for this process which extends shelf life in a substantial way.

Product is filled; package is sealed and then sterilized by retorting process. High barrier cups and lids suitable to withstand retort are used are used.

Aseptic Form fill: Low acid dairy, puddings, gelatins, fruit, vegetable and meat purees. Machine surfaces are sterilized with hydrogen per oxide solution. Product is heat sterilized and cooled for filling. Package is sterilized by steam or hydrogen per oxide.

Micro wave Assisted Thermal Sterilization (MATS): This is the latest advancement of the retort technology. The principle of this technology is Mw assisted volumetric heating of the product which keeps the texture and sensory properties of the product.

Roll and Blow Technology: This is an end-to-end solution in beverages packing. The add-on values it adds to your operations are drastic cost reduction in logistics and packaging wastage. It has more differentiated USPs like customized bottle designs and manifold barrier properties from conventional PP and PET bottles.

Printpack Inc, 60 years old Atlanta based packaging material company with its multiple and evolving manufacturing capabilities delivers packaging solutions which are conditioned with all the technology platforms we discussed. Our team in India does not work in transactional basis, we work with our customers on transformational basis right from giving market insight- product idea – product formulation-process stabilization- resource sourcing-commercialization.

Advances in Instrumentation & Automation in Dairy Industry

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Introduction

Industrial evolution in the middle of the twentieth century was mostly influenced by progress in (digital) technology, advances in science, evolution of societal requirements and demands and particularly over the past three decades evolution of business concepts.

Developments in digital technology and in systems theory led to major progress in automation and information technology and a revolution in the availability of distributed control systems and PLC system with open communication protocol and software applications. New concepts, particularly in dairy industries knowledge based measurement and advanced control methodologies, are slowly but steadily being brought into the practice of process operation, performing on line and in real time.

The increasing concern for food safety and sustainability issues, quality requirements, cost pressure and the company strategy for local and global business concepts, all together reflected on plant investment decisions, favoring process automation for safe and accurate operation, higher product quality and improved process efficiency and productivity. Efforts are being geared up towards the minimize total cost of owner ship, increase flexibility of process and reduce down time, maintain a consistently high quality in large quantity, reduce human operator intervention by implementing automated systems. Automation in dairy industries is presently viewed as a versatile tool for improving productivity, product quality and profitability as well as for energy conservation.

Instrumentation and Automation in Dairy Industries

The most important properties of dairy processes subject to measurement that reflect both process operation and product quality are classified as objective or subjective. Examples of the former are PH, temperature, flow rates, pressure, level, etc. Sensors for on-line measurement of such properties have been available already for a long time. Properties such as taste, flavour, colour and consistency are considered as subjective and difficult to measure.

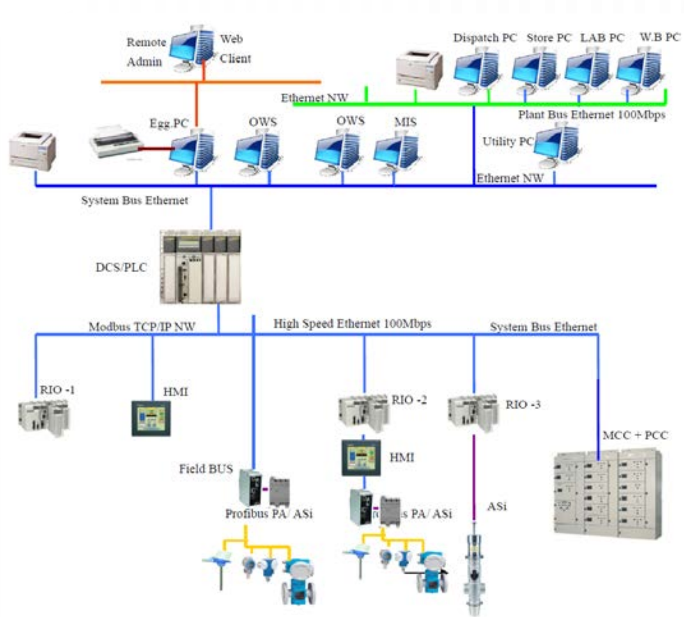
Dairy industry now is the fastest growing segments for plant automation. The control of process parameters in processing of milk and manufacturing of different product is one of the essential requirements to achieve desired quality product. In addition to consistency in product quality, automation provides scope for operational flexibility, energy conservation and safety in the plant.

Automation has completely change the field of packaging of dairy and food products. The dairy equipments such as robotic milking at the farm level, milk reception and storage at the society level, vehicle tracking system in milk transportation, and in processing and packing equipments, such as, Ice-cream freezers, packaging machines, UHT plants, milk evaporators, spray dryers, equipments for dairy plant utilities etc. are available with adequate level of automation in the system. Automated storage is the need of the hour, keeping in view the high production rate with latest technology high speed packing machines and large operations.

Not but the least and integrated plant management system such as Management execution system (MES), SCADA network.and SAP/ERP is needed for efficient management of the milk and milk products.

Typical Automation block diagram

In dairy industries it is need to measure, optimize and control the processing parameters and manage the plant operations. Dairy industry demands for new



technologies and smart instrument that can provide a cost-effective quality evaluation/control operation. The rapid development and emergence of smart instrument and field network technologies have made the networking of smart transducers a very economical and attractive solution for a broad range of measurement and control applications. Development of new process control instrument for the dairy industry, in parallel with developments in process control technology, has the potential to increase the levels of process automation in the dairy industry. In moving towards the PLC based, automation and smart instruments have big role to automate the processes.

Robotic Automation applications in dairy industries:

The use of robotic technologies has long afforded manufacturers the advantages of greater productivity, higher product quality, reduced production costs and labor savings.

"Trends in Robotics Market Assessment 2014, the Association for Packaging and Processing Technologies, illustrated the growth in robotics use. According to the study, 75% of end users employed robotics at some point on their manufacturing lines by 2014, compared with only 20% in 2008. Now, robots and their benefits are moving far beyond their early uses in palletizing, working their way upstream and into more primary and secondary packaging applications.

An industrial robot is an automatically controlled, reprogrammable, multipurpose manipulator programmable in three or more axes, which may be either fixed in place or mobile for use in industrial automation applications. Dairy industry has been lagging behind other industrial sectors in implementing robots, as dairy products by their very nature differ significantly in consistency and shape. However there is a broad range of potential applications for robotics in dairy and food industries. Amul Dairy has taken initiative for Automatic milking systems (AMS) and one of the most successful and important application of robotics in the dairy industry. In Dairy industry the concept of use of robotics is catching up fast. It is widely spread at the end of processing lines like packaging and palletizing, and automated movement of pallets by AGVs / LGVs and finally storage of the products in High bay Warehouses with ASRS. The benefits of robots to industry include improved management control and productivity and consistently high quality products. Consequently, they can greatly reduce the costs of manufactured goods. As a result, industries that effectively use robots will have an economic advantage on world markets.

Robotic Milking

Milking cows by machine, to replace the practice of milking by hand, has been known for more than century. Automatic milking systems (AMS) or milking robots are one of the most successful and important application of robotics in the dairy industry. The world's first commercial robotic milking rotary has been unveiled by Swedish dairy equipment company DeLaval at a pilot farm at Quam by Brook, Tasmania, Australia. Milking robots are different from the ordinary milking machines in one crucial aspect: the robot uses sensors to find the teats of the cow and then connects the cups to the teats with a robot arm (Halachmi et al., 2000). So milking is done without intervention of the farmer. This saves the farmer serious amount of labour . The milking robot uses an ultrasonic or a laser sensing system to locate the position of teats and a robot arm that move the teat cups to the teat end to attach the cup on the teat.

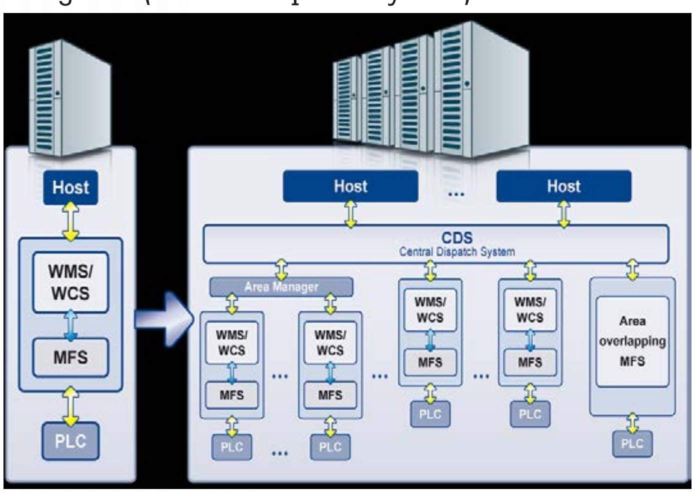
Automated Dairy Packaging

Robots can also be used for picking and placing items such as Milk pouches, Butter Blister packs, chocolate pralines, into primary packing. Additionally, robots are already used in packing lines to handle the individual packed and palletized products. Reducing demands on labour can be a big plus point for robots especially when labour is expensive and in high demand. Moreover, robots minimize the human workers direct contact with the products. The main aim of using an industrial robot is to reduce production costs and occupational injuries while improving process efficiency and hygiene. The strength of robotics, particularly in packing lines where labour costs are inherently high, is in their ability to perform the required repetitive tasks more efficiently and consistently than is currently possible.

ASRS system and warehouse management

High density storage is being utilized to improve energy efficiency in the chilled warehouse environment. High-bay automated storage and retrieval systems (ASRS) allow more pallets and crates to fit into a denser cube of space to reduce refrigeration costs while speeding up order throughput. Robotic layer picking helps fulfill the need for less than full pallet deliveries. Automated guided vehicles (AGVs) move pallets through the warehouse with efficient precision. Fully and semi-automated light goods technology for case and crate picking solutions minimize labor challenges. Modular and energy efficient conveyor systems move cases, crates and pallets through the warehouse with unprecedented throughput while maintaining product integrity. And the latest warehouse management systems (WMS) smoothly integrate with the dairy plant's upstream production output and the supply chains' regional DCs as well as downstream to the retail stores. Dairy is unique in the food industry for the varied containers used to store and transport its products, which include plastic crates for fresh milk and cream, cases, roll containers and pallets. Each of these formats requires specialized handling. Dairy distribution centers can integrate a variety of automated storage and picking approaches to optimize the complete handling of all product ranges

Architecture : The centralized software architecture using CDS (Central Dispatch System)



An automated storage and retrieval system (ASRS or AS/RS) consists of a variety of computer-controlled systems for automatically placing and retrieving loads from defined storage locations.

Automated storage and retrieval systems (AS/RS) are typically used in applications where:

There is a very high volume of loads being moved into and out of storage.

Storage density is important because of space constraints.

No value is added in this process (no processing, only storage and transport).

Accuracy is critical because of potential expensive damages to the load

The systems operate under computerized control, maintaining an inventory of stored items. Retrieval of items is accomplished by specifying the item type and quantity to be retrieved. The computer determines where in the storage area the item can be retrieved from and schedules the retrieval. It directs the proper automated storage and retrieval machine to the location where the item is stored and directs the machine to deposit the item at a location where it is to be picked up. A system of conveyors and or automated guided vehicles is sometimes part of the AS/RS system. These take loads into and out of the storage area and move them to the manufacturing floor or loading docks. To store items, the pallet or tray is placed at an input station for the system, the information for inventory is entered into a computer terminal and the AS/RS system moves the load to the storage area, determines a suitable location for the item, and stores the load. As items are stored into or retrieved from the racks, the computer updates its inventory accordingly.

The benefits of an AS/RS system include reduced labor for transporting items into and out of inventory, reduced inventory levels, more accurate tracking of inventory, and space savings. Items are often stored more densely than in systems where items are stored and retrieved manually.

ASRS for High Density Pallet Handling – ASRS are computer controlled systems for automatically depositing, storing and retrieving pallets from defined storage locations. They allow inventory to be moved quickly, safely and precisely within a warehouse environment. High-bay systems optimize cubic space usage, not only by their vertical stacking capability, but also by minimizing aisle cubic footage. By eliminating the need for forklift trucks, aisles can be made significantly more narrow, allowing 3.7-meter (12-feet) wide aisles to become just 1.5-meter (5-feet) wide. This space can then be used for more pallet positions. The latest generation of automated pallet cranes provide a uniquely flexible and modular design that is equipped with a multi load pallet handling capability, ideal for moving pallets of dairy foods in chilled environments. High-bay warehouses are used for high volume SKUs such as cheese and butter, whereas mini load systems are applied for faster moving milk and cream products transported in crates. These ASRS systems allow rapid configuration to the right storage and retrieval need for any dairy foods storage application. From floor level to up to 40 meters (131 feet) tall, the latest generation of stacker cranes can provide single deep, double deep, triple deep and multi-deep pallet stacking, with the flexibility to handle one load at a time or multi loads. When a pallet is on the load handling device it is transported off the pallet crane into the rack. Conventional ASRS machines only go one or two pallets deep, using a fork attached to the machine. The latest systems can go three pallets deep utilizing a telescope fork. Then with a satellite remote unit they can run a pallet 12 meters (40 feet) into the racking, as much as 10 pallets deep. Pallet cranes are now designed to deliver energy efficiency. They are typically optimized for peak throughput, performing many moves in and out of the racking and also generate electricity from lowering their lift carriages, using their motors as a generator. The power gained is used to aid horizontal travel. The system can also contribute energy when braking during horizontal travel to aid vertical motion. This energy recuperation both reduces the ASRS' total power usage and, with other measures, can reduce the incoming power required.The most advanced models of ASRS use integrated controls architecture for material flow control, enabling optimized speed and precision positioning. Infrared or wireless is used to communicate between ASRS units and the control system, which instructs the ASRS where to place incoming pallets and crates, and where to retrieve them for shipping.

Conclusion

In the dairy industries, there is growing trend in adoption of complete automatic plant starting from milk reception to finished product storage and dispatch with PLC based automation and use of robotics in material handling will be of immense benefit to dairy and food processing industry. Manual handling of finished product is not going to end soon, but still there is a huge scope for automation and robotics in the dairy industry. In spite of robots have many advantages like safety, consistency and efficiency, the challenges that lies in implementing robotics are high investment and the requirement of highly skilled manpower for operation and maintenance.

Dairy Engineering Education – Present Status and Future Revamps

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Introduction

The country is presently poised at an interesting cusp of state as far as Education, in general and Technical Education, in particular are concerned. There is a rapid growth in what is called as the Knowldege Society and a much needed impetus is being provided to skill development among the youth. The education sector in all spheres of technical knowledge is being revisted for revisions advancements and developments in light of the globalised economy and changing needs due to technical advancements. In this regard, Dairy Engineering Education also needs to reflect upon its present form and reorient itself to be inclusive of the demands of the times. Dairy Engineering as we all know is a fied that traverses across multidisciplinary boundaries and successfully encompassing the knowhow from allied fields of Engineering including Mechanical, Chemical and Electrical Engineering ably supported by the sciences of Dairy (Food) processing including Technology, Chemistry and Microbiology. The subject applies basic engineering principles and mathematical approaches to gain a basic understanding and modeling of the processes and process rates and design and develop mechanised unit of processing for manufacture, transport, packaging and storage of milk and milk products using energy efficient, labour and time saving and environmentally friendly means. A student of Dairy Engineering, in addition to gaining the knowledge and skills required to satisfy the requirements of the Academicia / Industry to meet the capacity requirement of this field; must also should be exposed to well-rounded curricula that keep him/ her abreast of the emerging technologies and equip him/ her with practical knowledge. The paper analyses the present curriculum in Dairy Engineering and suggests revisions to uplift the same to keep up with the demands of the times ahead.

Academic Programmes

The present Academic Programmes in Dairy Engineering is widely restricted to Masters and Doctoral courses in the subject. It has been our experience that the students joining the Dairy Engineering programmes are primarily graduates from the B Tech (Dairy Technology) background. Other candidates joining the programme include graduates with a B. Tech (Agricultural Engineering / Food Engineering) degree. The syllabus for B. Tech (Dairy Technology) is well structured with providing an extensive theoretical and practical understanding of concepts of Technology, Chemistry and Microbiology in addition to adequate coverage of the basic Engineering subjects and this works in favour of the students undergoing the Dairy Engineering programmes since under the circumstances, Dairy Engineering practically acts as a specialisation for the candidates with excellent basic knowledge in all streams of Dairy Processing.

A close perusal of the major subjects currently offered under the PG programme for Dairy Engineering indicates that the syllabus of the subjects adequately covers the various aspects related to Dairy Engineering with the right mix of basic Engineering subjects (Heat Transfer and Transport Phenomena) and applied subjects including Design / Instrumentation etc. The mathematical treatment of the basic subjects also attempts to equip the candidates with minimum working knowledge of Engineering Mathematics.

As per the prescribed norms, the students also have to choose a minor subject and undergo certain minimum credits from the chosen minor; the most preferred option for the minor subject for students of Dairy Engineering continues to be Dairy Technology. This choice results in candidates completing the PG programme in Dairy Engineering having the best possible combination of Engineering and Technology, probably giving the students an edge over their peers from other streams of Process Engineering (Mechanical / Chemical) while in the working field. A minimum credit load of supporting courses from allied subjects such as Dairy Chemistry / Dairy Microbiology / Dairy Economics & Statistics are also offered to the students to round off the academic requirement of the programme.

All universities offering PG programmes in Dairy Engineering prescribe intensive coursework for one year followed by a research dissertation work to fulfil the requirements of the programme. Masters' students usually complete their dissertation work in one academic year (spanning 2 semesters); thus completing the Academic requirements of the Masters' degree in 2 years, while doctoral candidates have a more extended research work, completing the academic requirements only after a minimum of 3 years. The dissertation work rigorously trains the students to identify a suitable research problem, plan experiments and carry out and report research independently.

Employment Avenues, Requirements and Suggestions

Dairy Engineering students usually find employment in the following avenues:

1. **Academicia** – Including Teaching and Research positions in Universities / Private Colleges and organisations such as ICAR / CSIR. The entry level designation for this employment is usually Assistant Professor / Scientist. Some candidates also enter this system in temporary positions as Teaching Assistants / Research Fellows or Research Assistants.

   As per the present guidelines, the requirement for any candidate to be considered for academic positions, is a successful qualification of the National Eligibility Test (NET) conducted by ICAR (this requirement is relaxed for candidates with a Ph. D degree). The candidates who wish to join ICAR for a research career need to qualify the Agricultural Research Service (ARS) process of the ASRB including examinations and interview. However, Dairy Engineering does not find a place in the list of Disciplines for the NET /ARS, as a result of which the students of Dairy Engineering appear for these exams in allied subjects such as Agricultural Processing. Even though, over the years, several candidates have successfully qualified both the NET and ARS examinations, the students have to put in an extra effort to prepare for topics under general Agricultural Processing.

   It is therefore suggested that a suitable elective or pre requisite course may be formulated and included in the PG course of Dairy Engineering to bridge the gaps in the syllabus vis-a-vis the NET / ARS syllabus, so that candidates who wish to take up an Academic career could opt for this elective and receive adequate support and guidance in this direction during their coursework.

2. **Process Engineering Firms** – A large number of companies dealing with either design and fabrication of dairy equipment or erection and installation of process plants recruit Dairy Engineers in the areas of Process Engineering, Marketing and Techno Sales and R & D and Project Planning.

   In the course of preparation of this manuscript, an attempt was made to collect feedback /suggestions on the subject from Alumni of our Institute currently employed with various organisations in the above capacities and also from representatives from the Industry. The salient points for upgradation / revision of the present curriculum from the feedback is as listed below:

   - Action-based learning and practical hands-on training on engineering aspects of critical equipment (Design, operation and Maintenance), basic working knowledge on Project Planning and execution
   - Preparation and understanding of P & I Diagrams
   - Working knowledge of Engineering softwares such as CAD/CAE, Creo etc and Simulation Techniques
   - Awareness on Sanitary Design and Audits, Life Cycle Impact, Regulatory Standards as per Industrial requirements
   - Knowledge on Basic Programming, Advanced Automation including tools such as PLC and SCADA
   - Encourage tie – ups with Industry for Student dissertation works to facilitate work on real time problems

3. **Dairy Plant- Managers** – Another employment avenue for the students is as Managers in dairy processing units in the organised sector / under MNCs. For this position, in addition to the basic skills the candidate should be well versed in Material Management, Equipment - Operation &

Maintenance and Practical Financial Accounting

4. Self Employment / Entrepreneurship – In recent times, there is an all-round encouragement in this direction and some students have opted to setup their own ventures in either manufacturing / project installations or consultancy. In addition to the technical knowhow, venture capital and confidence required for this option, it would always be prudent (especially for a greenhorn) to gain exposure to and experience in the industry for a minimum duration to strengthen the skillset of the candidate.
5. Allied Jobs – Software / Financial Institutions – Students of this discipline have also sought employment in allied sectors such as in the Software Industry or in suitable positions in Financial Institutions such as NABARD or Banks. Even though it is never the mandate of the academic programme to equip the students for such avenues, the basic analytical ability gained during an engineering course would stand in good stead for such candidates.

In addition to the specific requirements of the above employment avenues, opportunity must be provided to the students to develop and polish their soft skills for documentation, computation and presentation. In addition to imparting them with technical expertise, the curriculum should also sensitise the students to the importance of Intellectual Property, needs of our society and fragility of the environment. Further, education as we all know is a continuous process and facility for periodic updation in the form of capacity building and open courseware / webinars to keep abreast of the recent advancements in equipment design / novel technology / statutory regulations needs to incorporated in the academic setup.

Hygienic Design of the Food Processing Equipments

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The hygienic/sanitary design of the equipment is one of the most important aspects to prevent microbial growth and contamination during process, or post process contamination of the food.

If the equipment is of poor hygienic design, it will be difficult to clean and keep free from microbes, which can then survive and multiply in cracks/crevices and dead areas of the equipments/machines/pipelines/joints.

For sanitary design of the equipments and pipelines it is necessary to consider the following points:

- ✦ Basic principles of hygienic design
- ✦ Selection of the raw material for the process material/pipe lines
- ✦ Surface finish of the equipment
- ✦ General design features
- ✦ Details of construction
- ✦ Protection of the product from microbiological or other contamination
- ✦ Effectiveness of cleaning and sanitation

Basic Principles Of Sanitary Design:

- Contact surfaces with food should be inert, non-toxic, and non-hazardous and must not be migrated or absorbed by the foods.
- All food contact surfaces should be visible, as far as possible. If need arises, they must be easily dissemble for manual cleaning and inspection.
- Under routine cleaning procedures the surfaces must be able to eliminate the possibility of contamination of microbes and insects.
- In case of cleaning in place (CIP) is performed, the desired cleaning and sanitation level must be achieved without dissembling or manual cleaning.
- All internal and interior surfaces must be so designed so that they are self-emptying or self-draining.
- Equipment design should be such that it should prevent external contamination.
- The exterior non-food contact surface should be designed not to harbor microbes, insects, dust etc. on itself, or from other equipment, floor, walls or hanging supports.
- The requirement of guarding machinery to ensure safety in operation may easily conflict with sanitary design requirements unless proper care is taken during planning/design, construction, installation and maintenance.
- Noise suppression is important for providing acceptable working conditions but installation of such devices should not give rise to microbial and infestation problems unless proper care is taken.
- Good plant layout is extremely important and critical to prevent the microbial cross contamination to the products and have significant implications for public health and product spoilage.
- The rubber/teflon gaskets/seals etc. may be replaced as per the instruction of the manufacturer even if it looks like in working order as this is most likely to develop a "bio-film", which will be very difficult to be dislodged.

Material of construction:

- The preferred grade of stainless steel for dairy and food industry is AISI-304 and AISI-316.
- Smooth (Roughness value-Ra £ 0.8 mm), hard, continuous and non-porous surfaces, free from cracks, crevices and pits, are also desirable to prevent contamination, so that tiny particles of food, bacteria or insect eggs are not caught in microscopic surface crevices and are difficult to dislodge, thus becoming potential source of contamination.
- Equipment surfaces not in contact with foods, e.g. frame work, cladding, etc., should also be smooth to facilitate cleaning.

General design features:

Surfaces and geometry

- ✦ Easy cleaning and accessibility
- ✦ Surface in contact with food products must be resistant to the product and cleaning and disinfectants.

Fabrication

- In design, construction, installation and maintenance, it is important to avoid end joints or dead space or other conditions that can trap food, prevent effective cleaning and allow microbial growth to take place.
- The welded joints must be properly ground and polished to prevent accumulation of product residues and microbial slime. Only rediused corners (optimum radius 20 mm) for proper cleaning must be there. Vertical or steep sides must be used to minimize the accumulation of the product.
- Overlap joints fixed by nuts and bolts or rivets should be avoided, as these are the areas where food particles and microbes accumulates.
- Sanitary design aspects of vessels, pipe lines, valves and pumps are also very important, while selecting the same for a particular process.

Plant lay out

- Straight line product flow is desirable.
- Try to segregate the location of the raw material storage, production, and packaging sections.
- The quality control department and starter propagation/handling area should be away and well isolated from processing area.
- Common rooms, canteen and toilets should also be away from processing sections.
- Visitor's gallery should be planned to restrict the direct access of the persons to the processing sections.

TEN Principles of Sanitary Equipment Design

1. Cleanable to a microbiological level. Food equipment must be constructed to ensure effective and efficient cleaning over the like of the equipment. The equipment should be designed as to prevent bacterial ingress, survival, growth, and reproduction on both product and non-product contact surfaces of the equipment.
2. Made of compatible materials. Construction materials used for equipment must be completely compatible with the product, environment, cleaning, and sanitizing chemicals and the methods of cleaning and sanitation.
3. Accessible for inspection, maintenance, cleaning & sanitation. All parts of the equipment shall be readily accessible for inspection, maintenance, cleaning and sanitation without the use of tools.
4. No product or liquid collection. Equipment should be self-draining to assure that liquid, which can harbour or promote the growth of bacteria, does not accumulate, pool or condense on the equipment.
5. Hollow areas should be hermetically sealed. Hollow areas of equipment such as frames and rollers must be eliminated wherever possible or permanently sealed. Bolts, studs, mounting plates, brackets, junction boxes, nameplates, end caps, sleeves, and other items must be continuously welded to the surfaces, not attached via drilled and taped holes.
6. No niches. Equipment parts should be free of niches such as pits, cracks, corrosion, recesses, open seams, gaps, lap seams, protruding ledges, inside threads, bolt rivets and dead ends.
7. Sanitary operational performance. During normal operations, the equipment must perform so it does not contribute to unsanitary conditions or the harbourages and growth of bacteria.
8. Hygienic design of maintenance enclosures. Maintenance enclosures and human machine interfaces such as push buttons, valve handles, switches and touch screens, must be designed to ensure that product residue or water does not penetrate or accumulate in and on the enclosure or interface. Also, physical design of the enclosures should be sloped or pitched to avoid use as a storage area or residue accumulation point.
9. Hygienic compatibility with other plant systems. Equipment that requires additional sub systems, such as exhaust, drainage, or automated cleaning systems, does not create sanitary design risk because of the soil load, operational conditions, or standard sanitation operating procedures. Consideration is given to exhaust duct design, the ability for drain lines to remove effluent effectively (especially when dealing with vessels), and the effectiveness of CIP systems for the process. This means the team completing the checklist is taking a look at the equipment and its supporting systems

together versus individually and evaluating how they will likely function as a system.

10. Validated cleaning & sanitizing protocols. Procedures for cleaning and sanitation must be clearly written, designed and proven effective and efficient. Chemicals recommended for cleaning and sanitation must be compatible with the equipment and the manufacturing environment.

Legislation:

Indian Standards

FSSAI has provided guidelines for auditing Food factories for food safety assessment. However, elaborate guidelines are missing on food / dairy factory design, layout & on sanitary equipment design. Even BIS also does not have these aspects. In absence of "appropriate" & "elaborate" guidelines, It will be good to study & adopt the suitable guidelines available in Europe/US as well as by ISO/Codex/WHO *etc*. under Indian conditions.

European Machinery Legislation and sanitary standards

Food equipment intended to be sold in European countries and designing operations in food factories must comply with:

- o European Machinery Legislation, consisting of the Machine Directives 2006/42/EC & 98/37/EC
- o Guide to application of the Machine Directive 2006/42/EC, published by the Industry and Enterprise department of the European Commission
- o Materials and Articles intended to come into contact with Food Directive 89/109/EEC
- o Materials and Articles intended to come into contact with Food Regulation EC N° 1935/2004
- o Council of Europe Guideline on Metals and Alloys used as Food Contact Materials
- o Plastics and Materials in Contact with Food Regulations Directives 2002/16/EC & 2002/72/EC
- o prEN 1672-1 standard
- o EN 1672-2 standard
- o Regulation (EC) No 852/2004 & Directive 93/43/EEC
- o EU commission - Scientific Committee on Veterinary Measures relating to Public Health: Cleaning and Disinfection of Knives in the Meat and Poultry Industry
- o Several EN Food Machinery-specific Standards, applicable to specific food production equipment (e.g. mixers, cutters, cooking equipment, etc.), developed by CEN /TC153
- o 41 EHEDG- (European Hygienic Engineering & Design Group – guidelines (http://www.ehedg.org)

Annex I of the Machine Directive 2006/42/EC & 98/37/EC (formerly 89/392/EEC and its amendments 91/368/EEC & 93/44/EEC) requires that all equipment used to handle food should be hygienically designed: (a) be so constructed, be of such materials and be kept in such good order, repair and condition as to minimize any risk of contamination of the food; (b) with the exception of nonreturnable containers and packaging, be so constructed, be of such materials and be kept in such good order, repair and condition as to enable them to be kept thoroughly cleaned and, where necessary, disinfected, sufficient for the purposes intended; (c) be installed in such a manner as to allow adequate cleaning of the surrounding area.

prEN1672-1 and EN1672-2 are Harmonized European standards specifying machinery, safety, and hygienic requirements for various food industries, drawn up by the Technical Committee CEN/TC 153 of the Comitée Européen de Normalisation (CEN). prEN 1672-1 deals especially with how to arrange interlocking of guards to allow safe cleaning according to the hygiene requirements (coded magnetic switches), how to apply electrical safeguards in wet environments and during hose-down operations, how to contain product to avoid slip risks, and how to proceed safe hopper feeding and product loading. prEN 1672-1 also provides the user instructions for safe and effective clearing blockage, cleaning, setting up and maintenance. EN 1672-2 sets design principles and requires the choice of a design which meets both safety and hygiene objectives. These two standards are supported by around forty EN food machinery-specific Standards.

EHEDG guidelines are developed by members of European research institutes and universities, food companies and food equipment manufacturers. EHEDG was founded in 1989 to provide European food equipment manufacturers and Food manufacturers guidance in the implementation of the hygienic requirements defined in the Machine Directives 2006/42/EC & 98/37/EC, and the EN standard 1672-2. Several members of EHEDG participate in CEN/

TC 153 to develop EN standards with respect to the construction of safe and hygienic food equipment.

Regulation (EC) No 852/2004 on the hygiene of foodstuffs that replaces Directive 93/43/EEC set out the framework for standards of food hygiene and food control. Both directives describe general requirements for food premises, specific requirements for rooms where food is prepared, particular requirements for transport, equipment, food waste, water supply, personal hygiene, storage/handling and training. To fulfill all these requirements, Directive 93/43/EEC and Regulation (EC) No 852/2004 have adopted the principles of HACCP as tool to identify and control food safety hazards (EC, 1993 & 2004). Therefore, the EC has published a Guidance document to facilitate the implementation of the HACCP principles in food and food related businesses (EC, 2005).

British sanitary standards

In Great Britain, the following hygienic standards are developed:

- o Campden Food & Chorleywood Research Association Guidelines;
- o Chilled Food Association - Hygienic Design Guidelines 2002
- o Institute of Food Science & Technology's Food and Drink – Good Manufacturing Practice: A guide to its Responsible Management, 5th edition, 2007

US sanitary standards

In the US, the following Government Agencies and Private Organizations have published sanitary standards for food processing equipment:

- o US Dept. of Agriculture (USDA): Food Safety and Inspection Service (FSIS) 11.000 series: Facilities, Equipment & Sanitation;
- o USDA Guidelines for the Sanitary Design and Fabrication of Dairy Processing Equipment;
- o US Public Health Service: Food and Drug Administration (FDA): Code of Federal Regulations, Title 21, § 110.40: Equipment, Utensils & cGMP;
- o International Association of Milk, Food, and Environmental Sanitarians, Inc. (IAMFES): committee on Sanitary Procedures "3-A Sanitary Standards";
- o American Society of Mechanical Engineers (ASME): ANSI-ASME F2-1: "Food, Drug and Beverage Equipment" & ASME Bioprocess Equipment International Standard (ASME BPE-2009);
- o Baking Industry Sanitation Standards Committee: ANSI-BISSC Sanitation Standards;
- o AFDOUS (Association of Food and Drug Officials of the United States): "AFDOUS Frozen Food Code";
- o NSF international: a) Food Service Equipment Standards; b) Food preparation and Service Equipment;
- o American Meat Institute (AMI) Equipment Design Task Force: 10 principles of Sanitary Equipment Design;
- o American Meat Institute (AMI) checklists, to allow processors to conduct a sanitary design audit of the equipment based on assigned points

To develop US sanitary standards, both NSF and 3-A cooperate with EHEDG.

International standards:

Several international operating organizations have developed hygienic standards on their own:

- o ISO/TS 22002-1:2009 ISO 22000:2005 contains the overall guidelines for food safety management.
- o ISO 22004:2014 provides generic advice on the application of ISO 22000
- o ISO/TS 22002-1:2009 contains specific prerequisites for food manufacturing ((replacement of the British Standard Institution standard, PAS220:2008;
- o ISO/TS 22002-4:2013 contains specific prerequisites for food packaging manufacturing
- o ISO/TS 22003:2013 provides guidelines for audit and certification bodies
- o ISO 14159:2002 Safety of Machinery - Hygienic Requirements for the Design of Machinery;
- o ISPE Baseline® Guides, ISPE Guides, ISPE Good Practice Guides;
- o Codex Alimentarius (developed by Food and Agricultural Organization (FAO) of the United Nations and the World Health Organization);
- o Codex HACCP Code;
- o GMP – WHO standards;_

3-A Sanitary Standards

The hygienic standards writing organization for dairy and food processing equipment is 3-A Sanitary

Standards Inc. (http://www.3-a.org/). 3-A SSI is an independent, not-for-profit corporation dedicated to advancing hygienic equipment design for the food, beverage, and pharmaceutical industries. Its Standards and Accepted Practices are recognized internationally. During the 1920s, the need for more stringent and uniform standards for dairy processing equipment became evident as the U.S. economy and consumers entered the modern era. Representatives of three interest groups—processors, regulatory sanitarians, and equipment fabricators—saw the need for cooperative action and introduced the first industry standards for equipment. These standards became known as 3-A standards for the three interest groups that forged a common commitment to improving equipment design and sanitation. Unlike other types of standards, 3-A Sanitary Standards relate to the cleanability of dairy equipment.

In 1944, the U.S. Public Health Service offered full cooperation with the 3-A program, which marked the beginning of a program to provide uniform equipment standards for the protection of public health. This integral participation of the regulatory sector of the industry has become important as the food industry complies with the requirements of the Food Safety Modernization Act (FSMA). Under FSMA, the industry must be able to demonstrate and document that they have implemented the necessary steps to assure the wholesomeness of the products they produce and the effectiveness of the cleaning and sanitation programs they employ. 3-A Sanitary Standards' involvement directly benefits the equipment fabricator and the processor through the routine acceptance of the equipment during regulatory inspections.

Introduced in 1956, the 3-A Symbol is a registered mark used to identify equipment that meets 3-A Sanitary Standards for design and fabrication. Use of the 3-A Symbol is strictly voluntary and is subject to licensing requirements established by 3-A SSI. A manufacturer may receive authorization from 3-A SSI to use the 3-A Symbol.

In 2003, 3-A SSI implemented a Third Party Verification (TPV) inspection and evaluation program for all 3-A Symbol holders. This requirement for independent verification of conformance to a 3-A Standard has substantially enhanced the integrity of the 3-A Symbol. Complete details on the TPV inspection requirement are available on this web site under 'The 3-A Symbol and Third Party Verification Program'.

Today there are around seventy 3-A Sanitary Standards and nine 3-A Accepted Practices. These documents cover a wide range of the basic equipment used in most food processing applications such as pumps, valves, sensors, heat exchangers, and vessels. There are also standards for specialized equipment for packaging, drying, conveying products, etc. A particular piece of equipment can demonstrate that it has been evaluated by a third-party evaluation and conforms to the hygienic standard requirements with the display of the 3-A symbol. Over decades of collaboration and recognition among the key stakeholders, the 3-A brand has attained wide recognition in the marketplace for food processing equipment and special stature built on a strong foundation of the following elements: trust, independence, and expertise.

Epilogue:

Microbes (Bacteria, yeasts, molds, viruses *etc.*) are ubiquitous in nature & generally cannot be seen by naked eye. They have ability to grow at normal environmental conditions (mesophiles) as well as under different & sometimes in extreme environmental conditions *e.g.* at low temperature (psychrophiles, psychrotrophs), high temperature (thermophiles), low water activity/humidity (xerophiles), under acidic (acidophiles) & alkaline conditions (alkalophiles), in presence of air (aerobes) as well as in absence of air (anaerobes). Unwanted & higher number of microbes will be responsible for reducing/limiting the shelf-life of food products and presence of pathogenic organisms will be responsible for spreading diseases to the consumers. These types of situations may result into even product recall.

Quality of raw materials or food ingredients, proper processing, packaging and storage of finished products decides the quality of the food products. An engineer's work to contribute towards quality begins as early as first lines for planning of the plant are drawn. Planning for plant & equipment layout, its design, services (water, air, refrigeration, steam), waste disposal *etc.* are some of the critical factors, which contributes to quality. During routine production food engineer's role is to see that equipments, pipes etc. are properly cleaned, sanitized & preventive maintenance is done regularly. Food Engineers from time to time; along with team of technologists, chemists & microbiologists have to diligently work together to ascertain the quality of food products. Sanitary design of food equipments is therefore of first & paramount importance for production of quality food products & should be given due weightage.

Glass Transition Phenomenon: Relevance and Application in Dairy Industry

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Introduction

A glass is operationally defined as an amorphous solid. In fact, a glass is actually an under cooled liquid of high viscosity that exists in a metastable state, mechanical solid state, in which it is capable of supporting its own weight against flow due to the force of gravity (Haward,1973). A glass transition in amorphous system is temperature, time and composition dependent which changes the state from glassy mechanical solid to a rubbery viscous liquid. The glass transition temperature is specifically the property of an amorphous material. Glass transition is second-order phase transition that occurs over a temperature range, although a single temperature is often referred (Fox and Flory, 1950, Roos, 1995 and Roos et al., 1996). As the temperature increases above T_g, many of the physical properties of the material suddenly change, among them, the most important are an increase in the free molecular volume, an increase in heat capacity (C_p), increases in the thermal expansion coefficient (α) and dielectric coefficient (ε) and changes in viscoelastic properties. The 'free volume' is the volume unoccupied by the "solid matter" of the molecules and represents the volume available for their free movements (Flink, 1983). Accelerated changes in the above properties as a function of temperature are the basis for detecting the glass transition temperature. The changes continue over a relatively narrow band of temperatures, therefore, onset and termination T_g values are observed. Some of the analytical methods to determine T_g are differential scanning calorimetry (DSC), differential thermal analysis (DTA) and thermal mechanical analysis (TMA). The former two methods detect changes in C_p, while the third detects changes in the elastic modulus.

Drying is one of the major food processing operations. There are several drying techniques, among them the most commonly applied are hot air (fixed and fluidised bed), freeze and spray drying. In most drying conditions, a signifcant amount of the dried product remains in an amorphous state, mainly due to the insufficient time for crystallisation to occur at the given drying conditions. Depending upon the rate of drying, the dried product obtained can also constitute some crystalline material. This will be however, influenced by the processing conditions, composition and property of the individual ingredients present (Roos, Karel & Kokini, 1996; Senoussi, Dumoulin & Berk, 1995; Flink,1983). There are many product quality attributes which are related to the physical state of the ingredients in the dried product. Any change in the physical state of the product has the possibility to affect the physicochemical characteristics of the minor as well as principal ingredients of the product. One of the factors which cause this structural change of the amorphous parts of the structure is the product temperature. Above a critical value, known as glass transition temperature (Tg), a glassy solid structure begins to change to a ``rubbery'' state. This structural change influences the process and physico-chemical quality of the products. The purpose of this paper is to highlight the importance of glass transition temperature on drying processes as well as on the storage stability of dried dairy products.

Glass transition in spray drying

Yrjo (2001) found that spray-drying is a rapid dehydration method allowing production of high quality dairy powders. In dehydration and subsequent powder handling and storage, however, both chemical and physical changes, such as caking, lactose crystallisation, and non enzymatic browning, may impair powder characteristics and result in loss of powder quality. Many of these changes are related to the physical state of lactose, as rapid removal of water in spray drying results in the formation of low moisture, amorphous, non crystalline structures of lactose and other milk components. The formation of amorphous, glassy lactose during spray drying allows production of a free-flowing powder. High temperatures or residual water contents at the later stages of the drying process, however, may cause stickiness, caking, browning, and adhesion of the powder particles to the processing equipment. At higher water contents, as the glass transition of amorphous lactose is well below storage temperature, dairy powders become sticky and the amorphous lactose may exhibit time-dependent crystallization. Crystallization of amorphous lactose may also release sorbed water from the amorphous material, which enhances other deteriorative changes, such as the nonenzymatic browning reaction. Amorphous lactose in dairy powders encapsulates milk fat, which, as a result of lactose crystallization, is released and becomes susceptible for rapid oxidation. The glass transition and water activity are, therefore, important factors controlling process ability, handling properties and stability of dairy powders.

Glass transition in freeze drying

In the freeze drying process, the product after drying becomes porous in nature. If the temperature of the dehydrating porous product is above Tg, the viscosity of the solid material may not be enough to support the structure and ``collapse'' or shrinkage occurs (To & Flink, 1978; Tsourouflis, Flink & Karel, 1976). To maintain the original volume, the product temperature should not be above Tg. This means that the collapse rate increases as the viscosity of the drying matrix decreases below 10^7 Pa s above its Tg. This structural shrinkage leads to poor aroma retention, poor rehydration characteristics and uneven dryness. For various food liquids during freeze drying, the collapse temperature can vary between 5°C and 60°C (Bellows & King, 1973) depending upon their composition. Foods which are high in sugars, such as fruit juices, will have lower collapse temperature. Therefore, it is important to know the collapse temperature so that the drying proceeds without any loss of product quality. In the freeze drying experiments of sugar solutions at various solids concentration, Tsourouflis *et al.,* (1976) showed that the collapse temperatures can be raised by the addition of high molecular weight materials.

Glass transition and powder stability

Jouppila *et al.,* (1994) determined the effect of glass transition temperatures on dehydrated milk products with various water contents and water activities. Glass transition temperatures of milk powders containing lactose were close to those of pure lactose. Skim milk powder with hydrolyzed lactose had significantly lower glass transition temperatures. Glass transition temperatures decreased as water content increased. The critical water content and water activity for stability at 24°C were predicted using data on glass transition temperature and water sorption. Lactose and milk powders containing lactose had the similar critical water activity or storage relative humidity, but a little different critical water contents. The critical values for skim milk with hydrolyzed lactose were much lower than those for regular milk powders. Loss of adsorbed water, indicating lactose crystallization, was observed in milk powders stored above the critical relative humidity.

Effect of glass transition on cohesion of amorphous sugar powders

Foster *et al.,* (2005) studied the time-dependent nature of glass transition related cohesion for amorphous sucrose, maltose, glucose, galactose and fructose powders. The powders were made by freeze drying and the low molecular weight sugars (glucose, galactose and fructose) were made as mixtures with lactose. The blow test was used to measure the cohesiveness of the different powders with respect to time while the powders were exposed to a constant temperature and relative humidity environment. The cohesion was related to the combined effect of temperature and moisture and not the individual temperature, water activity or moisture content of the powder. The study revealed that the mechanism for sticking and caking of amorphous sugars is through the phase change of the amorphous sugar from a glass to a rubber at temperatures above the glass transition temperature. Furthermore, it confirms that the rate of cohesiveness development is proportional to the T-Tg value, that is, the greater the temperature above the Tg, the quicker the powders will develop liquid bridges which may result in caking.

Glass transition and the flowability and caking of powders containing amorphous lactose

Fitzpatrick et al., (2007) studied the relationship between the glass transition and water content for predicting caking problems with powders containing amorphous components. The powders contain amorphous components, such as amorphous lactose in milk powders, which when given sufficient conditions of temperature and water content, will mobilize as a high viscosity flow making the particles sticky. This can lead to increased cohesiveness, powder caking and increased adhesion to surfaces. The transition from the glassy state is established by increasing the powder temperature to above its glass transition temperature which can be measured using differential scanning calorimetry. Exposing milk powder to over 10–20 °C above the lactose glass transition makes the powder more sticky, rendering it a lot more cohesive and also increases its adhesion to a stainless steel surface. This glass transition induced stickiness is time-dependent. Over time, crystallisation can take place converting the amorphous lactose into crystalline lactose. Furthermore, the caking behaviour of powders depends on the amount of component present in the amorphous state.

Conclusion

Glass transition, have a crucial role in a proper control of the spray drying process of dairy materials and the quality of the products obtained. Additionally, the transitions are important in understanding the stability of dehydrated dairy products. The glass transition of amorphous lactose affects the development of the particle properties during spray drying and following agglomeration processes. Further knowledge of particle temperature and water content in dehydration is required to understand and reduce undesired stickiness and caking of particles in different stages of the drying process and powder handling.

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3D Printing - The future of Food Industry

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Introduction

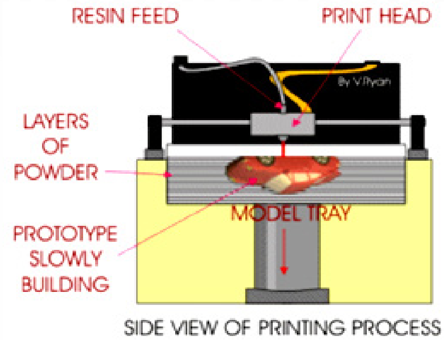
3D printing is a form of additive manufacturing technology where a three dimensional object is created by laying down successive layers of material. It is also known as rapid prototyping, is a mechanized method whereby 3D objects are quickly made on a reasonably sized machine connected to a computer containing blueprints for the object. The 3D printing concept of custom manufacturing is exciting to nearly everyone. This revolutionary method for creating 3D models with the use of inkjet technology saves time and cost by eliminating the need to design; print and glue together separate model parts. It creates a complete model in a single process using 3D printing. The basic principles include materials cartridges, flexibility of output, and translation of code into a visible pattern.

The Conventional manufacturing techniques are known as 'Subtractive Manufacturing' because during this process the material is removed to generate a preformed block. Processes such as Milling and Cutting are subtractive manufacturing techniques. This type of process creates a lot of waste since; the material that is cut off generally cannot be used for anything else and is simply sent out as scrap. 3D Printing eliminates such waste since the material is placed in the location that it is needed only, the rest will be left out as empty space.

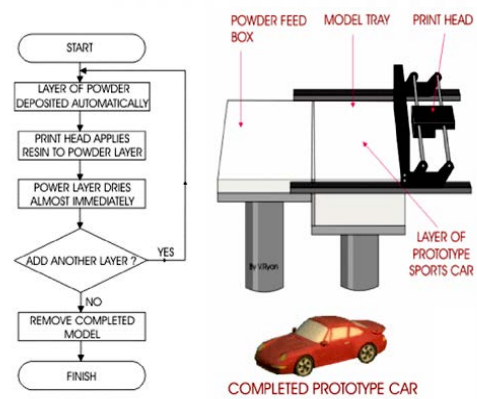
History of 3d Printing

The technology for printing physical 3D objects from digital data was first developed by Charles Hull in 1984. He named the technique as Stereo lithography and obtained a patent for the technique in 1986. While Stereo lithography systems had become popular by the end of 1980s, other similar technologies such as Fused Deposition Modeling (FDM) and Selective Laser Sintering (SLS) were introduced.

Manufacturing Model With The 3D Printer

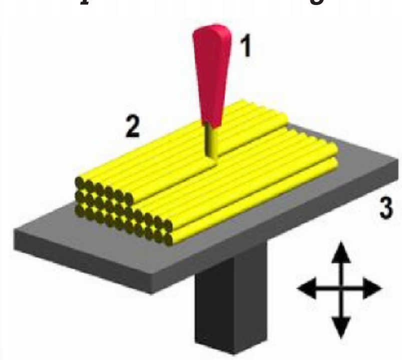


The model to be manufactured is built up a layer at a time. A layer of powder is automatically deposited in the model tray. The print head then applies resin in the shape of the model. The layer dries solid almost immediately. The model tray then moves down the distance of a layer and another layer of power is deposited in position, in the model tray. The print head again applies resin in the shape of the model, binding it to the first layer. This sequence occurs one layer at a time until the model is complete.



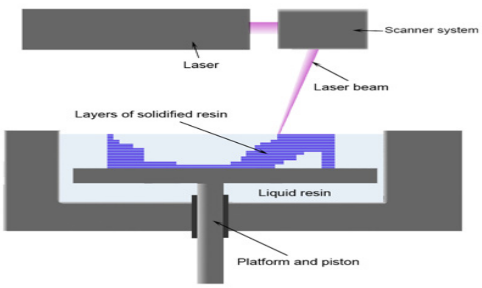
Current 3D Printing Technologies

FDM – Fused Deposition Modeling



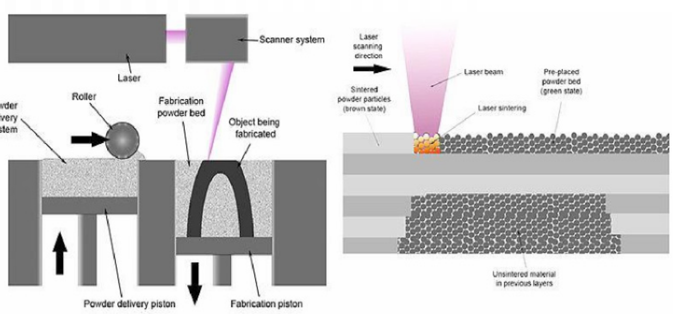
Fused Deposition Modeling, is an manufacturing technology commonly used for modeling, prototyping, and production applications. Here a hot thermoplastic is extruded from a temperature-controlled print head to produce fairly robust objects to a high degree of accuracy.

SLA – Stereolithography



Stereo lithography - Stereo lithographic 3D printers (known as SLAs or **s**tereo lithography **a**pparatus) position a perforated platform just below the surface of a vat of liquid photo curable polymer. A UV laser beam then traces the first slice of an object on the surface of this liquid, causing a very thin layer of photopolymer to harden. The perforated platform is then lowered very slightly and another slice is traced out and hardened by the laser. Another slice is then created, and then another, until a complete object has been printed and can be removed from the vat of photopolymer, drained of excess liquid, and cured.

SLS - Selective laser sintering



Selective laser sintering is an additive manufacturing technique that uses a high power laser (for example, a carbon dioxide laser) to fuse small particles of plastic, metal (direct metal laser sintering), ceramic, or glass powders into a mass that has a desired three-dimensional shape.SLS technology is in wide use around the world due to its ability to easily make very complex geometries directly from digital CAD data. While it began as a way to build prototype parts early in the design cycle, it is increasingly being used in limited-run manufacturing to produce end-use parts. One less expected and rapidly growing application of SLS is its use in art.

Multi-jet modelling (MJM)- This again builds up objects from successive layers of powder, with an inkjet-like print head used to spray on a binder solution that glues only the required granules together.

The ***VFlash printer***, manufactured by Canon, is low-cost 3D printer. It's known to build layers with a light-curable film. Unlike other printers, the VFlash builds its parts from the top down.

Desktop Factory is a startup launched by the Idealab incubator in Pasadena, California.

Fab@home, an experimental project based at Cornell University, uses a syringe to deposit material in a manner similar to FDM. The inexpensive syringe makes it easy to experiment with different materials from glues to cake frosting.

The **Nanofactory 3D printing** technologies are introduced that are related to the nanotechnologies.

Table showing all available types of 3D Printers:

Type	Technologies	Materials
Extrusion	Fused deposition modeling (FDM)	Thermoplastics (e.g. PLA, ABS), eutectic metals, edible materials
Granular	Direct metal laser sintering (DMLS)	Almost any metal alloy
	Electron beam melting (EBM)	Titanium alloys
	Selective heat sintering (SHS)	Thermoplastic powder
	Selective laser sintering (SLS)	Thermoplastics, metal powders, ceramic powders
	Powder bed and inkjet head 3d printing, Plaster-based 3D printing (PP)	Plaster
Laminated	Laminated object manufacturing (LOM)	Paper, metal foil, plastic film
Light polymerized	Stereolithography (SLA)	Photopolymer
	Digital Light Processing (DLP)	liquid resin

Designing for 3D Printing

All the parts created using a 3D printer need to be designed using some kind of CAD software. This type of production depends mostly on the quality of the CAD design and also the precision of the printer.

There are many types of CAD software available, selection of software will depend on the kind of designing requirement. However for beginners, that simply want to learn CAD and create basic shapes and features, any of the free CAD software packages will do.

When designing a part to be 3D printed the following points need to be kept in mind:

- The part needs to be a solid, that is, not just a surface; it needs to have a real volume.
- Creating very small, or delicate features may not be printed properly, this depends greatly on the type of 3D printer that is going to be used.
- Parts with overhanging features will need supports to be printed properly. This should be taken into account since after the model needs to be cleaned by removing the supports. This may not be an issue unless the part is very delicate, since it might break.
- Be sure to calibrate the 3D printer before using it, it is essential to ensure that the part sticks properly to the build plate. If it does not, at some point the part may come loose and ruin the entire print job.
- Some thought should be given to the orientation of the part, since some printers are more precise on the X and Y axes, then the Z axis.

Application of 3D printing

3D Printers are machines that produce physical 3D models from digital data by printing layer by layer. It can make physical models of objects either designed with a CAD program or scanned with a 3D Scanner. It is used in a variety of industries including jewelry, footwear, industrial design, architecture, engineering and construction, automotive, aerospace, dental and medical industries, education, Food industries, process equipments manufacturers and consumer products. In broad sense major applications can classify as below:

- Prototyping
- Specialized parts – aerospace, military, biomedical engineering, dental
- Hobbies and home use
- Future applications– medical (body parts), buildings and cars

Current and future applications of 3D Printing

Food Industry

3D printing is a way to make three dimensional solid objects using a machine and digital file. 3D printing can create edible food to using a piping bag to decorate a cake. 3D food printing takes modifications both in the machinery, such as using a pastestruder instead of a traditional extruder, and in the digital file, as printing with food is different than printing with plastic or metal. 3D printing could one day be used to create on demand customized food for people with special dietary needs, such as pregnant women, athletes or those who are managing health conditions, such as diabetes. It could enable food service providers to more easily substitute vegan or vegetarian options for animal proteins or create novelty items with personalized messages or shapes. It could even be used in specialized environments, such as outer space or schools without full kitchens. The technology also could generate huge cost savings for food companies by eliminating the need for giant manufacturing facilities filled hundreds of workers operating multiple machines that prepare, package and transport food. 3D printer in a GMP compliant building can print food with only four or five workers.

When it comes to 3D food printing, safety is a major concern for companies, consumers, and the FDA. To print foods that are both edible and safe, certain food safe materials have to be used both for the food itself as well as any parts or machinery that touch the food in the printing process. Currently food grade syringes made of food safe plastic and edible rice paper are used for the printer bed. The 3D food printing industry doesn't end at just food. It also includes any other materials that touch food, such as plates, utensils, containers, and teapots. These 3D printed objects must also be made of food safe materials.3 D printing technology will also produce novel 3D printed kitchen appliances which leads to produce food with more novel shape and size. Investing in 3D printing could open new markets and generate huge cost savings for food manufacturers and retailers, but first companies must overcome potential regulatory and legal hurdles, many of which are not yet identified. The growth potential of 3D printing is *"unlimited"* for pioneers in the food industry.

Biomedical Engineering: In recent years scientists and engineers have already been able to use 3D printing technology to create body parts and parts of organs. By creating the cells specifically for a particular patient, one can be certain that the patient's body will not reject the organ. Another application of 3D printing in the biomedical field is that of creating limbs and other body parts out of metal or other materials to replace lost or damaged limbs.

Aerospace and Automobile Manufacturing: High technology companies such as aerospace and automobile manufacturers have been using 3D printing as a prototyping tool. 3D printing has allowed these companies to advance their designs faster than ever before due to the large decrease in the design cycle. From what used to take months between design and the physical prototype, now within hours the design team can have a prototype in their hands for checks and testing.

Construction and Architecture: Architects and city planners have been using 3D printers to create a model of the layout or shape of a building for many years. Now they are looking for ways of employing the 3D printing concept to create entire buildings. The goal is the replace many cranes and even construction workers with these printing systems. Major innovation in this area will have to come from the creation of the novel materials.

Product Prototyping: The creation of a new product is always one of that involves many iterations of the same design. 3D Printing revolutionized the industry by allows designers to create and the next day see and touch their design. No longer did it take several meetings for everyone to agree on one design to create, and then wait months for the actual part to arrive.

Conclusion:

Layer by layer production allows for much greater flexibility and creativity in the design process. 3D Printing significantly speeds up the design and prototyping process. There is no problem with creating one part at a time, and changing the design each time it is produced. Parts can be created within hours. Some 3D printers are now within financial reach of the ordinary consumer or small company. The limitations of 3D printing in general include expensive hardware and expensive materials. This leads to expensive parts, thus making it hard if you were to compete with mass production. It also requires a CAD designer to create what the customer has in mind, and can be expensive if the part is very intricate.3D Printing is not the answer to every type of production method; however its advancement is helping accelerate design and engineering more than ever before. The products like chocolate, pizza, ravioli, nuggets, chips and sugar candies are capable of being printed using 3D printing. NASA is studying the feasibility of making food in space using 3D printing. 3D Printing revolutionized the industry by significantly speeds up the design and prototyping process. 3 D printing is not only a novel approach to food fabrication, but also an economical, eco friendly and powerful technique for mass customization.

The beginning impact of 3D printing have witnessed by many industries. There have been articles saying that 3D printing will bring about the next industrial revolution, by returning a means of production back within reach of the designer or the consumer.

Engineering Interventions for Technological Advancements in Dairy Industry

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Technical Articles

Introduction

India today is already the worlds' largest producer of milk but the country is not a dominant force in the world market of milk and milk products. The growth potential of Indian Dairy Industry is enormous and challenges exist in improving the efficiency level and quality in complete chain of milk processing at every stage. The production of quality milk and milk products begins on the farm and continues through further handling, processing, packaging and distribution. One of the most important tasks amongst the quality control is to control and follow up regularly the fulfilment of quality standards at every stage of process flow in order to guarantee the best possible quality of end products through technological advancements. Engineering interventions have vital role to play in achieving this objective. Following fields have been selected for engineering interventions for technological advancement in dairy industry.

Engineering Interventions put into practice in Dairy Industry

Dairy farming

Good quality raw milk is very essential for production of good quality milk product. Hygienic condition is very important for production of good quality of raw milk which is very difficult with human interference. Robotics in milking is very novel engineering intervention in which complete milking done by machine or robotics arms. Large scale mechanized dairy sheds are designed for clean milk production at large scale. Shed is designed with good ventilation, comfortable flooring, automatic watering system, automated feeding system, mechanized manure scrapping, automated grooming system and automated robotic milking system. A voluntary milking system or milking robot is a system in which a cow is milked completely automatically. The cow is lured with food and then submits to the robot voluntarily. When the cow enters the robot, it is recognized and the entry gate closes behind the cow. Based on the last milking and other information about the animal from the sensor with individual coves, the robot decides if the cow should be milked or not. When this is the case, the cow receives a small amount of feed to keep her calm and quiet during connecting cups and milking. The milking process begins with pre-milking. Pre-milking is the connection of a cup on the teats of the udder, washing and stimulating the teats. This promotes the release of oxytocin hormone which stimulates the release of milk. This pre-milking cup is connected to all four teats by the robot arm using a 3D vision system. When the pre-milking is done, the robot arm connects the four milking cups after which the actual milking process starts. The milk is subsequently checked on several points by the milk analysis technique in the robot. When this is considered right, the milk is pumped to the milk storage tank that is situated in a separate space. The milk is kept cool and pumped to milk tanker and driven to the milk factory. A milking robot is fitted with a cleaning system which cleans teats, important components of the milking system after each milking as well as the entire milking system. This greatly reduces manpower, chance of bacterial contamination, growth, ensuring food safety, increase the milk yield and increase the milking speed.

Milk reception

Milk is received in cans at village co-operative societies (VCS) where it is stored in Bulk Milk Coolers (BMC) and that milk is transferred to milk chilling centres and dairy factories in tankers. Now a days mobile BMCs are provided at VCS which reduces the temperature of raw milk immediate after milking, store the milk at lower temperature and when enough amount of milk collected, it is transferred directly to Dairy. Milk pilferage at collection centre, milk theft during transit, milk adulteration and loss of life are the burning issues faced by dairy industry which estimated annual loss of over 36 million. To overcome these losses, new engineering interventions in selected brands of BMC are automated volume measurements, theft protection, alert for tank tilting, modular attachments to BMC, Automatic startup of generator during failure of grid power, self-powered with in-built battery charging, two way access to data, multiple outputs, continuous monitoring of compressors, daily machine data backup in storage media, etc. Double plate types of evaporators are provided in place of traditional coil type of evaporators. Two small capacity refrigeration plants are practiced instead of single big capacity plant and based on level of milk inside BMC, starting and stopping of second refrigeration plant is done. The Direct Current (DC) motor is provided to rotate the shaft of agitator in BMC which runs continuously. In this manner saving of electricity is done. To avoid the milk theft in milk tankers, security system is provided in many road tankers. The security system is based on temperature, vibratory, light, infra-red and pressure sensors. Addition to these sensors, milk tankers are made GPS enabled to know the location of tanker. The new engineering interventions in BMC are also applied to milk tankers also. Application of these sensors and GPS system, reduces the milk theft and improve the milk quality. Computerized data entry of milk reception, continuous and mechanized can washing system and clarifier are new advancements at milk chilling centres. Glycol chilling is also provided to reduce the temperature of chilled milk near to zero degree centigrade which avoid the raise in temperature of raw milk during transit.

Milk processing

Self-cleaning clarifier, bacto-therm, new generation cream separators, in line standardization, new generation HTST pasteurizers, aseptic homogenizers are mechanized production of traditional Indian dairy products are the main selected technological advances in milk processing area. Impurities and foreign matters are separated from milk in clarifier based on centrifugal force. Self-cleaning clarifiers remove the extra materials deposited at the wall of the clarifier bowl at some intervals automatically by opening and closing of sludge removing ports with the help of hydraulic pressure. Bactofuge is used for separation or removal of bacteria and spores from raw milk which can be used for manufacture of cheese and UHT milk. The overall efficiency of new generation cream separator is increasing by changing of power transmission mechanism from gear and belt type system to direct drive type system. We can get the efficiency of power transmission in gear type less than 80 % while in direct or integrated drive more than 90%. The direct or integrated drive system also reduce the maintenance cost also as compared to traditional system in cream separator. Advancements in HTST pasteurizers are improvement in component design, easily opened and closed hydraulically driven twin screw frames that improve worker safety while easing the burden of field inspecting, automation, instruments and process controls, skid mounted pasteurizer modules, two flow diversion valves (FDV) after holding tube as well as at the end of pasteurizing system and chart recorder. In line standardization is done by connection of different product lines through different valves with the help of automatic opening and closing of different valves in sequence. Aseptic homogenizers and aseptic storage tanks are used in UHT milk processing and storage in which inlet, outlet valves, the pump block, piston seal and cooling system are designed for aseptic processing and storage. All these parts are provided with steam jacket to avoid contamination from external media.

India's annual milk production is 137.7 MMT (2013-14) from which liquid milk, Western dairy products and Traditional Indian Dairy products (TIDPs) share is 46% (~61.64 MMT), 04% (~5.36 MMT) and 50% (~ 67 MMT) respectively. So, 50 % of total milk production is converted to TIDPs. The total value of TIDPs is more than 750 million. The limitations for manufacture of TIDPs are time and labour consuming manufacturing process, large variation in quality, poor keeping quality, small scale production and burnt flavour. To overcome these issues, large scale mechanized production of TIDPs is very useful. Many scientists have developed different types of scraped surface heat exchangers (SSHE) and other engineering interventions for continuous and semi continuous manufacturing of TIDPs from which few designs are very successfully work in different dairies. Mechanized production of *khoa* at Sabar Dairy, Himatnagar, Gujarat, India is done by concentration of standardized pasteurized milk in rising film evaporator and the condensed milk is fed in inclined SSHE having different pressure adjusting valves at different part of jacket. The *khoa* is collected in trays from outlet valve of ISSHE which is immediately cooled in vacuum tray cooler. For mechanized manufacture of gulabjamun, all the required ingredients are mixed properly in planetary mixture, the dough prepared is fed in portioning unit in which mass is pushed through augurs, sensor based cutting is done and that cut portion is transferred to ball forming unit through belt conveyor. After formation of ball, the ball transferred to frying unit where frying is done and followed by sugar syrup soaking and packaging. *Paneer* is manufactured mechanically by transfer of pasteurized milk from HTST pasteurizer to coagulation tank in which proper strength of acid solution is transfer from acid tank. After coagulation of milk, whey is separated out through pump and *chhanna* is transferred to *panner* press. The *paneer* block obtained from *paneer* press is transferred to pneumatic *paneer* dicer where dicing of *paneer* is done.

Cleaning

Cleaning is very important process in dairy industry to maintain hygienic condition of equipment and dairy.

Cleaning in place (CIP) is a common unit operation in any industry. Many engineering interventions are done in many industries in the field of CIP for automatic operation. Application of instruments and process control is very important for automation of any process. Application of pigging system for CIP as well as for recovery of product in pipe line is very new concept in dairy industry. Double ball pig and ice pigging systems are the main in the CIP. In double ball pigging system, there are pre conditions like product should be in liquid state, same internal diameter of entire pipeline, no deformation of pipe or bends, no sharp edge of welding, etc. Pumping of an engineered 2-phase ice-water-slurry through a pipe which is typically 50 – 90% ice fraction and flows like a plug wherever possible. A freezing point depression is used to retard the aging process of the ice slurry and to stop the crystals freezing into a solid plug. Application of ice pigging system for CIP having advantages like it can flow through any type of pipeline with different types of fittings, no chances of blockage, efficient removal of material at slow speed and ease of operation for introduction and removal of pigging ice.

Quality Analysis

Quality assurance is the process of assuring the safe milk and milk products for human consumption. Majority of chemical analysis of food products is done by accurate and precise instruments. Sensory quality of dairy product is one of the most important criteria for the acceptability of the product by the consumers. Sensory evaluation of milk and milkproducts is normally done by expert judges in terms of flavour, body & texture and color & appearance scores. However, it requires technical skill and experience and many times leads to human error. The sensory scores of the same products differs person to person and also mood, location and preference of judges and it is time consuming. The various instruments using different types of sensors and transducers have been developed to evaluate the sensory profile of various food products. The newer developments such as electronic tongue, electronic nose, machine vision and textural profile analyser have been developed for sensory analysis of dairy products. The odour and taste of the product can be sensed by instruments by volatile components and dissolved components present in food. The e tongue and e nose are one type of system which needs training for identification of good or bed quality sample. As per the feedback of the expert judges, the data to be entered in computer system and by sensing the food, the final result of quality of sample is to be given by machine.

Packaging

Antimicrobial packaging is one of the many application of active packaging. Active packaging system possesses attributes beyond basic properties, which are achieved by adding active ingredients in the packaging system and/or using actively functional polymers. Antimicrobial packaging is the packaging system that is able to kill or inhibit spoilage and pathogenic microorganisms that are contaminating milk and milk products. The new antimicrobial function can be achieved by adding antimicrobial agents in the packaging system and/ or by using antimicrobial polymers that satisfies conventional packaging requirements. When the packaging system acquires antimicrobial activity, the packaging system or material limits or prevents microbial growth by extending the lag period and reducing the growth rate or decreasing the live counts of microorganisms. The primary goals of an antimicrobial packaging system are safety assurance, quality maintenance and shelf-life extensionwhich is the reverseorder of theprimary goalof conventional packaging system. Nowadays security is a big issue and antimicrobial packaging could play a food security assurance.

Generally food is preferred for consumption in hot condition. Ready to eat foods is one of the major categories of foods in market today. Requirement of suitable heating gadgets to warm the food in pouch is still a difficult task. There were long lasting problem of convenience, palatability, long shelf life of food. These disadvantages pave way in introducing shelf heating systems for heating foods and beverages. Product with shelf stability of greater than one year is quite convenient and handy for use. The only viable form of heat engine for self-heating is an exothermic chemical reaction. A number of options are available with varying degrees of heat output, but the most reactive are also the most dangerous, using potentially toxic chemicals and produce undesirable gaseous by-products. The exothermic chemical reaction of choice for consumer packaging is lime reacted with water because it generates substantial heat output, lime is cheap and readily available, and the by-products of the reaction are environmentally acceptable. An alternative reaction is the hydrolysis of calcium chloride, which has the advantage of producing no reaction by-products, but generates a lower heat output.

Storage and Distribution

Storage and distribution plays very important role in final quality of product. In the era of social networking and online shopping, automatic milk vending machine (AVM) is very good concept for selling of loose milk as well as packed milk. AVM is being used for selling pasteurized & homogenized loose milk in the market. It ensures the accurate as well as hygienic vending of the milk and designed to vend only single type of milk. Milk is stored at ideal temperature for fresh milk preservation and guarantee certified safe milk quality. The entire equipment is made up of stainless steel. The advantages of AVM are to dispense pasteurized & homogenized loose milk directly to the end user, to save cost of packaging material, avoid the leakage from milk sachets, small, compact, can be installed using very less space and any time milk is available.

Conclusion

Engineering intervention is very significant tool for technological advancement in any segment of dairy industry. It is very important to increase production capacity, to reduce manpower, to improve the product quality and many more. We have discussed many engineering applications in different field of dairy industry, but there is no end of it. It is continuous process and based on requirements in various field changes take place through research and development.

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Automation in Packaging Machineries

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Introduction

Food industries are in a state of change driven by cost of operations. Increasing safety and liability issues are a major concern for food companies and they are affecting their investment decisions. The need for more automated system for processing as well as packaging. Automation is the use of control systems, such as computers or robots, and information technologies for handling different processes and machineries in an industry to replace or minimum involvement of human being. Food processors use a variety of machines for different production lines and for various food types. Several machine types are integrated into a single packaging line. Some of the machine types are cartooning, wrapping, labelling, shrinking, sealing, case and tray forming, caping, cooling and drying, feeding, palletizing, picking and placing (robotic systems), cleaning and sterilizing, in addition to inspection and detecting machines. According to the Organization for Machine Automation and Control (OMAC), the number of packaging machine types employed in a packaging line ranges from two to ten.

Packaging Machineries and Automation Systems

The food industries are in a state of change driven by cost of operations. This change is driving the need for automation solutions and IT equipment that can enable the industry to become leaner and more agile. Increasing safety and liability issues are a major concern for food companies and they are affecting their investment decisions. The need for more automated traceability has become a basic requirement. Although PLC (Programmable Logic Controller) – based architecture has been commonly used in the food industry, they were not designed for making secure electronic records, nor were they designed with version control and software security in mind. It is becoming increasingly difficult to make PLCs compliant with regulations. The FDA and USDA (U.S. Department of Agriculture) will be looking for evidence of control system validation for regulated food processes. There are about 28,000 establishments manufacturing food in the US. Processed food sales worldwide are in the order of trillions of dollars and over tens of millions of people work in the industry. Implementation of advanced automation and control strategy in the food packaging domain plays a vital role. Compared to traditional methods, advanced control methods have several advantages. The traditional methods use discrete electronics, PLCs, Industrial Computers and even high-computing systems such as the DSP (Digital Signal Processor) platform. These automation platforms have issues such as reliability, flexibility, scalability. For example, PC- or PLC-based systems are considered to be redundant because they require maintenance and additional expertise. They have restricted interoperability due to incompatibility in host-platform requirements. Similarly, DSP systems require customization and expertise in addition to being very costly. Conversely, the modern food industry entails sophisticated control architecture. The food processing and packaging control system embeds a generic set of essential requirements with regard to timing, error diagnostics, coordination, periphery-control acknowledgement, and synchronization. Moreover, its imperative error recovery and fault corrections are needed during run time. Furthermore, the control systems should satisfy other fault-tolerant features such as interlock checking, lockout checking, and user- friendly, intuitive status display with error messaging. Applying modern control network technology to the food industry can markedly improve food productivity, manufacturing, preservation, and handling. Currently, however, the industry's automation systems are predominantly centralized. Though there is some modular approach, the overall system is implemented with static functionality. The conventional PC-, PLC-, or DSP-based centralized automation strategy characterizes a central processing unit with peripheral devices such as sensors, actuators, and drives. One of the important requirements is the integration of drive systems, I/O interfacings, instrumentation hardware, supports for diagnostics and prognostics, data collection and operator interfaces. The architecture needed to be Automation: According to ARC Advisory Group the food industries are in a state of change driven by cost of operations. This change is driving the need for automation solutions and IT equipment that can enable the industry to become leaner and more agile. Increasing safety and liability issues are a major concern for food companies and they are affecting their investment decisions. The need for more automated traceability has become a basic requirement. Although PLC (Programmable Logic Controller) - based architecture has been commonly used in the food industry, they were not designed for making secure electronic records, nor were they designed with version control and software security in mind. It is becoming increasingly difficult to make PLCs compliant with Food and Drug Administration (FDA) regulations. The FDA and USDA (U.S. Department of Agriculture) will be looking for evidence of control system validation for regulated food processes. Compared to traditional methods, advanced control methods have several advantages. The traditional methods use discrete electronics, PLCs, Industrial Computers and even high-computing systems such as the DSP (Digital Signal Processor) platform. These automation platforms have issues such as reliability, flexibility, scalability. For example, PC- or PLC-based systems are considered to be redundant because they require maintenance and additional expertise. They have restricted interoperability due to incompatibility in host-platform requirements. Similarly, DSP systems require customization and expertise in addition to being very costly.

Application of Robots:

Applications of robots are found in welding and assembly lines. Food processing is still a minor application area for robots. Higher cost and lower productivity are leading towards increased application of robots in the food sector. Robotic system can pack meat and chocolates into the trays faster. FANUC robotics, Inc. has developed several models of pick-and-place articulated robot for the food industry that meet stringent hygiene requirements. The exterior design is smooth with no dark/damp regions for contaminants or microorganisms. The robot comprises of several arms called kinematic chains linking their base to mobile parts. Some robotic system can handle 300 parts a minute and attain accelerations of 200 m per square second with loads of two kilograms. Many food processing plants are constantly automating their final product with the palletizing robot due to the demand for increased productivity. The sophisticated control system with a built-in palletizing function makes it possible to load and unload the objects with high precision and accuracy. Robotic palletizers can handle up to four production lines and multiple product types simultaneously. Their compact design makes them ideal for small space. Depalletizers provide an efficient means to sort containers from bulk layered pallets onto a conveyor or conveying system. Some palletizers are equipped with up to more than 4000 slots. The system also palletizes 1000 cases with a load of 20 lbs.; working hours up to 10 h per day for 5–6 days is common. The machine can provide quality, reliable and high performance palletizer solutions to diversified industries. KUKA Robotics is one of the world's leading manufacturers of industrial robots, with an annual production volume approaching 10,000 units, and an installed base of over 75,000 units. The company's five and six-axis robots range from 3 kg to 570 kg payloads, and 635 mm to 3700 mm reach.

Factors Influencing Increased Robotic Usage:

Robots can also handle multiple products in a compact space, driving increased usage of robotic case packers and palletizers, for example. These machines range in complexity, handling up to 50 product variations simultaneously. Order picking and assembly of mixed pallets is also generating significant interest. New ROBOGUIDE-PalletPRO and PalletTool software from FANUC Robotics America (Rochester Hills, MI) can automate the building of mixed pallets. Generally, this requires a robot mounted on a linear slide so it can cover the distance across multiple packaging lines. Automating mixed pallet building may also require integration with vision and tactile sensors and sophisticated communication technology.

Speed and software

Higher speeds and modular software are also influencing the growing interest in robots. Faster speeds are possible through mechanical design improvements and robot controllers with better motion architecture. FANUC, for example, has more than doubled the wrist rotation speed of its M420iA robot from 350 degrees per second to 720 degrees per second and the M-6iB/2HS from 1200 degrees per second to 2000 degrees per second. Adding vision systems supports higher rates by making it possible for the robot to pick up multiple items at a time. On the software side, ELAU Inc. (Schaumburg, IL) has developed a software object library for robots. The array of IEC 61131-3-conforming Function Blocks contain all the complex kinematics algorithms needed for Cartesian, articulated, SCARA, portal and gantry robots to perform the most popular packaging functions including pick-and-place, carton and case packing and end-of-line tasks. The blocks of code eliminate black box proprietary robot controllers and simplify integration of robotic action into packaging machines. Since over 80% of the Function Blocks programming is predone, this technology is estimated to save over 50% of engineering time compared to traditional programming. More robust software can also enhance machine safety and productivity. Omron Electronics' (Schaumburg, IL) Secure-One DeviceNet Safety Controller, for example, uses standard DeviceNet network wiring and preprogrammed safety Function Blocks to eliminate separate cabling and communication. Monitoring safety through DeviceNet makes it possible to identify faults in an instant and simplifies installation and modification.

Safety, traceability and supply chain

The most important requirement in food production and packaging is food safety. According to the USDA, more than 75 million people per year become ill from food poisoning. In the US, per year, 325,000 people are hospitalized, and 5000 of them die from pathogens like salmonella and E. coli that can be found in raw meat products. The FDA has widened food safety regulations to encompass vegetables, including tomato and jalapeno, as these industries have suffered big losses due to pathogens. Food safety research activities entail combined knowledge and understanding from science and engineering, as well as technology fields. The importance of this collaborative effort is to use the expertise in these mutually inclusive sub-fields so as to help understand and eventually find the best feasible solution to real-world problems. Currently, the bar coding and RFID (Radio Frequency Identification) methods are very popular for exchanging information sophisticatedly. RFID technology provides many advantages for temperature and humidity monitoring and tracking. Compared to conventional circuitry, RFID confirms a reduced amount of required instrumentation and interfacings. The most important feature with RFID is that it does not demand manual scanning without ever requiring line of sight between the tags and the reader, thereby saving considerable time and man hours, as well as decreasing the number of errors. Research interests in these areas are biosensors design intended for the detection of pathogens in food and cells. Broadly, the interests are feasibility study and characterization of various spectroscopy and imaging approaches in order to enhance the sensitivity of the detection of target pathogens, and design of devices by the use of appropriate technology and methods. Considering the speed of detection, sensitivity, precision, accuracy, size and cost, the research should focus on analysis, design and development of biosensors as well, as other interfacing devices such as micro fluidic devices and systems.

PC-Based Control for the Packaging Machinaries

With its PC- and EtherCAT-based technology, it is possible to have highly efficient, flexible and compact packaging machines. Because of its openness and its universal design, PC-based control delivers technological and economical benefits. TwinCAT is the standardized software and engineering platform for all automation processes from PLC, motion control and robotics to condition monitoring.

Highly flexible, resource-efficient packaging machines:

PC-based control technology integrates all automation functions, including measurement technology and simulation. PC-based control is the ideal solution for applications involving high speed and precision or complex motion control interactions. It also delivers maximum flexibility for applications where packaging systems must be quickly adaptable to changing requirements or be able to easily accommodate new features.

Benefits along the entire line:

With PC and EtherCAT-based control technology. It is possible to automate individual packaging machines as well as entire lines. All steps such as forming, filling, sealing, labelling, collecting, boxing and palletising can be programmed and controlled via a single platform. Optimally coordinated hardware and software interfaces as well as extensive expertise in implementing each process step guarantee a high level of process stability.

Resource-efficient packaging: Maximum process speed and precision

Implementing PC Control ensures that the consumption of resources is reduced to the absolute minimum. XFC ("eXtreme Fast Control") technology. With I/O response times of less than 100 µs, the system scans the machine's status up to 10,000 times per second so that the process can be controlled with exceptional precision and repeat accuracy.

Minimum material usage:

The technology"s quick and precise response to fiducials makes it possible to save on packaging material. For example by placing products more closely together in blister packs, this reduces the amount of sealing foil needed as well as any waste. The ability to precisely control the sealing temperature allows using thinner plastic films.

Minimum material usage:

The fast and highly accurate process control capabilities also minimize the wall thickness of PET bottles as well as reduce the amount of paper and aluminium when producing cardboard containers. The more accurate approximation of the minimum fill level generates significant material and cost savings when packaging high-volume products.

Flexible packaging: Fast and efficient product and format changeovers

The PC-based control platform executes machine setup changeovers due to product or package changes essentially in software by adapting the process parameters. This speeds up the process considerably, resulting in faster product changes and more line efficiency for the operator. Easy format changeovers ensure more productivity even with many short runs.

Available in stainless steel for the food industry:

For packaging applications in the food, beverage and pharmaceutical industries, it offers a complete control solution in stainless steel with "hygienic design" that meets the strictest sanitation and cleanroom requirements.

eXtended Transport System (XTS):

XTS combines the benefits of linear and rotary transport systems. Straight sections and the curves are used for the material transport, there are no empty trips, making for a faster overall process. Automation software makes the engineering process easy with its integrated standard features such as automatic accumulation, collision prevention and shock prevention.

E-maintenance:

The food industry faces diverse challenges such as government regulations, harsh working conditions and complex equipment requiring constant maintenance to preserve safety and standards. The need for continuous cleaning mostly creates a wet environment which in turn causes havoc on processing machineries and equipment. Food safety regulations can affect a company in many different ways. The Hazardous Analysis and Critical Control Point (HACCP) regulation is an FDA quality-related guideline. E-maintenance has becoming a trend in food industries. E-maintenance integrates software backbone, information and communication technology for remote monitoring and control. Advanced technology systems such as sensor network, RFID, apps, and open-system standards are used to replace human-centered maintenance.

Other Machinery Technology Trends

Laser cutting: It is easier to change packaging formats if cutting system can handle anything. Flexibility can do almost any shape in many materials/ substrates. Cost main barrier to wider adoption & extraction (intricate shape personalisation possible) for Thermoform (HFFS) & some other Pouch / Bagging (VFFS) applications. New exciting possibilities with texture & hope on labels & paper / card sleeves etc.

Resource efficient: Today's packaging machines of a given production output use significantly less electricity, compressed air & water than yesterday's models. Increasing adoption of **servo motors** in place of pneumatics on a wide range of packaging equipment has significantly increased accuracy & reduced energy consumption & can report exactly where & what they are doing with what frequency & force

Management & Production Data Capture: Widely available (for a number of years) but not as widely used in many sectors. Already offer the potential for sharing production line data from each line component with a central office or site. Key to truly understanding Line Efficiency & Productivity & variations across lines & sites

Remote diagnostics of packaging machines & production lines by OEM or central engineering team easier than ever where machine is accessible via intranet / extranet

Future Aspects

Automation & Robotics: It has big growth in food. Already extensive at end of production lines. Expect greater use of flexible affordable pick & place robots & other systems for auto-loading of products into packaging & packaging machines.

Food Information Regulation (FIR): Labelling / pre-printed packaging - current trends & now EU legislation require much greater front of pack information. Printed or on labels. This will potentially drive packaging formats. Pre-printed films/materials or larger labels / sleeves / bands etc.

Flexible stand up (Doy) pouches will continue to grow in applications. Last 5+ years grow massive growth in pet food, detergents, cleaning products, then into drinks (even wine), soups, sauces, microwaveable rice, coffee refills & other products.

Flexible packaging machinery that is even quicker & easier to change pack formats. Already these can be pre-programmed on flow-wrappers & baggers for fast changeovers. Traysealer toolings are increasingly quick to change & thermoformers can have multiple toolings or drawer change systems for quickly changing die sets & pre-programmed products.

3D Printers: For Food Not strictly packaging but it is another way to get food into consumers' homes. Sounds science fiction but it has already been done with sweets, chocolate, pasta & other foodstuffs. Supporters claim they could be as ubiquitous as microwaves in a generation. Food "inks" or components of course will still need to be produced & packaged.

Improvements in paper / card laminate allowing cardboard containers boxes / cartons with full colour print on 4 sides to replace traditional plastic trays for high barrier MAP applications.

Downgauging / lightweighting will continue in Glass, Metal, Plastics & Paper/Card Laminates bringing with it design & production challenges.

Multi-faceted inspection systems. Multiple QA systems on production lines. Production lines may increasingly routinely incorporate: vision, x- ray, check weighing as well as seal testers.

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High-Pressure Processing of Milk and Milk products Products

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Introduction:

High pressure processing (HPP), Pascalization, bridgmanization, or high hydrostatic pressure (HHP) processingis a method of preserving and sterilizing food, in which a product is processed under very high pressure, leading to the inactivation of certain microorganisms and enzymes in the food.High pressure processing can be novel and non-thermal alternative to milk and milk products processing. High pressure processing of foods offer a commercially viable and practical alternative to heat processing by allowing food processors to pasteurize foods at or near room temperature. HP treated food can be preserved in a safe state and still will have most of the attributes of a fresh product. In addition, high pressure can cause rheological changes in food that may result in beneficial sensory and structural effects.Research into the application of HPP for milk preservation demonstrated that the shelf life of milk could be extended by pressure treatment.It has been established that the effects of HPP on the constituents of food can be helpful in formulation of novel and value added dairy products. Apart from increasing the shelf-life of the dairy products, this novel technology also imparts variedphysio-chemical, sensory and functional properties resulting in the improvement in quality of products which in turn offers exciting opportunities for the dairy industry.The application of high pressure processing to food enables microorganisms to be destroyed without causing significant changes to the colour, flavour and nutritional attributes of the food. Pressure in combination with moderate temperature (PATP) also seems to be a promising approach for producing shelf-stable foods.

Equipment and process description

The main components of a high pressure system are:

- a pressure vessel and its closure
- a pressure generation system
- a temperature control device
- a material handling system

The construction of high pressure machinery is a specialised and expensive operation. A report published in 1996 states that *"...a high pressure fruit juice plant was twenty times the cost of an equivalent capacity plate heat exchanger system."* (Manvell, 1996). However, companies that manufacture equipment to press metal and ceramic engineering components and quartz crystals for the electronics industry, have the necessary expertise. Their methods are being adapted in the food industry where batch presses are available having vessels of up to 9400 L capacity which can operate at pressures of 200–500 MPa with operating cycles of as little as of two to three minutes. Palou *et al.,* (1999) reported of a batch press having a throughput of 600 L/hr, operating at 420 MPa, being used for the commercial production of pineapple juice in Japan.

Most pressure vessels are made from a high tensile steel alloy 'monoblocks' (forged from a single piece of material), which can withstand pressures of 400–600 MPa. For higher pressures, pre-stressed multi-layer or wire-wound vessels are used (Mertens, 1995). Vessels are sealed by a threaded steel closure, a closure having an interrupted thread, which can be removed more quickly, or by a sealed frame that is positioned over the vessel. In operation, after all air has been removed, a pressure transmitting medium (either water or oil) is pumped from a reservoir into the pressure vessel using a pressure intensifier until the desired pressure is reached. This is termed 'indirect compression' and requires static pressure seals. Another method, termed 'direct compression' uses a piston to compress the vessel, but this requires dynamic pressure seals between the piston and internal vessel surface, which are subject to wear and are not generally used in commercial applications.

Typically, high-pressure processing(HPP) of food is performed at 300–600 MPa at the room temperaturefor 2–30 min. During HPP,the pressure is instantaneouslyand uniformlytransmitted in all directions, regardless of theshape or volume(based on Pascal's principle)ofthe food in question.The low temperature at which high-pressure treatments are usually performed ensures little or no heat induced changes in its components.

During pressurization, an increase in temperature (3–9°C per 100 MPa, depending on the pressure-transmitting fluid) occurs due to adiabatic heating (Balasubramaniam*et al.,* 2004) and a corresponding decrease occurs during depressurization. Temperature control in commercial operations can be achieved by pumping a heating/ cooling medium through a jacket that surrounds the pressure vessel. This is satisfactory in most applications as a constant temperature is required, but if it is necessary to regularly change the temperature, the large thermal inertia of the vessel and relatively small heat transfer area make this type of temperature control very slow to respond to changes. In such situations, an internal heat exchanger is fitted. There are two methods of processing foods in high pressure vessels: in-container processing and bulk processing. Because foods reduce in volume at the very high pressures used in processing (for example, water reduces in volume by approximately 15% at 600 MPa), there is considerable stress and distortion to the package and the seal when in-container processing is used. It is likely that conventional plastic and foil pouches are suitable but research is continuing on the optimum design of the package, seal integrity and other suitable packaging materials. Material handling for in-container processing is achieved using automatic equipment, similar to that used to load/unload batch retorts. Bulk handling is simpler, requiring only pumps, pipes and valves.

However, recent developments in the use of Pressure Assisted Thermal Processing (PATP) and Pressure Assisted Thermal Sterilization (PATS) utilize both heat and pressure and hence cause some heat-induced changes.

The large bio-molecules suchas proteins, nucleic acids and polysaccharides that depend on non-covalent bonding (i.e. hydrophobic interactions, hydrogen bonds etc.) to maintain structure and function are most affected due to this. On the other hand,smaller organic molecules such as those responsible for colours, flavours, and nutrients (e.g., vitamins)in which covalent bonding is the dominant oronly type of bonding are hardly affected.

Destruction of microorganisms

A major function of high-pressure processing of food is destruction of microorganisms. When a microbial cell is subjected to high pressure, the following detrimental changes take place:

- Cell membranes are destroyed via irreversible changes into structures of the membrane macromolecules, particularly proteins
- The homogeneity of the intermediate layer between the cell wall and the cytoplasmic membrane is disrupted
- Membrane ATPase is inactivated
- The nucleic acids and ribosome involved in synthesis of proteins are disrupted.

The result is permeabilization of the membranes and concomitant leakage of the contents of the cells and organelles, leading to eventual death of the bacterial cell. In general, Gram-negative bacteria are inactivated at a lower pressure than Gram-positive bacteria, and rod shaped bacteria are more sensitive to pressure than cocci.

HPP at around ambient temperature is limited in its ability to destroy bacterial endospores. Spores are more resistant than vegetative cells because it contains calcium rich dipicolinic acid which protects them from excessive ionization (Timson and Short, 1965; Smelt, 1998).

Applications in milk processing

Research into the application of HPP for milk preservation began when Hite (1899) demonstrated that pressure treatment can extendthe shelf life of milk. Heinvestigated such treatment asan alternativemethodfor milkpasteurization.He observed 5–6 log cycle reduction in the number of microorganisms when milk was treated at 680 MPa for 10 min at room temperature. Only a small proportion of the bacterial population (mostly sporeformers) could not be inactivated under high-pressure operating conditions.A number of researchers have studied inactivation of microorganisms (such as*Listeriamonocytogenes ,Staphylococcus aureus,* or *Listeria innocua*) either naturally present or introduced in milk (Erkman and Karatas 1997; Gervila*et al,.* 1997) and this offers a promising alternative for the cold pasteurization of milk (Vachon*et al.,*2002). Milk subjected to a microbial 4D high pressure process at 350 MPa had a shelf life of 25 days at 0 °C, 18 days at 5 °C, and 12 days at 10 °C (Mussa and Ramaswamy 1997) . High Pressure technology (HPT) (400 MPa for 15 min or 500 MPa for 3 min) of thermally pasteurized milk increased shelf life by 10 days (Rademacher and Kessler 1997) .Milk treated at 400 MPa results in no significant loss of vitamins like B1 and B6 (Sierra *et al.,*2000). Raw milk pressurized at 400 MPa for 30 min at 25°C contained <7 log psychrotrophs/ml after storage for 45 days at 7°C, whereas unpressurized milk contained > 7 log of these bacteria after only 15 days (Garcia- Risco*et al.*1998).Further, the combination of high pressure with a bacteriocin (lacticin) was shown as a promising and natural method for increasing the efficiency and safety of HPP of milk. It resulted in a synergistic effect in controlling microbial flora of milk without significantly influencing its cheese-making properties (Morgan *et al.*, 2000). Other antimicrobial peptides such as lactoferrin and lactoferricin(500 µg/ml) in combination with high pressure (155–400 MPa) also resulted in enhanced microbial inactivation (Masschalck*et al.,*2001). The gram-negative bacteria, in this case, were found to be more sensitive to high pressure, either alone or in combination with nisin, than gram-positive bacteria (Black *et al.,* 2005).It is known that fat increases the thermal-resistance of microorganisms, but in case of high pressure treatment, fat content in milk (0–5 %) had no significant effect on the destruction (Ramaswamy*et al.,* 2009). Although Casein and lactose present in milk provided the major baro-protection effect to*Escherichia coli*in milk during HP treatment.It was also investigated that combination of high pressure withtemperature for the processing of milk promoted the formation of few compounds leading to generation of 'cooked' milk flavour and sensory acceptance of treated milk was not very high (Vazquez *et al.,* 2006, 2007).

Effect of HPP on milk components

Water:

Water content of the food gets compressed by about 4 per cent at 100 MPa and 15 per cent at 600 MPa. Depression in freezing point of water wasobserved at high pressure to -4°C, -8°C, -22°C at 50, 100 and 210 MPa, respectively (Kalicheveskyet *al.,*1995). Thus, this technique enables sub-zero temperature food processingwithout ice crystal formation. It also facilitates rapid thawingof conventional frozen food.

Proteins:

Changes occur in thecasein micelles when pressure is applied at around ambient temperature. Little or no change occurs at 100–200 MPa;at 250MPa the casein micelle size is increased and at >300MPa the casein micelles gradually disintegrates. At 500 MPa theparticles remainingare about 50 per cent of thesize of the original micelle. Thus, skim milk that has been pressure treated at 500 MPa has a clear,almost transparent appearance and a turbidity of about one-thirdof that of untreatedskim milk.At the same time, the viscosity is increased by about 20 per cent. Individual caseins are dissociated fromthe micelle;the order of dissociation beingβ-casein>κ-casein > αs1-casein > αs2-casein (Needs *et al.,*2000).

High pressure up to 300 MPa did not result in significant decrease in β-lactoglobulin in whey, whereas further increase in pressure resulted in decreased β-lactoglobulin (Pandey and Ramaswamy*et al.,*1998; Brooker*et al.,* 1998). Denaturation of β-lactoglobulin took place at pressures as low as 200 MPa. Also, α-lactalbumin was denatured only at pressures 400 MPa, and no effect on milk solids concentration was observed (Anema 2008). A pressure treatment of 500 MPa at 25°C denatures lactoglobulin, whereas denaturation of immunoglobulins and lactalbumins occurs only at the highest pressures, particularly at temperatures above 50 °C (Felipe *et al.*, 1997).HPP of whey protein concentrate increased the number of binding sites which led to certain modifications in proteins, enhanced hydrophobicity, and showed promising results for improving functional properties of foods (Liu *et al.,* 2005).

Enzymes:

Milk enzymes vary in their sensitivity to high pressure. Lipase, xanthine oxidase and lactoperoxidase are resistant to pressures up to 400 MPa. Phosphohexoseisomerase, γ-glutamyltransferase and alkaline phosphatase in milk are partially inactivated at pressures exceeding 350, 400 and 600 MPa respectively and are completely inactivated at pressures of 550, 630 and 800 MPa respectively. The effect on alkaline phosphatase is of interest in milk processing. Since complete inactivation of alkaline phosphatase occurs only at very high pressures, this specific enzyme is not an appropriate indicator of effective 'pasteurization' by high-pressure treatment.

HPT influenced proteolysis in milk. During the storage of treated milk, treatment at 50 MPa had little effect on proteolysis, but at 300–400 MPa proteolysis was increased, possibly due to changes in micelle structure facilitating increased availability of substrate bonds to plasmin; whereas after 500 MPa, the proteolysis during storage of milk was less than that observed in raw milk.

The combined effects of high pressure (300–600 MPa, 40–60°C) and homogenization resulted in inactivation of protease activity in milk, which extended its shelf life (Sainz*et al.,* 2009).

Fat:

Crystallization of fat can be accelerated, enforced, or initiated because of the shift in the phase transition temperature caused by application of high pressure. As a consequence, high-pressure treatment reduced the ageing time of ice cream mixes and aided the physical ripening of cream for butter making. The fat globule size distribution and flow behaviour of pasteurized liquid cream are not significantly modified by HPP at 450 MPa and 25°C for 15–30 min or 10°C for 30 min. Mean diameter of the milk fat globule remains unaffected after high pressure treatment. Following, high pressure treatment, there is some incorporation of whey proteins into milk fat globule membrane (MFGM) but there is no increase in lipolysis (Buchheim and Frede, 1996).

Milk sugar:

Pressurization of milk(200-400 MPa for 10-60 min at 25°C) lead to no changes in the lactose, suggesting no Maillard reaction and isomerization occurs due to pressure treatment (LòpezFandiñ̃o *et. al.,*1996).

Mineral:

Mineral balance of milk gets affected at high pressure and effect is on both the distribution between colloidal and diffusible phase as well as on the ionization. The increase in the content of diffusible calcium has been reported by following HPP. In case of previously heated milk, HPP treatment solubilizes both native and heat precipitated colloidal calcium phosphate (CCP) which leads to slight increase in pH (Johnston *et al.,*1992). In general pH of milk increases following high pressure treatment and this change in pH is reversible.

Applications of HPP in dairy products processing

High pressure processing of milk has shown to have a significant effect on the milk constituents. That could influence the characteristics of the products like cheese, yoghurt, ice-cream etc.

Cheese:

HPP resulted in casein micelle disruption, whey protein denaturation, increase in milk pH and cheese yield, and reduction in rennet coagulation time, which indicates its significant potential in the cheese-making process (O'Reilly *et al.*, 2001; San- Martin *et al.,* 2006).

As the heat treatment of milk, in spite of killing harmful pathogens makes the same unsuitable for cheese making leading to increased RCT(rennet coagulation time) and delayed maturing. So, HPP can be good alternative for cheese milk heat treatment. HPP also leads to denaturation of whey proteins and their interaction with casein, which in turn increases the retention of whey proteins in casein matrix. This also improves cheese yield and RCT (Gonzalez *et al.*, 2001). HPP treated milk cheeses have higher moisture, salt and total free amino acids content than raw or pasteurized milk cheeses. High moisture led to pasty and weak texture defects. Such an effect was attributed to the increased water-holding capacity of the milk proteins (Drake *et al.,* 1997). High-pressure treatment of cheese curd rather than cheese milk had beneficial effects. Rennet coagulation time was not dependant on the pressure in the lower range (less than 150 MPa), whereas at higher pressures (200–400 MPa) it decreased (Needs *et al.,* 2000).HP treatment (400 MPa) of pasteurized milk resulted in decreased rennet coagulation time. At 600 MPa, the rennet coagulation time was found to decrease along with decrease in pH, initial counts of nonstarter lactic acid bacteria, protein and fat content. The treatment increased incorporation of β-lactoglobulin leading to increased yield (Voigt *et al.* 2010) .

Using HPP, cheese ripening process can be greatly accelerated.HP induces changes in biochemical processes such as glycolysis, lipolysis, and proteolysis during ripening of cheese leading to reduction in ripening time and quality improvement. The rate of ripening of commercial cheddar cheese due to HPP accelerated the degradation of α_{S1} -casein and accumulation of α_{S1} -1-casein (O'Reilly *et al.,* 2001). HP-treated (500 MPa) goats' milk had higher pH and salt content, matured more quickly, and developed strong flavours (Trujillo *et al.,* 1999).

Ice-cream:

HPP induces fat crystallization, shortens the ageing time required to achieve a desirable solid fat content& thereby reduces the ageing time of ice-cream. HP treatment (300 MPa, 15 min) enhanced the foaming properties of whey protein concentrate, which was added to low-fat ice cream to improve body and texture. Due to the impact of HP on the functional properties of whey proteins, the ice cream mix containing the whey protein exhibited an increased overrun and foam stability and hardness than ice cream produced with untreated whey protein (Lim *et al.,* 2008).

Yoghurt:

High pressure treatment at 200 - 300MPa for 10 min at 10 - 20°C can be used to control 'post- acidification' of yogurt without decreasing the number of viable lactic acid bacteria (LAB) or modifying the yogurt texture. Treatment at higher pressures destroyed LAB. Above 400 MPa for 15 min, *Lactobacillus delbrueckii* subsp. *bulgaricus* was inactivated, whereas *Streptococcus thermophilus* was more resistant but it lost its acidifying capacity. An extended shelf- life 'Probiotic yogurt' has been developed using pressure treatment of 350–650 MPa at 10–15°C.HPP (550 MPa) of yogurt maintained desirable sensory characteristics longer than controls during storage for 4 weeks at refrigerated (4°C) or room (20°C) temperature(Jankowska*et al.*, 2005).

Cream, butter:

Whipping properties improved when cream was treated at pressure of 600 MPa for up to 2 min (Eberhard*et al.*, 1999) probably due to better crystallization of milk fat.

In case of pasteurized cream, pressurization at 450 MPa at 10 or 25°C did not modify its fat globules size distribution or its flow behaviour or the pH(Dumay*et al.,* 1996). HPP has a potential application in the physical ripening of dairy cream for butter making.

Other dairy products:

HP treatment (up to 500 MPa) reduced the turbidity of reconstituted skim milk for all combinations of pH (5.5–7.5) and temperature (5–40 °C) due to micelle dissociation (Orlien*et al.,* 2010).Sahu (2010) optimized the levels of HP (200–400 MPa), pressurization time (0–100 min), and coagulation temperature (30–70 °C) for the preparation of chhana (Indian cottage cheese).There is a great scope for utilizing HPP for the development of probiotic dairy foods with higher viable count.

Conclusion

The main effects of high pressure treatment in milk appeared to involve dissociation of caseins micelles from the colloidal to the soluble phase, resulting in reduced turbidity of milk, decreased RCT, increased pH and reduction in whiteness. Flavour and aroma components contributing to the sensory quality, and nutritional quality remained unaffected by pressure treatment. The effect of HPP on lactose has not been studied so far. This 'novel' and non-thermal technology has the potential for use in the development of a whole new generation ofvalue-added foods with enhanced functionality. The varied physio-chemical and sensory properties obtained when harnessing such novel technology offer exciting opportunities for the dairy industry. New opportunities in preservation of colostrum and human milk by HPP treatment may be of interest to the entrepreneurs.

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Carbon Trading System - A New Strategic Approach

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Introduction

Surface temperatures over the last century increased gradually around the world. During twentieth century, the average global surface temperature had increased by 0.4-0.8°C [50]. Current climate models predict a rise in global temperatures of 1.4-5.8°C between 1990 and 2100, which would be higher than any century time scale trend for the past 10,000 years. The mean sea level has already rise by 10cm to 20 cm and it is predicted to rise 9 cm to 88 cm by the year 2100 [2, 44]. The route cause to all these atmospheric contingencies is the GHG. As defined by United Nations Framework Convention on Climate Change (UNFCCC), the gaseous constituents of the atmosphere, both natural and anthropogenic which absorb and re-emit infrared radiation are called GHG. Everything that runs in our office, home and industry creates carbon footprints. These carbon footprints in fact are responsible for production of GHG that lead to global warming which is proving a big threat to the world [16]. In compensation for the emissions done through various activities, an approach termed as carbon trading is developed to subside the effectof the emissions. Carbon trading is a systematic approach to reduce the GHG emission by incorporating a newerconcept of carbon trade through carbon credits and carbon footprints. It is dealt under the system described in Kyoto protocol, in which some listed countries in annexure of the protocol are supported by non-annexure countries by generating carbon credits and exchanging them in the form of carbon currency [6]. India signed and approved the Protocol in the year 2002, getting exempted from the framework of the treaty and it is expected to gain from the protocol in terms of technology transfer and foreign investments [45].

Kyoto Protocol

It is the first international treaty aiming at limiting the emissions of GHG [5]. About 180 countries have signed up the agreement to reduce their emissions [7], thereby reducing GHG emissions in the developed country by 5.2% in the first commencement period (2008-2012) related to the baseline year 1990 level [26]. The Kyoto Protocol creates specific goals to be achieved by each participating country in a specific time, called the "commitment period". The Kyoto Protocol has two annexes: Annex A sets out the six GHGs and the various sectors/source categories to be addressed while Annex B lists each country's reduction or limitation obligation. The protocol obligates countries listed in Annex B, which are virtually the same as those listed in Annex I of the UNFCCC. The Kyoto Protocol in Annexure A lists six main GHG that urgently need to be reduced or limited: Carbon dioxide (CO_2), Methane (CH_4), Nitrous oxide (N_2O), Hydro fluorocarbons (HFCs), Perfluorocarbons (PFCs), Sulphur hexafluoride (SF_6). The share of GHGs emitted at global level are: CO_2 64%, methane 20%, HFC 10%, nitrous oxide 6% [7]. To meet the objectives, the Kyoto Protocol imposes GHG emission limitation or reduction obligations on the countries listed in Annex I countries. "Non-Annex I countries" are those which are Parties to the Protocol but have no limitation or reduction commitment and therefore are not listed in annex B of the Protocol [2]. It opens the possibility of sequestering carbon in sinks, and subsequent trading through a number of articles [18].

Kyoto protocol mechanisms: Since global warming is an atmospheric problem that covers the entire earth, it does not matter where or how the reduction of GHGs occurs or who achieves it. Thus, it makes a great deal of economic sense to carry out GHG reduction activities in the least costly places in the world, if the reduction is recognized by the issuance of internationally transferable carbon credits to meet the reduction obligation at home. It also makes economic sense to encourage an entity that can achieve GHG reduction in the most cost-effective way. Kyoto mechanisms associated with carbon trading are as follows:

Clean Development Mechanism (CDM): Clean Development Mechanism is defined in article 12 of the Protocol. In this mechanism, emission reductions at source are achieved by projects carried out in non-Annex I countries with the carbon credits in form of Certified Emission Reduction units (CERs), being transferred on to Annex I countries [2]. The CDM provides for Annex I Parties (industrialized countries) to implement projects hosted by non-Annex I Parties (developing countries) that lead to emissions reductions and thus to climate benefits and a contribution to the ultimate objective of the Convention. In return, the Annex I Parties obtain certified emission reductions (CERs) that can be used to meet their own emissions reduction commitments. CDM project activities are designed so that they assist the host parties in achieving sustainable development. In addition, the investor will require that the CERs are generated in a cost-competitive way [21, 32].

Emissions Trading Scheme (ETS): Emission Trading Scheme is defined in article 17 of the Protocol. Under Emission Trading Scheme, Annex I countries may acquire Assigned Amount Units (AAUs), Removal Units (R, CERs and ERUs) by trading with other Annex I countries directly [2]. This scheme is applicable in European countries. In return, the Annex I parties obtain certified emission reductions (CERs) that can be used to meet their own emissions reduction commitments. One condition is that the CDM project activities are designed so that they assist the host parties in achieving sustainable development [32].

Procedure for applying for the cdm project [4,33]

Step 1: Preparation of Project Design Document (PDD)
Step 2: Approval by national Designated National Authority (DNA)
Step 3: Validation by Designated Operational Entity (DOE)
Step 4: UNFCCC registration
Step 5: Identification of buyer
Step 6: CER transaction

Carbon accounting: Traditional carbon accounting methods follow the approach for emission accounting which is proposed by the Intergovernmental Panel on Climate Change (IPCC). Similar national accounting methods could be developed for carbon sequestration activities. These methods account only for the annual carbon emission reduction represented by sequestration activities. Carbon emissions that relate to energy use, transportation, raw materials etc., to accomplish the sequestration are accounted for by other industries on a national basis [29]. Few tools are available to estimate the amount of carbon currently on their land and the potential rate of accumulation of carbon on their land. The simplest tool is INFORM (Interactive Fast Online Report Maps). INFORM provides estimates of the standing stock of carbon in coniferous or deciduous forests for any county in the South-Eastern USA. The final tool is one developed by the USDA Forest Service called COLE (Carbon On Line Estimator). COLE produces similar data as the carbon calculator [14].

Estimation of Carbon Sequestration: The approach for estimation of sequestered carbon involves direct measurement from fields, use of predefined models or the look-up tables. The method for carbon sequestration estimation was developed in National laboratory, Tennessee, byThomas Klasson and Brian Davison, which was presented in First National Conference on Carbon Sequestration held at Washington DC in May, 2001. Another approach was described by Warnell in National Commission on Science for sustainable Forestry. Measurement of Carbon sequestration can also be done involving Eddy Covariance Technique [23].

Carbon mitigation techniques: The mitigation opportunities could be created through environmental friendly energy supply technologies of through technologies for efficient utilization of energy.

Afforestation & Reforestation [28,34,35]	Anaerobic Treatment Process [46]
Bioenergy Technologies [41]	Rotational Grazing At Farms [47]
Forests [2,21,36,37]	Biomethanation [49]
Biomass Application [20,41]	Pharmaceuticals [17]
Renewable Energy Sources [48]	Liquefaction [43]

Carbon trading strategies in India: India is switching on CDM project for mitigation of emissions. India already commands 30%share of the carbon trading market. Highest number of CDM projects isbeing hosted by India followed by Brazil and Chile[25,26].Granular anaerobic processes for waste water treatment have become an attractive choice of treatment technologyespecially for high strength wastewaters, considering the fact that in addition to efficient waste degradation, the carboncredits can be used to generate revenue and to finance the project [46]. A 65MW wind energy project in thestate of Madhya Pradesh has been issued 10,413 CER for offsetting GHG emissions over a 13-month period.Wind turbines in another 9.6MW project being developed by a hotel firm are also operated and maintained by their supplier.This project is expected to generate 15,245 CER annually for 10 years. Small hydro-electric projects of various sizes aretaking advantage of carbon credit financing. In India, an additional 70,000 MW of electricity generation capacity is expected tobe built by 2020 and about 21% of this addition is expected to come from renewable sources. Themountainous state of Uttarakhand has an active list of hydro electric projects of various sizes under development and at theproposal stage. One bagasse-based renewable energy project at a sugar factory in India is expected to offset 42,446 tons ofcarbon dioxide annually for ten years. It supplies electricity to the state electricity grid, replacing the need to build more fossilfuelbased power plants [40, 48].

Source of greenhouse emissions in dairy industry: The most important GHG emitted by dairy industry are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O)and some refrigerants including HFC, CFC, etc. Enteric fermentation from cows is only responsible for 3% of the globalwarming in the world [7]. In ruminant,methane is naturally produced as a result of microbial fermentation process in therumen. N_2O isproduced naturally as a result of nitrification and de-nitrification in agricultural soil due to nitrogen fertilizers. CO_2 is emittedmainly at the manufacturing level, due to the energy consumption required by the process, andat the farm level with theconsumption of fossil fuels. The evaluation of GHG emission in the dairy industry must consider not only the dairy farm andthe manufacturing process, but also incorporate the other indirect contributors that have emitted the gases during theirproduction (fertilizers and transport etc.). The average estimated emission was found to be around 1 kg of CO_2 per litre of milk. It is important to keep in mind that the grass lands could also store carbon and that sequestration could partly balance the emissions.For mitigation of carbon emission, the following measures can be adopted by dairy industry: Renewable energy fired boiler, anaerobic treatment plant and biogas utilization, wind power utilization, solar power utilization using photothermic and photoelectric cells, vapour absorption plant, cogeneration, etc. [7].

Conclusion

Carbon trading can act as an important tool for reducing the threat of global warming. For a developing country like India, it can serve for economic strengthening. By investing in Carbon-trading we do not only earn money, but can also get value added offsets, protecting many of the world's most endangered species and habitats whilst also mitigating climate change.We can keep our energy sources reserved for a longer time by substituting it with renewable energy sources. For dairy industry, it can provide side benefits that can add to the profit margins. The dairy industry can play a part in reducing global emissions by examining the fuel sources and energy efficiency.

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Technology, Processing and Properties of Cheese Powder: An Overview

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Introduction

Cheese is a food derived from milk that is produced in a wide range of flavors, textures, and forms by coagulation of the milk protein such as casein. Dehydrated cheese is usually used as a food ingredient to improve both the flavor and mouthfeel of food products (Guinee, 2011). Powdered cheese is one kind popular product in many food industries for making sauce bases, dips, dressings, biscuits, and chips as flavoring ingredient. Today, cheese powder is a product of major economic importance because of their immanent use as flavoring agents and/or nutritional supplements in a wide range of foods. They may also be included in processed cheese and cheese analogue products as flavoring agents or as a functional ingredient. Following are the certain advantages of cheese powder over natural cheese.

1. Suitability of use by formulated food manufacturers. Cheese powder can be applied easily to the surface of snack foods (e.g., potato chips, puffed rice products, popcorn) or incorporated into formulated foods (e.g., as in dried soup, sauce, or cake mixes). Cheese powder does not require size reduction like natural cheese during their use and it produce product with consistent quality in large scale operation.
2. Cheese powder has longer shelf life than natural cheese, due to their low water activity, a_w is 0.2–0.3 compared to 0.91–0.99 in cheese. This is the reason cheese powder is stable for long period without affecting their quality.
3. Cheese powder has more variation in flavor compared to natural cheese, because it is made by the use of different type cheese, EMCs, and other ingredients.

Composition	Value
Moisture %	2.60±0.29
Protein %	36.70±0.29
Fat %	52.10±1.00
Lactose %	0.32±0.002
Ash %	6.70±0.18
Calcium %	1.60±0.08
Phosphors %	0.54±0.001

Table 1. Composition of cheese powder (Deodhar and Duggal, 1981)

Cheese powder made using natural cheeses, emulsifying salts, and natural cheese flavors called natural and made by incorporating other ingredients, such as dairy ingredients like skim milk solids, whey, lactose, etc., starches, maltodextrin, flavor enhancers, and/or colors. Cheese powder can be classified according to the proportion of cheese solids, as a percentage of total dry matter: high cheese solids (~95%, w/w), medium cheese solids (>50%, w/w), or low cheese solids (<50%, w/w) (Guinee, 2011). The composition of cheese powder is mentioned in Table 1.

Technology for Manufacturing Cheese Powder

The Cheese powder manufacturing process required pasteurized processed cheese slurry which contains 35–45% TS, which is then spray dried. A manufacturing process has following steps:

- *Formulation of slurry*: It includes mixing of selected different types of ingredients to give the desired powder composition and characteristics. The blend usually consists of comminuted natural cheese(s), water, emulsifying salts, flavoring agents, flavor enhancers, colors, antioxidants, and/or filling materials such as whey, skim milk solids, starches, maltodextrin, and/or butterfat.
- *Processing the slurry*: This involves heating by direct or indirect steam injection to ~75–85 oC for 1–5 min while constantly agitating/ shearing. This step is carried out to kill any potential pathogenic and spoilage microorganisms, and thereby extend the shelf life of the final product and facilitate the physicochemical and microstructure changes that transform the blend to an end product with the desired characteristics and physicochemical stability.
- *Homogenization of the hot molten slurry*: This step is carried out typically at first and second stage pressures of 15 and 5MPa, respectively, to assist further mixing and size reduction of any coarse particles or non-dissolved particles; and also promote a finer dispersion of fat droplets, which leads to a smoother, thicker and firmer consistency during spray

drying.

- *Drying of the hot molten slurry*: It is done using any one of several spray-drying processes (single-stage or two-stage) and dryer configurations (e.g., tall-form, Filtermat) available. Generally drying is conducted in a conventional spray drier with a cooling fluid bed with an air inlet temperature of 180-200^0C an outlet air temperature of 85–90 ºC, depending on the dryer type. Cooling of the powder is achieved in a Vibro-Fluidiser supplied with ambient air in the first section and cold dehumidified air in the last section.

Processing Aspect

Several kinds of drying techniques can be applied for production of better quality cheese powder but majority of the processing are patented. The general production process of cheese power in shown in Figure 1.

Erbay *et. al.* (2014) give optimize process condition for production by using pilot scale spray dryer. In this study they found optimum operating conditions, an inlet drying temperature of 174 ºC, atomization pressure of 354 kPa, and an outlet drying temperature of 68 ºC. At this optimum condition, nonenzymatic browning index, solubility index and bulk density were found to be 0.123 OD/g dm, 82.7% and 252 kg/m^3, respectively.

Mounir *et. al.* (2011) use Instant controlled pressure (DIC) process to produce cheese powder. It is an innovative process for cheese powder production by inserting a texturing process, the instant controlled pressure drop (DIC) treatment in place of traditional hot air drying processes. They obtain low-cost/high-quality powder with open microstructure particles. Such porous particles promote improved reconstitution, solubility, and functional characteristics. Instant controlled pressure drop (DIC) process is defined as a swell-drying operation followed by a grinding stage. Pieces of dried cheese (with water content of about 8–10 g H_2O/100 g dry basis) are transformed into snacks through an expansion process by DIC treatment; they are then dried and crushed using an appropriate mechanical system.

Factor Affecting The Manufacturing Cheese Powder

Several parameters like raw material, cheese slurry processing, homogenization and drying condition are main factor that affect the quality of cheese powder.

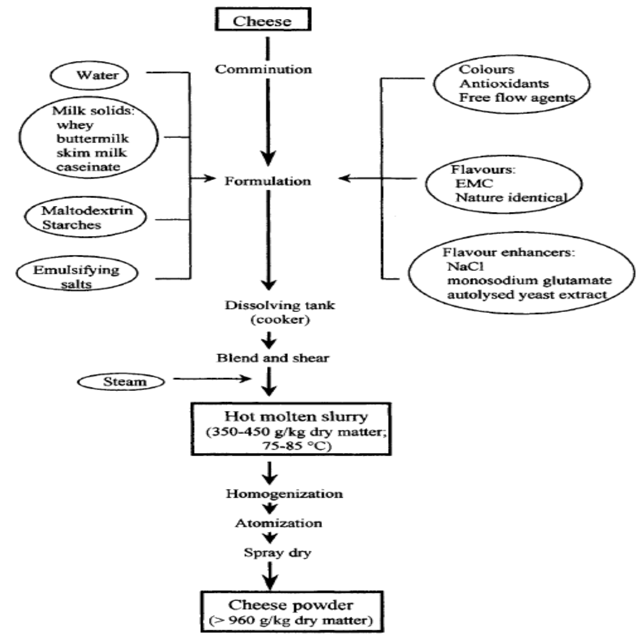

Figure 1. Process flow diagram on cheese powder (Source: Fox *et al.,* 2000)

1) Raw material

Cheese powder made from one or more kind of cheese varieties, so the cheese composition, types, age of ripening and microbial quality are the main factor affect the cheese powder. Beside of that other ingredient like emulsifying salt, flavoring agents and enhancer, colors, and filling materials also affect the cheese powder quality. Generally, ripened cheese with an intense flavor is used to give a strong flavor to the final product. Fresh cheeses are generally not used because of their lack of flavor and high concentration of intact casein, which imparts high viscosity to the slurry, making it difficult to atomize and dry efficiently (Guinee, 2011).

2) Processing of cheese slurry

Processing involve formulation of slurry, heating and homogenization before spray drying. Heating of cheese slurry cause loss of important volatile cheese flavor and also increase the browning index of cheese powder due to maillard reaction, to avoid this problem temperature is typically maintained at <85 ºC. Homogenization make smooth cheese slurry, and make cheese powder lump free. It improve mixing of slurry, reduce the size of coarse and non-dissolve particle (Guinee, 2011).

3) Spray drying condition

The properties of cheese powder are mainly influence by spray drying condition. Inlet and outlet air temperatures caused significant variations on bulk, tapped, and particle densities of the powders. White cheese powders produced at low inlet or outlet air temperatures had higher bulk, tapped, and particle density values. In general, low outlet air temperatures contribute to uniform drying of droplets, controlled particle shrinkage, and higher density values (Kelly *et. al.*, 2002). Higher outlet temperature reduces the brightness of powder and increase redness or yellowness, it also decrease the solubility of powder. Low atomization pressure increases the particle size and improves the solubility and wettability (Koca *et. al.,* 2015).

Properties of Cheese Powder

Several parameters are used to evaluate cheese powder quality. The composition of cheese powder provides useful information on its physical, structural, and morphological features (Kim *et. al.,* 2002).

1) Flavor

The flavor of cheese powder is an important quality factor in most applications where cheese is used as an ingredient. The flavor development occurs due to chemical, enzymatic and microbial changes like proteolysis; lipolysis fermentation of lactose etc., during ripening period of cheese. Beside of that it also depend on type and composition of milk used, cheese making condition, type of starter culture, ripening condition and spray drying condition. Fat plays a role in flavor development and stability, because lipid oxidation is responsible for off-flavor formation and reduced shelf life (Park and Drake, 2014). Due to flavor lost during spray drying, natural or artificial flavor enhancers are added to cheese powders to replace the lost flavor volatiles. The outlet air temperature contributed significant effect on cheese powder flavor (Koca *et. al.,* 2015).

2) Color

Color is one important property of cheese powders to evaluate the quality; abnormal color indicates any defects during processing and storage. The Maillard reaction is induced by high temperature, which is depend on the outlet air temperature in spray-drying processes. Inlet air temperature during spray drying had no significant effect on cheese powder color. However, atomization pressure increased color values (Koca *et. al.,* 2015).

3) Bulk density (BD)

Generally, average cheese powder has BD values ranges from 215-261 kg/m^3. Fat is main component that affect BD values, the rise in the fat content causes a decrease in *BD* (Kelly *et. al.*, 2002). Powder with smooth and uniform structure increases BD, whereas porosity that increases the air in the powder structure decreases BD. Outlet air temperature had the greatest effect on the physical characteristics of cheese powders. Generally, low outlet drying temperatures promote uniform drying of droplets, controlled particle shrinkage and resulted in higher BD (Kelly *et. al.*, 2002). However, higher inlet air temperatures contribute to the formation of vacuoles and air bubbles, which decrease powder density (Kelly *et. al.*, 2002).

4) Solubility index (SI)

Solubility index is the measure of reconstitution properties like solubility, wettability and dispersibility of cheese powder. Solubility is mainly affected by powder composition, especially its protein structure (Kim *et. al.*, 2002). The outlet drying temperature important process factor affecting solubility, increasing the outlet drying temperature caused a decrease in SI (Erbay *et. al.*, 2014). Atomization pressure is less affect on SI, the powders made by lower atomization pressures is more soluble because it increases the particle size (Kim *et. al.*, 2002; Erbay *et. al.*, 2014).

Conclusion

Cheese powder made from cheese or a blend of their varieties, with or without addition of dairy ingredients like whey, skim milk powder and other food ingredients. It has many advantages like higher shelf life, easy to use in formulated food and available in greater variety of flavour. For production of cheese powder, cheese slurry is made using different kind of cheese and then formulated with desirable additional ingredient and obtain 40-45 % TS slurry for processing like heating and spray drying. In spray drying, mainly outlet temperature is main influencing factor which impart cheese powder properties like bulk density, solubility, wettability, flavour and color.

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Mechanized and Continuous Cheese making Processes for Cheddar Ripened Cheese

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Introduction

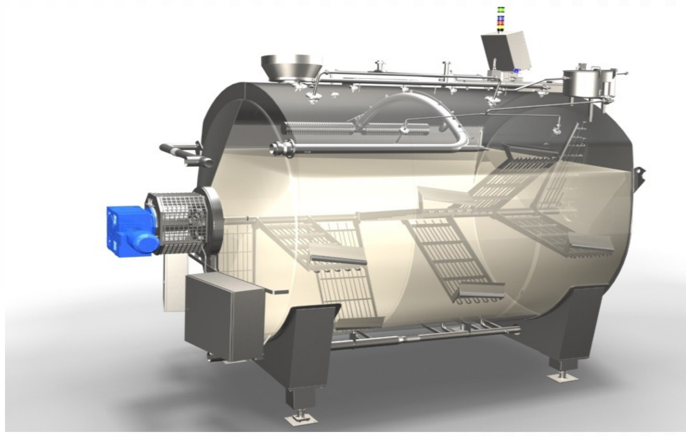
Gujarat Co-operative Milk Marketing Federation continued to lead cheese with a value share of 46% in 2015. The company's stronger distribution network, increasing advertising campaigns and stronger brand recall value have made its brand Amul a market leader. Furthermore, competitive pricing and smaller SKUs also helped the company to maintain its market share. For full filling the demand of market cheese GCMMF Amul group of Banas Dairy have installed fully automated plant having capacity of 30 MTPD at Banas dairy Palanpur.

In fully automated plant having process involve of pretreatments of milk for cheese making like standardization, bactofugation, pasteurization, starter production, curd making, cutting, cheddaring, hooping, conveying, packaging, block forming, etc. Here the description given for commercial plant having the capacity of 30 MTPD cheddar cheese installed at Banas dairy Palanpur.

Cheese Vats: Horizontal

The cheese-making vats have designed for the following functions in automation mode:

- Facility for culture addition & mixing with milk
- Facility for rennet addition & mixing with milk
- Maintaining temp. of milk coagulation
- Cutting of coagulum for syneresis
- Stirring of the curd/whey mixture during syneresis
- Heating / cooling of the curd/whey mixture;
- Cleaning in place (short & full)
- Automatic control of all the process parameters.
- Online pH sensing
- Automatic detection of coagulation status



Banas have 7 (min) No. cheese making vats for the continuous cheese making line. The cheese making vats having sufficient bottom slope for steady &complete unloading of curd & whey mix. The lower half of the cylindrical section of the tank has provided with a jacket to facilitate heating and or cooling of the product. The jacket have provided with a suitable steam inlets/distribution facility for uniform/even heating of coagulum/curd & whey mass. The jacket have designed for atmospheric conditions& have bottom outlets for the discharge of condensate /or cooling water.

The tank have supported by adjustable legs with ball feet, standing on stainless steel discs. The legs have made in such a way that a slope towards the outlet is created. The adjustability of the legs have capable to compensate a floor slope of 5 degree. The cutting and stirring tools inside the Vat should rotate with a minimum clearance to the tank wall. Blades have located in axial and radial direction such that efficient stirring & cutting is obtained. The designs of the stirring& cutting blades have in opposite direction. The rotational speed of both actions has able to regulated by means of a frequency converter. The cutting blades should retain sharpness for longer duration. The main shaft, with the cutting and stirring tools, have driven by ageared motor or with gearbox. The geared motor/gearbox mounting arrangement have such that it facilitates easy accessibility of the seals and easy fixation of the main shaft. The other end of the shaft have supported by an external bearing giving easy accessible for maintenance. The tank have designed for clean in place by means of spray nozzles (preferably rotating type) and connections to the shaft seal housings. All points have piped up to one "CIP" connection. The shaft seal housing have provided with facility to detect/visualize seal leakage during production and to help drain the CIP pipe after cleaning. Drainpipes have provided at the bottom of the tank. The vat design have such that the milk have able to be filled in the vat from the bottom. Bottom inlet type helps in less foam formation. The design should prevent unfavorable foam forming on the cheese milk in the cheese making vat. The vat outlet valve battery have designed such that a free flow passage is provided to the curd/whey mixture with proper selection of pneumatic valves & large radius bends/connections to ensure hygienic cleaning. To ensure an even distribution of diluted rennet over the milk surface, specially designed rennet distribution nozzles and a filling funnel have provided. The filling funnel should have a lid and rennet distributors. The rennet distributors have suitable for a non-pressurized rennet supply. The tank have equipped with a control panel. The panel have designed to operate a cheese vat automatically, starting from the supply of cheese milk with starter up to and inclusive emptying. The panel have provided with an "operating panel" (OP) with a display and function keys to show and operate the status of the machine, manual as well as automatic. An offline pH measuring instrument along with calibration test kit have provided for pH measurement of coagulum from vats & curd from cheddaring machine.

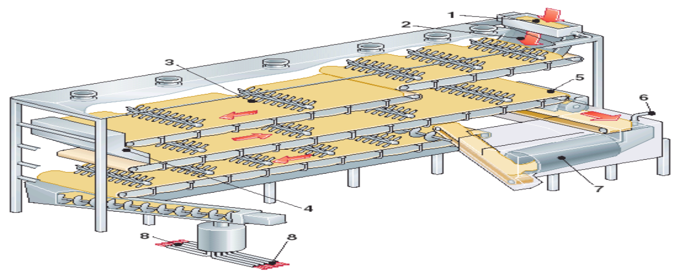
Description of Cheddar Master Machine

Belt 1 – Draining belt

The first belt have perforated type of hygienic design made of food grade synthetic/plastic material (FDA approved).It have equipped with stirrer(s) to assist in removing free moisture and keeping the curd granular. The remaining free whey have fully removed from the draining belt. The stirrer(s) have pegs only on 180° of the shaft and have able to be 'parked' and turned off. The belt have perforated with a special multi-head drilling technique that produces conical holes. This shall ensure minimum curd losses and a self-loosening effect because of the tapered hole. The slats of the belt have connected with standard FDA approved plastic pins. Strength test have performed to ensure belts can withstand 3-4 times higher loads than those generally considered for the belt machine. The residence time on the belt have variable through a frequency inverter. The belt have equipped with separate plastic side guides within the sidewalls of the machine. The main function of the guides have to keep the curd on the belts and to minimize product losses. The drive shaft have a machined solid shaft with grooves running the full width of the machine. This shall ensure equally distributed pulling force over the whole width of the belt and prevent stress concentrations. The shaft have supported by separate external bearings, shielded from the environment by stainless steel covers. No internal bearings have there, ensuring hygienic circumstances in the machine and minimal maintenance requirements. Below the drive shaft, a scraper have placed on the return part of the belt to remove sticking curd particles from the belt and feed it back into the main curd stream. Just after the scraper a belt-tensioning device have there to ensure that the belt tension have maintained under all circumstances. The device shall consist of suitable no. rollers (fixed and moving). The tension have maintained by gravity. The idler shaft have a round pipe shaft with two sprockets positioned towards the sides of the belt for belt tracking. A rotation counter have attached to the shaft for speed feedback and as a safety device in case of belt breakage.

Where the shafts penetrate through the machine wall, heavy duty sanitary seals have fitted to prevent CIP or product leakage for maintaining required hygiene. The design have such that the seals can be replaced easily from the outside of the machine. The drive assembly have mounted to the outside of the machine on a separate support frame. The drive have rated IP55 and protected by a special heavy duty coating. The shaft of the drive have made of AISI 304 stainless steel. The drive have connected to the conveyor drive shaft using a shaft coupling that can be disassembled easily for maintenance. The belt have supported by a fishbone frame to ensure even support and wear. The frame have made of solid bar and rest on support pipes welded between the sidewalls. The pitch of the bars have 190 mm maximum, providing an optimal support for the belt. The sanitary, open design of the frame have ensure easy cleaning of both frame and conveyor. Every part of the belt have open to the cleaning devices for the majority of the cleaning cycle.

Belt 2 – Cheddaring belt



The second belt shall also be FDA approved plastic belt. The design and execution of the belt have the similar to belt 1.

Chip mill and knife-receiver

At the end of the second belt conveyor, the cutting assemblies have placed. It shall consist of a knife-receiver plate and the chip-mill. The curd leaving the end of the belt conveyor shall slide down onto the knife receiver. At the bottom of the knife receiver, the chip-mill shall cut off the curd layer into chips. The knife receivers have a heavy duty stainless steel plate with equally spaced slots at the bottom to allow the vertical knives of the chip-mill to pass through. For CIP, the knife receivers have moved away from the chip-mill. This shall give greater clearance for expansion at CIP temperatures. 2 proximity sensors have used to detect the position of the knife receiver. The chip-mill has a rotary drum mounted across the machine. It shall have two cutting operations. The first have performed by a number of interspaced rows of vertical knifes, welded perpendicular to the cylindrical surface of the drum. These knives shall precisely fit through the slots of the knife receiver. A horizontal knife shall run the full width of the belt, does the second operation. The combined action of the knives shall cut the curd mattress very consistently into square chips of about 14x14 mm. The speed of the chip-mill have variable and have controlled by a frequency drive. The chip-mill speeds have interlocked with the speed of conveyor 2. In the control system allowance have made to enter different chip sizes, this shall control the speed of the mill relative to conveyor 2 speed.

Dry Salting

Dry salting has done by sprinkling on curd pieces through lances before or after milling operation. Further stirring have carried out for efficient mixing of salt with curd pieces. Due to salting of curd further whey removal shall take place. This salted whey has collected in a separate sump from where it have pumped out.

Stirrer(s)

The stirrer(s) shall have three rows of pegs spaced at 90° to each other around the shaft, thus covering 180°. This makes it possible for the stirrer to be 'parked' out of the way of the curd stream by not activating it in the recipe. The stirrer have made up of a thick wall hollow tube and solid bar pegs. Before fitting in the machine the fully welded assembly has pressure tested to make sure there is no leakage. The threaded holes in the tube end have closed of with a removable threaded plug, to allow for pressure testing at later stages of the lifetime of the stirrer. The stirrer shaft have supported by bearings on either side. Each stirrer have connected with a split coupling to a drive assembly that is mounted on a separate frame. A sanitary seal have fitted on each side, similar to the seals used on the conveyor belts. The bearings have shielded from the environment by stainless steel covers. The stirrer(s) have VFD operated &drives have IP55 and protected with a special high duty coating. The shaft of the drive have AISI 304 stainless steel.

Block Former

The Block former have designed for following functions:

- Transport of curd into the tower by means of air flow, induced by vacuum
- Vacuum sing of the tower to remove air from the curd particles
- Compacting the curd by venting back to atmospheric pressure
- Draining of the small amounts of free whey during the compacting
- Fusing of the curd
- Lowering of the curd column.
- Cutting of the block
- Secondary pressing of the block
- Ejecting of the block into a bag and onto the discharge conveyor

The block former installation have consist of at least two block forming units providing enough capacity for current production and at least 20% spare capacity for future expansion. The whey discharged by the block former have pass through a fines separator (vibrating type)& collected in the intermediate salty whey balance tank. The system have able to receive mellowed cheese curd pieces from the cheddaring machine and form it into standard 20 kg blocks. The formed cheese blocks have transported to the downstream equipment for vacuum sealing and shrinking etc. before blast cooling &storage. The curd from the cheddaring machine have transported to the block forming towers by air stream created through vacuum pump. The block former have designed to pick up curd pieces, form them into a fused block of closed and uniform consistency. The well-shaped blocks would eject out automatically into plastic bag presented manually. When the tower is full, vacuum have applied to evacuate the air from the curd pieces/particles. The column of curd in the block former have compressed by the static weight of the curd column and by the effects of the vacuum cycle. The applications of the vacuum have ideally a cyclic operation. The whole operations have carried out in an enclosed environment and under the cyclic influence of vacuum.

The weight of the block have adjusted by altering the cutting height. The design have such that it can be done automatically via a weight feedback system or manually from the screen. A conveyor system shall transport the blocks to packaging area where the blocks vacuum-sealed, shrink wrapped on the way. The conveyor system shall include a metal detector & a check weight system with label printing facility. The main components of the block former have the base unit, the tower, the vacuum pump(s) and the control system.

Tower

The block former tower have placed on top of the base unit. It shall consist of an outer jacket and an inner liner. Both the liner and jacket have fully welded. The jacket and liner surfaces shall have all butt welds, ground flush and have completely polished inside. Additional to this the internal surfaces of the liner shall have a special surface finish that shall have easy product release and sanitary properties. The liner have perforated with conical holes, designed to minimize loss of small particles. On the top of the tower the top plate have bolted to the top flange of the jacket. The top plate have designed to accommodate a number of items:

- The curd feed pipe
- The curd transport vacuum connection
- An electronic pressure transmitter
- The level probe(s)
- Rotating spray balls
- Separation sieve

Spray nozzles have mounted in the four sides of the jacket top for hygienic cleaning of the entire tower. A second vacuum connection have placed at the bottom of the jacket for deep vacuum in the tower. This line shall connect to a separate high vacuum source. Pressure transmitter(s) have provided to monitor vacuum level.

Vacuum Pumps

The rotary claw pumps have used for constant vacuum or pressure is required, along with totally oil free compression. The vacuum pump assembly have placed on a frame, which can be directly mounted to the floor via anti-vibration mounts.

Then, The conveyor-system have designed to transport cheese blocks from the block former to the in-feed of the vacuum-sealing machine and further to shrink wrapping /drying unit.

Conclusion

Cheese Automation can address the critical issues of product safety and security both proactively and reactively with its integrated logistics, material handling and warehousing systems in term of product microbial quality. Proactively, automated systems reduce the number of people with direct access to products so its increase the cheese product hygiene condition. This alone can improve product reliability significantly while reducing the risk of contamination. This key feature of automation can easily facilitate any recalls that may be required. But beyond enhancing food safety and security, a fully integrated automation system can provide many compelling business benefits. Advanced cheese automation systems increase visibility into food-manufacturing operations by improving the transparency and traceability of vital food business information. The result is lower labour costs, increased productivity, reduced scrap and waste, and meeting, and even anticipating, the continually increasing product safety, self life and legal demands.

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Application of *Moringa oleifera* in food products

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Moringa is an outstanding source of nutritional components. In literature, *Moringa* is often called the *Power house of minerals* and/or *Mother's best friend*. *Moringa oleifera* has numerous medicinal uses, which have long been recognized in the Ayurvedic and Unani systems of medicine (Mughal *et al.,* 1999). The taxon name *Moringa* comes from *murunggi* or *muringa* from Tamil and Malayalam (Manzoor *et al.,* 2007). Its leaves (weight per weight) have the calcium equivalent of four times that of milk, the vitamin C content is seven times that of oranges, while its potassium is three times that of bananas, three times the iron of spinach, four times the amount of vitamin A in carrots, and two times the protein in milk (Pandey, 2013). *Moringa* provides a rich and rare combination of nutrients, amino acids, antioxidants, antiaging and anti-inflammatory properties used for nutrition and healing. The indigenous knowledge and use of *Moringa* is referenced in more than 80 countries and known in over 200 local languages. *Moringa* has been used by various societies (Roman, Greek, Egyptian, and Indian) for thousands of years with writings dating as far back as 150 AD. The history of *Moringa* dates back to 150 BC. Ancient kings and queens used *Moringa* leaves and fruit in their diet to maintain mental alertness and healthy skin. Ancient Maurian warriors of India were fed with *Moringa* Leaf Extract in the warfront. The Elixir drink was believed to add them extra energy and relieve them of the stress and pain incurred during war. These brave soldiers were the ones who defeated "Alexander" the Great " (Fuglie and Lowell., 2001).

In India, drumstick pod is known as *munga, saragwa* or *saragwe* and is often referred to as *Moringa* in generic name. Tender drumstick leaves are used to make a nutritious soup (Pandey, 2013). *Moringa* can be a good tool to combat not only Vitamin A deficiency, but also other micronutrient deficiency at a global level. Moreover, drumsticks are rich in dietary fibers and it has been postulated that fibers can provide a multitude of functional properties when they are incorporated in food systems (Madukwe *et al.,* 2013).

Moringa has been described as "one of the most amazing trees God has created". Almost every part of drumstick viz. bark, root, fruit, flowers, leaves, seed and gum is a rich repository of proteins, vitamins and minerals including potassium, calcium, phosphorus, iron, folic acid as well as β carotene. Leaves can be eaten fresh, cooked or stored as dry powder for many months without refrigeration, without loss of nutritional value. Almost all the parts of this plant have been used for various ailments in the indigenous medicine of South Asia (Anjorin *et al.,* 2010; Khalafalla *et al.,* 2010; Pandey *et al.,* 2012). Various drumstick based commercial healthcare products are available viz. *Moringa* Zinga, *Moringa* Pharm, *Moringa* seeds, *Moringa* tea, *Moringa* capsule, *Moringa* fruit prowder, *Moringa* dried leaves, Miracle Malunggay,Ponga Monga *Moringa* tea and Ziga Smart Drink (Singh, 2010).

There are considerable variations among the nutritional values of *Moringa*, which depend on factors like genetic background, environment and cultivation methods. Nutritional composition of the plant plays a significant role in nutritional, medicinal and therapeutic values (Al-Kharusi *et al.,* 2009). Green leaves and fruit pods of drumstick are rich sources of minerals like calcium, iron and good sources of vitamin A, B, C and protein(including fair amounts of sulfur containing amino acids, viz. methionine and cystein (Ram, 1994)). Both young and older leaves are edible, though older ones are milder and tender. Along with green foliage and pods, immature seeds are often cooked and eaten as a fresh vegetable, while mature seeds can be dried and roasted. The flower can be cooked or oven dried and steeped. Dried leaves can be stored as future soup or sauce supplements. Blossoms are edible and taste like radish. Browning seeds from mature pods that are mashed and placed in boiling water causes an excellent cooking or lubricating oil to float to the surface. The oil preserves well although become rancid with age. Its root are used a flavouring and in poultices and edible oil can be extracted from its seeds. The green pods and surrounding white material can be removed from larger pods and cooked in various ways. A study was conducted to evaluate the chemical composition and nutritional values of dried *M. oleifera* leaf powder collected from two different regions in Mexico. All samples of *M. oleifera* exhibited moisture levels varying from 3.06 to 3.34 %, lipids from 10.21 to 10.31 %, fiber from 7.29 to 9.46 %, ashes from 10.71 to 11.18 %, crude protein from 10.74 to 11.48 %, and carbohydrates from 54.61 to 57.61 % (Valdez-Solana *et al.*, 2015). The predominant mineral elements in the leaf powder according to ICP-MS were Calcium (2016.5-2620.5 mg/100 g), Potassium (1817-1845 mg/100 g), and Magnesium (322.5-340.6 mg/100 g). It has been reported that *Moringa concanesnis* contains in seed more protein and fat and is rich in oleic acid than *Moringa oleifera*. Seeds fat was 33 and 27 % and protein in detoxified seed meal 72.6 and 50 %, respectively (Rao *et al.,* 2008).

Most parts of this tree (leaves, flowers, fruits and immature pods) are used in various traditional food formulations, medicines and for industrial purposes in several Asian and African countries. Therefore, it is now considered one of the most useful trees. Some edible products obtained from *Moringa* viz. *Moringa* pod, *Moringa* leaves etc. are reviewed in this section.

Moringa Pods

The name drumstick derives from the shape of the pod, resembling the slender and curved stick used for beating. The *Moringa* pods are rich source of calcium, iron and fiber out of which 40% is soluble dietary fiber. The nutrient value per 100 g raw *Moringa* pod is Carbohydrates: 8.53 %, Proteins: 2.10 %, Total fat: 0.20 %, Cholesterol: 0 %, Dietary fiber: 3.2 % (USDA National Nutrient data base). The pods of drumsticks are used as vegetables and have great nutritional and medicinal value (Gopalan *et al.,* 2004; Ramachandran *et al.,* 1980). Nutritionally, drumstick pods are of great value as sources of calcium, phosphorus and Vitamin C. Edible portion of drumstick pods are rich in calcium (30 mg/100 g), phosphorus (110 mg/100 g), iron (5.3 mg/100 g) vitamin C (120 mg/100 g).

Moringa Leaves

Leaves possess high protein value as well as low fiber content which has made it suitable for the extraction of leaf protein for use as low cost source of protein (Awasthi and Tondon, 1988). Its tender green leaves are good source of neutral detergent fiber (NDF) and acid detergent fiber (ADF). Leaves are rich source of major and trace elements viz. calcium, phosphorous and zinc vary from 0.9 to 2.9, 0.4 to 1.2 % and 17.5 to 46.2 mg/kg, respectively (Gopalan *et al.,* 2004). Since dried *Moringa* leaves retain their nutrient content, it is possible to convert them into leaf powder. Mishra *et al.* (2012) standardized a method for processing of *Moringa oleifera* leaves for human consumption.

Moringa oleifera is a highly valued plant with a profile of important minerals and is a good source of protein, vitamins, β-carotene, amino acids and various phenolics. In the present study, methanolic extract of leaves and pods were analyzed for phytoconstituents, antioxidant properties, nutrient, mineral and vitamin. The results of the antioxidant activities were moderate in comparison to the standard antioxidant and the leaf extract was superior to the pod in terms of antioxidant potentials. The IC_{50} values for DPPH radical scavenging activity was 150, 240 and 14 µg/ml for leaf, pod and standard respectively. Pod was a good source of carbohydrate, lipid, protein and amino acids as indicated by the results. The moisture, ash and crude lipid of leaves were 80.02 %, 6.85 % and 1.83 % respectively; those of the pod were 74.06 %, 7.18 % and 2.32 % respectively. The mineral composition unravels a high concentration of iron and calcium followed by sodium, potassium and magnesium. The present results revealed that, the leaves and pod contain an appreciable amount of nutrients and can be included in diets to supplement our daily nutrient requirements (Raghavendra *et al.,* 2015).

Table: Nutrient content *Moringa oleifera* leaves (per 100 g)

Nutrient	Content Average	USDA National Nutrient Database	Nutritive Value of Indian Foods
Energy (kcal)	86.6 kcal	64 kcal	92 kcal
Moisture (mg)	76.4	78.7	75.9
Protein (g)	8.8	9.4	6.7
Carbohydrates (g)	7.6- 12.5	8.3	12.5
Fiber, crude (g)	2.2	2	0.9
Fiber, total dietary (g)	(5.3 – 7.3)	NA	NA
Fat (g)	1.5	1.4	1.7

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Nutrient	Content Average	USDA National Nutrient Database	Nutritive Value of Indian Foods
Ca (mg)	532	185	440
P (mg)	90 – 112	112	70
Fe (mg)	10.8	4	0.85
Folate (µg)	NA	40	NA
Vitamin A (µg RAE)	1286	378	1640
Vitamin C (mg)	162	52	220
Vitamin E (mg)	25	NA	NA

Source: Pandey (2012)

Antinutritional Factors

Moringa leaves contain various antinutritional factors (Makkar and Becker, 1996), like oxalates and phytates which may hinder efficient utilization and absorption and digestion of nutrients, and thus reduce the nutrient bioavailability and nutritional status (Lestienne et al., 2007). Haristoy *et al.* (2005) reported that the soluble oxalate content (as percentage of total oxalates) in drum stick leaves was 28 and Calcium:oxalate ratio was 3.6. Different cooking methods (blanching, pressure cooking, open pan cooking, drying, boiling and sprouting) have varied effects in reducing the levels of oxalate and phytate (Sood *et al.,* 2012). The reduction of anti-nutritional factors by cooking can help to enhance the nutritional value of *Moringa* (Oulai *et al.,* 2014). Devisetti *et al.* (2016) reported that alkali treatment induced changes in content of nutrients and antinutreints in *Moringa* leaf in addition to making it suitable for product formulation. Alkali treatment of leaves resulted in is a reduction in content of antinutrients and improved functional properties when leaves.

Asiedu-Gyekye *et al.* (2014) conducted a study which was aimed at measuring the micro- and macroelements content of dried *Moringa oleifera* leaves using energy dispersive X-ray fluorescence spectroscopic (EDXRF) and assessing its toxicological effect in rats. Results showed significant levels of thirty-five (35) elements (14 macroelements and 21 microelements) in *M. oleifera* extract. There were no observed overt adverse reactions in the acute and subacute studies. Although there were observed elevations in liver enzymes Alanine transaminase and Alkaline phosphatase ($P<0.001$) and lower creatinine levels in the extract treated groups, no adverse histopathological findings were found. The authors concluded that *Moringa oleifera* dried leaf extract may, therefore, be reasonably safe for consumption Based on the levels of minerals present in *Moringa oleifera* leaves and the permissible amount in the human body, the authors recommended that the consumption of *Moringa oleifera* leaves be limited to a maximum of 70 g per day in order to prevent excessive consumption and subsequent accumulation of some of these essential elements. At 70 g per day, most of these elements in the leaves could be found in high quantities approaching the RDA limit.

Medicinal Value and Health Benefits

Moringa oleifera Lam (*Moringaceae*) is a highly valued plant, distributed in many countries of the tropics and subtropics. It has an impressive range of medicinal uses with high nutritional value. Different parts of this plant contain a profile of important minerals, and are a good source of protein, vitamins, β -carotene, amino acids and various phenolics. The *Moringa* plant provides a rich and rare combination of zeatin, quercetin, β - sitosterol, caffeoylquinic acid and kaempferol. In addition to its compelling water purifying powers and high nutritional value, *Moringa oleifera* is very important for its medicinal value.

The supplementation of *Moringa* leaf powder appears to be effective in improving the nutritional recovery of severely malnourished children (Zongo *et al.,* 2013). The aqueous extracts of *Moringa oleifera* was found to be inhibitory against many pathogenic bacteria, including *Staphylococcus aureus, Bacillus subtilis, Escherichia coli,* and *Pseudomonas aeruginosa* in dose dependent manner (Saadabi and Abu, 2011). Fresh leaf juice and aqueous extracts from the seeds inhibit the growth of *pseudomonas aeriginosa* and *Staphyalococcus aureus* (Mashiar *et al.,* 2009). A number of medicinal properties have been ascribed to various parts of this highly esteemed tree.

Application of *Moringa* as an ingredient in foods

In the recent past, country has witnessed a positive growth in ready to serve beverages, fruit juices and pulps, processed fruits and vegetables products, i.e., dried or preserved and dehydrated vegetables and fruits. *Moringa* are among the most well-known plant being used in our food due to its wide availability. Its leaves are highly nutritious, being a significant source of beta-carotene, vitamin C, protein, iron and potassium. The use of drumstick powder is mainly in curries, *kormas* and *dal*. Apart from that, it also makes good savory cutlets. It imparts special flavour to *sambars* and is used as a thickening agent. It gives a distinct palatable taste and is rich source of glutamic acid and it is highly useful in joint pains. Dehydrated drumstick powder is an integral part of Indian cuisine and is extensively used in many food and curry preparations. It is a mass consumption item used round the year. Apart from individual households, it is used in large quantities in restaurants, road-side eateries, hotels and canteens and many such places.

In the first report on fermentation of *Moringa* leaves in combination with Beet Root Juice (BRJ), *Moringa* leaves were made into a paste, supplemented with BRJ at different ratios (1:1, 1:2, 1:3 and 1:4), and fermented with *Lactobacillus plantarum* and *Enterococcus hirae* for 48 h at 37 °C. The fermented *Moringa* leaves based beet root (MLBBR) beverage made with one part of *Moringa* leaves paste, and two parts of BRJ was found to have good viable lactic population. Adjusting the pH of the fermented MLBBR beverage to 6.5 could extend the shelf life up to 30 d at 4 °C. Fermentation also reduced the raffinose content by around 60 %. The fermented MLBBR beverage had showed antibacterial activity against foodborne pathogens such as *Bacillus cereus*, *Escherichia coli*, *Listeria monocytogenes* and *Staphylococcus aureus*. It also exhibited radical scavenging activity (20.79 %) with a phenolic content of 5 mg/ml and had minerals (mg/ml) like 11.8 of calcium and 0.2 of iron. Overall, the fermented MLBBR beverage has the potential for commercial exploitation as a refreshing health drink (Vanajakshi *et al*., 2015).

Devisetti *et al*. (2016) studied the effect of alkali pre-treatment on the nutritional, anti-nutritional and functional properties of *Moringa* (*Moringa oleifera*) leaf flour (MLF), and sensory assessment of MLF-based snack product. The pre-treatment reduced the content of anti-nutrients and improved the functional properties of MLF. The MLF-based ready-to-eat puffed snack exhibited high protein (21.6 g/100 g) and dietary fiber (14.8 g/100 g) contents while it contained low fat of 3.7 g/100 g. The HPLC analysis of phenolics revealed that chlorogenic and gallic acids were the predominant phenolic acids present in the raw leaf flour, whereas p-coumaric, caffeic and gallic acids were the major phenolic acids in the pre-treated leaf flour. Flavonoids such as catechin, kaempferol, rutin and luteolin were present in both MLFs and the prepared snack. Overall sensory quality indicated that the snacks had acceptable textural attributes and improved nutritional profile at the 20 % level of substitution. It is possible to develop ready-to-eat convenience food product with good functional and nutritional properties using pre-treated *Moringa* leaf.

Alam *et al*., (2014) formulated a fibre enriched herbal biscuits using *Tulsi* (*Ocimum sanctum*) and *Moringa* (*Moringa oleifera*)) that contain sufficient nutrients (protein and fibre enriched). Fibre enriched herbal biscuits were developed by incorporating *Tulsi* leaves, *Moringa* leaves, whole wheat flour, egg white, vegetable oil, margarine (dalda) and other necessary ingredients. The recipe was standardized and evaluated for organoleptic acceptability. It was noted that the quality characteristics were improved due to incorporation of acceptable level of *Tulsi* and *Moringa* leaves at certain proportion. The organoleptic test showed that the addition of both *Tulsi* and *Moringa* leaves at 1 % was more acceptable in comparison with all quality characteristics.

Nwakalor and Chizoba (2014) used the blend of wheat flour and *Moringa oleifera* leaf powder or flour and processed into cookies in the ratios of 100:0, 90:10, 80:20, 70:30, 50:50. The sensory profile showed that there was marked difference in the different attributes such as colour, crispiness, taste, flavour and general acceptability. The sensory scores showed that the best *Moringa* flour substitution levels for making cookies were revealed 10 % (90:10) and 20 % (80:20).

Nadeem *et al*., (2013) evaluated the antioxidant potential of a Leaf Extract of *Moringa oleifera L.* (LEMO) for the stabilization of butter at refrigeration temperature. LEMO was obtained by extracting the ground and dried leaves with 80 % ethanol at room temperature for 48 hours. LEMO was added into butter at three different concentrations, 400 ppm, 600 ppm, and 800 ppm and compared with a treatment, which was not supplemented with LEMO. The addition of LEMO at all three levels did not have any effect on butter composition. Free fatty acids, peroxide value and α-anisidine value (AnV) of LEMO having 600 ppm after 90 d of storage were 0.10%, 0.71 meq/kg and 14.85 meq/kg as compared to 0.16%, 1.24 and 28.85 meq/kg respectively. Peroxide value of the control and LEMO with 600 ppm in Schaal oven test after 5 d in oven was 8.19 and 2.99 meq/kg respectively. It was suggested that LEMO at 600 ppm may be used for reasonable storage stability of butter at refrigeration temperature with acceptable sensory characteristics.

Devisetti *et al.,* (2016) reviewed the prepared cookies with blends of *Moringa oleifera* leaves powder and ginger extract. *Moringa* leaves powder (MLP) and ginger extract (GE) were processed into flour and used to substitute wheat flour at different proportions (0, 5, 10, 15, and 20 %). The pasting properties of the different wheat-*Moringa*-ginger flour blends were determined. The composite flour was there after processed into cookies and the proximate compositions of the cookies were determined. There were markedly differences in all the proximate parameters with the highest values of 24.08, 1.80 % and 1.29 % recorded by cookies from 90 % wheat, 5 % MLP and 5 % GE in terms of protein, ash and crude fibre, respectively. Also markedly differences were observed in all the minerals parameters tested for in the cookies. Calcium, magnesium, phosphorus and iron were considerably increased with 3 % MP and 2 % GE and in 5 % MP and 5 % GE. Similarly, vitamin A, B_1, B_2 and E were significantly ($P<0.05$) elevated. The most notable improvement was in Vitamin E with 5 % MP and 5 % GE of the supplements. It was observed that vitamin E sample with 5 % MP and 5 % GE of the supplements was almost twice that of the control sample (0 % wheat). However, there were no significant difference in the pasting profile of the wheat-*Moringa*-ginger flour except for trough and pasting temperatures. Sensory evaluation showed that cookies incorporated with 5 % MP and 5 % GE were acceptable. The results showed the possibility of utilizing *Moringa* leaves and ginger extract to improve the nutritional characteristics of cookies to becoming a functional food.

Dairy Products

A study was conducted to evaluate the effects of adding selected fruits and vegetables on the sensory qualities of probiotic yogurt supplemented with *Moringa oleifera.* A total of five samples were evaluated: (1) Probiotic yogurt (control, C), (2) *Moringa* probiotic yogurt, (3) *Moringa*-banana probiotic yogurt, (4) *Moringa*-sweet potato probiotic yogurt, and (5) *Moringa* avocado probiotic yogurt. The control sample and the *Moringa*-banana sample had significantly higher ratings ($P<0.05$) than the *Moringa* sample for appearance, flavour, texture and overall quality. Addition of banana to *Moringa* probiotic yogurt resulted in a product with comparable sensory qualities to C (Kuikman and O'Connor, 2015).

Apilado *et al.* (2013) manufactured cream cheese from buffalo's milk mixed with 0, 0.5, 1 and 1.5 % *malunggay* leaf powder (MLP). Moisture, fat, protein and calorie content of the cream cheese did not differ significantly ($P<0.05$) among treatments while crude fiber content increased significantly with the addition of MLP. It was reported that acceptability of cream cheese with 0.5, 1 and 1.5 % MLP was lower than 0 % MLP. The authors opined that malunggay leaf powder cannot be added to cream cheese from buffalo's milk at the levels greater than 0.5 % in the production of cream cheese.

In a study by Tienen *et al.* (2011), the growth of the probiotics in *M. oleifera* supplemented yogurt was found to have a growth enhancing effect. The results suggested that *Moringa* did not inhibit the growth of bacteria, except perhaps in higher doses in samples that did not contain sugar. Sugar may have countered any antibacterial properties *Moringa* has at larger quantities as it would be an additional food source for them. The authors reported that MRS broth with the 5 % *Moringa* had significantly greater growth of probiotic organisms than the control, which may suggest growth enhancing properties and could be further tested for prebiotic properties. Tienen *et al.* (2011) tested *Moringa* in concentrations at approximately 0.854 % and 1.709 % and without added sugar or as a form of dip and found that the product was acceptable. In-house testing for *Moringa* fortified yogurt suggested that, a level of 0.5 % *Moringa* with 5 % sugar was acceptable as yogurt. Also, it was suggested that *Moringa* without sugar at 0.5 % could be acceptable as a dip with a good flavour. At 1 % *Moringa*, the yogurt samples had a strong undesirable flavour. Although 0.5 % would not satisfy meeting the criteria for a 'good source' of vitamin A as suggested by the authors, it would be a source of nutrients and could potentially improve the acceptability of the *Moringa* fortified yogurt or dip. In another study, herbal ghee was prepared by incorporating *Arjuna* and *Moringa*, popular medicinal herbs containing antimicrobial and nutritional value. The result showed that 0.5 % level of *Arjuna* and 1 % level of *Moringa* were best and had highest acceptability in sensory evaluation (Ibrahim *et al.,* 2015)

Dry leaves of *Moringa oleifera* (DLMO) were added to Labneh cheese at concentration 1, 2, or 3 %. Subsequently, the chemical, microbiological and organoleptic properties of Labneh cheese during storage 3 weeks at 5±1°C were determined. Nutritional and biological values of Labneh were evaluated when fresh. Addition of DLMO had considerable effect on Total Solids (TS), protein, acidity, carbohydrate and ash. The highest values were recorded with Labneh fortified with DLMO (innovative Labneh). The addition of DLMO had a significant effect on carbohydrate. Acidity increased gradually for all treatments during storage. The highest values were obtained with Labneh fortified with DLMO. Labneh fortified with DLMO can be considered as a good source of minerals (Ca, Fe, Zn and Si) and vitamins (A, B1, B2 and E). The results indicated that total counts were higher in Labneh fortified with DLMO. Organoleptic scores revealed that the Labneh fortified with DLMO was acceptable during storage period (Salem *et al.,* 2013).

The antioxidant potential of a leaf extract of *Moringa oleifera Lam.* (*Moringaceae*) – LEMO for stabilization of butter was studied by Nadeem *et al.* (2013). LEMO was obtained by extracting the ground and dried leaves with 80% ethanol at room temperature for 48 hours. LEMO was added into butter at three different concentrations, i.e. 400 ppm (T1), 600 ppm (T2), and 800 ppm (T3) and compared with a treatment which was not supplemented with LEMO, i.e. control (T0). The addition of LEMO at all three levels did not have any effect on butter composition. Free fatty acids, peroxide value and p-anisidine value (AnV) of T2 after 90 d of storage were 0.10%, 0.71 meq/kg and 14.85 as compared to the control 0.16 %, 1.24 meq/kg and 28.85 respectively. Peroxide value of the control and T2 in Schaal oven test after 5 d in oven was 8.19 and 2.99 meq/kg, respectively. Induction period and overall acceptability score of the control and T2 were 6.35 h, 8.91 h and 7.6, 7.2, respectively. The results of this study suggest that LEMO at 600 ppm may be used for reasonable storage stability of butter at refrigeration temperate with acceptable sensory characteristics.

Moringa truly appears to be a "Miracle" plant having countless benefits for humanity and thus is a valuable **gift of nature.** *Moringa* is very impressive and amazing plant due to its tested, trusted and potential benefits from nutritional as well therapeutical point of views. Moreover, drumsticks are rich in dietary fibers and it has been postulated that fibers can provide a multitude of functional properties when they are incorporated in food systems. Hence, incorporation of *Moringa* in foods is envisaged to capitulate a product that is leveraged with micronutrients and hence making it a complete food.

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Food Grade Lubricants for Food Industry

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Introduction

Health and safety are the most significant priorities for food, drink and drug manufacturers. Standards of cleanliness and hygiene are as important. Lubricant leakages and maintenance are an inevitable part of all industries. Lubricants do not discriminate against the materials with which they come into contact. The food processing and pharmaceutical industries have additional challenges in selecting the right lubricants to do the job.

It is never desirable for lubricants to be allowed to contaminate produced goods. However, the consequences of lubricant contamination are more intense in the food industry. Some important historical food safety incidents have been mentioned here below:

1. In 1996, a total of 4,740 pounds of turkey sausage was recalled by JennieO Foods because the product had been contaminated with grease. One year later, only 31 pounds were recalled.
2. In 1998, more than 490,000 pounds of smoked boneless hams were recalled by Smithfield Foods because they were contaminated by a gear lubricant after several customers reported a "bad taste" and "burning in the throat for up to three hours" from eating the ham.
3. In 2000, 86,000 pounds of sliced and packaged turkey products (mostly deli meats) were voluntarily recalled from exposure to a non food grade lubricant. Consumers reported off odor and off flavor product. A few experienced "temporary intestinal discomfort."
4. On September 1, 2000, the StokeonTrent City Council in the United Kingdom confirmed that tests on a can of baby food revealed a toxic substance. The investigations indicated that a can of Heinz Cheesy Parsnip and Potato Bake was contaminated with mineral oil lubricant, possibly from a machine in the manufacturing process or from the can manufacturing process. A mother complained that the food smelled of tar and alerted the environmental health officials.
5. In 2002, Arinco, a manufacturer of milk powder at Vidabaek, Denmark, found contamination in its product. A total of 1,100 tons of milk powder manufactured between January 3 and June 28, 2002, were contaminated by onehalf to three quarters of a liter of lubricating oil containing very fine iron particles. This was discovered when a customer in Thailand complained that the milk powder had a pale gray tint. This was traced back to a packaging plant, to a worn axle in a gearbox. This allowed oil to seep out through a ball joint and into the powdered milk.

Challenges Facing Food Grade Lubricants

The food processing industry poses unique lubrication challenges. Large scale food processing requires machinery such as pumps, mixers, tanks, hoses and pipes, chain drives, and conveyor belts. Machinery used in food processing facilities face many of the same tribological and lubrication challenges found in other nonfood processing plants. Lubricants must offer similar protection of internal surfaces to control friction, wear, corrosion, heat and deposits. They must also offer good pumpability, oxidation stability, hydrolytic stability and thermal stability where the application requires. In addition, certain applications within the food and drug manufacturing facilities demand that lubricants resist degradation and impaired performance when in contact with food products, certain process chemicals, water (including steam) and bacteria.

What is a Food Grade Lubricant

Food grade lubricants must perform the same technical functions as any other lubricant: provide protection against wear, friction, corrosion and oxidation, dissipate heat and transfer power, be compatible with rubber and other sealing materials, as well as provide a sealing effect in some cases. They must withstand a broad range of contamination such as process water, steam, high pressure water cleaning/ sanitation and acidic conditions. Other contaminants that food grade lubricants must withstand include chemicals, sugar and substances that are present in the manufacturing process. These oils must also comply with food/health and safety regulations, as well as be physiologically inert, tasteless, odorless and internationally approved.

Lubricants can be subjected to intense environmental contaminants. A corn milling environment generates significant dust. Although not as hard as silica based dust, it still presents a problem for filtration. A meat plant requires stringent steam cleaning at all times, so the risk of water contamination is high. Some plants experience as much as 15 percent by volume of water in their gear oils. Another aspect of lubrication contamination that poses a risk to food grade lubricants is the growth of microorganisms such as bacteria, yeast and fungi. While these can be a risk in industrial environments, the opportunity for contamination in the food production environment is even greater.

Food Grade Categories and Definitions

A joint effort by three recognized industry professional associations – the National Lubricating Grease Institute (NLGI), the European Lubricating Grease Institute (ELGI) and the European Hygienic Equipment Design Group (EHEDG) – developed a Joint Food Grade Lubricants Working Group. This group has been active in drafting an authorization program for food grade lubricants and developed DIN V 0010517, 200008 (Food Grade Lubricants – Definitions and Requirements). There have been plans to use the DIN standard to develop an ISO (International Standards Organization) standard.

Food grade lubricants are lubricants acceptable for use in meat, poultry and other food processing equipment, applications and plants. The USDA created the original food grade designations H1, H2 and H3, which is the current terminology used. The approval and registration of a new lubricant into one of these categories depends on the ingredients used in the formulation. The three designations are described as follows:

FGL Grade	Description	Comments	Potential Applications
H1	Lubricants may be used in machinery or equipments where incidental food contact may potentially occur. Such incidental contact is limited to a trace amount: It must not exceed 10 PPM parts per million (i.e., 0.001%), or else the food is deemed unsafe for consumption. H1 lubricant formulations may only contain certain base stocks, additives and thickeners as specified by FDA regulations (21 CFR 178.3750). Usually, when people refer to "food-grade" lubricants, they mean H1 lubricants.	Most of the FGL used in food industry are H1, since the definition of "incidental product contact" could be very subjective for its implication and definitions.	**General – incidental contact** Food-grade Lubricants: This includes lubricants, hydraulic oils and greases used in equipment for cleaning, sanitizing, canning, bottling, blending, chilling, frying, cutting, slicing and peeling, along with pumps, mixers, tanks, hoses, chain drivers, and conveyor belts.
H2	Lubricants can be used in food processing facilities, but only where there is absolutely no possibility of contact with food. Most substances used in lubricant formulations in general are acceptable in H2 lubricants, but there are restrictions pertaining to toxicology and other considerations. For example, H2 lubricants cannot contain carcinogens, mutagens, teratogens, mineral acids or intentionally heavy metals such as antimony, arsenic, calcium, lead, mercury or selenium.	In order to avoid this potential confusion and classification, most of the current FGL are H1.	**General – No Contact** Non-food Contact Lubricants: These products are not intended for use where there is a possibility of food contact, but it may still impact human health. They are not required to meet 21 CFR requirements, however, they do have to conform to Section 5.1 of the NSF Registration Guidelines – no carcinogens, mutagens, teratogens, mineral acids, odorous substances, and no intentionally added heavy metals.
H3	Lubricants may only contain edible oils that satisfy FDA21 CFR 172.860 (such as corn, soybean or cottonseed oils), certain mineral oils that meet FDA 21 CFR 172.878, and oils generally recognized as safe (GRAS) under either FDA 21 CFR 182 or FDA 21 CFR 184. H3 lubricants are typically used to clean and prevent rust on hooks, trolleys and other such equipment.	Under Particular and specific FGL used in limited processes and industries, such as the meat industry.	**Soluble Oils** Food-grade Lubricants: These are typically edible oils that are used to prevent rust on hooks, carts and similar equipment that come in contact with food.

Approval and Compliances for Lubricants

The USDA approvals are based on the various FDA Codes that dictate approval for ingredients used in lubricants that may have incidental contact with food. These are mentioned in the following sections.

1.CFR 178.3570 – Allowed ingredients for the manufacture of H1 lubricants Some information from these standards is highlighted below.

Acceptable Food Grade Basestocks

Depending on whether a food grade lubricant is H1 or H2, the list of approved basestocks will vary. H2 lubricant basestock guidelines are less restrictive and, consequently, allow a broader variety of basestocks. Many products used in industrial (nonfood) plants are also used in food plants for H2 applications. H1 lubricants are much more limited since they are designed to allow for accidental exposure with the processed foods. H1approved lubricant basestocks can be either mineral or synthetic:

Petroleumbased lubricants – Mineral oils used in H1 food grade lubricants are either technical white mineral or USP type white mineral oils. They are highly refined and are colorless, tasteless, odorless and non staining. Technical white oils meet the regulations specified in 21 CFR 178.3620. USP mineral oils are the most highly refined of all white mineral oils.

Synthetic lubricants – Synthetic H1 lubricant basestocks are often polyalphaolefins (PAO). Compared to white mineral oils, they have significantly greater oxidation stability and greater range of operating temperatures. Another approved H1 synthetic basestock is polyalkylene glycols (PAG). These lubricants are more increasingly used in high temperature applications.

Dimethylpolysiloxane (silicones) with a viscosity greater than 300 centistokes (cSt)7 is also permitted for H1 lubricants. Silicones have even higher thermal and oxidation stability than PAO and PAG base oils.

Acceptable Food Grade Additives and Thickeners

Often, basestocks are not able to meet the severe demands required in food processing work environments. To improve the performance characteristics of base oils, additives are blended into the formulation. The types of antioxidants, corrosion inhibitors, anti wear, extreme pressure additives and concentration are limited by 21 CFR 178.3570.

Greases are lubricating oils that have a thickening agent added to the formulation. The approved grease thickeners are aluminum stearate, aluminum complex, organo clay and polyurea. Aluminum complex is the most common H1 grease thickener. They can withstand high temperatures and are water resistant, which are important properties for food processing applications. Prior to 2003, greases with calcium sulfonate thickeners were not designated as H1 by the USDA or FDA but have since been approved.

Selecting Which Machines Require Food Grade Lubricants

Selecting whether to use an H1 or H2 lubricant can be challenging. A lubricant used on a conveyor system running over a food line must be an H1 category oilα however, a conveyor system running underneath a food line may not necessarily be safe to use an H2 oil.

According to the Hazard Analysis and Critical Control Point (HACCP) program, each lubrication point has to be evaluated for where contamination might occur. Most major food producing companies have begun using the HACCP system, but their plans don't always recognize the importance of a lubrication survey. Because H1 lubricants are limited by types of additives and in the past only used mineral oil basestocks, H1 lubricants in certain instances provided less protection and shorter lubricant life. Some H1 lubricant performance can exceed by addition of non food grade lubricants. This is significant in allowing consolidation and avoiding accidental cross contamination of H1 and H2 oils and contamination of H2 oils with food.

Formulation Guidelines

The product shall not contain intentionally added heavy metals, and shall not contain ingredients classified as carcinogens, mutagens or teratogens. For certain types of lubricants, these shall be neutral in taste and odor, and in addition, should be selected according to the use such that the lubricant withstands temporal, chemical, biological, thermal or mechanical stresses without premature degradation or impact to its neutral state.

The evaluation criteria cover three main aspects: food grade lubricants, evaluation requirements and ingredients. The food grade lubricants must comply with the requirements of the draft standard as well as CFR Title 21 §178.3570, and more specifically, sections 172.860 for vegetable oils and 172.878 for mineral oils. Ingredients and/or compounds must comply with 21 CFR parts 182 and 184.

Evaluation requires that the manufacturer or supplier disclose the product name, a qualitative/quantitative identification of all constituents, the Chemical Abstract

Service (CAS) number where applicable, the chemical ingredient names based on the International Union of Pure and Applied Chemistry (IUPAC) rules, suppliers or sources of each ingredient, any prior product approval from a state or country regulatory authority, and any appropriate FDA regulatory reference for each ingredient.

Other Issues Surrounding Food Grade Lubricants

Using H1 food grade lubricants is no replacement to sound design and maintenance. H1 lubricants are still only approved for minimal, incidental contact. If a plant uses food grade lubricants, the FDA limits lubrication contamination to 10 parts per million – that's 0.001 percent. The lubricant certification process does not include lubricant plant audits and sample testing to ensure formulationα it is strictly comparing the formulation to the approved list.

Conclusion

Understanding the differences between H1, H2 and H3 lubricants and making the proper lubricant selection is critical to food safety and machine reliability. Good quality H1 lubricants will meet current and future demands on safety as well as the technical expectation by the equipment designer. The product prepared by such materials safeguards the consumer health and improves food product attributes.

Ultrasound Technology for Dairy Industry

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Introduction

A number of non-traditional preservation techniques are being developed to satisfy consumers demand with regard to nutritional and sensory aspects, convenience, absence of synthetic additives, law energy demand and environmental safety. There is also growing interest amongst consumers to have minimally processed foods. Among various "emerging technologies" such as ultra-high pressure processing, pulsed electric fields, supercritical fluid extraction, microfluidization and ultraviolet light treatment, ultrasonication has been identified as a promising technology for processing specific food materials, including dairy products. Most studies till date have been carried out in a batch mode where small volumes of the solutions are sonicated in laboratory-scale vessels for a defined period of time. However, efficient large-scale continuous flow-through ultrasonic systems have become increasingly available over the last decade. In these systems, the solution is pumped continuously through a vessel containing a sonicating device. The availability of these systems has facilitated this technology to move from the laboratory into fully operational commercial food processes throughout Europe and USA.

Ultrasonication or Ultrasound (US)

Sound waves with a frequency greater than the upper limit of the human hearing range are known as ultrasound (~>18 kHz). Typically, US has a frequency in the range from 20 kHz to 10 MHz, which can be subdivided into three main regions: low-frequency, high-power US (20–100 kHz); intermediate-frequency, medium-power US (100 kHz–1 MHz); and high-frequency, low-power US (1–10 MHz).The frequency range selected for food processing depends on the requirements of the processes. Low-frequency, high-power US uses intensities higher than 1 W/cm^2, which induce strong cavitation effects that influence the physical, mechanical or chemical/biochemical properties of foods. Examples of suitable applications include emulsification and homogenisation. In contrast, high-frequency low-power US uses intensities below 1 W/cm^2 where the physical effects are comparatively gentle and as such can be utilised for processes such as non-invasive analysis and monitoring food materials, and non-destructive separations of multi-component mixtures. The intermediate frequency range is characterised by peak sonochemical effects and as such can be selected to initiate chemical modifications in food systems.

Generation of Ultrasound

The most applicable generation of US is carried out using the principle of electrostrictive transformer. This is based on the elastic deformation of ferroelectric materials within a high frequency electrical field and it is caused by the mutual attraction of the molecules polarised in the field. For polarization of molecules a high frequency alternative current will be transmitted via two electrodes to the ferroelectric material. Then, after conversion into mechanical oscillation, the sound waves will be transmitted to an amplifier, to the sound radiating sonic electrode (sonotrode) and finally to treatment medium.

Mechanism and effect of Ultrasound

When US energy passes through the medium, it produces a continuous wave type motion. Longitudinal waves will be generated which creates alternative compression and expansion of the medium particles and strong vibration of the medium occurs. Such mechanical vibration effects can be used in cleaning and extraction applications. In addition to the mechanical vibration effect, US also generate acoustic streaming with in liquids. During the expansion cycle, high intensity ultrasonic waves make small bubbles grow in liquid. When they attain a volume at which they can no longer absorb enough energy, they implode violently. This phenomenon is known as cavitation. During implosion, very high temperatures (approximately 5000 K) and pressures (estimated at 50000 kPa) are reached inside these bubbles. Many researchers has reported various mechanisms and their effects of ultrasonication which follows as under.

Heating: As a result of specific absorption of acoustic energy by membranes and biomaterials, particularly at their interfaces, a selective temperature increase may take place. Some investigators claim that localized temperature increase of up to 5000 K can be expected for a few nanoseconds in a sound field.

Cavitation: Acoustic cavitation is the formation, growth, and violent collapse of small bubbles or voids in liquids as a result of pressure fluctuation.

Structural effects: When fluids are placed under high intensity sound fields, the dynamic agitation and shear stresses produced affect their structural properties, particularly their viscosity.

Turbulence: High-intensity US in low viscosity liquids and gases produces violent agitation, which can be utilized to disperse particles.

Ultrasound in Dairy Processing applications

The following recent dairy processing applications of US have been reported.

Ultrasonic imaging

There are numerous examples of the use of US as a non-invasive analytical tool in dairy research and analysis. The changes in the velocity and amplitude of the acoustic wave as high-frequency (> 1 MHz) US is passed through a sample provide accurate information on the elastic properties of a material. The use of ultrasonic spectroscopy to monitor the gelation of milk components has been reported. This involved the measurement of the velocity and the attenuation of the ultrasonic amplitude at different frequencies in the processed samples. In order to assess the renneting properties of casein solutions after heat treatment, the use of low intensity US has been reported. Ultrasonic imaging has also been used to study structure development in various cheeses, cut-time in cheese making, the rheological properties of cheese, structural changes in cheese due to heating and cheese maturity.

Ultrasonic degassing, emulsion formation and homogenization

The foaming of dairy solutions during processing can reduce the final product yield and may accelerate oxidative degradation. A 20 kHz pulsed US was used to degas reconstituted skim milk. While gas bubbles were easily removed in < 5 min of sonication, the dissolved oxygen content could not be significantly reduced even after 20 min. More recent research shows airborne US can be an effective approach to foam minimization.

The preparation of very fine emulsions is of increasing interest to the beverage, food and dairy ingredients industry, as this can permit novel oil-soluble ingredients to be added to water-based products with negligible impact on solution clarity and stability. Low frequency US has been effectively used for the preparation of such food emulsions. A particular advantage of the ultrasonic approach is the ease of equipment cleaning relative to traditional homogenizers or the newer microfluidic devices. This assists in the maintenance of an aseptic environment. The comparison of the emulsification efficiencies of ultrasonic and microfluidization techniques has been studied. An oil-in-water Nano-emulsion was prepared using a 24 kHz horn-type sonicator and air-driven microfluidizer operating at 20–124 MPa, the size range of the emulsion droplets were compared. Both techniques were found to generate emulsion droplets in the size range 150–700 nm; however, the ultrasonic method was found to be better in terms of operation and cleaning. US may be a more cost-effective processing option than microfluidization. However, some researchers suggested that ultrasonic homogenization is more energy intensive leading to higher costs. The demonstration of the possibility of incorporating novel food oils into milk systems by ultrasonic emulsification has been carried out. A 20 kHz US horn was used to emulsify flaxseed oil in a volume of skim milk. No addition of surfactants was required to stabilise the emulsion, as it was found that a small amount of partially denatured whey proteins surrounded the emulsified oil droplets, providing sufficient stability for a minimum of 9 days. The advantage of US is further highlighted since no stable emulsions could be produced when emulsification was instead performed with high-energy mechanical mixing (using matched specific energies).

The comparative study of the ultrasonic homogenization of milk at 20 kHz with those of a conventional homogenizer has been carried out. The size distribution of the fat globules after the conventional homogenization process (at 200 bar and 55 °C) was about 2–5 µm. However, the size range of fat globules in ultrasonically homogenized milk samples was much smaller. The mean size and size distribution of the fat globules were dependent on the ultrasonic power and duration of sonication. Many other researcher also observed the similar ultrasonic homogenization effects on fat globules in milk. They observed that the fermentation time of the ultrasonically homogenized milk to form yogurt was significantly reduced due to sonication increasing enzyme activity. In addition, reduced syneresis and improved viscosity of the yogurt were also observed. These latter effects were attributed to increases in the water-retaining casein becoming available as the fat globule membrane surface area increased.

The changes to the microstructure of fat globules in whole milk following thermosonication treatment has been studied. The sonication (24 kHz, 400 W for 30 min) of whole milk at high temperatures (63 °C) resulted in fat globules of < 1 µm with more binding sites on the fat globule membrane favouring the amalgamation of casein and serum proteins, and thus producing an ideal ingredient for cheese making. The observed changes were due to cavitation since heat treatment alone did not show similar changes to the fat globules. The study of rheological properties of the yogurt made from milk subjected to thermosonication resulted in significant improvement of the texture and firmness of the product.

To investigate the particle size reduction of whey protein concentrate (WPC) systems in the presence/ absence of cavitational conditions a 20 kHz ultrasonic horn and a high-pressure homogeniser were used. The particle size reduction in WPC systems under high-pressure conditions showed comparable results when subject to US under similar energy conditions. Notably, cavitation derived shear forces were found to be absent in high-pressure homogenisation. Hence, the study highlighted the fact that the shear forces generated were mainly responsible for the observed particle size reductions even in the absence of cavitational effects. In the case of US application, the shear forces are resultant from strong bubble collapse.

Membrane flux enhancement and milk fouling

Fouling of ultrafiltration membranes is a major issue affecting the cost and efficiency of many dairy manufacturing operations. During the filtration of processed milk and its constituents, a build-up of particles occurs on the filtration membranes leading to membrane fouling, and ultimately reduced throughput in large-scale processing. A detailed discussion on the parameters that affect fouling of ultrafiltration membranes is provided.

US was used in both the production and cleaning cycles of whey ultrafiltration and found that sonication was effective in both cases. US significantly improves membrane cleaning efficiencies. However, it was suggested that the capital and operating costs associated with the application of US for the membrane cleaning cycle alone are unlikely to be economic. More significantly, US was effective in improving production flux values by between 40% and 70%.

The flux rate enhancement during sonication was analysed using the Ho and Zydney's model for combined cake formation and pore blockage. It was found that the pore blockage parameter was not significantly affected by US. However, both the initial deposit resistance and cake growth factors were significantly affected by sonication.

By considering several reports on the effect of US on filtration processes, a number of specific effects generated by ultrasonic processing have been noted: (i) sonication can cause agglomeration of fine particles, thus potentially reducing pore blockage and cake compaction; (ii) the turbulence associated with US can be used to separate physical aggregates of proteins by disrupting the intermolecular forces; (iii) the asymmetric collapse of cavitating bubbles can scour surfaces and this leads to removal or control of the fouling cake layer; and (iv) acoustic streaming and/ or cavitation causes turbulence which results in bulk water movement near the membrane surface, which reduces the effects of concentration polarization and thus increases the mass transfer coefficient at the membrane surface.

US can be used effectively in reducing whey protein fouling in processing equipment. The study of the fouling of a heat transfer surface with milk in the presence and absence of US was found to be effective in two ways. Firstly, the convective heat transfer coefficient was enhanced which led to a lower heating surface temperature for a constant heat energy input. This lower surface temperature resulted in reduced fouling. Secondly, even when the surface temperature was fixed, fouling was delayed when sonication was used, probably due to scouring and acoustic streaming effects at the surface. Other workers have reported the use of US for cleaning cheese molds.

Spray drying using ultrasonic atomization

Atomizing devices provide a high surface-to-mass ratio during the spray drying of dairy products, enabling rapid heat transfer and high evaporation rates. The two most common atomizing devices used in dairy applications are centrifugal (rotary) and pressure (nozzle) atomizers. However, ultrasonic atomizers offer a viable alternative. In this case, it is important to distinguish between ultrasonic nozzles that produce an aerosol by passing a liquid feed through a vibrating horn and ultrasonic nebulizers that operate at higher ultrasonic frequencies and generate a "fountain-like" structure in a thin liquid film. The droplet sizes produced by an ultrasonic nebulizer are an order of magnitude smaller than that which is available from an ultrasonic nozzle. While ultrasonic spray driers containing nozzles are available for large-scale operations, ultrasonic nebulizers have not yet been developed for large-scale industrial use. Both devices have the technical advantage over classical spray-drying atomizers in that they produce a spray at a much lower velocity. This means that the spray chamber required for drying can be much smaller. While these devices would appear to offer much promise for spray-drying applications.

Sonocrystallisation

Sonocrystallisation is the use of power US to control the crystallisation process commonly used during the nucleation phase of crystallisation. Rapid sonocrystallisation for lactose recovery in the dairy and food industry relies on different aspects of US. The crystallisation of biological soft materials with the use of US plays a key role in controlling the crystal structure, shape and rate of crystallisation. US is a promising tool for rapid crystallisation of food materials, which will increase the efficiency of some traditional processes, leading to cost effectiveness. Some of the interesting dairy applications for sonocrystallisation follows.

Lactose Crystallisation

In the dairy industry, liquid whey is spray-dried to manufacture WPC as a means of utilising whey waste streams. In liquid whey, lactose is the most abundant component. However, its presence restricts the spray-drying abilities. The removal of lactose by crystallisation is hence an important process that is required prior to spray drying liquid whey.

Conventional methods for lactose crystallisation are, however, laden with issues such as long induction times and slow crystallisation rates. A rapid recovery of lactose by US assisted crystallisation has been reported recently. In one study, the whole process of lactose sonocrystallisation was rapidly completed from reconstituted lactose solutions in the presence of ethanol as an anti-solvent at 30 ± 2 ^{0}C. The lactose recovery was much higher (91 %) in the case of sonicated samples when compared to non-sonicated (14 %) samples at the end of 5 min. As US travels throughout the crystallisation vessel, it mixes the anti-solvent uniformly in the lactose solution. Cavitation events are also likely to be increased due to the lowering of the vapour pressure of the solution as a result of the addition of ethanol. This causes a sharp decrease in the local solubility of lactose. The solution reaches super saturation, causing nucleation and rapid lactose recovery.

Similarly, sonocrystallisation for lactose recovery from whey waste streams was studied which reported with yields in the range of 80–92 % within 4 min of sonication. A recent pilot-scale study focussed on crystallisation of lactose in whey systems using a non-contact approach at flow rates of up to 12 litre per minute, where lactose was concentrated to 32 % prior to sonication at 30 ^{0}C. The rate of sonocrystallisation was faster compared with mechanical stirring for processing durations of approximately 120 min. The investigation on the effectiveness of US in enhancing the crystallisation process of lactose in aqueous (i.e., non-solvent) systems has been carried out. In the study, US with a frequency of 20 kHz was applied using an ultrasonic probe to the lactose in water solutions maintained at a constant temperature of 22±1 ^{0}C. The variables that significantly (P>0.05) affected the responses were found to be the lactose concentration and amplitude, with concentration being the most significant. The sonicated sample at the optimal sonication conditions led to nucleation rates 10.6 times higher and yields 5.6 times higher compared with the control.

Fat Crystallisation

There has been considerable interest in the application of US with regards to crystallisation of fats within the food industry. The crystal size and shape of fats within a product play a significant role to the texture and mouth feel. Within the dairy industry, controlling fat crystallisation is a key factor governing the structure and texture of secondary dairy products. Examinations of pure triacylglycerides (TAG's), confectionary fats, vegetable fats and milk fats indicate that US affects the rates of polymorph-dependant crystallisation, crystal size and morphology. The study shows that the use of US as an additional processing condition decreases induction time of crystallisation, generates smaller crystals and higher viscosities of anhydrous milk fat. However, the degree of super cooling and US settings influenced the degree of US effect on the crystallisation to a great extent. The studies reviewed above indicate that US affects the crystallisation behaviour of fats in many ways.

The fact that US irradiation is an effective tool for controlling polymorphic crystallisation of fats and reducing induction times. Furthermore, a range of crystal structures can be controlled. This means it is possible to tune the desired texture conditions for a particular dairy product. However, the US induced cavitation that produces free radicals appears to have restricted the use of sonocrystallisation for systems containing fats and oils, which are susceptible to oxidation by free radicals. The formation of off flavours prevents using US as a viable choice for fat crystallisation in dairy systems. On the contrary, one report indicates that sonication at 66 kHz did not cause any off flavour production due to oxidative changes to palm oil. The results indicate that the optimum conditions for obtaining small crystals in the shortest time period are just below the cavitation intensity threshold.

Ice Crystallisation

For a desired creamy mouth feeling within the frozen product like ice cream, the ice crystals are required to be as small as possible. When US is applied during the crystal growth phase, fragmentation of large crystals under acoustic stress will occur and lead to crystal size reduction. It has been shown that during freezing of ice-lollipops, the ice crystals that were formed with the application of US were significantly smaller and distributed evenly across the product. The resulting product also adhered more strongly to the supporting stick. But at the same time, smaller crystals made the product harder and difficult to bite.

Ice-cream contains up to 50 % by volume of entrapped air. Ultrasonic degassing can occur during the application of US, and this process can result in undesirable modifications to the ice-cream texture. This issue has been overcame by increasing the initial gas content so that the proportion of air lost due to US can be compensated. But the question that remained unanswered was how much extra air needs to be added to obtain the desired texture. Therefore, unique approaches and conditions are needed for each and every product for obtaining desired textures.

Further, high-intensity US may lead to fat oxidation. Despite the favourable effects of sonication on the crystal structure, the aforementioned effects (degassing and fat crystallisation and oxidation) can lead to off flavours and improper textures in ice-creams. However, by keeping the cooling regime constant, it has been found that the structure of the crystallised product can be adjusted by varying the ultrasonic intensity. One study found that application of 20 min pulsed US resulted in the best sensory flavour, texture and mouth feel evaluations of ice-creams. Flavour and texture of samples prepared with 5 and 20 min time also had better mouth feel than the control. Hence, the conditions need to be carefully monitored in using US on ice cream applications.

Conclusion

Ultrasonics is a relatively new field of endeavour in dairy research and development, the availability of industrial scale or even pilot scale ultrasonic processing equipment is still quite limited. This may hinder adoption of the technology in the short term, but experience with the development of US technology in other industries suggests that this issue could readily be overcome once the economic advantages of US use are clearly demonstrated. In the dairy industry at present, the best opportunities for adoption of this technology would seem to be either as an adjunct process in an existing processing line or as a way of developing a new or improved functionality in a relatively low volume/high value dairy ingredient stream.

Achieving Excellent Dairy Technology Education

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Introduction

The Indian Dairy cooperative structure has a huge contribution in raising the milk production in the country upto 146 million tonnes in the year 2014-15 from a meagre milk production of 17 million tonnes in the year 1951. The per capita availability of milk in the country has reached about 315 gms /day. Further, milk is the largest agricultural crop in India with market value exceeding Rs. 4 lakh crore per annum and the milk group contributes the highest to the total output of our agricultural sector, surpassing the output value of wheat, rice and oilseeds. GCMMF's brand "AMUL" is the "Largest Fully Integrated Food Brand" of the country. In the year 2014-15, it has touched a whopping Rs. 20,733 crore, a 14% increase from previous year's turnover of Rs. 18,143crores.

Dairy Science Education in India

Highly motivated technical and non-technical manpower are the backbone for any rapidly growing organisation. Hence the supply and demand of quality manpower in any sector are of prime importance.The following table shows the institutes imparting dairy science education in the country with their intake capacity.

Table No.1 Dairy Science and Technology Colleges in India

Sr. No.	Name of the College	University	Intake capacity
Western region			
1	SMC College of Dairy Science Anand, Gujarat.	Aanand Agricultural University, Anand	65
2	College of Dairy Science and Food Technology,	Sardar Krushinagar Dantiwada Agricultural University, Dantiwada,Gujarat	40
3	Dairy Science College, Amreli, Gujarat	Kamdhenu University, Gujarat	40
4	Mansinhbhai Institute of Dairy & Food Technology (MIDFT), Mehsana	Affiliated to Kamdhenu University, Gujarat	40
5	College of Dairy & Food Science Technology	Maharana Pratap University of Agriculture and Technology Udaipur, Rajasthan	25
6	College Of Dairy Technology	Covas Campus, Kavalkhed Road, Latur, Udgir, Maharashtra	32
7	The College of Dairy Technology,	Warud (Pusad) Distt. Yaovatmal – 445 204, Maharashtra.	32
Northern region			
11	National Dairy Research Institute, Karnal	NDRI, Karnal (Haryana)	47
12	College of Dairy Science and Technology	Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana	33
Eastern region			
8	College of Dairy Technology, Raipur, Krishak Nagar	Indira Gandhi Krishi, Vishwavidyalaya (IGKV), Raipur, Chhattisgarh	43
9	Sanjay Gandhi Institute of Dairy Technology	Rajendra Agricultural University, Pusa, Samstipur, Bihar	25
10	Faculty of Dairy Technology	West Bengal University of Animal & Fisheries Sciences (WBUFS), Kolkata	25
Southern Region			

Sr. No.	Name of the College	University	Intake capacity
17	Dairy Science College	Karnataka Veterinary Animals & Fisheries Sciences University, Hebbal, Bangalore, Karnataka	25
13	Institute of Food and Dairy Technology	Tamil Nadu Veterinary and Animal Sciences, , Koduvalli, Chennai	20
14	College of Dairy Science & Technology	Kolahalamedu Mannuthi Agricultural University, Mannuthi, Thrissur, Kerala	25
15	College of Dairy Technology, Chittoor	Sri Venkateswara Vetrinary University, Tirupati, Andhra Pradesh	25
16	Dairy Technology Programme, Kama Reddy	Sri Venkateswara Vetrinary University, Nizamabad Dist.,Tirupati	25
	Total		**567**

As indicated above, the total intake capacity for B.Tech (D.T/D.F.T) is 567. Considering the dropout, failure, etc. of the students; it is likely to have about 500 students be made available to serve dairy fields such as cooperative plants, public and private dairies, entrepreneurs, teaching profession, government / private administration, consultancy, etc.

Dairy technologists of poor quality and Quantitative expansion brings the following disadvantages.

(a) **Educated Unemployed:** An unemployed educated person results in waste of resource produced by the education system. It is finally a lose - lose situation for all.

(b) **Lowering of salaries**: As more candidates are available for a given job, the employer tends to exploit the situation by offering lower salaries to the candidate. This is very de- motivating to the bright students.

(c) **Shifting Abroad**: With the lack of opportunities in the domestic country, it is possible that candidates / graduates may start moving to foreign countries in search of a decent job. It also leads to the brain drain of skilled manpower of the country.

(d) **Shifting to other disciplines**: It is also a side effect of over production of graduates in specific field which cannot be absorbed in the same field.

(e) **Ultimate devaluation of Degree**: This may arise in the event when due to overproduction, overqualified candidates start offering themselves for posts requiring only the basic degrees, e.g. Ph.D. and M. Tech qualified candidates applying for a job which is requiring only a fresh graduate.

Therefore there is a need to have an appropriate number of intake capacity and to give them the best teaching/ practice/work experience, etc. at the college itself, so that, they are more valued and immediately get employed in the dairy field with good status and perks. For this, it is required that each and every Dairy Science College should achieve an excellence in Dairy Education.

Achieving Excellence in Dairy Education

Following are some important measures to be taken care of for achieving excellence in Dairy education.

(a) Experiential learning course

The paradigm shift of the dairy education in India indicate that the employers in the dairy industry prefer to recruit candidates who have practical experience of handling/operating various dairy plant operations and equipment. Along with SMC college of Dairy Science, Anand; few other colleges of India have effectively responded to the demand of these employers to take care of quality education by introducing an experiential learning course in the syllabus of the B.Tech. (Dairy Technology) programme. This training boosts the confidence of students and imparts the skills necessary to handle all the dairy operations effectively. The experiential learning course, at commercial dairy plant be offered for effective learning by dividing students into different groups of five to six students in each group. Each group may undergo hands –on training for a period of about one month in different modules viz. Milk Processing, Cleaning-in-place (CIP), Milk Packaging, Cheese and Fermented Milks, Ice cream, Butter and Ghee , Quality Assurance, Engineering Services and Plant Maintenance, Shoppe (a retail outlet of the Dairy), administration, Marketing and Dispatch and MIS, Automation and House Keeping.

At the end of each semester, the performance of students be evaluated.

(b) Application of ICT tools Used to improve Dairy Science Education

ICT tools	For Dairy Science Education
1. Interactive video	• To show Video Clipping to students for interactive learning. • It is easy to provide relative information. • In Dairy Technology it is very useful to solve the problem.
2. Video Conferencing	• It is very useful technology for students for one way or two way interactive learning. • Helps for Direct interaction with the concern person to solve the query of students. • One Student can ask questions and all others are benefited. Hundreds of students interact with speaker at a time.
3. Audio conferencing	• Very effective way now a days to train the students by conferencing. • It saves manpower and improves the effectiveness by two way audio conferencing helps to Interact with Industrial person by students for practical solution.
4.Teleconferencing conferencing	• Teleconferencing is used in both formal and non-formal learning contexts to facilitate teacher-learner and learner-learner discussions, as well as to access experts and other resource persons remotely.
5. Multimedia	• Useful in Dairy Business management for Information delivery. • Video and animated version of all the process can be shown which is used in Dairy science in different courses.
6. Internet	• Information can be made available to the students round the clock. • All division of Dairy Science will use as much as possible the Multimedia for better result in Searching and get well updated with the today's world.
7. e-mail	• Providing information at the right time for students and also for Faculties. • It is must now a days to use this application and connect with people over the world. • Faculties also send the documents, papers and all material to students on one click and make it available for the years to save it in the email.
8. website	• To provide some good web sites to students to refer all material including good research done by the researcher. • Students can easily find whatever they need for studies
9. Mobile phone	• Now a days it is the most significant tool used by the student. The power of mobile technology is used by the today's generation is very well. • Students can get advantages of mobile phone to get material from faculty. • Students can also watch video clip and animated clip on phone. • Faculties and students remain in touch with each other. • Any time student get assisted by faculties by some good application alike Twitter, What's up, Yahoo messenger, Facebook Messenger and all.

(a) Recognition as IIDT: The status / level of, reputed and well established colleges with a proven track record, should be raised to national and international levels by recognizing them as **Indian Institute of Dairy Technology (IIDT)** , in line with the IITs and IIMs. e.g. There is a strong case for SMC college of Dairy science to raise it to IIDT considering its proven track record, location in the Milk city, proximity to important organisations like AMUL, GCMMF, NDDB & IRMA.

(b) Disclosure of placement record and infra-structure facilities: Points pertaining to the qualitative aspects of education should be mandatorily be disclosed before the aspiring candidates so that they can take an important decision regarding their careers.

(c) e-courses: In order to benefit the students by the revolution in the Information Technology sector, reputed colleges of India having competent faculties have prepared the e-content under NAIP project of ICAR for all its B.Tech (Dairy Technology) courses, which can be accessed by the students at any time. The e-courses prepared by the colleges are rich in content, diagrams, animations, graphics etc and hence are very useful to the students. The e-content of all the subjects of B.Tech (Dairy Technology) prepared and made available by ICAR through national server as well as off-line CDs, be utilised by all colleges. At present ICAR has also decided and initiated to prepare e-content for post-graduate course of few disciplines of Dairy Science. Similarly it would be also of great interest to the students, teachers and colleges, if *e- content is prepared to conduct minimum practicals to be carried out, both at Under Graduate and Post Graduate levels for all disciplines of Dairy Science*.

(d) Issues related to – degree, staff, students, admission, administration, etc.

(i) Degree related :

- **Non- uniformity in Degree Nomenclature:** The degrees offered by various dairy science colleges differ in the nomenclature only, e.g some colleges give B.Tech (Dairy Technology) while some use B.Tech (Dairy and Food Technology). It creates problem for the students when they desire to seek admissions in Post Graduate programmes.
- **Degree recognition by AICTE**: The B.Tech (Dairy Technology) degree is approved by the UGC and ICAR but not recognized by the AICTE even though the course is in line with engineering college.
- **Staff/ Faculties:** It would be of great interest, if minimum staff members be recruited by the concerned colleges as per the ICAR guideline, to import quality education.

(ii) Admission related:

- **Filling up of multiple admission forms:** With the increasing number of Dairy Science Colleges of both the SAUs and self-financed, the candidate seeking admission to dairy science course has to fill up application forms at more than one college and also undergo the admission procedure at different locations. This causes unnecessary monetary burden on the candidate. It is advisable to have a common admission procedure for all Dairy Science Colleges.

Conclsuion

It will be highly efficient and more advantageous to use ICT tools viz. Smart classroom, Interactive video, Video Conferencing, Audio conferencing, Multimedia, Internet, Mobile phone applications, e-course, experiential learning etc., for achieving excellence in Dairy Science Education. However, it can be made more attractive and career oriented, if there is uniformity in degree nomenclature, degree recognition by AICTE, admission to the course by AIEEE score, minimum infrastructure facilities to teach the course along with teaching and supporting staff facilities as per ICAR guidelines.

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Dairy waste water treatment by Membrane systems-Possibility of reuse

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Introduction

Water reuse is the greatest challenge of the 21st century. It is the only solution to close the loop between water supply and wastewater disposal. The gradual banning of wastewater discharge into the natural resources of water, primarily the rivers (Ahmed *et al.,* 2001) due to environmental protection agencies have imposed more stringent regulatory prohibitions. This has made the water treatment more expensive and to comply with the discharge quality standard itself, is becoming a huge burden for the industries (Sarkar *et al.*, 2006) Thus, water reuse has become an environmentally and economically feasible solution for industries. The practice of reusing effluents can improve the industry's image in terms of environmental impacts and raise its profits.

In dairy industries, water is a key processing medium. Water is used throughout all processing steps of the dairy industry including cleaning, sanitization, heating, cooling and cleaning of external areas as a result, the water requirement is huge (Sarkar *et al.*, 2006). Moreover, the liquid effluents generated through dairy product production exhibit high concentrations of organic matter, fats, suspended solids and nutrients. These are considered to be the main sources of pollution in this industry. Dairy industry effluents are generally treated using biological and physico-chemical methods. Among these methods, membrane processes have been shown to be convenient for wastewater treatment. Membrane treatment of dairy wastewaters could simultaneously lower the total water consumption and the effluent production of the dairy plant by recovering milk components present in wastewaters (lactose, proteins) and producing treated water (Vourch *et al.*, 2005).

Waste water sources in dairy industry

The dairy industry is water intensive and uses large quantity of water for different operations including cleaning (cleaning silos, tanks, homogenizers, pipe sand, heat exchangers other equipment), sanitization, heating, cooling and floor washing etc. which ranges from 1 to 3 liters for processing a liter of milk and generates large quantity of effluent about 2.0 to 2.5 liters of wastewater per liter of milk processed (Kavitha *et al.*, 2013). It is estimated that about 2 % of the total milk processed is wasted into drains (Munavalli and Saler, 2009). In the dairy industry, some amount of wastewater gets produced during starting, equilibrating, stopping, and rinsing of the processing units (flushing water, first rinse water, etc.). These process waters, which contain diluted fractions of the dairy products, significantly contribute to the non accidental losses of milk or dairy products and to the total waste water production.

Membrane processes

There are five types of membrane processes, which are commonly used in water and wastewater treatment are Micro Filtration (MF), Ultra Filtration (UF), Nano Filtration (NF), Reverse Osmosis (RO) and Electro Dialysis (ED). These methods are very promising where product recovery is feasible and produce high quality effluent suitable for direct reuse. General advantages by membrane processing are increase the quality of outlet wastewater, reduced energy consumption, reduced mass transfer, high efficiency and ease of use.

Membrane applications to treat/recycle dairy waste

Nonetheless one single membrane operation is insufficient for producing water of composition complying with the requirements for drinking water. Because of the high COD level of the dairy process waters and despite high rejection of lactose, COD and milk ions, concentration in permeate remained too high even with reverse osmosis membranes. Among available technologies for wastewater treatment, membrane technology, especially NF and RO have been often considered as a promising method because it can permit both water reuse and protein and lactose recovery in the same operations (Sarkar *et al.,* 2006; Luo *et al.,* 2010a).

Bennani *et al.*, (2015) investigated the treatment of dairy wastewater using UF and more than 99% of retention rate was observed for turbidity and BOD_5, above 80% for suspended matter and 95% for proteins. Moreover, a reduction of 40 and 55% was recorded for conductivity and the total dissolved salts, respectively.

A dairy effluent model solution was treated by NF and RO process. The higher permeate quality was obtained with RO membranes that shown lactose rejection was 97 % and 95 % for NF membrane for model effluent solutions of skim and whole milk, respectively and 99.9% for RO membrane. Rejection of mineral salts was 62-63% for NF and 98-99% for RO, the low mineral content of RO permeate makes it possible to be reused in the dairy industry for washing floors and the outside of plant vehicles (Kyrychuk *et al.,* 2014).

A combined UASB-MBR system was developed to treat dairy wastewater to join the advantages of the methanogenic and reusing of dairy waste water. The average total and soluble COD removal rate in final water were above 95% and 99% respectively with an average methane content of 73% biogas production. (Sánchez, 2013**)**

Chen and Liu, (2012) investigated the possibility and applicability of MBR hybrid system with coagulation in reclaiming dairy wastewater. The results shown that polyaluminium chloride as the appropriate coagulant was effective for turbidity removal before membrane treatment application. The final water quality was as follows, turbidity of 0.01–0.26 NTU, COD of 5.07–8.8 mg/L, aluminum of 0.03–0.07 mg/L and chloride of 16–22 mg/L.

Luo *et al.* (2011) demonstrated that the two stage UF and NF treatment of dairy wastewater was a viable and promising method to recycle water and nutrients for production of bioenergy. In first stage, protein and lipid were concentrated by the Ultracel PLGC UF membrane and could be used for algae cultivation to produce biodiesel and biofuel. The permeate from UF was concentrated by the NF270 membrane in the second stage to obtain lactose in retentate and reusable water in permeate, while the NF retentate could be recycled for anaerobic digestion to produce biogas.

NF applied to ultrafiltrate of whey has a twofold purpose; recovery of lactose from the retentate and reduction on volume of wastewater required to be treated at the plant since the nanofiltrate can be discharged directly into the sewer (Atra *et al.,* 2005; Cuartas-Uribe *et al.,* 2009).

Purified water complying with drinking water criteria could be achieved by a two-stage RO + RO process treatment of dairy effluents (Vourch *et al.,* 2005; Frappart *et al.,* 2008).

Treatment of the dairy wastewater was carried out by RO until 90-95 % water recovery to attain a removal rate of above 99.8 % for TOC and above 99.5% for lactose, 96% for nitrogenous matter and 95% for multivalent ions and 87% for monovalent ions. Final demonstrated that quality of purified water was similar to vapour condensates from dairy processing (Vourch *et al.* 2008).

Dairy effluent model solution i.e. diluted skimmed milk (dilution of 1/3) was treated by NF and RO results were shown that COD removal was 99 %, Lactose removal was 98.2-99.9 %, divalent cations removal was 90 % and reported that permeate COD levels were significantly higher than the threshold acceptable for human consumption water due to high initial load of effluent (COD α 36 g/L) and final water quality was close to vapour condensate issued from milk and whey drying steps so only a two stage filtration treatment (very likely NF + RO or RO + RO) would be able to provide reuse of dairy waste (Balannec, *et al.* 2005).

Turan, (2004) investigated the influence of filtration conditions on the performance of NF and RO membranes for dairy wastewater treatment, in which RO and NF membranes showed excellent performance by removing at 99.7% and 98% of the COD, respectively along with the performance evolution.

Chmiel *et al*. (2000) shown that low contaminated vapour condensate from milk processing treated by NF and RO can produce reusable water.

Reusable quality water was produced by MBR (Membrane Bioreactor) system with pre and post treatments of chemical precipitation and RO system respectively followed by UV and sodium hypochlorite dosing disinfection steps and up to 50% recovery rate was obtained by single pass or 70% recovery with a two pass RO system with an average of 97% COD removal and 95% nitrogen removal rate was obtained in final water quality (Chapman et *al.* 2000).

Recovery of CIP solutions

Among the potential techniques to eliminate soils particles from caustic cleaning solutions used in dairies, membrane technologies were the most extensively studied. The effectiveness of CIP coupled with MF (Tragardh and Johansson, 1998), UF (Dresch, 1998) and NF (Suárez *et al*., 2012) operations was demonstrated for both ensuring the recovery of NaOH solutions and reducing the load of industrial solutions discharge. MF was found to retain less surfactants compounds and provide a less expensive technology than UF and NF. However, it results in higher COD concentration in the recycled caustic solution by these membrane processes (Gésan-Guiziou et al., 2007). According to some authors (Merin et al., 2002; Alvarez et al., 2007), as recycled cleaning solutions had a lower cleaning efficiency compared to newly prepared one.

Membrane fouling

Fouling is a major problem in the efficient operation of membrane treatment plants. It forms as a result of the attachment, accumulation, or adsorption of foulants onto the membrane surface and/or within the membrane pores, which causes a decline in permeate flux over time. Membrane lifetime and permeate productivity are primarily affected by concentration polarization and fouling at the membrane surface. Fouling by particles will depend on several factors including the type of membrane used and the membrane properties, nature and characteristics of the particles, that is, size, size distributions, surface properties (e.g., hydrophobic/hydrophilic and zeta potential), type of particles (e.g., inorganic/organic, aggregates), and mode of operation.

Control of membrane fouling by advanced treatments

In order to increase the permeate flux and membrane life time, some of advanced treatments were developed to control the membrane fouling these are as follows,

A) Surface coatings of membrane materials such as use of Poly-An surface and C3M (complex coacervate core micelles) coating, B) Vibration enhanced membrane separation, C) Cleaning methods such as sponge ball cleaning, CO_2 back permeation, osmotic backwashing with hypersaline solution and ultrasonic cleaning and D) Electric fields and Magnetic fields (Ebrahim, 1994; Al-Amoudi and Lovitt, 2007).

Conclusion

Membrane processes to be convenient to treat dairy wastewater for recovering of milk components present in wastewaters and producing reusable water. The significant improvements in reliability and cost effectiveness of membrane technology have increased the reuse probability and recycling extent of dairy wastewater. In contrast, reuse of treated effluent should be encouraged for replacing the water in cooling towers or boilers and for good manufacturing practices such as washing the floors and external part of trucks and rinsing outside areas in dairy industry.

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Predictive Modelling: An Emerging Application in Dairy Industry

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Introduction

Most dairy industry manufacturing processes are now high capacity continuous and need for a high level of process control during manufacturing. To be able to control an industrial process, it is necessary to know the relationship between raw materials, process settings and end product results. Measured input parameters can be mathematically modelled to end product attributes without any prior knowledge or hypothesis of their contribution to those end product attributes. Predictive modelling methodologies such as white box modelling (a mechanistic or first principle approach), black-box modelling (e.g. artificial neural networks (ANNs) where training data sets can be used to build predictive models for target responses), or hybrid models (grey box models) that combine the benefits of a first principles approach of white box models and the database approach of black box models are providing efficient ways to study the complexities of interactions in the manufacture of dairy products. The use of statistical modelling methodologies allow the study of multiple factors simultaneously, neural networks and fuzzy logic systems are also able to self interpret data presented to them after appropriate training of the application. The use of predictive modelling methodologies has assisted in the design and maintenance of dairy process line equipment and dairy manufacturing processes, resulting in significantly enhanced process efficiency in the production of an array of dairy products.

Predictive modelling and control of dairy product manufacturing

Most industrial dairy manufacturing processes are now continuous and high capacity plants so receives raw material throughout the year, resulting in a need for a high level of process control during manufacturing. The use of predictive modelling methodologies has assisted in dairy manufacturing processes, resulting in significantly enhanced process efficiency in the production of dairy products.

1. Pasteurization

Predictive modelling has been used in the dairy industry for determining the keeping quality of raw milk and pasteurized products.

Generalized predictive control has been applied to a milk pasteurization process in order to improve pasteurization temperature control using a nonlinear ANN based model (Khadir and Ringwood, 2003a, 2003b). Predictive modelling of Enterobacter sakazakii inactivation in bovine milk during HTST pasteurization has been described (Nazarowec-White, *et al.,* 1999) and further work from the same group has shown that predictive modelling of the inactivation of bovine milk alpha-L-fucosidase in HTST pasteurizer can be used as an indicator of thermization of milk for cheese making (McKellar and Piyasena, 2000). Statistical process modelling and monitoring have been alaso applied to HTST pasteurization (Negiz, *et al.,* 1998).

2. Cheese manufacture

Predictive modelling of cheese manufacturing processes have focussed on cheese yield and starter culture performance specific compositional parameters (e.g., salt), syneresis of cheese curd and measures of quality control from vat parameters.

Predictive modelling has been successfully used to predict the pH of cheese curd and moisture at various stages during the cheese making process (Paquet, *et al.* 2000). A model has also been developed for the amount of cheese fines (a yield loss parameter) of cheese making (Jorgensen and Naes, 2004). Burke, (2006) has recently addressed two mathematical programming models for standardization of cheese milk. Mathematical modelling of syneresis of cheese curd has also been carried out (Tijskens and De Baerdemaeker, 2004). Chemometric models have been developed for the prediction of moisture and inorganic salt content in cheese manufacture (Fagan, *et al.,* 2005). A batch fermentation model of Lactococcus taking into account the effect of pH has been described (Carcoba, *et al.*, 2004).

3. Milk powder manufacture

Recent advances in the understanding of process mechanisms and product properties are allowing model based process control strategies to be developed for the manufacture of milk powder.

Mathematical model has been developed to predict milk powder quality (Birchal, *et al.,* 2005). An interactive computer model has been used to determine relationships between the energy consumed by the drying process, process parameters, properties of the raw material and powder produced in a two stage dryer for dairy products (Straatsma, *et al.*, 1991). To predict the heating behaviour in milk powder deposits, a mathematical model describing self heating in low moisture solids has been developed (Chong and Chen, 1999).

Predictive modelling of dairy product quality

1. Predictive microbiology

Predictive growth models can be used to predict the shelf-life of products at any point from processing to purchase.

The predictive performance of a modelling approach has been applied to the growth of L. monocytogenes and Salmonella in pasteurized milk (Bovill *et al.,* 2000) and during ripening of camembert cheese (Liu and Puri, 2005). Predictive modelling of growth of L. monocytogenes has been determined based on NaCl, pH, storage temperature and $NaNO_2$ (McClure, *et al.,* 1997). Predictive models of the effect of temperature, pH and acetic and lactic acid on the growth of L. monocytogenes in a variety of foods, including milk and dairy products have been developed (George, *et al.*, 1996). Mathematical models have also been developed for the growth kinetics of several lactic bacteria useful as starter cultures for ewes cheese production (Olivares, *et al.,* 1993). The effect of water activity on the colony growth of Penicillium roqueforti has been studied by predictive modelling techniques (Valik, *et al.*, 1999). A mathematical model has been developed for prediction of profiles of viable numbers of Bif. lactis and Lb. acidophilus in cheese by the time of consumption (Gomes, *et al.,* 1998). A mathematical model has been developed to describe the growth and death of the yeast Kluyveromyces fragilis in cheese whey under aerobic batch fermentation (Mansour, *et al.,* 1993). Predictive modelling of the combined effect of low temperature, water activity and pH on the activity of bacterial lipases has been developed in milk (Braun and Fehlhaber, 2003).

2. Prediction of sensory attributes

Predictive modelling has also been used successfully to predict the effect of variations in processing and storage conditions on cheese ripening (via the NIZO-Premia software tool) and the development of cheese flavour (via the use of hybrid (grey-box) modelling) (Verschueren, *et al.,* 2002). Response Surface Methodology has been used to study the effect of whole milk powder, soluble soy solids and cheese whey solids on flavour of formulated puddings. The response, using a non-structured hedonic scale, showed a mathematical model that was statistically significant and had a good predictive value for optimal formulation (Dasilva and Decastro, 1992).

Predictive modelling of dairy product functionality

While most studies on predictive modelling have been focussed on final dairy product composition, there is now growing number of studies using such methodologies to predict dairy product functionality (e.g., texture, stretchability, etc).

A numerical model to simulate flow inside a deep channel twin screw cheese stretcher has been developed (Yu and Gunasekaran, 2005). A mathematical model has been developed to quantitatively analyse the rheological data of rennet casein gelation at different cooling rates (Zhong and Daubert, 2004). A mathematical model has also been developed for water diffusion during brining of hard and semi hard cheese (Luna and Chavez, 1992) and in a white cheese during short term brining (Turhan, 1996) and long term brining (Turhan and Kaletunc, 1992) at different temperature. Mathematical models have also been described for water and salt diffusion during cheese ripening (Simal *et al.,* 2001). A mathematical model has been developed to know salt penetration in finite cylindrical cheeses (Zorrilla and Rubiolo, 1991). Regression modelling has been used to define the patterns of organic acids during early ripening of cheddar cheese by mathematical equations (Lues and Bekker, 2002). Mathematical models of pizza baking by forced and natural convection heating methods have been developed for describing heat and mass transfer phenomena (Dumas and Mittal, 2002).

Conclusion

From a research viewpoint, studying the effects of large numbers of compositional variables of ingredients, production process variables and the post manufacturing effects of product ripening and changes in product functionality during storage is extremely complex. Adequately studying of composition, physical functionality and sensory attributes of dairy products using traditional experimental strategies, such as step changes of input variables would be prohibitively time consuming as well as expensive. So the use of predictive modelling methodologies is providing increasingly efficient ways to study the complexities of interactions in dairy products.

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Impact of ICT Tools in Dairy Industry

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Introduction

Dairy sector is one of the fastest growing sector in India. With the advancement in dairy indusrty total production of milk is increasing day by day thus there is need to handle such huge ammount of milk and its a herculian job to perform. Here comes the role of ICT tools to perform various function related to milk collection and processing upto it reaches to the consumer.Demand is increasing day by day as the population is increasing rapidly. There are various stages through which milk reaches to the consumer, thus there are chances of its quality being deterioates occurs at each stages right from the production, collection, transportation, storage, processing packaging till it reaches to milk selling units. Moreover milk is perishable product thus need to be handle as soon as possible and efficiently. Its our prime duty to ensure the comsumer about safe and nutritious milk.

Here the role of dairy engineer to develop new system using ICT tools which maintain the following activites. Speeding up the data processing activities and maintaining the quality of milk and milk product computer based information system and process controlled machine helped alot much. And reduce down the human efforts. Various computerised operations like receiveing milk at dock yard, checking its quality instantly, timely payment to producers, monitoring manufacturing processes labour efficency FSSAI standards of milk product, tracking employees record etc. Have sown tramendous emprovement and impact of it on end users. In dairy industry use of ICT tools in various department like milk collection, processing, storage departmemt and engineering section.

The Concept of ICT

Agbetuyi and Oluwatayo (2012) stressed that ICT is the term used to describe the tools and processes to access, retrieve, store, organize, manipulate, produce, present and exchange information by electronic and other automated means. These include hardware, software and telecommunications in the forms of personal computers, scanners, digital cameras, handhelds/ PDAs, phones, faxes, modems, CD and DVD players and recorders, digitalized video, radio and TV and programs like database systems and multimedia applications. The term is often used in plural form (ICTs) to mean a range of technologies instead of a single technology. It represents a broad and continually evolving range of elements that include the television (TV), radio, mobile phones and the policies and laws that govern the widespread use of these media and devices. (Magawata, 2013)

Use of ICT tools at different section in dairy plant

Computer is used for varieties of purposes in dairy industry. The requirement has been increasing due to its attractive features. Its application as management information system (MIS) for effective decision making, optimizing product mix, product composition, procurement and distribution routes, inventory management and maintenance of plant–machineries etc. has been found very popular. The most important thing is that the technology needs to be an economical investment.

ICT tools help in climate change

In dairy industry nowadays use of renewable energy source because energy resources very limited due to higher usage in the production of various food product. Dairy engineer nowadays to use this renewable energy in dairy industry for various purpose like solar lights, solar energy use in hot water making and wind energy use for the electricity production etc. In rural area electricity may not be available for all time that's why dairy engineer design the solar energy based milk bulk cooler which helps lots of for energy conservation point of view. In solar plant work based on the solar intensity. If we have this ICT tool which help to weather condition characteristics to identify plant is working or not. That type of information analysis by internet application which helps for production planning. If solar intensity or wind speed is not full fill requirement that time alternate generator option we can select without any time wastage.

Milk collection system

The special nature of milk (perishable and bulky) leads to the necessity of strict and comprehensive quality regulation and to high transport costs. The large dependence of milk producers on the dairy processing industry has resulted in a strong position held by the co-operatives in milk marketing and in the processing industry.In the AMUL pattern of milk collection system the milk is collected from the farmers at village co-operative society where farmer are suppose to give there produce to the soecity and according to the quality interms of fat and SNF content the are paid. But without the IT these all process are carried out manually. But the shree kamdhenu electronics private limited (SKEPL)developed an IT enabled " Automatic milk collection station" marketed under the brand name of AKASHGANGA. This system incorporates and electronic weighing system a milk analyzer to test milk quality a pesonel computer and accounting and management software that cover all the functionalities of primery cooperative societies. Compare to manual procedure the AKASHGANGA system reduce the labour handling and increase efficiency with transferency in the system, which creates a based for improving quality of milk produced. That means milk can be sent on to the cooperative union for processing more quickly, reducing spoilage; farmers can see for themselves the weight and quality of their milk via a display and get priented recipt which increase that trust in cooperative process

After the collection of milk at society it is transported to the cooperative unions for further processing, it is a key point to notice that the quality of milk product is purely depend upon the qulality of milk produced and handled. Thus its prime responcibility to trace the route of milk through which the milk reaches to cooperative union. Thus the IT produced GPS system which is fitted on the tanker which shows the position of tanker and thus avoid the malpractices which can be perfromed during the transportation. There is also one system where it cames to notice that whether the valve of tanker is opened during the transportation, and if opened the massage is sent to the concerns authorities within no time. There are various things which are added to milk as an adultrants and the complex and inherant nature of milk is such that it makes detection of adultration difficult as some of the adultrants are the natural constituent of the milk. Thus there is aneed to develop such ICT tool which can educate and increase awreness among the consumers, it would be very difficult for such people to sell their adulterated milk for this various ICT tool can be used to send images and videos to detect some common adultrants using commonly avialable ingredients among the consumers.

Laboratory section

In laboratory use of different equipment like milkoscan, acidometer, pH meter, weight balance, refrigerator, oven and incubator etc. Using of all equipment need some automation required for the various acticvities which helps in several performance like record keepping, analysis etc. ICT tool helps in laboratory equipment for proper estimation of product analysis and to minimize the losses and maintain the quality of product using this ICT tool. Some software are use for the equipment for performing better and less energy consumption by them that type computer based application use in equipment design by engineer.

Milk Processing

The complex production processes must be controlled, monitored and analyzed in an integral and secure manner. The flow of milk to the seperator, homogenizer, pasteurizer has to be maintined for proper working of these equipment with full efficeincy thus pumps and various valves are provided to regulate the flow, the ICT tool are provided to control the flow milk. Like pneumatic valves which opens and close accroding to our requirement. The software system called SCADA which helps in layouting total processing plant on the computer screen and it also enbled the user to operate any valve or pump or machine from his cabin just by clicking on the computer screen, SCADA also enble the user to judge the quantity of milk present in the milk storage tank or silo.Computerized operations can control the product quality in better way. For this sensor or good sensitivity is employed to measure the process outcome. Sensor feedback is given to controller for adjustment of variable that are responsible for quality attribute. Process control is used to run these operations economically to give safe products consistently.IT also play a significant role in online standardization of milk which help in reducing time and manpower. In dairy surplus milk is convert in to the milk powder for further use that's why high temperature required for the production of milk powder but the due to high temperature risk also in powder plant for blasting of that plant. Use of camera during the production of product if powder choke up in the nozzle line and spray dryer we can stop that plant using camera and that type technology is available in mainly plants. Camera helps in the check the product moving inside in plant also. If plant require CIP or not that type information collect from using this ICT tool.

Software tools can be applied to generate useful information relating to processing of milk and milk products. Some of the possible applications include: procurement and billing system, handling losses, cost of production of dairy products labour efficiency, and sale proceeds of dairy products. The cost of manufacturing dairy products needs to be worked out off and on so as to fix the selling price of products which should, as far as possible, match with the prevailing market price. Software can be developed to find out these costs instantly by providing variable inputs costs, e.g., raw material, labour, etc. and by using the pre-determined overhead costs in the process of manufacturing.

ICT in dairy engineering services

In dairy industry lots of use of steam, water and electricity. Supply of these utility in various department for processing of milk to manufacture various milk product is very difficult and take huge labour work for doing this activities. Here the main role of ICT tool to operate the all system online. No need to control all system manual. Now a days SCADA system which helps to optimize the processing parameters like temeperature, flow rate, humidity, pressure etc. In dairy industry mainly use of refrigeration system this system now a day PLC based control where no need to manual control here just click on the computer screen and change the various condition online in whole refrigeration plant. This ICT tool which minimize the production cost as wll as minimize the utilities that's why computer based system is more use in dairy plant.The data /information of each equipment /machine with required periodicity is helpful in carrying out preventive maintenance effectively. Operator / Technician in manual system and auxiliary equipment in the automatic system will perform the operation of preventive maintenance as per the displayed instruction of computer based on the input data. This will help in automatic generation of break down and maintenance information required for management decision of optimum resource utilization.

Dispatch and sales section

The more common system of inventory management that is used in conjunction with a product date stamping system is FIFO (First In First Out). Using FIFO, the product with the soonest expiration date is preferentially placed on the retail shelf for sale. As milk is a perishable product thus cold chain is need to be maintained till the product reaches to the consumer. It's a good practice to maintain the temperature of milk below 10^{o}c preferably at 4^{o}c for the safe and quality delivery of milk. The dairy plants loses its control once it reaches the retailers shop or the cold chain is broken when consumers take pasteurized milk to their homes. This can pose a microbiological hazards if post processing contamination occurs. Here is need of IT. ICT tool helps in tracking the position of retail vehicle and also helps in determining the temperature of milk maintained in the vehicle this help in determining mishappening which is occurring during the transportation. The data can also be analysed and can be helpful in design of efficient distribution methods.

Conclusion

Computer Application will optimize solution in dairy industry. Using solution, user has optimized their production in the reducing production cost and unit costs. Computer application/ automation will improve the physical working environment considering the number of monotonous, repetitive tasks to be eliminated or minimize, increasing efficiency in production. Computer application available in the agriculture today, makes it possible to manage a dairy industry on a more detailed level than before. The dairy manager can make more rational decision through acquiring amount of information, the dairy manager has to operate several computers each day and manually transfer data from one unit to another. Most computerized systems are capable of generating accurate and detailed documentation of dairy processing under computer control. What is important is that the computer generated records contain all of the information required by the system. The use of computerized systems within the dairy industry continues to increase. The use of computerized system technology is expected to continue to grow in the dairy industry as the cost of components decrease, as components are continually improved to withstand the rigors of dairy processing environment, and as dairy companies continue to update production facilities, equipment and manufacturing processes in an attempt to produce high quality, high value products, at the same time reducing production time and cost. The use of computerized control systems in the production of dairy products lends itself to fulfilling those goals.

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High Hydrostatic Pressure – A Non-Thermal Processing for Dairy Industry

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Introduction

Among the moderntechnologies in the food industry, the most important are those involving non-thermaltreatment of the product.Among these techniques more research work are focused on HHP and PEF application for food processing

The application of high hydrostatic pressure (HHP) in food preservation has received particular attentioneconomically and technologically to thermal processes (Patterson, 2005).High hydrostatic pressure (HHP) processing as a novel non-thermal method has shown great potential in producing microbiologically safer products while maintaining the natural characteristics of the food items.The first research on the effect of high pressure on food was first carried out in the nineteenth century (Hite, 1899) describing an increase in shelf-life for products such as milk, fruit and other foods, but, its application in the food industry,have taken place in the past two decades (Considine et al., 2008).

High Hydrostatic Pressure

The basic principle behind high hydrostatic pressure processing is that pressure causes a decrease in the available molecular space or increase in chain interactions. The reactions involved with formation of hydrogen bonds, are favoured by high pressure, because bonding results in a decrease in volume.

The process is isostatic, i.e. the pressure is transmitted uniformly and instantly, and adiabatic, which means that no matter the food shape or size, there is little variation intemperature with increasing pressure; the temperature increases approximately 3°C per 100 MPa, depending on the composition of the food(Wilson et al., 2008). This prevents the food from being deformed or heated, which would modify its organoleptic properties.

A typical high hydrostatic pressure system consists of a high pressure vessel and its closure, a pressure generation system, a temperature controller and a material handling system (Dalai and Sahu, 2010).

(i) High pressure vessel: The heart of a high pressure processing system is in many cases,simply a forged monolithic, cylindrical vessel constructed by a low-alloy steel of high tensile strength. The wall thickness is determined by the maximum working pressure, the vessel diameter, and the number of cycles for which the vessel is designed. The required wall thickness can be reduced by using multiplayer, wire-wound, or other pre-stressed designs (Dalai and Sahu, 2010).

(ii) Closures: Most fast cycling CIP systems use interrupted threaded closures allowing very fast opening and closing of the vessel and hence, minimum vessel down time for loading and unloading. These threaded closures are self-centering and can be automatically opened and closed by means of a hoist device, guiding the closure without any thread friction.

(iii) Pressure transmitting medium: In most current cold applications, the pressure medium is simply water mixed with a small percentage of soluble oil for lubrication and anticorrosion purpose.

(iv) Pressure generation: After all air is removed from the high pressure vessel, the highpressure is generated by direct compression (piston type) or indirect compression type (pump type).

(v) Temperature: Temperature of the load and pressure medium inside the vessel can be controlled by heating/cooling the entire pressure vessel or by internal heating/cooling in which case the heated/cold source is placed inside the vessel. The simplest execution of external heating uses electric heater bands wound around the vessel (Dalai and Sahu, 2010).

HHP spectrum for microbial inactivation

The utility of HHP depends on extent of destruction of the microbial population, which results in increase in shelf-life and food safety (Considineet al., 2008).HHP applied at ambient temperature destroys vegetative cells and inactivates certain enzymes (Simpson and Gilmour, 1997), with a minimal change in the organoleptic properties (San Martin et al., 2002). ***Factors influencing microbial inactivation include p***ressure applied, holding time, type of microorganism and food matrix.

High hydrostatic pressure usually has a higher destructive effect in organisms with a greater degree of organization and structural complexity. Prokaryotes are usually more resistant, compared to eukaryotes (Yuste et al., 2001).Vegetative forms of yeasts and moulds are the most pressure sensitive (Smelt, 1998). Mould spores particularly resistant to high hydrostatic pressures.(Chapman et al., 2007).

The bacterial spores are always more resistant than vegetative cells and they can survive at pressure of 1000 MPa. Bacterial spores, however, can often be stimulated to germinate by pressures between 50-300 MPa. Germinated spores can then be killed by heat or mild pressure treatments. Gram-positive microorganisms tend to be more resistant to pressure than gram-negative microorganisms.Gram-positive microorganisms need the application of 500-600 MPa at 25˚C during 10 min to achieveinactivation, while gram-negative microorganisms are inactivated with treatments of 300-400 MPa at 25˚C during 10 min.

It is possible to obtain 'raw' milk pressurised at 400–600 MPa with a microbiological quality comparable to that of pasteurized (72ºC, 15 s) milk depending on the microbiological quality of milk (Buffa et al., 2001) but not sterilised milk due to HP resistant spore.

HHP in milk processing

Micellar calcium phosphate solubilization increased milk pH by 0.08 U, although this effect was reversed on storage at 20 and 30°C (Zobrist et al., 2005). The buffering capacity of HP-treated milk was enhanced at pH 6.7–5.5, and decreased at pH between 5.5 and 4.6 (Salaun et al., 2005).

In addition to the reduction of particle size, micelles in HP-treated milk are irregularly shaped and of enhanced voluminosity, due to higher hydration, and all these factors contribute to an increased viscosity in skimmed milk with increasing pressure and treatment time (Harte et al., 2003).

HP treatments decrease the ethanol stability of milk, particularly below its natural pH (Johnston et al., 2002). This has been attributed to the solubilization of calcium, as well as to the dissociation of k-casein that decrease the stability of casein micelles, facilitating their ethanol-mediated coagulation (Huppertz and Grosman et al., 2004).HP treatment of milk affected proteolysis to a greater extent on storage at higher temperatures, closer to the optimum temperature of plasmin activity. Thus, at 37°C proteolysis in milk treated at 300-400MPa for 30min was more extensive than in untreated milk, suggesting an increased availability of substrate to plasmin (Huppertz et al., 2004e).Lactose in milk and milk products may isomerise in lactulose by heating and then degrade to form acids and other sugars. No changes in these compounds are observed after pressurisation (100–400 MPa for 10–60 min at 25 8C), suggesting that no Maillard reaction or lactose isomerisation occur in milk after pressure treatment (Lopez Fandino et al., 1996).

Cheese

Cheese manufactured from high pressure-treated milk

The denaturation and resulting incorporation of whey proteins into the curd, induced by HP treatment, enhancecheese yield by 14% to 20%, respectively, at 300 or 400MPa applied for 30 min at 20–25°C (Lopez-Fandino et al., 1996), possibly due to the incorporation of additional α-Lg in the curd and more moisture retention.HP processing at low temperatures (e.g. 3°C versus 21°C) contributed to a faster coagulation rate (Pandey et al., 2003).It is known that milk with casein micelles of reduced diameter enhance milk coagulation properties.In fact, hydration of casein micelles was increased by treatments at 100-600MPa (Huppertz et al., 2004c). However, no differences were found in the syneresis from curds prepared from untreated milk or milk HP treated at 200 and 400MPa (Needs and Stenning et al., 2000). Curds from milk treated at 600MPa expelled less whey, probably because the coagulum consisted of a more finely structured network (Needs andStenning et al., 2000). This could account for yield increases of 25% at 600–800MPa due to enhanced protein and moisture contents as observed by (Huppertz et al.,2004f).

Acid coagulation and yogurt manufacture

HP treatment of milk favors acid coagulation. HP-treated bovine milk inoculated with lactic acid bacteria acidified faster than its unpressurized equivalent,probably because casein disruption enhances the supply of accessible nitrogen for bacteria (Huppertz et al., 2004d).HP treatment of milk at 55 ºC led to yogurts with high firmness without apparent micellar disruption, which points to the important contribution of whey.

Advantages of HHP technology

1. Food processing at ambient temperature or even lower temperatures
2. Instant transmittance of pressure throughout the system, irrespective of geometry.
3. It causes microbial death whilst virtually

eliminating heat damage and the use of chemical preservatives/additives, thereby improving food quality.

High-Pressure Commercial Products

Pressurized products were first marketed to consumers in the early 1990s, such as Japanese jams, jellies, and sauces produced by Meidi-ya Food Co (Rastogiet al., 2007). The famous avocado sauce ''guacamole'' in the United States, are now part of HHP's early history in the food industry. One of the big commercial niches for high-pressure use is the seafood industry. It has been widely reported that high pressure can open the shell and release the meat, but at the same time it can also kill pathogenic and dangerous species in the Vibrio family such as *V. cholera, V. vulnificus*, and *V. parahaemolyticus* (Cook, 2003). This technology is currently applied in some seafood processing facilities in the United States.

Some companies are working together as a consortium to develop new pressurized products; companies such as Kraft, Hormel, Unilever, Basic American Foods, Stork Food and Dairy Systems, Washington Farms, ConAgra, and Fresherized Foods (previously, Avomex) (Barbosa-Ca´novas and Juliano, 2008).

Effects of high pressure on milk proteins

Treatment of milk at pressures over 100MPa at 25°C leads to a progressive α-Lg denaturation, estimated by the loss of solubility at pH 4.6, while α-La and BSA are resistant to pressures up to 400MPa (Lopez-Fandino et al., 1996). Treatments at 200 and 400MPa, applied at room temperature for 15-30 min, denatured 14-16% and 82-90% of α-Lg, respectively (Huppertz et al., 2004a). A pressure of 600MPa for 15–30 min denatured 15–33% of α-La (Huppertz et al., 2004a).The extent of denaturation is dependent on the pressure level, treatment time and temperature (Huppertz et al., 2004b).The stability of α-La toward HP is higher than that of α-Lg, probably due to differences in the secondary structure, in the number of disulfide bonds and Ca^{2+} binding sites. Preferably α-La, there is a free thiol group in α-Lgplays a crucial role in HP-induced α-Lg aggregation by thioldisulfide exchange reactions (Funtenberger et al., 1997).

HP treatments solubilize the colloidal calcium phosphate of casein micelles from raw milk, although a portion of the dissociated colloidal calcium phosphate is reformed during subsequent storage of HP-treated milk (Schrader et al., 1997). HP also dissociates the heatinduced crystalline calcium phosphate of heat-treated milk (Schrader et al., 1998).

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Vacuum Frying: A Novel Processing Technology

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Vacuum frying is a novel frying process that is carried out at pressures well below atmospheric level. Vacuum frying offers an alternative way to improve the quality of fried fruit and vegetables over the atmospheric frying. The main factors that influence fried products are the frying time-temperature combination of the cooking process. Vacuum frying has been reported to have several advantages including, significantly lowered final oil content in comparison to atmospheric fried vegetables and slower development of rancidity of the oil. Most of the benefits of vacuum frying are attributed to the low temperatures used and the minimal exposure to oxygen, which reduces the adverse effects on the oil quality, preserves the natural colour and flavour, decreases the acrylamide content and preserves nutritional compounds, such as vitamins and minerals. Vacuum frying system consists of three main components mainly vacuum frying chamber, refrigerated condenser and vacuum pump. Vacuum frying chamber is an airtight vessel consisting of oil heater and frying basket,the refrigerated condenser is provided to trap the evolved steam during frying by condensing it on a cold surface.The vacuum pump provides the required low pressures for the process and gets rid of non-condensable gases. However vacuum frying technology have been applied for frying of fruits and vegetables and more research is needed on the sensory impact of foods treated with vacuum fryingtechnology. Researchneeded to use vacuum frying technology for traditional Indian dairy products like *Khoa* based *Gulabjamun/pantoa and* its impact on physical and sensorycharacteristics.

Pilot study experimental set up for evaluating B.*cereus* MTCC 25641 in bio-stabilization of dairy waste

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Dairy is one of the industries which is producing waste water richer in organic matter and thus leading to generation of odorous and high COD containing water. Dairy waste disposal, pollution caused and safety are agitating the minds of policy makers, regulators and all citizens. Pilot plant study was planned to evaluate and validate ability of *B.cereus* MTCC 25641; a culture tested and confirmed at laboratory level at Dairy Science College for bio-stabilization in treating dairy effluents. A pilot plant was constructed of two tanks made up of cement concrete having 7 feet depth with 5000 lit capacity. Air supply was provided at the bottom of tank with air pressure 6 kg/cm^3 through galvanized pipe and was distributed uniformly in the tank. Dairy waste effluent after primary clarifier was taken in both the tanks, which were filled up to 2000 lit. First tank was considered as control where aeration was done without any culture addition with native microflora of effluent only while second tank was inoculated with *B. cereus* MTCC 25641 @1%. Reduction in COD was recorded in every 24 h up to 7 days. In a control study, COD reduced up to 642.00±14.27 mg/l from 797.40±11.63 mg/l in 24 h which indicated a reduction of 19.49% by native microflora present in the effluent. When the same effluent was inoculated by *B.cereus* MTCC 25641, COD reduction significantly increased up to 50.68% in 24 h. Extended study up to 7 days was carried out with and without the culture in the same pilot plant. Maximum reduction in COD was observed on 7th day. It ranged from 51.86±2.25% in 24h to 93.41±0.45% on 7th day having inoculated with *B.cereus* MTCC 25641 while control experiment showed reduction of 15.79±1.54 % after 24 h to 74.88±3.46 % on 7th day which was less when compared with test culture. Aerobic culture *B.cereus* MTCC 25641 was found effective in COD reduction. This suggests that the seeding of this efficient active culture at higher rate can lead to more degradation of wide scale of organic compounds.

Abstracts

Standardization of technology for manufacture of *Moringa* Leaf Buttermilk

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Buttermilk, a "ready-to-serve" fermented milk product, is used as a refreshing beverage from time immemorial in India. An attempt was made to develop a buttermilk containing *Moringa* leaf powder (MLP) to improve its nutritional value. Buttermilk was prepared from dahi containing 4.5% milk fat and 8.5% MSNF. A Mesophilic/ Thermophilic culture was used for preparing dahi. The most acceptable level of total milk solids (TMS) in buttermilk, acidity of dahi and MLP in buttermilk were optimized using Response Surface Methodology with central composite rotatable design. It was found that 5.31% TMS, 0.91% acidity of dahi and 0.62% MLP gave the most acceptable product. A blend of 0.08% pectin and 0.03% carrageenan was selected and addition of salt, sugar and spices @ 0.5%, 4.0%, 0.5% respectively were most suitable. The proximate chemical composition of *Moringa* buttermilk was 11.33% total solids, 1.58% protein, 1.8% fat and 0.83% ash. One serving size (300 g) of the product could be "a good source of Vitamin A, calcium and iron" providing 10, 18 and 11% DV respectively. The shelf-life of the product was 20 days when packaged in Polyethylene terephthalate (PET) bottles and stored under refrigeration (7±2°C).

Intelligent Packaging : An Novel Food Packaging Technology

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Abstracts

Food packaging is used to contain, enable marketing and provide passive protection against contaminations which affect the shelf life of the food products to a great extent. In conventional packaging, the package is used for communicating with consumers as a marketing tool; protect the product against the deteriorative effects of the external environment. Conventional food packaging systems failed to monitor certain aspects such as shelf life, freshness etc., and convey related information to the consumer. Intelligent packaging (IP) is a novel technology which utilizes the communication tool of the package to facilitate decision making during each and every step of marketing and storage to enhance food quality and safety. IP includes time-temperature indicators, gas detectors, freshness and/or ripening indicators. The latest advances in smart package devices include barcode labels, radio frequency identification tags and biosensors as well. At the same time, it is expected that advances in nano materials will enable the development of better active and intelligent packages. Such packaging systems will not only improve freshness, shelf-life of food but also put great impact on food industry to allow monitoring at every step to control the storage conditions from the point of production to the stage of consumption. Apart from the above benefits, the major problems associated with IP system are the potential migration of the particles from the packaging material into the food products and the cost of intelligent packaging which limits its use commercially. Further investigation is required to develop low-cost indicators and microsensors which provide an enormous potential for commercial applications to improve supply chain management and ensure product quality for consumers.

Comparative Performance Evaluation of Developed Clean Air System with ISO and WHO Air Quality Standard

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A research work was conducted to develop an efficient air purification system with innovative approach which includes filtration, positive pressure, ultra violet rays irradiation and material selection. The clean air system was evaluated by a discrete-particle-counting, light-scattering instrument to determine the concentration of airborne particles, at designated sampling locations. From performance evaluation it was concluded that the developed Clean Air System meets the WHO Standards of Grade A even after 2 years of its working.. The evaluation study exhibits ISO 5/class 100 at HEPA outlet and ISO 7/class 10,000 at working table of clean air room. The innovative clean air system can be replicated in the numerous areas viz. Dairy Industries, Hospitals sectors, Pharmaceuticals division, Agriculture and Tissue culture division, Food firms, Meat Export Industries, Fisheries, where the clean air is the criterion. The technology can be also employed to aeronautics where clean air is obligatory.

Significance of Ultrasonication on β-Galactosidase production from Lactobacillus cultures during fermentation

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In this study, nine Lactobacillus cultures i.e. *Lactobacillus helveticus* (V3), *Lactobacillus rhamnosus* (NK2), *Lactobacillus casei* (NK9), *Lactobacillus rhamnosus* (NK10), *Lactobacillus fermentum* (M5), *Lactobacillus paracasei* (M16), *Lactobacillus rhamnosus* (M31), *Lactobacillus plantarum* (M38) and *Lactobacillus pentosus* (M22) were evaluated for the production of β-Galactosidase enzyme. We know that β-Galactosidase enzymes are intracellular and break down the lactose into glucose and galactose. Ultrasonication alone or in a combination with lysozyme or SDS-chloroform treatment are done to rupture the cell wall to release the β-Galactosidase enzymes. It was found that *Lactobacillus fermentum* (M5) produced highest amount of β-galactosidase enzyme, followed by *Lactobacillus rhamnosus* (NK10) and *Lactobacillus plantarum* (M38) compared to other isolates after 12 h and 24 h of incubation at 25, 37 and 370C respectively after sonication in MRS broth. After combine treatment with sonication and lysozyme, *Lactobacillus rhamnosus* (NK10) produced highest amount of β-galactosidase enzyme, followed by *Lactobacillus rhamnosus* (NK2) and *Lactobacillus plantarum* (M38) compared to other isolates after 24 h of incubation at 37°C. Similarly, after combine treatment with sonication and SDS-chloroform, *Lactobacillus pentosus* (M22) showed highest amount of β-galactosidase enzyme, followed by *Lactobacillus plantarum* (M38) and *Lactobacillus helvieticus* (V3) compared to other isolates after 24 h of incubation at 25, 37 and 37°C respectively. Out of these nine isolates, two isolates *Lactobacillus plantarum* (M38) and *Lactobacillus rhamnosus* (NK10) exhibited highest production of β-galactosidase enzyme during the treatment of sonication and combine with lysozyme or SDS-chloroform. However, these two cultures can be used for the extraction of β-galactosidase enzyme for the production of lactose hydrolyzed milk in dairy industry.

Energy Conservation and its Management in a Commercial Dairy Plant in West Bengal

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The audit has been successfully completed and concluded if feed water temperature increase up to 65oC savings will be 2, 31,000/annum where boiler efficiency 79%. The total lighting load is around 60.6Kw.AfterLED lamp use total annual savings is 13.324lac. Due to installation of screw type refrigerator compressor total saving is 826,000/annum and payback period of screw compressor is 2 year. After installation of VFD power saving is 141,600/annum and simple payback period of VFD is 1.2 year. In electrical energy, the analysis of the electrical bill shows that the power factor is well maintained by the distillery unit, it varies from 0.98 to 0.99. The most of the electrical energy is utilized to drive electrical motors used for various processes. Energy will be saving in case of motors with the help of the variable frequency drives, which reduces the speed of the motors as well as energy.It shows that replacing the conventional tube lights with energy saving CFLs or LEDs reduces the energy consumption drastically. Energy audit in all the sectors with few changes in the existing system can conserve energy, which in turn will reduce the power demands in our country.

The Impact of High Intensity Ultrasound Treatment on the Physico-chemical, Microbial and Sensory Quality of raw milk

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Milk is almost a complete food and have a high commercial value. Because it is consumed daily by a large number of peoples, itssensory and microbiological characteristics are of extremeimportance. Pasteurization is a common thermalprocessing system used to inactivate pathogenic bacteria and fewenzymes in milk. Thus, there is an increased demand for novel processing system thatwill have a reduced impact on the nutritional content, sensory attributesand the overall food quality.In the study, raw cow milk (100 mL) was placed in a glassvessel (200 mL), which served as the treatment chamber.An ultrasonic processor (Labman, India), set at 750 W, 20 kHz, and 12–260 mmwith a 6-mm diameter probe, was introduced into thevessel. The same part of the probe was immersed in themilk (about 2 cm) and placed at the 'centre' of the sample. Ultrasonications were carried out with 60-80% amplitude and 60 sec: 60 sec pulse at 20°C. The raw milksamples were treated by ultrasound for 10, 15 and 20 min. The control (without ultrasonication) and ultrasonicated samples were analyzed for the total plate counts (TPC), Coliform Count, Yeast & mold count after 0 and 24 h. In case of TPC, the samples treated for 10, 15 and 20 min exhibited microbial reduction upto 97.76%, 99.94% and 99.97% respectively after 0 h as well as 99.84 %, 99.995 % and 99.996 % respectively after 24 h. Coliform counts after 0 and 24 h, were found to reduce in the range of 70 – 90 % and 27 – 89% respectively. While yeast & mold counts after 0 and 24 h, were observed to reduce in the range of 61 – 93 % and 20 – 47% respectively. In all the counts (TPC, Coliform count and Yeast & mold count), highest microbial reduction was observed in 20 min treated sample and lowest in 10 min treated sample. Then, Physico-chemical analysis (pH, acidity (%LA), TS, fat, protein and SNF) of the control and treated samples was also carried out and there was no significant difference observed between control and ultrasonicated samples except Fat content. The slight increase in fat was observed immediately after ultrasonication (0 h) due to homogenisation effect of ultrasonication. It was found that there was no significant difference in sensory attributes between control and ultrasonicated samples.

To improve the performance of Tubular heat exchanger by inserting wiry sponge, using Passive Augmentation technique.

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Enhancing heat transfer surface are used in many engineering applications such as heat exchanger, air conditioning, chemical reactor and refrigeration systems, hence many techniques have been investigated on enhancement of heat transfer. One of the most important techniques used are passive heat transfer technique. These techniques when adopted in Heat exchanger proved that the overall thermal performance was improved significantly. Experiment works have been taken by researchers on the Augmentation Technique such as Twisted Tape. This work has been carried out on double tube Heat Exchanger, fabricate this counter flow heat exchanger type Experimental setup & make Comparative Study of plain tube type HE, HE with twisted tape insert and HE with twisted tape insert with metallic wiry sponge. From this experiment it has been observed that the twisted tape insert with metallic wiry sponge gives more heat transfer as compared to twisted tape insert and plain tube respectively in the counter flow heat exchanger. Also small increment of friction factor has been observed in twisted tape with sponge inserts at higher Reynolds number as compared to the twisted tape insert and plain tube.

Gellan gum: Future thickeners of dairy based ready to drink beverage Industry

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Due to the complexity of food, it is difficult to make a new product with consistent quality. Consumer's behavior is changing day-by-day towards the food. They want more reliable food with better nutrition. Further food professionals are incorporating additional ingredients to the traditional food to enhance its functionality. Thickeners makes feasible to make the traditional food with better nutritional value especially beverages. Gellan gum is one of the effective binder for beverages because of its low concentrations, low temperature gel formation, microbial origin, etc. Gellan gum or heteropolysaccharide-60 (PS-60) is produced by *Sphingomonas paucimobilis* (formerly *Pseudomonas elodea*). It has a pKa value near 3.5, which is given by its monomer, glucuronic acid. Due to diversity of its configuration and properties, gellan gum has a wide range of applications in the food, pharmaceutical, and other industries as stabilizing,thickening, emulsifying, gelling agents, texturizing, etc. The total gelatin market in the Western Europe is about 60,000 tons per year, of which 80% is in foods. It is one of the gelatin alternatives for food. There are two types of gellan, high acyl and low acyl. Gellan gum shows very good gelling properties with milk protein. Milk is having calcium in abundant, which will aid in the binding of gellan well. So, the ingredients which are suspended in milk based beverages will not get set down throughout its shelf life. Western countries have many beverages with gellan gum but in India its use is still limited because of legal requirement and cost. Researcher will have to work closely with milk beverages with gellan gum to enhance the stability of functional dairy drinks.

Heat Transfer Performance of Scraped Surface Heat Exchanger During Manufacture of Bottle Gourd *Halwa*

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India had emerged as the world's largest producer of milk with half of its production being used for the manufacture of different Traditional Indian Dairy Products (TIDP). The manufacture of traditional dairy products on large scale requires mechanization and optimization of operating conditions in order to get uniform acceptable quality. Scraped Surface Heat Exchanger (SSHE) of appropriate design is found suitable for production of highly viscous dairy products. Bottle gourd *halwa* is one of the TIDP prepared from grated bottle gourd cooked with sugar, *khoa, ghee* and flavoured by spices like cardamom. The various unit operations involved in preparation of bottle gourd *halwa* are shredding, cooking and desiccation with sugar and *khoa*. The study was under taken to evaluate heat transfer performance of the SSHE during manufacture of bottle gourd *halwa* under variable operating conditions. The horizontal SSHE was used for the manufacture of *halwa* using the recipe standardized by Response Surface Methodology. The performance of the SSHE was evaluated at different scraper speeds and operating steam pressures. The rate of evaporation ranged between 12.379 and 19.947 kg water/h during manufacturing of *halwa* in SSHE at different operating conditions. It was observed that overall heat transfer coefficients (U-values) increased with the increase in scraper speed and steam pressure in range of 406 - 600 W/m^2K. The *halwa* manufacturing in the SSHE at 1.5 kg/cm^2 steam pressure and 30 rpm of scraper gave maximum overall acceptability score of the product. The values of steam consumption and electrical power consumption under different operating conditions during manufacture of bottle gourd *halwa* ranged from 18.56 to 36.76 kg/h and 0.398 to 0.410 kWh, respectively. The values of specific steam consumption ranged from 1.659 to 1.697 kg steam/kg water evaporated. The total heat losses during manufacture of *halwa* in the SSHE ranged from 20.84 to 23.83 % of the heat input at different steam pressures and scraper speeds.

Mechanized and Continuous Cheese making Processes for Cheddar Cheese

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Mechanization and automation of the manufacture of cheese have a number of the basic developments have been refined and adapted into commercial use. The mechanization process of vats, Cheese master, block former and mechanical curd-handling equipment cheddar cheese plant presented. A commercial plant having 30 MTR per day capacities has been selected for the parametric investigation of various operating parameter. Here we are investigating the effect of various operating parameter like temperature, pH, moisture, culture and rennet addition time & rate and maturity time on quality of final product. The automated system having the following advantages like uniformity of cheese, energy conservation, hygienically design, and minimum losses, lowering the product cost, higher the yield and consistence quality were presented.

Chimney Aluminizing

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In dairy industry, for heat treated products chimney is required to transfer hot flue gases or smoke to the external environment.The height of chimney influence its ability to transfer flue gases .This type of construction may corrode easily due to the reaction of gases to its surface.Aluminising is a preventive metal coating process against wear factors such as corrosion and heat resistance.This twin wire arc spray technique replaces the conventional aluminium painting.The chimneys which is exposed to highly corrossive industrial gases get worn out immediately.Aluminising gives pure metallic mechanical bonding with the base material which enhances the life by 5-6 times , and also it is a cost saving method too.The job is executed with out any shut down where as painting requires a complete shut down.This is a pure engineered process which will provide good lifeengagement andcost reduction for dairy process industry.

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Development of Technology for Carbonated Lemon Whey Beverage

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Whey is the largest and highly nutritious by-product obtained during manufacturing of cheese, chhana and paneer. It contains valuable milk solids predominantly lactose, nutritionally superior whey proteins and minerals. Product diversification is quite feasible using whey in formulated foods, especially beverages. Various types of whey beverages has been developed from native sweet or acid whey, de-proteinized whey, fresh diluted whey, fermented whey or powdered whey. Utilization of fruits to whey beverages aids in nutritive value and mask the typical whey flavor. Consumer acceptance study of whey beverage was carried out for 150 consumers and showed highly acceptable beverage on basis of sensory attributes. The developed fresh whey beverage attained score of 7.97, 8.08, 8.34, 8.20 and 8.38 for color and appearance, consistency, flavour, sweetness/ tartness balance and overall acceptability respectively. The beverage is highly accepted in overall acceptability score (scored 8.58 on hedonic scales) as compared to commercially available whey beverage (scored 5.83 on hedonic scale). It is concluded that most acceptable carbonated lemon whey beverage can be prepared by addition of 4.5% lemon juice, 10 % sugar, 1 % ginger juice and 0.6 % salt with carbonation at 15 psi with shelf life of 49 days at refrigerated temperature (7±1°C). The cost of developed whey beverage was computed at `5.33 per 200 ml sized bottle.

Effect of dry salting of Mozzarella cheese at pre- and post-plasticizing stages on its quality characteristics

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Mozzarella is a fresh, glossy white, soft cheese with a characteristic stretch property that is found useful as a pizza topping. Low-moisture part skim Mozzarella cheese is preferred for pizza applications. In the manufacture of cheese, salting plays an important role in contributing to salty taste, has an impact on cheese texture through syneresis control, controls microorganisms and enhances shelf life. Salting of Mozzarella cheese has been practiced in the cheese industry through use of dry as well as brine salting techniques. Dry salting, in turn, has been attempted at two stages viz., pre-plasticizing and post-plasticizing. The change in the method of salting has a marked influence on the quality characteristics of product, of which, baking qualities are of prime importance. Mozzarella cheese was prepared from standardized (2.8% fat) mixed milk (cow: buffalo) using direct acidification technique; dry salting was performed at two stages viz. (i) to cheese curd @ 2.0, 2.5 and 3.0% by weight before plasticizing and (ii) to the plasticized cheese curd @ 0.75, 1.00, 1.25% by weight. The effect of salting techniques on the yield, composition, textural, baking qualities and sensory quality of cheese topped on pizza pie was studied. Mozzarella cheese salted @ 2.5 and 1.0% at pre- (vs. 2.0, 3.0%) and post-plasticizing (vs. 0.75, 1.25%) stages respectively resulted in product having 1.02 and 0.77% NaCl. These cheeses had reasonably good textural characteristics resulting in desired shredability, maximum meltability and stretch values, but had intermediate values for fat leakage and melting time. When judged as pizza topping, they exhibited maximum score for appearance, meltability, stringiness, and total score. The yield of cheese remained unaffected by the methods of dry salting. Based on the findings, the Mozzarella cheese makers are recommended to adopt dry salting at pre- and post-plasticizing stages at the rate of 2.5 and 1.0% by weight respectively to yield 'lightly-salted' cheese. Amongst dry salting at pre- and post-plasticizing stages, the latter salting technique was found to be superior with regard to cheese firmness; meltability; and appearance, melting as pizza topping along with low adhesiveness and reduced melting time in the oven.

Ice Content during Freezing of Kulfi – A Mathematical Analysis

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Kulfi is an indigenous dairy dessert prepared by immersion freezing of a mix composed of concentrated milk and sugar. The water contained in the *kulfi* matrix is either in the state of free water or as bound water and only free water can undergo possible state transitions such as ice crystallization. Hence, the knowledge of the total ice content during freezing of *kulfi*would provideimportant basic information to visualize and understand the morphological and physical behavior of *kulfi* during the freezing process. *Kulfi* mix was prepared by condensing Cow /Buffalo/Mix milk to various levels i.e. 1.5:, 2: 1and 2.5:1 and the ice content was determined as a function of temperature by a mathematical model based on Raoult's law. It was found that the decrease in the temperature (from freezing point to -30°C) exponentially increased the ice mass fraction for all the *kulfi* samples studied at different concentration levels. The rate of ice formation was found to be faster during the initial stages of freezing accounted to the easy availability of free water in the mix; the rate of ice formation stagnated to a near constant value at the later stage of freezing. The availability of free water and its influence on ice fraction was also reflected as the decrease in ice mass fraction with increase in concentration (1.5:1 to 2.5:1) of the product formulation across all combinations evaluated for the study.

Parabolic Trough Collector: A Potential tool in utilizing Solar Energy Radiation

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The solar energy radiation on earth ranges between 1 to 7 kWh per m^2 area in tropical zone. It shows that huge potential lies in utilization of solar energy as renewable source especially in tropical countries like India. It has lead to the development of several solar technology systems viz. solar collectors, photovoltaic panels, solar cooking and drying systems, etc.; amongst which, solar parabolic trough collector has emerged as the most effective technology in last few decades. Moreover, parabolic trough collectors are able to produce high temperature over 400 °C with high thermal efficiency upto 75 %. Parabolic Trough collector (PTC) covers 90% of the total concentrated solar plant systems because it is more mature technology among the concentrating collector technologies. It is being used in the production of steam, heat generation, co-generation and other thermal processing systems. Also, its few applications have been observed in researcher's work for dairy and food industries. It consists of a parabolic trough on which small segments of mirrors or mirror polished aluminium sheets is mounted. This assembly is placed over a supporting structure which can facilitate the movement of trough with the changing angle of the solar radiation. This paper highlights the design, construction, sun tracking mechanism in PTC and its applications in various industrial sectors.

Low Temperature Cryogenic Freezing

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Cryogenic freezing is a relatively new method of freezing in which the food is exposed to an atmosphere below -60 °C through direct contact with liquefied gases such as nitrogen and carbon dioxide. Due to very low operating temperatures and high surface heat transfer coefficients between product and medium, rate of

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freezing of cryogenic systems are often substantially higher than other refrigeration systems. Liquid nitrogen (LN) is used in many cryogenic freezers in which product is placed on a conveyor belt and moved into the insulated chamber, where it is cooled with moderately cold gaseous nitrogen moving counter current to the product. Industrially it has advantages of reduction in freezing time, weight loss (less than 1%), enzyme and oxidative deterioration, improves texture, color and appearance of the product, the small size and mobility of cryogenic freezers allow for flexibility in design and efficiency of the freezing application. Cryogenic systems are best suited for cooling thin products with a high surface area to weight ratio in which heat conduction within the product is not rate limiting, such as ice-cream, pizza, seafood, sliced/diced meats, and vegetables.

Use of Non-Conventional Energy at Rural Milk Collection Center

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Chilling milk at village level to improve the quality of milk and overall shelf life, and also avoid losses, has been recognized as the technological intervention that is needed. Bulk milk coolers installed at rural areas are operated with electricity and generators for uninterrupted running. To reduce the cost of operation, solar photo voltaic systems along with battery back-up and inverter is used to run the bulk milk cooler especially IBT type. The trial was taken with water in Bulk milk cooler with a capacity of 500 litres and the initial temperature of water was 25°C with an ambient temperature of 32°C. The batteries were charged by solar energy sufficiently and then were operated for cooling of milk. The process continued for 4 hrs for the water to reach a temperature of 5.2°C. The initial current drawn from the battery was too high for few seconds later on it reduced to constant power for cooling of water. It is possible to meet the requirement with solar photo voltaic system with a minimum back up of 4-5 hrs at rural level. The time for cooling could further be reduced if plate heat exchanger is used. The time could further reduce if the 500 litres of milk is received in two shifts i.e. morning and evening.

Pulsed Electric Field: Design Aspects

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High quality and extended shelf life demand from consumer lead to finding of novel technologies. Pulsed electric field (PEF) is one of the best non thermal processing techniques. The technique has its application in food, pharmaceutical, biotechnology etc. Wide ranges of pulses can be applied to food products depending on target inactivation of micro-organisms for very short duration. Design of PEF is critical issue as high voltage (thousands of kV) is involved. Selection of all components is crucial as one input give output to other. PEF setup design is based onselection of Charging capacitors (0.1-10 µF), Resistors (2α-10 Mɖ), Switches (ignitron, thyratron, tetrode, spark gap, semiconductors), Voltage pulse generator network, Treatment chamber, Electrodes and Control panel with different pulses forming networks like simplest resistance-capacitance based to, more complicated like using transformers, non-linear capacitors, power-electronics based, bidirectional flyback, CASACASED and MOSFET (parallel and series) etc. There are uncountable possible application of pulsed electric field and concepts related to design aspects. Setup could be design in variable waves according to requirement. Selection of switches, chamber type, dimensions, switched, capacitors etc. play very important role in overall performance of the equipment. With defined design application variability is also there.

Abstracts

Development of Technology for Manufacture of Probiotic Shrikhand

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In the present study, different combination of probiotic starter culture used for *Shrikhand* viz., *Streptococcus thermophilus* (NPC), *Acidophilus Bifidobacterium* yoghurt culture (PC 1), Yo-flex + *Lactobacillus helveticus* (PC 2), Yo-flex + *Lactobacillus rhamnosus* (PC 3), *Streptococcus thermophilus* + *Lactobacillus helveticus* (PC 4) and *Streptococcus thermophilus*+ *Lactobacillus rhamnosus* (PC 5). The culture *Streptococcus thermophilus* (NPC) was used for control-Shrikhand. The *Shrikhand* samples, as per need of the experimentation, were analyzed for composition (i.e. moisture, fat, protein, sucrose and ash); physico-chemical properties (i.e. acidity, soluble nitrogen, free fatty acids and water activity); rheological attribute (i.e. consistency by penetrometer); sensory quality (i.e. flavour score, body and texture score, colour and appearance score and overall acceptability score) and microbiological attributes (i.e. probiotic count, standard plate count, coliform count and yeast and mold count) using the standard techniques. From present investigation it was observed that, based on the physico-chemical, rheological, sensory and microbiological qualities, the performance of different probiotic cultures on quality of the fresh as well as stored Shrikhand was obtained in order of PC 3 > PC 2 > PC 1 > PC 4 > PC 5 and the shelf-life of Probiotic Shrikhand was more than 28 days on storage at refrigeration (7±2°C) temperature.

Process Re-Engineering for the Manufacture of *"Shrikhand"*

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Shrikhand is an indigenous fermented and sweetened milk product. The traditional method of manufacture of *shrikhand* involves preparation of *chakka*, which requires 12-18 hours to remove whey from the curd and the disposal of whey is a serious problem at many places. In addition to this, there is a loss of considerable amount of milk solids in the whey. The objectives of present study were to standardize the process for manufacture of *shrikhand* without generation of whey. Three different types of milk were used to manufacture experimental product. Based on the sensory evaluation, the reconstituted concentrated skim milk (RCSM) having different TS was selected as a superior option for the preparation of *shrikhand.* Manufacturing of *dahi* from concentrated skim milk requires specific culture which can grow at higher TS level. Different cultures were tried and the good quality of *dahi* without generation of whey was manufactured by Layofast YL 348 F(Sacco). The rate of culture addition was 1 % of RCSM. The incubation temperature was 40 ˚C till acidity of *dahi* achieved up to 2 % LA. The different levels of total solids in RCSM and different rate of sugar addition in dahi were tried in the experiment and the *shrikhand* which was prepared by using RCSM having 35 % (TS_2) total solids and 50% (S_2) rate of sugar addition in *dahi* got highest sensory score in terms of overall acceptability. The sensory scores of control and experimental product (S_2TS_2) were compared and the experimental product got lower sensory scores than control sample due to slight weak body and inferior flavour. In order to improve body & texture and consistency of the product, partial replacement of sugar was done by liquid glucose. Based on the sensory evaluation the product prepared from 50 % sugar replacement yielded most acceptable product and sensory scores of product also improved.

Effect of Vapour Ejection System on Performance Parameters of Scraped Surface Heat Exchnager

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Scraped Surface Heat Exchanger (SSHE) is versatile heat exchanger extensively used for viscous and sticky product processing. SSHEs are used for various purposes in the industry and also have significant role in the manufacture of the Traditional Indian Dairy Products. Hence, industries are focuses on the efficient working of the equipments with effectiveness. Up till now, it is reported that efficiency of SSHE are comparatively lower compare to evaporators used for thermal concentration of milk. Efforts were made to improvise the thermal performance of SSHE by means of Axial Flow Type Vapor Ejection System (ATVES). The present work investigated with an intention to intensify the process of heat transfer. The applied steam pressure and air flow rate of ATVES were held variable while scraper speed, feed rate and initial total solids of milk held constant for assessment of performance parameters. The effect of ATVES was studied on parameters i.e. Evaporation rate, Overall Heat Transfer Co-efficient, Steam consumption and Steam Economy considering major influencing factors of SSHE performance. The significant increased in Rate of Evaporation, Overall Heat transfer Co-efficient, Steam Economy was found with increase in air flow rate and steam pressure. Whereas, steam consumption was significantly reduced compared to SSHE without ejection system. The vapour removal mechanism prevents accumulation and condensation of vapours inside the SSHE shell which reduces the partial vapour pressure which exerts when evaporation of water in SSHE. Implication of vapour exhaust system on SSHE considerably improved thermal performance with economy in energy and processing cost.

Keywords: Scraped Surface Heat Exchanger, Traditional Indian Dairy Products, Axial Flow Type Vapour Ejection System, Overall Heat Transfer Co-efficient

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Textural properties Variation of Market Sample of *Khoa* Based Products

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It has also been reported that from the total milk production, 50% milk produced is converted to traditional Indian dairy products. About 7% of milk produced in India is converted to *khoa.* The different*khoa* based products differ in textural properties from different producers and different batch from same manufacturer. Variation in textural properties ofmarket sample of *khoa*based productswere determined by using Texture Analyser model TA-XT Plus (M/s Stable Micro Systems, Surrey, UK fitted with 50 kg load cell and 75 mm compression plate)on regular interval for one month. The samples were taken from different popular brands located in Ludhiana city. The properties like hardness, cohesiveness, adhesiveness, springiness and backward extrusion were examined and significant difference have been observed in samples. The three different trials were conducted in a month at an interval of one week from four major brands in Ludhiana. The average hardness of sample A was 2147.978,sample B=4329.21, sample C=2121.07 and sample D=3983.786. There was significant difference in adhesiveness of four sample as Sample A= -3.56, sample B= -67.863, sample C= -59.285 and sample D= -8.028.Result of this study shows that the variations examined in samples may be due to the difference in sugar content, difference in methods and equipment used for preparation. Whereas in case of backward extrusion (khoa with sugar 6%) the two samplewere analysed at 45° C and 65°C. The firmness value of sample A was1741.8 and sample B was 983.75.

Key words: khoa, milk, texture, market, burfi.

Abstracts

Designing of Continuous Chhana Ball Making Machine for Large Scale Production of Rasogolla

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Rasogolla is undoubtedly the king of all Indian sweets. Kneading and ball forming are the first step in the preparation of rasogolla. Traditionally, kneading and ball forming of chhana is done manually which may leave some particle ungrounded which consequently affects the sphericity of rasogolla during cooking. Under the present study, an attempt was made to design, fabricate and testing a continuous chhana ball making machine with capacity of 9 to 56 kg/h of 9-10 g each. Both the units i.e. kneading and ball forming were hygienically designed for easy cleaning. In case of kneading unit included investigation of effect of the screw rpm and gap between conical barrel and kneading element on the overall hedonic grade (included smoothness, crumbliness and oiling-off) of kneaded chhana. In case of ball forming unit included investigation of effect of peripheral speed of the forming unit, length of ball forming unit hollow cylinder and shape of die on sphericity of final chhana ball. Studies were conducted with three different screw speeds i.e. 30, 40 and 50; three different gap between conical barrel and kneading element i.e. 1.5, 2.0 and 2.5 mm, four differentperipheral speed of ball forming unit i.e. 35, 42, 49 and 56 cm/s; two different lengths of hollow cylinder i.e. 400 and 600 mm and two different shape of die i.e. circular and square. The best overall hedonic grade of kneaded chhana was obtained at 2.0 mm gap and 50 rpm. The working capacity of machine was 34.9 kg/h at 50 rpm and 2.0 mm gap. The maximum sphericity 0.98 was obtained when the ball forming cylinder of length 600 mm at 42 cm/s peripheral speed and circular die.

Significance of Whey Protein Concentrate for the production of antimicrobial peptides derived from fermented milk by Lactic acid bacteria

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Lactic acid bacteria compose a group of bacteria that degrade carbohydrate (e.g., fermentation) with the production of lactic acid as a main end product. The proteolytic system of LAB converts proteins to peptides and then to amino acids, which is essential for the bacterial growth and also contributes significantly to flavour compounds as end-products. The peptides produced have properties like antithrombotic, antioxidative, antimicrobial, ACE-inhibitory, anticancerous, immunomodulatory etc. WPC when added to milk improves the viability of lactic acid bacteria (LAB) due to providing the extra nutrition to the cultures.In this study, L. rhamnosus(NS4) produced maximum acidity at 1.5% WPC as compared to L. helveticus(V3), S. thermophilus(MD2) and L. bulgaricus(NCDC09). Maximum total lactic counts were also observed in NS4 at 1% WPC in comparison to V3,MD2 and 09. Highest lowering of pH was observed for V3 at 1% WPC as compared to NS4, MD2 and 09. In case of Proteolytic activity, 09 showed maximum activity at1% WPC compared to MD2, V3 and NS4. Maximum zone of inhibition was observed in case of MD2 against S.aureusat 1.5% WPC as compared to V3, 09 and NS4. During the fermentation, NS4 produced the higher amount of peptides in skim milk supplemented with 1.5% WPCwhich were purified by RP-HPLC method as compared to V3, 09 and MD2.Fermentation of milk supplemented with different concentrations of WPC with lactic cultures found to increase the growth and proteolytic activity of LAB. Rise in antimicrobial activity of LAB was observed with addition of WPC. It also released potent peptides during fermentation which can be further explored for validation of biofunctional attributes. It can be concluded that WPC can be supplemented to milk for enhanced growth, production of proteases or bioactive peptides with antimicrobial activity during fermentation of milk by these four lactic cultures.

Effect of Ultrafilteration Concentration Level of Milk and Inoculum Level on Titratable Acidity Development and pH Drop During Incubation of Chakka

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Chakka is an indigenous fermented milk product of Indian origin. The simultaneous effect of different ultrafiltration concentration level (UFCL) and inoculum level on the acidification process in ultrafiltred (UF) cow milk fermented with *dahi cultures* to yield *chakka* were investigated. Simultaneously *shrikand* was also prepared out of that *chakka.* The interrelationship between pH and titratable acidity (TA) changes with change in protein content of milk. Highly significant increase was observed in rate of TA development and of pH drop during incubation, with increase in UFCL. The rate of TA development was highly and significantly faster in *dahi* prepared for *chakka* from UF concentrated milk as compared to the conventionally prepared one. The implementation of ultrafiltration technique in the processing of *chakka* will have the potential to increase yield through recovery of whey proteins, reduces the level of inoculum added and also the coagulation temperature which in turn reduces the production cost and easy automation. It also has an economical importance that it reduces the BOD (biological oxygen demand) of whey, a waste product out of processing.

Experiential Learning and Experimental Dairy Plant for Dairy Technology Colleges: A Study

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After the ICAR has recognized the need to develop practical skills at the under graduate level to make them industry ready, the focus was on providing Experimental Dairy plants at the Dairy Technology colleges. However provision of funds has not commensurate with the state policy of recruitment of technical staff and other facilities like raw material etc.The optimal sizes of dairy equipment is also an aspect that needs careful consideration for better practical training with the limited resource. A Survey has been made to know prevailing situation and the steps to mitigate the short falls, and eventually to meet the desired objective of the funding agency.

Optimization of Pressing Temperature and Pressure for Ensuring Textural Attributes of Buffalo Milk *Paneer*

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Paneer is an important Indian dairy product obtained through heat-acid coagulation of casein component, entrapping almost all the fat, a part of denatured whey protein and colloidal salts in milk and subsequent pressing of it. Good quality buffalo milk paneer is characterized by a white color, sweetly, mildly acidic and nutty flavor; firm, cohesive and spongy body and closely knit smooth texture. The present investigation was carried out to study the effect and to optimize the process parameters,mainly temperature and pressure for ensuring the textural attributes ofpaneer. The buffalo milk after coagulating using citric acidwas pressed at different temperature (62-70° C) and pressure (2-3 Kg/sq cm)viz obtained based on preliminary trials. Textural attributes of paneer with differentparameters are analyzed using TPA textural analyzer. Based on idle values obtained, the optimum temperature and pressure were selected. The analyzed textural attributes for optimized parameters were Hardness, Adhesiveness, Springiness, Gumminess and Chewiness.

Conversion of Plastic waste to Fuel, A promise to Dairy waste management and an energy solution

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Milk is a highly perishable fluid commodity, and hence packaging is a requisite. Owing to the query of a convenient packaging, it has ended up with laminates of LDPE and LLDPE combinations. Packaging loss occurred due to faulty machines, break-opening of unsold milk bags, manual errors are conventionally treated by landfill, incineration and recycling. LDPE in the presence of UV light take an average of 1000 years to degrade in the soil. When the wastes are incinerated, the bottom ash accounts for about 10% by volume and 20-35% by weight of the solid waste input. In the absence of control systems, harmful pollutants and gaseous compounds will be emitted, which will be hazardous to live species and environment. Recycling of plastic waste is often a false promise since it leads to the production of substandard products together with the harmful effects of environment pollution. Since the conventionally practiced techniques in one or other way stay harmful, the study here focus on a novel technique on Dairy plastic waste management; Pyrolysis. It is the thermo-chemical decomposition of organic material at elevated temperatures in the absence of oxygen. It occurs under pressure and at operating temperatures above 430°C. Plastic wastes in dairy industry are well suitable for pyrolysis.

The product obtained from the process; either gas or its condensed form can be used as a fuel. Hence it is a promising solution to the packaging waste management and the generation of an alternate energy resource and thus serves as an ideal measure towards sustainable environment. The technique is designed ergonomically to suit the lifestyle of general population in India.

Rheological Characteristics of Different Types of Payasam; A Comparative Study

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Payasam is a milk based delicacy popular in the southern parts of India. There are several varieties of payasam with distinct characteristics that may be attributed to the area of their origin and method of preparation. When the base material is milk it is called as payasam and when it is coconut milk it is termed as 'prathaman'. The present study focuses on the rheological properties of cereal (Rice) based payasam. Four varieties of payasam were prepared by using cow milk, buffalo milk, sweetened condensed milk and coconut milk. All other ingredients and processing conditions were kept constant. Viscosity and other rheological properties were analyzed. The products were also subjected to sensory evaluation by a panel of expert judges.

Performance Evaluation of Solar Hot Water Assisted Vapour Absorption Refrigeration System Using Heat Pipe Evacuated Tube Solar Collectors

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Solar energy is one of the most efficient, clean and affordable energy alternatives available today. With the current concerns about global warming and ever increasing energy rates, countries are seriously looking for domestic and industrial usage of solar energy. In this aspect, present work is planned with LiBr-H_2O vapour absorption cooling system driven by 147 m^2 heat pipe evacuated tube collectors with objectives to assess the performance of solar hot water generating system under different operating conditions and to determine theoretical and actual COP *during the months of October, November, December-2014 and January, February and March-2015*. The experimental LiBr-water solar vapour absorption refrigeration (SVAR) system having rated installed capacity of 5 TR was used for the study. The Experimental set up of proto type vapour absorption refrigeration using solar energy has been used for generation of chilled water for the cold storage. The system consists of Evacuated tube collectors with heat pipe system, Components of Lithium Bromide –water absorption refrigeration system (Absorber, Generator, Condenser and Evaporator). *The highest value of intensity of solar radiation of HP-ETC obtained during experimental months was 961 W/m² in the month of March, 2015. The interaction effect of month and time was also found significant. The maximum recorded HP-ETC outlet fluid temperature was 99.05 °C. The highest efficiency value of HP-ETC obtained during experimental months was 80.25 in the month of March, 2015. The interaction effect of month and time for efficiency of HP-ETC was found significant.* The efficiency of HP-ETC ranged from 24.57 to 55.44 %, 25.22 to 59.00 %, 29.35 to 61.13 %, 31.58 to 66.91 %, 35.12 to 70.33 % and 44.84 to 80.25 % during the different corresponding months of the study. *It was found that efficiency of HP-ETC varies throughout the day depending on the intensity of solar radiation. The statistical analysis revealed that there is significant effect of month of operation and operating time on intensity of solar radiation of HP-ETC.* The values of actual COP of the SVAR system ranged from 0.20 to 0.58, 0.25 to 0.62, 0.24 to 0.66, 0.27 to 0.76, 0.34 to 0.80 and 0.35 to 0.89 during the respective months of the study period. The results from this study showed that actual average COP of the system was 0.49 while the maximum and minimum values were 0.84 and 0.20 respectively. These results were obtained based on the average solar collector's efficiency at an ambient temperature of 32 °C.

Application of LED as a non-thermal technology in the dairy industry

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Effective processing of milk is essential to ensure food safety, as it is highly perishable and as its low acidity and high nutrient content make it the perfect breeding ground for bacteria, including pathogens. Traditional milk processing relies on heat to kill foodborne pathogens to make food safe to consumption, but the applied heat may also cause undesirable biochemical and nutritious changes that may affect sensory attributes of the final product. Researchers have been studying several non-thermal processing methods (methods that do not use heat) that will destroy pathogens and keep foods safe to eat, while retaining the sensory attributes and nutrient content similar to raw or fresh products. Photopurification which uses ultraviolet light is a technology that holds immense potential in processing milk. However, this technology is not very inexpensive. Light-emitting diode (LED) is a semiconductor that emits light when an electric current passes through it. LEDs can be manufactured to emit light in the ultraviolet range, although practical LED arrays are very limited below 365 nm. Such LED arrays are beginning to be used in water purification, UV curing etc. There is no literature available on the utility of this technology in dairy industry. This work is intended to study the effect of application of UV- LED in dairy industry.

Energy conservation in refrigeration and cold storages

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Refrigeration is one of the most important utilities for dairy and food processing plants. It is required for cooling of milk, processing of milk, manufacture and storage of dairy and food products. Vapour compression refrigeration system (VCR) is widely used in India for bulk milk coolers, ice bank refrigeration system, glycol chilling system and cold storages. The refrigeration system uses electrical energy for operation of compressor and other auxiliary components of the system. As the electricity consumption of refrigeration plant alone is about 50-60 % of total electrical consumption of the dairy plant depending on the nature of processing operations, management in refrigeration systems is a key for overall conservation of electrical energy. The conservation of electrical energy not only helps in reducing the operating cost of the system but also contributes in reduction of Green House Gases (GHG) in the environment. Energy conservation is the strategy of adjusting and optimizing operating conditions of the system and adoption of newer technology in the field of refrigeration and cold storages. Energy audit is a basic requirement for conservation of energy which provides information for improving the performance of the refrigeration systems and adoption of energy efficient technology.The design of the refrigeration system and its components, use of energy efficient electric motor for compressor, operation of the system under optimum conditions and maintenance of the plant are very important considerations for the conservation of electrical energy. The use de-super heater for generation of hot water, liquid over feed system, PHE type pre-chiller, VFD for capacity control of compressor are some of the ways for conservation of electrical energy in refrigeration systems. Design of cold storages and minimizing refrigeration losses in cold storages are very important for conservation of energy.

Image Analysis of *Ghee*: Effect of method of preparation

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Image analysis is a rapidly growing tool for food analysis that could be applied for analysis of ghee. It is well known that milk fat crystallization is influenced by processing and storage parameters, such as, time – temperature combinations at ageing, methods of preparation. A methodology based on image analysis was applied for evaluation of Cow and Buffalo ghee to study the effects of method of *ghee* preparation on mathematical descriptors of its image colour and texture. Test samples of Cow *ghee* and Buffalo *ghee* samples were prepared by Direct Cream Process and Creamery Butter Process; with and without seeding. The raw images of the samples were acquired and subjected to the standardized methodology of preprocessing and segmentation and then analyzed for deriving the parameters to describe the image quality of Cow and Buffalo *ghee*. A total of 210 images were acquired and analyzed and it was observed that seeding did not significantly influence the image characteristics. The image characteristics were found to be device dependent parameters. Method of preparation had no significant influence on image parameter except the colour descriptors viz. hue, Chroma and Yellowness Index of Buffalo *ghee* image. Cow *ghee* imagesshowed influence of method of preparation on Lightness, Pixel Intensity, Particle Count and Junctions of the image. The effect of method of preparation was attributed to the intense heat treatment of the Direct Cream Process.

Image Colour and Texture Analysis of blends of Cow and Buffalo Ghee

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Image analysis is a novel analysis technique that has found wide application in defining and monitoring quality in the food industry. An attempt was made to analyze the blends of Cow and Buffalo ghee with this technique. *Ghee* was prepared by clarification of cream from Cow and Buffalo milk using the standard creamery butter method before being blended in pre-determined proportions of 0:100, 25:75, 50:50, 75:25 and 100:0 to prepare the test samples that were crystalized in Steriplan dishes at 29 °C for 180 min. The dishes were scanned using a fat bed scanner to acquire the images which were imported to ImageJ and Adobe Photoshop to analyze the image texture and colour, respectively. The quality parameters were defined by 29 mathematical descriptors, including 8 colour and 11 texture indicators. The data was modeled using multivariate analysis to develop mathematical models to discriminate the blends. Five select parameters were finalized for the model based on regression analysis and the models were found to predict the level of blending with an accuracy >90%. The developed models were validated for test samples at 35:65 and were found to perform adequately.

Biofilm Formation in Dairy Industry & Recent Advances for its Prevention & Control

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Biofilms are communities of microorganism that are form on solid or fluid interfaces and are designed to protect the individual cells, such as bacteria, from the environment. The mass is formed by microorganisms attached to a surface, such as a surface of a medical device, and the associated extracellular substances produced by one or more of the attached microorganisms. It is a natural tendency of microorganisms to attach to wet surfaces, to multiply and to embed themselves in a slimy matrix composed of extracellular polymeric substances (EPS) that they produce, forming a biofilm. Bio films are problematic in particular food industry sectors such as brewing, dairy processing, fresh produce, poultry processing and red meat processing. It is estimated that 99.9% of the bacteria in nature are attached to a surface in the form of bio film. They have potential to contaminate dairy products through the introduction of pathogenic microorganisms or spoilage bacteria Microbial colonization of solid surfaces and the formation of biofilm is a process consisting of three successive stages Adherence of free planktonic microbial cells; Colonization of the preconditioned surfaces; Release of microbial cells from the biofilm structures. Current methodologies in bio film studies include Atomic force microscopy (AFM), confocal laser scanning microscopy. The preventive measure for controlling biofilm includes Cleaning and disinfection, the green strategy for biofilms control – enzymes, phages and bio regulation. Micro and nanotechnology and Quorem sensing are new approaches for controlling the formation of biofilm in dairy industry.

Extrusion Technology in Dairy Industry

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Extrusion technology has become a very popular and is being increasingly used for the manufacture of food products. It is utilized in many areas of the food industry, including the production of snack foods, breakfast cereals, animal feed, and other diverse food products. Food extrusion is a process of shaping a plastic or dough like material by forcing it through a restriction or die. A food extrusion machines is a device that expedites the shaping and restructuring process for food ingredients. It can be visualized as a high temperature short time (HTST) device that can transform a variety of raw ingredients into intermediate and finished products. Food extruder use single or twin screws to transport, mix, knead, shear, shape, and/or cook multiple ingredients into a uniform food product by forcing the ingredient mix through shaped dies to produce specific shapes and lengths. Extrusion is currently utilized to produce textured protein products, snack foods, toast and confectionary products. In the dairy industry extrusion technology is hardly known but some research work has been done, for example on casein/caseinate conversion, production of processed cheese, mozzarella cheese, sandesh, rasogolla etc. It is a very useful technology for dairy processing operations involving conveying, mixing, kneading, cooking, shearing and shaping which is yet to be exploited by the dairy industry.

Trends and Energy Management Strategies for the Road ahead in Dairy, Food and Chemical Industries

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Despite commendable efforts to reduce energy consumption, the world's consumption of fossil fuels continues to grow. Industrial energy users remain unaware of the energy efficiency opportunities available to them. The size of global processed food industry is estimated to be valued around US $3.6 trillion and accounts for three-fourth of the global food sales. Despite its large size, only 6% of processed foods are traded across borders compared to 16% of major bulk agricultural commodities. Indian food-processing industry is miniscule in comparison and is estimated to be US $40 billion and is likely to grow at over 10%, on the basis of an expected GDP growth rate of 8-8.5% p.a. Dairy industry knocks – out as a major agricultural produce dominating in GDP of 28 per cent of agricultural GDP i.e. 13.9 per cent in 2014-15 by producing 146.3 million tonnes of milk. Cost and energy management is an effective tool to maximize the profit in producing food and chemical products with high quality and safety along with sustainability by protecting the environment and ecology. Modern management approach is needed without large investment by launching energy conservation programs with commitments of all from management to plant operators. This requires training, monitoring, implementation, record keeping, motivation and passing information on energy performance and management strategies to minimize the losses, improving the efficiencies of the systems and selection and utilizations of non-conventional i.e. renewable energy resources such as solar energy, biomass energy and wind and tidal energy etc. Apart from this, alternative technological approaches such as high hydrostatic pressure (HHP) technology, Super critical fluid extraction technology, Ohmic heating, membrane technology, nanotechnology, biomethanation, biotechnological approaches, Pulse electric field and eco-friendly packaging of final food and chemical products strategic tools are also significant. For sustainability, research and development goals must be oriented towards these alternative technologies and energy conservation monitoring programs involving research institutions and R & D wings of industries introducing eco-friendly production, transportation and storage chains or in shorts green technologies and innovations for producing green products with higher returns and safety. Different energy intensive sections such as roasting, frying, cooking, heating, cooling, pasteurization, sterilization, evaporation, steam generation, Refrigeration, drying and freezing are discussed with reformation and changes needed for cost and energy management.

Superheated Steam Drying of food: An Overview

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Superheated steam is an extremely high-temperature vapour generated by heating the saturated steam obtained by boiling water at a given pressure. Superheated steam is now drawing attention in the food, medical, and other industries where cleaning, disinfection, and drying play a crucial role. In Superheated steam drying (SSD) drying technology the drying takes place through direct contact between superheated steam and the product to be dried. It involves the use of superheated steam in place of hot air, combustion, or flue gases as the drying medium in a direct (convective) dryer to supply heat for drying and to carry off the evaporated moisture. Superheated steam drying is a potential drying method due to its several advantages. They are: absence of oxidative reactions (enzymatic browning, lipid oxidation, no fire or explosion hazards) due to lack of oxygen, higher porosity of dried food product which result into better rehydration, high heat transfer coefficients, higher drying rates, deodorization , energy saving due to latent heat supplied to the dryer can be recovered, environment friendly since it is a closed system it enables emitted odours, dust, or other hazards components to be contained and avoids the risk of these hazards. Superheated steam drying permits pasteurization or sterilization and deodorization of food stuffs.

Temperature dependent hydration modeling during pre-cooking of basmati rice for mechanized production of *kheer*

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Cooking of rice for *kheer* production is a complex process due to simultaneous changes in kernel structure, heat transfer, moisture uptake and starch gelatinization. Rehydration of rice grains is an important process to attain better cooking quality for *kheer*. In the present study mathematical modeling can be used to optimize the time, temperature and other associated characteristics liable for cooking of rice. This study investigated the hydration effects of two basmati rice cultivars (Pusa 1121 and Pusa 1509) and the quality of pre-cooked rice with the different temperature soaking time treatments on the physical properties. Soaking temperature had significant effect on physical properties of pre-cooked rice. The data were tested on the standard hydration equations to determine the model parameters, correlation coefficient (R^2) and the predicted values was in good agreement with the observed data. The effects showed that the increasing the soaking temperature reduces the cooking time for the basmati rice grains and helps to optimize time-temperature combination to get desired hardness of pre cooked rice. These highlights were mainly attributed to the gelatinization of starch with increase in temperature and time for producing quality of pre-cooked rice. The results of present studies reveals that the mathematical modeling can be used for predicting the moisture content, temperature-time profile, diffusivity and activation energy in context with the rice hydration process.

Effect of Total Solids on Engineering Properties of *Rabri*

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In India, dairy sector plays a crucial role in the socio-economic development, and rural economy. Dairy industry in India is growing potentially with time. It is transforming from small scale regional entrepreneurs to large scale pivot level. In spite of this, a large extent of milk produced in India is utilized by unorganized dairy sector at village household. In traditional Indian dairy products, some products such as *Rabri*, *Basundi, Shrikhand, Kunda* and *Palada payasam* etc. are region specific. *Rabri*, one of the delicious Indian dairy products, is very much popular in India (especially in north east part of the country) and other Asian countries. It is especially prepared concentrated and sweetened whole milk product, containing several layers of clotted cream. It is heat desiccated thickened milk sweet, pale yellow to light caramel colour and flavour. Its manufacturing process is complicated. Handling and storage are also difficult. For small households, batch production may be used but for large scale, bulk production of *Rabri*, this method becomes highly laborious and energy intensive / consuming. So, mechanization for *Rabri* production becomes very important. Engineering properties of *Rabri* are prime factor to design the process equipment. Very little published information is available on engineering properties of *Rabri*. Therefore, in present investigation, effect of total solids on engineering properties of *Rabri*, e.g. density, rheological characteristics and colour at different total solids (40%, 45%, 50% and 55%), were determined. Different rheological models were also applied to characterise rheological behaviour of *Rabri* serum. Engineering properties of *Rabri* especially viscosity and density was found to have high variation with change in total solids of final product. Density of *Rabri* was increasing with increase in total solids content of *Rabri*. Colour of *Rabri* was found to be affected significantly by change in total solid content of *Rabri*.

Effect of Cooking Time for Preparation of Rasogolla by Conventional Method

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Indian milk sweets have played a vital role in the economic, social, religious and nutritional security and safety aspects of our country people. Traditional milk sweets are value added products with a distinct advantage of having great mass demand. About 50 to 55 per cent of milk produced, processed by the traditional sector (*halwais*) into a variety of Indian milk products. The chhana is used extensively as the base and filler for the preparation of a large variety of Indian delicacies namely, *Rasogolla, sandesh, cham-cham, rasmalai, pantoa, rajbhog, chhana-murki* and many more such products. *Rasogolla*, regarded as the king of Indian milk sweets, is prepared by controlled cooking of kneaded cow milk chhana balls in boiling sugar syrup. *Rasogolla* cooking is a major step in the preparation of *Rasogolla*. In present study, the effect of different cooking times (10, 12.5, 15, 20, 25 and 30 minutes) for the preparation of *Rasogolla* was investigated. The geometric mean diameter (GMD) of cooked chhana ball ranged from 2.6 to 3.5cm. The GMD was attributed to the formation of void space in the product, formed by flash evaporation of moisture and got maximum value at 20 minute, afterwards its GMD decreased due to crust formation, disintegration of ball at higher cooking time. The per cent absorbed sugar was significantly different at different cooking times of chhana ball and it ranged from 73.7 to 126.5 %. In *Rasogolla* cooking, the water was evaporated from the boiling sugar syrup. The boiling hot water has been added into the sugar syrup after specific time interval during cooking to compensate the required concentration. The energy consumption was found significant at various cooking times of chhana ball. Sensory characteristics of *Rasogolla* were found significant ($p<0.05$) for different cooking times.

Role of Community Colleges in Dairy Engineering Education

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University Grants Commission (UGC) has launched a scheme of skill development based higher education as part of College/University education leading to Certificate/ Diploma/Advanced Diploma/ Degree (B.Voc.) with multiple entry and exit options under the National Skill Qualification Framework (NSQF). These programmes also incorporate specific job roles and their National Occupational Standards (NOS) along with general broad based education. An assessment and certification for specific job role is done by respective sector skill council. India is topmost producer of milk in the world, produces around 130 million tones of milk with the growth rate of 4 % annually. Milk production in India is mostly confined to small and marginal farmers. About 35% of milk is processed. Milk collection in India is done mostly through the network of cooperatives. The private dairy sector in India is also growing up rapidly. About 50-55% of milk is converted into Indian milk products. An important products manufactured are Indian milk products (Peda ,Burfi, Gulabjamun & Paneer etc.) The western milk products manufactured are Cream, Butter, Milk powder & Cheese. This scenario of Indian dairy industry expects huge requirement of skilled manpower at various levels. As per the NSDC data, in dairy product sector the human resource and skill requirement till 2022 is 11,94000 persons. Most of the human resource developed in dairy sector in India is at higher level. However, dairy industry strives for shortage of skilled manpower at lower levels for specific job roles and had no other options than lateral entry. This compromises the issues of quality and safety which became the buzzword of new era. The UGC Community College of scheme is the greater initiative to address these concerns. With an industrial collaboration the Community Colleges are trying to fill up this gap of human resource requirement in dairy sector at various levels. However, the manpower generated is quite meagre as compared to the requirement. The paper enumerates various opportunities and challenges pertaining to skill development through community Colleges in dairy engineering education in India.

Nozzle Applications for Cleaning Operations in Dairy Processing

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Dairy industry is growing at significantly faster rate in India. For production of milk and milk products with satisfactory quality and safety standards, cleaning and sanitization is one of the most important unit operations in dairy industry. Due to various limitations of manual cleaning, it's not feasible for every equipment to be manually cleaned. It is difficult to clean equipments in large plants hence need some sustainable, economic and efficient method for cleaning purpose. Automated cleaning processes can be adapted through nozzles to virtually any equipment configuration such as large, small, simple, complex, easy or difficult. Among the various forces affecting cleaning process nozzles can significantly enhances the mechanical force and efficiency in both CIP (Cleaning In Place) as well COP (Cleaning Out of Place) applications. Traditionally only limited types of nozzles were available but with technological advancements huge varieties of nozzles are available with various types of spray patterns. Spray ball, free spinning heads, gear driven/ fluid driven type, spray gun etc types of nozzles are available in the market on their own advantages and disadvantages. Nozzles are being used successfully for cleaning of milk tanker, silo, processing vats, tanks, milk can, crates, conveyors. Proper selection and optimization of nozzles can significantly reduce the water and energy requirements and can give satisfactory CIP results. Thus nozzles have promising future for dairy cleaning applications.

Advances in *Ghee* and Butter Oil Manufacturing

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In traditional Indian diets, milk fat is usually consumed in the form of *malai, makkhan and ghee* which contributes significantly towards nourishment of people of all age groups. *Ghee,* also known as "*desi" (indigenous) ghee*, is one of the most widely used milk product in the Indian sub-continent. It is also considered as supreme frying medium. In general, *ghee* is an Indian counterpart of butter oil. Butter oil is basically a fat concentrate obtained exclusively from butter, resulting from removal of almost entire water and solid-not-fat. Methods of *ghee* manufacture vary with the raw material used (milk, cream and butter), the intermediate treatment of raw materials and the handling of the semi or fully formed *ghee*. In general, there are six methods for the production of *ghee* such as (i) milk butter (ii) direct cream (iii) cream butter (iv) pre-stratification (v) continuous and (vi) Improved methods. In continuous production of *ghee*, several *ghee* boilers, scraped surface heat exchanger, clarifier and concentrator are used. This method results in lack of uniformity (i.e. flavour variation) from batch to batch, high energy consumption, and almost rare chances of heat regeneration are possible. Newer methods of butter oil manufacturing such as (i) cream and (ii) butter as raw material are used. This method utilizes double cream separator, plate heat exchanger along with vacuum dryer having provision for continuous neutralisation of free fatty acids. This operation helps in removing moisture as per the degree of heat supplied by the steam with level of vacuum and centrifugal force applied to the raw material. It gives high heat transfer coefficient along with possibility of heat re-generation. Therefore, in this paper, *ghee* and butter oil making have been presented which should be high energy efficient, heat re-generation, and having uniformity in terms of flavour and texture.

Application of Ultra-High Pressure Processing on Dairy Product

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High-pressure processing (HPP) is a novel non-thermal method that has shown great potential for reducing microbial loads, at temperatures below sterilization conditions. Ultra high pressure (UHP) technique subjects liquid and solid food to pressures between 100 and 1000 MPa with exposure times ranging from a few seconds to over 30 min. Ultra-high pressure processing (UHPP) technique is a new technique in cold sterilization of foods, which has a broad application prospect. The ultra-high-pressure processing technique has make good processing quality and less destructiveness in the nutritive component, flavour, colour etc. Pressure ranges between 100 and 1200 MPa have been considered as effective to inactivate microorganisms including food-borne pathogens. HHP also improves rennet or acid coagulation of milk without any detrimental effect on flavour, body and texture and nutrients. These characteristics offer the dairy industry numerous practical applications to produce microbially safe and minimally processed dairy products with improved characteristics. The main effects of high pressure treatment in milk appeared to involve dissociation of caseins micelles from the colloidal to the soluble phase, resulting in reduced turbidity of milk, decreased rennet coagulation time, increased pH and reduction in whiteness. Flavour and aroma components contributing to the sensory quality, and nutritional quality remained unaffected by pressure treatment. There are many alternate novel food processing techniques available, amongst them high pressure processing seems a very promising technique for dairy products, as it offers numerous opportunities for developing new shelf stable foods, retaining its natural nutritional value with excellent organoleptic characteristics. Some investigations on methods of ultra-high-pressure processing, such as magnetization and ultrasonic wave, are carried on fruit juice. Research on development of dynamics model about sterilization and enzyme inactivity due to ultra high pressure processing on dairy products are also needed.

Spray Drying for Microencapsulation of Dairy and Food Ingredients

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One of the greatest challenge food researches is facing in this century lies in maintaining sustainable food production and at the same time delivering high quality food products with an added functionality by incorporation or fortification of bioactive components (vitamins, minerals, antioxidants, omega-3 fatty acids, plant extracts, prebiotics and probiotics, and fibre enrichments). Many of bioactive ingredients are prone to degradation and/or can interact with other components in the food matrix, leading to loss in quality of the functional food products. This problem can be overcome by using microencapsulation technology. In microencapsulation sensitive bioactive is packaged within a secondary material for delivery into food products. Microencapsulation by spray drying is a one of the cost-effective one-step process as compared to other encapsulation methods. During spray drying process, the evaporation of solvent, that is most often water, is rapid and the entrapment of the interest compound occurs quasi instantaneously. This process involves four stages: the first stage is formation of a fine and stable emulsion of the core material in the wall solution, and then the homogenization of dispersion followed by atomization of infeed emulsion and dehydration of atomized particles. Micro encapsulation using spray drying is mainly used in the food sector to protect bioactive compounds or functional foods from light, temperature, oxidation, etc.

Recent Developments in Proceesing of *Kulfi*

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In India, traditionally, milk and milk products have great importance as a nutritional product. In present scenario, consumers prefer value added milk products which are rich in vitamins and minerals. About 0.7 per cent of the total milk, produced in India, is converted into *Kulfi*, Ice-cream and other frozen desserts. *Kulfi* is an indigenous frozen milk product and widely popular in the northern region of India. It is mostly consumed for its rich flavour thirst quenching and cooling effect. The traditional method of production for *Kulfi* varies from place to place, producer to producer (region specific). Generally, it is made by condensing of milk without prior standardization up to desired total solids (minimum 36 % total solids) and adding sugar just before to the finishing stage of the concentration process. Various methods have been tried by several researchers on *Kulfi* production such as standardized conventional method for making the *Kulfi,* different ingredients for manufacturing of *Kulfi*, method developed for *Kulfi* making using soy solids and milk solids, method developed for *Kulfi* mix powder, method developed for probiotic *Kulfi* by replacing milk fat with the vegetable fat, *Kulfi* using the artificial sweeteners, method for making chhana based *Kulfi*. It has been reported that the quality of *Kulfi* viz. reduced sugar, lactose hydrolysed, reduced fat, dietary fibre added and control *Kulfi* varies from method to method. There are some recent developments in processing equipments for *Kulfi* (or *Kulfi* like products) in market such as continuous candy making machine, continuous ingredient dozer, continuous rotary type freezer, continuous filling and wrapping machine, application of robotics for carrying the products as well as automation in *Kulfi* and Ice cream making plant.

Advances in Automation for Dairy and Food Processing Industry

ArvindKumawat*[1], P.S., Minz[2], Chitranayak[3], A.D. Vairat[4], Dharin Jayswal[1], P. Subramani[1], Priyanka[1],

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Automation will no longer be seen only as automatic production, but as a complex of technologies that guarantee reliability, flexibility, safety, for humans as well as for the environment in food processing plants. Rapid advances in computertechnology and heightened expectation of consumer and regulatory agencies for improved food quality and safety features have forced the food industry to consider automation of most manufacturing process in food industry. In the industries, automation of the manufacturing operations holds the promise of increasing productivity of the labours. This means greater output per hour of labour input.Automation (robotics) relieves man of both the repetitive monotonous mental and physical responsibilities usually associated with mechanical handling because, it is a self regulating system due to its capability of feeding back pre- selected output standards or values to a control point. Various software like SCADA (Supervisory Control And Data Acquisition) and SAP (Systems, Applications, and Products in data processing) are well adopted in modern dairies. Use of latest technologies for Tracking and traceability improves management with better transparency. Despite of having few disadvantages, automation must be adopted in these industries to sustain in highly competitive world. Although India is largest milk producing country in the world, the level of automation in Indian dairy sector is low to medium. Thus Indian dairy sector has yet to experience the full potential of automation, both in milk production as well as processing.

Water Hammer Effect in Pipe Line System

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College of Dairy Science and Food Technology, C.G.K.V., Raipur (C.G.)

Water hammer is a force that can arise in any pump system that undergoes abrupt changes in its rate of flow. These fluid velocity changes can result from the pump start/stops and valve opening/closing. Generally in dairy plants, water hammer can occur when a slug of condensate is pushed by the steam pressure along a pipe instead of draining it away. Its harmful impact is more on a valve or fitting such as a pipe bends or tee. Actually, during water hammer formation, the water velocity (kinetic energy) is converted into pressure energy. It is nothing but formation of pressure wave as a result of sudden change in liquid velocity. This gives particularly cascading effect in condensate bi-phase systems and water carrying pipe lines. Condensate bi-phase system contains two fluids, the liquid (condensate) and vapour (flash steam). Typical equipment where formation of water hammer may be formed are heat exchanger, UHT sterilizer, evaporator etc. Water hammer may be produced because of hydraulic shock, thermal shock, and differential shock. The excessive pressure head created by water is directly proportional to length of the pipe and velocity differentials of bi-phase system. Hence it is advisable to have lower velocity of these fluids. The pipeline is suppose to perfectly rigid and non-elastic but in actual practice due to its elasticity, the radial pressure of water hammer on the pipe causes circumferential and longitudinal stresses. Water hammer can damage steam traps, pressure gauges, valves and entire pipe system. The effect of water hammer can be minimized by installation of steam trap at correct location, non-return valve, surge guard and control valve etc.

Use of Advance Automation in liquid milk and powder plant

Chaudhari A.G.[1], khasetiya R.A and Parikh U.M.

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In dairy industry automation is very important because it improve the productivity, product quality, and profitability. Though the dairy industry presents many unique challenges to complete automation, the industry has been successful in putting many automatic processes into operation. In the dairy milk plant there are many operations carried out for processing milk. Electrical installation plays an important role in completion of every process. Consistent product quality made using advance predictive control (APC) system. Advance Process control shall have simultaneous control of more than one controlled variable by the coordinated adjustment of more than one manipulated variable. CO system is also designed for the early detection of thermal disintegration and smouldering fires in drying processes for products which release carbon monoxide. Online moisture analyzer shall measure the moisture content in the powder online and transmit the data to the DCS/high end PLC through local junction box to RIO panel. Microprocessor based distributed control system (DCS/HIGH END PLC) shall be used for centralized operation of the plant. The DCS/HIGH END PLC system offered shall have open architecture and shall use common engineering tool for operator station, automation system, PLC programming is facilitated and its essential functions are configured via PC. All settings and program parameters are held in SQL (*Structured Query Language,*) database where that can be viewed and modified by authorized users without the need of a programming.

Vacuum Cooling: An Advanced Cooling Technology

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Cooling technology is one of the effective method used for preservation of several food products. Various researchers and scientists have done number of studies and have found effective methods of cooling. Vacuum cooling has proven to be one of the promising method of efficient cooling. Vacuum cooling is a rapid evaporative cooling method for porous and moisture foods to meet the special cooling requirements. The principle of vacuum cooling is based on the rapid evaporation of moisture from the surface and within the products. When water evaporates, it needs to absorb heat in order to maintain higher energy level of molecular movement at gaseous state. The amount of heat required is called latent heat, which must be supplied from the product or from the surroundings that consequently are refrigerated. The temperature at which water starts to evaporate is directly dependent on the surrounding vapour pressure. Vacuum cooling has major advantages like rapid cooling; lowest energy cost per unit of cooled product and the vacuum cooling unit is sanitary. Inspite of these advantages it has some disadvantage such as it is highly product specific process, which is applicable to moist produce with porous structure only and higher amount of moisture loss results in lower yield. Extensive research is needed on mathematical modelling of vacuum cooling process that would lead to better equipment design and process control, thus making this technology even more attractive.

Vidya Dairy

"Necessity is the mother of invention"

The Prodigy:

The need for skilled dairy professionals to run the ever progressing Indian milk industry has been increasing constantly, which gained momentum since the Father of White Revolution embraced the Indian Dairy industry with his idea of Operation Flood. This "necessity" led to the inception of Sheth MC College of Dairy Science in the Milk City of Anand in 1961. The college provided quality dairy education to the aspiring students from all over India. In order to stay ahead in the era of competitiveness, the curriculum of the course was updated from time to time. A similar incident happened in 1987. The "necessity" of providing practical exposure to the dairy graduates and to make them 'Industry-Ready' led once again to an "invention". An ICAR-NDDB joint panel was formed to amend the curriculum of the course of Dairy Science College, Anand. Some changes that were made on that fateful day were:

1. Degree nomenclature was changed from B.Sc. (DT) to B.Tech. (DT).
2. The degree of 4 years included one year training programme.
3. Students were to be paid stipend for their in-plant training of one year.

The meeting paved a road to the inception of Vidya Dairy.

The Vidya Dairy, spread across 20 acres of land, has been a helping hand for all the students of Sheth MC College of Dairy Science, Anand by making them sound and preparing them for the dairy industry. The idea of Vidya Dairy was perceived by the Father of White Revolution, Late Dr. VergheseKurien. The dream came true in 1994 to provide full one year *hands-on training* to B.Tech. (Dairy Technology) students of SMC College of Dairy Science, Anand. Students of the College coming from nook and corners of the nation undergo 365 days training programme at Vidya Dairy during their 4th Year of the degree curriculum. Vidya Dairy follows the principle of 'Learning-by-Doing' and hence, here students work with their own hands and gain skills and experience which can be utilized later in their professional career.

Vidya Dairy has an installed capacity of 1,00,000 litres of milk handling per day. For making the training programme effective, the hands-on-training is imparted through a module of 12 sections varying from production to engineering and accounts to administration which enables the students to get the knowledge of each and every process which is carried out in any state-of-the-art dairy plant.

Vidya Dairy is a unique model in itself because not only it is working for a noble cause but also it is autonomous. Vidya Dairy receives milk from Amul Dairy, Anand. The raw chilled milk reaches the dairy in road tankers of varying capacity and it is then processed and transformed into various products like Market milk, Ice-Cream, Dahi, Cheese, Ghee and Paneer. All necessary care is taken to ensure that all the products comply to FSSAI requirements in the quality and food safety. The products manufactured at Vidya Dairy are sold under the brand name of 'Amul-The Taste of India' through the distribution channel managed by Gujarat Co-operative Milk Marketing Federation Ltd., (GCMMF Ltd), Anand.

The aforesaid activities of the dairy helps in the financial viability of the plant and also for achieving its main mission i.e. student training. The students cover the training in 12 modules which are completed in 12 months in order to gain hands-on experience competency in the respective area.

Vidya Dairy is awarded the status of Company (Not for Profit Organization) under section 25 of the Companies Act, 1956 which is now under section 8 of the Companies Act, 2013. The company's motto is "Of the Students, For the Students and By the Students". Vidya Dairy has been a Mogul of dairy training since last 22 years and will continue to strive for improvements of self as well as the trainees in the future as well.

Technical Session on "Stretcher Cooker Machine" by Ms. Claudia Mucci, Director, Milky Lab, Italy

Safety Day Celebration

IDMC Visit

External Training Programmes - A Step Ahead...

Vidya Dairy was established to fulfill the dreams of Dairy graduates who will serve the dairy industry of India and abroad. But, as it is wisely said that there is no age for dreaming, Vidya Dairy has taken an initiative to fulfill the dreams of already working dairy professionals of the country by providing them short term training and refresher courses so that they are constantly exposed to new development. Due to never ending demand of the industry, researchers have been striving to develop new technologies day by day. In order to accept the technology at a higher scale, dairy personnels are required to be trained accordingly to gain access to latest advancement. The short term training programmes and refresher courses for dairy professional are being jointly organized by Vidya Dairy and Sheth MC College of Dairy Science. By mixing a good quality theoretical information of Faculty of Dairy Science College and practical skills of Staff of Vidya Dairy, nectar of knowledge is being delivered to the dairy industry of India and abroad since 2009. The year round schedule of External Training Programmes encompasses various segments of dairy industry starting from raw material to finished products. These aspects refresh their knowledge and enrich the skills of practicing dairy/non-dairy executives which ultimately help their organization to improve efficiency, reduce cycle time and cost. Apart from the regular schedule of training programmes, Vidya Dairy also arranges tailor made training programmes as per the requirements of the concerned organization.

Research & Development activities at Vidya Dairy

The enthusiastic and well-educated staff of Vidya Dairy have come up with various new ideas related to developments in dairy industry. In-spite of being a small dairy plant, it is being chosen as a centre for research and development by GCMMFL. Moreover, Vidya Dairy has successfully transferred the process technology to various other unions after successful completion of the research trials. Some of the products which have been launched by GCMMFL after taking successful trials at Vidya Dairy are:

- Amul Ice-cream
- Amul Frozen Paneer
- Amul Mozzarella Cheese
- AmulEmmental Cheese
- AmulKadhiDahi
- Amul Sour Cream

Apart from new product development, Vidya Dairy has been a pioneer organization in developing/utilizing a number of new technologies which are helpful in terms of energy conservation and improving the process efficiency. .

The products and technologies developed by Vidya Dairy has further sharpened the quality dairy education for which Vidya Dairy has been striving since 1994.

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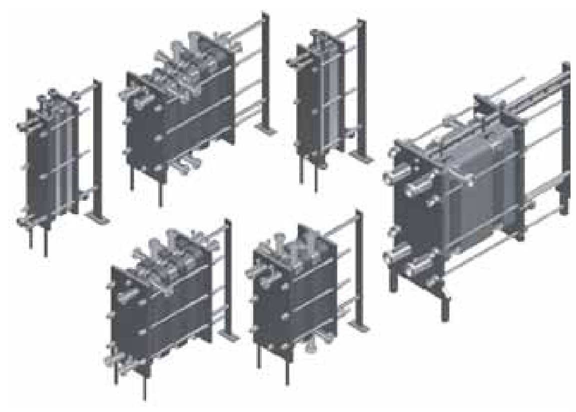

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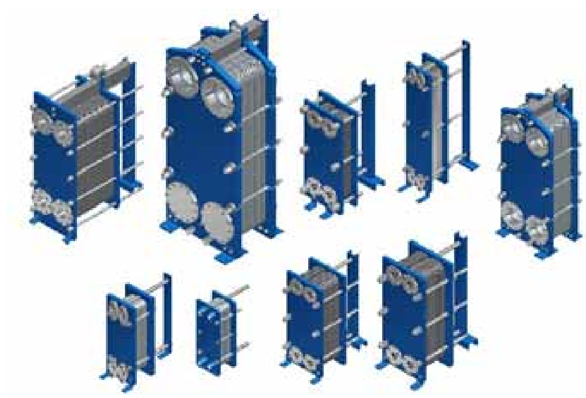

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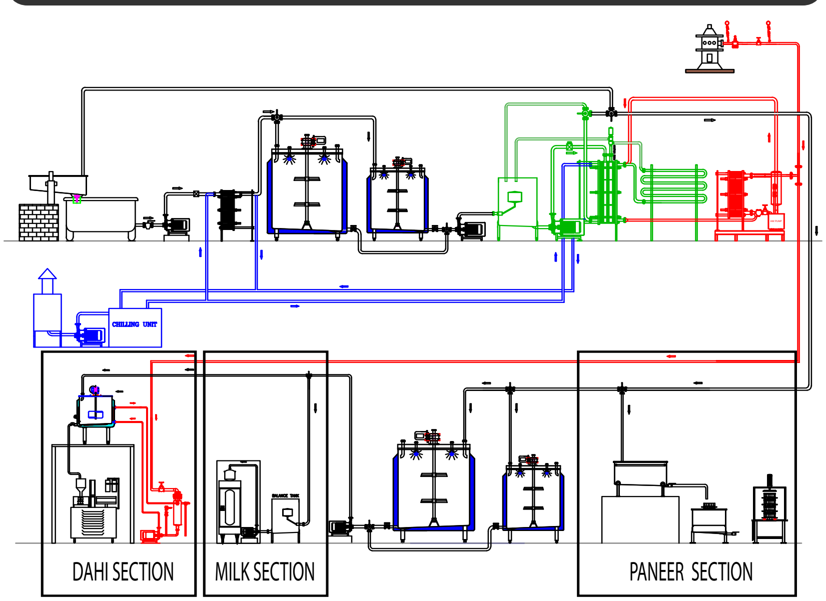

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* CUP RINSING,WASHING,DRYING & STERLIZATION MACHINE
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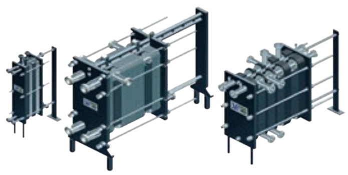

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विद्या डेरी Vidya Dairy

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TRAINING PROGRAMME SCHEDULE FROM OCTOBER 2016 TO MARCH 2017

Vidya Dairy a Student training Institute imparts hands-on-experience to the B. Tech (Dairy Technology) students of SMC college of Dairy Science-Anand. Besides imparting regular training to B. Tech (DT) students, the dairy also organizes Short-Term Training Programmes for the benefit of the industry in association with the Faculty of Dairy Science, Anand. These programmes are aimed at giving broad orientation of technological and analytical aspects of milk and major milk products along with hands – on – experience to the dairy / non-dairy personnel working in plant and laboratory areas. This helps the organization to improve efficiency, reduce cycle time and cost.

Month	Schedule	Course Name	Fee* (INR)
Oct-16	13.10.2016 to 15.10.2016	Management of Bulk Milk Cooling System (Guj)	5500/-
	17.10.2016 to 22.10.2016	Dairy Technology for Non-Dairy Technologists (Eng)	11000/-
Nov-16	03.11.2016 to 05.11.2016	Detection of Adulterants in Milk	6000/-
	07.11.2016 to 10.11.2016	Dairy Supervisor Training	7000/-
	21.11.2016 to 23.11.2016	Technology of Fermented and Probiotic Dairy Products	7000/-
Dec-16	05.12.2016 to 10.12.2016	Technological and Engineering aspects of Ice Cream Plant	12000/-
	15.12.2016 to 17.12.2016	Management of Bulk Milk Cooling System (Guj)	5500/-
Jan-17	02.01.2017 to 07.01.2017	Dairy Technology for Non-Dairy Technologists (Eng)	12000/-
	18.01.2017 to 21.01.2017	Sensory Evaluation of Milk and Milk Products	9000/-
	23.01.2017 to 28.01.2017	Laboratory Practices in Dairy and Food Plant	12000/-
Feb-17	06.02.2017 to 11.02.2017	Dairy Technology for Non-Dairy Technologists (Guj)	12000/-
	13.02.2017 to 17.02.2017	Management of Bulk Milk Cooling System and Clean Milk Production (Hindi)	10000/-
	20.02.2017 to 22.02.2017	Detection of Adulterants in Milk	7000/-
Mar-17	02.03.2017 to 04.03.2017	Technology of fermented and probiotic dairy products	7000/-
	06.03.2017 to 08.03.2017	Management of Bulk Milk Cooling system (Guj)	6000/-

Fee* to be paid by DD in favour of VIDYA DAIRY payable at Anand, is inclusive of food, accommodation (double occupancy, A/C rooms) and service tax. Due to unforeseen circumstances, programme dates may change / get cancelled in some cases. Prior confirmation is therefore, a must before participating in any program. Contact: Training Co-ordinator 09377211866 / 09377925124, 02692-221503, 02692-262501 Email: trainings@vidyadairy.in paoffice@vidyadairy.in Website : www.vidyadairy.in


સુમુલ 'પ્રો-ફીટ પ્રોબાયોટિક દહીં'...
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પ્રસ્તુત છે
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