SOUVENIR

9th NATIONAL CONVENTION OF INDIAN DAIRY ENGINEERS ASSOCIATION (IDEA)

AND

NATIONAL SEMINAR

ON

Engineering Interventions for Global Competitiveness of Indian Dairy Industry

September 8-9, 2014

ndri

IDEA

Organized by

INDIAN DAIRY ENGINEERS ASSOCIATION (IDEA)

&

ICAR - NATIONAL DAIRY RESEARCH INSTITUTE (NDRI), KARNAL

Venue:

National Dairy Research Institute

Karnal-132001, Haryana (India)

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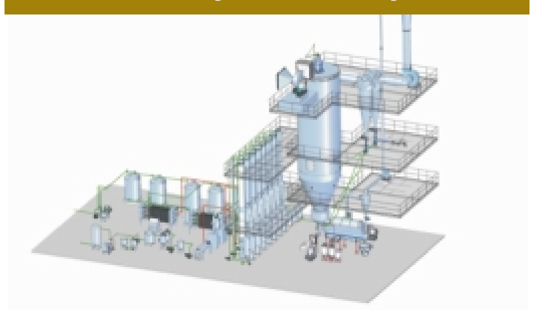
Redefining Efficiency Defining Quality

About Us

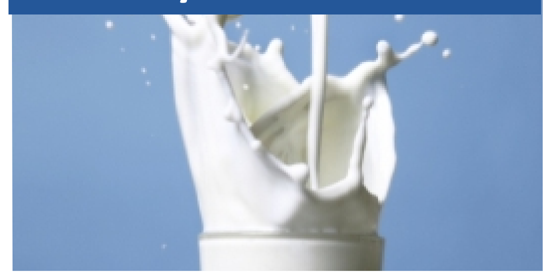
- 'SSP' was founded in 1977.
- The company provides customized turnkey projects & solutions to the industries, pertaining to Food processing sector, Dairy processing sector, Fruit & Vegetable processing sector, Chemical industries and Effluent Treatment Plant for various industries.
- It has client base in 47 countries.
- 'SSP' is an ISO 9001:2008 certified & ASME 'U' stamp holder.
- 'SSP' has FOUR manufacturing units with latest generation fabrication machines.
- 'SSP' has technically sound, highly skilled & experienced work force, numbering to 500+.
- 'SSP' is equipped with state of the art R&D Center which is approved by DSIR, Govt. of India.

Projects for Dairy Industry



- Milk Powder Plant
- Malted Milk Plant
- Evaporated Milk Plant
- Dairy Whitener Plant
- Liquid Milk Processing Plant
- Baby Food Formulation Plant
- Sweetened Condensed Milk Plant
- Whey, Casein & Lactose Processing Plant

Unique Features of Dairy Based Plants



- Equipment designed and manufactured by 'SSP' complies to international food grade standards (HACCP, FDA, 3A, GMP) and are highly energy efficient, cost effective & operator friendly.
- Equipment designed by 'SSP' handles milk gently thereby minimizing protein denaturation and increasing shelf life.
- SSP provide an integrated CIP system for cleaning the process line thoroughly.

Unique Features of our Powder Plant

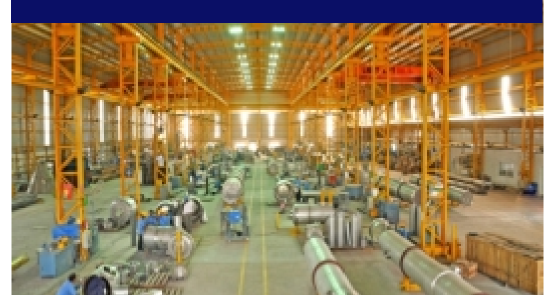
- Highest Steam Economy.
- In 5 effect system with TVR 1 Kg Steam → 8 Kg water evaporation.
- In 7 effect system with TVR 1 Kg Steam → 10 Kg water evaporation.
- Low Power Consumption.
- Maintenance Free Design.
- Lower ΔT ensures gentle heat treatment of the product.
- PLC operator plant available with 100 % automation.
- Production of instant quality powder.
- Flexibility in controlling powder quality.
- Winch driven special cleaning lift.
- Negligible deposition of powder in chamber.
- Stack loss < 0.3%.
- Expandable up to 100 %.

Do You Know?

- 'SSP' has supplied more than 69 "Milk Powder Plant" from 2 TPD - 50 TPD.
- SSP has enhanced capacity in 23 "Milk Powder Plant"
- SSP has exported several Milk Powder Plants.
- SSP is supplying 11 "milk Powder Plant" during the current year with capacity ranging from 15 TPD - 50 TPD.
- SSP is supplying 3 "Evaporators without condensor".
- SSP is supplying 2 "Three Stage Spray Dryers".

Our Clients...

Why SSP ?



- More than 37 years of experience.
- Supplied projects world over in 47 countries.
- State of the art 4 manufacturing units.
- State of the art R&D Centre.
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- Customized Projects as per client's need.
- On-Time Delivery (Using CCPM Methodology).
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- Falling Film Evaporators
- Forced Recirculation Evaporator
- Batch Type
- Serapped Surface Evaporator
- Wiped Film Evaporator

Dryers

- Spray Dryer
- Fluid Bed Dryer
- Vacuum Band Dryer
- Vacuum Tray Dryer
- Ring Dryer
- Rotary Dryer
- Drum/Roller Dryer

MISCELLANEOUS EQUIPMENTS

- Milk Silo
- Butter Churn
- Butter Melting System
- Road Milk Tanker
- Khoa Pan
- Screw Conveyor
- Bottle Sterilizer
- Rotary Valve
- Blow Through Valve
- Steam Radiator
- Disc Atomizer
- 10-25 kg Butter Packing Machine
- Twin Shaft Mixer
- Turbo Blender
- Paddle Mixer
- Cone Mixer
- Sigma Mixer
- High Solids (75% Ts) Mixing equipments
- Ribbon Blender
- Finger Stirrer With Baffles
- Mixer With Turbine Agitator At Bottom And Paddle' Stirrer At Top
- Auto Hot Water Washing Station
- Ss Pump
- Lobe Pump
- Cheese Kettle
- SS Valve
- Cip Spray Nozzle (rotary Type & Turbine Type)
- Triple Concentric Tubular Heater
- Sifter
- Mist Type Jet Condenser
- Compactor
- Online Sieving System
- Milling Machine
- Rotary Extractor
- Vertical Extractor
- Reactor

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Contact No. : 9312069945, 01275-262157, 01275-262158 Fax: 01275-262259

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to

All Delegates & Participants

the 9th Convention & National Seminar

on

Engineering Interventions for Global Competitiveness of Indian Dairy Industry

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Message

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डा. एस. अय्यप्पन
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SECRETARY & DIRECTOR GENERAL

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AND
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MINISTRY OF AGRICULTURE, KRISHI BHAVAN, NEW DELHI 110 001
Tel.: 23382629; 23386711 Fax: 91-11-23384773
E-mail: dg.icar@nic.in

I am pleased to know that the Dairy Engineering Division, ICAR - NDRI, Karnal is organizing the 9th National Convention of Dairy Engineers jointly with the Indian Dairy Engineers Association during September, 8-9 2014 and ICAR – NDRI, Karnal is the venue of the convention.

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 and distribution. One of the most important tasks amongst the quality control is to control and follow up regularly the fulfillment of quality standards at every stage of process flow in order to guarantee the best possible quality of end products and the engineering interventions have vital role to play in achieving this objective. The focal theme of this convention "Engineering Interventions for Global Competitiveness of Indian Dairy Industry " thus assumes great significance.

I extend my hearty support to the convention and hope that deliberations in this convention will bring out constructive suggestions and improve understanding amongst researchers, engineers and end users.

All my best wishes for the convention and National Seminar.

(S. Ayyappan)

Message

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Indian Council of Agricultural Research
Krishi Bhawan, Dr. Rajendra Prasad Road, New Delhi-110114

iks- Ñ".k eqjkjh yky ikBd
mi egkfuns'kd ¼i'kq foKku½
Prof. K. M. L. Pathak
Deputy Director General
(Animal Science)

I am happy that the Dairy Engineering Division, NDRI, Karnal and Indian Dairy Engineering Association (IDEA) is jointly organizing 9th National Convention of Dairy Engineers and National Seminar on “Engineering Interventions for Global Competitiveness of Indian Dairy Industry” during 8-9 Sept. 2014 at NDRI, Karnal.

Dairy development in India has been acknowledged the world over as one of the highly successful programmes. Milk produced without any subsidies gives global advantage to the Indian dairy sector. In order to access the lucrative markets of developed countries such as the European Union, USA and Japan, we need to gear ourselves to improve both quality of milk produced and processed dairy products. Intensive efforts are needed to meet the WTO's Sanitary and Phyto-sanitary (SPS) and Technical Barriers of Trade (TBT) agreements and Codex Alimentarius Commission guidelines on quality and safety. Human resource development, infrastructure, strategies and processing technologies need to be upgraded to meet these standards. Engineering inputs are very important in this up gradation. With this background, I feel that the theme of convention is appropriate and timely.

I hope the delegates will deliberate on all these issues and come out with plausible recommendations.

I wish the Convention all the success.

(K.M.L. Pathak)

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E-mail : ddgas.icar@nic.in

Message

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Deputy Director General (Education)

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E-mail : ddgedn@icar.org.in
Website: www.icar.org.in

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I wish the Convention all the success.

(Arvind Kumar)

Message

राष्ट्रीय डेरी अनुसंधान संस्थान
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प्रोफेसर (डा.) ए.के. श्रीवास्तव
निदेशक
Prof. (Dr.) A. K. Srivastava
Director

संदर्भ सं./**Ref. No.**
दिनांक/**Dated**

I am pleased to know that Dairy Engineering Division of National Dairy Research Institute and Indian Dairy Engineers Association (IDEA) are jointly organizing the 9th National Convention of Dairy Engineers and National Seminar on "Engineering Interventions for global competitiveness of Indian dairy Industry" during September 8-9, 2014 at N.D.R.I. Karnal.

India today is already the world's 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 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 and the engineering interventions have vital role to play in achieving this objective. The focal theme of this convention "Engineering Interventions for global competitiveness of Indian dairy Industry" thus assumes great significance.

I extend my hearty support to the convention and hope that deliberations in this convention will bring out constructive suggestions and improve understanding amongst researchers, engineers and end users.

All my best wishes for the convention.

AKSrivastava

(A. K. Srivastava)

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dir.ndri@gmail.com

Message

INDIAN DAIRY ENGINEERS ASSOCIATION (IDEA)
ICAR-National Dairy Research Institute
Karnal – 132 001 (Haryana)

S.C.Aggarwal,
President, IDEA
Technical Advisor
Milkfed Punjab
Chandigarh.

It pleases me to be part of the 9th Convention of Indian Dairy Engineers Association (IDEA) and National Seminar on "Engineering Interventions for Global Competitiveness of Indian Dairy Industry" being organised at ICAR – NDRI, Karnal on September 8-9, 2014.

Our quality must equal, if not exceed the best in the world. In this respect, there must be no compromise, since we are dealing with milk/milk products where the highest hygienic/bacteriological/ organoleptic standards need to be maintained. The quest for reliable and continuous quality standards starts at the village level with the farmer and only ends when the consumer is satisfied with the product.

In ensuring quality, our Dairy Engineers have a vital role to play. They must make sure that every link in the chain from the producer to the consumer is part of the total quality process. They must work together to build upon their mutual strengths and mull over their weaknesses. They must allocate responsibility and once they have accepted responsibility, they must all meet their commitments.

Though India has emerged as the largest milk producer in the world we cannot be complacent. We must now strive to be globally competitive in processing to make them internationally quality compliant and energy efficient.

I hope that these issues will be addressed to during the Convention and strategies evolved which would benefit both the producer and the consumer. I wish the Convention all success.

(S.C. Aggarwal)

Message

9th National Convention of Dairy Engineers
ICAR-National Dairy Research Institute
Karnal – 132 001 (Haryana)

Dr. I.K. Sawhney
Organizing Secretary
IDEA National Seminar 2014
Principal Scientist,
Dairy Engineering Division

On behalf of the organizing committee of 9th National Convention of Dairy Engineers it is my pleasure to welcome you all for IDEA National Seminar hosted by Dairy Engineering Division at National Dairy Research Institute, Karnal in collaboration with the Indian Dairy Engineers Association. The professionals from dairy industry, researchers and academicians from various parts of the country are participating in the convention, presenting their research work, exchange views and propagate their knowledge and experiences on the focal theme of the National Seminar "Engineering Interventions for Global Competitiveness of Indian Dairy Industry ".

To reflect the convention theme we have invited renowned speakers on various aspects of engineering interventions, viz., Recent developments in dairy and food processing equipments in India vis-à-vis global scenario, Engineering solutions for quality management in milk processing, Automation and energy management in dairy industry and Strategies to increase profitability of processing units and promotion of entrepreneurship, which have been grouped into five Technical Sessions. It is heartening to receive an overwhelming response from the participants. Around 150 scientists, academicians, industry professionals and entrepreneurs are participating in the convention.

I am confident IDEA National Seminar 2014 will generate lot of new ideas and an exchange of information amongst the Dairy Engineers fraternity will take place. I would like to take this opportunity to express gratitude towards the Patrons, members of Steering Committee and other Committees for their valuable advice, suggestions and support in organizing National Seminar. I thank all the reviewers, sponsors of various events and the media. I am thankful to all my colleagues for their sincere efforts in taking as challenge of National Seminar.

I thank you all for your participation and expect your critical comments to improve. The organizing committee regrets any inadvertent errors or omissions.

(Dr. I.K. Sawhney)

Tel: 0184-2259269
Email: ishsawhney@yahoo.co.in

Message

DAIRY ENGINEERING DIVISION
ICAR-National Dairy Research Institute
Karnal – 132 001 (Haryana)

Dr. A.K. Dodeja
Head

The 9th National Convention of Dairy Engineers is being organized at N.D.R.I., Karnal.

Like previous convention, efforts are made to make this a memorable event. Executive members deliberated to choose appropriate theme and subsequent technical sessions with specific aims and objectives. In the present era the quality is of prime importance. How to achieve it and the role of Dairy Engineers in enhancing the quality assurance are the specific issues for discussions.

The topics of presentation are targeted towards engineering solutions for assured quality products by hygienically designed plant and equipments, all in-built systems to eliminate possible contamination reaching the process line. Discussions will be held to improve dairy education by imparting relevant curriculum of engineering knowledge and skill. In the modern age automation in process becomes an essential feature. Engineers attending the convention will get enriched with the adaptable level of automation. Younger scientists and the students will get opportunity to display their activities through a poster session.

I wish to congratulate the Organizing Secretary and his team for meticulous planning to make the convention a success.

(Dr. A.K. Dodeja)

INDIAN DAIRY ENGINEERS ASSOCIATION

Extends

WARM WELCOME

to

All Delegates & Participants

to

the 9th Convention of Indian Dairy Engineers & National Seminar

on

Engineering Interventions for Global Competitiveness of

Indian Dairy Industry

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9th National Convention of Dairy Engineers (IDEA)
&
National Seminar on

Engineering Interventions for Global Competitiveness of Indian Dairy Industry

8-9th September, 2014

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CONTENT

PAPERS FOR ORAL PRESENTATION

ABSTRACTS

INDIAN DAIRY ENGINEERS ASSOCIATION (IDEA)

CITATION

AWARD FOR PROFESSIONAL EXELLENCE TO

Shree Narender Kumar Gupta

Shree Narender Kumar Gupta has been chosen by the IDEA for conferring this honour on him during the 9th convention (2014), in recognition of his professional excellence in the field of dairy Engineering. He did his schooling from Delhi with Distinction in “Engineering Drawing” in the year 1974. He then graduated with B.Tech in Dairy Technology and M.Tech in Dairy Engineering from NDRI Karnal in the year 1981. This was the first Batch ever of Dairy Technology and Dairy Engineering combination at NDRI during the tenure of Dr S C Sarma as Head DE Division.

Mr Gupta started his career with Horlicks as R&D Engineer and went on to develop his expertise covering many aspects of the Dairy Industry. Subsequently, he gathered experience in Dany Dairy under the dynamic leadership of Sh. M M Malik where he contributed in set up of many multi-product milk plants viz Dynamix Dairy, Paras Casein plant, Mahan dairy plant and others.

In the year 1991, Mr Gupta moved on to start his own business of trading of world renowned American and European Dairy Equipments in India under the name of PMS Engineering International Services viz Waukesha Cherry Burell USA , Delavan UK , GECI Tech France , Tecnoice Itlay, IAC USA (For Sonic Horns) and CSE Taiwan. In the year 1995, he visited Gea Ahlborn Germany for 4 weeks training of Designing of Plate Heat Exchangers and trouble shooting. Mr Gupta has attended various trainings in USA, Germany, Italy, France and UK for latest innovations in the Dairy and Allied Industries. He has made over 40 Foreign Trips for latest technical know how and attended International Exhibitions.

He is guest lecturer at IGNOU, New Delhi, School of Agriculture and live telecasts of his lectures are being broadcasted on national television for the benefit of students. Mr Gupta has made immense contribution to Dairy industry through his expertise and innovative thinking. He started work on “Recovery of Milk Powder from Spray Drier Exhaust” by using Venturi Scrubbers at NDRI Karnal under supervision of Dr S C Sarma. He contributed to minimise the sticking problems in spray drying process at Amul Anand / Dynamix Dairy and other major milk plants by installation of Sonic Horns from USA that reduced the sticking and increased the overall efficiency of powder plant. He has also promoted “Membrane Technology” for Concentration of Milk.

In the year 2008, Mr Gupta set up a factory in the name of JMD Sonic Engineering Pvt Ltd for equipments manufacturing in RIICO Bhiwadi, Rajasthan from where they have manufactured and exported Dairy / Pharma equipments to Canada, Dubai and Nepal with joint venture with his son Mr Abhishek Gupta, who is a brilliant Biotech Engineer and Masters in Business Administration.Currently, Mr Gupta is also engaged in designing of Solar Projects that involve utilisation of Solar Energy at the village level for the benefit of the Dairy Farmer.

It is vital to say that he is a self made man, who started business on his own from a humble beginning and made huge success through his determination, grit and blessings of God. Mr Gupta attributes this success to his wife, who stood beside him in all good and bad times and provided her full support.

In recognition of his meritorious service to the Dairy Industry, the IDEA pays rich tribute to Shri Narender Kumar Gupta and present this citation

INDIAN DAIRY ENGINEERS ASSOCIATION (IDEA)
CITATION

AWARD FOR PROFESSIONAL EXELLENCE TO

Mahesh Chand Chawala

Shree Mahesh Chand Chawala has been chosen by the IDEA for conferring this honour on him during the 9th convention (2014), in recognition of his professional excellence in the field of dairy Engineering. He did his BSc in Dairy Technology in 1979, & completed his MSc Dairy engineering, 1981 from NDRI Karnal then he Acquired expertise and sound knowledge of Manufacturing Plate Heat Exchangers and other Dairy Equipment during working with M/S HMT Ltd. Aurangabad wef 1981 till March 1992. He Had an opportunity to work with renowned companies like M/S GEA Ecoflex, Germany, M/S SWEP Sweden, M/S Taibong Industries, Inchon, South Korea,M/S Makina Machinen, Turkey in the field of Plate Heat Exchangers and Packaging machines .Based on these experiences, developed Packaging machinery for filling Dahi and Ice cream, Yeast Extruder with PLC controlled Cutting machine for yeast Block. He has also developed the Multi Function skid mounted Milk Processing systems which can be used as Pasteurizer, Thermizer, Milk Heater as well as Milk Cooler for the Small Milk plant who desire to manufacture Paneer, Dahi as well Pasteurize the Milk and also desire to use the same as Milk Chiller while receiving the Milk. This unique design system has become very popular with the Mini Milk plants and is being used by more than 20 such Plant all over India.

His major achievements are that he is First in India undersigned developed the Continuous Foam Re-bonding Machine which was the dream of the Company like M/S Sheela Foam. Now such two machines are working in India and Australia. He has also Developed Dimple jacketed Vessels with unique Dimple design to increase the Heat transfer in the Jacketed Tanks with minimum Pressure drop in the Cooling Media. This design has become so effective that today we have more than 100 such Dimple Jacketed tanks working in Pharma, Beverage, Juice and dairy industries for various applications of Cooling / Heating in the Tanks and also Developed the Geneva Gear Box for indexing of Cup filling machine leading to smooth indexing of Turn table of Cup Filling machine

In recognition of his meritorious service to the Dairy Industry, the IDEA pays rich tribute to shri Mahesh Chand Chawala and present this citation

NEED ASSESSMENT OF DAIRY ENGINEERING EDUCATION IN THE PRESENT SCENARIO

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Science discerns the laws of nature and application of science to industry is technology and engineering. The role of educational institutions is helping this linkage between science and engineering. The Indian dairy industry has to meet the growing demand for milk and milk products within the country and also meet the challenges of exporting to other parts of the world. We have various specialized institutions, universities and regular science colleges running courses in dairy science and technology. However, there is a woeful shortage of focussed technical education needed for the personnel who will design and man the highly mechanised dairy farms and processing plants and storage facilities of the future. The inevitable shortage of fossil fuels and also their adverse effects on environment is driving the industry to explore more efficient and economical ways of tapping renewable sources of energy for a pollution-free industry. There is also the need to bring in the developments in pure sciences through technological innovations for use in dairy industry.

Dairy engineering integrates the application of engineering principles, especially chemical, mechanical and electrical engineering and allied fields, to the multidisciplinary subject of dairy processing and production. It is the branch of dairy processing that deals with the analysis, design, fabrication, maintenance and operation of dairy equipment. The mandate of Dairy Engineering Education could be divided into 1) Industry needs 2) Research capabilities and 3) Teaching & Training needs. The last one is also in demand due to growing number of colleges and institutions offering dairy and food technology courses.

Industry needs:

The demands of any industry is to have graduates proficient in atleast rudiments of engineering, if not mastery at the time of appointment. Dairy Industry is no exception and preference is always for those graduates who have the latest knowledge of the dairy equipment as well some knowledge of the latest equipment.

With more and more equipment coming to be used in industry, especially in the areas of processing and packaging, the need of the industry is to have graduates familiar with these. However, in India, Industry leads the teaching institutions, and not the other way round. Exceptions may be in small niche areas only.

Examples rapid development is many in the industry. The basic pasteurizer itself has passed four generations, starting with direct vacuum steam as heating medium, then hot water mixing battery, plate heat exchanger and now the tubular heat exchanger. Similar is the developments in the gaskets, glues, flow patter of the fluids, in the pasteurizer. These developments in the industry are based on sound knowledge and experience, which the educators will have to assimilate and pass it on to the students in the college. Industry naturally expects this knowledge from the graduates and are disappointed if there is some lack of up to date knowledge of equipment that are in daily use in dairy industry.

There is a need to upgrade the curriculum, with little more focus on equipments for processing of dairy products like ice cream, butter, indigenous dairy products etc. The emphasis on food safety is also focusing on clean milk production, and adequate knowledge for dairy engineers about farm housing, machine milking, design and handling of bulk milk coolers. The civil structure design of external and internal of dairy building, and plant layout has also to be learnt to adequately meet the above challenge.

Further, with extending the expertise of dairy knowledge into food industry, it is now both an opportunity and a challenge to both the graduates as well as the teachers who handle these courses. Not only the industries that overlap both dairy and food like malted foods, chocolate industry etc, but the graduates are now into food flavours, microbial cultures, food analysis and many more areas hitherto handled by pure science graduates of people from other streams of education.

The focus of industry is on quality and food safety to meet both domestic and international markets. Greater focus is also on indigenization, customization, and low total cost production. It is on the other hand also looking for areas of investment that are stable in future. Automation is also contributing to major changes in how the plants are run, for the reasons of labour saving, as well as food safety. A tall order may be for the dairy graduates and the teachers, but that is the challenge.

There is a recent trend that some of the dairy plants are having their own in-house training facilities, especially where the organization has many plants, that require training dairy personnel. They are catering to the extent of plant operators and supervisory level only, due to the limitation of time and knowledge of the trainers, usually the senior staff. The contribution by distance learning mode, especially by IGNOU is significant for two reasons, that at supervisory level, the organization may not be able to spare their time, even for short course of certificate course offered elsewhere. Secondly, there is a legal requirement as per FSSA 22006 that all dairies must have qualified personnel at certain level of management.

Research capabilities:

As the industry needs are growing, the research institutions and colleges will have to tune their focus on industry specific problems. The levels can be sometimes short term and require rudimentary level of technical knowledge. The dairy personnel may not be having time to spare for these, but need some information all the same. These can be projects taken up by undergraduate students during their in-plant training itself. There are government agencies that are also encouraging this kind of short term projects.

Next level could be industry specific, product specific problems that might need deeper knowledge of the technology and its manufacture. There can be specific demands, for which, the dairy plants may not be having the knowledge, time, information sources, and sophisticated instruments. They may not be able to invest for the above facilities. It could be energy audit, quality assurance which needs engineering solutions. In such cases, the experience of the faculty of the universities or the Institutes will come handy. The curriculum of under graduate and post graduate studies needs some applied aspects of mathematics and statistics to adequately meet this demand.

For long term goals, like product development, design of dairy plants that are in need of futuristic planning, the dairy industry will need expertise from many sources, including dairy engineering faculty. Equipment development for indigenous dairy product handling, dairy plant designs that take food safety aspects that are evolving rapidly to meet international standards are some of the areas of this category.

Teaching & Training needs:

There is a tremendous growth in number of institutions related to dairy related courses in the past decade. The starting of these colleges may be partly political or partly to show some growth by the Universities themselves. This is not a healthy approach, as the starting of these without sufficient experienced staff or funds will only lower the standards of teaching and training. This will further erode the confidence of dairy industry on the graduates passing out.

Properly qualified and experienced teachers are now in greater demand, until the fresh recruited staff gains knowledge and experience to handle the courses. With this objective, a e-course content development under the aegis of NAIP was taken up and provided to all the colleges that are offering undergraduate courses in dairy technology. However, a periodic review of these is a must, at least whenever the syllabus is updated. Otherwise, the effort will become outdated and will not be of use any further, though some fundamentals may remain the same.

The institutions also develop a mechanism to retain their experienced teaching staff, who are retiring in some such schemes like the ICAR's emeritus professor scheme. There can be an arrangement where the guest lectures are invited with sufficient remuneration and compensation to encourage cross fertilization of ideas among the teaching institutions. This will go a long way in making the teaching community up to date with developments in other institutions of higher learning and having better facilities and faculty.

There had been some initiatives from leading institutions like NDRI and AAU, offering short term and long term training courses, but very few are focussed on engineering aspects of dairy industry. This is a significant area where improvement is needed. That too it is urgent. The dairy engineering departments of the lead institutions have to take up this challenge in the right earnest. To start with IDEA may organize competitions for UG students on dairy engineering aspects. It could also offer a fellowship for the Dairy engineering students in postgraduate studies.

The offer of certain courses or specific lectures through internet should also be initiated first on experimental basis and after observing the response, may be expanded to conduct on more regular basis, for the benefit of other less developed colleges and institutions. This could be done on payment from the benefiting institutions.

An institutional mechanism is also needed to grade the colleges on the basis of facilities available, and also derecognizing such of those institutions that are not meeting the minimum requirements. This could be taken up by ICAR or such national level governing bodies that are capable of monitoring these colleges and institutions. A legal binding may be required in future, as the industry deals with food which is essential for the society in large.

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STRATEGIES FOR ENERGY CONSERVATION IN DAIRY PROCESSING INDUSTRY

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ABSTRACT

Energy is one of the very essential requirements for the growth and progress of any nation. Our civilization runs on energy and energy resources are finite. Though, dairy industry is not falling in energy intensive category, sizeable amount of thermal and electrical energy is required for processing of milk and manufacturing of various milk products. The conservation of energy is not only significant for improving profitability of the dairy plants but also helps in reducing the emission of Green House Gases in the environment which is responsible for global warming.

The conservation of energy can be achieved by adopting principles of total energy management and efficient utilization of energy in all dairy processing operations. It is reported that about 95-105 liters of milk can be processed using one liter of furnace oil while 10-12 liters of milk can be processed in one kWh power consumption. Adoption of newer technology in milk processing and plant utilities having potential of energy saving is one of the ways for conservation of energy in dairy industry. Two important utilities namely steam and refrigeration should be given proper attention as these services consume considerable energy. The installed electrical power generation capacity of India is 205.3 GW as on June, 2012 and rank 5th in power generation capacity. There is about 10 % shortage of electrical power based on the installed power generation capacity. The total demand for electricity in India is expected to cross 950,000 MW by 2030. Therefore, it is necessary to take all measures for the conservation of electrical power in the interest of the nation.

Adoption of various newer technologies such as direct expansion glycol chillers, HRU in condenser, PHE type pre-chillers, liquid overfeed system evaporators are some of the major energy saving concepts in vapour compression refrigeration systems. The use of VFD/VSD to maintain load current ratio, avoiding use of oversize/undersize and rewound motors, use of capacitors and power factor controller apparently reduces the power consumption. Selection of energy efficient boiler and its components, performance evaluation of boiler at regular interval and operational management can aid in reducing the losses and conservation of thermal energy. Reduction in discharge pressure, decrease in air inlet temperature and use of screw compressor can conserve energy from 1-5% in compressed air supply. In addition to this, various strategies for the conservation of energy in different dairy operations, optimization of process parameters, energy audit and management of dairy plant utilities have been discussed in this paper.

INTRODUCTION

Energy is one of the very essential requirements for the growth and progress of any nation. Indian economy is growing at the sustained GDP of around 7.8 % and agriculture produces play a major role in contributing the GDP of the country. Livestock sector contributes 5.59% in national GDP and 28% in Agricultural GDP. Electrical and thermal energy are required for various dairy processing operations and providing utilities in dairy plants. It is necessary to adopt all strategies for the conservation of energy in dairy plants. There has been an increasing consciousness regarding relationship between economic development, enhanced use of energy and adverse environmental implications due to emission of Green House Gases (GHGs). In this regard, many national, international and intergovernmental bodies across the world have been working to formulate program to reduce the energy use in various sectors to combat the phenomena leading to global warming. It has become exceptionally critical to manage the use of energy and to adopt all possible measures to conserve it in order to boost the profitability at industrial level and to reduce emission of GHGs.

DAIRY AND ENERGY SCENARIO OF INDIA

India is the largest milk producing country in the world since 1997 and in the year 2013-14 the annual milk production of India has reached to 135 million metric tons amounting around 16% of total world milk production. The milk utilization pattern of India reveals that 50% of milk produced is used as liquid milk and 47% of the milk is utilized in manufacture of Traditional Indian Dairy Products. Livestock sector contributes 5.59% in national GDP and 28% in agricultural GDP. This shows the importance of dairy sector in the GDP of the country. Indian agriculture and livestock sectors support 17.5% of world population with 2.3% of global land and 4.2% of water. It is reported that 57% of world's buffalo and 16% of cattle population is in India and milk accounts for 68-70% of total contribution of livestock produce. Organized dairy plants processes 20-25% of the total milk produced in the country in about 1500 dairy plants. The productivity of Indian milch animal is 987 kg/year (world average is 2200 kg/year) while the per capita availability of milk in India is 246g/day (world average is 270g/day). Annual milk production growth rate of India is 4.6%.

The energy scenario reveals that oil and gas reserves are estimated to last for just 45 and 65 years respectively, whereas the coal is likely to last about 200 years. It is observed that 80 % of the world's population of the developing countries consume only 40 % of the world total energy consumption and the rest is consumed by developed nations. The world average energy consumption per person is equivalent to 2.2 ton of coal. India is 6^{th} largest energy consumer, accounting for 3.4% of global energy consumption. The total demand for electricity in India is expected to cross 950,000 MW by 2030. Electricity is generated 75 % from thermal power plants, 21 % from hydroelectric power plants and 4 % from nuclear power plants. India has also embarked in the realm of renewable energy resources.

IMPORTANCE OF ENERGY CONSERVATION

Energy conservation is one of the central issues for all the nations. Energy conservation means maximizing the processed product output from unit energy input without compromising with the quality of the finished product. It acts as an effective tool to minimize the cost of production, maximize the profit which is indispensable for the sustainability of any dairy and food processing plant in this competitive era. It is reported that about 95-105 liters of milk can be processed using one liter of furnace oil and 10-12 liters of milk can be processed in one kWh electric power consumption. It is reported that average composite processing cost of milk stands at about Rs. 0.65-0.85 per liter. Estimations say that 10 to 20 % saving in the fuel bills can be achieved by adoption of energy management. There is also possibility of CDM projects based on energy conservation by adopting newer technology, process re-engineering and with the use of renewable energy sources.

ENERGY MANAGEMENT

Energy Management is the strategy of adjusting and optimizing energy using systems and procedures so as to reduce energy requirement per unit of output. The energy management has become very important necessity in the present era of uncertainties in availability of fuel, increasing cost of fuel, worldwide competition and concern for environment control. Principles of Energy Management include:

- Procure energy at low cost considering level of emission of GHGs
- Manage energy use at the highest energy efficiency
- Reusing and recycling of energy
- Use of most appropriate energy efficient technology
- Reduce the avoidable losses
- Re-engineering and optimization of processing operations

Management techniques that use energy information as a basis to eliminate waste, reduce and control current level of energy usage and improve the existing operating procedures is done by energy monitoring. It builds on the principle "You can not manage what you do not measure". Elements of Monitoring and Targeting system are recording of parameters, analyzing them, comparing with standard data, setting targets based on the comparison, monitoring the subsequent processes, reporting new energy consumption data for decision making, relating energy consumption and production, controlling up to the positive results.

Energy management strategy includes identifying strategic corporate approach, accountability, financial and staffing resources, reporting procedures, commitment at all levels and generating awareness, appointing energy manager with proper skills and knowledge, setting up energy monitoring and reporting system, conducting energy audit regularly and finally formalizing energy management policy statement.

For the successful outcome of the energy management the 4 pillars of energy action planning to be strengthened are

- Technical ability
- Monitoring System
- Strategy Plan
- Top management Support

A worksheet for economic feasibility must be prepared which should include investment, annual operating cost and annual saving considering payback period.

ENERGY CONSERVATION STRATEGIES IN DAIRY PLANT UTILITIES

Refrigeration

Vapour compression refrigeration system using ammonia as refrigerant is widely used in India for industrial refrigeration, air conditioning and cold storages. In dairy and many food processing plants, ice-bank system of refrigeration is used for chilling and processing of milk while direct expansion air chillers are employed for cold storages. Direct expansion glycol chillers are also being used for chilling of milk in many dairy plants. The refrigeration system uses electrical energy for operation of compressor and other auxiliary components of the system. It has been found that electricity consumption of refrigeration plant alone is about 50-60 % of total electrical consumption of the dairy depending on the nature of processing operations. The efficiency of refrigeration plant measured in Co-efficient of Performance (COP) which is the ratio of refrigerating effect produced to the work of compression. It varies from 2.5 to 4.0 depending on the operating conditions of the refrigeration plant. The important factors affecting the COP are as under.

- Selection of refrigeration system and its components.
- Design of plant components
- Operational management of the system
  - Evaporating pressure or temperature
  - Condensing pressure or temperature
  - Sub-cooling and super heating of refrigerant
  - Heat transfer at evaporator and condenser
  - Presence of non-condensable gases in the system
  - Volumetric efficiency of compressor
- Multi-stage compression and throttling system
- Maintenance of plant
- Adoption of energy efficient technology
  - Screw compressor
  - PHE type condensers
  - PHE type pre-chiller
  - Liquid overfeed system
  - Fan less cooling towers
  - Heat recovery from discharge gas
  - Ice silos

The use of vapour absorption refrigeration system using lithium bromide as absorbent and water as refrigerant using waste heat as source of energy can be considered for chilling requirement of dairy plants. I addition to this, the technology of heat pump using carbon dioxide as working fluid can contribute in conservation of energy.

Electricity

It is found that about 80% of total electricity is consumed by motors in dairy plants. The efficiency of the motor varies with load and at the full load it is maximum. Therefore, selection of motor for the given application is very vital for the conservation o0f electrical energy. It is suggested to use high efficiency motors in place of old motors. In addition to this, it is desirable not to use repeatedly rewound motors as rewinding leads to an efficiency loss up to 5 %. The electrical tariff for High Tension (H.T.) consumer of electricity is divided in to 2 categories i.e. Demand charges and Energy charges. Therefore, installation of capacitors to reduce demand charges and line losses within the plant is necessary to improve power factor. Improvement of power factor from 0.85 to 0.96 will reduce 11.5 % peak demand and reduce 21.6 % losses. Use of variable frequency drive for variable speed applications such as fans, pumps, compressors; avoiding use of oversize / undersize motors further help in minimizing energy usage.

Steam

Steam is widely used as heating medium for thermal processing of dairy and food products. Steam is produced in boiler using various types of fuels such as coal, fuel oil, natural gas, biogas etc. It has been estimated that two-third of the total fuel oil is used for the generation of steam in various industries in India. There are more than 20,000 industrial boilers which are operational in India. The performance of boilers depends on several factors such as combustion efficiency, quantity of excess air, temperature of flue gas and optimization of all operating parameters is very essential to achieve higher efficiency of steam generating systems. Automation employed in the modern boiler has help a lot in achieving optimum boiler performance and safety with minimum adverse effect on environment. Selection of energy efficient boiler and its components, performance evaluation of boiler at regular interval and operational management can aid in reducing the losses and conservation of energy. The following points are very important for generation and distribution of steam.

1. Selection of boiler of optimum capacity considering the type and cost of fuel is very important factor to be considered. Oversize boiler operated all the time at part load may not be efficient. The cost of steam varies from Rs. 2.0 to 4.50 depending on the type of fuel used in the boiler. The use of coal and fuel briquette prepared from agricultural biomass can give low cost of steam as compared to natural gas and furnace oil. However, the emission of carbon dioxide on burning of fuel and storage as well as maintenance aspects of the boiler should be critically evaluated. The properties of fuel such as moisture content, ash content in case of solid fuels and viscosity and impurities in case of liquid fuels are also important parameter affecting the performance of boilers.
2. Boiler stack temperature is the temperature of the combustion gases leaving the boiler. The higher temperature of flue gases indicates less transfer of energy which lowers the boiler efficiency. Low temperature of flue is desirable to get higher efficiency of the boiler. Recovery of heat from flue gases improves the performance of boiler. However, it should not be too low which may cause water vapour to condense in the chimney.
3. Measurement of boiler performance using direct method as well as indirect method as suggested by Bureau of Energy Efficiency of India is periodically necessary. Indirect method of performance evaluation of boiler gives details of energy losses.
4. Optimization of combustion efficiency is very important factor to achieve conservation of energy. Stoichiometric quantity of air is not adequate for the complete combustion of fuels due to improper mixing of air with the fuels in the combustion chamber. Excess air is supplied to the boiler beyond what is required for complete combustion primarily to ensure complete combustion. It is found that inadequate supply of air caused inefficient combustion and less boiler efficiency. Hence, optimum quantity of air is very essential for better overall efficiency of boiler. The optimum level of excess air is to be maintained to get optimum efficiency. Higher level of excess air causes reduction in efficiency of the boiler due to higher amount of heat loss in the flue gases. Oxygen analyzer is used to measure the oxygen level in the flue gas to monitor the quantity of the excess air. Automatic controls to monitor the amount of air based on the measurement of oxygen in the flue gases are used in modern boilers.

5. Optimization of boiler performance can be achieved by operational management of boiler and effective maintenance programme of the boilers. The following aspects are important for the optimization of boilers in order to conserve the energy.
   - Optimization of combustion process
   - Use of efficient economizer
   - Provision of air preheater
   - Controlling radiation and convection heat losses
   - Adoption of automation for blow down control
   - Regular maintenance of heat transfer surfaces
   - Adoption of variable speed controls for monitoring speed of blowers and pumps
   - Treatment of water
   - Proper scheduling of boilers
6. The various types of automatic controls used in industrial boiler have greatly helped to improve the efficiency of boiler by optimizing the combustion process and achieving stringent standards for emissions. The safety requirements in operation of boiler can be accomplished with the automatic controls. The different boiler manufacturers have reported the use of various types of automatic controls depending on the capacity, types of fuels used, safety requirements, etc. The use of PLC-SCADA based automatic controls for operation of boiler and precise control of combustion and safety interlocking has been reported. The major controls commonly used in boiler are automation stating and shutdown, water level control, pressure control, combustion control, temperature controls at various points, TDS control, automatic blow down, warning alarm etc.

Compressed air supply

Compressed air supply for pneumatic controls and operation of milk packaging machines is relatively least energy efficient system of the dairy plant. The following aspects should be evaluated critically for the conservation of energy.

- Compressed air supply is very energy intensive and only 5% of electrical energy is converted to useful energy.
- Air leakage is a major loss in compressed air.
- Reduction in discharge pressure by 10% saves energy consumption up to 5 %.
- Decrease in inlet air temperature by 3 ^{o}C decreases power consumption by 1%.
- Air output of compressors per unit of electricity input must be measured at regular intervals.
- Use of screw compressor in place of reciprocating reduces the electricity power consumption.

Effluent treatment system

It is an unavoidable process requiring energy to meet the legal requirements. Electricity is mainly required for operation of various pumps and air diffusers. The following aspects are important for the conservation of energy for effluent treatment systems.

- New technology and methods of treatment for waste water should be adopted for generation of renewable energy.
- Combination of anaerobic and aerobic digestion system enhances the efficiency of the ETP plant.
- The Hydro Methane Reactor and UASB processes are anaerobic processes for the effective biodegradation of organic wastes into methane.
- The removal of 1 kg COD by aerobic process requires 0.5 - 0.75 kWh energy while anaerobic process generate 1.2 kWh energy from 1 kg of COD removed.

SCOPE OF NON-CONVENTIONAL SOURCES OF ENERGY

As the use of non-conventional sources of energy is eco-friendly, there is a scope to use solar energy in dairy plants to conserve energy as well to contribute in the carbon foot print cutback. The use of solar water heating system is an established practice for heating of water required for boiler feed water, cleaning application etc. However, due to certain economical, operational and maintenance problems, it is not exploited to its fullest extent. A solar water heating system of 50,000 liter capacity designed to heat water from 30 ºC to 75 ºC can collect 9,418,500 kJ per day which is equivalent to about 205 kg of furnace oil resulting into saving of about Rs. 25.8 lakh every year. As a result of advancement in solar collectors and related technology, it is prudent to use solar energy in dairy now days. Similarly, solar lighting, wind power, bio-gas etc. can be considered for conservation of energy along with preparing CDM projects and obtaining CERs.

CONCLUSION

Energy is one of the very vital requirements for dairy industry as heating and cooling operations are mainly involved in dairy plants. In the wake of the tremendous rise in fuel price and decline in the fuel supply in the recent year and there is a need of conservation of energy. It is requisite to make efficient use of energy by adopting principles of TEM to improve profitability and to reduce emanation of GHGs in the environment. Efficient use of energy in processing of milk, manufacture of dairy products, CIP cleaning etc. would help in conservation of energy. There is an ample scope for conservation of energy by optimization of various unit operations, adopting newer technologies and using non-conventional sources of energy. Projects on energy conservation can also provide opportunities for carbon trading by obtaining CERs.

IMAGE PROCESSING AND ITS APPLICATION IN QUALITY CONTROL

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Introduction

Assurance and control of quality during and post processing is an integral part of the food processing industry. Conventionally, various subjective and objective methods are employed for the same. Subjective evaluation of quality stipulates the involvement of trained judges to visually identify, scale in linguistic terms or score in a numerical scale, the relevant quality parameters for the product. In addition to being a highly skill – oriented procedure, the subjective evaluation of quality is also time consuming, laborious and prone to human error and fatigue. Objective evaluation of quality is carried out using a range of measurement techniques, simple or sophisticated involving rigorous protocols of sampling and preparation steps of chemical analyses and physical experiments. With the need for more rapid and economical objective measurement of quality, in recent times, computer vision technology or image analysis technique is garnering prominence as a relevant tool for the qualitative and quantitative assessment of quality parameters in food processing.

Image analysis is defined as the extraction of meaningful information from digitised images. The system involves a device for capture of images of the product either during processing or a processed product, at finish or during storage, under standard illumination and a computational unit for processing the digitised image and evolving data for defining and characterising the required quality attribute. A digitised image transforms the picture of the object to an 2-D array of numeric data, each element of the array is called a pixel (picture element); usually a 8– bit integer is used to store each pixel value. Two important information are stored for each pixel, the brightness value and its assigned location co-ordinates. It is the mathematical extraction and manipulation of this information that is the basis of the output during image processing. Thus, the process protocol generally involves acquisition of the image, importing the image to the software, pre processing and refinement of the digital image (if necessary) and extraction suitable mathematical descriptors relevant to the quality parameter(s) under consideration

Image acquisition

This is the first step in image processing and is based on the general principles of reflection of electromagnetic waves (light) incident on the object that is detected by a suitable sensor and captured and stored in hardware device.

Illumination system

During image capture, it is very important that proper and uniform lighting is provided as illumination is a subsystem to the image acquisition unit with a significant influence on the spectrum of reflected light and hence the quality of image capture. Both incandescent and fluorescent lighting have been reported and the standard illuminants used in food imaging are A (2856K), C (6774 K), D_{65} (6500K) and D (7500K). Among lighting arrangements, front lighting is better suited to obtain good quality surface images than back lighting. Online capturing of images is practically more prone to difficulty as far as standard illumination is concerned. However, it is imperative that global and temporal uniformity in illumination standards are maintained and the effect of environmental influences like vibrations and dust etc. need to be balanced during image capturing.

Devices for image capture

The devices capture the pictorial image of the object as an electric signal and transform the same as a numeric form. Different sensors can be used to generate the image, typically for image processing applications the sensor is based on solid state charged couple device (CCD) technology (still or video images).

Table 1. Image acquisition devices

Sl. No.	Acquisition Device	Remarks
1.	Flat bed Scanner	Resolution 300-1200 dpi. Versatile, low cost, easily available.
2.	Digital Camera	Resolution - > 2.1 megapixels, Versatile, low cost, easily available.
3.	Hyper spectral / Multispectral Imaging	Light in UV, visible, and NIR spectral regions (300 nm–2,600 nm), better feature extraction
4.	Confocal Laser Scanning Microsopy	Depth profiling at high resolution, 3- D imaging, Expensive hardware
5.	Other imaging techniques such as MRI, X ray, CT etc.	Expensive techniques to be considered a likely choice

CCD units may either be of array type or line scan type. The former consist of a matrix of minute photosensitive elements (photosites) from which the complete image of the object is obtained based on output proportional to the amount of incident light. The line scan cameras use a single line of photosites which are repeatedly scanned up to provide an accurate image of the object as it moves under the sensor. Table 1. outlines the various devices to acquire images for computer vision systems.
In addition to the resolution during image capture, an important consideration determining the image quality is the file compression File compression reduces the memory space occupied by the file in the computing hardware, however the same is at the cost of image quality. Hence, it is preferred to store the file in non compressed format (TIFF) rather than compressed formats (like JPEG).

Image Pre - Processing

This step forms the core of the activity to extract desirable feature descriptors. The initial operation on the raw data generated under image acquisition is to refine and enhance the quality of the image in order to distinguish the region of interest (ROI) on the image and to remove defects and noise, adjust the brightness / contrast of the image. One of the important steps in this intermediate level processing is the segmentation of the image whereby the image is partitioned into segments with strong correlation within the ROI. The most common technique employed for segmentation is called thresholding involving the selection and input of a threshold value. At the end of pre-processing the true-colour image could transition through a gray-scale image into a binary image; the latter being the form most conducive to observe textural features.

Image analysis

The later stage of processing involves the analysis of the image to draw suitable interpretations and extraction of desirable attributes and features relevant to describe the quality of the product. The important quality aspects related to food research and food processing includes colour and texture of the image.

Image Colour Processing

Colour is an important attribute influencing the visual perception of product quality. Since the pixel array for the digitized image includes information on the brightness of each pixel, it is possible to extract colour values for the image using software packages such as MATLAB (The MathWorks Inc.) or Adobe Photoshop (Adobe Systems). The composite colour of an image is often described in formats as presented in Table 2.

Table 2. Colour space models

Sl. No.	Colour Model	Details
1.	RGB	Additive model in Primary colours – Red, Blue, Green each represented in 8 bits resolution; all points in image at 8x3 = 24 bits, Numerical value ranging between 2^o-2^8 (0-255) Device dependent format
2.	CMYK	Based on light absorbing quality of ink – printed paper Composite colour created by components Cyan, Magenta, Yellow. Black to represent true black. Device dependent model
3.	L* a* b*	CIELAB model Luminance L* (0 – black, 100 – white) and chromatic components a* (green to red) , b* (blue to yellow) Device independent model
4.	HSI	Hue – representing the pure colour shade Saturation – dilution of colour with white (gray level) Intensity – Brightness / vividity of the colour

The colour features in any of the above models can be extracted from the image (acquired off - line or online) to indicate the influence of processing / storage conditions or as a tool to monitor and assure quality.

Image Texture Processing

The image texture is different in its description from conventional texture analysis. It is described in terms of the surface fineness, coarseness, smoothness, graininess etc as deduced by the spatial arrangement of brightness and relative location of pixels in the ROI of the image. The focus during textural image analysis is on extracting mathematical descriptors to characterize the size and shape of the particles within the image. The software packages employed fro image analysis include ImageJ (NIH), MATLAB (The MathWorks Inc.), Image – Pro plus (MediaCybernetics) etc. Various methods are available for the description of image texture and the same are summarized in Table. 3.

Table 3. Texture Analysis Methods

Sl. No.	Texture Analysis	Details
1.	Structural	Used to describe very regular textures Very limited application food industry
2.	Statistical	Indirect representation of texture in terms of the distribution and relationship between adjacent gray levels of an image. Most widely applied method for food texture
3.	Model Based	Use fractal and stochastic models to interpret image texture Computationally complex Fractal model more commonly used for food texture
4.	Transform	Fourier and wavelets transforms Wavelet transform attractive for image segmentation

Learning Techniques in Image Processing

Since textural features obtained by image processing are not visually related to the perceived food quality, there is need to correlate or connect the obtained data with real – time food quality attributes. Therefore the computational system needs to be trained to correlate the generated training sets with textural behavior of the food product. Only then can the image processing system work as a complete module to analyse, compare and decide on the response (accept / reject) during quality control operation. The learning techniques that have emerged in association with image analysis for decision making and classification include Statistical Learning (SL), Fuzzy Logic (FL) and Artificial Neural Networking (ANN).

Application of Image processing

A wide variety of applications have been reported for image analysis/ processing in quality control during food research and food processing. A few applications are summarized vide Table 4.

Table 4. Applications of Image Processing to Describe Quality of Food

Sl. no.	Application Note	Reference
1	Cheese microstructure was evaluated using ImageJ software for Image Analysis. A number of shape descriptors were proposed to characterise quantitatively the microstructural features of traditional Sicilian cheese varieties	Impoco *et al*., 2007
2	A method based on digital image processing was used to quantify adulteration in roast and ground coffee beans. Pure arabica coffee and mixtures of coffee husks and straw, maize, brown sugar and soybean were used as investigation materials.. The results indicated that image analysis method developed could be applied to analyze precisely and quickly a large number of ground coffee powders.	Sano *et al*., 2003
3	Imaging technique was applied for visualizing structure and quantifying oil migration from a nile red stained phase composed of a mixture of peanut oil and chemically inter-esterified hydrogenated palm oil into a cocoa butter matrix and was quantified using a flatbed scanner and epifluorescence light microscopy.	Marty *et al*., 2005
4	An image processing technique was applied to bread crumb digital images for colour and texture analysis. Mean cell area and void fractions were extracted from the images with ImageJ software. Result showed that cell area and void fractions were affected by formulations and storage of bread crumb.	Mohebbi *et al*., 2009
5	Three different methods image post-processing techniques, Heterogeneity parameter (HTG), the Gray Level Co-occurrence matrix (GLCM) and Angle Measure technique (AMT) were applied for image texture analysis to study the surface texture of cooked and uncooked pasta. The developed algorithms could be used to make a quantitative evaluation of the physical surface characteristics and their changes during the cooking process of pasta.	Fongaro and Kvaal, 2013
6	Image analysis of lamb chops was carried out to investigate the usefulness of raw meat surface characteristics in predicting cooked meat tenderness. Four geometric and textural feature sets were extracted through image processing techniques such as Gray level difference method (GLDM), Gray Level Co-occurrence matrix (GLCM) and Gray level run length matrix (GLRM). These feature sets, individually and in different combinations, were utilised to predict cooked meat tenderness using neural network, linear and non-linear regression analyses.	Chandraratne *et al*., 2006
7	Image analysis methodologies were applied to characterize the structure of aerated foam prepared using three different commercial proteins and a conjugated protein. 57 structural parameters were extracted from the image analysis data which were then classified into seven feature groups. Canonical and Bayesian discriminant analysis were used to identify/ classify different foam architectures.	Germain and Aguilera., 2012

Conclusion

Quality is an important responsibility of the stake holders of food processing industry and there is need to develop rapid, non destructive objective tools to evaluate and monitor the same during both online and offline modes. Image processing has been steadily gaining acceptance as a relevant methodology in quality control and assurance and has the potential to form an important component of this activity in the future.

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MODELLING MOISTURE SORPTION ISOTHERMS IN SELECTED INDIAN MILK PRODUCTS USING SOFT COMPUTING APPROACH

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1. Introduction

All dehydrated milk products absorb moisture at moderate and high water activities that leads to protein insolubility and accelerated flavour deterioration. Equilibrium relationship between moisture content of food and the water activity at any temperature is quantified in the form of Moisture Sorption Isotherms (MSI). Knowledge of sorption isotherms of a food product is essential for product and process development, besides food engineering applications. The deteriorative mechanisms in food system are dependent on water activity and, therefore, water activity modifications are suggested for storage stability. Moreover, the evaluation of thermodynamic functions of water sorbed provides valuable information to characterise storage and packaging problems as well as in appraising the shelf life of packaged food product under varying environment interactions.

MSI of food products including milk products have been described mathematically by many researchers with the help of several classical empirical, semi-empirical and theoretical models (Table 1). Soft Computing (SC) models particularly connectionist and neuro-fuzzy models describe relations between independent and dependent variables mainly when the explicit form of mapping is unknown. In recent years, the concept of soft computing has gained wide acceptance in food engineering for predictive modelling. Several studies have been reported in literature that demonstrated successful application of soft computing models for predicting MSI in various foods.

Therefore, this oration aims to share the salient findings of the ongoing research study by the authors at NDRI Karnal, on emerging soft computing modelling paradigm to predict the MSI in selected Indian milk products, viz., dried acid casein powder, skim milk powder, fortified Nutrimix powder (weaning food) and whey protein concentrate powder.

Table 1: Classical empirical models investigated for fitting moisture sorption data.

Model	Equation
BET	$W = \frac{C \cdot W_m \cdot a_W}{(1-a_W)[1+(C-1)\cdot a_W]}$
Caurie	$W = e^{[a+b\cdot a_W]}$
Halsey	$a_W = e^{(-a/W^b)}$
Oswin	$W = a \cdot \left[\frac{a_W}{(1-a_W)}\right]^b$
Smith	$W = a - b\ln(1-a_w)$
Guggenheim-Anderson-de Boer (GAB)	$W = W_m \cdot \frac{C \cdot k \cdot a_W}{(1-k\cdot a_W)(1-k\cdot a_W + C\cdot k\cdot a_W)}$
Modified Mizrahi	$W = \frac{a + a_w(ca_w + b)}{a_w - 1}$

2. Soft Computing Models

Soft Computing (SC) is a consortium of evolving methodologies, which endeavours to exploit tolerance for imprecision, uncertainty and partial truth to achieve robustness, tractability, and low total cost. It differs from conventional Hard Computing (HC) in the sense that, unlike hard computing, it is strongly based on

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intuition or subjectivity. Therefore, SC provides an attractive opportunity to represent the ambiguity in human thinking with real life uncertainty. Connectionist Models (CM) and Fuzzy Logic (FL) are two core methodologies of SC. However, CM and FL should not be viewed as competing with each other, but synergistic and complementary instead. It is evident from the literature on various combinations of these two methods that the fusion of individual SC methodologies has already been advantageous in numerous dairy and food processing applications. On the other hand, hard computing solutions are usually simpler to analyse; their behaviour and stability are more predictable; and, the computational burden of algorithms is typically either low or moderate.

2.1. Connectionist models

The field of connectionism is a branch of cognitive science and has originated from diverse sources ranging from the fascination of mankind with understanding and emulating the human brain to broader issues of copying human abilities such as speech and the use of language; to the practical, commercial, scientific and engineering disciplines of pattern recognition, modelling and prediction.

Feed-forward connectionist models described in this paper, allow signals to travel in one direction only, *i.e.*, from input towards output. These models can be considered as simple straightforward networks that associate inputs with outputs. Connectionist models consist of the following three principal elements: a) Topology – the way a connectionist network is organised into layers and the manner in which these layers are interconnected; b) Learning – the technique by which information is stored in the network; and c) Recall – how the stored information is retrieved from the network. The basic structure of a connectionist model consists of artificial neurons also sometimes referred to as processing elements and are analogous to biological neurons in the human brain, which are grouped into layers (or slabs).

Error back propagation learning algorithm

The Error Back Propagation (EBP) algorithm *ab initio* is a gradient descent algorithm in which the network weights are moved along the negative of gradient of performance function. The term error back propagation refers to the manner in which the gradient is computed for nonlinear multilayer networks. There are a number of variations of basic algorithm that are based on other heuristics and standard optimisation techniques, such as variable learning rate gradient descent, conjugate gradient and Newton methods. The EBP learning algorithm based on Bayesian Regularisation (BR) and Levenberg-Marquardt (LM) optimisation techniques have been used to develop the proposed connectionist models in this paper. The Neural Network Toolbox under MATLAB software has been used for all simulation experiments. The 'trial and error' method is used to reach optimum model configuration in all the simulation experiments.

2.2. Adaptive neuro-fuzzy inference system model

It is hybrid of connectionist models and Fuzzy Inference System (FIS). The connectionist networks are used to determine the parameter of the FIS.

It combines the advantages of the FL and CM. FL is a departure from classical Boolean logic as it implements soft linguistic variables on a continuous range of truth values, which allows intermediate values to be defined between conventional binary. FL application to problem solving involves three steps: converting crisp (numerical) values to a set of fuzzy values, an inference system (based on fuzzy if-then rules) and defuzzification.

FIS model can be of two types, *i.e.*, Mamdani and Sugeno. The Sugeno-type system is used in this study. The Adaptive Neuro-Fuzzy Inference System (ANFIS) was introduced by Jang. The architecture of ANFIS has following five layers to accomplish the tuning process of the fuzzy modelling system:

i) Layer 1: Every node in this layer is an adaptive node with a node function called Membership Function (MF). Parameters of MF's are referred to as premise or antecedent parameters.
ii) Layer 2: Every node in this layer is a fixed node, which multiplies the incoming signals and sends the product out. Each node represents the firing strength of a fuzzy rule.
iii) Layer 3: Every node in this layer is a fixed node, which calculates the ratio of the one firing strength to the sum of all rules' firing strengths. The outputs of this layer are called normalised firing strengths.

iv) Layer 4: Every node in this layer is an adaptive node with a node function (*i.e.*, linear combination of input variables). Parameters in this layer are referred to as consequent parameters.

v) Layer 5: The single node in this layer is a fixed node that computes the overall output as the summation of all incoming signals.

This five-layer network architecture, ANFIS being a hybrid model puts the fuzzy model into the framework of adaptive networks that can compute gradient vectors systematically. The Fuzzy Toolbox under MATLAB software has been used for all simulation experiments. The 'trial and error' method is used to reach optimum model configuration in all the simulation experiments.

3. Conventional Empirical Sorption Models

In this paper, several conventional empirical models have been explored to fit the experimental data on moisture sorption for different milk products so as to compare the performance of the soft computing models discussed above. The relevant isotherm equations have been presented in Table 1. The notations: W, W_m and a_W in the Table 1 denote equilibrium moisture content, monolayer moisture content and water activity, respectively. The other symbols are the model constants. The linearised forms of the two-parameter models, *viz.*, BET, Caurie, Halsey, Oswin and Smith were used for evaluating the best fit values of constants using the linear regression technique. For the three-parameter models, *viz.*, Guggenheim-Anderson-de Boer (GAB) model and Mizrahi Mizrahi model used in this study, the regression coefficients/constants, *i.e.*, a, b and c significantly depend on the type of regression analysis. A nonlinear least squares procedure was chosen because it is widely considered as a reliable technique.

4. Measure of Prediction Accuracy

The accuracy of fit of different models was evaluated by calculating the Root Mean Square percent error ($\%RMS$) of moisture between the experimental and predicted EMC using following equation:

$$\%RMS = \sqrt{\frac{1}{l}\sum_{1}^{l}\left(\frac{W_{EXP} - W_{PRE}}{W_{EXP}}\right)^2} \times 100$$

where W_{EXP} = Experimental moisture content; W_{PRE} = Predicted moisture content; and l = Number of observations.

5. Soft Computing Models vs. Classical Empirical Sorption Models

Soft computing modelling paradigm (including connectionist and ANFIS models) has been explored experimentally to predict the MSI in selected Indian milk products, viz., dried acid casein powder, skim milk powder, fortified Nutrimix powder (weaning food) and whey protein concentrate powder. Also, classical empirical sorption models have been used to fit the same sorption data to assess the performance accuracy of the soft computing models developed for modelling MSI in the selected milk products. The experimental results are summarised and discussed here under:

- Experimentation and compilation of data for moisture sorption in the aforementioned milk products have been carried out at Dairy Engineering Division, NDRI Karnal.
- Soft computing (*i.e.*, connectionist and Adaptive Neuro-Fuzzy Inference System-ANFIS) models to predict sorption isotherms in Casein Powder and Nutrimix Powder have been developed and validated.
    - Soft computing models have been developed to predict sorption (adsorption and desorption) characteristics at three temperatures, i.e., 25, 35 and 45°C over a water activity range of 0.11–0.97 in dried acid casein prepared from buffalo skim milk. Also, several conventional empirical sorption models were used for fitting the sorption data. The ANFIS models predicted the adsorption characteristics with an accuracy ranging between 0.09 and 0.2 %RMS; whereas the connectionist models attained accuracy ranging between 1.32 and 2.60 %RMS; and the best (among six conventional empirical models used) GAB model attained %RMS between 1.92 and 5.77. While for desorption characteristics, the ANFIS models attained %RMS between 0.15 and 0.33; the connectionist models attained %RMS between 1.56 and 4.08; and the best (among six

conventional empirical models used) GAB model attained %RMS ranging between 1.4 and 5.01. Hence, the results revealed that the soft computing paradigm especially the hybrid approach: ANFIS outperformed the conventional empirical models and, generally, best described the experimental adsorption and desorption data for dried acid casein prepared from buffalo skim milk.

  - Several intelligent models based on connectionist and ANFIS approaches have been developed to predict the sorption isotherms at four different temperatures—that is, 15, 25, 35, and 45°C—in a milk and pearl millet–based weaning food, fortified Nutrimix. The connectionist models developed using an error back-propagation learning algorithm based upon BR/LM optimisation mechanisms along with various combinations of different values of network parameters were empirically explored for this purpose. Similarly, ANFIS models were constructed for the different temperatures, with various combinations of different parameters. The prediction potential of these soft computing models was compared with that of the conventional empirical models that were also developed in this study. The performance of the neuro-fuzzy hybrid model seems to exhibit the best with prediction accuracy of 99.91% compared to that of the simple connectionist model with accuracy as 97.51% and that of the best classical empirical sorption model; that is, the GAB model with an accuracy of 94.52%. Thus, it is deduced that intelligent models based on an SC paradigm seems to be a better alternative to the conventional sorption empirical models to predict moisture sorption isotherms in the fortified Nutrimix at different temperatures. However, among the SC models, a hybrid approach—that is, ANFIS—was found to perform far better than the simple connectionist model. Hence, it is recommended on the basis of the results of this study that the hybrid SC ANFIS model can potentially be used as a superior alternative technique over simple connectionist models and the conventional empirical sorption models to effectively predict equilibrium moisture content in the fortified Nutrimix powder.

- Connectionist models to predict sorption isotherms in Skim Milk Powder and Whey Protein Concentrate Powder have been developed and validated.
  - The connectionist approach has been investigated empirically to model the moisture adsorption isotherm in skim milk powder. The dataset comprised 105 points. Also, conventional empirical models, i.e., Halsey, Smith, Oswin, Caurie, Modified Mizrahi and GAB models were used to fit the adsorption data. The data were split into two disjoint subsets with 80% data points used for training and remaining 20% records for validation of the model, using five-fold cross-validation technique. Unlike the classical sorption models that do not involve temperature as a variable, the connectionist model comprised two inputs variables, viz., temperature (°C) and water activity (ranging 0.11-0.97); with equilibrium moisture content (g water/100 g solids) as the output variable. The best configuration of the connectionist model consisted of two hidden layers each containing 5 neurons. The Error Back Propagation learning algorithm based on BR and LM optimisation techniques with several combinations of network parameters was used to develop the proposed model. The developed model predicted moisture adsorption isotherm with an accuracy of 1.1 %RMS as compared to that achieved by the best GAB model among the six conventional sorption models, which attained %RMS ranging between 4.92 and 6.25 for three different temperatures: 25, 35 and 45°C as reported in literature for the same dataset. Hence, the results revealed that connectionist model outperformed the conventional models and best described the experimental adsorption data for buffalo skim milk powder.
  - The connectionist approach has been investigated empirically to model the moisture adsorption isotherms in whey protein concentrate powder at three different temperatures, i.e., 25, 35 and 45°C and water activity ranging between 0.11 to 0.97. Several supervised feed forward neural network models founded on back-propagation learning algorithm equipped with BR and LM optimisation techniques vis-à-vis six conventional mathematical sorption models, viz., Halsey, Smith, Oswin, Caurie, Modified Mizrahi and GAB models have been developed. Single hidden layer having neurons varying between the range 2 to 10 with sigmoid functions, i.e., log-sigmoid and tangent sigmoid functions have been used, while the linear function was applied to the output

layer neuron for neural network models. Also, various combinations of internal network parameters were experimentally explored. The developed intelligent models predicted moisture adsorption isotherms with an accuracy up to 99.98% as compared to that achieved by the best GAB model among the six conventional sorption models, which attained accuracy up to 95% for three different temperatures studied. The results allow us to deduce that intelligent models can potentially be used as superior alternative technique over conventional sorption models to effectively predict moisture adsorption isotherms in the whey protein concentrate powder.

6. Conclusions

Soft computing based intelligent models have been described to predict moisture sorption isotherms in various Indian milk products, such as dried acid casein powder, skim milk powder, fortified Nutrimix powder (weaning food) and whey protein concentrate powder at different temperatures over a specific range of water activity. Connectionist and Adaptive Neuro Fuzzy Inference System (ANFIS) models have been discussed. Back-propagation algorithm with Bayesian Regularisation/Levenberg-Marquardt optimisation mechanisms has been delineated to develop connectionist models. While Sugeno-type fuzzy inference system based ANFIS models have been illustrated. Also, several empirical models have been explored for fitting the sorption data. The soft computing models in general and hybrid ANFIS models in particular outperformed the conventional sorption models for predicting isotherms in the aforementioned milk products. Further work is in progress to develop hybrid models using genetic algorithms and connectionist models.

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References are available on request through email.

ENGINEERING INTERVENTIONS IN SANITARY DESIGN & MANUFACTURE OF DAIRY & FOOD PROCESSING EQUIPMENTS

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Introduction:

The first sanitary design criteria for equipment in the dairy industry originated in the 1920s and became known as "3-A" standards in recognition of the cooperation and consensus reached among the three associations International Association of Food Industry Suppliers (IAFIS), the International Association for Food Protection (IAFP) and the Milk Industry Foundation (MIF). representing fabricators, processors, and regulatory sanitarians. The 3-A Symbol was introduced in 1956 to identify equipment that conforms to a 3-A Sanitary Standard for design and fabrication. Voluntary use of the 3-A Symbol on dairy and food equipment assures processors that equipment meets sanitary standards, provides accepted criteria to equipment manufacturers for sanitary design, and establishes guidelines for uniform evaluation and compliance by sanitarians.

To ensure safe food and adequate sanitation programs, the equipment used for processing and handling food products must be designed, fabricated, constructed, and installed according to sound sanitary design principles. This ensures the equipment can be adequately cleaned and sanitized, and that surfaces are resistant to daily exposure to corrosive food products and cleaning/sanitizing chemicals.

Equipment Standards

Federal, state, and local regulatory agencies routinely inspect food equipment for general sanitary fabrication, construction, and design as well as proper installation. In India FSSAI /ISI the approves equipment for use in food and Dairy processing (FSSAI- 2011).

Similarly, 3-A, EHEDGE has an approval process for equipment used in manufactured dairy facilities under their inspection. Food and Drug Administration (FDA) inspectors follow Current Good Manufacturing Practices (cGMPs) which generally address the fabrication and clean ability of food equipment (FDA, 2004a). In addition, the FDA has developed a general equipment evaluation program for equipment used in Grade A Dairy Facilities (FDA, 2000).

The European Hygienic Design Group (EHEDG) is the primary organization for food equipment approval in Europe. While EHEDG has published a series of guidelines for the construction and design of food processing equipment, they have chosen not to issue standards. Acceptance for food processing equipment used in some European countries is based upon "cleanability" testing performed in EHEDG laboratories. International trade associations [e.g. International Dairy Federation (IDF)], and international standards organizations [e.g. Codex Alimentarius and the ISO are also generally involved in equipment hygiene standards. Some of these organizations have symbol or insignia use authorization programs that require third party verification of compliance with the appropriate standard or guideline.

General Aspects of Sanitary Construction and Design of Food Equipment

The surfaces of food equipment can be subdivided into two categories:

1. Food product contact surfaces, and
2. Non-product contact surfaces.

A *food product contact surface* is defined as a surface in "direct contact with food residue, or where food residue can drip, drain, diffuse, or be drawn" (FDA, 2004b). Because these surfaces, if contaminated, can directly result in food product contamination, rigid sanitary design criteria must be met. *Non-product contact surfaces* are those that are part of the equipment (e.g., legs, supports, housings) that do not directly contact food. As contamination of *non-product contact surfaces* can cause indirect contamination of the food product, these surfaces cannot be ignored with regard to sanitary design.

Food Product Contact Surfaces

In terms of sanitary design, all *food contact surfaces* should be:

- smooth; impervious; free of cracks and crevices; nonporous; nonabsorbent; non-contaminating;
- noncreative; corrosion resistant; durable and maintenance free; nontoxic; and cleanable.

If the surface is coated with metal alloy or non-metal (e.g. ceramics, plastic, rubber) in any way, the final surface must meet the above requirements. 3A Standards require that such coatings maintain corrosion resistance, and be free of surface pitting, flaking, chipping, blistering, and distortion under conditions of intended use. Similarly, if any other modification or process is used in fabrication (e.g., welded, bonded, or soldered) it should be done using appropriate materials and in a manner that ensures the final surface meets the sanitary design criteria.

Materials

A variety of materials are used in the construction and fabrication for different applications in food equipment. These materials vary in their properties with regard to workability, compatibility, and sanitary design features. Depending upon the application, various metals as well as non metals (e.g., plastics, rubber) are used. Some materials are not recommended and should be avoided.

Metal

Stainless steel is the preferred general use metal for food contact surfaces because of its corrosion resistance and durability in most food applications. However, not all stainless steel is equal. In general, the properties of the stainless steel alloy are related to its relative composition with regard to chromium and nickel level. Corrosion resistance varies with chromium level, and structural strength varies with nickel level. The relative levels of these components are often given as a ratio. For example, the American Iron and Steel Institute (AISI) 300 Series Stainless Steel, commonly recommended for food contact surfaces is also termed 18/8 indicating that it is 18% Cr and 8% Ni. 3A Sanitary Standards require AISI-316 (or 18/10) stainless steel for most surfaces. They allow the use of 304 stainless steel only for utility usage (e.g. pipes), and restrict the use of 303 stainless steel. Simple platform test (moly test) is used for differentiating AISI-316 SS, AISI-304 SS and AISI-202 SS grades Most of Dairy and Food equipments are made from austenitic stainless steels of AISI-304 and AISI-316

ASTM	**TYPE**	**CHEMICAL COMPOSITION**
304	Austenitic	18Cr, 9Ni
316	Austenitic	17Cr, 10Ni, 2Mo

The table indicates the grades of SS used for the different equipment used in the dairy industry.

Equipment	Products manufacture	Grade of SS
storage tank	All dairy products	AISI-304
Centrifuges, Pasteurizer	Milk , Curd, cream Butter	AISI -304 AISI 316
Plate and tubular heat exchangers	Milk, Cheese, Cream, Butter, Yoghurt	AISI-316
Packaging machine	Milk, Cream, Yoghurt	AISI-316
Ultra filtration equipment	Cheese	AISI-316
Maturation tank	Cheese, Ice Cream, Cream, Butter	AISI -304 AISI 316
Other equipment	All dairy products	AISI -304 AISI 316

3A

Standards also provide specifications regarding alloys and other coatings used in fabrication. The properties of stainless steel can change with continued use, especially under conditions where the chromium oxide layer is altered (e.g. incompatible cleaners, abrasive cleaners, abrasive cleaning pads, or chlorine and related sanitizers). Therefore, it is recommended that surfaces be passivated (using nitric acid or other strong oxidizing agents) initially and on a regular frequency thereafter, to maintain a passive (non-reactive) oxide film on the surface. Passivation of stainless steel food contact surfaces is recommended after any surface repair, polishing, or working.

- **Titanium** has excellent durability and corrosion resistance (especially in an acidic environment) . However, its use is limited by high cost. Titanium is used in stainless steel alloys for food equipment used in the processing of food products with high acid and/or salt content (e.g., citrus juice, tomato products).
- **Copper** is primarily used for equipment used in the brewing industry, with some use for cheese vats in Swiss cheese manufacture, due to tradition. Care should be used with copper equipment when processing acid products, as copper residues can leach into the product.
- **Aluminum** is used in certain parts and components where lighter weight is desired. However, aluminum has poor corrosion resistance and can become pitted and cracked with continued use. Care should taken when cleaning and sanitizing aluminum components as oxidizing chemicals can accelerate the pitting of the metal. In most food contact applications, aluminum must be coated with an acceptable material. Plastic coatings such as polytetrafluorethylene (PTFE or Teflon®)are common.
- **Galvanized iron** should be avoided as a food contact surface because it is highly reactive with acids.

Non-metals

A variety of non-metal materials are used as food contact surfaces in specific applications of food equipment (e.g., probes, gaskets, membranes). These materials should meet the same sanitary design and cleanability requirements as metals when used in these applications as described in 3 A Sanitary Standards and other standards. Non-metal surfaces, in general, lack the corrosion resistance and durability of metal surfaces, therefore, maintenance programs should include frequent examination for wear and deterioration under continued use, and replacement as appropriate.

Non-metal materials used in food contact surfaces include:

- **Plastics**, **rubber**, and **rubber-like** materials that should be food grade and should meet the requirements designated under 3A Sanitary Standards (18-03 and 20-20). Multi-use plastics, rubber, and rubber-like materials may also be considered as *indirect food additives* under FDA regulations.
- **Ceramics** are used primarily in membrane filtration systems. They may also be used in other limited applications if wear resistance is necessary.

- **Glass** may be used as a food contact surface. These applications are limited due to the potential for breakage. Specially formulated glass materials such as Pyrex® have proven successful. When glass is used, it must be durable, break resistant or heat resistant glass. Some applications where glass is used are light and sight openings into vessels and in very limited glass piping applications.
- **Paper** has been used over the years as a gasket material in piping systems designed for daily disassembly. Paper is considered a single use material.
- **Wood**, which is highly porous and difficult to clean, should be avoided as a food contact surface. Wood is restricted in food service applications by most regulatory agencies, with the exception of hardwood cutting boards and tight grain butcher blocks.

Surface Texture and/or Finish

If any surface is ground, polished, or textured in any way, it must be done so the final surface is smooth, durable, free of cracks and crevices, and meets the other sanitary design requirements described above. 3A Sanitary Standards require that ground or polished stainless steel surfaces meet a No. 4 ground surface, and unpolished surfaces meet a No. 2B or mill finish. The 3-A Sanitary Standards development group has recently adopted an industry recognized method for determining an acceptable food contact surface termed *roughness average* or *Ra value*. The Ra is determined using a sensitive instrument (termed a profilometer) which employs a diamond tipped stylus to measure peaks and valleys in a relatively smooth surface.Surface Finish -All product contact surfaces shall have a smooth uniform surface free of pits, folds, cracks and crevices. Within the product zone, surface roughness height shall be no greater than 32 micro inches Ra. (0.8 micrometer) obtained by 150 grit silicon carbide properly applied to stainless steel. Glass beading or sand blasting is not an acceptable alternative to required grinding and polishing of welded junctures to provide a #4 finish. Glass beading or sand blasting of product contact surfaces may be approved provided the treatment serves a specific functional purpose, the surface has been previously Prepared to the equivalent of the #4 finish, and the glass or sand grit does not exceed the coarseness of 150 grit silicon carbide

Grit	Max Ra. µ m
120	1.01- 1.14
150	0.68 -0 .88
180	0.46 - 0.58
240	0.34 -0.45
320	0.23-0.28

Construction and Fabrication

Food equipment should be designed and fabricated in such a way that all food contact surfaces are free of sharp corners and crevices. All mating surfaces must also be continuous (e.g., substantially flush). Construction of all food handling or processing equipment should allow for easy disassembly for cleaning and inspection. Where appropriate (e.g., vessels, chambers, tanks), equipment should be self-draining and pitched to a drainable port with no potential hold up of food materials or solutions.

Non-Product Contact Surfaces

Non-product contact surfaces of food equipment are a well documented source for environmental contamination of a food facility with pathogens (especially *Listeria monocytogenes*). These areas can also be harborage areas for insects and rodents. Therefore, care should be used in evaluating these surfaces of equipment with regard to sanitary construction and design. In general, non-product surfaces of equipment should be constructed with appropriate materials and fabricated in such a manner as to be reasonably cleanable, corrosion resistant, and maintenance free. As much as is practicable, tubular steel equipment framework should be entirely sealed and not penetrated (e.g., bolts, studs), to avoid creating niches for microorganisms (see Fig. 10). Whenever practicable, attachments should be welded to the surface of the tubing and not attached via drilled and tapped holes.

Ledges or areas where dust can collect should be avoided. Tops of equipment, shields, covers, or boxes, should be sloped at a 45 degree angle or more. To avoid niche areas for microbiological growth, the legs of equipment should be sealed at the base and not be of hollow design. Threads used on leveling components should be of the enclosed type as shown in Fig. 11.

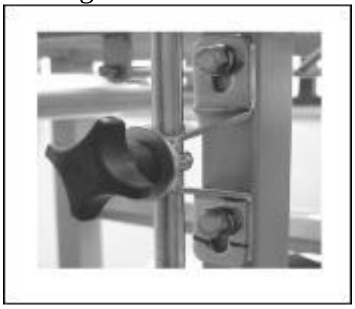

Figure 10. Tubular Framework with Bolted Attachments Potential Microbial Niche

Figure 11. Enclosed threads on leveling components (from Marconnett, 2004)

Food Equipment Installation
Food equipment should be installed in a logical sequence to avoid cross contamination. Space around and between equipment and between equipment, and walls should be adequate enough to allow for sufficient cleaning. There should be no potential harborages for insects and rodents. Unless sealed to walls, food equipment should be at least 4 inches from walls. Floor mounted equipment should be sealed to the floor, platform, or pedestal or should be no less than 6 inches from the floor. Table mounted equipment should be sealed to the table, or be no less than 4 inches from the counter top
.

PRINCIPLES OF SANITARY DESIGN AND MANUFACTURE MILK PROCESSING EQUIPMENTS
The ten Principles of Sanitary Design listed below address an important aspect of sanitary design associated with the successful implementation of this industry model as detailed in this article. By developing an industry model rather than a company-specific model for sanitary equipment design, processors benefit from improved design that is accepted by other member companies, and equipment makers benefit from improved manufacturing efficiencies.

Principle 1. Cleanable to a Micro-biological Level.
Equipment should be constructed to be cleanable to a GMP, product hazard (microbiological, chemical, physical), and quality level that is validated and verified by active monitoring programs. *Food equipment must be constructed and be maintainable to ensure that the equipment can be effectively and efficiently cleaned and sanitized over the lifetime of the equipment. The removal of all food materials*

is critical. This means preventing bacterial ingress, survival, growth and reproduction. This includes product and non-product contact surfaces of the equipment. While a piece of equipment may be visually clean, absent of soil or organic matter, it does not necessarily mean that it is microbiologically clean. What food processors would like to see is a piece of equipment that can be cleaned to a microbiological level, as well as clean to the eye. This principle refers to any kind of unwanted microorganisms, including pathogens and spoilage organisms.

Principle 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. Equipment materials of construction must be inert, corrosion resistant, nonporous and nonabsorbent (Figure 1).

This principle emphasizes the importance of making sure that a product surface is impervious to the materials to which it is exposed. This is very important because the use of incompatible construction materials may cause corrosion or pitting on a material such as aluminum, for example, that would create a harborage area where microorganisms, water, soil or food can collect. Essentially, the processor wants to minimize areas where microorganisms can hide, live and survive. By eliminating incompatible materials in the construction of the processing equipment, the processor reduces the likelihood of creating a hospitable environment where bugs can grow.

Principle 3. Accessible for Inspection, Maintenance, Cleaning and Sanitation.
All parts of the equipment shall be readily accessible for inspection, maintenance, cleaning and/or sanitation. Accessibility should be easily accomplished by an individual without tools. Disassembly and assembly should be facilitated by the equipment design to optimize sanitary conditions.

Dave Kramer's quote applies here: "If you can't see it and you can't touch it, then you can't clean it." In other words, in a non-CIP environment you need to be able to get everything clean. There are four elements of cleaning that processors use: mechanical action, temperature, a chemical that will break up fats and proteins, and time. With these, the processor should be able to remove any food soil from equipment, as long as he gets the mechanical action and chemicals in the right amount of time and in the right concentration into those places where there are soils. Designing equipment to increase accessibility for cleaning ensures the success of this four-pronged protocol, since the soil will be more visible.

In addition, the more accessible the equipment is for cleaning by sanitation employees, the easier it is for them to do the job safely, properly and procedurally. If you are a sanitation employee and you need to call a maintenance employee to come and remove a guard or to mechanically get access to a certain area on a piece of equipment, cleaning will take that much more time and be that much more difficult to do. Principle 3 underscores the benefit of making systems easy for people to do the right things.

Principle 4. No Product or Liquid Collection.
Equipment shall be self-draining to assure that food product, water, or product liquid does not accumulate, pool or condense on the equipment or product zone areas.

The processor does not want to have any areas in the system where water can collect, or where product can collect and later develop into a foreign material as it dries out, crusts and hardens. Standing water can serve as a harborage or growth point for microorganisms, and any time moisture is introduced into an environment there is an increased chance for microbial growth.

Principle 5. Hollow Areas Hermetically Sealed.

Hollow areas of equipment (e.g., frames, rollers) must be eliminated where possible or permanently sealed (caulking not acceptable). Bolts, studs, mounting plates, brackets, junction boxes, name plates, end caps, sleeves and other such items must be continuously welded to the surface of the equipment and not attached via drilled and tapped holes (Figure 2).

In most food processing plants, there is a lot of framework used on pieces of equipment, and we want to make sure that there are no penetrations that would allow moisture and/or food materials or organic matter to get inside or under the surface of equipment. If this occurs, microorganisms will grow, leak out and recontaminate the environment. Elimin-ating or sealing hollow areas is easily addressed by equipment designers. One example is when equipment manufacturers would put a name tag on the piece of equipment, using a pop rivet to attach it. But a pop rivet is a penetration of the equipment surface that is not sealed, allowing water to get in. Because of the EDTF's work, many designers are eliminating the pop-riveted name tags today.

Principle 6. No Niches.

All parts of the equipment shall be free of niches such as pits, cracks, corrosion, recesses, open seams, gaps, lap seams, protruding ledges, inside threads, bolt rivets and dead ends. All welds must be continuous and fully penetrating.

This principle means just what it says: Food processing equipment should not have harborage points. Not only should equipment be evaluated to ensure that the original welding by the manufacturer is continuous and niche-free, but processors also should take care when modifying equipment in the plant environment. Often equipment is modified by the processor to make it fit into a room or to make it consistent with other designs or product lines existing in the plant, and during such modification activities a hollow framework might be penetrated and create a microbial growth niche.

Principle 7. Sanitary Operational Performance.

During normal operations, the equipment must perform so it does not contribute to unsanitary conditions or the harborage and growth of bacteria.

This principle is linked to Principle 4: A processor doesn't want anything on the production line that is going to cause microbial counts to increase throughout the course of the day. During operation, you want to make sure that you have minimal moisture and product buildup in different product zones. In an ideal world, the processor wants to increase productivity and run the lines as efficiently and safely within the regulated timeframe. If, for example, the processor operates a wet process that adds moisture all the time, there likely will be increased microbial counts on the conveyor. Designing the conveyor or other equipment parts to minimize product buildup and moisture allows the production run to be increased to the extent allowed by regulation and to maximize the benefit of the operation during that time while minimizing any type of quality defect.

Principle 8. Hygienic Design of Maintenance Enclosures.

Maintenance enclosures (e.g., electrical control panels, chain guards, belt guards, gear enclosures, junction boxes, pneumatic/hydraulic enclosures) and human machine interfaces (e.g., pushbuttons, valve handles, switches, touch screens) must be designed, constructed and be maintainable to ensure food product, water, or product liquid does not penetrate into, or accumulate in or on the enclosure and interface. The physical design of the enclosures should be sloped or pitched to avoid use as a storage area. Human/machine interfaces such as push buttons, valve handles, switches and touch screens, must be designed to ensure product and other residues (including liquid) do not penetrate or accumulate in or on the enclosure or interface.

Engineers involved with the EDTF stressed the importance of this principle, noting that there are many equipment installations whereby an ideally designed piece of equipment is placed adjacent to an electrical box (a perfect harborage place for water leakage) and/or pushbuttons that are not cleanable. This principle not only addresses product contact surfaces, but the entire asset represented by the piece of equipment. This moves the consideration beyond the surface to ensure that all of the maintenance enclosures and other connections to the equipment are appropriately designed and also can be cleaned and sanitized.

Principle 9. Hygienic Compatibility with Other Plant Systems.
Design of equipment must ensure hygienic compatibility with other equipment and systems (e.g., electrical, hydraulics, steam, air, water).

Ensuring the hygienic compatibility of the equipment with other systems is both a processor responsibility to the equipment manufacturer as well as an equipment manufacturer responsibility to the processor. The processor wants to make sure that equipment introduced into a facility is designed and built to be usable with the plant systems. Processors can communicate to equipment manufacturers the established electrical, hydraulic, steam, compressed air and oil filtration and water systems information to assist in improved design strategies prior to the equipment being built and arriving at the plant.

Principle 10. Validated Cleaning and Sanitizing Protocols.
The procedures prescribed for cleaning and sanitation must be clearly written, designed and proven to be effective and efficient. Chemicals recommended for cleaning and sanitation must be compatible with the equipment, as well as compatible with the manufacturing environment.

Equipment manufacturers are not cleaning procedure experts; their manufacturing facilities resemble machine shops teeming with lathes and metal shaping equipment. It is a rare equipment manufacturing operation that would have the ability to wash a piece of equipment, much less sanitize it. However, food processors utilize cleaning and sanitizing systems everyday, and can provide useful insight as to the best way to clean and sanitize equipment in given plant environments. This principle recommends that the equipment manufacturer work with the individual processor during the equipment design stage, so that by the time the equipment is being constructed, the equipment company will have a fairly good vision of how the equipment can be cleaned and sanitized in a processing plant. When it is delivered to the processing plant, the processor also will have a clear vision of what needs to be done to successfully clean it.

PROCESS FLOW FOR DESIGN REVIEW
The sanitary equipment process flow chart for design review illustrates the interaction of the processor and the equipment manufacturer to achieve the benefits of an industry model approach within the framework of the 10 Principles of Sanitary Design (Figure 4). As an example, let's say that a food company wants to purchase from an equipment manufacturer. The two companies begin the design review process for this piece of equipment by using the checklist tool that allows for consistent evaluation of equipment by both processors and manufacturers.

Figure 5 shows a portion of the checklist developed for the review of Principle 1: Cleanable to a Microbiological Level. Both the food company and the equipment supplier will go through these equipment checklists, which are based on the 10 Principles of Sanitary Design, and if they determine through this preliminary review that the equipment is well-designed in accordance with the sanitary design principles, the process continues to Phase 2. If not, the equipment goes back to redesign.

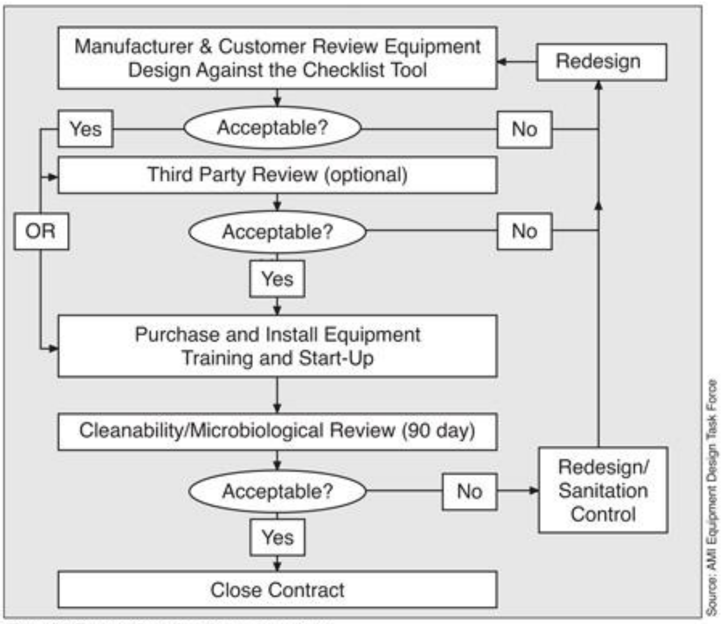

Figure 4. Process flow chart for design review.

At Phase 2, the processor now has the option of going to the USDA AMS or NSF International, both of which offer a service for third-party evaluation of equipment for sanitary design. If this option is exercised, the third-party reviewer will look at the piece of equipment in question as an additional check to verify that the equipment incorporates the desired sanitary design elements. In most cases, the equipment will be acceptable if the equipment manufacturer and the processor use the checklist tool to conduct a preliminary inspection. Again, if at any one of these review steps the parties find the equipment unacceptable, it goes back into a redesign phase.

If the equipment is acceptable following Phases 1 and 2, the processor purchases and installs the equipment in the plant. The significant aspect of Phase 3 is the 90-day period of cleanability and microbiological review by the processor in a real-world environment. In this way, the processor is able to actually test the sanitary design of the equipment in the individual plant environment, something that cannot be accomplished in the equipment manufacturer's facility as discussed earlier. During the 90-day period, the food company runs product on the new equipment and applies the appropriate cleaning and sanitizing protocols. The processor can now better determine whether the equipment is, in fact, microbiologically cleanable; for example, whether any unfriendly organisms have found harborage and at what location, or whether organisms are easily removed by routine cleaning and sanitizing.

If after the 90-day in-plant period the equipment is deemed acceptable in terms of sanitary design criteria, the processor closes the contract. If the equipment is not acceptable, either the equipment manufacturer must redesign to address the problem or the processor must develop a sanitation control that will augment a reduction in the microbial counts for that piece of equipment. For example, the parties may determine that the types of belts used need to be reconfigured or that the finish on a piece of stainless steel allows for the creation on niches, and therefore the piece needs undergo redesign. If the processor identifies an area that is extremely difficult to access and clean, it may indicate the need to redesign that specific area.

Conclusion

The goal with the 10 Principles of Equipment Design is continuous improvement with the robustness of sanitation, cleaning and food safety programs. The complete implementation of design principles helps to manufacture hygienic quality equipments of international standard which shall confirm to 3-A/EHEDG/IDF/FDA norms .

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KHEER AND ITS ENGINEERING PROPERTIES

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Abstract
Milk is the most desirable and valuable food source. Processing of milk and manufacturing of milk products are practiced to ensure the quality over longer durations of time. Dairy products are consumed not only for nutritional resources but also for therapeutic benefits. When rice is cooked in milk, it results into a thick product which is known as rice pudding in United States and Europe and *kheer* in India. It is a very nutritious product combining benefits of both milk and rice. Experiments were carried out to determine the physical and textural properties such as flow behaviour index (n), consistency coefficient (k), density and apparent viscosity etc. at 25% total solids content of *kheer* at room temperature (30±2°C) using a controlled stress rheometer fitted with CP 75 probe and a texture analyzer equipped with a load cell of 25 kg and a cylindrical probe (P/25). Density was determined using a pycnometer and precision weighing balance. The experiments on textural characterization of *kheer* yielded the values of firmness, work of adhesion, work of shear and stickiness as 2.000±0.388 N, - 0.205±0.088 mJ, 3.930±0.702 mJ and – 0.048±0.006 N, respectively. The flow behaviour index, consistency coefficient, density and apparent viscosity values *were found as* 0.327±0.169, 4.055±2.502 $kg_f sec^n/m^2$, 1320.50 kg/m^3 and 0.502±0.069 Pa-s, respectively. These properties of *kheer* are useful for designing process equipment such as metering and filling systems for the organized preparation, packaging and distribution of *kheer.*

Keywords: *Kheer*, Engineering properties, Flow properties, Texture analysis

Introduction

Ever since the start of civilization of mankind, from the Neolithic ages, the consumption of milk started to make its mark as part of human diet. This was a result of the adaption of a settled practice of acquiring food and resources to consume food. The most important turn around in this period of civilization occurred through ventures into agriculture and domestication of ruminants which began 11,000 years ago in the Middle East (Nagpal et al., 2011). Milk, in addition to being the most desirable and valuable food source, began to take its place in society as “nature’s most perfect food” (Barłowska et al., 2011). Short – lived quality and storage life of fluid milk, drove civilizations to ensure this valuable source of nutrition stays good for longer. Processing of milk thus found its way through preparation of products accidentally rather than intentionally as in case of cheeses.

Product preparations were then characterized leading to commercialized processing and production of milk and Milk products in organized and un–organized dairies. Milk and milk products have long been acknowledged as an important constituent of a balanced diet. It is an optimally rich source of vital nutrients such as proteins, fat, lactose, vitamins, minerals, enzymes, hormones, immunoglobulins, and cells. Dairy products are consumed not only for meeting the nutritional requirements of the consumers, but also for their role in preventing various disorders such as osteoporosis (Uenishi, 2006), dental caries (Shimazaki et al., 2008), cardiovascular diseases (Lamarche, 2008) and others such as improved immunity etc. (Sharma and Rajput, 2006).

Today, India is one of the most economic and largest milk producing country in the world, producing around 132.4 Million tonnes per annum (NDDB, 2012). The hydro-thermal processing of rice has become one of the most widespread food industries of the world since it constitutes a major part of the global nutritional need for carbohydrates (Bello et al., 2007; Bhattacharya, 1990). One of the major constituents widely present in preparation of the food products is starch. Starch is added in many food products as a thickener, texture improver, stabilizer and in controlling the consistency and water retention capabilities.

Starch enables achievement of these functionalities by affecting pasting, gelatinization and retro-gradation properties of many foods. It is known that these properties of starch are marginally affected by addition of some additives. In this respect, dietary fibers are among the most preferred additives that can be used in the food industry to improve functionality of starch based products (Gurmeric et al., 2012). The behaviour of starch in the fiber containing medium should be very important since starch is a widely used ingredient in the food industry for different purposes. This includes cooking of rice at boiling conditions resulting in both water migration as well as starch-water reaction (gelatinization).

If rice is cooked in milk, starch and milk reaction results into a thick product, which is very popular in India known as *kheer* (Table 1). It is a form of a sweet dish commonly known as rice pudding in the United States and Europe (Kadam et al, 2012). *Kheer* also known as *Payas* or *Payasam* in many parts of India as an extremely popular rice based heat concentrated and sweetened dairy dessert (Kumar et al., 2005). Conventionally, *kheer* is prepared by concentrating milk with simultaneous cooking of rice in an open pan over low fire and addition of sugar toward the end of cooking (Aneja et al., 2002; De, 1980). In many cases dry fruits are added to make it nutritionally rich e.g. in southern states of India (Table 2). This *kheer* has a creamish colour as well as sweet, nutty and cooked flavour due to prolonged cooking (Jha et al., 2002). *Kheer* is considered a nutritious dessert since it contains nutrients from both milk and rice (Kumar et al., 2005).

Table 1: Popular varieties of *kheer* in India

S.No.	Types	Ingredient(s)	Specific Name
1.	Pulse based	Bengal *gram dal*, Green *gram dal*	*Kadale bele, Hesaru bele, Parippu, Halu kheeru*
2.	Cereal based	Rice, Wheat	*Gil-e-firdaus, Godhi*
3.	Cereal product based	Beaten rice, *Sooji*, *Vermicelli*, Ade	*Happal Kuthida, Akki, Nuthchu* etc.
4.	Tuber based	Sago	*Sabbaki, Kaddu ki kheer*
5.	Fruit based	Mango, Jackfruit	*Mavina, Halasina*, Mango *prathaman*, *Chakka prathaman*
6.	Seed based	Poppy	*Khus-khus*

Source: Kulkarni, 1999

Table 2: Varieties of *kheer* in southern states of India

S.No.	State	Popular varieties	Others
1.	Andhra Pradesh	*Vermicelli*, Sago	*Shirkurma, Gil-e-firdaus, Phirni*
2.	Karnataka	*Shyavige*, Bengal gram *dal*	Poppy seeds (*Khus-khus*), Green gram *dal*
3.	Kerala	Pal, *Palada*	*Semiya*, Bengal gram
4.	Tamilnadu	Pal, *Vermicelli*	*Thirattupal*

Source: Kulkarni, 1999

The quality of food materials is represented by different parameters such as mechanical characteristics and textural properties like firmness and chewability. Starchy food products suffer from fracture mechanical damage by means of a series of static and dynamic loads, leading to significant loss in quality and resulting in an increased perishability to deterioration during storage. In the literature, some recent studies can be found on the stress–relaxation properties of some starchy food materials (Singh et al., 2006).

Kadam *et al.*, (2013) conducted study for optimization of process parameters (operating pressure and cooking time) for continuous *kheer*-making machine. Sensory trials of *kheer* prepared conventionally and using pressurized methods were analyzed. Sensory results of open pan samples indicated that there is a small range of Whiteness Index (WI) and Hardness (H) values that is desirable in *kheer* (Kadam *et al.*, 2013). In order to improve the shelf life of *kheer*, a process based on in-pouch thermal processing employing a rotary retort was developed (Jha *et al.*, 2000). Product development included optimisation of rice/milk solids ratio (0.18–0.52) and total milk solids levels (16–26%) to simulate the conventional product in taste, appearance and textural attributes. Various process lethality values (F_o = 12.4–14.8) were examined with regard to product quality (Jha *et al.*, 2000). Effect of temperature on the moisture desorption isotherms of *kheer* was analysed (Kumar et *al*., 2005). Desorption isotherms of *kheer* were analyzed in the temperature range of 10 to 40ºC (Kumar et *al*., 2005). Engineering properties of *kheer* are required in order to design process equipments including filling systems for the organized and hygienic preparation, packaging and distribution of *kheer* and similar traditional dairy products. Changes were reported in quality and acceptability of *kheer* as temperature and concentration changes, making it essential to develop a mass based metering and filling system of *kheer* rather than a volume based filling system. There is almost no published information on mass based metering and filling system of *kheer*. Therefore, the various engineering properties of *kheer* have been investigated in the present study.

Methodology

Kheer was prepared using the conventionally adopted method by local sweet makers or *halwais.* The product was prepared using long grain rice (procured from local market, Karnal, Haryana, India), toned cow's milk and granulated sugar. Toned cow's milk was filtered and pre-heated to 45ºC. Cleaned, washed and soaked (45 min. soaking) rice was taken at 5% of the mass of milk taken. This was then added to milk and the mixture was cooked at a temperature of 95ºC till the mixture was concentrated to two fold times of the original mass of milk. The mixture was then cooled to 55ºC after which finely granulated sugar was added at 5% of the initial mass of milk. The mixture was then stirred well, cooled to room temperature and then later chilled to 4ºC.

Textural characteristics of *kheer* were determined using a texture analyzer (TAXT2i, Stable Micro Systems Ltd., Surrey, England) equipped with a load cell of 25 kg and a cylindrical probe (P/25) supplied with Texture Exponent Programs. The hot *kheer* samples were filled at 55^0C into cylindrical canisters of 30 mm diameter and were compressed once by a cylindrical probe (P/25) at a control force of 5 g at the speed of 1 mm/s and the deformation distance was determined as 5 mm. The measurements were performed in duplicate with four replications. Firmness, Work of adhesion, work of shear and stickiness of the kheer *samples* were determined. Density of *kheer* sample was determined using a pycnometer and an electronic precision weighing balance.

Flow properties of *kheer* were determined using an Anton Paar Rheometer (model: MCR 52, Anton Paar, Germany, Software Rheoplus 132 v3.6) at 30ºC using the cone and plate geometry probe CP–75 (inclination : 1.002º, gap : 0.149 mm) and by applying different rates of shear for 0 to 100 rad/s with interval of 10 rad/s. Flow behaviour index and consistency coefficient values were evaluated using the power law model. The power law model was solved by using single linear regression models.

From Power Law equation,

$$\tau = k \times \gamma^n$$

Where, τ= shear stress (Pa), γ = shear rate (s^{-1}), n =Flow behaviour index and k=consistency coefficient

Taking logarithm of both side,

$$\ln(\tau) = \ln(k) + n\ \ln(\gamma)$$

Comparing with Y=mx + C, we get , Y=$\ln(\tau)$, m=n and C = ln (k)

Therefore, Flow behaviour index , n=m and consistency coefficient , k=e^C.

Results and Discussion

The experiments on textural characterization of *kheer* yielded the values of firmness, work of adhesion, work of shear and stickiness as 2.000±0.388 N, - 0.205±0.088 mJ, 3.930±0.702 mJ and –0.048±0.006 N, respectively (Table 3).

Table 3: Textural characteristics of *kheer*

Kheer Sample	Firmness (N)	Work of Adhesion (mJ)	Work of Shear (mJ)	Stickiness (N)
R1	1.540	-0.105	2.992	-0.039
R2	1.870	-0.190	3.795	-0.053
R3	2.136	-0.206	4.415	-0.047
R4	2.453	-0.320	4.516	-0.051
Mean	2.000	-0.205	3.930	-0.048
Std. Deviation	0.388	0.088	0.702	0.006
Variance	0.151	0.008	0.492	0.000

The flow behaviour index, consistency coefficient and apparent viscosity values at 25 % total solids content of *kheer were found as* 0.327±0.169, 4.055±2.502 $kg_f sec^n/m^2$, 0.502±0.069 Pa-s, respectively. The results of flow behaviour index and consistency coefficient are in agreement with Dharmendra (1999) who reported the flow behaviour index range and consistency coefficient range of *kheer* at processing temperatures as between 0.298 to 0.56 and 0.35 to 8.40 $kg_f sec^n/m^2$, respectively. The flow behaviour index values decreased with increase in temperatures while the consistency coefficient values increased with increase in temperatures (Dharmendra, 1999). *Kheer* showed a decrease in viscosity at constant shear rate thus being thixotropic in nature. In addition, flow behaviour index values <1 infers *kheer* being pseudoplastic in nature (Dharmendra, 1999). These properties of *kheer* are required to design process equipment as well as filling systems for the organized preparation, packaging and distribution of *kheer*.

Conclusions and recommendations

From present study, following conclusions and recommendations may be drawn:

1. The firmness, work of adhesion, work of shear and stickiness of *kheer* at 25% total solid and 30±2ºC was found as 2.000±0.388 N, - 0.205±0.088 mJ, 3.930±0.702 mJ and –0.048±0.006 N, respectively
2. The flow behaviour index, consistency coefficient, density and apparent viscosity values *were found as* 0.446, 2.286 $kg_f sec^n/m^2$, 1320.50 kg/m^3 and 0.55 Pa.s, respectively for *kheer* at 25% total solid and 30±2ºC.
3. Information on engineering properties of kheer would be useful for designing various equipment required to improve the mechanized production and packaging of *kheer*.
4. Texture analysis of kheer can be used as a measure of changes occurring in kheer as a result of process mechanization.

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IN- LINE STANDARDIZATION TECHNIQUE: AN ALTERNATIVE CONCEPT FOR MILK STANDARDIZATION

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ABSTRACT

Standardization is essential step in the processing of Milk and Milk products. The process of standardization involves separation or mixing of two predetermine quantity of components which aids the uniformity throughout the mass .Dairy Industries require more accurate and high precision processing system for reducing losses with a profitable business. In- line standardization systems helps to provide precise level of components in the processing fluids. In-line standardization system for milk involves separator, regulating valves, temperature, density and flow rate sensor based control system which automatically integrates level of components in the milk. This reduces the cost of the intermediate storage and analysis. In-line standardization system has potential to process high capacity of milk with cost saving performance.

Introduction

Standardization of milk refers to the adjustment which means raising or lowering of fat and solids not fat levels of milk. The standardization of milk is commonly done in case of market milk supply and also in case of manufacture of milk products. e.g. condensed milk, milk powder, ice-cream and cheese etc. This is essential to meet the legal requirement of regulatory agencies. Standardization of milk helps to give uniformity throughout retail market and product manufacture. There are four methods for standardization. These are batch, continuous, automatic standardization, and Tri-purpose separators. They all involve the separation of whole milk into skim milk and cream and then proceeding for blending the required quantities only. In-line standardization is advantageous in terms of reducing loss by high accuracy standardization, avoids intermediate storage and analysis for quality clearance.

1. Batch /Manual standardization -It is a process most commonly used in the dairies. Raw milk is held in a silo and its fat content is evaluated. Some quantity of milk is removed and separated into skim milk and cream. The amount of skim milk or cream required is determined by the calculation (or from charts) and then added to the bulk milk under continuous agitation. The bulk milk is retested to check whether the fat content is as per the desired figure or not. If it is not, further adjustments are made until the batch is standardized correctly. The demerits of batch standardizing are the time taken for agitation, testing and final mixing.

Manual mixing of cream and skim milk is calculated by using fat and mass balances. With this, the amount of cream and skim milk needed to get a given amount of standardized milk can be calculated. The mass of cream and skim milk into the system have to be equal to the mass of standardized milk out of the system. Similarly, the mass of fat in has to be equal to the mass of fat out. This can be illustrated in equation (1) and (2) where C is the mass of cream (in kg), S the mass of skim milk, M the mass of standardized milk, fC the fat content in the cream (between 0 and 1), fS the fat content in the skim milk and fM the fat content in the standardized milk.

$$CfC + SfS = MfM \qquad (1)$$

$$C + S = M \qquad (2)$$

If fC, fS, fM and M are known, the mass of needed skim milk, S, is calculated as (3) and the mass of needed cream, C, is then calculated as $M - S$ or by using Equation (4) (Christian and Andreas, 2006).

$$S = \frac{M(fC - fM)}{fC - fS} \qquad (3)$$

$$C = \frac{M(fM - fS)}{fC - fS} \qquad (4)$$

2. Continuous standardization -Continuous standardization employs an inline sampler in association with a testing device, which samples, measures and displays the fat content every 20 seconds. The operator observes the fat content displayed and adjusts the values to blend skim milk or cream into the milk line, before the sampling point, to alter the fat content to the required level.

3. Automatic standardization-It is an extension of the continuous process. The separator is replaced by a microprocessor/controller unit linked to the sampler/tester system. The microprocessor / controller unit has information about the desired fat content and flow rates of the whole and skim milk. It receives signals from the sampler/tester system and responds by opening or closing a valve, which regulates the amount of skim milk added to the whole milk. The merits of this automatic process are time and labour savings and ensure accurate standardization than other methods. Standardization depends on correct sampling, accurate testing of fat content, efficient separation and the correct amount of skim milk or cream needed.

Even though manual standardization is an easy way of mixing together skim milk and cream it is not applicable when larger volumes or higher accuracy is wanted. Since the fat content is not constant in raw milk, it has to be measured continuously to get a more precise fat content in the final product. The actual mixing will then have to be done in the tubes rather than in the tank. A similar approach can be used for protein standardization; all you need is some way of measuring the protein content. One way to do this is to measure the SNF content which can be done with a density meter. The protein is about 40% of the SNF and 80% of all protein is casein (which often is the interesting protein).

The rest of the SNF consists of lactose and minerals (also called ashes). A more accurate, and expensive, way to measure protein content is to use some sort of IR sensor, most commonly based on NIR technology. When standardizing the fat content to a lower fat content than in the raw milk there will be some surplus cream since the inflow of raw milk is continuous and not all is remixed. The surplus cream can then be processed and stored for more fat needy products like butter or whipping cream. This is the big advantage with inline standardization which quickly pays back the investment for a dairy (Christian and Andreas, 2006).

A. Compomaster Inline standardization system- Compomaster Inline standardization system is almost always done directly after a separator; the cream fat content is then standardized by a cascade controller that combines measurements of flow and density. Both flow and density meters are used because of the variations in fat content in the inflow raw milk. If a density meter had not been used, these variations would not had been detected which would had affected the fat content in the outgoing product. The normal setting is to have the inflow to the separator controlled to a fixed value. The amount of cream and skim milk out from the separator can then be calculated. These are derived from the mass and flow balances of the separation point (CompoMaster Standardization Systems APV, 2009).

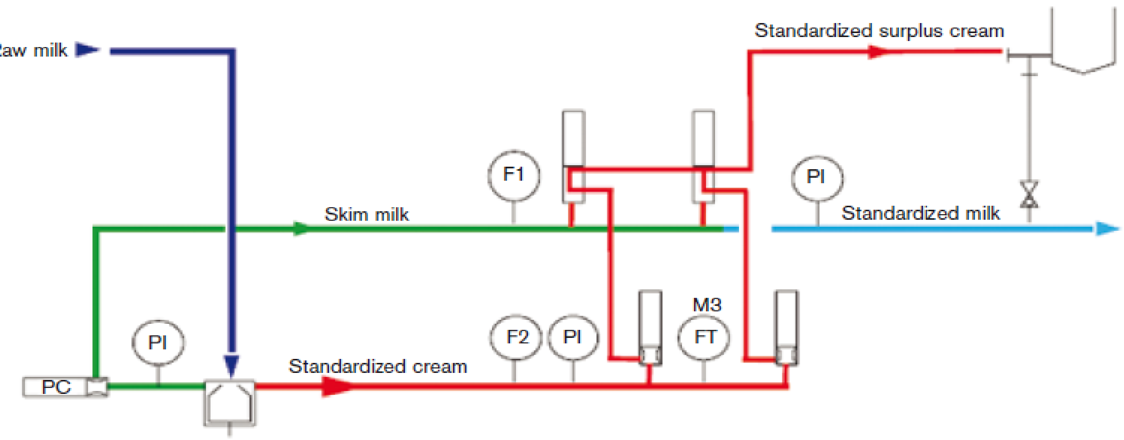

Fig.1 Line diagram of In-line standardization System for Milk and Milk products (APV – CompoMaster)

This type of system gives advantages as follows:

- High accuracy- no post-standardization
- Fast setting owing to a special valve arrangement
- Preset of recipes with automatic product changes
- Display of fat content and amount of raw milk
- Automatic determination of fat content of raw milk by means of density transmitters
- Automatic compensation for variations in skim milk composition and temperature
- Fully integrative solutions for existing plants
- Competitive prices

B. Tetra Alfast Plus - Tetra Alfast Plus is designed for automatic in-line standardization of the fat, SNF and protein content in milk and cream direct after milk separation for dairy products including; low and high fat market milk, market cream, flavoured milk, cream for butter making, milk for fermented products and powder production, cheese milk, whey, ice-cream mix, formulated products and functional foods. Tetra Alfast Plus is fully automated to ensure uniform product quality while in production.

By continuously controlling the back pressure of the separator cream outlet in a Cascade Control System, an accurate fat content is achieved, regardless of variations in the raw milk fat content. The raw milk is separated in the separator where the skim milk pressure is kept constant by a constant pressure-modulating valve. A flow transmitter measures the cream flow from the separator and the fat content is calculated from a temperature compensating density transmitter. Another flow transmitter measures the flow of standardized milk. On receiving signals from the transmitters, the computer in the control panel calculates the fat content, in relation to set points and flow rates, and then transmits control signals to the cream flow modulating valve, thereby controlling the fat content, whenever required (Tetra Alfast Plus- Direct in line standardization, 2006).

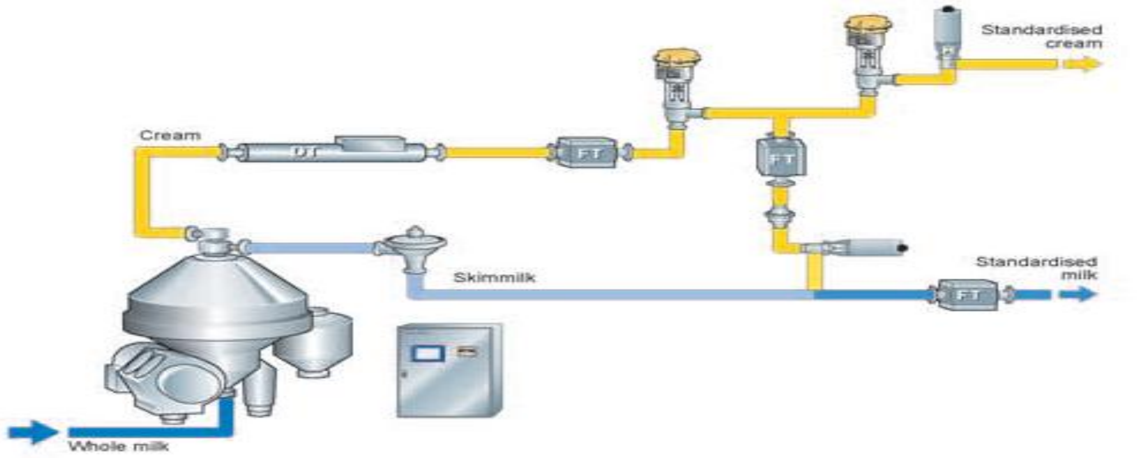

Fig.2 Tetra Alfast Plus- Inline standardization system for milk

C. GEA Diessel system (DICON-MS) - The GEA Diessel system, type DICON-MS™, is designed for the high-precision standardization of cream and milk. Changes of the fat content of the raw milk are corrected automatically. The standardization system is installed downstream of the separator. From the separator it is fed with skimmed milk and cream. The fat content of the raw milk, the flow ratio of cream and skimmed milk, and the separation precision of the separator determine the fat contents of cream and skimmed milk. At fat contents of cream of ≥38 %, the separation precision of the separator can be regarded as constant, i.e. the fat content in the skimmed milk is known.

The fat content of the cream is calculated using a high-precision density metering system and a temperature measurement following well proven algorithms in the GEA Diessel controller. Dependent on this metering value and the set point value entered, the flow ratio is automatically set (the lower the flow of cream, the higher the fat content in the cream). This means, that the fat content of the cream is independent of the fat content of the raw milk. The design and the effectiveness of the separator determine the upper limit for the fat content. The constant fat content of the standardized milk is achieved by means of the ratio control between standardized cream and skimmed milk. On the basis of the entered set point value, the controller calculates the ratio automatically.

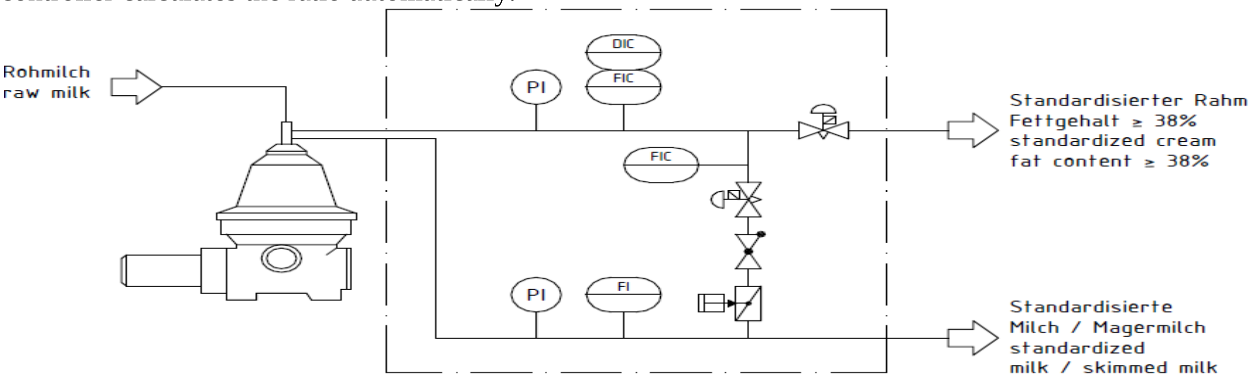

Fig.3 GEA Diessel system (DICON-MS)

High-quality control valves enable to control in an ample flow range and with this they enable as well the standardization using an ample range for the fat content. The system is ready for connection, mounted on a base frame made of stainless steel and its function is tested. It goes without saying that it is suitable for CIP (GEA Diessel Type DICON-MS, 2008).

D.GEA BASK-IN Standardization system -The BASK in-line standardizing system uses a solid-state sensor mounted directly in the process pipe, eliminating maintenance and consumable costs. The controller automatically corrects for variations in temperature and flow and responds immediately to changes in the milk fat concentration. The sensor can even compensate for fouling and can be left in the process line during cleaning. Initial calibration takes approximately two hours. This system works with the accuracy

±0.02% fat and because of that it can be used to standardize the Cheese milk, powder milk and retail milks (BASK-IN Inline Standardization system, 2014).

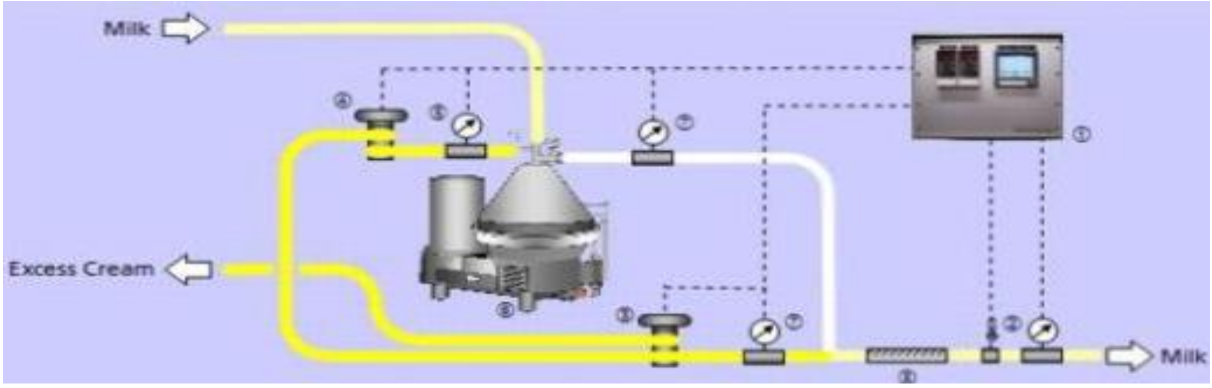

Fig.4 GEA BASK-IN standardization system for Milk and Milk Products

(1)Control Unit 5 Density Transmitter (2) In-line Fat Sensor & Temperature (3) Cream Control Valve (4) Excess Cream Control Valve (5) Transmitter (6) Separator (7) Flow Meter (8) Static Mixer

4. Tri-purpose cream separator-Tri-process machine is designed to clarify, separate, and standardize milk in a single unit. The general construction is similar to that of standard cream separator. The tri-process separator has external valves in the discharge lines of cream and skim milk. A precise needle valve is fixed in the outlet for cream, which controls the cream flow rate. There is a bypass line connected from the cream discharge line to the skim milk discharge line. This bypass line has a needle valve which would control the flow of the cream coming in the bypass line. A cream meter is installed in the cream outlet line. For standardization of milk to the desired fat content, the needle valve in the bypass line is adjusted to such a position that the bypass cream when mixed with the skim milk would result in the desired fat % in the standardized milk (Tetra Pak A/B, Lund ,Sweden).

Cost saving using In-line standardization system (5 lac litres per day milk processing plant)
Assuming the milk plant capacity of processing 5, 00,000 LPD per Day .The variants of milk is considered as Full cream Milk (FCM), Standardized Pasteurized Milk (SPM), Toned Milk (TM), Double toned Milk (DTM).

Calculation for Fat savings using In-line standardization system

Variables	Quantity	Min.	Conventional Method	In-Line method	Kg fat required	Kg fat Saved	% Saving of fat	Saving in Money
(FCM)	100,000	6.00	6.10	6.05	6100.0	50.0	0.82	15750.0
(SPM)	100,000	4.50	4.60	4.55	4600.0	50.0	1.09	15750.0
(TM)	200,000	3.00	3.10	3.05	6200.0	100.0	1.61	31500.0
(DTM)	100,000	1.50	1.60	1.55	1600.0	50.0	3.13	15750.0
Total	500000							
							Total =	78750.0
							Annual Saving =	2,87,43,750

Calculations for SNF savings using In-line standardization system

Variables	Quantity	Min.	Conventional Method	In-Line method	Kg SNF required	Kg SNF Saved	% Saving of SNF	Saving in Money
(FCM)	100,000	9.00	9.10	9.05	9100.00	50.00	0.55	10500.0
(SPM)	100,000	8.50	8.60	8.55	8600.00	50.00	0.58	10500.0
(TM)	200,000	8.50	8.60	8.55	17200.00	100.00	0.58	21000.0
(DTM)	100,000	9.00	9.10	9.05	9100.00	50.00	0.55	10500.0
Total	500000							
							Total=	52500.0
							Annual Saving=	1,91,62,500
						Total Savings (Fat +SNF) =		4,79,06,250

Conclusions-

In-line standardization systems which make the standardization process easy to rebuild and adapt to new duties. Standardization with accuracy optimizes the use of raw materials and reduces the need for manual sample control and analysis. The daily savings easily bring the payback time of the investment down to a year or less with high processing capacities.

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SCIENTIFIC INNOVATIONS FOR OPTIMISING PROFITABILITY & ATTAINING GLOBAL COMPETITIVENESS

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Keeping in view the ever widening gap between farm gate price of milk being paid by dairy plants to dairy farmers and prevalent price of pasteurized milk charged by them from urban consumers, dairy business appears as most profitable business proposition among F.M.C.G segment. Surprisingly actual balance sheets of many reputed dairy business entrepreneurs are either in red or indicate only nominal profits.Need of the hour is to realistically analyse the underlying reasons for low net profits and devise ways and means to optimise profitability through scientific analysis and initiating corrective measures by implementing innovative business management techniques.

Milk procurement, processing, marketing and financial management are key performance functions that ultimately determine bottom line results of dairy business. Through this presentation I would not onlyhighlight following unresolved core issues and techno-commercial problems that come in our way as obstacles in optimising profits and attaining global competitiveness but also suggest practical scientific solutions for converting seemingly impossible tasks in to easily possible propositions.

1. How to procure on commercial scale buffalo or cow milk without any intermixing, adulteration, dilution or manipulation?
2. How to eliminate all middlemen from the value chain or replace them with ethical service providers willing to discharge their obligations on reasonable cost plus basis?
3. How to procure process, pack and market absolutely pure pasteurized buffalo or cow milk meeting with international quality requirements having shelf life of two to three weeks when stored under refrigeration?
4. How to reduce abnormally high gap (Rs.10-15/Kg.) between farm gate prices reaching the milk producers and that being charged from the consumer?

Solutions to these problems /core issues have been eluding the dairy business entrepreneurs for the last many decades. During this period many short cut quick fix solutions and undesirable conventions have gradually emerged and become accepted practices for the organized sector of Indian dairy industry. You will agree with me that all these issues are closely connected to quality, productivity, profitability and ultimately global competitiveness of dairy business. Iwould also like to avail the opportunity of sharing with fellow dairy professionals summary findings of our research on this subject and also explain to you as to why we could not solve these problems for so long.

1. How to procure on commercial scale buffalo or cow milk without any Intermixing, Manipulation,Adulteration and Dilution?

Unlike India most of the advanced dairy countries have only cows so they fix per unit purchase price for standard cow milk say 3.50% Fat & 8.50% S.N.F, 12% milk solids, 88% natural water that corresponds to 30 as corrected lactometer reading (C.L.R.).

Based upon freezing point of milk of this composition they measure corresponding refractmeter index reading and calibrate the same using cryoscopy to find out % of added water in diluted milk. No payment is made for added water in milk and if the dilution is more than prescribed limit then that milk cannot be sold to milk plants processing and marketing pasteurized milk. Product manufacturing plants offer relatively lower price to such milk thus discouraging intentional or unintentional dilution with added water.

Due to strict implementation of stringent quality regulations in those countries, chances of adulteration other than unavoidable normal dilution during milk collection/processing becomes a remote possibility. Dairy plants, therefore, get microbiologically safe and pure raw milk on their dairy docks so production of dairy products conforming to international quality requirements. is easily possible.

Countries like India where we have buffaloes and cows and mixed milk is being sold and purchased using 60:40 two axis formulae based on C.L.R. for working out S.N.F. content in raw milk. Application of empirical thumb rule by allocating ½ of specified per kg. Fat rate to fat content in mixed milk and 2/3rd for S. N.F component is helpful in controlling dilution and manipulation to a certain extent for determining actual worth of mixed milk. Due to collection of milk in small quantities from large number of milk suppliers at village level within short span of time, it becomes practically difficult to measure quantity. Fat and S.N.F of milk for each milk purchase transaction accurately and simultaneously carry out its cross comparison with gravimetric results.

Taking undue advantage of this practical problem unscrupulous middlemen over a period of time have devised perfect ways and means to manipulate ,adulterate and dilute raw milk thus syphoning out up to 30 % of cost of raw milk as hidden gain for themselves. Even knowledgeable dairy experts will find it difficult to believe that unethical traders in our country can produce milk at a cost less than Rs. 5/litre. (Please watch a video telecast by TV channel sometimes ago on the following linkhttp://www.ndtv.com/video/player/news/video-story/252023)

Digital analysis of milk bills of reputed dairy plants in north India as carried out by our Mission associate in Canada clearly indicates that majority of the commercial dairy plants in private sector, multinational companies and milk co-operatives are purchasing diluted milk having 10-30% water.
Digital analysis of actual milk bills of one such premier dairy institution indicated annual hidden loss of more than Rs. One hundred crores only due to dilutionand manipulation.(Assumingno adulteration other than added water). Concerned professional executives of this institution in the presence of their chief executive admitted that these hidden losses are beyond their control as no practically feasible solution is available with them to control or eradicate this menace .Raw milk with heavy dose of added water is more prone to adulteration with edible or even dangerously harmful chemicals /adulterants to substitute milk fat with vegetable fat and add starch, sugar ,salt, urea, melamineetc. to increase S.N.F content.

Most of the professionally qualified dairy experts employed by commercial dairy plants in India are thus facing impossible task of converting such badly manipulated/adulterated/ diluted (M.A.D.) raw milk in to dairy products conforming to international quality parameters.Even the best cook in the world cannot make a good omelette out of rotten egg so it is unfair to blame the dairy professionals who are only helpless spectators of this kind of melodrama.

Problem of improving raw milk quality over a period of time has become so complicated and complex that it is now almost impossible to solve it even by using sophisticated chemical analysis or allied tests. Freezing point of standard buffalo milk (6.50% Fat, 8.84% S.N.F, 15.34% Milk solids, 84.66% natural water corresponding to corrected lactometer reading 29(C.L.R.) will vary with change in S.N.F./Fat Ratio and simultaneous dilution with added water. Due to multiple complex equations resulting out of such manipulated formulations it becomes extremely difficult to work out exact % of added water so hidden losses remain undetected with conventional milk billing calculations.

Term Manipulation by dilution in milk is a unique problem unknown to most of the dairy experts or software engineers who design conventional software programs for milk billing calculations(Based on two axis 60:40 formula) used by one and all in India to work out payable dues for milk purchase transactions. It is not easy to comprehend as to how 60:40 is converted in to 40:60 and added water becomes milk and gets paid as milk causing corresponding hidden loss to purchaser.

This kind of hidden loss cannot be calculated with conventional milk billing calculations. Innovative solution for this problem is cost analysis using Hydro analysis and Digital Analytical Technique (I.P. of our Mission associate in Canada). Software Called D.K.D & P.K.P. (Doodh Ka Doodh aur Paani Ka Paani) based on this technique as designed by our associate is capable of calculating such hidden losses with accuracy up to 10 decimal points. (This software is now available with free download facilityon our website http://apnidairy.com)

LOGIC BEHIND MANIPULATION BY DILUTION IN MILK:
Assume 100 Kgs. buffalo milk (6.50% Fat, 8.84% S.N.F, 15.34% milk solids, 84.66% natural water corresponding to corrected lactometer reading 29)

1. Manipulator will take out 20 Kgs. milk out of this and replace that quantity with 20 Kgs. added water so the ratio of milk to added water becomes 80:20 i.e. 4:1
2. He will again take out 20Kgs. milk out of this modified milk and add equivalent quantity of water (Please note that this replacement is done from 100% of already modified milk and not from 80% of original milk. Therefore the ratio of milk to added water becomes 60:40 i.e. 3:2
3. Repeating the same act once again will result in modifying the ratio to 40:60 i.e. 2:3

Reversal of ratio from 60: 40 to 40:60 will help the manipulator to convert 20 Kgs. added water as milk and get hidden gain of equivalent amount. Practical solution of this problem is only possible with accurate hydro digital analysis of milk bills relating to milk purchase transactions. Alternatively we should purchase cow milk and buffalo milk without any intermixing with each other and do not allow milk suppliers to temper natural S.N.F /Fat ratio and specific gravity of each kind of milk while it remains in transit between milk collection points and dairy plants

Gravimetric testing of raw buffalo milk and cow milk separately for each purchase transaction and its close monitoring till such time milk is finally received at dairy dock is essential prerequisite to eliminate such losses. **Silver lining in this exercise is that buffaloes and cows are incorruptible because they cannot manipulate or change their natural S.N.F.: Fat ratio (Uniquefor different species of animals).**

Dairy institution purchasing milk directly from actual milk producers by taking all possible precautions mentioned above will have no difficulty in procuring raw milk on commercial scale without any intermixing,manipulation,adulteration and dilution.

2. **How to eliminate all middlemen from the value chain or replace them with ethical service providers willing to discharge their obligations on reasonable cost plus basis?**

More than 80% cost of dairy business is the amount spent on raw milk purchase. Unfortunately majority of dairy plants in organized sector of Indian dairy industry have delegated this job to network of middlemen operating in the unorganized sector. Three tier system comprising of milk man (Dudhia), small contractor and big contractor are neither qualified to scientifically handle this perishable commodity nor willing to follow ethical trade practices so vital for maintaining its purity and microbiological safety.

During the last six decades these middlemen have further tightened their noose on the organized sector of Indian dairy industry and also increased their bargaining strength/ undesirabledominance. Public Private Partnership (P.P.P.) initiatives being introduced by Government in different fields is likely to further complicate this issue in dairy segment and may also cause irreparable damage to successfully operating co-operative infrastructure based on original Anand pattern of Gujarat.
Milk co-operative sector is also working on three tier system i.e. cooperative society at village level for milk collection, district union for milk processing and state federation for marketing operations. Only the co-operative institutions having well established deep rooted milk procurement infrastructure at village level and operating genuinely on Anand pattern principles are procuring undiluted pure milk suitable for producing dairy products meeting with international quality requirements. Due to better business

realization these institutions are not only paying remunerative rates to milk producers regularly but also progressing well as profitable business ventures. Major reason for the co-operative dairy plants that are suffering losses and offering low price to milk producers is week milk procurement infrastructure and gross violation of fundamental principles of original Anand pattern conceived by Dr.V.Kurien (legendry professional and father of Indian dairy industry). These units due to this reason become easy victims of manipulation by dilution and start procuring manipulated, adulterated and diluted raw milk. They also suffer heavy hidden losses on this account thus paying much lower price to milk producers as compared to their genuine and successful counterparts.

Professionally managed dairy plants interested in attaining global competitiveness by improving quality of raw milk will ultimately be left with no option but to create their own infrastructure for procuring pure raw milk directly from milk producers. Basic fundamental principles of original Anand pattern program followed by many Gujarat co-operatives are quite appropriate for achieving success in this objective

Our Mission with the assistance of our associates has designed a unique conceptual system like “Anand Pattern”for procuring raw milk directly from a self-sustaining network of genuine and ethical milk producers. This system called “APNI DAIRY” is based on unconventional concept of informal co-operatives (N.G.O.’s), farmer friendly policies, fool proof organized system for purchasing pure raw milk without any dilution or inter-mixing of buffalo milk with cow milk.It not only eliminates almost all middlemen from the value chain but works in a self-governing cost effective manner thus helping the beneficiary institution to drastically reduce its milk procurement and processing costs.
Service providers deployed for milk collection, chilling and transportation of milk to dairy plant get reasonable remuneration for their service contribution while remaining fully accountable for milk contents in their custody while milk remains in transit, exactly like cashiers handling cash for banking operations.

Unique advantage of “APNI DAIRY” concept and system of milk procurement is that dairy plants will get assured regular supply of pure and safe raw milk ideally suitable for producing dairy products conforming to international quality requirements.

3. **How to procure process, pack and market absolutely pure pasteurized buffalo or cow milk meeting with international quality requirements having shelf life of two to three weeks when stored under refrigeration?**

All professionally managed dairy plants in advanced dairy countries worldwide procure, process, pack and market microbiologically safe and pure pasteurized milk having shelf life of more than two weeks.
Consumer can safely consume that milk within specified period even without heating or boiling. Contrary to this concept there is no company at least in our knowledge in India that may be marketing pasteurized milk meeting with these international quality requirements. It has become almost customary for all processing plants in India to label shelf life of one to three days on pasteurized milk packs. As compared to designated shelf life of such pasteurized milk even raw milk produced under normal farm conditions in India just by taking basic sanitary precautions remains good for consumption for 5-7 days when stored under refrigeration at temperatures below 4 degree Celsius. It is quite unfair proposition from consumer’s point of view as virtually no value addition has taken place in this kind of pasteurized milk. Urban consumer in this situation has no option but to purchase such milk that needs boiling before consumption even though he is paying Rs.10- 15 per Kg. more than farm gate price of raw milk paid to milk producers by dairy business entrepreneurs.
Frankly speaking pasteurized milk available in poly packs to urban consumer in India has no third party guarantee for its purity and bacteriological safety.

Pilot scale research project sponsored by our Mission and implemented by one of our Mission associate in India brought a sigh of relief and joy to us when we found that it is only a myth that we in India cannot procure, process, pack and market pasteurized meeting with international quality requirements for purity, microbiological safety and shelf life.

As per our research findings if pure milk produced in India is scientifically pasteurized, packed in sanitary environment using food grade sanitized temper proof packing material, without any post pasteurization contamination and stored/transported under refrigeration at temperatures below 4 degree Celsius till it is finally deliveredto the consumer at his door step then that milk also remains good for consumption for more than two weeks.

4. **How to reduce abnormally high gap (Rs.10-15/Kg.) between farm gate prices reaching the milk producers and that being charged from the consumer**?

Due to big leap in scientific developments worldwide during the last few decades, technology for food processing, packing and management of business operations has undergone sea change. Unfortunately majority of Dairy business entrepreneurs in India continue to follow same age old conventional techniques for milk production/collection/chilling/processing and managing overall business operations. Due to manifold increase in cost of energy and other inputs total milk processing/handling cost has become abnormally high.

Gap between farm gate price of raw milk and consumer price for pasteurized milk has been constantly on the increase and has almost doubled during the last one decade. Due to simultaneous increase in cost of buffaloes /cows, feed concentrates, fodder and other milk production inputs dairy business is fast becoming unprofitable especially for landless/marginal farmers.

Need of the hour is to invent cost effective new techniques to process milk at farm level itself without using any conventional dairy equipment or capital intensive processing machinery. One of our Mission associate who has been carrying out research on this subject for the last one decade has achieved significant breakthrough in evolving innovative processing technique called Thermo Electric Processing Technology (T.E.P.T) for milk pasteurization and sterilization. This technology when introduced for commercial use of ethical dairy business entrepreneurs in India would usher in era of yet another white revolution and benefit millions of needy dairy farmers and innocent consumers. Time has come for us to even think of introducing the concept of consumer cooperatives by ensuring supply of pure raw chilled milk to consumers on their door steps and empowering them to pasteurise milk using home pasteurisation process and produce conventional dairy products of daily use in their own kitchen.

Thermo Electric Processing technology would be ideally suitable for commercial dairy farmers besides consumer dairy business entrepreneurs located in cities where installation of solar systems is being encouraged and subsidised by the government. This technique is based on solar/bio energy and does not require capital intensive conventional dairy equipment. Recyclable environment friendly packaging material with temper proof seal can be used for pasteurized /sterilized milk. New Innovative conceptual model (Producer to consumer) called “APNA DOODH-APNI DAIRY-APNI MANDI” when implemented along with this technology will establish direct flyover link between milk producer and consumer thus eliminating all middlemen from the value chain. It will not only cut down total milk handling costs by more than 50% as prevalent now but also ensure perfect product traceability between the two prime beneficiaries of dairy business i.e.producer and consumer. Cost savings in this process will result in upgrading dairy business in India to such levels that it will become most profitable among F.M.C.G. business propositions.

As per techno-commercial cost benefit projections of this innovative technology, it will play a major role in transforming rural agro based economy of our motherland. Dairy farmer maintaining a herd of about ten animals would be able to generate sufficient income from dairy business alone to comfortably meet all his family expenses relating to his basic needs i.e. "ROTI KAPDA AUR MAKAAN".

Unique feature of solutions evolved by our Mission associates to tackle these unresolved problems is that no subsidy or financial support will be required from state or central government for implementing these professionally scientific recommendations. Logical legal amendments in existing regulatory mechanism and strict implementation of laws against adulteration in milk are the only requirements from the Government for successful implementation of this scheme being proposed by our Mission.

Good news for ethical dairy professionals and eminent dairy institutions of India like N.D.R.I.(our Gurukul), "AMUL"(Our Role model), N.D.D.B. (our Mentor) and I.D.A (our Professional associate) is that there is no need to wait for long to realize our collective cherished dream of winning gold in dairy Olympics and becoming No.1 milk exporting country. With active participation of ethical dairy professionals supporting our Mission and blessings of management of our prestigious dairy institutions mentioned above, we can achieve all this with in coming five to ten years.

On behalf of our Mission and professional associates supporting our Mission I would like to extend cordial invitation to authorized representatives of premier dairy institutions and ethical entrepreneurs owning dairy business in India for contacting us to seek any allied information or clarification. They may also scrutinize relevant documentary /video evidence available with our Mission. We can also provide live demonstration of all our claims and contentions mentioned in this presentation including the software D.K.D & P.K.P. Besides it we can also provide samples of milk produced in India and pasteurized /sterilized by us using innovative cost effective "Thermo Electric Processing Technology" for authentic counter verification of purity, microbiological safety and shelf life of such milk.

APPLICATION OF CRYOGENIC TECHNOLOGY IN FOOD PROCESSING AND PRESERVATION

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Abstract

Cryogenic technology gives low temperature applications in food sector. There is a tremendous scope for application of cryogenic technology in food processing and preservation. Cryo-preservation is the only viable method available for long-term preservation of the both plant and animal origin species. Cryogenic preservation of food offers great promise for the country, both for export and also for domestic consumptions due to assurance of the food quality and safety. Most industries employ evaporative air chilling systems, preservation by cryogenic technology is less familiar in this sector. Product shrinkage, toughening and loss of tenderness, products shelf life, microbial activity, drip loss and dehydration losses are the major quality considerations in freezing of the food products e.g. meat products. The preservation by cryogenic technology will improve the situation. Proper economic considerations including payback period and life of the system etc. should be taken into account while selecting the cryogenic applications. Cryogenic grinding of spices is a new development in India and needs demonstration and promotion in spice pilot plants. The availability of indigenous cryogenic technology for food processing would ensure production of better quality products within the country and export the processed products to different countries.

Keywords: Cryogenic, Food processing, Food preservation, Cryogenic grinding

Introduction

Cryogenics may be defined as the branch of Physics and Engineering which deals with the production of freezing "cold" and the study of materials at such low temperatures. The word 'cryogen' is used to describe a low temperature boiling liquid. The National Bureau of standards, UK has defined cryogenic temperature as -150°C and below. According to this definition, liquid nitrogen (boiling point -195.6°C) falls in cryogenic range, whereas carbon dioxide (boiling point -78.5°C) does not. However, in general, cryogenics is defined as a branch of engineering specializing in technical operations at very low temperature, generally below -50°C and to create such a low temperature, cryogenic liquids are used. Cryogenic liquids are those which boil at cryogenic temperatures at atmosphere pressure. Liquid forms of hydrogen, helium, nitrogen, oxygen, inert gases, air, methane, carbon dioxide, etc are common cryogens. Liquid nitrogen (LN_2) and carbon dioxide (CO_2), in liquid or solid form, are the two major cryogens used for food applications. The thermo-physical properties of these two cryogenic liquids are given in Table 1.

The use of cryogens in industry, defence and space programmes has simulated the emergence of the new field of cryogenic engineering. As a refrigerant, liquid nitrogen (LN_2) is being for many decades. In recent years, it is finding widespread applications in almost every branch of science, vacuum technology, electronics, space technology, biology, medicine, agriculture, etc. The scope for application of cryogenic technology in the area of food processing is no less important. The cryogenic technology has found application for production of high value frozen products. Cryogenic freezing offers a wide range of unique benefits including high cooling rates, high throughput, flexibility in terms of acceptability to different products, low capital cost, low dehydration loss and better quality.

Table 1: Some thermo-physical properties of liquid nitrogen (LN_2) and liquid Carbon Dioxide (LCO_2)

Properties	**LN_2**	**LCO_2**
Density, kg/m^3	808	464
Boiling point, ^oC	-195.6	-78.5
Thermal conductivity, W/mK	0.14	0.19
Specific heat of liquid, kJ/kgK	2.05	2.26
Latent heat of evaporation, kJ/kg	199	352
Total usable refrigeration effect, kJ/kg	690	565

Cryogens are ultra - cold fluids which require proper precautions and safety measures during its handling. An instantaneous contact between cryogen and exposed skin can produce a painful burn and a splash of cryogenic liquid to eye may result in loss of vision. Hence, adequate personal protective equipment such as heavy gloves, face shield, safety goggles, and proper safety mechanisms should be installed including warning sensors for cryogens handling.

Some applications of cryogenic technology are: freezing the food for preservation by spray of liquid nitrogen, economic transport of ice cream, shrink fitting of metals, liquid oxygen is used in welding, liquid oxygen in artificial breathing in hospitals & aircrafts, for the preservation of blood, dead bodies and medicines, for quick healing of wounds, cooling the body parts by anesthesia, preservation of bull insemination for better creed, for the manufacture of cryogenic magnets, super conductive transformers and super conduction motors etc.

India is one of the largest consumers of foods, quantity –wise because of its large population. The industries for preservation of food products, particularly those of easily perishable nature, is not well developed as expected. Against the background of the huge spoilage of foods, the preservation technology calls for its special attention. The Indian products have to be cost effective by using latest state of art of technology to produce world-class quality goods.

Advantages in Using LN_2 as refrigerant:

Dehydration loss is less than 1% as against 3 to 10% in conventional freezing; exclusion of O_2 minimizes oxidative rancidity during freezing; minimum drip loss, improved quality in terms of flavour, texture, appearance; reduced floor space equipment; reduced handling losses of the products, flexibility, high through-put, low investment cost, reduced maintenance cost, minimum man power requirement and rapid installation and compactness.

Freezers

Primary freezers:

Product is in contact with refrigerant in the form of a cryogenic gas or liquid or solid. Its merits are: very much suitable for small and thin product, very small ice crystals, insignificant dehydration, color, flavor, structural changes, drip loss on thawing. Its demerits are: it may induce considerable thermal stresses; large product may display severe cracking due to extremely uneven cooling at the surface and interior.

Secondary freezers:

Plate freezers refrigerant moves heat by circulation within the plates those are in contact with the product. Its merits are: in it, different refrigerants are used to cool air. Its demerits are : irregular shaped product are very difficult to freeze, time of freezing is very high, larger ice crystal are formed.

Tertiary freezing:

Air blast freezers are circulated over the product. Its merits are: varied and irregular shaped product can be frozen, wide variety of shapes, sizes are available. Its demerit are: freezer burn, drip loss etc.

Individual Quick Freezing (IQF)

It is an established fact that preservation by quick freezing retains the desirable qualities of foods. Cryogenic technology not only offers the quick-freezing but also the numerous advantages such as less energy requirement, good retention of original quality attributes, less dehydration, low capital investment, minimal space requirement, maintenance/simplicity of operation, continuous, in-line freezing, minimum off-stream time, maximum turn-down/up capacity, maximum versatility in relation to products handled and least cost per unit of food shipped.

Applications of cryogenics have revolutionized the food industry providing low temperature applications for food processing, food preservation, quick freezing, and food grinding, etc.

Dairy Processing

The fresh food begins to deteriorate its quality from the moment it is harvested. Preservation of fresh as well as processed food by conventional means including refrigeration often leads to quality deterioration viz. discolouration, browning, loss of vitamins as well as aroma and flavour because of enzymatic and chemical interaction of the products. During the freezing process, the temperature of food products first falls rapidly from the initial temperature to just below 0°C. The temperature then falls very slowly until most of the water has changed its state to ice. Once the critical zone is passed, the temperature drops again quite quickly. Since spoilage continues fairly rapidly at temperature just below 0°C, it is important to pass the critical range quickly. The more rapid the freezing, the better quality of the product obtained.

Ice creams, sherbets and other dairy products can be made by directly injecting liquid nitrogen into the mixture while it is being churned. This method of manufacturing not only increases the storage life of the product but also decreases deterioration during storage and in fact it actually decreases the cost of manufacturing. Commercial viability of using liquid nitrogen in making ice cream, sherbets etc has been examined and practices in developed countries.

Cryo Preservation of Food

Food preservation means destruction of micro-organisms and spores, slowing the rate of chemical reactions such as oxidation and inactivation of enzymes etc. Food Processing are generally practiced for destruction of toxins, improving physico-chemical, sensory and aesthetic properties. Most varieties of food items like meat, fruits, vegetables and marine products are perishable in nature. They deteriorate fast because of bacteriological, enzymatic, oxidative and other chemical reactions. Since most chemical reactions die down below minus 120°C, the shelf life of these products can be significantly enhanced by Instant Quick Freezing (IQF) technique. The technique enables to preserve the taste, aroma, texture or the nutrition value of the food product. Shelf life of the products is increased dramatically. The cryo preservation of food and marine products for storage and exports has become an ever growing industry with large market share.

Preservation of Fruits and Vegetables

Although the country is one of the largest producers of fruits and vegetables, it is estimated that a considerable part of the total production is waste due to poor preservation technique and shortage of cold storage. Controlled Atmosphere and Modified Atmosphere Packaging of fruits and vegetables for consumer marketing is currently drawing the attention of researchers and processors. The quality and shelf life of many foods can be improved by deposing droplets of liquid nitrogen into their packaging on the production line. The droplets of LN_2 vaporize almost instantaneously and as the vapours expand by nearly 200 folds of the liquid volume; this gives a large dilution effect of air and displaces most of the air originally present in the pack to create a controlled atmosphere that will not support any microbial action.

Cryogenic Grinding of Spices

Spice grinding is an ancient industry like cereal milling industry with the difference that in spice grinding there is the additional problem of natural volatile flavouring components and essential oils getting lost during grinding. Spices are valued for aroma and flavour, these impart to various foods.

The fat content of spices generally poses a problem and is an important consideration in grinding. The other considerations are particle size, product yield, product uniformity, freedom from contamination, economy and dust free operation.During grinding, spices lose a significant fraction of their volatile oils or flavouring components due to the heat generated. There are considerable losses of oil and moisture from different spices during normal grinding. For different spices the product temperature ranged between 42 and 95^{o}C during grinding.

The quality of spices could be retained by the technique of cryogenic grinding. In cryogenic grinding liquid nitrogen is used to reduce the temperature of the product prior to and during the grinding operation in order to minimize the loss of flavouring volatile components of the product. Thus the flavour strength per unit mass of the resultant ground product is significantly higher than that in the conventionally ground product.

With cryogenic grinding, the temperature of the product can be as low as -195.6^{o}C. But generally such low temperatures are not used for all spices. In practice, temperatures are regulated anywhere from -195.6^{o}C to a few degrees below the ambient temperature. Cryogenic grinding is accomplished by the controlled injection of liquid nitrogen directly into the mill's grinding zone. The instantaneous evaporation of liquid nitrogen quickly chills both the spice and the mill. It also absorbs the frictional heat of grinding. Thus, the temperatures in the grinding zone generally are well below -73^{o}C.

The function of the cryogenic pre-cooler is to remove the heat from the material before it enters the grinder. The pre-cooling unit (a cooling device) consists of a screw conveyor assembly, an air compressor, a liquid nitrogen (LN_2) dewar, a power transmission arrangement and control panels. The cryogenic pre-cooler is made up of a screw conveyor enclosed in a properly insulated barrel and a system to introduce liquid nitrogen into the barrel, thereby providing refrigeration (liquid and cold gas) within the system. The particle temperature must be low enough to absorb the heat generated in the grinder and still fracture. Cryogenic pre-coolers, therefore, must have the ability to reduce the temperature of the seed below its brittle point as well as the freezing point of its oil, before it enters the grinder.

There must be provision to control the temperature of the pre-cooler and the feed rate to the grinder for the obvious purpose of controlling the grinding process. Consumption of liquid nitrogen and the operating cost are important considerations and matters of concern for a cryogenic pre-cooling system. The liquid nitrogen losses can be minimized to a great extent by proper consideration of the design and insulation of the pre-cooler. The design of the pre-cooling unit is to prevent the material from being heated up during grinding. The unit would pre-cool the material before the actual starting of the grinding operation. Thus, the pre-cooling unit is being designed to match with a commercially available grinder (a pin mill and a hammer mill) that could withstand low temperature operations. The extremely low temperature in the grinder solidifies oils so that the spices become brittle, they crumble easily permitting grinding to a finer and more consistent size. The high quality ground product would have domestic as well as international market.

In order to obtain high quality ground spices products, CIPHET – Cryogenic Spice Grinding System (Fig.1) has been developed under NAIP sub-project "Studies on Cryogenic Grinding for Retention of Flavour and Medicinal Properties of Some Important Indian Spices" (Anon., 2013). It is a complete system consisting of a pre-cooling unit, grinding unit, fine powder collection unit using cyclone separator, sieving unit and a control panel (Fig.. The precooler is screw conveyor assembly enclosed in a properly insulated barrel, thereby providing refrigeration (liquid and cold gas) within the system.

The material to be ground is loaded into a feed hopper. From the hopper, the material enters the cooling conveyor through vibro-feeder and two rotary valves where liquid nitrogen (LN_2) at -195.6°C is mixed directly to the spices. The liquid nitrogen vaporizes by absorbing the required heat of vaporization from its surroundings including spices. For thermal equilibrium, the cold nitrogen gas continues to cool the spices. Temperature controllers are used to control and monitor the temperature at inlet of grinder (i.e. outlet of pre-cooler) and outlet of grinder. The spice enters the grinding chamber of dual mill (pin or hammer mill) where the spice is ground. During the grinding stage, liquid nitrogen reduces the temperature rise in grinding zone of the grinder by absorbing heat from spice and grinding surfaces. Now, the spice powder is collected through cyclone system and sieved in sieving system to get the desired particle size.

Fig.1: CIPHET – Cryogenic Spice Grinding System

Fig.2: Technology transfer of CIPHET – Cryogenic Spice Grinding System during Agro-Investors Meet, July 18-19, 2013, NASC Complex, New Delhi.

In comparison to the conventional practice of spice grinding, 25% and 30% higher volatile oil content has been obtained in cryogenic grinding of black pepper and coriander, respectively. Similarly, the cryogenic grinding resulted higher retention of medicinal compounds, like total phenols, flavonoid content and anti-oxidant content in black pepper and coriander. The lighter colour and finer particles size have been obtained in cryogenic grinding in comparison to that of conventional grinding of the spices. Due to smooth grinding under cryogenic condition, the specific energy consumption was lower in comparison to that conventional grinding. Also, the entire grinding operation has been smooth without any choking under cryogenic condition unlike convention grinding where the grinders are choked time to time and continuous operation is not possible. The CIPHET – Cryogenic Spice Grinding System has been commercialized through it technology transfer (Fig.2) to M/s Spectra Cryogenic Private Limited, Kota, Rajasthan during Agro-Investors Meet , July 18-19, 2013, NASC Complex, New Delhi.

Therefore, there is a tremendous scope for application of cryogenic technology for dairy and food processing operations in our country as it will provide better quality products for consumers and ensure the export of dairy and food processed products.

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ROBOTICS IN DAIRY & FOOD INDUSTRY

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ABSTRACT

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. Food industry has been lagging behind other industrial sectors in implementing robots, as food 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. Automatic milking systems (AMS) or milking robots are one of the most successful and important application of robotics in the dairy industry. While, commercial application of robots in food industry is widely spread at the end of processing lines like packaging and palletizing, there is a broad range of potential applications for robotics in food processing.

Keywords: Robotics, Dairy Industry, Food Industry, Automation

Introduction

When asked to define what a “robot” was, Joseph Engelberger, who is generally credited as “the father of the industrial robot” replied, “I can't define a robot, but I know one when I see one” (Carlisle, 2000). Though Engelberger didn’t give a definition for robots, so many others have given their own definitions. The Robotic Industries Association defines robot as a reprogrammable, multifunctional manipulator designed to move material, parts, tools or specialized devices through variable programmed motions for the performance of a variety of tasks. According to ISO 8372:2012, which defines terms used in relation with robots and robotic devices operating in both industrial and non-industrial environments, 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.

The term robot comes from Czech and means ‘forced labour’. The term in its present interpretation was coined by the Czech writer Karel Capek in his 1921 play titled “Rossum’s Universal Robots”. The term 'robotics'was coined and first used by the Russian-born American scientist and writer Isaac Asimov, which refers to the study and use of robots. The concept of an industrial robot was patented in 1954 by G. C. Devol and the first industrial robot was installed by Unimation Inc. in 1961(Koren, 1985). Since then thousands of robots have been put to work in industries throughout the world.

Robots are distinguished from other types of machinery mainly on the basis of their programmability and ability to be adaptable to different tasks.Industrial robots can improve the quality of life by freeing workers from dirty,boring, dangerous, and heavy labour.The benefits of robots to industry include improved management control andproductivity and consistently high quality products.Industrial robots can work tirelessly night and day on an assembly line withoutany loss in performance. Consequently, they can greatly reduce the costs of manufactured goods.As a result, industries that effectively use robots will have an economicadvantage on world markets.

Parts of a robot

Robots come in many shapes and sizes. Robotsconsist of a number of components that work together: thecontroller, the manipulator, an end effector, a power supply, and a meansfor programming (Schilling, 1990). The relationship among these five components is illustrated in Figure 1.

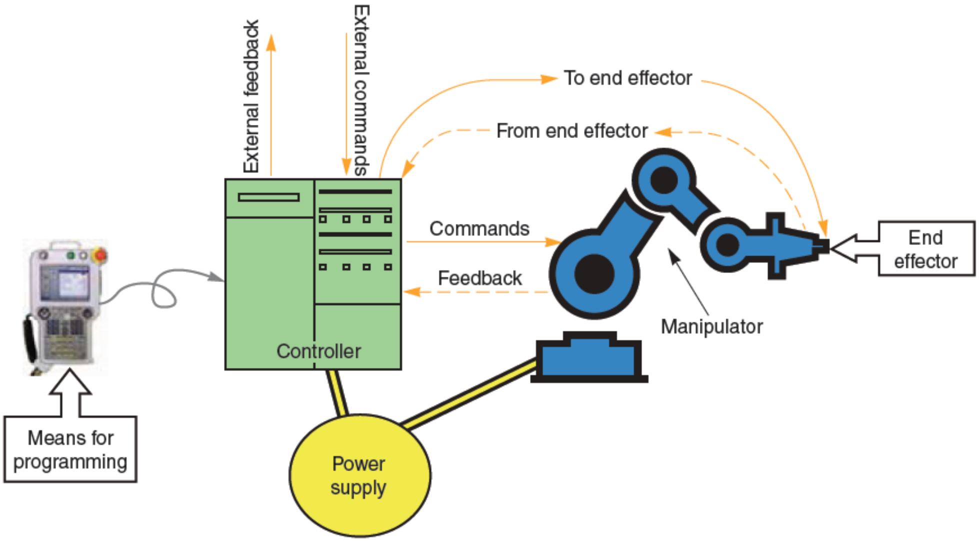

Figure 1: Parts of a robot

The controller is the part of a robot that coordinates all movements ofthe mechanical system. It also receives input from the immediateenvironment through various sensors. The heart of the robot's controller isgenerally a microprocessor linked to input/output and monitoring devices.The commands issued by the controller activate the motion control mechanism,consisting of various controllers, amplifiers, and actuators. Anactuator is a motor or valve that converts power into robot movement. Thismovement is initiated by a series of instructions, called a program, storedin the controller's memory.

The manipulator consists of segments that may be jointed and thatmove about, allowing the robot to do work. The manipulator is the armof the robot which must move materials, parts,tools, or special devices through various motions to provide useful work.

The end effector is the robot's hand, or the end-of-arm tooling on therobot. It is a device attached to the wrist of the manipulator for the purposeof grasping, lifting, transporting, maneuvering, or performing operationson a workpiece.

The power supply provides the energy to drive the controller and actuators.It may convert ac voltage to the dc voltage required by the robot'sinternal circuits, or it may be a pump or compressor providing hydraulicor pneumatic power. The three basic types of power supplies are electrical,hydraulic, and pneumatic.

The means for programming is used to record movements into therobot's memory. A robot may be programmed using any of severaldifferent methods. The teach pendant, also called a teach box or handheld programmer teaches a robot the movements required toperform a useful task. The operator uses a teach pendant to move the robotthrough the series of points that describe its desired path. The points arerecorded by the controller for later use.

Robot arm configurations

Onemethod of classifying a robot is by the configuration of its work envelope.Some robots may be equipped for more than one configuration. Five basic configurations are identified with most of the commercially availableindustrial robots (Groover, 2008;VCSU), they are:

a) Cartesian configuration: Robots with Cartesian configurations consist of linksconnected by linear joints. Because the configuration has three perpendicularslides, they are also called rectilinear robots or x-y-z robots.

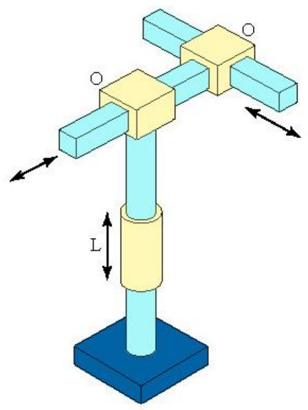

Figure 2: Cartesian configuration

b) Cylindrical configuration: In the cylindrical configuration, robots haveone rotary joint at the base and linear jointsto connect the links. The space in which thisrobot operates is cylindrical in shape, hencethe name cylindrical configuration.

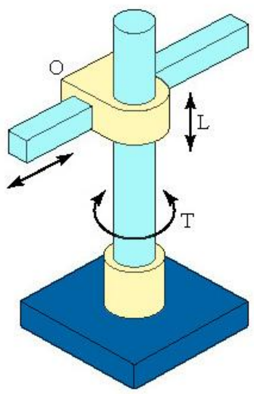

Figure 3: Cylindrical configuration

c) Polar configuration: Polar robots have a work space beingspherical shape. Generally, thearm is connected to the base with atwisting joint and a combination ofrotary and/or linear joints. Theserobots are called spherical (twisting,rotary and linear joint) or articulated(Twisting, rotary and rotary),thelatter more closely resembles thehuman arm.

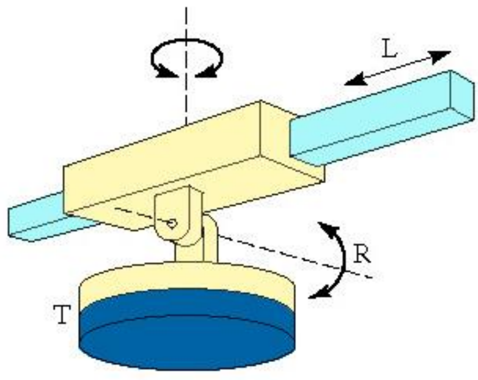

Figure 4: Polar configuration

d)Jointed arm configuration: The jointed arm configuration is a combination ofcylindrical and articulatedconfigurations. The arm of the robot isconnected to the base with a twistingjoint. The links in the arm areconnected by rotary joints. Therotations generally take place in thevertical plane. Several commerciallyavailable robots have thisconfiguration.

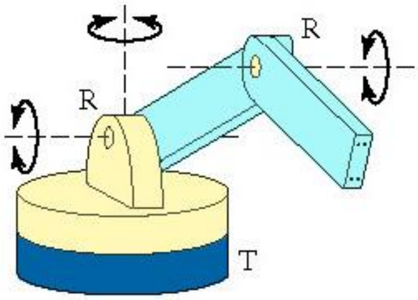

Figure 5: Jointed arm configuration

e) SCARA robots: SCARA stands for Selectively Compliant Assembly Robot Arm. It is similar to jointed-arm robot except that vertical axes are used for shoulder and elbow joints to be compliant in horizontal direction for vertical insertion tasks.

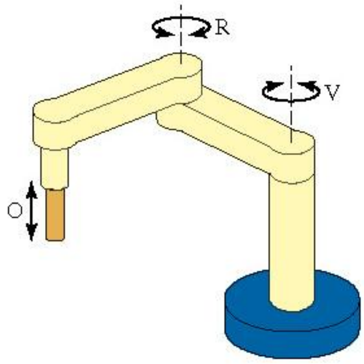

Figure 6: SCARA robot

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 Quamby Brook, Tasmania, Australia. Milking robotsare different from the ordinary milking machines in onecrucial aspect: the robot uses sensors to find the teats ofthe cow and then connects the cups to the teats with arobot arm (Halachmi*et al*,2000). So milking is done without intervention of the farmer.This saves the farmer serious amount of labour (Butler *et al*, 2012).In an AMS situation cows are expected to visit voluntarily a milking stall several times daily (Rossing*et al*, 1997). The top view of one such robotic milking stall (Devir*et al*, 1996)is shown in Figure 7.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.

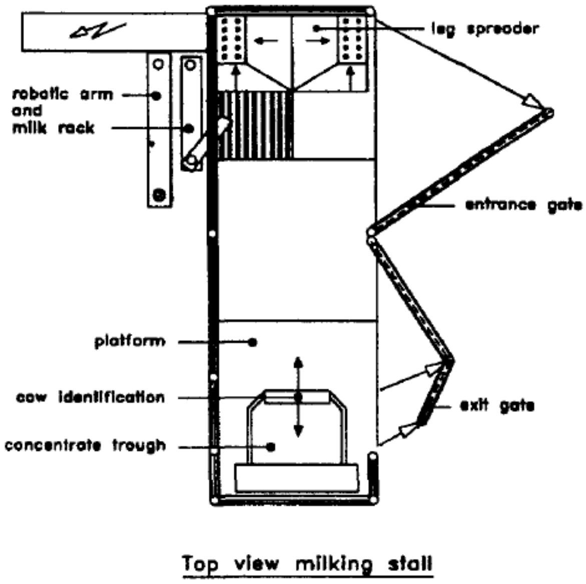

Figure 7: Robotic milking stall

Robotic food processing

The food industry is a highly competitive manufacturing area, but with relatively little robotic involvement as compared to the automotive industry. This is due to the fact that food products are highly variable both in shape, sizes and structure which poses a major problem for the development of manipulators for its handling (Chua et al, 2003).So far, commercial application of robots in food industry is widely spread at theend of processing lines like packaging and palletizing. However there is a broad range of potential applications for robotics in food processing: in the meat industry, robots are used in slaughtering, deboning, cutting, sorting and packaging applications, while in cheese production they stir curds, transfer cheese moulds, and turn, cut, portion, package and palletise cheeses.Robots can also be used for picking and placing itemssuch as cookies, hamburgers, chocolate pralines, croissants, chicken fillets orpancakes into primary packing. Additionally, robots are already used in baking lines to handle hottrays (Hightech Europe, 2013; KUKA). 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.

Main functions of robots in food industry include:

• Packaging
• Handling
• Orientating
• Aligning
• Sorting
• Slaughtering
• Palletizing, de-palletizing; and
• Inspection

Any design should meet the guidelines for food-handling and be ideally of stainless-steel constructionwith ingress protection rating to IP67, and all parts visible and accessiblefor inspection and manual cleaning. As food products, by their nature, tend to be irregular in shape, sticky/slippery, soft or fragile, any automated procedure will require thedeployment of a suitable end effecter or gripper and, given the variability of foodproducts, the design will generally be unique to the target product (Gray& Davis, 2013). A lot of research has been reported in this sector and a few of them are mentioned below.

Industrial Research Ltd. has developed a robotic food processing system for ice cream portioning in soft serve ice creams(Friedrich and Lim,2001). In soft serve ice creams, the size of the portion depends mainly on the opening time of the spigot and the length of time the spigot is open and the final shape of the serving is dependent on thedistance of the cone from the outlet valve. Automation was done by sensing indirectly the ice cream flow, modifying the predefined motion path and synchronization for the spigot opening profile to the cone movement.

Optical sorting is a well-established robotics and automation technique thatcontinues to find new applications within the food industry. Application of robotic vision using advanced sensors is a proved technology in rice, grain, nut, fruit and vegetable sectors (Hamid *et al*, 2013).

The potential applications of robots in the meat processing industry have been investigated for several years. 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 boning rooms where labour costs are inherently high, is in their ability to perform the required repetitive tasks more efficiently and consistently than is currently possible (Food Science Australia).Georgia Tech researchers have developed a system that uses advanced imaging technology and a robotic cutting arm to automatically debone chicken and other poultry products. This robotic system is used for the intelligent cutting and deboning of a chicken, as it prepares to slice through the shoulder joint of a chicken, cutting close to the bone to maximize breast meat yield and ensuring food safety by avoiding creation of bone chips (Calderone, 2013). In beef production the first use of robotic equipment was in splitting acomplete carcass into carcass sides.The Meat Industry Research Institute of NewZealand (MIRINZ) has in particular been very active in automation of sheep and lamb slaughtering. The Danish company SFK-Danfotech has, in co-operation with the DanishMeat Research Institute (DMRI),has developed a series of dedicated robots forautomation of pig slaughterline processes (Madsen & Nielsen, 2002).After the meat is cut and deboned, it is then sliced, packaged, and shipped to the customer. Vision-guided robots are speeding up these practices to make certain that the pieces are accurately portioned and cut, while packaging equipment is incorporating volumetric scanning systems.

In cheese manufacturing, robots can be employed to assist with handling and packaging operations, e.g. where theywould carry blocks of cheese from storage to a packing line, cut it to the required size andshape, weigh and pack it for the consumer, assemble the packs into larger units, which are inturn palletised by robot and made ready for loading or storage. Robotic systems with vacuumgrippers have been developed for handling wax-covered cheese rounds (Guinee& O'Callaghan, 2010)Staubli Robots have developed an automated cheese curd slicing line, in which robot allows a large choice of automated and specific slicing tools depending on the recipe of the cheese being manufactured. Other applications of this robotic line includes turning of cheeses on cheese trays, loading and unloading of cheese trays, mixing of curdles – serum, removal of cheeses from the mould and packaging / palletisation(Staubli, 2009).

Robots in packaging

Industrial robots have emerged as a valuable packaging tool for food manufacturers, as the performance and user-friendliness of the robots has increased while costs have come down. Vision-assisted robots emulate the flexibility of human hand-eye coordination, and they perform a number of inspections for quality assurance. Many food companies have successfully applied robots in a wide variety of processes in the dairy, meat, baking, confection, frozen, snack, beverage, and produce industries (Calderone,2013). Some of the applications of robots in packaging are given below (FANUC, 2014):

- Placing products directly into top-loading cartons
- Loading the infeed of a flow-wrapper
- Filling the product pockets in a form, fill and seal (FFS) machine
- Arranging products in blister and thermoforming machines
- Creating product arrays or stacks at the infeed to a bagging operation

- Placing products directly into clamshell packaging
- Loading and unloading a retort process
- Descrambling bottles from bulk for the infeed of filling, capping, and/or labeling machines
- Topload and sideloadcasepacking of bags, pouches, tubes, bottles, bundles, cartons, etc.
- Packing products into reusable or single-use trays
- Unloading various types of baked goods from pans
- Unloading and casepacking single-serve portion packages from filling machines
- Palletizing and depalletizing beverages, cases, bags, pails, totes, bulk containers, cans, bundles, etc.

Conclusion

Robotics has the potential to become next frontier in the dairy and food industries. Looking to the future, manual handling of foods is not going to end soon. But still the acceptance of automation and robotics in the industry is increasing. Even though robots bring with them so many advantages like safety, consistency and efficiency, the challenges that lies before food robotics are the high costs involved and the requirement of skilled engineers. Hence there is immense potential of research in robotics for those specialized in automation, while educational institutions have an equally important role in imparting the advanced knowledge to keep the food industry at par with other more advanced sectors

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ZERO DISCHARGE SYSTEM: AN UNIQUE APPROACH FOR POLLUTION REDUCTION FOR PROCESS PLANT

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ABSTRACT

The effluent treatment has received a lots of attention in recent years.zero discharge system is novel technique that can be a effective tool to reduce the pollution to very great extent and also the reduction of water consumption. As the name indicates zero discharge system which will ensure that whatever the effluents, pollutants, waste water forms during processing will not be allowed to go outside of the plant The concept of zero discharge essentially emerged from the situation where industry is unable to meet the discharge norms set by the regulatory authorities. In coming years zero discharge system will become the essential part of the every processing industry.

Introduction

For development of any country the industrialization plays the vital role. But pollution caused by industrial is a serious concern in throughout the world (Braio et al., 2007). Of all industrial activities, the food sector has one of the highest consumptions of water and is one of the biggest producers of effluent per unit of production in addition to generating, besides to generate a large volume of sludge in biological treatment. The dairy industry is one of a major source of waste water (Britz et al., 2006).

The milk industry generates between 3.739 and 11.217 million m3 of waste per year (i.e. 1 to 3 times the volume of milk processed (Monroy et al., 1995). Waste water is generated in milk processing unit, mostly in pasteurization, homogenization of fluid milk and the production of dairy products such as butter, cheese, milk powder etc. Most of the milk processing unit use “clean in place” (CIP) system which pumps cleaning solutions through all equipment in this order water rinse; caustic solution (sodium hydroxide) wash, water rinse, acid solution (phosphoric or Nitric acid) wash, water rinse, and sodium hypo-chlorite disinfectant. These chemicals eventually become a part of waste water (Thompson et al., 1998)Large amount of water is used to clean dairy processing plants; hence, the resulting waste water can contain detergent, sanitizers, base, salts and organic matter, depending upon source. (Floor spills vs regular equipment cleaning (Belyea et al., 1990). With an increasing demand on natural water resources, and unabated pollution posed by industrial discharges into the environment, it has become necessary to implement zero discharge systems in industrial waste water treatment plants.

Emergence of zero discharge system

There are so many investigations underway to finding solution for cheaper treatment, easy disposal and utilization of waste water from milk processing unit, in India as well as in abroad one of the effective way which can reduce the pollution due to effluents coming out of the dairy and food plants to great extent is zero discharge system.

In India, the concept of zero discharge essentially emerged from the situation where industry is unable to meet the discharge norms set by the State and Central Pollution Control Boards. This led to pollution of the environment and subsequent litigation. Initially, the polluters were penalized to an extent necessary to clean the environment that they polluted. This concept was called Polluters Pay Policy. The essential ingredient of this policy, however, led the industry to initially pollute the environment - and later pay for environmental losses. Realizing that pollution is still uncontrolled and monitoring has become very much difficult with so many industries discharging the waste water into the environment, finally a solution was conceived and the concept of zero discharge has emerged (Eswaramoorthi 2001).

Why zero discharge system

Achieving strict waste water treatment regulations and “reducing water usage have become one of the most critical considerations in industry today. Numerous environmental regulations, rigorous permitting processes, and lack of water availability, among other factors, are driving many industrial facilities to implement zero liquid discharge (ZLD) systems as a solution". Zero Liquid Discharge (ZLD) technologies help to achieve environmental compliance, reduce carbon footprint, create positive public perception, and recover high purity water for reuse(Fatima 2011).

Zero discharge system

In a waste water treatment facility, zero discharge theoretically means no discharge of any kind of pollutants into the environment. But this is practically impossible and, the term zero discharge is loosely used to define no liquid discharge into the environment. So, quite often, zero discharge and zero liquid discharge are used in the same meaning. For all practical purposes, the concept of zero discharge necessarily means the following:

1) Recovery of reusable water/other materials from waste water.

2) Minimization or, no discharge of polluting substances into the environment away from the waste water treatment facility.(Eswaramoorthi 2001)

As with conventional waste water treatment systems, zero discharge system also includes primary treatment, secondary treatment and tertiary treatment. However, the main objective in a zero discharge treatment system is to check the following things

i) The processes utilized for waste water treatment does not generate any additional pollutants.

ii) Production of waste is minimized by suitable selection of unit processes and adjusting operating parameters.

iii) As far as possible, pollutants in the wastewater are transferred to solid phase (sludge).

iv) Sludge is stored in a secured landfill.

v) Recovery of reusable materials, especially water, is achieved (Eswaramoorth 2201).

Design aspects of zero-discharge system

The implementation of a zero discharge plant also involves setting up a pilot plant to test process validity and scalability, reducing energy consumption through optimal measures to reduce operating costs for successful operation and efficient maintenance of machinery. They are discussed in detail.

Uses of Pilot Plant:

Before designing a zero discharge system, employment of pilot plant with important unit processes is very much essential to ascertain that chosen treatment procedure is able to successfully achieve its purpose. The data collected from pilot plant tests may be useful for the following purposes:

i) Applicability of the chosen process for given waste water can be studied.

ii) Development of mathematical model using the collected data is important for scale-up.

iii) Variability in the feed characteristics over a period of time and the ability of the system to respond to these variations can be studied.

iv) Adequacy of each unit process can be validated beforehand. This ensures that full-scale plant does not attract process modifications/additions on a later date due to performance inadequacy.

v) Details on process adequacy, efficiency, and system performance can be studied. This shall provide enough input for full-scale plant design.

vi) The preliminary data obtained from a pilot plant may also be useful in mass balance calculations to achieve zero discharge. (Eswaramoorth 2201).

Advantages of Zero Liquid Discharge Operation

Permitting a new industrial plant is often a long and tedious process. Designing a plant for zero wastewater discharge right from the start wins faster community acceptance and streamlines the permitting process. Recycling wastewater greatly decreases the amount of makeup water that must be purchased from the local utility and eliminates the local control and costs of sewer disposal. Wastewater recycling also allows a greater freedom in selecting a site for an industrial plant because there are fewer concerns about adequate water supply. In many cases, poor quality water can be used for make-up since it is upgraded in-house. For example, at several zero discharge sites, secondary sewage effluent or wastewater from other industrial sites is used as make-up (Bostjancic et al., 1996).

Conclusion

With increase in the stringent rules of pollution control board of India the processing industries in India requires a smart solution to tackle the problem related pollution and effluent. The studies done on the zero discharge system shows its potential application in any process industry. Zero discharge system is beneficial to industrial and municipal organizations as well as the environment because it saves money and no effluent, or discharge, is left over. Zero discharge system systems employ the most advanced wastewater treatment technologies to purify and recycle virtually all of the wastewater produced. Also Zero liquid discharge technologies help plants meet discharge and water reuse requirements.

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MACHINE VISION SYSTEM AND ITS APPLICATION IN DAIRY AND FOOD INDUSTRY

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ABSTRACT

Machine vision based on image processing/analysis techniques have been increasingly employed in the dairy and food industry for quality inspection, classification and evaluation, with great advantages in its objectiveness, efficiency and reliability. The food industry now ranks among the top ten industries using machine vision technology. Especially machine vision has recently been investigated as a tool to evaluate the functional properties of cheddar and mozzarella cheeses, topping percentage and distribution of pizzas and quality attributes such as shrinkage, pores size and distribution, texture and colour of cooked meats, which has significantly expanded its possible application in the dairy as well as food industry. This paper reviews the most recent progress in the application of machine vision in the food industry for quality evaluation including meat, poultry, fish, fruit and vegetables, grains, bakery and confectionary products and other foods with future trends and challenges.

1.0 INTRODUCTION

Machine vision is becoming one of the most important non destructive, rapid, economic, consistent and objective inspection & evaluation technique in the dairy and food industry (Gumus *et al*., 2011). Machine vision technology utilizes image processing techniques for the purpose of extracting visual features about an object for a variety of qualitative, quantitative and control applications (Alhusain *et al*., 2012). The technology is used in a variety of different industries to automate the production, increase production speed and yield and to improve product quality. This inspection approach is based on image analysis and processing and has found a variety of different applications in the food industry. Considerable research has highlighted its potential for the inspection and grading of fruits and vegetables based on shape, size and color. Machine vision also has been successfully adopted for the quality analysis of meat and fish, pizza, cheese, and bread. Likewise grain quality and characteristics have been examined by this technique (Brosnan & Sun, 2004).

In machine vision system (MVS) image capturing devices or sensors are used to view and generate images of the samples. Some of the devices or sensors used in generating images include charged coupled device (CCD), scanners, ultrasound, X-ray and near infrared spectroscopy. The color image is analyzed by a computer program/software and quantifies color values in a relevant color scale (Minz *et al*., 2013).

Machine vision systems can be employed for visual inspection and process monitoring for accurate results. Machine vision systems can perform repetitive tasks faster, more accurately, and with greater consistency over time than humans. They can reduce labor costs, increase production yields, and eliminate costly errors associated with incomplete or incorrect assembly. They can help to identify and correct manufacturing problems on-line by forming part of the factory control network. The net result is greater productivity and improved customer satisfaction through the consistent delivery of quality products. As a result automated visual inspection is undergoing substantial growth in the food industry because of its cost effectiveness, consistency, superior speed and accuracy (Lochtetal, 1997 and Sun, 2000).

2.0 PRINCIPLE OF OPERATION

Machine vision is the construction of explicit and meaningful descriptions of physical objects from images (Sonka *et al.*, 1999). Timmermans (1998) stated that it encloses the capturing, processing and analysis of two-dimensional images, with others noting that it aims to duplicate the effect of human vision by electronically perceiving and understanding an image. These systems work by capturing the image of an object, processing the image to measure the desired parameters, comparing these parameters with predefined inspection criteria, and then helping to make decisions / taking some type of corrective action on the object or the manufacturing process. The sample is incidental to a light object, where its image is captured by camera and analyzed through frame grabber. Then, if it is defected it gets rejected or otherwise is being accepted. The whole system is works on PLC based image analysis system. All the parameters in system are set as per the final requirement of the products.

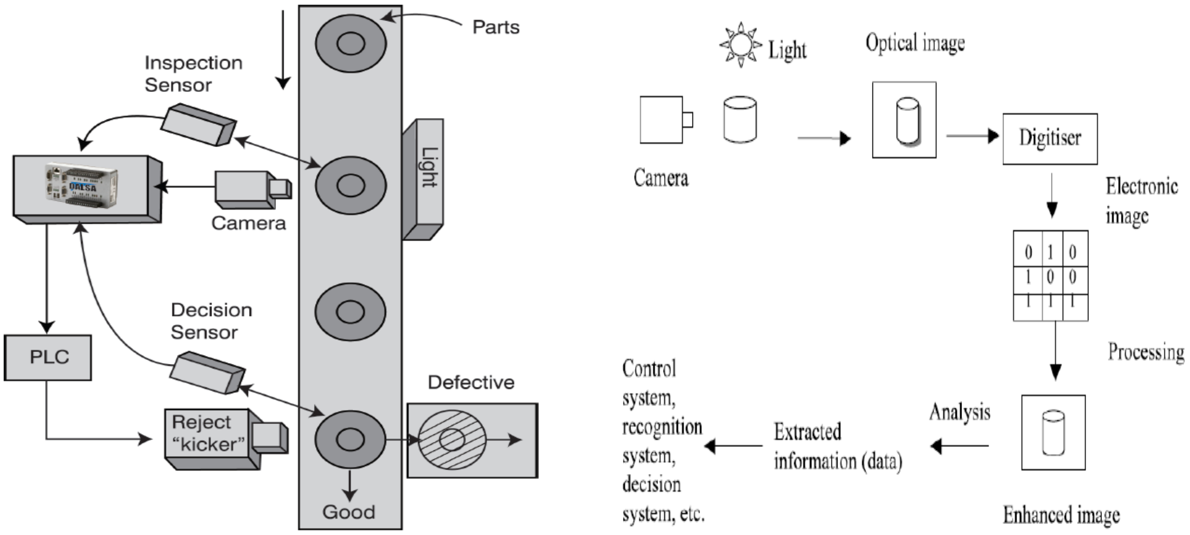

Fig.1: Principle of machine vision system

3.0 COMPONENTS OF MACHINE VISION SYSTEM

Five basic components of a machine vision system consist of illumination, camera, an image capture board (frame grabber or digitiser), computer hardware and software (Wang and Sun, 2002).

3.1 IMAGE ILLUMINATION

Vision systems are affected by the level and quality of illumination as with the human eye. The performance of the illumination system greatly influences the quality of image and plays an important role in the overall efficiency and accuracy of the system. Illumination systems are the light sources as shown in Figure 1 above. The light focuses on the materials (especially when used). Lighting type, location and colour quality play an important role in bringing out a clear image of the object. Lighting arrangements are grouped into front or back lighting (Gunasekaran, 2001). Front lighting serve as illumination focusing on the object for better detection of external surface features of the product while back-lighting is used for enhancing the background of the object. Light sources used include incandescent lamps, fluorescent lamps, lasers, X-ray tubes and infra-red lamps.

3.2 CAMERA (IMAGE ACQUISITION)

Image capturing devices or sensors are used to view and generate images of the samples. Some of the devices or sensors used in generating images include scanners, ultrasound, X-ray and near infrared spectroscopy. However, in machine vision, image sensors used are the solid state charged coupled device (CCD) (i.e. camera) technology with some applications using thermionic tube devices. Recent technology has seen the adoption of digital camera, which eliminates the additional component required to convert images taken by photographic and CCD cameras or other sensors to readable format by computer processors. Images captured or taken by digital camera maintain the features of the images with little noise due to its variable resolution. With advances in digital cameras, the camera and the image capture system generally merge into a single device. This device communicates with the computer via cables (e.g., USB or Fire wire), or by wireless means. There can be three light detection sensors in the camera, dedicated to each primary color (Red, Green, Blue), or one sensor can be selectively used to handle all the three primary colors. The software can control the camera settings, the timing of image acquisition, the light source and can analyze the image to extract desired features to make decisions. These may include non-contact sensing, measuring object shape and its dimensions, detecting product defects; providing process control feedback alerting production line operators for process system failures; and providing product quality statistics (Sarkar, 1991; Sun, 2004; Balaban *et al.*, 2005).

3.3 IMAGE CAPUTURING BOARD (FRAME GRABBER OR DIGITIZER)

The process of converting pictorial images into numerical form is called digitization. In this process, an image is divided into a two dimensional grid of small regions containing picture elements defined as pixels by using a vision processor board called a digitiser or frame grabber. There are numerous types of analogue to digital converters (ADC) but for real time analyses a special type is required, this is known as a flash ADC. Input signal conditioning such as the ability to control gain and offset, is important to minimize effects from camera variability or lighting fluctuations (Chen *et al*., 2002). Such frame grabber boards are capable of pre-processing imaging with functions such as "First-In-First-Out" (FIFO) and "Look-Up Table" (LUT). A modem frame grabber board can communicate with the host CPU's memory via software driver at speeds of 80-130 Mbytes/s. This speed is appropriate to meet the needs of many real time operations in food industry (Gunasekaran and Ding, 1994). Selection of the frame grabber is based on the camera output, spatial and grey level resolutions required, and the processing capability of the processor board itself.

3.4 COMPUTER HARDWARE AND SOFTWARE (IMAGE ANALYSIS)

Image processing and image analysis are recognized as being the core of computer vision. Image processing involves a series of image operations about a product from a single image in a fraction of a second, making it possible to analyze products as they pass on a conveyor belt, that enhance the quality of an image in order to remove defects such as geometric distortion, improper focus, repetitive noise, non-uniform lighting and camera motion (Storbeck and Daan, 2001). Image analysis is the process of discriminating the objects (regions of interest) from the background and producing quantitative information, which is used in the subsequent control systems for decision making. Image processing/analysis involve a series of steps, which can be broadly divided into three levels: low, intermediate and high level of processing (Sun, 2000).

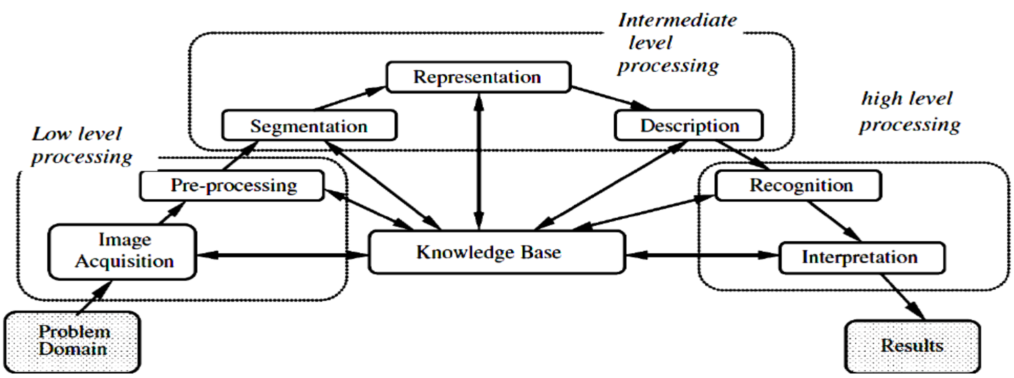

Fig.2: Different levels in image processing

3.4.1 LOW LEVEL PROCESSING

Low level processing includes image acquisition and pre-processing. Image acquisition is the transfer of the electronic signal from the sensing device into a numeric form. Image pre-processing refers to the initial processing of the raw image data for correction of geometric distortions, removal of noise, grey level correction and correction for blurring. Pre-processing aims to improve image quality by suppressing undesired distortions or by the enhancement of important features of interest. Averaging and Gaussian filters are often used for noise reduction with their operation causing a smoothing in the image but having the effect of blurring edges. Also through the use of different filters fitted to CCD cameras images from particular spectral regions can be collected (Brosnan and Sun, 2004).

3.4.2 INTERMEDIATE LEVEL PROCESSING

Intermediate level processing involves image segmentation, image representation and description. Image segmentation is one of the most important steps in the entire image processing technique as subsequent extracted data are highly dependent on the accuracy of this operation. Its main aim is to divide an image into regions that have a strong correlation with objects or areas of interest.

3.4.3 HIGH LEVEL PROCESSING

High level processing involves recognition and interpretation, typically using statistical classifiers or multilayer neural networks of the region of interest. These steps provide the information necessary for the process/machine control for quality sorting and grading. Statistical procedures from basic image statistics such as mean, standard deviation and variance to more complex measurement such as principle component analysis can be used to extract features from digital images. Once image features are identified, the next step is feature classification (Minz *et a*l., 2013).

4.0 APPLICATION AND POTENTIAL OF MACHINE VISION IN DAIRY AND FOOD INDUSTRY

The system offers the potential to automate manual grading practices thus standardizing techniques and eliminating tedious human inspection tasks. Machine vision has proven successful for the objective; online measurement of several food products with applications ranging from routine inspection to the complex vision guided robotic control (Gunasekaran, 1996).

4.1 FRUIT AND VEGETABLES

Shape, size, colour, blemishes and diseases are important aspects, which need to be considered when grading fruits and vegetables (Kanali *et al*., 1998; Chatli *et al*, 2013 and Mahendran *et al*., 2013). Colour provides valuable information in estimating the maturity and examining the freshness of fruits and vegetables. The automated inspection of produce using machine vision not only results in labor savings, but can also improve quality inspection objective (Kanali *et al*., 1998). Machine vision is being implemented for the automated inspection and grading of horticulture produce to increase product throughput and to improve objectivity of the industry (Brosnan and sun, 2004). Narendra and Hareesh (2010) reported variety classification, defects detection and segmentation, identification of stems and calyxes and sugar content prediction in apples.

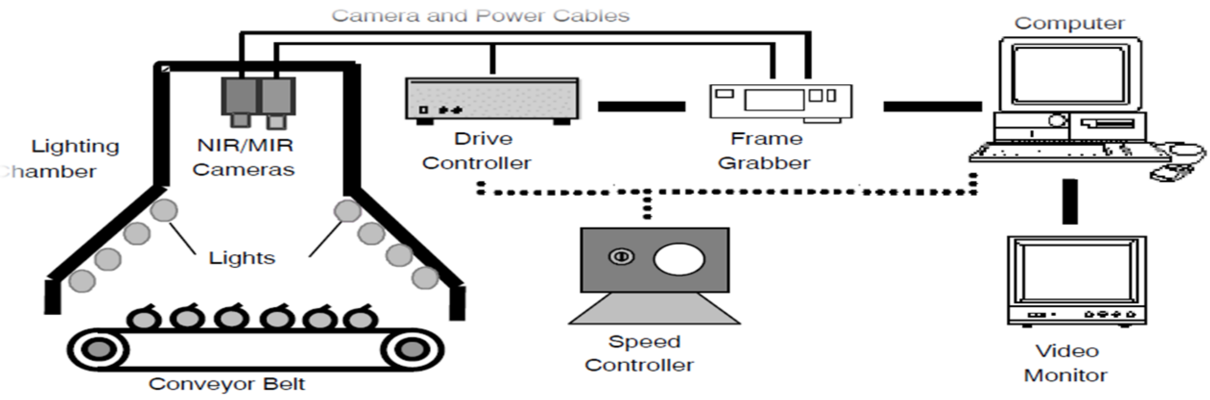

Figure 3 Schematic representation of the machine vision system for the online defect inspection.

Sample is conveyed through the conveyor belt across the NIR/MIR camera under lighting. These images are transmitted through frame grabber through a computer based system where they are analyzed. A speed controller is associated with drive controller which controls the speed of belt conveyer. The vision can be seen through a video monitor machine vision system for automatic online defect inspection is needed to speed up the inspection procedure. Lighting is used to provide uniform illumination for the infrared sensor. The near–infrared sensor utilized in the system is monochromatic camera. Two image sensors are mounted in the top center of the chamber. Lighting is provided by ten warm–white fluorescent lamps arranged uniformly around a v–shaped surface right above the conveyor. One side of the chamber can be opened to allow camera mounting. Both near–infrared images (NIR image) and mid infrared images (MIR image) are captured, processed, and analyzed by a host computer equipped with an imaging board. A roller conveyor belt is constructed to support and move apples for up to six lanes. The apples are rotating and moving when they are passing through the field of view of the image sensors. The online imaging system grabs images at a rate of 30 frame/sec. It guarantees the entire surface of each apple is imaged and processed. Drive controller and speed controller are coordinated with an optical encoder, providing timing signals for both online mechanical and electrical synchronization. They also investigated the use of computer vision in sorting fresh strawberries based on size and shape, shape characteristics of papaya, tomato color, size, shape and abnormalities with inner quality, inspect and grading of mushrooms, separation method for grading of potatoes, color of lemon etc.

Marakeby *et al*. (2013) also studied on fast quality inspection of food products using computer vision. Brosnan and sun (2004) classified the carrots for forking, surface defects, curvature and brokenness. Arjenaki et al. (2013) sorted the tomato online based on shape, maturity, size, and surface defects using machine vision. Silvia (2011) reported quality assessment of blueberries by computer vision. Sadegaonkar (2013) evaluated the quality inspection and grading of mangoes by computer vision & image analysis. The algorithm was able to identify ripened tomato by high accuracy in different lighting conditions of greenhouse (Arefi, 2011).

Golmohammadi (2013) developed a machine vision system for online evaluation of potato sorting. To separate potatoes, an accelerator system based on pneumatic control valves and air pressure was used. As the system was online, all of timings related to image processing, product transferring and accelerators operation were calculated and applied based on the speed of the potatoes being fed to processing and sorting system. For the primary evaluation of the system, 100 kg of potatoes were manually sorted into three categories. Then the same potatoes were fed to the system, which has sorted them out with an accuracy of 97.4% with the speed of two potatoes per second.

Rajin *et al.* (2013) evaluated the quality of grapes using non-destructive machine vision system. Singh and kamal (2013) used machine vision system for tea quality determination based on tea quality index (TQI). Gumus *et al*. (2011) identified the aquatic food processing line based on sorting by species, by size, and by visual quality attributes, as well as automated portioning. Aquatic foods is grouped as determination of composition, measurement and evaluation of size and volume, measurement of shape parameters, quantification of the outside or meat color of aquatic foods, and detection of defects during quality evaluation. It can provide fast identification and measurement of selected objects, perform quality evaluation of aquatic foods, and their classification into categories based on shape, size, color and other visual attributes.

4.2 DAIRY

Machine vision application has been employed for dairy products like cheese. Wang and Sun (2001, 2002, 2003, and 2004) studied over the functional properties of cheese like melting, browning, oiling off, shredding and streachability using a computer vision. The system included a 12 mm lens, CCD camera, supported by a copy stand, a frame grabber, monitor and a computer for image processing. A lighting unit with 2 dulux fluorescent lamps each of power 11W having 5000 K colour temperature provided illumination in the dark room for analysis.

4.2.1 BROWNING AND MELTING PROPERTIES OF CHEESE: Area of cheese slices was extracted from the images for studying melting and the Gray value (GV) of cheese slices and dark patches extracted from the images were used for studying the browning factor.

4.2.2 OILING OFF PROPERTIES OF CHEESE: The areas of the cheese disc and oil ring were determined through image analysis and the percentage area was correlated to fat leakage, indicating that a better representation of oiling off with image features is available by careful thresholding and appropriate parameter definition (Wang and Sun, 2004)

4.2.3 MONITORING OF CHEESE CURD SYNERESIS: The monitoring of cheese curd syneresis through computer vision and colorimetric techniques were investigated by capturing images ($100mm^2$) of the surface of the curd/whey mixture during syneresis at regular time interval. Each image was subdivided into a area of curd or whey respectively according to color threshold and then converted into a grey scale image which was further de-noised using a 2 dimensional noise removal filter. One limitation of this study was that optical measurements were taken at the surface, and it was found that low stirring speeds were not effective in resuspending sinking curd and this confounded the prediction of curd moisture. This suggests that the use of submerged optical probes, installed on the vat wall, may be worthy of investigation for this application (Everard et al., 2007).

4.2.4 COLOR EVALUATION OF KUNDA: Vyawahare and Rao (2011) studied the possibility and suitability using reflectance systems such as scanner digital camera and digital image processing software for numerical quantification of color intensity of heat desiccated products like kunda.

4.3 BEVERAGES

The classification of beverages was conducted using three approaches: by using the electronic nose only, by using machine vision alone and by using the combination of electronic nose and machine vision. A supervised support vector machine was used to classify beverage according to their brands. Results show that by using the electronic nose alone and machine vision alone were able to respectively classify 73.7% and 92.9% of beverage correctly. When combined the electronic nose and machine vision, the classification accuracy increased to 96.6%. Based on results, it can be concluded that combination of both is able to extract more information from sample, hence improving the classification accuracy (Mamat and Samad, 2012).

4.4 MEAT, POULTRY AND FISH PRODUCTS

Machine vision application in meat industry can be grouped as: determination of composition, fat/muscle ratio, measurement and evaluation of size and volume, measurement of shape parameters, quantification of the outside or meat colour, and detection of defects during quality evaluation. Moisture and fat content of meat has been correlated with the colour (Chen *et al*., 2002). Several companies have developed water-jet cutters that employ three-dimensional machine vision systems to calculate volume. The volume dictates where the cutting should take place in order to obtain the optimal yield from a piece.

On-line poultry automated inspection was develop and that can operate on-line in real-time (at least 140 birds per minute) in the poultry slaughter plant. These systems should be able to accurately detect and identify carcasses unfit for human consumption. Hu *et al*. (2012) classified fish species by color, texture and multi-class support vector machine using computer vision. Tan *et al*. (2000) described the Assessment of fresh pork color with color machine vision. Vote et al. (2003) predict the online beef tenderness using a computer vision system equipped with a Beef Cam module.

Online poultry inspection by a multi-camera system can be employed to accurately detect and identify carcasses unfit for human consumption (Chen *et al*., 2002). By automating this process, the level of accuracy in identifying defective eggs increases; and the rate of sorting is higher. The 1.4 Megapixel cameras are positioned in such a fashion as to capture images from every angle as the eggs roll down a conveyor belt. The cameras monitor the quality of eggs passing through the system and the images are analyzed digitally, with complex algorithms identifying any hairline cracks or detritus on the egg's surface.

4.5 BAKERY/CONFECTIONARIES/SNACKS

Appearance of baked products is an important quality attribute which influences the visual perceptions of customers and hence potential demands of the products. The appearance of the internal and external features contributes to the overall impression of the products quality. Machine vision has been used to measure characteristics such as colour, size and shape with a view to sorting them to products with same characteristics before packing. Rajin *et al.* (2000) developed a programme in FORTRAN using the principle of edge detection in image analysis to determine the edge of sliced breads and biscuits (round and rectangular) with a view to detecting defects (breakage). Scott (1994) described a system, which measures the defects in baked loaves of bread, by analysing its weight and slope of the top. The internal structure (crumb grain) of bread and cake was also examined by machine vision (Sapirstein, 1995). Dos Mohammed *et al*. (2000) also developed a system for the automated visual inspection of muffins. A prototype-automated system for visual inspection of muffins was developed by Abdullah *et al*. (2000) and they reported that it was able to correctly classify 96% of pre graded and 79% of ungraded muffins with an accuracy of greater than 88%. Now, the machine vision system has also been used in the assessment of quality of crumb grain in bread and cake products (Sapirstein, 1995). The application of this method is therefore a promising approach to solving quality control inspection in the bakery industries. Davidson *et al*. (2001) measured the physical features of chocolate chip biscuits, including size, shape baked dough colour, and fraction of top surface area that was chocolate chip using image analysis. Vision systems have been used in inspection applications ensuring that moulds used in the production of confectionery are empty and properly cleaned. The internal and external appearances contribute to the overall impression of the products quality consequently such characteristics have been evaluated by computer vision. Scott (1994) described a system which measures the defects in baked loaves of bread, by analyzing its height and slope of the top. The internal structure (crumb grain) of bread and cake was also examined by machine vision (Sapirstein, 1995). The brightness, cell density, cell area and uniformity of the grain analyzed indicated that even the most minor deviations from the required specifications can be identified through machine vision system, allowing corrective measures in the bakery to be taken sooner. In a more recent study, digital images of chocolate chip cookies were used to estimate physical features such as size, shape, baked dough colour and fraction of top surface area of chocolate chip (Davidson, Ryks and Chu, 2001). Nia S A (2012) investigated the physical characteristics of bread using machine vision.

Machine vision can be used to: classify objectively potato chips according to their colour in different categories, identify broken crackers, determine edge, ensure uniform baking/cooking and colour development, detect defects in colour, shape, topping and packaging, visually inspect chocolate chip cookies and muffins (Sun, 2000).

4.6 PROCESSED FOOD PRODUCTS

Visual features such as colour and size indicate the quality of many prepared consumer foods. Patel *et al*. (2012) and Sun (2000) investigated this in research on pizza in which pizza topping percentage and distribution were extracted from pizza images. Then it was found that the new region-based segmentation technique could effectively group pixels of the same topping together and the topping exposure percentage can be easily determined with accuracy of 90%. To avoid the misguideness of quality assessment by visual based human perception, computer vision is widely used in the assessment of confectionary products so far.

4.7 CEREALS

Quality inspection of cereal grains and pulses like rice, corn, wheat, gram, beans, etc., can be performed based on size (length/width) and color quantification of samples. Machine vision systems are being used to sort grains falling off the end of a conveyor belt. The cameras capture images as the beans are in mid-air, identify the produce that do not meet the quality standards and direct classification of type's, disease infection, weed identification, size (whole and broken kernel), whiteness and grading heat damage analysis, degree of milling, yield and percentage whole.

Narendra and Hareesh (2010) used machine vision to identify different variety of wheat and to discriminate wheat from non wheat components, developed a machine vision algorithm for corn kernel mechanical and mould damage measurement and whiteness of corn has been measured by on line computer vision approach, measuring the degree of milling of rice.

4.8 AUTOMATIC PROCESS MONITORING

Application of machine vision has been reported for controlling drying process of sliced apple (Fernandez *et al*., 2006). The vigilance of a drying process was provided due to online image analysis and correlation of image attributes (area, colour and texture) with physical parameters of drying (moisture and quality). A relationship between area shrinkage and moisture content was used for online estimation of actual moisture content. A relationship between color intensity and quality was used for online estimation of quality degradation during drying of ginseng roots (Martynenko, 2006). Strickland (2000) reported the use of digital imaging technology for the automatic monitoring of dry sugar granules and powders. This system provides particle size data to production line operators for process control and product quality improvement.

4.9 FOREIGN OBJECTS IDENTIFICATION

The detection of foreign objects and contaminants in food is a critical safety task. A machine vision system is much more effective at this task than human observers that can automatically detect foreign matter along the way. First, the vision system continuously watches the product stream and does not become distracted. Second, the vision system can freeze motion on a relatively high-speed belt, and its resolution can be specifically tailored for the observation task at hand (Minz, 2013).

4.10 OTHER PROVEN APPLICATION IN FOOD AND BEVERAGE INDUSTRY

QUALITY CONTROL
- Defect Detection
- Color grading and sorting
- Assembly verification
- Orient based on shape

BOTTLING AND LABELING
- Container filling and sealing
- Label and cap presence
- Fill level detection
- Label inspection
- Sorting
- Safety seal presence
- Bottle counting

PRODUCT SAFETY
- Cap presence
- Safety seal absent
- Safety ring absent
- Foreign object presence

PRODUCT TRACEABILITY AND ALLERGEN
- Read and store ID data
- Date and code verification
- Code reading

MATERIAL HANDLING
- Robot pick and place
- Carton inspection
- Labeling and marking

4.11 CHALLENGES AND FUTURE TRENDS

Computer vision systems have become a common and scientific tool in industrial automation due to superior performance, ongoing improvements in cost, ease of use, and algorithmic robustness. Traditional computer vision system is a tool for the inspection of color, texture, size, shape, and some relatively obvious defects, but has less effectively in detecting defects that are not clearly visible. Machine vision systems provide powerful tools to detect some defects that are impossible or difficult to detect with traditional computer vision system due to the superiority of spectral images. The challenges include stem–

calyx recognition, the uneven distribution of lightness on curvature surface, whole surface inspection, long time consuming of acquisition and processing for spectral image, efficient wavelengths selection for different application, and different defects discrimination, etc. Also, major advances in 3D techniques, Terahertz imaging, X-ray, and Raman imaging can be expected to be used in the quality inspection of Food products (Zhang *et al*., 2014)

5.0 CONCLUSION

A conceptual framework of machine vision system has its potential application for automatic food quality evaluation which is very useful for Indian food and beverage industry in today's quality conscious and competitive world. Machine vision systems have been used increasingly in food industry for inspection and quality evaluation purposes as they can provide rapid, hygienic, consistent, economic and objective assessment. However, difficulties still exist, evident from the relatively slow commercial uptake of machine vision technology in all sectors. More complex systems are needed for the automated grading of fresh produce because of the greater range in variability of quality and also as produce orientation may influence results. Image processing is recognized as being the core of machine vision with the development of more efficient algorithms assisting in the greater implementation of this technique. The automated, objective, rapid and hygienic inspection of diverse raw and processed foods can be achieved by the use of machine vision systems. Machine vision has the potential to become a vital component of automated food processing operations as increased computer capabilities and greater processing speed of algorithms are continually developing to meet the necessary online speeds. With few exceptions, research in this field has dealt with trials on a laboratory scales. The flexibility and non-destructive nature of this technique also help to maintain its attractiveness for application in the food industry. However, continued development of machine vision techniques such as X-ray, 3-D and colour vision will ensure higher implementation and uptake of this technology to meet the ever expanding requirements for accuracy and quality in this highly competitive and changing food industry. Various aspect of food quality such as product quality and safety; classification and sorting; and process automation have much need in future for implementation of machine vision system. In the design and operation of a vision system, the image formation and visual process, computational methods and algorithms, depth information, image representation, and modeling and matching must be considered. On the other hand, the systematic consideration is important in the efficiency and the performance of the selected machine. The integration possibility, robustness, ease of operation, and adding intelligence into the system in order to make it a smart system are features of the advanced machine vision systems.

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INNOVATION FOR PRODUCTIVITY ENHANCEMENT IN DAIRY INDUSTRY

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India is a land of villages and over 75% population resides in them. The prosperity of the nation therefore lies in prosperity of the villages. Rising populations and divisions in successive generation of the families has resulted in small land holdings and small number of cattle heads. As a result, the marginal milk producers were at the mercy of the middleman, and were never came out from poverty.

National Dairy Development Board (NDDB) with the vision to recognize and uplift the socio economic status of the marginal milk producers by themselves strengthened the dairy co-operative movements.

Rajasthan Electronics and Instruments Limited, Jaipur (REIL) was set up in 1981 by Government of India & Government of Rajasthan with the aim to empower rural masses with latest technology tools. REIL under guidance of NDDB successfully developed and indigenized Electronic Milk Tester (EMT) originated by a Danish company to fulfill the need of Indian Dairy Industry for transparent fat testing. EMT became primary need of dairy cooperative societies across the country.

So far more than 1,00,000 villages have been benefited with this innovation and response is overwhelming. REIL launched 47 product variants in past 33 years and is still maintaining them.

REIL step further and introduced Data Processor Milk Collection Station (DPMCU) in 1992. Initially this customized equipment was designed to automate the milk management activities. This served well to the dairy co-operatives for a decade and eliminated the human intervention in data recording and farmer payment. This further ensured the transparency and encouraged village producers for pouring more milk to the organized dairy sector rather then middleman.

This DPMCU was easy to use and economic. The only limitation was its memory and processing speed.

REIL worked and introduced a PC based Automatic Milk Collection Unit (AMCU) in 1999 integrated with Society Accounting and Management Software (SAMS) which was built on NDDB study report The aim was to computerize the Dairy Cooperatives for Milk Management, Inventory management, Services and Financial

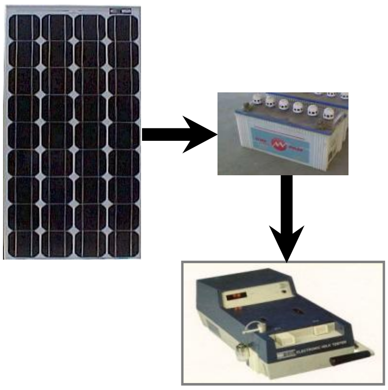
Accounts Management. Smart Cards were also introduced in AMCU to work as Milk Producer identifications and electronic pass book. This Smart Card was aimed to use in village with multiple activities like Bank ATM Card, Credit Card and for various Government initiatives.

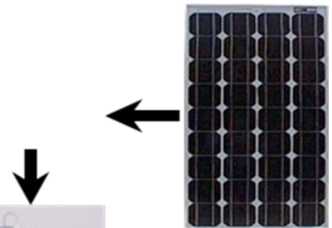
The innovations by use of Information Technology at village were further taken up by introducing RMRD Automation system. This is essential to meet the need of the value chain where village dairy cooperative societies are computerize with AMCU, thus dairy plants do need to give immediate data on quality and quantity for the milk received at dairy dock. RMRD Automation System is primary and essential to meet automation need of milk collection (reception) process.

Milk billing is another key area where client server architecture needed to automate the milk collection and deduction processes for the items/services extended to the societies. REIL introduced a web based state-of-the-art milk billing software with a business intelligent system to meet the need of RMRD, procurement, input, services and financial accounting departments. This low cost Version is essentially suitable for those milk unions who cannot afford ERP/SAP with its heavy capital and recurring expenditure.

With the introduction of Multi state co-operative and increase in private dairies, the competition grew during 2006 and milk producers had more choices to give milk to the desired dairy co-operative/multi state co-operative/private dairies. In the process, emphasis was given more on double axis payment system. Hence a need was felt for an instrument, which can measure Fat and SNF simultaneously. REIL fulfilled this need by introducing Ultrasonic Milk Analyzer. REIL is in process of indigenizing this equipment with the aim to meet low cost of ownership for the dairy cooperative.

REIL also used the core expertise of design and development of Solar Photovoltaic (SPV) Power system for dairy sector. REIL innovated cost effective solutions to run EMT & DPMCU on SPV. This solution reduces the cost of operation and also increases the life of the equipments.





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REIL further implemented the idea to use SPV solution to meet typical power need of Dairy Plant/MCC for lighting, computer, printer etc. Many milk unions came forward to use their waste land & roof tops to meet the power demand.

Running cost of Diesel Generator for Bulk Milk Cooler (BMC) is another critical area identified by dairy industry. REIL is working on SPV power back up solution targeting uninterrupted power at affordable cost.

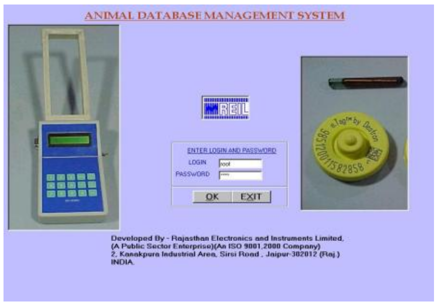
Food safety is a key concern area for all of us. Milk being primary food, need more focus. Synthetic milk & adulteration in milk has caused serious concern on human health. This generated a need for detection of harmful adulterants at primary milk collection level.

REIL came forward with **Electronic Milk Adulteration tester (EMAT)** to address this need. The equipment is an indigenized solution, high on accuracy and low on cost. The EMAT detect the harmful human adulterants like **Urea, Detergent, Liquid Soap, caustic soda, Salt, Soda and Hydrogen Peroxide**. This basic model is compatible with existing deployment of above 1,00,000 milk testing solutions already installed. REIL is also launching an advance model of EMAT with Fat and SNF measurement shortly.

The task of the dairy is to transform raw milk into a maximum amount of high nutritional value end product. For standardization of milk and milk product the available technologies like IR are highly expensive and the filter based IR Technology is the proven technology for parametric analysis. In order to meet the challenges ahead to become an active and consistent player in global market, REIL is working on the cost effective Infra Red based solution.

Today we live in the 21st Century with global innovations in communication and information technology. Dairy Industry is also looking at this to further strengthen the value chain.

REIL empowered the dairy industry by providing GPRS connectivity to DPMCU and AMCU. This innovation is to get instant information about milk procurement and transportation. It also helps in better planning and effective logistics. Simultaneously the solution provides information to the individual milk producers about the details of milk quantity, quality and amount payable to them through SMS.



Scientific breeding and life cycle management of Milch Animal are most important factors for productivity enhancement. REIL also contributed by RFID technology for life cycle management of milch animals.

After series of field trial and development, REIL came out with RFID tags for cattle identifications. These self-energized tags are ear mounting, skin inject able and bolus in shape. REIL developed dedicated “Animal identification & database management software” for life cycle management of the milch animals. This includes information and alerts about birth, breed, vaccination, disease, lactation, milk quality and quantity.

The product also has applications for cattle insurance, cattle life cycle management and cattle database etc. The dependable after sales services is always a key to success of any product. REIL is focused on after sales support since beginning. Teams of more than 200 technical persons are strategically located around the country to cater this need.

The Company covers 7,000 villages annually. It has countrywide presence with a base of more than 1,35,000 installations. This has benefited 40 million Milk Producers and more than 1, 00,000 Villages. It has contributed a lot in improving the economy of rural milk producers and motivated them to produce more milk. As a result India became largest milk producer in the world in the year 1998 and still maintains the status. REIL has emerged as largest Milk Analyzers deployer and a trust worthy partner for progressing Indian Dairy Industry."

IN-LINE SENSORS IN PROCESSING INDUSTRY FOR MEASUREMENT OF PARAMETER AND PROPERTIES

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ABSTRACT

Sensor technology is a crucial element for assessing the quality and traceability of raw materials, intermediates and final products throughout the entire food chain. Within the area of food processing, sensors are used for the design, control and optimization of the manufacturing processes including storage. Improved process control contributes to food chain sustainability through optimization of product quality, including reduction of quality losses and defects, as well as reduced consumption of water, energy and high-value ingredients. Use of various sensors assesses the quality parameters and properties of the products by direct or indirect measurement of the parameter and produce precise results.

Introduction

Food production and processing has evolved into a global system that is complex, immense and rapidly changing. Producers and processors require methods to trace raw materials, determine purity and/or adulteration, validate safety, optimize utilization of raw materials, monitor quality of product produced and incorporate process sensors and mathematical models to modify processing conditions in real time. Considerable advances have been made in developing sensor technology specific to measuring food ingredient and product properties. Common to property measurements for all sensors is linking the fundamental measured values to a quality specification of the product. Translating the sensor measurement to a specific quality feature ranges from straight forward (e.g., speed of sound to density of a liquid) to challenging (e.g., rheological properties of suspensions to quality assurance measurements). Scientific understanding of material properties and sensor technological. Developments are emerging to address the needs identified by food processors. The food industry has generally lagged behind other process industries in the use of sensors and related microprocessor control instrumentation. Among the more important reasons for this are the variability in raw ingredients used in food processing, the complexity of food materials, the lack of availability of online sensing systems that can perform in harsh food processing environments, and the clean-in-place needs for safe food processing systems (McCarthy et al ,2013).

Smart sensors can also contribute to the efficient use of resources in other parts of the food supply system. Adaptive storage conditions based on the simultaneous measurement of oxygen, carbon dioxide and ethanol during storage allow for long term stability of perishable fruits like apples and pears. With the application of monitoring devices (equipped with the required sensors) viable information can be obtained about the actual conditions under which products have been stored and shipped. Unique identification of each product is possible through combining such monitoring devices with radio frequency identification (RFID) tags. Tags containing a microcontroller enable on-chip interpretation of the environmental data. Upon reading the chip the actual status of the goods is immediately available, while the expected future status can be described by quality models using the experienced environmental conditions an input. This technology enables the use of guaranteed quality statements, the supply of consumption-ready products to the supermarket as well as the application of logistical concepts such as FEFO (First Expired First Out) and FIFO(First in first out) (Langelaan et al ,2013).

Classification of sensors

Three main classes of sensors used for the measurement of key processing parameters such as temperature, pressure, mass, material level in containers, flow rate , density, viscosity, moisture, fat content, protein content, pH, size, color, turbidity etc.

- Penetrating sensors: these sensors penetrate inside the processing equipment and Come into contact with the material being processed.
- Sampling sensors: these sensors operate on samples which are continuously withdrawn from the processing equipment.
- No penetrating sensors: these sensors do not penetrate into the processing equipment and, as a consequence, do not come into contact with the materials being processed.

Characterization of sensors according to their applications

- Inline sensors: these form an integral part of the processing equipment, and the values measured by them are used directly for process control.
- Online sensors: these too form an integral part of the processing equipment, but the measured values can only be used for process control after an operator has entered these values into the control system.
- Offline sensors: these sensors are not part of the processing equipment, nor can the measured values be used directly for process control. An operator has to measure the variable and enter the values into a control system to achieve process control.

Sensors and its applications

Humidity Sensors

This type of sensors measures the pressure of water vapor or absorbs the water vapors .The measurement gives input data Configured with integrated circuitry to provide on-chip signal conditioning, with inter changeability of ±3 % accuracy. Standardized and platform-based potential applications include air compressors, food and beverage packaging and processing like drying of particulates etc. The major advantages of this type of sensors can be Low cost , rapid feedback, data transformed in to another parameters like water activity and dew point temperature (Honeywell Sensing and Control, 2010)

Biosensors

Biosensors are analytical devices, which utilize the sensitivity and selectivity of a biological recognition element (such as enzyme, microorganisms, cells organelles, plant or animal tissue slice, antibody or DNA) closely connected to or integrated within a physical transducer (e.g., electrochemical, mass, optical, thermal) and coupled to a data acquisition and processing system. The biological recognition element is usually immobilized in the close proximity of the transducer surface, thereby facilitating a direct or mediated signal transfer. The immobilization also plays an important function by stabilizing the biological material. The detection principle is based on the ability of the transducer to transform a biochemical and/or physico-chemical change into a measurable signal1-3 as a result of a bio recognition event between the biological recognition element and its target analyte. This interaction assures the selectivity of the biosensor, whereas the sensibility is determined by the transducer. The measured signal is generally proportional to the concentration of the analyte. Chronologically, the first biosensor was an enzyme sensor developed by Clark and Lyons in 1962.This sensor utilized glucose oxidase attached onto the surface of an amperometric oxygen electrode and was used to directly quantify the amount of glucose in a sample. Since then, a great number of biosensors in different configurations have been developed and many are used for the detection of compounds involved in food fermentation, as substrates or products. The use of biosensors for food analysis can provide a route to a specific, sensitive, rapid, and an inexpensive method for monitoring a range of target analytes. This applies to monitoring carried out not only under laboratory conditions but also at on-site locations. These devices can be designed such that the non-specialist operator can use them effectively (Barthelmebs et al, 2013).

Wireless sensors

Wireless sensor networks (WSN) have a strong impact all over the world over the wired networks due to the development of new standards and technologies from the last decades. Wireless sensor networks are used in a wide range of applications including remote Monitoring, health care, industrial automation or environmental monitoring. Each Wireless sensor networks (WSN) may have specific objectives and application goals. To assure maximum quality and minimum spoilage of the stored food in food industry, by maintaining and monitoring of the temperature and humidity of the environment. Sensory data comes from temperature and humidity sensors of different locations, where food is stored and received at the receiver. The upgrade system can be attached to the sensors like Bluetooth and wifi for getting data in the data logger (Kaushik and Singh, 2013).

Level sensors

The level sensors fulfil their tasks signalling full, empty or demand states ruggedly, reliably and highly accurately. The measurement principle of the tuning fork reacts to changes in density, therefore they operate independently of silo shape, tank material and they are also wear-free and maintenance-free. The sturdy stainless steel tuning fork is piezoelectrically energized and vibrates at its resonance frequency. If the tuning fork is covered with bulk material, the resonance frequency changes. This change is reliably detected by the integrated electronics and converted into a switching signal. While the sensor is principally used to signal full states or mounted laterally for demand or empty states, with suspension cable and the tube-extended sensor are used for vertical mounting in silos. This have advantages like Maintenance-free limit sensor, reduced maintenance costs, No calibration required, fast commissioning saves time, Sensor test in mounting position, Low installation cost, Flexible level sensor (SICK Engineers, 2010).

Metal oxide sensors

Metal oxide semi-conductors sensors (MOS), are readily available. They have been more extensively used to make arrays for odour measurement than any other type of gas sensors. Although the oxides of many metals show gas sensitivity under healthy conditions, the most widely used material is tin dioxide (SnO2) doped with a small amount of a catalytic metal such as palladium or platinum. By varying the selection of catalyst and working conditions, tin dioxide resistive sensors have been developed for a group of applications. Materials with enhanced performance with respect to relative humidity differences have been found by observed testing. Titanium-substituted chromium oxide (CTO) is an example of such a material. Other available oxide-based gas sensors include zinc oxide (ZnO), titanium dioxide (TiO2) and tungsten oxide (WO3). MOS-based electronic noses are those that are associated to quality control, monitoring process, aging, geographical sources, adulteration, contamination and spoilage of foods like Milk and Milk products, Fruits, Fish, Meat etc. This is widely used sensors for maintaining the storage quality of foods (Zohora et al, 2013).

Opto-electronic and photo electronic sensors

The high power spray, caustic chemicals and hot temperatures required during the wash down and sanitation process is not a recommended environment for most electronic devices. This type of sensors used for the Often the harsh environment which causes premature failures of standard electronic sensors. The innovative di-soric sensors with their stainless steel casing and completely encapsulated design, to be resilient to high-pressure wash downs, preventing the need to continuously replace damaged sensors allowing for proper sterilization of equipment. This helps to check the efficiency of the Sterilization and sanitization .The absence of live bacteria as a microbial hazard can be detect by using this Opto-electronic sensors (Trelectronic, 2012).

Local thermal pulse analysis sensor

The thermal sensor includes a hot wire, generating a heat flux and temperature measurements for wall and bulk. A platinum probe acted as a sheathed hot wire sensor. A platinum wire with ceramic and stainless steel sheaths was used. The ceramic sheath ensured electrical insulation between the stainless steel case and the platinum wire. The platinum wire (hot wire) was connected to a direct current generator (0–50 mA). The electric current (I) and potential (V) applied to the standard resistance were recorded and the heat power (P, mW), the flux (u, kW/m2) and its electric resistance (R) calculated. The electric resistance enabled us to determine the average temperature in process of pasteurization using ohmic heater (Crattelet et al, 2013).

Spectral sensors

The spectral sensors can be applied in process quality monitoring, such as in fat, protein and moisture measurements. As an example, moisture content is a critical quality parameter in many industrial processes, like pharmaceutical, paper and food production. Applications also include hydrocarbon measurements in oil & gas industry, CO2 in ventilation applications and much other gas measurement applications. They advantages of Inexpensive, Small size, Versatile, Low power consumption, Speed, Robustness, Scaleability to high volumes (Spectral engineers, 2013).

Refractive Index Sensor

The sensor that provides in-situ refractive index measurements and allows continuous monitoring of any process, whether industrial, chemical of food-engineering, thus eliminating manual sampling and measurements repeatability problems. These sensors are also designed to withstand variable temperature, Equilibrium Moisture content and vibration conditions. Unique design is based on the variation of a liquid-filled Fabry-Perot optical cavity length to precisely determine the refractive index of the liquid. The liquid filled optical cavity length varies in direct proportion with the refractive index of the liquid sample. The refractive index measurement is achieved by measuring the Fabry-Perot cavity length using white light interferometer technology. The fiber optic signal conditioner has the capability to perform the refractive index measurement under challenging conditions of temperature, humidity and vibration with uncomplicated calibration tasks that the user can perform. The fiber optic refractive index sensor provides the industry with better and more reliable refractive index measurements for existing applications, and with extended capabilities for new applications requiring continuous in-situ monitoring of fluids refractive index under adverse conditions. The fiber optic refractive index sensors are available in a miniature package or in a rugged stainless steel package, suitable for industrial applications (FISO Technologies, 2010).

Electrochemical Sensors

An important application of electrochemical sensors in agriculture is in the direct measurement of soil chemistry through tests such as pH or nutrient content. Soil testing results are important to obtain optimal crop production yields and produce quality, tasty food. Two types of electrochemical sensors are commonly used to measure the activity of selected ions (H+, K+, NO3-, Na+, etc.) in the soil: (1.) ion selective electrode (ISE) sensors, and (2.) ion selective field effect transistor (ISEFT) sensors. ISE and ISEFT sensors have also been used to monitor the uptake of ions by plants. The rate of nutrient uptake is determined by the demand of the plant, which is dependent on the growth rate and on the status of the plant’s nutrient content. Most macronutrients (e.g., nitrogen, phosphorous, and potassium) are absorbed actively. Monitoring ion concentrations in plants or growing systems enables farmers to design fertilization strategies that optimize production (Simonian and Chin, 2010).

CIP Sensors

Clean-in-Place (CIP) sensor is designed for applications in the food and beverage industries where processing equipment is routinely cleaned with caustic at temperatures up to 100 degrees temperature.

They have sanitary design and maintain hygienic conditions during processing (Emerson Process Management, 2012).

Technology	Description	Target
Uni-molecular sensors	Single biomolecule enclosed or attached to nanomaterials (liposomes, nanoparticles, nanorods, or carbon nanotubes).	Pesticides, gases such as CO_2.
Bioarrays (including electronic noses/tongues)	Multiple biomolecules enclosed or attached to nanostructured materials.	Multiple chemicals & microbes.
Solid state sensors	Thin film or nanowire (carbon nanotube, silicon, metal oxide, metal alloy or conducting polymer) sensors.	Gases.
Optical & spectrographic sensors	CCD, lasers and spectrometers.	Plant growth, presence of different chemicals.
Radio Frequency Identification (RFID) tags		Monitoring of produce condition during transit.
Sensor networks	Individual sensor nodes that can be dispersed over an area, measure local variables, and report to a central processing unit.	All aspects of crop and livestock monitoring for precision farming.

Figure: Examples of sensor technologies relevant to food production and processing (Trelectronic, 2012).

Ion-selective sensors (ISE)

Ion-selective sensors have been developed to detect a variety of ions. Ion-selective sensors (ISE) sensors have been developed to monitor nitrogen ions in the soil and crops, such as potatoes, and vegetables for fertilization management. Concentrations of ions, such as iodide, fluoride, chloride, sodium, potassium, and cadmium, in plants or soils have been measured by Ion-selective sensors (ISE) sensors to investigate plant metabolism, nutrition, and toxicological effects that heavy metals may have on plants. With the advent of Ion-selective sensors (ISE) and Ion-selective field effect transistor ISEFT, the development of ion-specific nutrient supply systems for crops/plants in the greenhouse industry is now possible. Several investigators have developed systems that inject liquid fertilizers based upon ion-specific concentration measurements. These systems automatically ensure that the nutrient demand of the plants is satisfied (Simonian and Chin, 2010).

Colour sensor

This type of sensors used for measurement of colour intensity based on the reflection of light. In order to reduce the risk of contamination, tamper-proof packaging is used to guarantee the purity of products. Implementing a colour sensor to monitor package seals can certify that the product is properly sealed. The colour sensor by di-soric is sensitive to varying shades of colour, enabling the detection of other flaws, such as burnt plastic or cracks in lids. Fork sensors may be used to ensure correct positioning to help reduce damages during packaging. This advantageous because of low cost of investment, high degree of accuracy, adjustable with position of sensors.

Conclusions

The prevention of product contamination is vital in today's fast-paced food processing industries in order to prevent production delays, product recalls and lost revenues. Sensors are complement, aimed to controlling the process parameters with feedback information about the quality of the processed product. An advantage of food sensors includes real time measurement, high sensitivity, and reproducibility, specificity, low cost with inline or standalone capacity. Novel, green and safe food sensors play an important role in maintaining the quality as well as hygiene in the industries.

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QUALITY MANAGEMENT IN INDIAN DAIRY INDUSTRY TO MEET INTERNATIONAL STANDARDS

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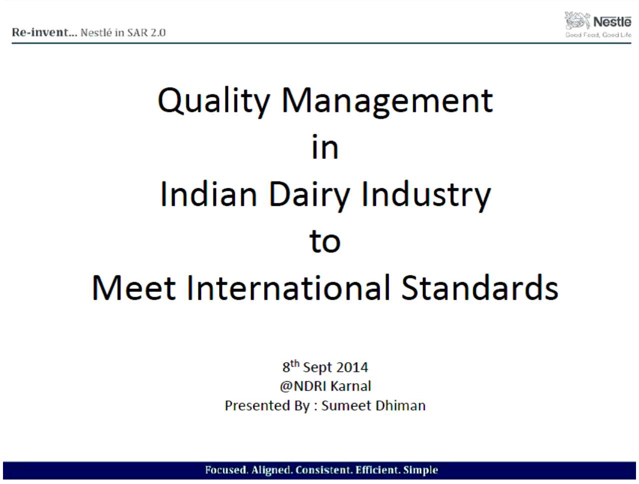
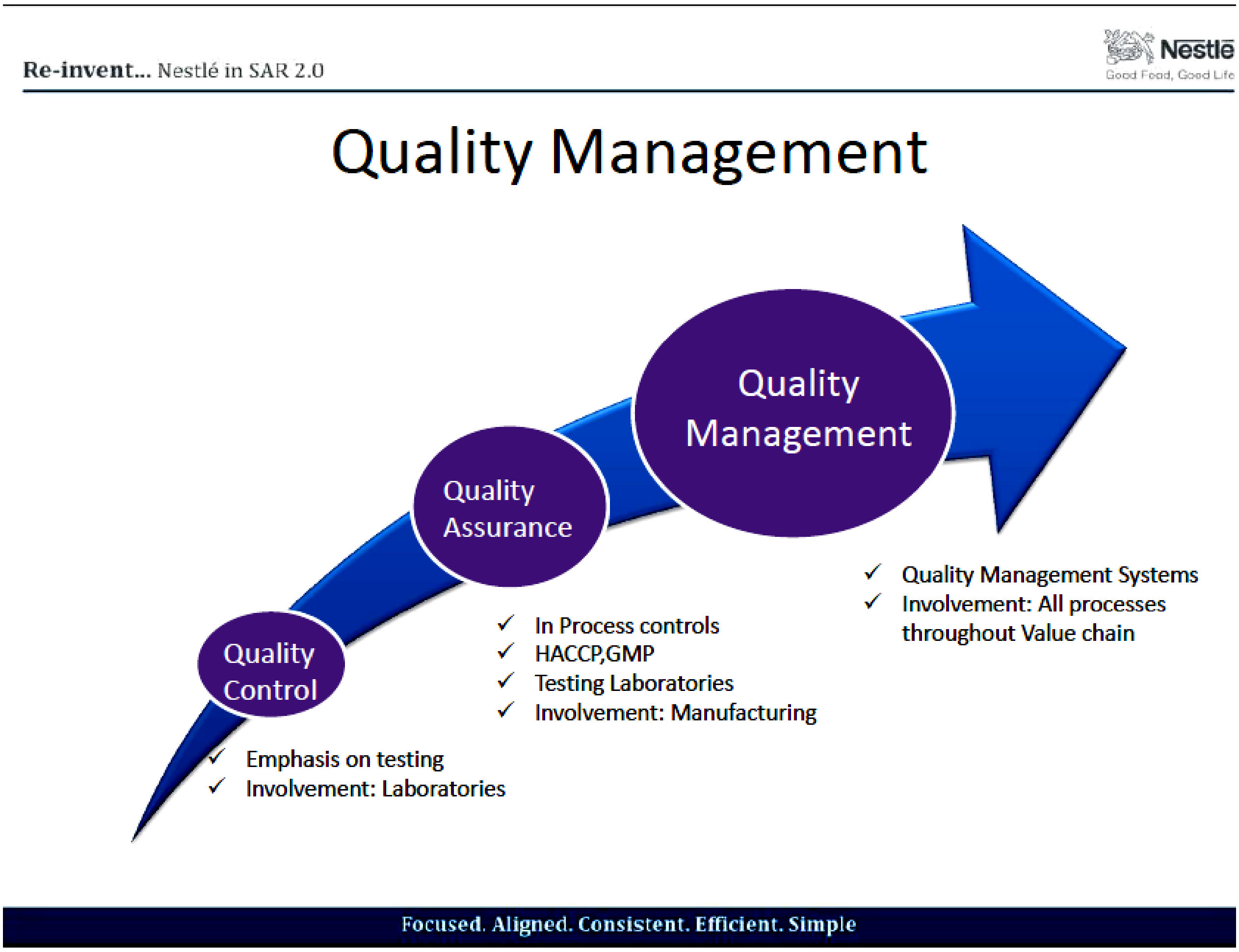
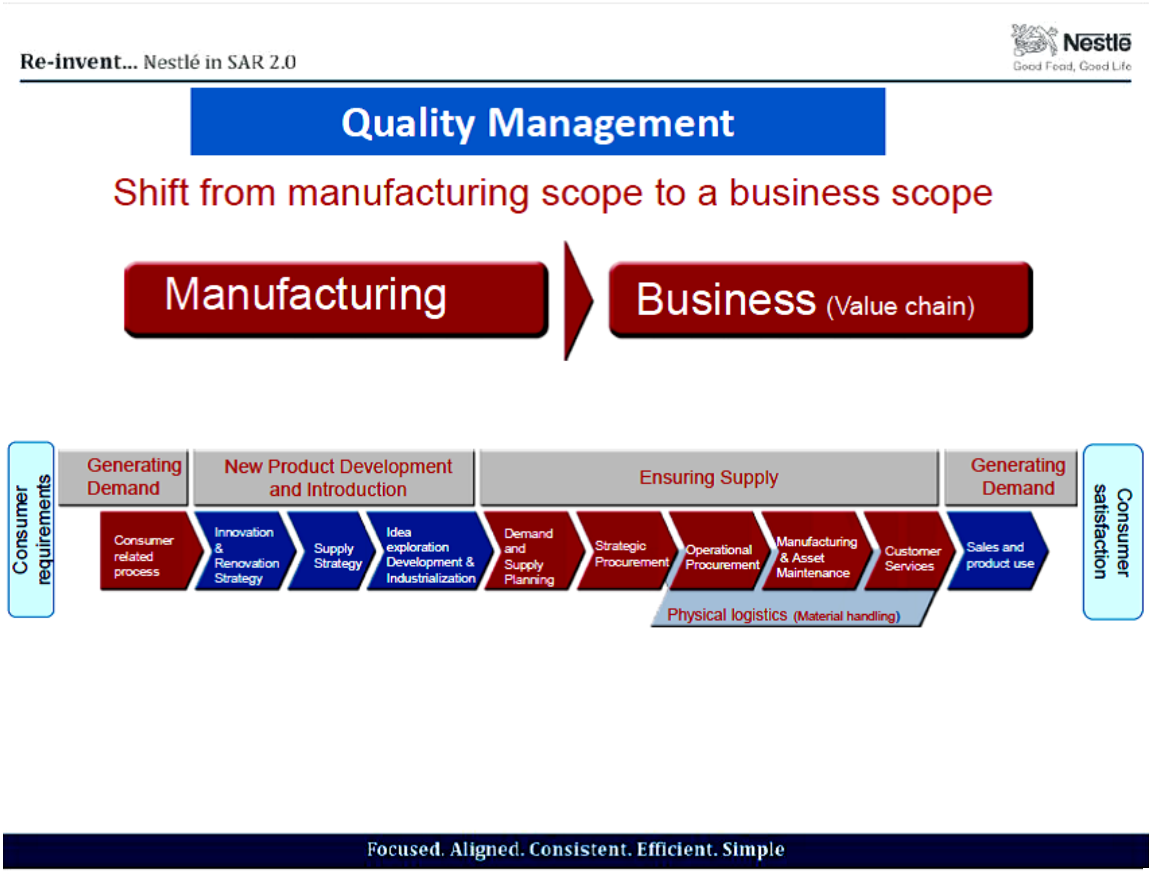
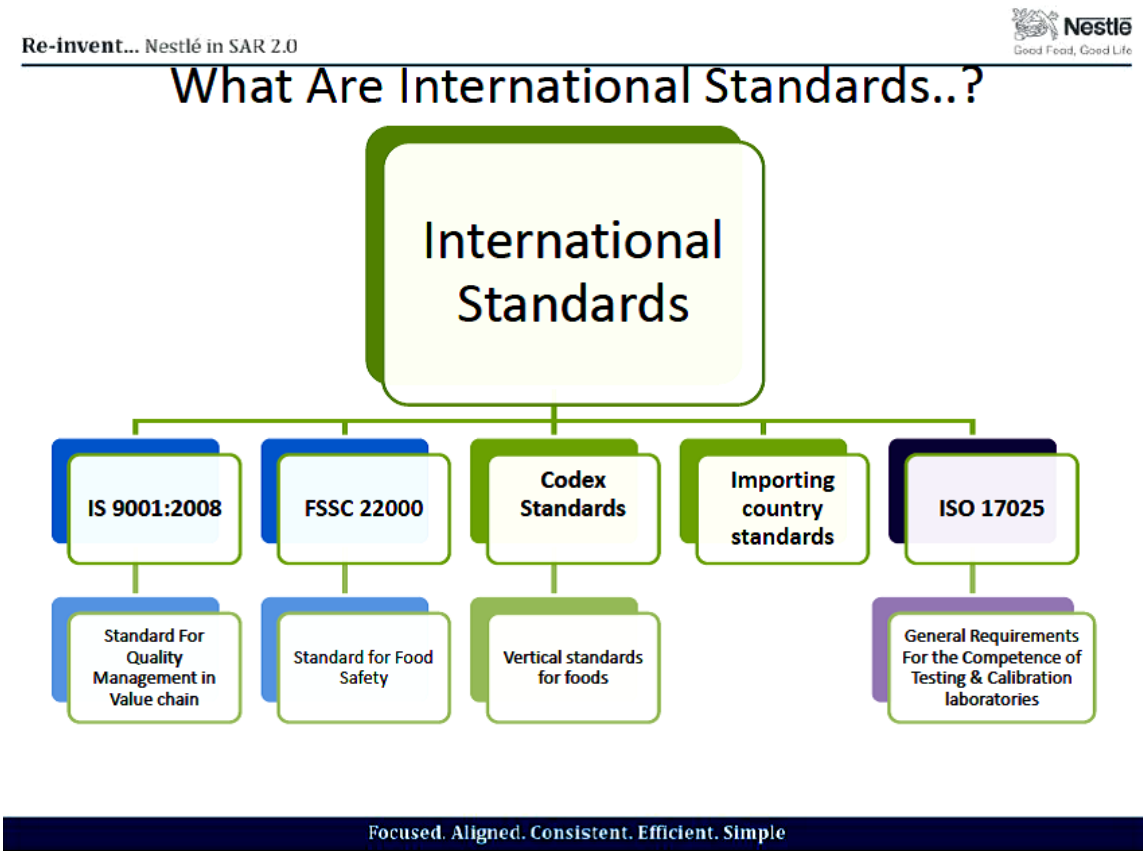






Re-invent... Nestlé in SAR 2.0
Nestlé
Good Food, Good Life
Quality Management
Shift from manufacturing scope to a business scope
Manufacturing
Business (Value chain)
Consumer requirements
Generating Demand
New Product Development and Introduction
Ensuring Supply
Generating Demand
Consumer satisfaction
Consumer related process
Innovation & Renovation Strategy
Supply Strategy
Idea exploration Development & Industrialization
Demand and Supply Planning
Strategic Procurement
Operational Procurement
Manufacturing & Asset Maintenance
Customer Services
Sales and product use
Physical logistics (Material handling)
Focused. Aligned. Consistent. Efficient. Simple



Re-invent... Nestlé in SAR 2.0
Nestlé
Good Food, Good Life
What Are International Standards..?
International Standards
IS 9001:2008
FSSC 22000
Codex Standards
Importing country standards
ISO 17025
Standard For Quality Management in Value chain
Standard for Food Safety
Vertical standards for foods
General Requirements For the Competence of Testing & Calibration laboratories
Focused. Aligned. Consistent. Efficient. Simple

Re-invent... Nestlé in SAR 2.0 — Nestlé Good Food, Good Life

Our Challenges

- Quality of Ingredients
  - Unorganized Vendor Base
  - Commitment for Authorities
  - Cost Vs Quality Mindset
- Quality By Design
  - Missing Elaboration at Project stage
  - *Jugaad* Mindset

Onus to deliver lies with Industry : Consumers are observing us

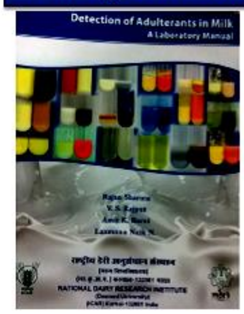
Focused. Aligned. Consistent. Efficient. Simple

Re-invent... Nestlé in SAR 2.0 — Nestlé Good Food, Good Life

How To Achieve... Milk Quality

- Focus from farm to Fork
- 20 Good Practices on Milk Management
  - 12 related to Milk production & Collection in the field
  - 5 related to Milk reception at factory
  - 3 related to Milk processing at factory

Leverage NDRI 's Adulterants Manual



20 Good Practices

Focused. Aligned. Consistent. Efficient. Simple

Re-invent... Nestlé in SAR 2.0

Nestlé Good Food, Good Life

Quality By Design - Starts with Plant layout

'Keeping out and keeping away' unwanted items, from the product contact points is a major step towards prevention of food hygiene problems....

Focused. Aligned. Consistent. Efficient. Simple

Re-invent... Nestlé in SAR 2.0

Nestlé Good Food, Good Life

Quality By Design

- Hygienic Engineering

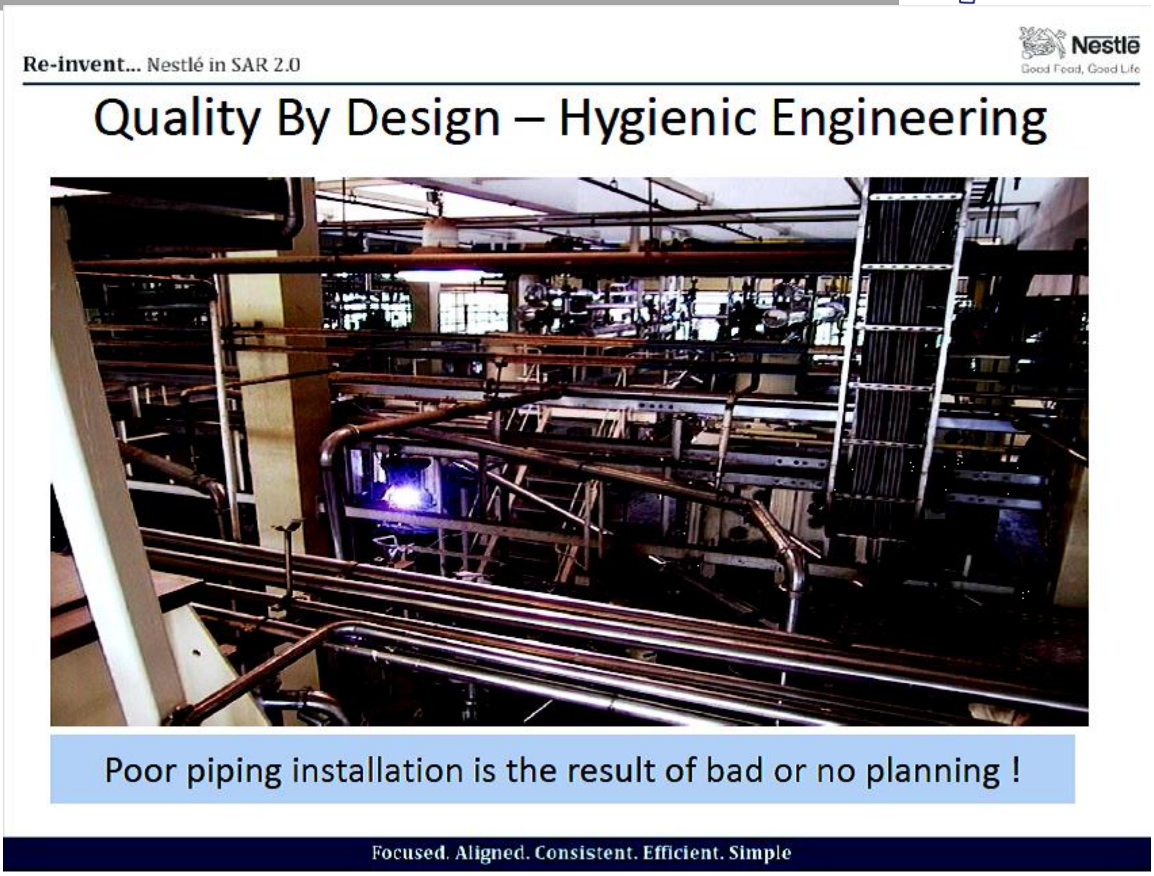
The engineer

Layout, Maintenance, CIP, Condensation, Building finish, Access, Dead Ends, Materials, Equipment Finish, Zoning, Building design, Welding, Lighting, Installation, Nestec Guidelines, Chemicals, Equipment design

Ten golden rules of maintenance

1	**Plan** - Involve everyone and inform everyone - Make a program noting responsibilities with names and times - Maintenance must always be supervised - warn those involved - Produce action plans - similar to QMS format
2	**Brainstorm** - What has to be considered specifically during the work - Check history of area - noting important date over last ten years
3	**Preparation of area(s)** - If required - seal off from other areas - Dry clean only - unless area is normally wet-cleaned - Release by team to start maintenance - team should include engineering, production and QA
4	**Check maintenance materials** - Where necessary (according to HACCP) food grade types must be available
5	**Participation in maintenance and monitoring of work** - Use appropriate monitoing tools
6	**Training of contractors** - If third parties are involved, pre-maintenance or construction training is essential
7	**Action plan for unusual findings (e.g. hidden residues)** - If movable - put suspect part into polythene bag(s) and take outside for cleaning - If unmoveable - dry clean completely - If infestation sighted or suspect - spray
8	**Cleaning** - Cleaning should be continuous and before reassembly - If areas are normally dry-cleaned - no wet cleaning - Use appropriate solvents to remove grease etc.
9	**Release by team** - Release is the joint task of engineering, production and QA
10	**Checking after start-up** - Sampling of line and/or product should be increased after maintenance

Focused. Aligned. Consistent. Efficient. Simple


Re-invent... Nestlé in SAR 2.0
Nestlé
Good Food, Good Life
Quality By Design – Hygienic Engineering
Poor piping installation is the result of bad or no planning !
Focused. Aligned. Consistent. Efficient. Simple

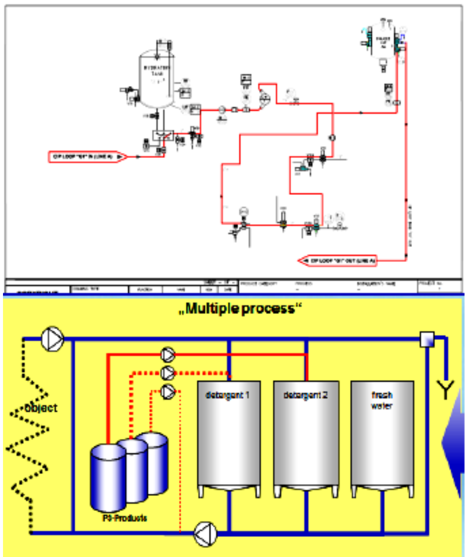

Re-invent... Nestlé in SAR 2.0
Nestlé
Good Food, Good Life
Quality By Design
Automated Operations
• Automatic Tanker Emptying
• Automated Evaporation & Drying
• Automatic Filling Machine
• Automatic Cleanings
Focused. Aligned. Consistent. Efficient. Simple

Re-invent... Nestlé in SAR 2.0

Nestlé Good Food, Good Life

Quality By Design

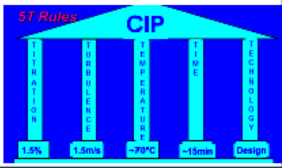
Cleaning Validation (CIP)



Validate
Titration
Turbulence
Temperature
Time
Technology

5 T's of CIP

A 6th T - **Training** is also critical effective and consistent CIP.



Focused. Aligned. Consistent. Efficient. Simple

Re-invent... Nestlé in SAR 2.0

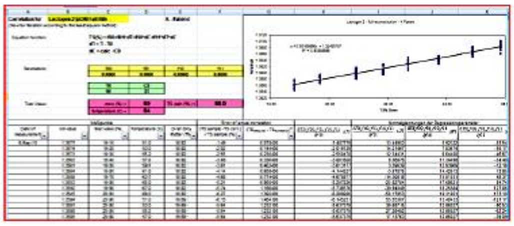
Nestlé Good Food, Good Life

Quality By Design – Conformation to Recipe

'Demanding International standards require both end process and in line controls'

In line Dosing Controls & measurements

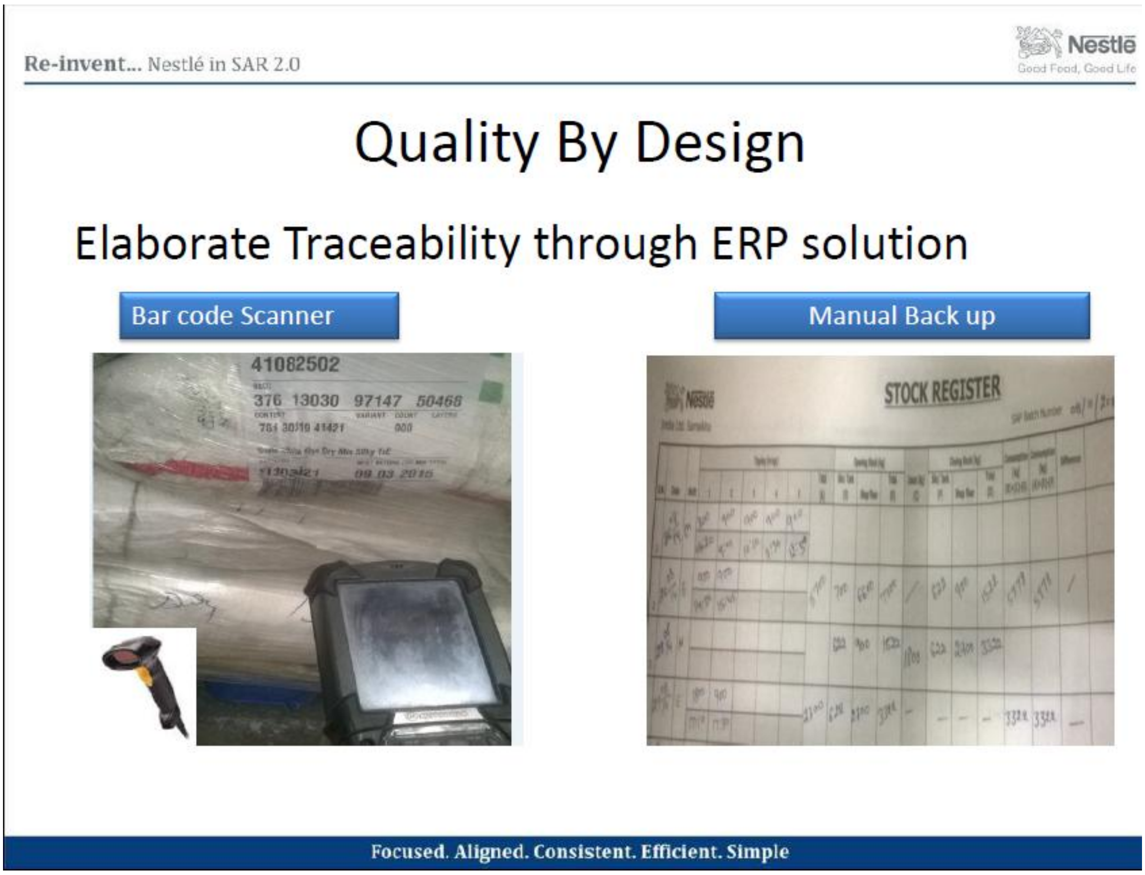
Verification of Semi Finished Product

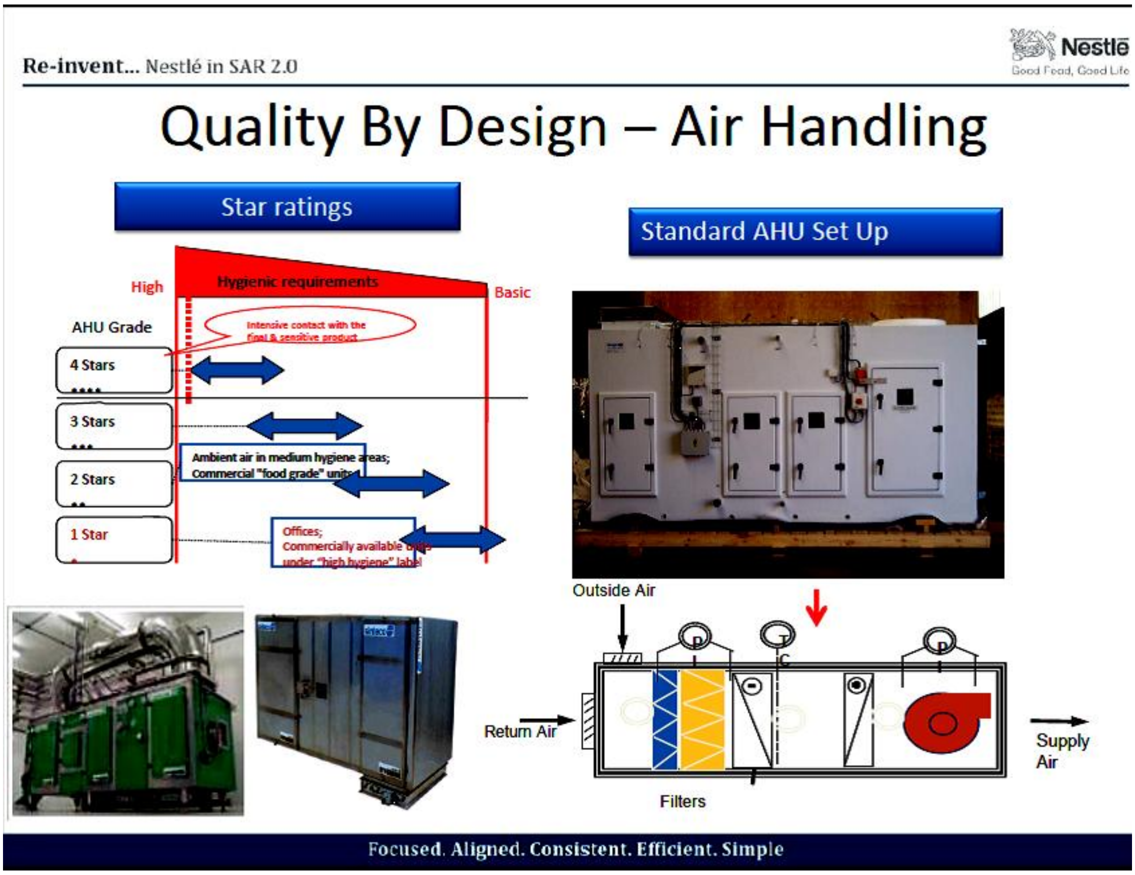


Focus Area- Calibration & Validation

'End Product Verification is necessary but not enough'

Focused. Aligned. Consistent. Efficient. Simple

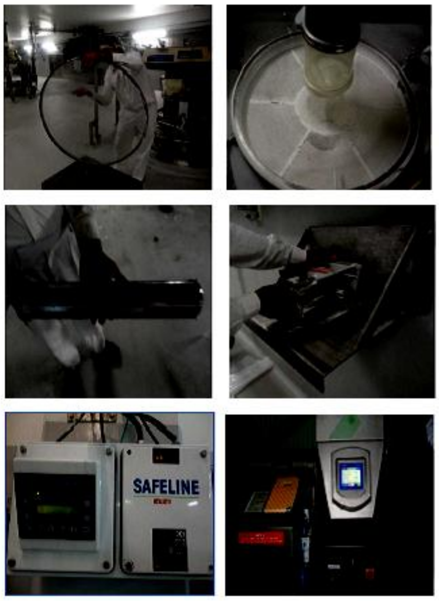

Re-invent... Nestlé in SAR 2.0
Nestle
Good Food, Good Life
Quality By Design
Elaborate Traceability through ERP solution
Bar code Scanner
Manual Back up
STOCK REGISTER
Focused. Aligned. Consistent. Efficient. Simple


Re-invent... Nestlé in SAR 2.0
Nestle
Good Food, Good Life
Quality By Design – Air Handling
Star ratings
Standard AHU Set Up
High
Hygienic requirements
Basic
AHU Grade
4 Stars
3 Stars
2 Stars
1 Star
Outside Air
Return Air
Supply Air
Filters
Focused. Aligned. Consistent. Efficient. Simple

Re-invent... Nestlé in SAR 2.0

Nestlé
Good Food, Good Life

Quality By Design – Foreign Body Management



Tipping Station : Sieves

In line - Filters & Magnets

Finished Product- X-Ray & Metal Detectors

Focused. Aligned. Consistent. Efficient. Simple

BIOLOGICAL TREATMENT OF DAIRY WASTEWATER IN AN ANAEROBIC BIOREACTOR FOR METHANE GENERATION

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Vidya Dairy, Anand
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Abstract

Dairy Industry serves as a breeder of huge quantities of wastewater with very high Biological Oxygen Demand and Chemical Oxygen Demand. The strict legislations regarding the disposal of wastewater leads to development of bioreactors which converts the organic wastes into Methane gas and hence providing a cleaner environment along with a sustainable and renewable source of energy. One of the focal ecological difficulties of todays is the constantly cumulative production of organic waste material in the solid, liquid and in gaseous phases. Numerous countries demonstrating a significant part of the mutual determinations to diminish pollution and greenhouse gas discharges and to moderate worldwide climate variations. Abandoned waste removal is no longer suitable today and even precise landfill disposal and burning of organic wastes are not measured ideal practices, as environmental principles hereof are gradually severer and energy retrieval and reutilizing of nutrients and organic matter is meant.

Keywords: Dairy Wastewater, Biological Treatment, Anaerobic

Introduction

Dairy industries, alike most other agro-industries, generates strong wastewaters described by high biological oxygen demand (BOD) and chemical oxygen demand (COD) concentrations demonstrating their high organic content (Demirel, *et.al.* 2005,Gavala,*et.al.* 1999,Kalyuzhnyi,*et.al.* 1997, Lo, K.V., *et.al.* 1988.). Furthermore, Cheese production worldwide generates more than 145 million tons of liquid whey per year. Mostly, dairy waste streams hold high concentrations of organic substances; these effluents may origin severe complications, in terms of organic load on the local community manure conduct structures (Goblos, S *et.al.* 2008,Mockaitis, G *et.al.* 2006,Saddoud, A *et.al.*1982). Initiative to employ the enormous aggregate of dairy by-products have commanded to the progress of several whey treatment approaches. Even with of the diverse potentials of whey application, roughly half of the cheese whey manufactured global is cast-off without treatment (Yan, J.Q., *et.al.*1988, Yan, J.Q., *et.al.*1989, Yan, J.Q *et.al.*1990). The dilution of cheese whey by mixing using supplementary wastewater is a technique for dropping the uncertainty and low competence difficulties instigated by its high organic components, specifically for high-rate anaerobic arrangements. Numerous cost-effective treatment technologies including anaerobic, aerobic and facultative processes have been developed for the treatment of whey. Recently, anaerobic treatment leading to biogas production has become an effective biological process for the treatment of many industrial organic wastewaters (Yilmazer, G. *et.al.*1999, Chen, Y., J *et.al.* 2008). In anaerobic processes, the major produced gas is methane, which is a valuable and renewable energy source used for heating and production of electrical energy. The lactose content of whey is readily degraded by acidogenic bacteria; this results in the occurrence of acid inhibition because of the differences in the rates of acidogenesis and methanogenesis. For an efficient level to be achieved, pH regulation is needed. Another possibility is to separate the acidogenic and methanogenic pathways, the acidogenic stage being under external pH control. Through control of the pH of the methanogenic stage, the biogas production rate and methane yield can be enhanced by reduction of COD and bio solids (Metcalf *et.al.* 2003).

Purpose and Need of Anaerobic Bioreactors

Biogas technology is a manure controlling process that encourages the retrieval in addition consumption of biogas as energy by adjusting manure management practices to accumulate biogas. The biogas can be used as an energy source to breed electricity or for sale to the electrical network, or for central heating or chilling essentials. The naturally alleviated derivatives of anaerobic digestion can be cast-off in a various ways, subject on local needs and resources. Positive derivative uses embrace practice as crop nourishment.Production of biogas concluded an-oxygenic digestion of animal manure and slurries and of an extensive variety of digestible biological wastes, alters these substrates into renewable energy and deals an accepted enricher for farming. It eliminates the organic portion after the total unwanted streams, aggregate this approach the competence of energy alteration by incineration of the enduring wastes and the natural steadiness of landfill locates.

Methodology

The process of biogas formation is a result of linked process steps, in which the initial material is continuously broken down into smaller units. Specific groups of micro-organisms are involved in each individual step. These organisms known as Methanogens, successively decompose the products of the previous steps. Methanogens are usually coccoid (spherical) or bacilli (rod shaped). There are over 50 described species of methanogens, which do not form a monophyletic group, although all methanogens belong to *Archaea*. They are anaerobic organisms and cannot function under aerobic conditions. They are very sensitive to the presence of oxygen even at trace level. Usually, they cannot sustain oxygen stress for a prolonged time. However, *Methanosarcinabarkeri* is exceptional in possessing a superoxide dismutase (SOD) enzyme, and may survive longer than the others in the presence of O_2. Some methanogens, called hydrogenotrophic, use carbon dioxide (CO_2) as a source of carbon, and hydrogen as a reducing agent.
The simplified diagram of the AD process, shown in Figure 1, highlights the four main process steps: Hydrolysis, Acidogenesis, Acetogenesis, and Methanogenesis.(AL SEADI *et.al.* 2001).

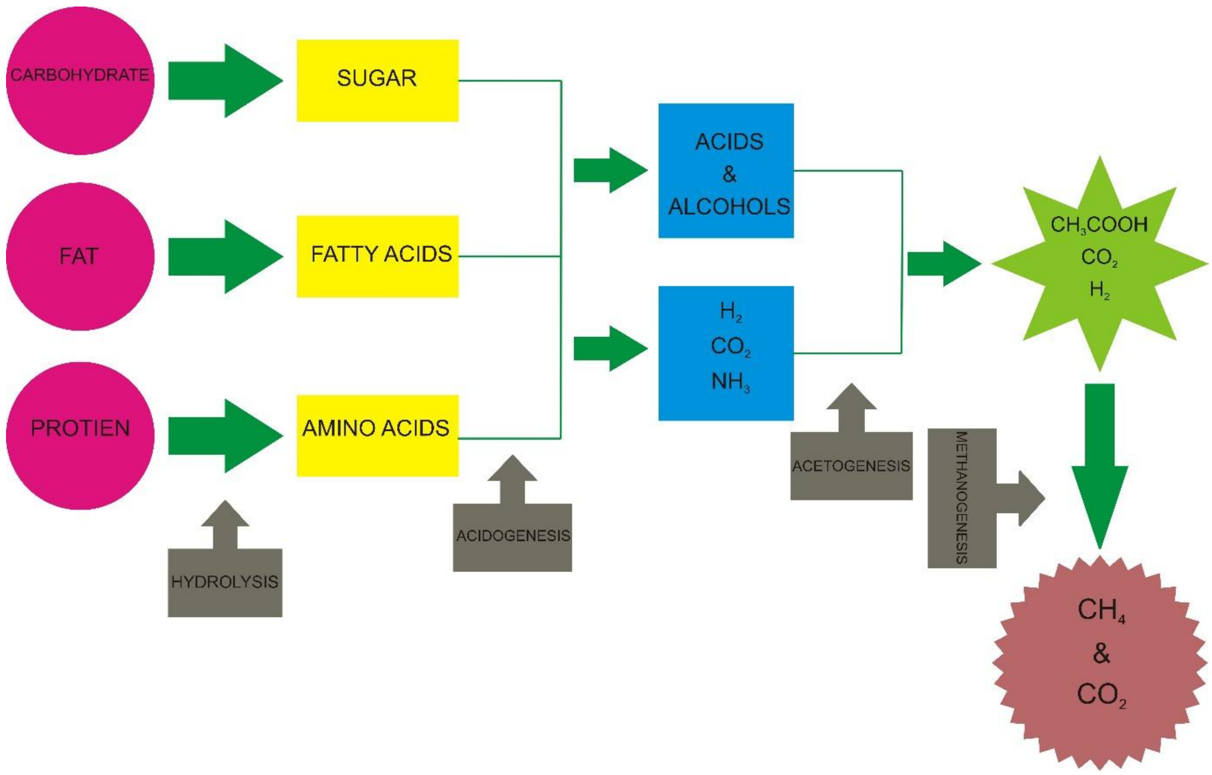


Figure 1: The process of Anaerobic Digestion

Bio-chemistry of the process

The process of Anaerobic Digestion takes place in following three steps:

1. Hydrolysis

Hydrolysis is hypothetically the primary stage of anaerobic digestion, during which the complex organic matter (polymers) is decomposed into smaller units (mono- and oligomers). During hydrolysis, polymers like carbohydrates, lipids, nucleic acids and proteins are converted into glucose, glycerol, purines and pyridines. Hydrolytic microorganisms excrete hydrolytic enzymes, converting biopolymers into simpler and soluble compounds as it is shown below in Figure 2:

Lipids → Fatty Acids

Polysaccharides (Carbohydrates) → Monosaccharide

Protiens → Amino Acids

Figure 2: Conversion of various biomolecules into simpler counterparts

A range of microbes is included in hydrolysis, which is supported out by exoenzymes, created through those microbes which decay the undissolved particulate solid. The products bring about after hydrolysis are additional decayed by the microbes included and consumed for their own metabolic routes.

2. Acidogenesis and Acetogenesis

All through acidogenesis, simple sugars, amino acids and fatty acids are degraded into acetate, carbon dioxide and hydrogen (70%) along with volatile fatty acids (VFA) and alcohols (30%). Alcohols are oxidized into methanogenic substrates alike acetate, hydrogen and carbon dioxide. VFA, stay oxidized into acetate and hydrogen. The generation of hydrogen increases the hydrogen partial pressure. It can be considered by means of a "waste product" of acetogenesis and prevents the metabolism of the acetogenic bacteria. During methanogenesis, hydrogen is converted into methane. Acetogenesis and methanogenesis commonly track parallel, as symbiosis of two groups of organisms.

3. Methanogenesis

Methanogenesis is the most important step in the intact anaerobic digestion practice, by means of this is the slowest biochemical reaction of the route. Methanogenesis is strictly inclined by process circumstances viz. composition of feedstock, feeding proportion, temperature, and pH, electrolyte concentration etc. The formation of methane and carbon dioxide from middle products is conducted by methanogenic bacteria. 70% of the formed methane creates from acetate, whereas the enduring 30% is formed from exchange of hydrogen (H) and carbon dioxide (CO_2), conferring to the following equations:

Acetic Acid → Methane + Carbon Dioxide

Hydrogen + Carbon Dioxide → Methane + Water

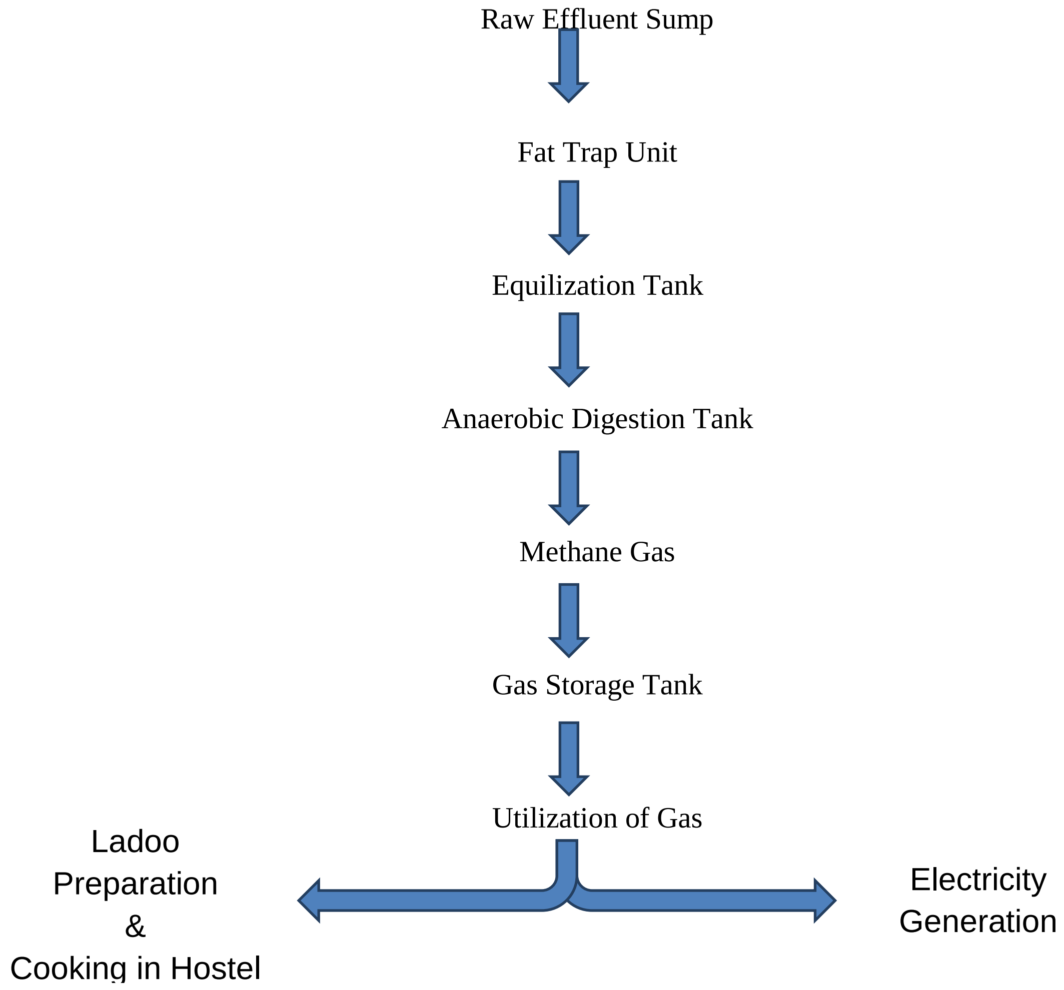
Figure 3: Process of Methanogenesis

Case Study: Anaerobic Digestion of Dairy Effluent at Vidya Dairy, Anand (Gujarat)

This study is done at the Vidya Dairy on its in house built anaerobic bioreactor for the production and utilization of methane gas from the organic sludge. The design of the Effluent Treatment Plant of capacity 300 m^3 per day installed at Vidya Dairy is as follows:

1. Raw Effluent Sump:
   Length: - 5.3 m, Width: - 5.3 m, Height: - 2.82 m, Total Area: 79.21m^3
2. Fat Trap Unit:
   Length: - 2.19 m, Width: - 1.5 m, Height: - 1 m, Total Area: 19.71m^3
3. Anaerobic Filter:
   Length: - 5.7 m, Width: - 5.38 m, Height: - 4.40 m, Total Area: 134.93m^3
4. Rot pump:
   Capacity 17,000 l/h.
5. Equalization Tank:
   Length: - 5.7 m, Width: - 5.38 m, Height: - 4.40 m, Total Area: 134.93m^3

The flow of the effluent in the ETP is as given below:



Vidya Dairy is a commercial dairy which handles 1 lac litre milk per day. Different products which are being manufactured at Vidya dairy including Pasteurized Milk, Mozzarella Cheese, Paneer, Cheddar Cheese, Butter and Ghee, Ice cream of plain as well as fruit and nuts varieties. During manufacturing CIP chemicals, sanitizers, waste water, traces of milk solids and cheese whey as a byproduct of cheese moved to Effluent Treatment Plant daily. On an average 1.5 lakh litre liquid effluent generates every day which has a BOD value of 2500 ppm.

As stated in diagram, the liquid wastes are collected in the screen sump from where it is shifted to Raw Effluent Sump. Asides of raw effluent sump, there is a provision of 2 roto pumps which transfer Raw Effluent to Fat Trap Unit where oil and greasy materials are committed for separation. From Fat Trap Unit, further the effluent is transferred to Equalization tank where the solid and liquid waste materialsare homogeneously distributed. From equalization tank, effluent is transferred to anaerobic tank. In the anaerobic gas tank, liquid waste is used as a substrate for the methanogenic bacteria which are provided for different steps including hydrolysis, acidogenesis, acetogenesis, and methanogenesis.After the process is completed, methane is produced having concentration of almost 70%. Along with methane, 30 % of the trace gases are also generated including carbon dioxide and Hydrogen Sulfide. Further this mixture of gas is treated with Gas Purification System where purity of methane gas rises to >90 %. Biogas slurry is further purified from with the treatment of aeration tank, secondary clarifier and final clarifier where the final discharge becomes an end product. Final Discharge water which is the end product of Effluent treatment plant has the COD value on an average 40 to 50 ppm is generally using for gardening process. Generated methane is used to generate electricity as well as for cooking purposes in the mess of Vidya Dairy hostel.

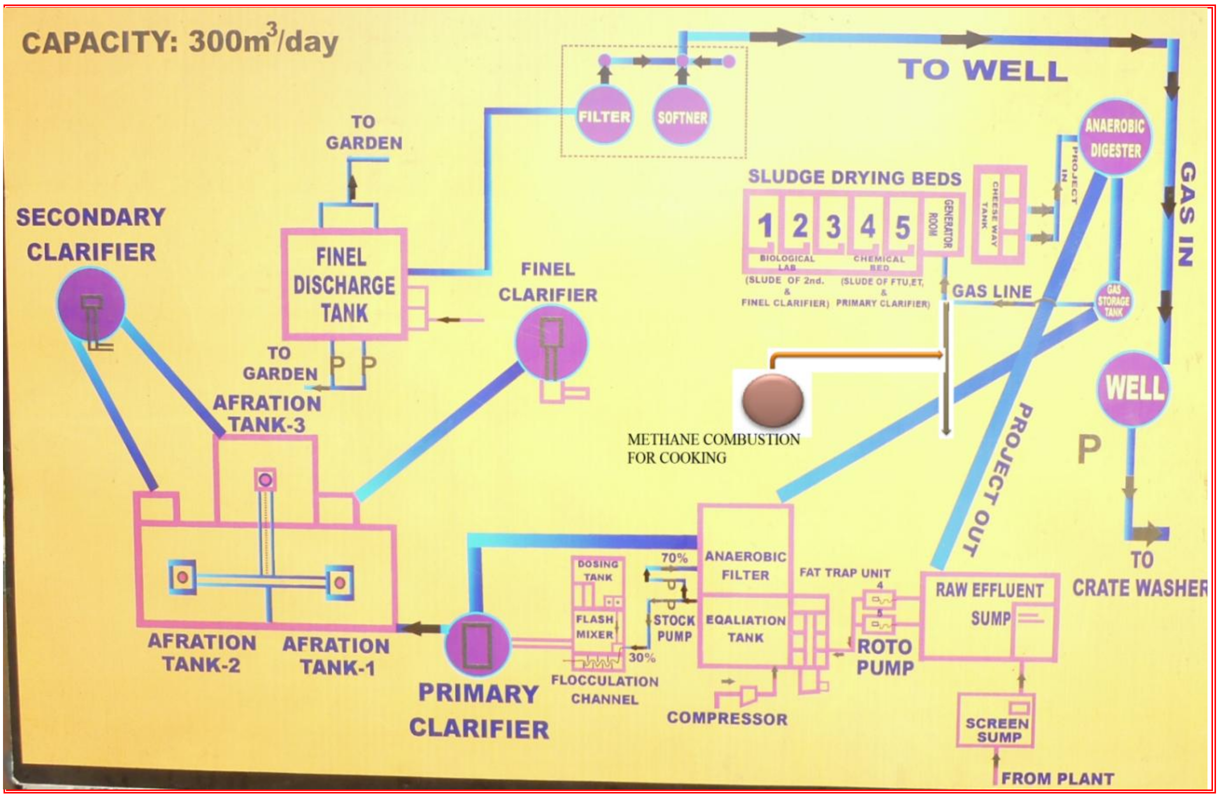


Figure 4: Schematic Diagram of Effluent Treatment Plant at Vidya Dairy

Benefits of the project:

Renewable energy source

The current global energy basis is enormously dependent on fossil bases. They are fossilized remainders of dead plants, animals and birds which tolerate to temperature and pressure in the Earth's missile upstairs hundreds of centuries. Conflicting fossil oils, biogas starting anaerobic biogas plants is permanently renewable and will not merely progress the energy equilibrium of a nation nevertheless furthermore make a dominant support to the secure the natural possessions and to environmental protection.

Reduced greenhouse gas emissions and mitigation of global warming

Application of fossil fuels alike hard coal, crude oil and natural gas transforms carbon, stowed for lots of years in the Ground's shell, and discharges it by way of carbon dioxide into the atmosphere. An upsurge of the existing CO2 concentration in the air origins global warming by means of carbon dioxide is a greenhouse gas. The burning of biogas also discharges CO2. Nevertheless, the focal dissimilarity, while compared to fossil fuels, is that the carbon in biogas is in recent times up taken from the atmosphere, by photosynthetic action of the plants.

Reduced dependency on imported fossil fuels

Fossil fuels are inadequate capitals, founded in limited terrestrial zones of our globe. This creates, for the countries outside this area, a enduring and insecure position of reliance on import of energy. Major nations are strongly reliant on on fossil energy importations from counties rich in fossil fuel bases. Emerging and applying renewable energy arrangements such as biogas from anaerobic digestion, created on domestic and local biomass capitals, will upsurge safety of countrywide energy resource and reduce reliance on imported fuels.

Waste reduction

The main returns of biogas generation are the capability to transform waste particulates into a appreciated supply, by means of it as substrate for anaerobic digester. Numerous emerging nations are in front of massive difficulties accompanying with overproduction of carbon-based wastes from manufacturing, farming and households. Biogas manufacture is an outstanding way to comply with increasingly restrictive national regulations in this area and to exploit carbon-based wastes for energy production,

Flexible and efficient end use of biogas

Biogas is a supple energy transferor, appropriate for several diverse uses. The humblest claims of biogas is the straight usage for cooking and illumination, nevertheless in numerous nations biogas is castoff currently for united heat and power generation or it is promoted and nourished into natural gas networks, utilized as means of transportation fuel or in fuel cells.

Low water inputs

While matched to another biofuels, application of biogas has some advantages alike is that the anaerobic digestion practice essentials the lowermost volume of process water. This is a significant feature allied to the probable forthcoming water scarcities in several areas of the globe.

Closed nutrient cycle

After the manufacture of feedstock to the submission of digestate as fertilizer, the biogas on or after anaerobic digestion delivers a closed nutrient and carbon cycle. The methane (CH_4) is used for energy generation and the carbon dioxide (CO_2) is released to the atmosphere and re-up occupied by plants through photosynthesis. Certain carbon complexes stay in the digestate, improving the carbon concentration of soils, as soon as digestate is smeared as fertilizer. Biogas generation can be faultlessly incorporated into conservative and organic farming, wherever digestate substitutes chemical nourishments, made with intake of huge extents of fossil energy.

Flexibility to use different feedstock

Numerous kinds of feedstock is castoff for the generation of biogas: animal dung and slurries, harvest rests, organic wastes from dairy manufacture, food trades and agro-industries, wastewater mud, organic segment of public solid litters, organic wastes from houses and from cooking business as well as energy crops. Biogas is also composed, with extraordinary setting up, from landfill locations. Main advantage of biogas production is the capacity to use "wet biomass" kinds as feedstock, altogether considered by wetness content upper than 60–70% (e.g. manure sludge, animal slurries, launch sludge from foodstuff treating etc.). In modern era, a number of energy harvests have been chiefly recycled as feedstock for biogas production in nations like Austria or Germany. In addition energy crops, total breeds of agricultural deposits, broken crops, inappropriate for nutrition or subsequent from critical rising can be recycled to generate biogas and fertilizers. A number of animal by-products, not appropriate for humanoid consumption, can also be administered in biogas plants.

Reduced odors and flies

Storing and use of fluid compost, animal manure and numerous carbon-based wastes are foundations of determined, unfriendly odors and attract flies. Anaerobic digestion reduces these odd smells by up to 80%. Digestate is practically odorless and the lasting ammonia odors evaporate soon subsequently use as fertilizers.

Future Issues

From the above installed anaerobic digestion plant, versatile benefits occurs due to generation of methane gas which suggesting that the small model can be employed and replicated for commercial production of methane by dairy effluents.

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OHMIC HEATING: SELECTIVE APPLICATIONS IN DAIRY PROCESSING

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ABSTRACT

Ohmic or resistance heating is a novel thermal process that have a great potential to heat foods volumetrically/uniformly at very rapid rates to produce foods which are microbiologically safe and have superior quality.Betterproducts with enhanced shelf life,rapidity, lower capital cost, better energy efficiency and eco-friendly process are main merits of this technique.This process is particularly suitable to treat viscous, fragile and foods that contains particulates. In food processing, it is being used for blanching, evaporation, dehydration, fermentation, extraction, sterilization, heating of foods to serving temperatures. Potential of this process in dairy industry can be utilized in aseptic processing, pasteurization and sterilization of milk and milk based products. In Indian scenario, OH had potential to treat particulates and concentrated foods like *Kheer, Basundi*and *Payasams*.

Introduction

In the current competitive situationof food processing sector due toan rapidincreasing number of global consumerthatkeeps aconstant watch on processed food quality as well as the impact of processing methods on environmental balance motivates the worldwide researchers/scientists to evolve and evaluate novel processing tools capable to satisfy theircustomized needs in terms safe, healthy foods without disturbing the eco-system. Over the decades, a number of alternative thermal as well as non-thermal processes have been developed to produce foods retaining “wholesomeness”yet the search of other such novel process is still ongoing. Ohmic heating, microwave as well as the infrared heating, high pressure processing etcare considered as novel thermal processeswhile ultrasonication, irradiation, white/ pulsed light technology, UV rays are falls under the non-thermal novel processes.Barbosa-Cánovas and Bermúdez-Aguirre (2010)reported that these processes have the potential to providepasteurized milk (most common dairy product) that is at par with classical pasteurizedmilk in terms of nutritional and sensorial quality attributesand with enhanced shelf-life.

Ohmic heating is one of the novel thermal process which is also known as Joule heating, Electric heating, electroheating, and electroconductive heating (Vicente et al. 2006). Moreover, recently Varghese *et al.*, (2012) reported that this process is one out of different electromagnetic oriented processes like capacitive dielectric, radiative dielectric,inductive and radiative magnetic heating.The process which, is exclusively developed to generate as well as dissipate heat within the material (which are suitable for OH, not all) itself using its own resistance by subjecting it to an alternating current is known as Ohmic heating.Thus, it is totally differed from other conventional processes which raise the temperature of target food material through three classical modes of heat transfer i.e. conduction, convection and radiation because the generated heat directly transferred to food omitting the need of any solid-liquid interfaces (Knirsch et al. 2010).

Principle of Ohmic Heating

In simple words, the basic principle of Ohmic heating consists,flow of electric current (AC) through the suitable (from which electrical current can pass) food material. As per Ohm’s law ($V= I\times R$) the electrical energy will convert into thermal energy owing to resistance of food material and also get dissipated volumetrically there itself.Moreover, the electrical device which uses the resistance of the treated material to heat it is known as Ohmic or Joule heater (Sakr and liu, 2014). Different components of an Ohmic heater and its block diagram of this process is shown in Figure 1 while,therelationship between electrical conductivity and ohmic heating of different foods are given in Table 1.

Important Terminology Related to Ohmic Heating

Electrical Conductivity (σ)

It is the main parameter that enables the Ohmic heating to occur and also decides the rate of heating in it. It is measured by the quantity of electricity transferred across a unit area, per unit potential gradient and per unit time. The electrical conductivity of any substance is typically given by the sum of the electrical conductivity of individual ions, molar equivalent concentrations of individual ions and molar equivalent conductivity (Robinson and Stokes, 1959). Ohmic heating is only possible**in range 0.01-10S/m σ** while, it works optimally in the range **0.1-5 S/m of σ**.It is the ratio of current density (J) and electrical field strength (E) and represented as Siemens per meter (S/m) in SI units. It can be calculated by following formula (Zell *et al.*, 2009).

$$\sigma = \frac{L \times I}{A \times V} \ldots\ldots\ldots 1$$

Where A is the cross -section area of the material in the heating cell (m^2), L- gap between two electrodes (M), I – electric current (AC) passing through the material (A), V- voltage across the material (V).

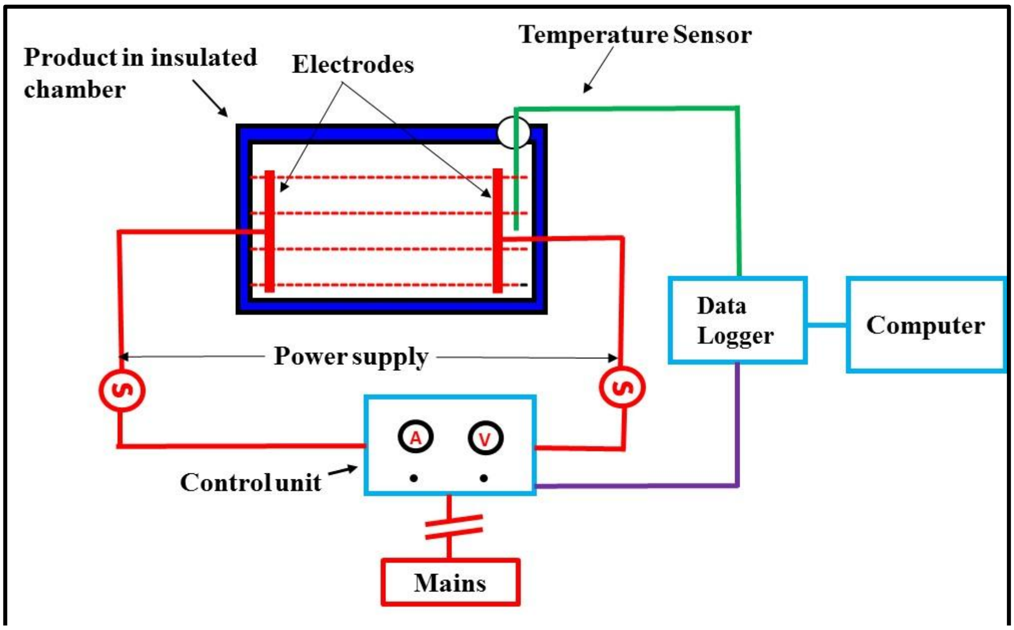

Figure1: Batch Ohmic Heater

Table 1 Relationship between electrical conductivity and ohmic heating of different foods.

Products	**σ (S/m)**	**Ohmic heating**
Condiments, eggs, yoghurts, milk desserts, fruit juices, wine, gelatine, hydrocolloids, etc.	> 0.05	Good
Margarine, marmalade, powders, etc.	0.005 < σ < 0.05	Low
Frozen foods, foam, fat, syrup, liquor, etc.	< 0.005	Poor

Source: Goullieux and Pain, 2005

Heating Power

The energy (P) given to the ohmic heating system to prescribed temperature are calculated by using the current (I) and voltage (ΔV) values during heating time (Δt) as reported by Icierand Ilicali, (2005).

$$P = \Sigma V I \Delta t \ldots\ldots\ldots\ldots\ldots\ldots 2$$

Heating Rate

Due tothe flow of electricalcurrentthroughtheheating sample, asensibleheatisgeneratedcausingthetemperatureof the samplerisefrom T_i(initial)to T_f(final), theamountofheatgiventothesystem can becalculatefromthefollowingequation as reported by Ghnimi*et al.*,(2008):

$$Q = mcp(Tf - Ti) \ldots\ldots\ldots\ldots\ldots 3$$

Energy Efficiency

Nguyen *et al.*, (2013) defined energy efficiency in OH as

$$Energy\ efficiency = \frac{Energy\ utilized\ to\ heat\ the\ sample, mcp(Tf - Ti)}{total\ input\ energy\ , \Sigma VI\Delta t} \ldots\ldots\ldots\ldots .4$$

Merits and limitations of Ohmic heating

Merits and limitation of OH system has been recently reported by Sakr and liu, (2014) and shown in following Table2.

Merits	demerits	Suggestions for betterment
Very quickly achieve desired temperature	Lack of generalized information	Develop predictive, determinable and reliable models of ohmic heating patterns
Rapid uniform heating of liquid with faster heating rates	Requested adjustment according to the conductivity of the dairy liquid	Further research should be conducted to develop a reliable Feedback control to adjust the supply power according to the conductivity change of the dairy liquid
Reduced problems of surface fouling	Narrow frequency band	Developing real-time temperature monitoring techniques for locating cold-spots and overheated regions during ohmic heating
No residual heat transfer after shut off of the current	Difficult to monitor and control	Developing of adequate safety and quality- assurance protocols in order to commercialization ohmic heating technology
Low maintenance costs and high energy conversion efficiencies	Complex coupling between temperature and electrical filed distribution	
Instant on -off facility		
Reduced maintenance costs because the lack of moving parts		
A quiet environmentally friendly system		
Reducing the risk of fouling on heat transfer surface		

Source: Sakr and liu, (2014).

Applications of Ohmic heating in dairy industry

Recently, Lien *et al.*, (2014) investigated the suitability of ohmic heating to heat soya milk (10 ^{0}Brix) up to 90˚C for tofu manufacture. They observed that as the result of voltage increase, rise in temperature of soya milk was ranged from 1.46-3.82˚C/min. this research group concluded that OH is an efficient and convenient technique for tofu making.Sun *et al.*, (2008) investigated the efficacy ohmic heating on microorganism's destruction in milk and compared with classical heating under equal temperature history. They sterilized milk samples by both methods and observed that reduction in microbial counts and D value of OH treatment were significantly lower than classical heating method. Their results revealed that OH had thermal and non-thermal effects on MO's due electrical current.Knirsch*et al.*, (2010) also proposed that OH induces electroporation of cell membranes.The application of Ohmic heating in milk pasteurization and sterilization has been investigated by number of researchers. To compare the inactivation effects of ohmic heating and conventional heating on total plate count, yeasts and molds, coliforms, *E. coli* and *salmonella*, in buffalo milk under identical temperature conditions, Kumar et al. (2014) carried out trials on heating of buffalo milk using ohmic heater and subsequent manufacture of paneer from that milk. Buffalo milk was heated from 20°C to 72°C using ohmic heater as well as conventionally. Then the paneer manufactured conventionally as well as using ohmically treated milk was evaluated sensorially as well as microbiologically. Paneer manufactured employing direct acidification process. The sensory evaluation of the revealed that all the sensory attribute score of paneer made from ohmically treated milk were significantly higher than paneer manufactured conventionally. Hardness value was found lower in case of paneer made from ohmically treated milk than that made conventionally. The microbial quality of ohmically treated milk was superior than raw milk and milk heated conventionally. The results of this study suggest that ohmic heating technique is more efficient in microbial inactivation than conventional heating.

Lien et al., (2014) investigated the suitability of ohmic heating to heatsoya milk (10 ^{0}Brix) up to 90˚C for tofu manufacture. They observed that as the result of voltage increase, rise in temperature of soya milk was ranged from 1.46-3.82˚C/min. this research group concluded that OH is an efficient and convenient technique for tofu making. Milk was pasteurized using OH at
the early 20th century (Quarini 1995).

Selective applications of Ohmic Heating in dairy processing:

Several researchers had reported different exists applications of Ohmic heating is presently being used forblanching, evaporation, dehydration, fermentation, extraction, sterilization, sterization and heating of foods to serving temperatures as well as for space foods (Knirsch*et al.*, 2010).

OH had great scope in in dairy processing to replace traditional sterilization/canning/ retorting as it can aseptically process different liquid products like milk, lassi, butter milk, condensed and evaporated milksetc because they fall in the prescribed electrical conductivity range. Ohmic heating is well known to process foods containing particulates and fragile as well as viscous products. It has wide potential in the manufacture of traditional dairy products like Kheer, *Payasams and Basundi*. Inactivation kinetics of different milk enzymes by Ohmic heating still awaited. Investigation to accesses the suitability Ohmic heating in fermentation process shouldbe taken more vigorously as it is already reported that OH had potential advantages during fermentation process which is the main process to produce several fermented Indian dairy products like *curd/yoghurt*,*lassi*, *Shrikhand* etc.It has been already established by Loghavi*et al.*, (2009) that due to electroporation carried out by OH, is helpful in faster and more efficient nutrient transport to the interior of the cell and reduced the lag phase of the fermentation process of *L. acidophilus*.This particular application must be studied for different dairy starters and probiotic cultures. Finally the pasteurization as well as sterilization of dairy fluids can be studied by paying attention particularly towards the destruction of minor milk components in OH in comparison traditional heating methods. Till now, systematic and scientific evaluations of the series of changes that occurs in pasteurization/ sterilization of buffalo milk needs to be studied.

Conclusion

Ohmic heating have a great potential to process suitable products volumetrically as well as rapidly. Viscous, fragile and particulate containing foods can be easily processed by OH compared to other classical processes without compromising with nutritional and sensorial attributes of that food. It requires lower capital cost compared to other electro heating methods. Awareness as well as lot of work is needs to be carried out to explore its full potential in Indian scenario.

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ENGINEERING PROPERTIES OF *TOUKIR* AND ITS INCORPORATION IN THE PREPARATION OF *GULABJAMUN*

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ABSTRACT

The engineering properties such as bulk density, angle of repose, colour, specific heat, thermal diffusivity, thermal resistivity, glass transition temperature, etc., and the microstructure of *toukir* were determined at moisture contents of 3, 6, 9 and 12% d.b. The bulk and tapped densities decreased from 630 to 530 kg/m^3 and from 930 to 750 kg/m^3, respectively, with increasing moisture content. The L*, a* and b* values were found to be 95.74, -0.01 and 3.30, respectively. The volumetric specific heat, thermal conductivity, and thermal diffusivity of *toukir* increased from 1466.1-1645.1 kJ/m^{3}K, 0.141-0.158 W/mK and 0.08-0.09×10^{-6} m^2/s with increasing moisture. The particle distribution analysis showed that the average particle size of *toukir* was 15.53±0.037 µm at 3% moisture, which increased considerably to 16.684±0.037 µm at 12%. The T_g decreased from 70.91 to 62.65ºC as moisture content increased from 3 to 12%. The SEM micrographs revealed that the starch granules had tetrahedral shape. The dough expansion of fried *gulabjamun* was 1.255 to 1.221 with the porosity value between 18.21 to 34.34%. Corresponding percent volume change was 25.11, 17.68, 24.60 and 21.91%. From the textural and sensorial qualities, it could be concluded that *maida* could be safely replaced with *toukir* at 12% level.

Introduction

Toukir, (*Curcuma angustifolia* Roxb, family Zingiberaceae), is a tuber commonly found in the hilly tracts of Central India, West Bengal and in some of the lower Himalayan ranges. It is also known as East Indian arrowroot. The rhizomes produced contain mostly starch (*toukir*), which is similar to arrow root. It is taken as a dietary aid in gastrointestinal disorders and also used for therapeutic purpose. In traditional local medicine, *toukir* is considered a cardiac tonic, diuretic and is good for peptic ulcers because of its soothing effect (Kumari *et al.*, 2012).

Toukir is used in the preparation of *khoa-jalebi* as a binder and to improve the soaking ability of sugar syrup. The process of preparation of *khoa-jalebi* containing *toukir* was optimized by Pagote *et al.* (2012). Similarly, Kumari *et al.* (2012) prepared *khoa-jalebi* containing *toukir*, and evaluated the samples for fat content, sugar syrup absorption, hardness and sensory parameters. The knowledge of engineering properties and their dependence on moisture content is useful in the design and development of processing methods and equipment. However, data on physico-thermal, microstructural and flow properties of *toukir* are not available. Determination of these properties as a function of moisture content becomes important because *toukir* has a wider application in the preparation of many indigenous dairy products. Particularly, it has the potential to replace maida in products such as *gulabjamun*, *pantoa*, etc. Therefore, the objectives of the present study were to determine the physico-thermal, microstructural and flow properties of *toukir* as affected by moisture content. In addition, the effect of substitution of *toukir* (as a replacement to maida) on the properties of *gulabjamun* was studied.

Materials and Methods

Toukir was collected from the local market of Nagpur, Maharastra. A Minolta colour spectrophotometer was used to determine the colour of *toukir* powder in terms of CIELAB parameters. For angle of repose, a free-standing pile was formed by allowing the powder to pass through a fixed funnel. The images of the

pile of *toukir* were acquired and the angle of repose was measured using Image J software (ver. 1.45). The "Drop snake" tool from the ImageJ plugin was used.
The particle size distribution of *toukir* in the dry method was estimated by laser diffraction technique in a Malvern Mastersizer 2000 particle size analyzer. The microstructure of *toukir* was examined using a scanning electron microscope. The glass transition (T_g) of *toukir* powder was determined using a differential scanning calorimeter. The thermal properties of *toukir* powder such as thermal conductivity, thermal diffusivity, thermal resistivity and volumetric specific heat were determined using a thermal properties analyzer. The powder flow properties such as dynamic, bulk and shear properties were determined using Freemans FT-4 powder rheometer. The basic flowability energy (BFE), specific energy (SE), stability index, conditioned bulk density (CBD), aeration properties, compressibility, permeability and wall friction were measured.

Incorporation of *toukir* in *gulabjamun*
Dough for *gulabjamun* was prepared by blending khoa, maida (or *toukir*), baking powder in required proportion. The *toukir* was added at three different rates of 6, 12 and 18% on w/w basis of dough. Maida at 12% on w/w basis served as control. The balls were fried in an electric fryer at 140ºC for 7 min, and were tested for various physicochemical, textural and sensory qualities. The crust colour of *gulabjamun* after frying was measured using image analysis. For the determination of porosity, images of *gulabjamun* were acquired at 300 dpi and pre-processing, segmentation and crumb grain measurements were done using ImageJ program, and the cell to total area ratio (porosity) was calculated. The sensory evaluation of fried and soaked *gulabjamun* balls were carried out using fuzzy-logic approach.

Results and Discussion
The bulk and tapped densities decreased from 630 to 530 kg/m^3 and from 930 to 767 kg/m^3, respectively with increase in moisture content from 3 to 12%. The densities decreased with increasing moisture content due to bridging up of *toukir* particulates. Colour of *toukir*, in terms of L^*, a^* and b^* values, were 95.74, -0.01 and 3.30, respectively. From these values, it could be concluded that *toukir* had a high value of whiteness and a low value of chroma. The angle of repose at 3, 6, 9 and 12% moisture contents were 50.02, 54.49, 55.55 and 56.14º, respectively. The flowability of *toukir* decreased continuously (angle of repose increased) with increasing moisture content.

The particle size distribution graph of *toukir* is presented in Fig. and the cumulative volume percentage under different particle size is presented in Fig. The particle size parameters such as d(0.1), d(0.5), and d(0.9) increased from 9.51 to 9.71µ, 15.57 to 16.79µ, and 178.63 to 224.36µ, respectively as the moisture content increased from 3 to 12%. Scanning electron microscopic analysis of *toukir* showed the powder particulates were tetrahedral in shape, and were similar in structure to cassava starch. The SEM micrographs at different moisture contents also revealed the increase in particle size of *toukir* powder with increasing moisture content. The mean particle size increased from 17.33 to 19.19µ as moisture in *toukir* increased from 3 to 12%.

The glass transition temperature decreased linearly from 70.15°C at 3% to 64.65°C at 12% moisture content. Significant changes in thermal properties of *toukir* flour were observed with moisture content. The volumetric specific heat, thermal conductivity, and thermal diffusivity increased from 1.53 to 1.58 kJ/m^3.K, 0.141 to 0.158 W/m.K and 0.089 to 0.097×10^{-6} m^2/s, respectively as the moisture content increased from 3 to 12%. Consequent to the increase in thermal diffusivity, the thermal resistivity decreased from 7.104 to 6.539°cm/W with increasing moisture content.

The BFE value for *toukir* at 3% moisture content was lower as compared to 12%, indicating that *toukir* powder at 3% would be easier to move as compared to 12% in this forced flow regime. The SE values for 3 and 12% moisture content indicated that both samples were moderately cohesive. However, the SE value at 3% moisture was lower as compared to 12% moisture, indicating that it was the least cohesive sample in an unconfined flow regime. The CBD values of both samples were distinctly different. The higher CBD value of *toukir* at 3% moisture indicated it had efficient packing as compared to 12%. Aeration tests indicated that *toukir* at 3% moisture was slightly more sensitive to low levels of aeration as compared to *toukir* at 12%. However, *toukir* at 3% moisture had higher aeration ratio values as compared to *toukir* at 12%. This suggested that the *toukir* at 3% moisture would have an overall lower cohesivity in an aerated environment. Compressibility tests suggested that both samples were moderately compressible. *Toukir* at 3% moisture was less compressible as compared to 12%, which was another indicator of lower cohesivity and better packing in the lower moisture content sample. *Toukir* at 12% moisture had a considerably lower pressure drop (higher permeability) than at 3% moisture content, which again validated the previous findings. Lower wall friction angle values were observed at 3% moisture, suggesting that *toukir* would be more free-flowing at 3% moisture.

Gulabjamun was prepared using 0, 6, 12 and 18% *toukir* in the dough. The geometric mean diameter of fried *gulabjamun* made from *toukir* at 0, 6, 12 and 18% ranged between 28.411 to 29.260 mm. The sphericity ranged between 0.97 and 0.985, which was closer to 1. The dough expanded after frying, and the expansion ratio ranged between 1.255 to 1.221, depending on the *toukir* content in the dough and the pore development. The porosity of the product, as determined through image analysis, ranged between 18.21 and 34.34%. The percent volume change in 0, 6, 12 and 18% *toukir* added *gulabjamun* after soaking was calculated as 25.11, 17.68, 24.6 and 21.9%, respectively. The highest percent change in volume was observed in control followed by *gulabjamun* added with 12% *toukir*. The mean L^* value of 6, 12 and 18% *toukir* added *gulabjamun* was measured as 26.22, 28.09 and 29.01, respectively as compared to 30.78 for control. *Gulabjamun* made with 6% *toukir* was the darkest in terms of colour.

The thermal conductivity of 0, 6, 12 and 18% *toukir* added *gulabjamun* was recorded as 0.256, 0.245, 0.260 and 0.265 W/m.K, respectively. The differences in thermal conductivities were due to differences in porosities and moisture contents. Similar to thermal conductivity, the volumetric specific heat of *gulabjamun* also was significantly dependent on *toukir* content ($p<0.05$). The specific heat of 0, 6, 12 and 18% *toukir* added *gulabjamun* was recorded as 2.101, 1.769, 2.049 and 2.192 MJ/m^3K, respectively. The thermal diffusivity of 0, 6, 12 and 18% *toukir* added *gulabjamun* was measured as 0.120, 0.125, 0.128 and 0.152 mm^2/s, respectively. Consequent to the increase in thermal conductivity, the thermal resistivity significantly decreased with increasing *toukir* content.

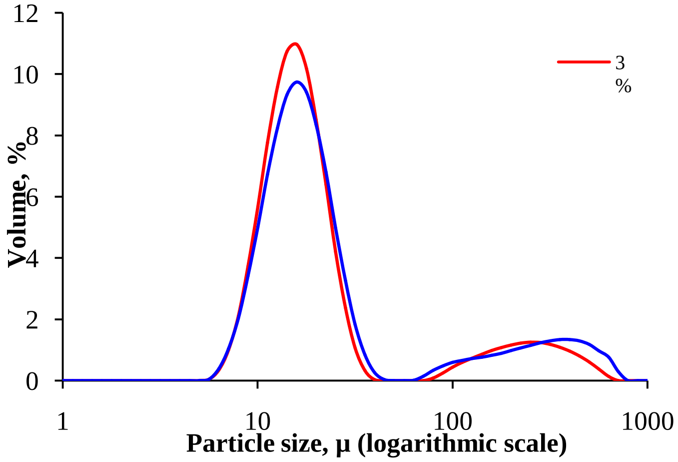


Fig. Particle size distribution of *toukir* at 3 and 12% moisture contents

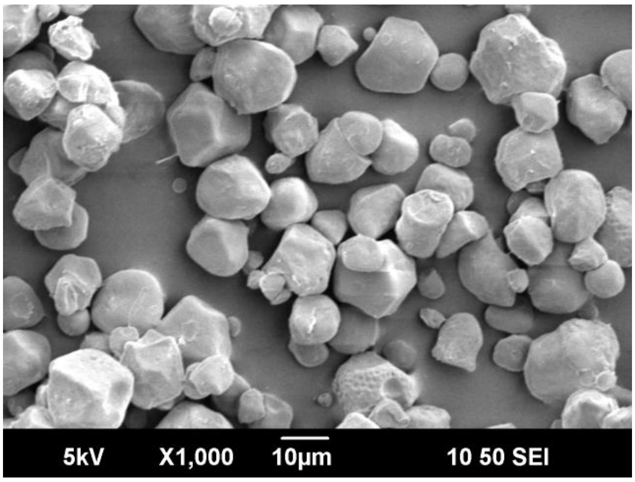
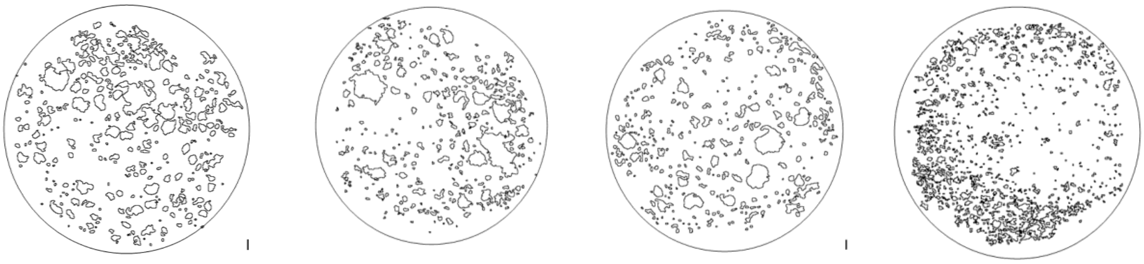


Fig. SEM micrograph of *toukir* at 12% moisture content

Sensory evaluation of *gulabjamun* was done using fuzzy-logic technique. For control and 18% *toukir* added *gulabjamun*, the highest similarity value was obtained under the category very good. For samples 2 and 4 (6% and 18% *toukir* addition), the highest similarity values were obtained under the category good and satisfactory, respectively. Thus, it could be concluded that both control and *gulabjamun* prepared using 12% *toukir* were adjudged as very good by the panelists. The addition of *toukir* had a significant influence on the sensory qualities of the product.



0% *toukir* (control) 6% *toukir* 12% *toukir* 18% *toukir*

Fig. Porosity in fried *gulabjamun* at different levels of *toukir*

Conclusions

Toukir could be characterized as a free-flowing powder, but could become cohesive at increasing moisture contents. Due to its cohesive nature, the bulk and tapped densities and flowability decreased with increasing moisture content. There was no significant difference in the characteristics of *gulabjamun* when *maida* was replaced with *toukir* at 12% level. However, as *toukir* content increased to 18% in the dough, the expansion and porosity of *gulabjamun*, and soaking became difficult. From the textural and sensorial qualities, it could be concluded that *maida* could be safely replaced with *toukir* at 12% level. *Gulabjamun* prepared is expected to have superior health benefits due to the medicinal properties of *toukir*.

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APPLICATION OF SOLAR ENERGY IN DAIRY AND FOOD INDUSTRIES

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ABSTRACT

Solar radiations are the most abundant energy source. With the advent of knowledge, these radiations can be converted into thermal and electrical energy. There are various operations in dairy and food industry where solar energy can be effectively used. For operations where heating of water/milk/Solutions to a temperature around 60-80^{o}C is to be done, Solar energy can be successfully used. The days are not far when each dairy farm/processing plant would have captive solar heating/ electrical energy generation units. Solar energy would prove to be boon for small as well as big milk product processing plant. Solar energy systems have already been developed for fulfilling the energy needs. The cost of processing would reduce by utilizing solar energy thus it would make products competitive besides improving textural and sensory properties. In the present paper, information has been collected for those dairy operations which have potential for utilization of solar energy. This would help in cutting the production cost so higher margin can be realized. The technology of utilization of solar energy is already developed but for adoption of the same long distance has to be traversed. The use of solar energy would bring revolutionary change in approach of small and big dairy processing plant towards energy needs and environment concerns.

Introduction

Solar energy is the most readily available and important source of energy because it is non-polluting, renewable, clean and inexhaustible. Solar energy also helps in reducing pollution and maintenance of eco-balance. Utilization of solar water heating system has been increased with 30% annual growth rate and these are now in commercialized stage and very mature in many countries in the world (Langniss and David, 2004). On earth's atmosphere the flow of solar radiation is 1353 W/m^2.This value is called solar constant. These radiations are divided into direct and scattered radiations. About 473 W/m^{2}is absorbed by the earth and can be used for various operations.Due to compact design and better heat transfer, solar systems find application in food, dairy, agriculture, textile, chemical, beverage industries for various purposes like water pumping, cleaning and sanitization, drying, sterilization, distillation, cooling, refrigeration and air conditioning etc. Solar energy system can be utilized for generation of photovoltaic and thermo dynamic electricity (Anantakrishnan and Simha, 1987). However, the limitations of solar energy are irregular availability, low flux density making necessary large surfaces to collect the energy for large scale utilization and energy storage problems.

Govindarajan *et al.* (1983) reported a few advantages of application of solar energy as a substitute or supplement to conventional sources of energy. Solar energy is an inexpensive and renewable source of energy for various industrial purposes. The processing industry uses considerable amount of energy in processing milk products. The cost of most of these energy resources is increasing continuously which in turn increases the processing expenses and hence the product cost. Emphasis need to be given on adopting energy efficient processing techniques and equipment for preparation of dairy products. It is necessary to adopt all possible energy conservation techniques to reduce gross energy required for processing. Solar energy based cabinet dryer have great potential for safe drying of dairy products.

Now a day, technology has been developed in such a way that solar energy is commercially feasible to collect. The cost of solar energy is static or rather decreasing. Simple technology of flat plate collectors installed on the roof of dairy plant and adjoining land area can be exploited for electricity generation. Solar energy system as non-conventional source is being developed for various applications. In process industries, it is mainly utilized for heating of water to be used for cleaning and as boiler feed. In this way, the dependency on already starving state electricity grids can be reduced which would result in less frequency of power cut offs. Presently, the Indian dairy industry has to bear increased cost of energy/litre of processed milk due to increased cost of traditional energy inputs/electricity. However these difficulties can be overcome by judicious exploitation of solar energy for meeting partial or full demand of energy requirement.

A. Application of solar energy in milk and milk products processing industries

(i) Application of solar energy in pasteurization

There is a tremendous scope of utilizing solar energy in dairy processing such as pasteurization of milk. Simple and reliable methods could be used to pasteurize milk and water with solar energy (Reddy and Verma, 1986; Safapour and Metcalf, 1998, Zahira *et al.*, 2009). Pandey and Gupta (2004) reported that the change in intensity of solar radiation had a direct impact on solar milk pasteurizer. The heat gain and temperature rises with the increase in solar intensity. In an experiment, milk was pasteurized successfully by solar energy using aluminum foil on cardboard. The glass window on solar milk pasteurizer increased the performance of pasteurizer. The milk temperature was reached the maximum value of 85°C. In some experiments, the temperature of milk was reached 72°C in two to three hours and this temperature is sufficient for pasteurization of milk (Pandey and Gupta 1983; Pandey and Gupta 2004).A practical low-cost milk pasteurizing system is fabricated and experiments were conducted in developing country like Pakistan (Zahira *et al.*, 2009). It was observed that the maximum base temperature of solar heated water reached up to 100^{o}C. They reported that pasteurizer have easily attained pasteurization temperature ranging from 65^{o}C to 75^{o}C in two to three hours.

Extensive studies have been made on a solar panel based milk pasteurization system to meet the demands for an acceptable pasteurization. Nielsen and Pedersen (2001) reported that the solar panel gave a maximum temperature of hot water at about 100^{o}C. For a large dairy processing plant, for milk pasteurization the requirements are (a) solar thermal loop containing collector array and storage with solar pump and (b) a process loop consisting of the pasteurizer and hot water pump and three way diverting valve and storage tank to store one day's peak solar collection.

(ii) Application of solar energy in drying

Shaw (2005) utilized an indirect solar cabinet dryer for drying of *khoa* and *chhana* which was developed by Malaviya and Gupta (1987) for drying of vegetables. In this dryer, atmospheric air enters through the front air inlet vent, it gets heated due to the solar radiations received by the solar collector. The solar reflectors help in further concentrating the radiations. The various parameters like specific heat thermal conductivity and thermal diffusivity of the product and convective heat transfer coefficient of process were applied to investigate the drying process. Solar dried *khoa* powder was found to have satisfactory reconstitutability while dried *chhana* did not give desired reconstitutability.

Dande *et al.* (2011) reported that the utilization of solar energy in dehydration of cow milk and manufacturing of *khoa*. They found that the chemical and sensory quality of *khoa* prepared using solar energy was as acceptable as made by traditional method. Benz *et al.* (1999) reported that evacuated flat plate and evacuated tube solar collectors were suited for heating applications in milk spray drying plant. Sahu (2012) utilized the solar water heating system assisted surface heat exchanger in preparation of *paneer*. They advocated that it could be effectively used at flow rate of hot water at 7 litre/min and inlet temperature of milk at 40^{0}C to produce good quality *paneer* with reduced manufacturing cost.

(iii) Application of solar energy for other milk processing purposes

In dairy processing centers, solar energy can be utilized for (a) preparing hot water for washing milk containers in milk chilling centers (b) preparing hot water for pasteurizing milk (c) making hot water for cheese making (d) chilling milk by adopting vapour absorption refrigeration system in milk chilling centers (e) air conditioning requiring hot or cold circulation and (f) drying *khoa* like products. Beside these operations solar energy can be utilized for generating electricity through photo-voltaic cells which can be conveniently used for operation of various fluid pumps/induction motors/air circulating fan and other electrically operated devices Hot water system ranging 5000 l/day to 75,000 l/day at 60°C to 85°C can be built depending upon the needs.

Efforts have been made to design and develop solar collectors for dairies. Use of solar energy is being widely emphasized given the fact that solar energy is abundantly available in the country. Hot water needed for washing, sterilization of cans and bottles and pasteurization of milk can be easily done by solar heaters. Different types of solar water heaters were fabricated and used for application in dairies (Verma *et al.* 1984).

Solar parabolic trough collector was used to run a vapour absorption system for refrigeration plant. It was also used for the chilling of milk in bulk milk cooler. Schnitzer *et al.*(2007) reported that in Austrian dairy industry, over 80% of the heating demands were in the range from 60°C to 80°C,For meeting this demand, solar energy is ideally suited for heating of water etc. Furthermore, they noted that this temperature was suitable for operations such as washing water in cheese production, preheating of cheese milk, outside cleaning, pasteurization, whey conditioning and cleaning in place (CIP) operations.

B. Application of solar energy in food processing industries

Utilization of solar energy for drying of foods has been in practice since ancient times. Open sun drying is slow and exposes the product to various losses and deterioration in quality. Benz *et al.* (1999) reported that solar heating can be applied also for cooking of meats (sausage and salami) and brewery industries for obtaining medium temperatures. In food industry also with solar heating, pasteurization and many other heat treatments like sterilization, dehydrations, drying, cooking, hydrolyzing, distillation, evaporation, extraction, polymerization, washing and cleaning can be completed. Solar dryers were also used successfully for drying of okra, pepper and maize. Drying took an average 3 days with the solar dryers compared to one week with ordinary sun-drying (Broos, 1996).

The dehydration of agricultural products can be completed utilizing solar energy. The system consisted of solar air heaters, blower, drying chamber and electrical back up. Philip (2006) reported drying of onion flakes in the solar dryer in 6.5-7 hours during the month of April-June. The cost of drying was estimated to be Rs 5.00 per kilogram of dried onion flakes. The quality of dried product was found to be acceptable (Malaviya and Gupta, 1987; Jayaraman *et al*., 1991). The pretreated vegetables were dried in solar cabinet drier away from direct sunshine. Maximum temperature attained inside the cabinet when run empty was 55°C.

Folaranmi (2008) designed, constructed and tested the simple solar maize dryer. It was designed in such a way that solar radiation is not incident directly upon the maize grains. The test results gave temperature above 45°C in the drying chamber and the moisture content of 50kg of maize reduced to about 12.5% in three days of 9 h each day of drying. Chandak *et al*. (2002) reported that different solar concentrators can provide excellent boiling, steaming, blanching and roasting capabilities while solar air dryers/heaters can effectively remove moisture. They also reported field trials on variety of solar gadgets like 'parabolic concentrators', box ovens and solar dehydrators.

Palaniappan (2009) reported that Planters Energy Network (PEN), a NGO has introduced roof mounted solar hot air technology. This is to be used for preheating or for final heating purposes depending on the temperature requirement for processing large quantities of food products. The technology was successfully adopted and is applied in the processing of various food products like tea, spices, fish, fruits, vegetables, pulses, grains and salt, etc. Sustainability of these units is already proven because 15 years old units are still functioning. Apart from larger solar air heating units in a hybrid mode with fossil fuel, PEN has demonstrated successfully smaller flat plate collector coupled with SPV operated driers for drying fruits in Ladakh and fish in coastal regions of India.

CONCLUSIONS

In recent years many solar gadgets have been developed for variety of applications. Efforts are required to integrate knowledge of dairy and food processing with capabilities of available solar thermal gadgets. Solar energy processed dairy and food products would not only benefit with huge fuel savings but would also acquire great value addition because of better quality of product in terms of colour, aroma and taste. Because of consistent product quality, food products processed on these units can enjoy great market potential for in-house and for exports as well. Capital investment in solar technology may further make it financially viable. Subsidy and incentive from Government of India may make the solar units to have a low pay back period and so it would have a greater potential in the country. Harnessing the solar energy to the maximum for dairy processing is advantageous. The use of solar energy will bring revolution particularly in the small scale dairy processing industries located in rural/far-off areas for dairy and food operations.

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INSTRUMENTS FOR SENSORY EVALUATION

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Introduction

Electronic Sensing systems such as Electronic noses and Electronic tongues have generated a great level of interest in the analytical laboratories of the world's leading food, flavours, and fragrance industries, as well as in the environment as a fast, simple, and reliable method of aroma/VOC analysis. Over the past 10 years, the sensing systems have demonstrated their ability to produce information (instead of a stream of data) and the ability to transfer expert knowledge from the R&D and trained sensory panels into a production environment for quality assurance and control. Smell and VOC qualities and intensities of chemicals products attracts an increasing level of attention from Food & Dairy industries and Research Institutes due to the fast , simple and reliable capabilities of the E-nose,E-Tongue and E-Eye approach. These systems reduce needs for GC and sensory evaluation and provide added safety when performing taste or olfaction assessment. These are simple to use and extremely fast.

The newest developments in the fields of Electronic Tongue in the Electronic Nose based on sensors arrays. ALPHA MOS is the leader among the companies in the world for smart sensing system. The working principles of instruments (E nose, E Eye and E tongue systems) for sensory evaluation are shown in Figs.1-4.

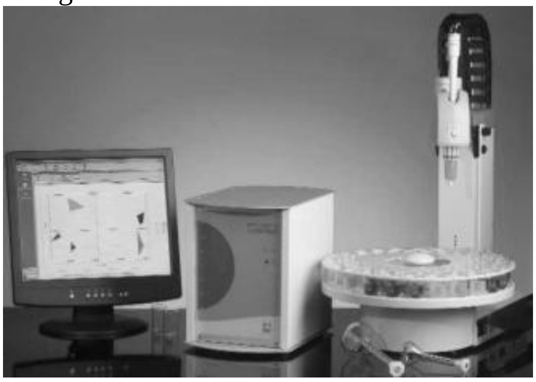

Fig. 1: ASTREE Electronic Tongue
Used for taste analysis study and formulation taste assessment, Taste ranking possible

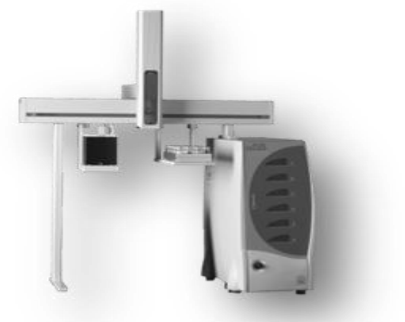

Fig.2: FOX Sensor Array Based Electronic Nose
Perform batch-to-batch variability control or pass/fail test correlated to human perception

Fig.3: HERACLES flash GC-pattern analyzer
Chromatogram obtained in 45 sec; sensitivity low ppb / high ppt range; several columns simultaneously; 44 000 molecules strong data banks and 2000 sensory attributes; used for flavor QC, release test, contamination

Fig.4: IRIS Eletronic Eye

Measure Colors type and intensities and identify and shape qualities
Correlates results with visual sensory appreciation

identification

Electronic Tongue

The Astree Electronic Tongue system represents an innovative smart sensing technique in the field of liquid and taste analysis. The instrument has been designed to analyze, recognize and compare complex dissolved organic and inorganic compounds in liquid matrixes (Fig.5.). As it is a fingerprint and comparative technique, correlations to the human tongue or liquid analysis technique can be made.

Fig. 5: Astree Electronic tongue system

Electronic Tongue Principle

The system principle can be compared to the taste human sense. A liquid sample is 'tasted' with the liquid sensors, which can play the role of the human gustatory receptor. The response is then analyzed as the brain can do (Fig.6).

Like human being, the instrument has to learn the different reference tastes to recognize. An unknown product can then be identified in terms of taste. A fingerprint is obtained which allows a quick comparison between the unknown sample and different classified tastes. The classification can be either done as same/different or good/bad samples. The Astree Electronic Tongue can be described as follows:

A sensor array

The technology used is currently based on electrochemical sensors. The system is built to be able to measure up to 7 sensors at the same time. The sensors are composed of an organic sensitive coating membrane to the species to analyze in the samples and a transducer, which allows converting the response of the membrane into signals that will be analyzed.

- Sensor response: few seconds
- Time between two measurements: 3 minutes
- Lifetime of the sensors: 6 months
- Accuracy: < 3 % dispersion
- Sensor to sensor reproducibility: good

An auto-sampler

The auto-sampler allows running automatically up to more than 40 different liquid samples plus some extra beaker for sensor cleaning purpose.

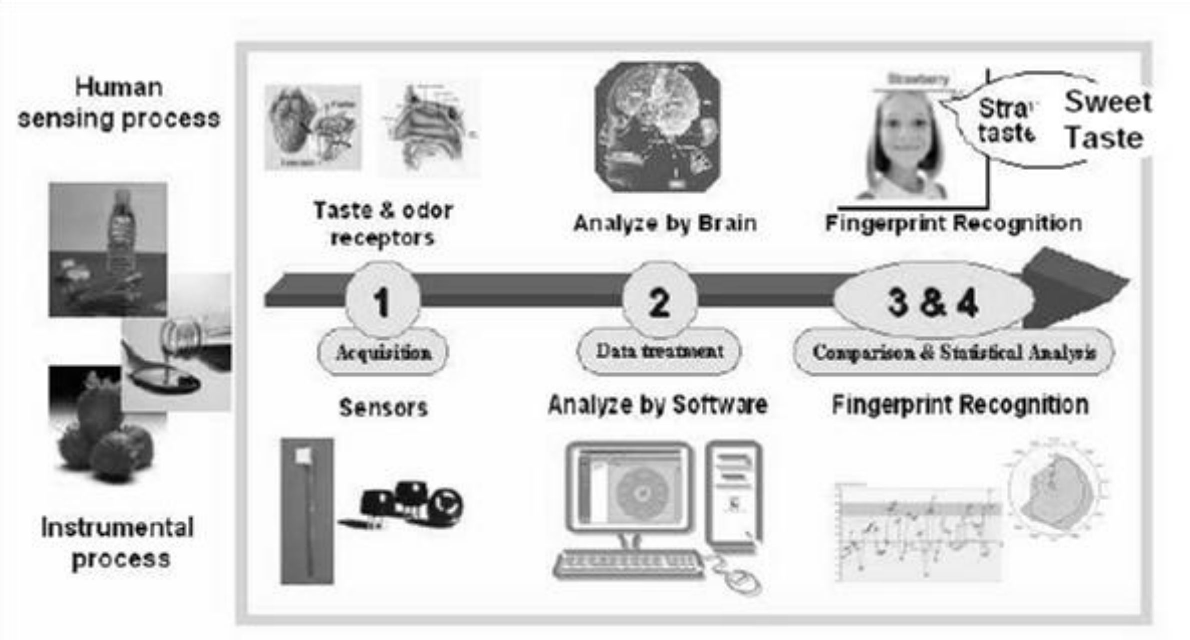

Fig. 6: Electronic tongue concept

The potentiometric electronic tongue

The α-ASTREE, Alpha M.O.S. Co., Toulouse, France is one of the best potentio-metric electronic tongue used in R & D. It includes the automatic sampling system, the sensor array with the reference electrode, the signal processing unit and a personal computer with the Software Astree 3.0.1 installed. The sensor array consisted of seven sensors coated with lipid/polymer material and a reference Ag/AgCl electrode. The interaction of compounds in the sample and the sensitive coating of sensors generate potential on the membranes which is measured between the sensors and the reference electrode. Potentio-metry is the direct application of the Nernst equation through the measurement of the potentials of non-polarized electrodes with no current flowing. The potentials depend on the nature and concentration of the ionic species in solution as well as on the medium and the type of electrodes.

The Astree Electronic Tongue instrument is based on the same principle than the Electronic Nose one.The Electronic Tongue allows the classification of liquid samples and quantification of present chemical species. This system gives qualitative and quantitative measurements of the liquid samples. This instrument presents the following advantages:

- Easy to handle
- Rapidity of the measurement
- Almost no sample preparation
- High throughput analysis with a liquid auto-sampler
- Objectivity compared to sensory panel
- No risk of toxic or Not Generally Recognized as Safe ingestion by humans
- No panel recruiting, no human fatigue

Electronic Tongue and Electronic Nose Comparison

Electronic Nose and Electronic Tongue instruments do not look at the same features when applied to the same sample. The information obtained is different. Electronic Nose sensors detect only the chemical species present in the headspace generated by the heating of the liquid samples.

The response obtained R can be formulated as follows:
R = f (SG , H (P))
SG corresponds to the gas sensors sensitivities; H (P) corresponds to the sample headspace generated.

Electronic Tongue sensors detect all chemical species present directly in the liquid samples. Only some of these species can be observed with the sample headspace generated H(P) – high vapour pressure species.

The response R obtained can be formulated as follows:
R = f (SL , P)
SL corresponds to the liquid sensors sensitivities; P corresponds to the liquid sample
The two instruments are complementary for most of applications.

Application of Sensory Instruments in Dairy and Food Industry

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Introduction

The demand for sensor arrays in the dairy and food industry is growing because the versatility and ease of operation of those instruments make them appropriate for fast and accurate analysis of various products or for monitoring quality in the production process. The commercial electronic tongue can be used for the evaluation of various products in the dairy industry.

The concept of electronic tongue or taste sensor has been developed rapidly in the last decade due to their large potential in food quality control. The electronic tongue is based on electrochemical sensors combined with multivariate data analysis. The electronic tongue uses a sensor array with partially overlapping selectivity to get information on quality parameters such as sample condition, the state of a process, or expected human perceptio. Sensors forming the array should exhibit various selectivity patterns to minimize correlation between sensor responses, which provides more information about the sample. The logic behind the applicationof low-selectivity sensors is based on an analogy to biological organization of the olfactory and taste systems in mammals. Millions of nonspecific olfactory receptors are located in the nose and tongue which respond to various substances in gas or liquid form. The signal is transmitted to the brain where olfactory neurons process the signal and the image of the sensed substance is formed. As the electronic tongue classifies particular properties in complex systems, the results are not necessarily compared to human sensation but with other quality properties in a sample. Various recognition techniques are appliedin electronic tongues; potentio-metry, volt-ammetry and conducto-metry being most commonly used. The data obtained from the electronic tongue is processed by multivariate data analysis (MVDA), primarily by principal components analysis (PCA) which explains the variance in the experimental data. Potentio-metric electronic tongues using lipid/polymer membranes have a concept of global selectivity which implies the abi-lity to classify vast kinds of chemical substances into several groups, as really found in the taste reception in biological systems. The measuring principle is based on the potential of electrodes across an ion-sensitive membrane with zero current flow. Volt-ammetric electronic tongues are based on metal electrodes with different selectivity and sensitivity patterns. Through these electrodes a varying potential is applied to change the current/voltage characteristics of an electrolytic solution which is then measured. Conducto-metry is the direct measurement of the conductance between two inert identical electrodes, so that most specific effects due to electrodes are eliminated. The use of sensor arrays in food analysis grew rapidly in the last decade. It has been used in wine analysis, honey classification, soy sauce analysis, water analysis and other beverages like soft drinks, beer, tea, coffee and milk. Other uses, which do not include food analysis, are microbial species detection, heavy me-tals detection , rare earth metal ion detection and ion detection. Sensor arrays combined with multivariate data analysis are a powerful tool for monitoring quality control in various fields of dairy industry. Both the electronic nose and electronic tongue were used in the assessment of dairy products.

Multivariate statistic

Interpretation of data with multiple variables such as several sensors and multiple samples requires the use of statistical interpretation methods. Chemometric techniques provide a way for presenting the data in an understandable format designed for a specific need: Discrimination, Quantification, and Quality control.

Principle of non-supervised and supervised algorithms, application to gas and liquid sensor and GC chromatogram data set, strategy to correlate the instrumental measurement with various sensory test (A/not A test, sensory descriptor intensity, consumer test).

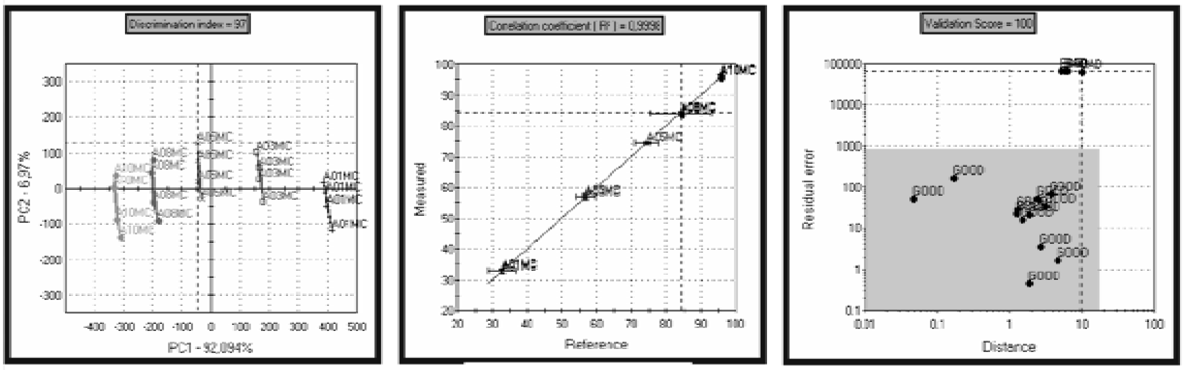
- Product development application with the Electronic sensing Instrumentation :
- Development of new products, consumer liking surveys, competitors benchmarking, shelf life

analysis, correlation with visual palatability

- Applications: Beverages shelf life, competitor benchmarking, retro engineering, taste masking or matching studies
- Stability / Shelf life of visual palatability
- Packaging selection
- QC &Q/A
- Sorting of quality flavors, and ingredients
- Batch to batch consistency of natural extracts
- Quantification of ingredients, dairy, ice cream, cereals, oils, flavors
- Batch to batch consistency / Suppliers specifications and suppliers monitoring / production lines monitoring
- quality control and process monitoring (Blending, roasting, Cleaning procedure) …..

For Packaging

- Quality control of raw materials Resins, Polymers pellets according to sensory measurements (German test, water test, ASTM standard in place…) , for the food Industry or the Car Industry
- Quality control of for Polymer packaging and film according to organoleptic specifications (off odour detection and off taste)
- At line Smell and VOC, Qualitative or Quantitative finished product QC /QA
- Development of new polymers / impact of additives on the off odors issues
- Stability / Shelf life of products into various types of packaging (caps, liners, closures, underground water pipe..)
- Packaging interaction and selection



Discrimination Identification	Quantification	Quality control
PCA and DFA provide a map with the different area of samples that allows a view of the discrimination and an identification of unknown samples	PLS is used to predict quantitative values, based on a calibration curve in correlation with sensory panel score, for unknown samples	SIMCA allows qualification of samples (Good, Bad) compared to a reference sample group defined as Good

The taste or smell of raw materials and finished products in food, beverage, pharmaceutical and cosmetic industries are of vital importance to the commercial success of the product.Human sensory panels typically assure the organoleptic characteristics of these products.In practice, these panels are extremely expensive to operate and present numerous problems when used to control the production process. The function of the systems is in many ways analogous to human perception, electronic systems provide easy to use alternatives to human organoleptic measurements which are often more reliable and easier to maintain.

Like human testers these systems require training or calibration using reference samples to ensure accurate taste recognition and reproducibility (Fig.1). The use of an electronic nose involves calibration and validation procedures.

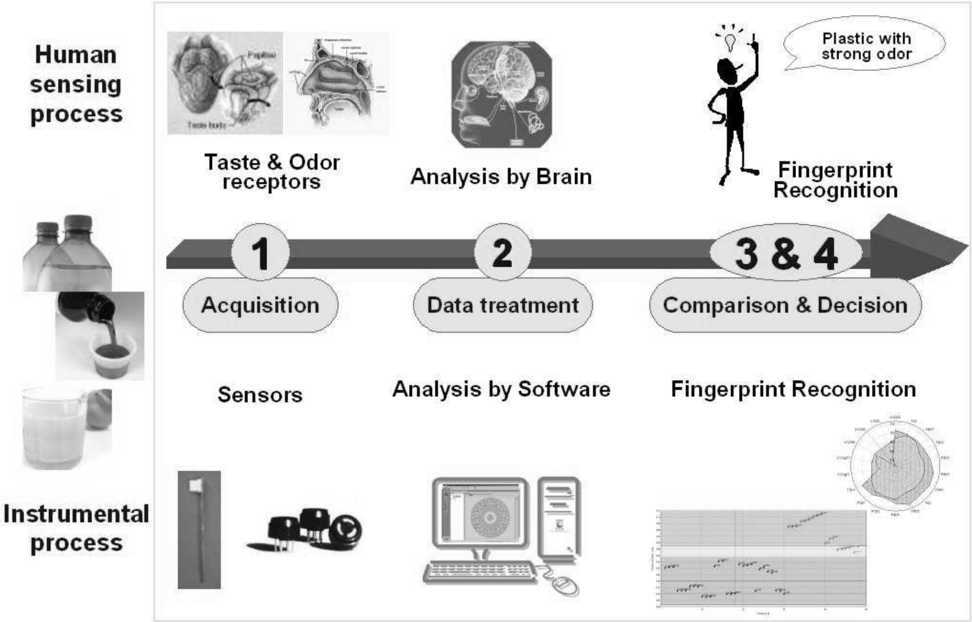


Fig.1: Electronic nose concept

Electronic Nose Principle

Electronic Nose systems are basically composed of following components:

A sampling system: The autosampler HS100 allows running automatically up to 96 samples with different vial size and syringe volume.

An array of sensors: the technology used is based on metal oxide sensors. Depending on the system, an array of 6, 12 or 18 sensors is there in the system.

An electronic data acquisition and control system: the unit permits to measure and save all the sensors data and systems parameters

Multivariate Statistic

Interpretation of data with multiple variables such as several sensors and multiple samples requires the use of statistical interpretation methods. Chemometric techniques provide a way for presenting the data in an understandable format designed for a specific need: Discrimination, Quantification, and Quality control.

An electronic unit for measurements:

The unit permits the measurement of the response of each sensor versus time. The software package allows mainly:

- to visualize in time the data collection
- to save all collected data
- to visualize all collected data
- to extract from the data the relevant features
- to make statistical analysis (PCA, DFA, SIMCA, PLS, …)
- to show the results
- to compare the results obtained with other analysis

SCOPE OF ENERGY AUDITING AND CONSERVATION IN DAIRY PROCESSING INDUSTRY

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1.0 Introduction

Energy Management includes planning and operation of Energy related production and consumption units. Energy management is the proactive, organized and systematic coordination of procurement, conversion, distribution and use of energy to meet the requirements, taking into account environmental and economic objectives.

The judicious and effective use of energy to maximize profits (minimize costs) and enhance competitive positions" (Cape Hart, Turner and Kennedy, Guide to Energy Management Fairmont press inc. 1997). The objective of Energy Management is to achieve and maintain optimum energy procurement and utilization, throughout the organization and:

• To minimize energy costs / waste without affecting production & quality

• To minimize environmental effects.

Energy Audit

Energy Audit attempts to balance the total energy inputs with its use and serves to identify all the energy streams in the systems and quantifies energy usages according to its discrete function. Energy Audit helps in energy cost optimization, pollution control, safety aspects and suggests the methods to improve the operating and maintenance practices of the system. It is instrumental in coping with the situation of variation in energy cost availability, reliability of energy supply, decision on appropriate energy mix, decision on using improved energy conservation equipments, instrumentations and technology. As per Energy Conservation Act, 2001, Energy Audit is defined as "verification, monitoring and analysis of use of energy including submission of technical report containing recommendations for improving energy efficiency with cost benefit analysis and action plan to reduce energy consumption".

1.1 Objectives of Energy Audit

The Energy Audit provides the vital information base for overall energy conservation program covering essentially energy utilization analysis and evaluation of energy conservation measures. It aims at:

Phase-I

- Collections of data on operational parameters, energy consumption both normal and electrical, coal and power quality etc., through a questionnaire.
- Study the existing plant capacities and their performance to assess plant operations.
- Study of the specific energy consumption (both thermal and electrical) department-wise and plant as a whole.
- Study of the power sources, distribution system and drive controls, load factor and efficiency of large motors, process automations, plant illuminations etc.
- Collection of requisite data and analysis and identification of specific areas with potential for conservation of thermal and electrical energy.
- Field measurements of operational parameters and carrying out heat and mass balance.
- Study of limitations, if any, in the optimal use of thermal and electrical energy.
- Discussion with specific recommendations along with broad system concept for conservation of thermal and electrical energy.
- Preparation of capital cost estimates and establishing techno-economic feasibility for recommended measures.
- No investment and/or marginal investment by doing system improvements and optimization of operations.
- Major investment due to incorporation of modern energy intensive equipment and up gradation of

existing equipment.

- Formulating tentative time schedule for implementation of the recommendation.
- Undertaking broad cost benefit analysis in terms of savings in energy consumption per unit of production and pay-back period.

Phase 2

Follow-up with the industry on periodic basis to ascertain the level of implementation of recommendation and assist, if require, in implementation of the measures to achieve energy user efficiency.

1.2 Types of Energy Audit

The energy audit to be performed depends on

- Function and Type of Industry
- Depth to which final audit is needed
- Potential and magnitude of cost reduction required

Thus, energy audit is classified as:

i) Preliminary Energy audit

ii) Detailed Energy audit

Preliminary Energy Audit Methodology is a relatively quick exercise to

- Establish energy consumption in the organization
- Estimate the scope for saving
- Identify the most likely (and the easiest areas for attention
- Identify immediate (especially no-/low-cost) improvements/ savings
- Set a 'reference point'
- Identify areas for more detailed study/measurement
- Preliminary energy audit uses existing, or easily obtained data

Detailed Energy Audit

A comprehensive audit provides a detailed energy project implementation plan for a facility, since it evaluates all major energy using systems. This type of audit offers the most accurate estimate of energy savings and cost. It considers the interactive effects of all projects, accounts for the energy use of all major equipment, and includes detailed energy cost saving calculations and project cost. In a comprehensive audit, one of the key elements is the energy balance. This is based on an inventory of energy using systems, assumptions of current operating conditions and calculations of energy use. This estimated use is then compared to utility bill charges.

Detailed energy auditing is carried out in three phases: Phase I, II and III.

Phase I - Pre Audit Phase

Phase II - Audit Phase

Phase III - Post Audit Phase

Energy Audit in Dairy Processing Industry

There is much scope of saving the energy in the dairy sector. The dairy industry uses the boiler system, refrigeration system, hot/cold water supply system consisting of thermal and electrical systems. The energy audit will optimize the resources judiciously and reduce the cost of the energy by suggesting the measures with small modifications. The energy auditing is the upcoming field in the dairy sector.

2.0 Flow diagram of Dairy Industry

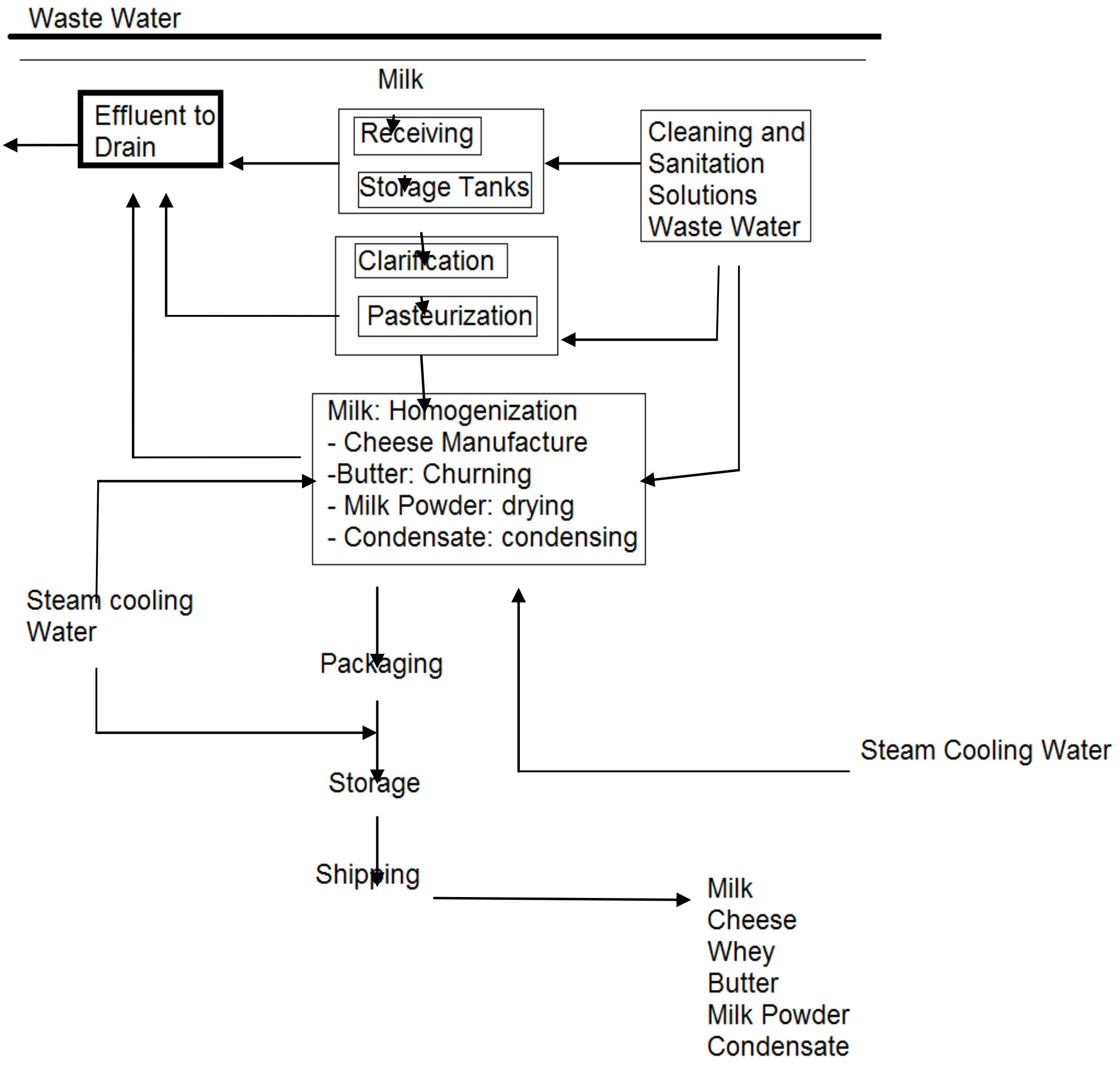

Fig 1: Flow Diagram of typical dairy plant

2.1 Major Energy Consumption centers in a dairy plant

- Milk Pasteurizer, Cream Pasteurizer, Wash Water Pasteurizer
- Refrigeration System
- Incubator Room having Electrical heaters
- Spray Driers
- Blowers, Air Compressors, Pumps
- Lighting Systems
- Other Motive Loads
- Boilers
- DG Sets

2.2 Scope of Energy Conservation in Dairy Industry

Electricity is used throughout the dairy processing industry to drive process motors, fans, pumps and compressed air systems, as well as building lighting and HVAC systems. In addition to machine drives, one of the primary uses of electricity in the dairy processing industry is for process cooling, freezing, and cold storage. The largest share of fuel consumed by the dairy industry (80%) is used for direct process heating and steam generation via boiler systems. The remaining 20% is used for miscellaneous process and building demands, such as HVAC systems. Although coal, residual oil, and distillate oils can be used as fuels, the dairy processing industry uses almost exclusively natural gas.

Various opportunities exist within the diary processing industry to reduce energy consumption while maintaining or enhancing production. As part of the dairy industry's aggressive move to reduce the carbon footprint and energy consumption of the industry as a whole, energy efficiency improvements to dairy processing facilities are key to attaining this goal.

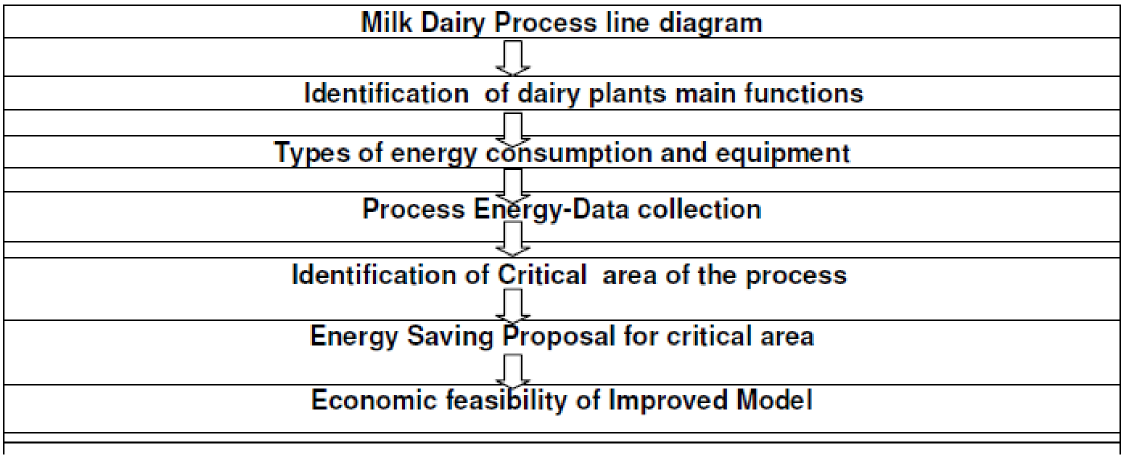

Fig 2: Methodology for Energy audit of the dairy plant

The most effective method to improving energy efficiency in a dairy processing facility is to implement energy saving techniques across various levels of production. At the component and equipment level, energy efficiency can be improved by preventative maintenance, proper loading and operation, energy efficient choices for new equipment, and the replacement of older components and equipment with higher efficiency models when feasible. At the process level, process control, optimization, and integration can ensure maximum efficiency. In addition, implementation of new or alternate process systems can improve efficiency and reduce operating costs. On the facilities level, efficient lighting, heating, and cooling can reduce energy loads, and implementation of combined heat and power or process integration systems can improve efficiency.

The various areas where energy conservation can be achieved in dairy plant are:

1. **Boilers** : Boiler process control Boiler replacement ,Reduction of flue gas quantities Direct contact with water heating ,Reduction of excess air Condensing economizer ,Properly sized boiler systems Segregate hot water system according to temperature ,Improved boiler insulation Boiler maintenance, Condensate return Flue gas heat recovery, Blow down steam recovery.
2. **Steam Distribution Systems:** Improved distribution system insulation Steam trap monitoring, Insulation maintenance Leak repair, Steam trap improvement Flash steam recovery, Steam trap maintenance, Process Integration, Process integration Pinch analysis.
3. **Motor Systems and Pumps** : Motor management plan Adjustable-speed drives, Strategic motor selection Power factor correction, Maintenance Minimizing voltage imbalances, Properly sized motors ,Pump system maintenance Multiple pumps for variable loads, Pump system monitoring Impeller trimming, Pump demand reduction Avoiding throttling valves, Controls Replacement of belt drives, High-efficiency pumps Proper pipe sizing, Properly sized pumps Adjustable-speed drives .

4. **Refrigeration Systems**: Refrigeration System Management, Good housekeeping Efficient piping design ,Monitoring system performance Thermal storage ,Ensuring proper refrigerant charge Checking for refrigerant contamination, Refrigeration system controls Segregation of refrigeration systems , Cooling Load Reduction ,Piping insulation Geothermal cooling , Minimizing heat sources in cold storage areas Tank Insulation for storage tanks, Reducing heat infiltration in cold storage areas Mixing in storage tanks, Reducing building heating loads Properly sized motors, Free cooling Optimized air flow pattern.
5. **Cooling towers:** Compressor control systems and scheduling Compressor heat recovery, Floating head pressure control Dedicating a compressor to defrosting, Indirect lubricant cooling Adjustable-speed drives, Raising system suction pressure Using an economizer with a single stage, low temperature compressor.
6. **Condensers and Evaporators:** Keeping condensers clean Adjustable-speed drives on condenser fans, Automatic purging of condensers Cycling of evaporator fans in cold storage, Reducing condenser fan use Adjustable-speed drives on evaporator fans, Reducing condensing pressure Demand defrost , Use of axial condenser fans Water defrosting.
7. **Compressed Air Systems:** System improvements Pressure drop minimization, Maintenance Inlet air temperature reduction.
8. **Monitoring Controls:** Leak reduction, properly sized pipe diameters, Turning off unnecessary compressed air Heat recovery from compressors, Modification of system in lieu of increased pressure Natural gas engine-drive compressors, Replacement of compressed air by other sources Buffer tank to regulate compressor duty cycle, Improved load management.
9. **Building Energy Efficiency Measures** : HVAC systems, Energy-efficient system design Efficient exhaust fans, Recomissioning Use of ventilation fans , Energy monitoring and control systems Infrared heating , Non-production hours set-back temperatures Solar air heating ,Duct leakage repair Building reflection, Variable-air-volume systems Building insulation, Adjustable-speed drives Low-emittance windows, Heat recovery systems Air curtains, Fan modification.
10. **Lighting**: Turning off lights in unoccupied areas Replacement of T-12 tubes with T-8 tubes, Lighting controls High-intensity discharge voltage reduction, LED Exit signs High-intensity florescent lights, Electronic ballasts Day lighting.
11. **Self-Generation**: Combined heat and power Photovoltaic panels, Tri-generation, Solar thermal water preheating, Backpressure turbines.
12. **Process Specific Energy Efficiency Measures**: Pasteurization/Sterilization/ Heat Treatment/Reclamation/adding plates Induction heating of liquids, Compact immersion tube heat exchangers Heat exchanger enhancement techniques, helical heat exchangers, Evaporation, Maintenance Mechanical vapor recompression, Multiple effect evaporators Concentration using membrane filtration, Thermal vapor recompression.
13. **Spray Drying**: Operating temperature optimization Exhaust heat recovery, Strategic placement of air intake Use of multiple stage drying , Inlet air monitoring Use of crystallization (dry whey only), Heat recovery from product Using other concentration techniques.
14. **Miscellaneous measures**: Good mixing in cooking tanks Creating 80% whey instead of powdered whey Cave aging (with use of heat pumps) Use whey permeate to feed biogas reactor.
15. **Emerging Technologies:** Heat pumps for waste heat recovery High hydrostatic pressure pasteurization, Pulsed electric field pasteurization UV pasteurization, geothermal heat pumps Microfiltration, Advanced rotary burners LED Lighting.
16. **Water Efficiency Measures**: CIP Improvements, Reuse or recovery distribution systems Pulse rinse on tanks, Single phase cleaning RO or evaporative water use in CIP, Over-ride procedure Air blows, Optimization of phase separation.
17. **General Techniques**: Good housekeeping Reducing cooling tower bleed-off, Wastewater treatment High pressure low volume sprays, Recycling of milk waste as fertilizer Low pressure foam cleaning, Use of water efficient building fixtures Pre-soaking of floors and equipment, Use of small diameter hoses Membrane filtration, Use of automated start/stop controls

3.0 Conclusion

Finally, on the organizational level, a strong company commitment to energy management, augmented by energy monitoring, target setting, employee involvement and continuous improvement, is essential to the long term success of energy efficiency improvements and its associated cost benefits. There is much scope of saving the energy in the dairy sector. The dairy industry uses the boiler system, refrigeration system, hot/cold water supply system consisting of thermal and electrical systems. The energy audit will optimize the resources judiciously and reduce the cost of the energy by suggesting the measures with small modifications. The energy auditing is the upcoming field in the dairy sector.

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Energy benchmarking: An effective tool for cost reduction in processing plants

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ABSTRACT

The whole world is striving for energy conservation methods they say "Energy saved is energy produced". Benchmarking has been recognized to be an effective analysis methodology and management tool that helps to improve efficiency and performance in many areas for different objectives. Industrial energy benchmarking is a process of evaluating energy performance of an individual industrial plant or sector against a reference plant or sector. Energy benchmarking based on the performance of industry leaders or best practices is particularly useful for identifying energy inefficiencies in the production processes and estimating the potential for energy savings. This study introduces industrial energy benchmarking and its use in dairy industry the results from case studies of an Ireland dairy has shown that 20% of energy can be saved using energy benchmarking.

Introduction

Benchmarking is the process of comparing one's business processes and performance metrics to industry bests or best practices from other companies. Dimensions typically measured are quality, time and cost. In the process of best practice benchmarking, management identifies the best firms in their industry, or in another industry where similar processes exist, and compares the results and processes of those studied (the "targets") to one's own results and processes. In this way, they learn how well the targets perform and, more importantly, the business processes that explain why these firms are successful (Bogan 1996). Energy consumption in an industrial sector is determined by the activity level, sector structure and energy efficiency (Phylipsen et al. 1997). In order to identify the potential to reduce energy consumption, it is important to differentiate energy efficiency effects from other effects. In order to estimate industrial energy improvement potentials, energy benchmarks can be used. Energy benchmarks can be applied at different levels of aggregation (e.g. sector, country, mill or process levels), depending on the typical goal of the benchmarking exercise (Laurijssen et al., 2013).

Businesses are reducing their energy costs by 10, 20, and 30 percent through effective energy management practices that involve assessing energy performance, setting energy-savings goals, and regularly evaluating progress. Facility- or building-level energy performance benchmarking is an integral part. It provides the reference points necessary for gauging the effectiveness of energy management practices and management for continuous improvement. Many companies have applied energy benchmarking tools with the result that they are using 35 percent less energy than the average, while providing the same or better services (USEPA, 2007).

Concept of energy benchmarking

It is widely accepted fact that what you don't measure, you can't manage. Companies often have the perception that they are highly energy-efficient. Benchmarking provides a tool to test this perception using accepted benchmark values for technology. Benchmarking can improve the understanding of a process and help identify best practices. Benchmarking provides insight in the efficiency relative to a reference (or benchmark) performance/technology. Benchmarking can help enterprises to identify inefficiencies and search for more efficient technology opportunities. Experience with benchmarking programs worldwide has shown increased attention for energy-efficiency and performance. Benchmarking approach depends on goals (Worrell, 2011).

Benchmarking is a useful tool for gathering data and understanding energy and water consumption patterns in dairy-processing plants and for designing potential programs and policies to improve energy and water efficiency. Energy and/or water benchmarking allows energy and/or water performance of an individual plant or an entire sector of similar plants to be compared against a common metric that represents "standard" or "optimal" performance. It may also allow comparisons of the energy and/or water performance of a number of plants with each other (Xu, 2011). Industrial energy benchmarking is primarily practiced in the following two contexts, as illustrated by the examples presented below ((Jing et al., 2013):

a. Evaluating an individual plant or an individual industrial sector

The first context for industrial energy benchmarking is to evaluate an individual plant or an individual industrial sector in order to (1) evaluate the energy performance of the plant or sector; (2) compare the performance of the plant or sector against the same or similar plants or sectors worldwide; and (3) estimate the potential for improving energy efficiency of the plant or sector based on best practice (Ruth et al., 2001).

b.Setting company- or industry-wide energy efficiency goals

The second context for energy benchmarking is to set company- or industry-wide energy efficiency goals using benchmarking approaches (Ruth et al., 2001). Energy benchmarking in this context often requires first determining a baseline, which is usually set as the current energy intensity or energy performance of the company or industry, though using the past energy performance of the plant or sector is also possible. The energy efficiency goals are often expressed as the estimated potential reduction of the baseline energy intensity (Ruth et al., 2001; Birchfield, 2001; Price et al., 2010).

Scope of energy benchmarking in dairy and food processing plants

Energy is a topic whose importance has rapidly increasing in last few years. Not only has been the cost of energy generally increased but the world has become increasing aware of both the unsustainability of our present modes of energy use, the effects of the co2 emissions from our fossil usage, operators of dairy processing facilities have also become increasing aware of the significance of energy use. For many processor this has become the larger cost components and one of the processing cost components that is most amenable to reduction by improved technology and closer management control (IDF, 2005).

Case studies on energy benchmarking

a. Dairy processing industries in Ireland

Environment & Green Technologies Department of Enterprise Ireland undertook a review of the sector in order to measure performance in Ireland and benchmark this against international best practice. The review assessed data from 15 plants representing over 90% of Ireland's milk processing capacity. Between 2006 and 2009, the Irish dairy sector invested significantly in energy conservation including the recovery of heat from condensate/evaporate/effluent/pasteuriser water), low energy cleaning/disinfection systems, insulation of pipes and tanks, economisers, lighting control, variable speed motor drives, etc. and the implementation of energy management systems. This resulted in a 20% reduction in mean annual energy use per plant (204,682 MWh to 163,771 MWh) which equates to a mean emission reduction of 11,000 tonnes of CO2 per plant. Despite only accounting for 15% of total energy use, reductions in electrical use per tonne of product were double that of thermal use per tonne due to the relatively low cost of metering and implementing change (Robert 2011).

b. European food and drink processing industries

The Federation of German Food and Drink Industries established the "Energy efficiency in the German Food and Drink Industry" network with international technology corporation, Siemens, in 2008. Under the guidance of the Siemens energy consulting department, 8-12 food and drink companies participate in n ationwide annual "Energy Roundtables" to develop individual energy concepts, i.e. corporate action plans to reduce energy consumption and improve energy efficiency. Since 2008, 200 of the food and drink companies that have participated show that organisational measures can reduce energy costs by up to 20% with minimal effort. This network has demonstrated that the food and drink industry plays an active and responsible role in addressing the challenges of climate change (FoodDrinkEurope, 2012).

FEVIA, the Belgian Food and Drink Federation, measures and benchmarks energy efficiency in the Flemish brewery sector. Poor performance in energy use and beer production is measured and, based on this, energy-specialists audit the least performing breweries to identify possible measures for energy efficiency improvements. Barilla has set targets to reduce total energy consumption per finished product by 10% by 2014 based on a 2008 baseline. Barilla also aims to reduce the carbon produced in its factories by 15% by 2014 (FoodDrinkEurope, 2012).

Summary

The results from case studies showed prominence in energy saving so we can conclude that it is feasible to use Energy benchmarking as an effective tool for cost reduction in processing plants. The basic idea of energy benchmarking is to evaluate the energy performance of an individual system against a reference system. Energy benchmarking can be designed to compare the energy performance of an individual system against a reference system that represents best practice, or to compare the energy performance of a number of systems against one another or to compare the plant against itself (ke et al ., 2013). Energy benchmarking at the plant or sector level helps to determine the gap between the plants or sectors and to estimate the overall potential for energy efficiency improvement. Process based benchmarking provides insights into where the major energy saving potential actually is and which areas or processes should be focused on and improved. Product-based energy benchmarking can be viewed as a particular case of the process-based energy benchmarking. (ke et al ., 2013).

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EMERGING APPLICATIONS OF OHMIC HEATING IN FOOD PROCESSING

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ABSTRACT

Ohmic heating is one of the alternate to thermal processing emerged during last 20 years, also known as joule heating, electrical resistance heating or electron conductive heating, direct resistance heating, electro heating. The basic principle of ohmic heating depends on the dissipation of electrical energy into heat, resulting in internal energy generation accompanied by temperature rise. Ohmic heating presents a large number of actual and potential future applications, including blanching, evaporation, dehydration, fermentation, extraction, sterilization, pasteurization and heating of foods to serving temperature in the military field or long-duration space missions. Still most applications are waiting for commercial exploitation. This paper deals with the potential applications of ohmic heating in food processing.

Introduction

The types of thermal process are many and varied e.g. drying, pasteurizing, sterilizing, blanching, melting, etc. However, each has to achieve a very specific physical, chemical or biological change in the product. In most cases, the mode of heat transfer throughout the product is either conduction or convection, which require long heating-up time exerting detrimental effect on quality of the end product. The research and developments in non-thermal or alternative processing techniques are mainly with the aim that undesirable microorganisms, allergens and enzymes should be inactivated without damaging nutritional and sensory properties of foods, resulted from thermal treatment. The ohmic heating method is a rapid means of heat generation throughout a material. The basic principle of ohmic heating depends on the dissipation of electrical energy into heat, resulting in internal energy generation accompanied by temperature rise (Sastry, 2003). The necessary prerequisite is that the material must be electrically conductive which may impose little limitation. Since, most dairy products have sufficient water content and dissolved ionic salts, it is not the instance for dairy products.

Principle

Ohmic heating of food is based on passage of alternating current (AC) through the body. When electrical current flows through a conductor, the motion of charges within the material results in agitation of molecules (or atoms) therein which results in temperature rise. In food materials, the charges are usually ions or charged molecules e.g. proteins, which migrate to the electrode of opposite polarity.

According to ohm's law, the power P (W) delivered by an electrical generator to a volume V (m^3) of product is proportional to the electrical field E (V/m) and the electrical conductivity of a product σ (S/m).The energy generation inside the material is proportional to the square power of the local electric field strength and the electrical conductivity. The power generated, ΔP, in a homogeneous element conductor of given length Δz in the *z* direction and area ΔA, perpendicular to the electrical field E, with constant physical properties, is given by

$$\Delta P = \frac{\Delta U^2}{\Delta \Omega} = \sigma E^2 \Delta A \Delta z = \sigma V E^2$$

Where, the potential difference in direction z is ΔU=EΔz and the ohmic resistance is defined by ΔΩ=Δz/σΔA. The above equation shows the volumetric nature of the ohmic heating process. This expression provides the basis for design of devices and formulation of products for ohmic heating. The electric field strength (E = *V*/*l*) may be varied by changing either the applied voltage, or the inter electrode gap *l*. The effective electrical conductivity, is a function of temperature, frequency and composition of the product. It may be increased by addition of ionic salts or acids or even decreased by addition of nonpolar compounds such as emulsified lipids. This means that for a product of a given electrical conductivity, it is possible to design an ohmic heater; conversely, for a given heater design and operational variables, it is possible to modify a product to enable its heating.

Advantages and Limitations of ohmic heating

This technology possess many advantages over conventional heat transfer methods. The advantages of ohmic heating technology given by Skudder (1988), Kim et al. (1996) are:

- Heating takes place volumetrically therefore, the product does not experience a large temperature gradient within itself as it gets heated.
- Ability of uniform heating of particulate and continuous phase of food at comparable rates making it possible to use High Temperature Short Time (HTST) and Ultrahigh Temperature (UHT) technique (Parrott 1992; Tucker and Withers 1994; Pereira *et al*., 2007) on solids and suspended materials (Imai *et al*., 1995).
- Higher temperature in particulates than liquid can be achieved, which is almost impossible for conventional heating.
- Reducing risks of fouling on heat transfer surface and burning of the food product, resulting in minimal mechanical damage and better retention of nutrients and vitamins.
- High energy efficiency because ~95% of the electrical energy is converted into heat.
- Optimization of capital investment and product safety as a result of high solids loading capacity.
- Accurate control of process variables is possible with instant switch-on and shut-down (Tempest, 1992; Reznick, 1996).
- As no moving parts in the equipment, it reduces maintenance cost.
- Ambient-temperature storage and distribution when combined with an aseptic filling system.
- A quiet environmentally friendly system.

The limitations of ohmic heatingtechnology are:

- It is troublesome to heat high fat products effectively by ohmic heating, as it is non-conductive due to lack of water and salt (Rahman, 1999).
- As the temperature of a system rises, the electrical conductivity also increases, which increases the risk of ‘runaway’ heating (FDA-CFSAN, 2000).

Application of ohmic heating in food industry

In the late 1980s, researchers started investigating practical potential use of ohmic heating in food processing. Ohmic heating is now receiving increasing attention from the food industry, once it is considered an alternative for the indirect heating methods of food processing (Castro *et al*., 2004; Pereira *et al*., 2007). Ohmic heating presents a large number of actual and potential future applications, including its use in blanching, evaporation, dehydration, fermentation, extraction (USA-FDA,2000), sterilization, pasteurization and heating of foods to serving temperature in the military field or long-duration space missions (Sastry*et al*., 2009). Still most applications are waiting for commercial exploitation (Sastry, 2005).The applications of ohmic heating in food processing are given in table 1.

Table 1 Applications of Ohmic Heating in Food Processing

Applications	Food items	References
Sterilization, eating liquid foods containing large particulates and heat sensitive liquids, aseptic processing	Cauliflower florets, soups, stews, fruit slices in syrups and sauces, ready to cook meals containing particulates, milk, juices. Fruit purees	Sandrine et al. (2001); Pataro et al. (2011); Icier and Ilicali (2005),Içi'er et al. (2008)
Ohmic cooking of solid foods	Hamburger patties, Meat patties, minced beef, vegetable pieces, chicken, pork cuts	Shirsat et al. (2004); Piette et al. (2004), de Halleux et al. (2005), Wills et al. (2006), Liu et al. (2007); Zell et al.(2009, 2010); Bozkurt and Icier (2009)
Space food and military ration	Stew type foods	Jun et al. (2007), Jun and Sastry (2005); Yang et al. (1997)
Ohmic thawing	Shrimp blocks	Roberts et al. (1996)
Inactivation of spores and enzymes	Process fish cake, Orange juice, juices	Loypimai et al. (2009)
Blanching and extraction	Potato slices, Vegetable purees Extraction of sucrose from sugar beets, extraction of soymilk from soy beans	Katrokha et al. (1984), Kim andPyun (1995), Wang and Sastry (2000)

Source: Varghese et al. (2012)

In the past two decades, application of ohmic heating in food industry has been developed significantly and the lack of that successes was associated to solving problem of electrode designsuch as electrode polarization and fouling (Singh and Heldman, 2014). At the same time,ohmic heating enables the food to heat at extremely rapid rate, in general, froma few seconds to a few minutes (Sastry, 2008).In the last decade, researchers studied the effect of different parameters such as pH of the heating fluid, electrode typeetc. on the performance of ohmic heating efficiency.

Samaranayake and Sastry(2005), studied the effect to pHon electrochemical behavior Fofanelectrodematerialisuniquetothe material itselfusinga60Hzsinusoidalalternatingcurrent.The experimental results show that, all the electrode materials exhibited intenseelectrodecorrosionatpH3.5comparedtothatofthe other pH values, although the titanium electrodes showed a relatively high corrosion resistance. Darvishi et al. (2013), investigated the behavior of pomegranate juice under ohmic heating by applying voltagegradientsintherangeof30-55 V/cm, the results showed that, as the voltage gradient increased, time and pH decreased.

Since the main critical parameter in ohmic heating is the electric conductivity (σ), in a non-homogeneous material, such as soups containing slices of solid foods, the electric conductivity of the particle and its relation to fluid conductivity is pointed as acritical parameter to the understanding of particles' heating rate under ohmic heating (Darvishi*et al*., 2013). Variation of electric conductivity with temperature of food products during ohmic heating carried out by several researchers and they concluded that, this increase mainly due to increase of ionic mobility and this phenomenon should be factored into the design of continuous ohmic heaters.

Conclusion

Ohmic heating is an emerging technology with large number of actual and future applications, from the literature reviewed as discussed above. It has proven advantages over conventional thermal processing and novel thermal alternative technologies like microwave heating, radiofrequency heating and induction heating. As the heating takes place during ohmic heating is volumetric, it has immense potential for achieving rapid and uniform heating of the food material. There are still a lot of challenges and difficulties to control the rate of heat during ohmic heating of food due to change of electric conductivity of the food.

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THERMIC FLUID: A POTENTIAL SUBSTITUTE FOR STEAM IN SMALL SCALE DAIRY AND FOOD PROCESSING APPLICATIONS

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Introduction

The Indian dairy industry has made rapid stride in the area of milk production which is presently at 139.68 MT per annum (Bhasin, 2014). The organized dairy sector handles 30% of available surplus milk and rest 70% of surplus milk (48.88 million MT/year) is handled by unorganized sector (Sharma et al., 2011). Indian dairy industry is dominated by small, informal and unorganized dairy processing units. In the absence of adequate integration and economies of scale, most of the milk is either sold unprocessed, or processed locally into low value-added products. Such products in absence of hygiene, quality and safety are unable to command premium prices from the consumers (Vivek, 2005). For small scale milk processing, use of boiler is sometimes not feasible as it requires high initial investment and its operation may not be economical. Also, boilers require regulatory clearances and technical manpower for its operation. Operational safety of boiler becomes a major concern if it is operated by an untrained person.

For small scale milk processing, thermic oil heating systems may be a good substitute for boiler. Thermic or Thermal fluids are high temperature heat transfer fluids. Thermal oils as a thermal fluid are used in a variety of applications and industries where high temperatures are required. Thermic fluid heaters are popular in Industry and are fast replacing steam boilers in certain applications. Thermic oils allow the use of low pressure heat transfer systems to achieve high temperatures which would otherwise have necessitated high pressure steam systems (NIL, 2010). Thermic oil can be heated using any of coal, wood, gas, diesel or solar heater. And can also be used for waste heat recovery from hot exhaust or condenser.

1.0 Thermic oil

A heat transfer oil, also called thermal/thermic oil or diathermal oil is used for heat transfer. Heat transfer oils are used as coolants, for heating and in other applications of heat transfer (OIL, 2013).
Thermal oil, glycol, and water are common heat transfer mediums. Thermal fluids offer the user the capability of high temperature operation (up to 315 °C with organic thermal oils and 425 °C with certain synthetics) at very low pressures. Due to the low operating pressure and properties of thermal oils, most heaters are built to ASME Section VIII, and a licensed boiler operator is not typically required (ST, 2012).
The desirable properties for thermic oil are (BPCL, 2012):

- The oil should be thermally stable.
- It should have high boiling point and flash point.
- It must possess excellent oxidation stability.
- The oil should not have too much viscosity drop during its hot run.
- It should have a reasonably low pour point so that the system does not get wax clogged at low ambient temperatures.
- It must have low volatility characteristics.
- Good corrosion preventive properties.

1.1 Classification of thermic oils

There are several types of heat transfer oils available on the market. Circulating coolants, chiller fluids, anti-freezes and refrigerants are used to provide cooling within machinery, process equipment or combustion engines. Hot oils, heater oils and other thermal oils are used to provide or transfer heat to a region near machinery or process equipment. The remainder of the technical investigation in this Report will concentrate on the use of high temperature thermal oils. In summary, high temperature heat transfer oils can be categorized by chemical structure into three primary groups (NIL, 2010):

A. Synthetics oil

The synthetics, also referred to as 'aromatics', are man-made fluids, specifically tailored for heat transfer applications. They consist of benzene-based structures and include the diphenyl oxide/biphenyl fluids, the diphenylenthanes, dibenzyltoluenes, and terphenyls. They are formulated from alkaline organic and inorganic compounds and used in diluted form with concentrations ranging from 3% to 10%. There are many advantages of the synthetics over hot oils or non-synthetics including higher temperature and heat transfer, with the synthetic able to obtain safe operating temperatures in the region of 400ºC, whereas non-synthetics are only thermally stable up to a maximum temperature of 300ºC. However they are more expensive to buy. As a general rule, the higher the bulk fluid temperature a fluid is rated the higher the cost of the fluid. The synthetics rated for use above 340ºC are two to three times more expensive than the average hot oil rated to 300ºC.

B. Hot Oil / Mineral oil

When crude oil is extracted from the earth it contains a vast mixture of organic compounds, which range from very light hydrocarbons to extremely high molecular weight species. In the refinery the crude oil is distilled and various distillation 'cuts' range from light fractions (gas and light solvents), fuel (gas oil), a lube cut, and the heavy tractions (heavy fuel oil and asphalts). Hot oils come from the lube cut and after further refining the hot oils are selected for viscosity (which partly defines the heat transfer properties) and stability, and are branded and marketed as heat transfer fluids. The overall bulk fluid temperature operating range of petroleum-based fluids is from 20ºC to just over 300ºC. Hot oils offer substantial advantages over synthetics in cost, ease of handling and disposal. In addition, the petroleum-based fluids do not form hazardous degradation by-products and do not have an offensive odour, therefore most spent hot oils can be easily disposed. However, hot oils are less thermally stable at elevated temperatures as they contain a certain degree of un-saturation (double bonds) and being more reactive, chemically than more highly refined petroleum products, are more susceptible to oxidative degradation.

There are at least three main categories in which white mineral oil can be further classified: Non-formulated, formulated and Dust suppression. Non-formulated white mineral oils are essentially straight white mineral oils with no additives. These oils are used in a wide range of food grade and technical grade applications where purity of the oil is extremely important due to the possibilities of direct contact and incidental contact with food or human consumption. Formulated white mineral oil, also known as food grade lubricants, are straight white mineral oils. It contains FDA approved additives that provides excellent rust protection, oxidation inhibition, and good anti-wear. These oils are used in applications where there is a possibility of incidental contact with food for human consumption. Dust suppression oils are food grade white mineral oils (SOC, 2001).

C. Others including silicones

Silicone-based fluids, and to a larger extent hybrid glycol fluids, are primarily used in specialized applications requiring process/product compatibility. This group's performance and cost factor disadvantages in the comparative temperature ranges of the synthetics and hot oils make silicone-based and other specialty fluids unlikely choices for most process applications.

1.2 Regulations for use of thermic oil in food processing industry

The term "food grade thermic oil" has been used to describe heat transfer fluids that are suitable for food processing applications. Until recently, the United States Department of Agriculture (USDA), Washington, had its own regulations, which included mineral oils used as machinery lubricants and release agents to prevent meat from sticking to grills. The reference, H1 status, was used to indicate that the oil was acceptable for use in meat and poultry establishments and could have incidental food or feed contact. USFDA specifications of 21CFR178.3620 covers the use of White Mineral Oils in food processing industry according to the limits and conditions of the regulation (USFDA, 2013). As per guidelines, in food process industry white mineral oil can is used in indirect heating loops for deep frying and baking. It is also chemically acceptable for use as a heat transfer fluid in plants operating under the Federal Meat and Poultry Inspection Program. It is recommended for medium pressure heat transfer system used for food processing, canning, and bottling. Mineral oils can be part or all of what is used as a "hot oil" for heat transfer (RADCO, 2013).

2 White mineral oil

White mineral oils are non-fluorescent, hydrophobic, tasteless and odourless products consisting of saturated aliphatic and alicyclic nonpolar hydrocarbons that are used not only in the pharmaceutical, cosmetics industries, but also in the food industry, as they are amongst the most versatile of petroleum product (PO, 2005).

3 Different grades of white mineral oil (WMO)

The different grades (15, 22, 32, 46, 68 and 100) of white mineral oil(WMO) available in the market. The major difference in various grades of WMO is in their physical properties like density, dynamic viscosity and kinematic viscosity (Table 2.1) and thermal properties like flash point and pour point (Table 2.2).

Table 1 Physical properties of different grades of white mineral oil

WMO Grade	Density (kg/m^3)		Kinematic viscosity (cSt)		Dynamic viscosity(mPa.s)	
	Min.	Max.	Min.	Max.	Min.	Max.
15	818	880	12.00	16.50	9.82	14.52
22	820	875	19.80	24.20	35.00	45.00
32	820	875	28.80	33.50	45.00	55.00
46	845	890	41.40	50.60	34.98	45.03
68	845	890	61.40	74.80	110.00	200.00
100	845	890	90.00	110.00	76.05	97.90

Source: Apar Industries Ltd., 2011

Table 2 The thermal properties of different grades of white mineral oil

WMO Grade	Flash point (^{o}c)	Pour point (^{o}c)
15	150	-15
22	170	-12
32	175	-12
46	190	-2
68	200	-9
100	220	-9

Source: Apar Industries Ltd., 2011

4.0 Application of thermic oil based heater in food and dairy Industry

There are number of food processing industry where thermic oil based heater is being used.

4.1 Heating of food extruder using thermic oil heater

In this system the thermic oil is used to control the temperature of extrusion process. It consists of a pipe inserted in to the bore. Thermic oil as heat transfer medium flows from central pipe to the tip of the screw and return in the gap between bore of the central screw shaft. Heat transfer medium exchanges heat to the food material via surface of the screw elements. The barrel is jacketed for the circulation of heat transfer medium (BUSS, 2014).

4.2 De-odorisation Process

De-odorisation is the last in a series of steps used to improve the taste, odor, color and stability of the oil by the removal of undesirable substances. The materials removed by de-odorisation include FFA, various flavors and odiferous compounds classified largely as aldehydes, ketones, alcohol and hydrocarbons. De-odorisation is primarily a high temperature, high vacuum, steam distillation process. Bleached oil from the tank is pumped into series of heaters to heat it at high temp. This heated oil is then fed into de-odoriser under absolute vacuum where open steam is given to carry out unit operation called steam distillation to de-odorize the oil completely. This deodorized oil is then pumped from deodorizer & passed through several heat economizers for heat recovery. Finally, oil is cooled in oil cooler and stored in refined oil tanks. Bleached soy oil is passed through series of Plate Heat Exchanger (PHE), Spiral Heat exchanger (SHE) and Thermic Fluid Heater (TFH) to get feed temp of 245 to 250 ^{o}C in Deodorizer, under vacuum 730 mm Hg, and agitate the oil with open steam pressure 1 to 1.5 kg/cm^{2} with retention time of 1.5 h. The heat exchange system in deodorization process is as follows (NPC, 2004):

(i) Spiral Heat Exchanger: For heat exchange between deodorizer inlet oil and Deodorizer outlet oil.
(ii) Thermic Fluid Heater: To heat the Deodorizer feed oil with hot Thermic Fluid to maintain temperature at 240 to 250 ^{o}C.

4.3 Solar Concentrator-Heat Exchanger System

Nandi (2013) developed a low cost solar heating system for food processing industry. The system was used for production of khoa. In the developed system solar heat was supplied to the evaporating container or frying pan with the help of heat-transfer fluid. After heat transfer thermic oil returns again to the concentrator forming a closed heating-loop. It is necessary to have an efficient heat exchanger but it is equally important to shape it in such a way as to accommodate the traditional boiling/frying-pan for user friendliness.

A Parabolic Trough Concentrator with a heat collector in the form of a coated copper tube carrying a heat transfer fluid, transfers heat to the processing container (essentially a flat bottom pan) through a heat exchanger. This has the advantages of the facility of controlling temperature as well as heat flow rate and secondly higher system efficiency. Coated copper tube was provided with a glass jacket to reduce convective heat loss but no attempt was made for evacuated jacketing of the absorber tube to reduce cost of developed system. A heat transfer fluid called Therminol 55 was pumped through the absorber tube which was connected in zigzag fashion under the cooking pot for exchanging heat to the item being cooked. Therminol 55 is a unique, synthetic heat transfer fluid designed to provide reliable, consistent heat transfer performance. This heat transfer fluid is a superior cost-performance alternative to common mineral oil-based heat transfer fluids. Its optimum use range is from -25°C to 290°C. On sunny days, when average solar radiation is 600W/m^2, the temperature rises above 150°C in the collector tube and the input temperature at the cooking pot can set at a level suitable for processing milk for sweetmeat production.

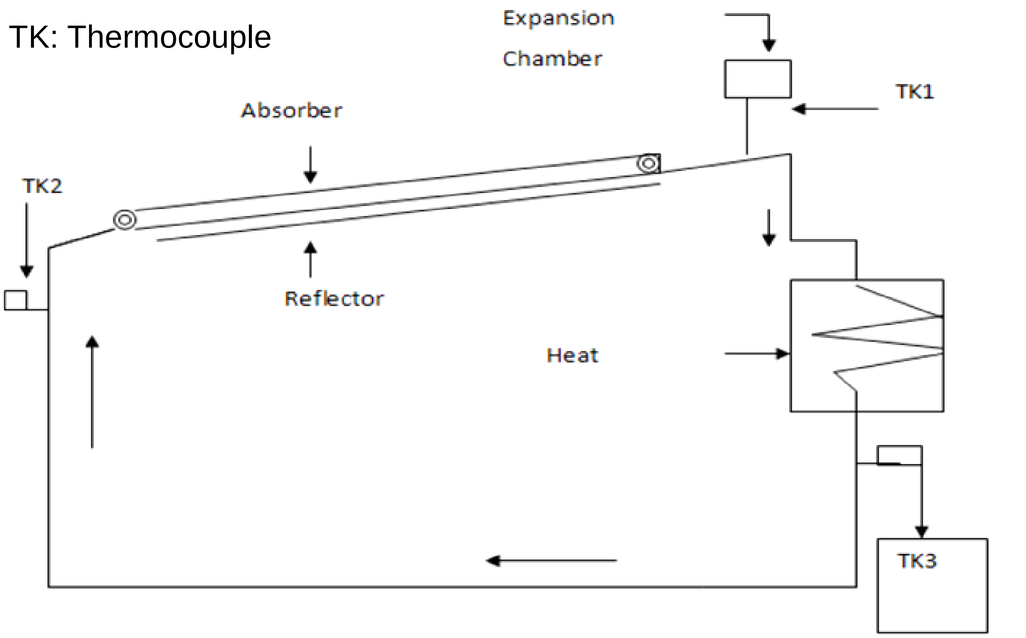

Fig. 2.3 Solar based thermic oil heater for food processing applications (Source: Nandi, 2013)

4.4 Thermic fluid Heater based *khoa* making Plant

In the market, thermic fluid heater based khoa making plant (400 -2000 l/day of milk) is available using Diesel/ LDO/ Fire wood/ Biomass Briquettes as fuel. Over a period of last 5-6 years, availability of good quality water (less than 5 ppm) in required quantity has become increasingly difficult. To handle this problem closed loop thermic fluid system was designed and developed as a substitute of steam heating system. Heating jacket of khoa making machine was modified to suit thermic fluid heating. Initial cost of this thermic fluid based heating system is higher than that of steam based system. But still it is worth to consider this system where availability of water is difficult and/or large heat generator is required which is out of purview of IBR (Khare, 2013).

4.5 Parboiling of Rice using thermic fluid

The unit consists of an insulated SS cylindrical drum (A) of 290 mm dia. placed over a stand (Fig. 2.4). The circular top plate (B), having round holes for the passage of 12 SS pipes (C) of 25 mm dia. and 2 mm thick for inserting temperature sensing devices (T) and hand stirrer (D), is removable, while the circular bottom plate (E) is fixed to the drum. All the SS tubes are braced with the bottom plate as shown in Fig. l(b). A movable shutter plate (F) with 12 holes synchronizing with that of the bottom plate is placed just beneath it. A thick 5 mm circular plate (G) with 12 holes and MS pipes (H) of 25 mm dia. is placed below the shutter plate. When the handle (I) of the shutter plate is moved to the left, the material in the SS tubes passes to the narrow mouthed glass bottle (J) through the MS pipes. The pre-heated thermic fluid (Servotherm medium, flash point 208°C viscosity index minimum 90, supplied by Indian Oil Corporation) is circulated in the drum through the Haake circulating bath. Fluid temperature in the drum is uniformly maintained by also operating the centrally placed stirrer (D). The chromel-alumel sensing probes connected with digital indicator (Digirad 200) are inserted in the paddy mass as well as in the thermic fluid to quickly monitor the changes in temperature. A portion (80 g) of HS and SSTpaddy was quickly charged into each of the SS tubes and the gap above the paddy layer was plugged with wooden cylinders (K) of 24 mm dia. At the end of the desired residence time (0.5-5 min), the handle (I) of the shutter plate was moved to the left and the parboiled paddy discharged to the glass bottles placed below each MS tube.

4.6 Thermic fluid heater for closed loop heating of cooking oil

Thermal oil is used for transferring heat to cooking oil used to fry potato chips in temperature controlled fryers. The temperature of the cooking fat is critical to the process and thermal oil offers the most economical option to meet the variable temperature fluctuations due to potato feed rate and moisture changes through the fryers (NIL, 2010).

References:

References are available on request through email.

DEVELOPMENT OF LOW-CALORIE DEEP FAT FRIED PANEER USING EDIBLE COATINGS

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Introduction

Deep fat frying is a most complex form of edible fat and oil application. Frying influences many qualities of finished product such as flavour, texture, shelf life, nutritional attributes, etc. The soft and moist interior with porous crispy crust provides increased palatability of food.Frying is the process of immersing and cooking of foods in hot oil that involves heat and mass transfer and includes complex interactions between the food and the frying medium. The purpose of frying is fast cooking, formation of unique crust, colour, flavour and texture. Globally available fried foods are potato chips, corn chips, onion rings, French fries, fried chicken, fish fillets, etc. In India, traditional fried foods such as *gulabjamun*, *jalebi*, *jhangri*, *laddoo*, *bhoondi*, *puri*, *papad*, potato *kachori*, *chewra*, a variety of *namkeens*, *paapri*, *mathri*, *samosa*, *samosa* stuffed with *paneer*, fried *paneer* curry, etc are most popular. Most of these traditional fried foods contain significant amount of fat and *trans* fatty acids (*gulabjamun*: 11.4g; fried *paneer*: 38.1g) due to fat uptake and partial hydrogenation of vegetable oil during frying, respectively (Dhaka, *et. al.*, 2011).In recent trends,due to health concern consumers are demanding low fat foods. Hence, there is a need for reducing oil uptake during deep fat frying of foods. For this purpose either we can change the formulation of these foods by incorporating fat substitutes or by adoptingother approaches*viz.* edible coatings. Various types of edible coatings are used now-a-days for coating of food products.

Paneer, an important indigenous dairy product, is usually used for culinary preparations or in snacks by deep frying. Because of high oil in fried foods, consumers are demanding low-fat foods for maintaining good health. In this context, the present study has been envisaged with the objective of reducing fat uptake in deep fried paneer using carbohydrate and protein-based edible coatings.

Materials and Methods

Materials used in the present study such as WPC-70, hydroxyl propyl methyl cellulose (HPMC), glycerol, soybean oil, sodium hydroxide, petroleum ether, diethyl ether, concentratedhydrochloric acid, ethanolwere procured from reputed suppliers.Two different formulations of HPMC (5% and 10% level) and WPC (5%) coating solutionswere prepared for using as coating solutions as per standard procedures. Both the solutions were degassed before use.Full fat paneer was prepared from pooled buffalo milk received from Experimental Dairy of NDRI, Karnal by following standard procedure. One percent citric acid solution was used as coagulant. Coagulation temperature was maintained at 70°C. Obtained milk solids were pressed for 20 minutes and dipped in chilled water for about 15 minutes to get paneer.Paneer was then cut into approximately 8 cm^3 sized pieces. The cut paneer pieces were then divided into 4 batchesas shown below:

- Batch 1: Uncoated paneer
- Batch 2: Coated paneer with dipping time of 5 min
- Batch 3: Coated paneer with dipping time of 10 min
- Batch 4: Coated paneer with dipping time of 15 min

Each batch of paneer was fried in soya bean oil at a temperature of about 150°C till golden brown colour was observed. It took about 3-4 minutes. After frying, paneer cubes were left undisturbed for some time for moisture equilibrium. Fried paneer cubes were then stored in air tight containers for further chemical analysis.

Fat content of paneer was estimated using acid digestion method (Werner Schmidt Method). In this method milk proteins are digested by concentrated Hydrochloric acid and fat is extracted by using ethanol (96%), diethyl ether and petroleum ether. Ethers were evaporated and residue left behind (fat) is weighed to determine the fat content of sample.Approximately three gramsof paneer sample was weighed in aluminium dish and dried in hot air oven at 100°C for 3 hours. Sample was transferred to a dessicator and then cooled. Drying was continued until the difference between two consecutive readings did not exceed 1 mg. The obtained data was subjected to one way analysis of variance (ANOVA) for drawing meaningful information.

Summary of Results and Conclusion

- In the present study an attempt has been made to reduce the oil uptake by the paneer during deep frying by using edible coatings of biopolymers such as WPC-70 and HPMC.
- The effect of fat content in milk and dipping time in the coating solutions i.e. 5% and 10% HPMC and 5% WPC on the fat uptake of paneer at the end of frying process was studied.
- In HPMC 5% solution, dipping times of 2, 3, 4, 5, 10 and 15 minutes was carried out while the uncoated batch served as control.
- However, for 10% HPMC and 5% WPC solutions, dipping times were fixed at 5, 10 and 15 minutes only.
- During the preliminary studies,it wasobserved that dipping times below 5 minutes could not result in desired reduction in fat uptake during deep frying of paneer. Hence, the dipping times of less than 5 minutes were discontinued for further studies.
- It wasalso observed that drying of film after dipping in coating solution had significant effect in reducing fat uptake as compared to undried coating. Drying of the coating solution to form a thin film overpaneer wascarried out with the help of conventional hair dryer**.**
- Significant reduction in fat uptake was obtained in samples of paneer dipped for 15 minutes and drying of 5% WPC-70 coating solution to form a thin film.

ON-LINE SMART SENSING TO ACHIEVE AUTOMATION IN FOOD INDUSTRY

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ABSTRACT

As food companies recognize more and more the necessity to measure, optimize and control the sensory properties of the food. Food industry demands for new sensing technologies stimulate the development of smart sensor that can provide a cost-effective quality evaluation/control operation. The rapid development and emergence of smart sensor 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. In some cases automation must ensure their inactivation to guarantee food safety and shelf life. Development of new process control sensors for the food industry, in parallel with developments in process control technology, has the potential to increase the levels of process automation in the food industry. In moving towards the automation smart sensors have big role to automate the processes. Hence sensors and associated measuring instrumentation circuits in the food processing industry pose a challenge for sensory scientist towards the development of low cost and intelligent sensing system needed to achieve automation. This review paper also pays attention to the importance and adoption of smart sensors, their development and application in food industry.

Keywords: Sensors, instrumentation, Smart Sensors, Process control, Machine Vision System, Process Automation

1. Introduction

Food processes have been particularly difficult to automate and control owing to nonuniformity and variability in raw-materials and lack of sensors for real-time monitoring of key process variables and quality attributes. It is well known that the food production processes are strongly non-linear, time invariant and often unstable. In factory-automation applications process can be defined as the use of noncontact sensors to ensure that specific quality processes have been followed to minimize the possibility of human error. In different operations of food processing, control systems maintain the proper ratio of ingredients to deliver a consistent product. The most important aspect for consumers referring to food production is its safety. In addition to safety, process control systems are central to maintaining product quality and consistency. The purpose of process control is to reduce the variability in final products so that legislative requirements and consumers' expectations of product quality and safety are met. It also aims to reduce wastage and production costs by improving the efficiency of processing. Adequate automation of food production strongly depends on the process design.

To automate the processes in food industry, measurement of plant outputs and feedback signals are of great importance in food processing industry with emphasis on maintaining the correct process conditions during steady-state operation. Process variables are measured in controlling a food process by using sensors. Sensing requires that a physical or chemical phenomenon be converted to an electrical signal for display, processing, transmission, and/or recording. The information from sensors on process and product variables is used by controllers to make changes to process conditions. If a food process is continuous, on-line sensing (which determines the state of a process in real time) is an ideal method to address this problem. For useful application, sensors must fulfill several requirements, e.g. ability to interface with plant monitoring/control systems, cleanability and stability with time and temperature.

The most important properties of food 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. Traditionally, good product quality has been ensured by monitoring parameters such as temperature, pressure and density, with emphasis on maintaining the correct process conditions during steady-state operation. Automation of food production has to handle these properties properly and also to employ them actively. This is, for example necessary for generating desired food structures, for inactivating microorganisms and for avoiding certain biochemical reactions which can lead to substantial decrease in food quality. Such variety in the demand, from the consumer side, is driven by social or ethical reasons as it is the case of products more compliant with the environment or produced by sustainable processes. Smart quality sensing and control for the food industry is necessary.

Sensors and actuators are assigned to the process. Therefore they form the base of observation, visualization and diagnosis of the process. Meanwhile, the actuators possess the task of intervening into the process in order to achieve the desired result. In general, a sensor is a device, that is designed to acquire information from an object and transform it into an electrical signal. As shown in Fig. 1, a traditional integrated sensor can be divided into three parts: (i) the sensing element (e.g., resistors, capacitor, transistor, piezo-electric materials, photodiode, etc.), (ii) signal conditioning and processing (e.g., amplifications, linearization, compensation, and filtering), and (iii) a sensor interface (e.g., the wires, plugs and sockets to communicate with other electronic components) (Kirianaki et al. 2002).

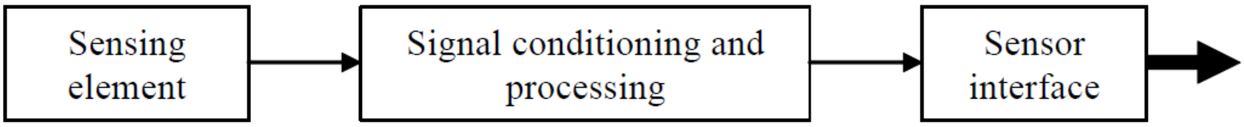

Figure 1: Traditional Integrated Sensor

A user must consider the following when selecting a sensor for their application: speed of response, measurement range, accuracy, resolution, interfering gases, operating range (temperature, humidity, pressure), temperature and humidity effects, sensor life, ease of calibration, calibration frequency, and replacement cost. Limitations include:

- All intelligence resides in the sensor controller;
- Communication from sensor to controller is analog;
- Controllers typically are dedicated to specific sensor types;
- Multiple sensors require multiple controllers;
- Calibration requires intrusive manual adjustments of transmitters and a corresponding adjustment of controllers.

Often, because of these limitations, operating decisions are based on the input from only a few devices, concerning a few parameters. The measuring techniques for on-line use in food industry are subject to a considerable research and manufacturing interest.

Smart Sensors

Smart sensors deals with the measurement, monitoring, control, display etc. of the several of energy exchanges which take place during process operations. Also they are widely used in alarming conditions and where controlling of the process conditions are required. It maintains the process conditions required and hence carried a safe and controlled operation. These sensors use wide range of voltage and currents that a sensor interface needs to accommodate. This, combined with higher drive requirements, creates challenges in processing and packaging. These sensors allows the simultaneous measurement of several ingredients, such as Fat, Solids, Protein, Moisture, etc. and offers many advantages. In addition, some smart sensors can deal with detection of intangible properties such as softness, freshness, sweetness, or aroma. Smart sensors improves the overall quality of both products and manufacturing processes. Smart sensors use digital signals rather than analog signals to transmit to the controller. Digital signals provide the opportunity for greater diagnostics and data checking.

Smart sensor diagnostics involve continuous checks to identify out-of bounds system operating criteria. The sensor accesses operating characteristics, checks the operating voltage, and continuously verifies that the dynamic range of the sensor provides adequate resolution. Warning messages from the sensor identify items such as low sensor sensitivity and low battery. Smart or intelligent sensors improve the communication from the sensor to controller and improve the reliability of sensor data by better signal processing. A smart sensor measures a complicated variable for which no direct or cost effective sensor for online measurement is available. A smart sensor utilizes online sensors for other easily measured variables e.g. temperature and pressure) and then relates these measurement to that of the complicated variable.

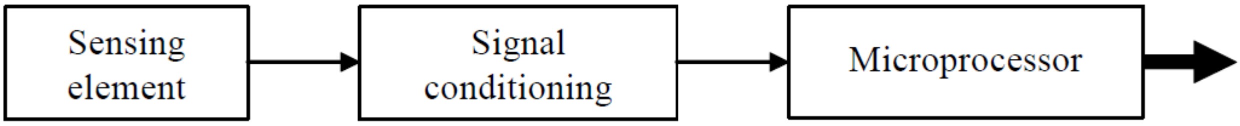

Figure 2: Smart Sensor

As illustrated in Fig. 2, the essential difference between a smart sensor and a standard integrated sensor is its intelligence capabilities, i.e., the on-board microprocessor. The microprocessor is typically used for digital processing, analog to digital or frequency to code conversions, calculations, and interfacing functions, which can facilitate self-diagnostics, self-identification, or self-adaptation (decision making) functions (Kirianaki et al. 2002). They are good candidates for increased built-in intelligence. Microprocessors can make smart sensors or devices a reality. With this added capability, it is possible for a smart sensor to directly communicate measurements to an instrument or a system. Primitive sensors used in smart sensors are devices or materials that have some electrical property that changes with some physical phenomenon. examples of common primitive sensors are current/voltage output temperature sensors, microphone transducers, and even the potentiometer, which is a rotational position sensor. Smart sensors then have the ability to make some decision. Physically a smart sensor consists of transduction element, signal conditioning electronic and controller/processor that support some intelligence in a single package [1]. Smart sensors often comprise the following elements: sensors for direct measurements, mathematical models and algorithms, data processing software, and system implementation hardware. Therefore, the electronic modules and transducer modules can be reused for different sensing requirements with only a need to develop a new sensing front end for each additional application. These sensing systems will be integrated into the overall process control system. Inside every smart sensor is one or more primitive sensors and support circuitry. The thing that makes a smart sensor "smart" is the additional, built-in electronics. The electronics make these sensors able to do one or more of the following:

- Pre-process their measured values into meaningful quantities.
- Communicate their measurements with digital signals and communication protocols.
- Orchestrate the actions of primitive circuits and sensors to "take" measurements.
- Make decisions and initiate action based on sensed conditions, independent of a microcontroller.
- Remember calibration or configuration settings.

Smart quality control: from sensing to acting

Smart sensing means that sensor information processing without redundant and unnecessary data acquisition. Intelligent sensing concepts that can monitor and predict food quality and/or safety within the supply chain. Food Industry, is nowadays facing critical changes in response to consumer needs, which in addition to health and safety awareness, demand an ever larger diversity of food products with high quality standards. In order to satisfy such needs and demands, which although driven by the product, directly affect the process, novel and efficient food and process engineering approaches must be developed so to comply with the proposed requirements. However, and from the automation and control point of view, there are a number of limitations in food processing plants which could prevent an appropriate response to such needs (Sasha et al, 2001). Among those weakness and limitations, also detected in other process industries (Qin and Badgwell, 2003) one should highlight the following ones:

- Most plant control schemes reduce to local and decentralized control loops acting on a usually very small number of states (typically temperature or pressure) not directly connected with product quality and in many cases neither with critical aspects of the operation such as water or energy consumption.
- Although presently, many food plants benefit from advances in data acquisition and monitoring of the full production lines to gather and store huge amounts of data, the use of such information is quite limited, usually not efficiently employed and reduced to configure alarms (often handled at a very low level) or to help producing simple production decision rules and off-line control of inventories.
- Often recognized as a specificity of food processes, the lack of sensors for relevant product characteristics is still a problem. Improving the reliability of sensing devices and developing new hardware-software sensing techniques to online estimate difficult-to measure quality product parameters are critical in developing smart control applications for food factories.

However, research is still needed to connect novel sensing techniques with advances in efficient modelling and simulation of quality kinetics and transfer models (essentially by defining accurate yet fast to integrate models) so to build up smart sensors able to inline predict food quality attributes.

Machine-vision applications

The online measurement of products quality is the need of an hour for the production on large scale in the continuous process of the production in food industry. This includes smart sensors that suppose to provide information that improves decision making. In general, a machine vision system is used to measure some aspect of manufacturing process (e.g., shape, size, texture, location) that is indicative of accuracy, efficiency, or quality of process. The measured parameters can then be used as feedback in real time control loop that optimizes the manufacturing process through variations in process parameters (speed, temperature, flow rate etc.). Smart Sensors used as on-line continuous sensors in food processing industry helps to improve food quality, reduce cost, and strengthen consumer confidence. In food processing, they are required for incoming material selection; material waste control; process quality control; packaging inspection; equipment maintenance/failure prediction, environmental control. These sensors improved the consistency and efficiency of the food processing. It is suitable for on-line evaluation of synthesis, provide continuous feedbacks by determining the threshold levels as well as improving the food economics by reducing the rejected or degraded volume.

Food product processing requires a variety of operations, such as sorting based on dimensions, shape and colour, on processing lines that run at very high speeds. Today, smart sensors are addressing important tasks including distance measurement, parts presence, color measurement, Data Matrix reading, pattern-matching, and three-dimensional (3-D) part profiling.

On-line smart sensor systems for monitoring rheological related parameters is the soul of any on-line inspection system because the inspection of products is completed in the processing line itself making the measurement time almost negligible. For years, system integrators have deployed limit switches and IR and LED sensors with which to detect the presence or absence of a part on a production line or used light grids to perform tasks such as profile detection, object recognition, overhang control, and height measurement. While these products are used to determine part presence, a host of laser-based triangulation products are now available that can precisely judge the position of the part, often to an accuracy of 0.1 µm.

While many of these smart sensors may not offer the sophistication of high-end machine-vision systems based around off-the-shelf cameras, frame grabbers, and PCs, they are increasingly being used in applications that do not require a high level of programmable image-processing applications. The presence of a machine vision system on a production line has come to represent unmistakable demonstration of an industry's commitment to quality.

Conclusions

Smart sensors provide support to the *food* industry for *new* product and process development. They contribute to the economic benefit by providing small and cost-efficient sensors, filters and other structures for food industry. They improves the overall quality of both products and manufacturing processes. It is feasible and cheap to turn a standard integrated sensor into a smart one, in a process. This will contribute to the overall food quality, reduce cost, and strengthen consumer confidence. Complex multisensory systems with ubiquitous measurements will be used in the near future as information source under Smart Control Strategies: optimal experimental design and predictive control. Continuous researches are going on to make the on-line evaluation suitable for small scale and on-farm scale of production and processing of food.

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NEW GENERATION CREAM SEPARATORS

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Abstract

Cream separation from milk is the first and one of the most vital step in milk and milk products production. The main purpose of cream separation is to standardize the milk as per the regulatory laws and also to manufacture fat rich dairy products. The cream separators which Indian dairy industry using today are of old generation, today we need equipments which are more efficient more faster and less energy consuming. Present study on new generation cream separator has revealed the potential of some of new equipments and techniques which can be far better than what old generation cream separators are delivering.

Introduction

Milk from the cow contains a number of large and small butter-fat particles held in suspension. They are lighter in weight than the other parts of the whole milk, much as would be the case were minute drops of oil mixed with a quantity of water. When milk is left standing, the skim-milk gradually settles at the bottom because it is heavier. This forces the butter-fat to the top. When the bulk of the fat globules have found their way to the top they constitute cream, which consists largely of the fat particles. A centrifugal separator consists of a stack of discs in a rotating bowl. The entering milk is accelerated to the same speed of rotation as the bowl and is distributed in the separation channels between the discs. The cream, having a lower density than skim milk, moves inwards towards the axis of rotation, whereas the skim milk moves outwards to the space outside the disc stack. The two fractions are then discharged from the separator through separate outlets. In most dairies the clarification and the cream separation is carried out by means of self-cleaning separators. The milk is separated into a stream of cream containing 40% fat and a stream of skim milk containing 0.04 - 0.07% fat. The separator also discharges sediment consisting of dirt particles, udder cells, bacteria, leucocytes, etc., which is normally led to the drain. The total amount of sediment in milk is normally about 1 kg/10000 liters. The separator is usually connected to the preheating section of the pasteurizer, as the optimum temperature for separation is about 65ºC.(www.fao.org).

History of Cream Separators

The earliest methods of cream separation made use of gravity. In one early method, milk was poured into shallow pans (2 to 4 inches deep) known as setting pans. The pans were placed in a cold, clean room for 36 hours allowing the cream to rise to the top. At that point, it was skimmed by hand with a tool called a cream skimmer. This method made it difficult to handle large amounts of milk. As much as 30 percent of the cream was left behind. However, if the milk was not stored properly, the cream would sour A Swedish engineer, Dr. Carl Gustaf De Laval, began experimenting with a mechanical cream separator in 1859, he used a barrel to spin the milk, then skimmed the cream from the top after the barrel came to a stop. He then built a separator that utilized a number of buckets to separate 35 gallons of milk at a time. In 1878 he launched a continuous cream separator that could process 300 pounds of milk an hour. This was based on the principle of centrifugal force (De Laval, Separator Company manual).

Different methods of cream separators available

There are many Cream separators in the market. The Cream separators are available in various sizes and these can be customized. These are manufactured using high quality materials like stainless steel 304,316 etc. These separators are corrosion resistant and preserve the original properties of the milk. Cream contains most of milk's energy and in the later 1800s the ever-growing market for more cream kicked off different inventions to separate the cream in larger quantities. Four types of cream separators became available and each type had its own set of uses.

Setting Pans

The original cream separators were shallow pans which held milk from 2 to 4 inches deep. These setting pans, they were left in cool, clean rooms for up to 36 hours when tools like cream skimmers were used to skim off the top.

Deep Setting

The deep setting method required shotgun cans or 20-inch-tall cans with a diameter of about 8 inches, which could contain up to four gallons of milk; These were thrust into tanks of cold water which caused the milk cooled quickly thereby forcing the cream to rise to the top and separate from the whey better. These were sealed lidded cans that kept out water and bacteria.

Water Dilution

This method used water dilution along with gravity. In this method, a 10- to 32-gallon tank was half-filled with milk. Then water was let in the tank through a tube at the bottom of the tank. After one or two hours, the cream was removed from the top. A valve at the bottom of the tank allowed the water and skim milk to go out of the tank. Thin, vertical glass windows revealed the cream line created.

Centrifugal Separator

Most modern cream separators use centrifugal force to separate the cream from the skim milk quickly by spinning the bowl containing the milk, causing the lighter cream to go into the center of the bowl while the heavier skim milk travels outward. A centrifugal cream separator has a strong, durable motor and a speed controller that gives the user the ability to adjust the thickness of the cream while adjusting the percentage of fat in the cream. An open-and-close valve at the top of the unit controls the flow of the milk into the separator. The tank below the valve holds the milk while it spins. The float under the tank fits on top of the float chamber in which the cream collects. The cream spout below the float chamber is used to send the collected cream out, while the remaining milk goes out a separator milk spout under the cream spout. (De Laval Separator Company manual).

New techniques and recent advances in cream separator

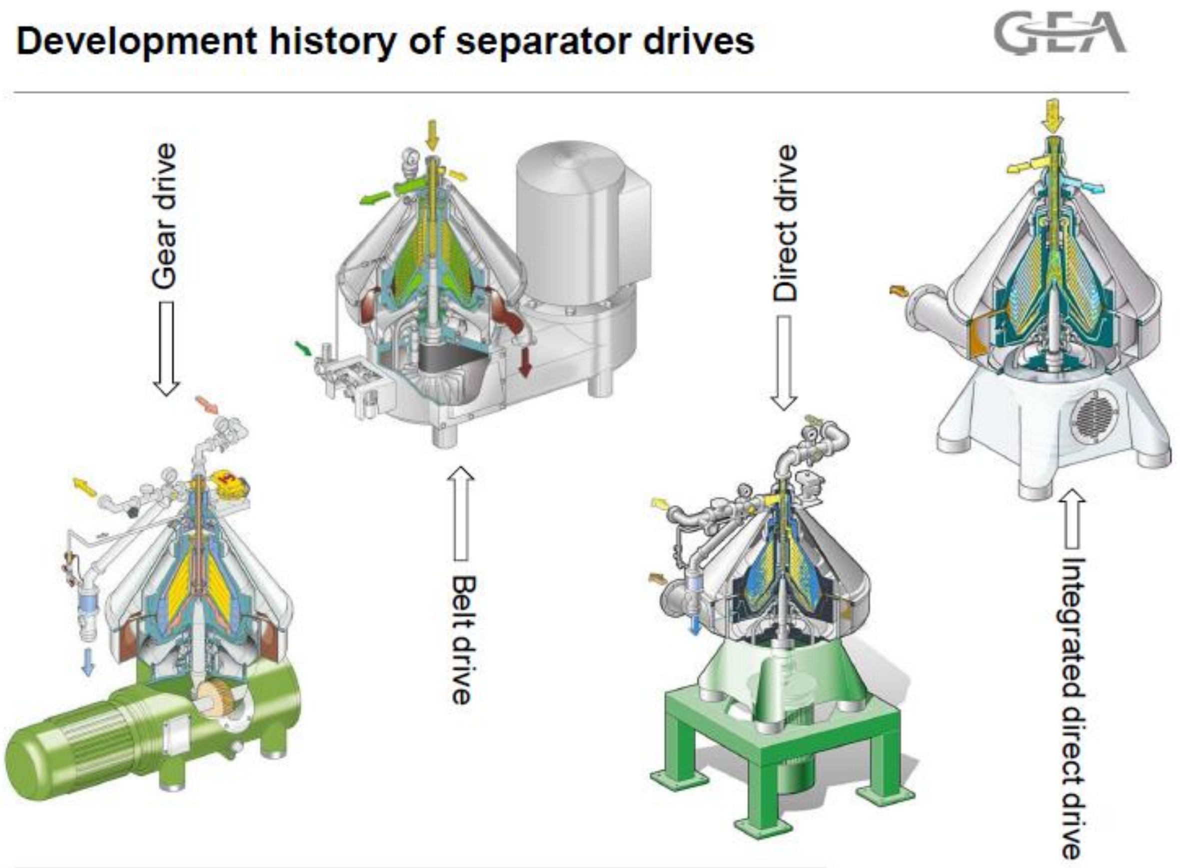
Gear drive

The conventional drive concept of the separators is the worm wheel gear, fluid clutch and standard motor with direct switching. The toothing of the worm wheel gear was optimized in order to reduce the noise level.

Advantages of the gear drive

- No requirement for the frequency converter.
- Reliable design, Suitable design for small machines.

Fig: cream separator with gear drive



Flat belt drive

Flat belt drive can be used for the heavy bowls of larger machines. The power transmission from the torque-controlled motor to the bowl spindle is via a single flat belt without an intermediary clutch. The design is very simple and maintenance friendly. The spindle can be removed together with the complete bearing assembly and can be serviced outside the machine. This reduces considerably the downtime for maintenance.

Fig: cream separator with Flat belt drive

Advantages of the flat belt drive

- Longer change interval.
- Longer maintenance intervals.
- Lower maintenance cost.
- Reduced noise level.

Integrated Direct drive

Direct drive is the intelligent simplification in separation technology. Direct drive is used in applications where the upper limit for gear loads has been reached or when belt drive is undesirable. Direct drive separators drive with virtually loss free power transmission. Less energy consumption, lower maintenance and space mean increased performance for production.

Optimized Feed and Discharge System

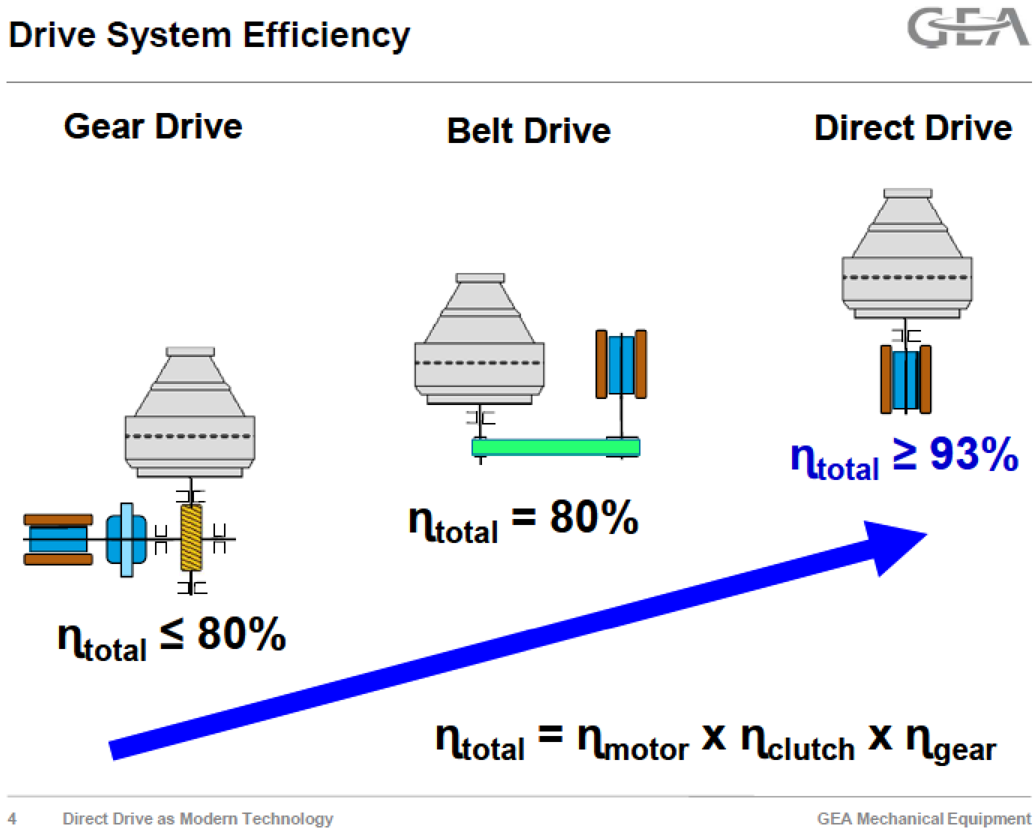
- Approx. 10-15% reduced energy consumption by means of optimized centripetal pump
- In some cases 20-30% energy reduction possible
- Discharge pressure can be provided without external pump
- High efficiency of the pump and compact design
- Gentle feed and discharge of the liquid
- Optimization by means of computer aided flow simulation (CFD)

Fig: Direct drive cream separator

Features of the integrated direct drive

- High efficiency, Integrated oil circulation system, Operation with frequency converter (VFD).
- Motor und VFD in asynchronous technology Low number of wear parts (no motor bearings, drive belt, clutch).
- The simple and service friendly drive concept provides high availability of the asset, Bowl can be removed as a complete unit (assembly and disassembly outside the frame).
- Drive and motor can be removed as a complete unit, Low space requirement.
- Maintenance-free motor, 35% less space requirement.
- Continuous condition monitoring, very high availability, easy maintenance.
- Reduced noise level, access from all sides.
- Only one lifting point for bowl and motor, hoist direction variable, less wear parts.

• Highest energy efficiency.



Self-cleaning separators

These separators are for applications that require continuous processing. Separation takes place in the disc stack; the solids are separated out in the solids holding space. The solids holding space is of double conical form and incorporates ejection ports which can be opened and closed by hydraulically lowering and raising the sliding piston. During production the accumulated solids can be ejected instantaneously at preset intervals by lowering the sliding piston. At the end of the production phase the separator is automatically cleaned in place. Operation can be fully automated by installing suitable control units.(GEA Westfalia Separator manual).

Recent development of cream Separator assembly

Fine Tuner

The Fine Tuner, is a combination between a centripetal pump and a paring tube. It is characterized by a substantially improved efficiency factor compared to conventional centripetal pumps. This is the ratio of the conversion of rotational energy into pressure. The efficiency factor with the fine tuner can be rated at almost 0.9. The effect is viscous media such as gums from super degumming installations can be discharged without difficulty. The adjustment of the Fine Tuner diameter can be done by a manual hand wheel or by a pneumatic actuator from the control unit.

Advantages

- For optimum adjustment of the separating zone

- Flexibility of the separators. A single machine can carry out all refining processes without the need for converting the machine
- Improved operating reliability and eliminates the risk of losses

Hydrohermetic feed

The hydrohermetic feed system protects the product from exposure to the high shearing forces, which would break up the particles and consequently making separation a lot more difficult. Emulsification is avoided at this point especially during washing and winterization also it has the hydrohermetic vapour seal (sealing by liquid) which prevents vapours from rising out of the feeding chamber into the lower centripetal pump chamber. This has a positve effect in case of higher separating temperatures (> 90°).

Advantages

- Protects the product from exposure to high shearing forces through gentle product feed.
- No mechanical seal and therefore no additional cooling water consumption, No oxygen pick-up
- Less star up time
- Higher work output without Slip

Conclusion

In India most of the milk and milk manufacturing plants are still using old generation cream separator which have less skimming efficiency higher maintenance cost and very noisy. To resolve this problem the new generation cream separator can be used which are far superior than normal cream separator not only in terms of higher skimming efficiency but also they are having low maintenances cost, less noisy, more energy efficient. In this era where efficiency and effectiveness are the integral part of any process industry the new generation cream separator can be an effective tool for achieving higher performance.

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BUSINESS PROSPECTS AND INVESTMENT OPPORTUNITIES IN DAIRY PROCESSING

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India is currently the largest producer of milk in the world, a status it has maintained since the late nineties. Milk production was estimated at 132.43 million tones in 2012-13 and was targeted to reach 139.67 mt in 2013-14. Milk is the country's biggest agricultural produce contributing 22% to India's agricultural GDP in FY13. Overall dairy industry is estimated at USD 70 bn in 2013; expected to double to USD 140 bn by 2020. Over the last decade, the Indian dairy sector has grown at an average of 4.04 per cent against the world average of 2.2 per cent. The per capita milk availability in India stands at 296 grams per day, higher than the world average. This has been largely achieved through a combination of favourable policies and an institutional network that has helped support millions of rural households in pursuing their livelihoods through small scale dairy farming. About one-fifth of the milk produced is collected and processed by the organized dairy sector. Cooperatives now link more than twelve million small scale dairy producers to urban markets and provide them a stable source of income. The growth of this network of institutions has been acknowledged to be a key factor in the growth of the Indian dairy sector. The dairy industry in India is going through major changes with the liberalization policies of the Government and the restructuring of the economy. This has brought greater participation of the private sector. This is also consistent with global trends, which could hopefully lead to greater integration of Indian dairying with the world market for milk and milk products. India today is the world's largest and fastest growing market for milk and milk products with an annual growth rate of about 6.1 per cent.

India is witnessing winds of change because of improved milk availability, a change-over to market economy, globalization, and the entry of the private sector in the dairy industry. The value addition and variety in the availability of milk products are on everybody's agenda. There is an increasing demand for new products and processes. The main reasons are - an increase in disposable incomes; changes in consumer concerns and perceptions on nutritional quality and safety; arrival of foreign brands; increasing popularity of satellite/cable media; and availability of new technologies and functional ingredients. From conventional milk products like paneer and cheese, the market has evolved over time and now caters to the wellness market as well with its sugar free and probiotic milk products. High margin dairy products like yogurt, ice cream and cheese constitute only 8% of the Indian dairy market currently; expected to grow at CAGR 25% over next 5 years. Moreover, with rise in disposable income and educational level, the awareness for nutrition and health improves which in turn raises the demand for health and nutritional products.

Organised Sector to Grow

As per Government of India's Economic Survey for 2008-09, about 80 percent of milk produced in the country is handled in the unorganised sector and the remaining 20 percent is shared equally by cooperative and private dairies. Industry sources however maintain that between 22-24 percent of India's milk output is handled by the organised sector and this is expected to increase significantly in the coming years.

This growth represents an opportunity for multinational food and dairy companies as well as input suppliers to expand their exports, facilitate technology transfer, sign new joint ventures and make profitable investments in India. The challenge would be to focus on: quality, product development and global marketing. The industry would concentrate efforts on human resource development, R&D in milk products, equipment technology and emphasis on exports.

The National Dairy Development Board (NDDB) has prepared a National Dairy Plan which aims at meeting the projected demand of about 180 million tonnes of milk by 2021-22. With an estimated outlay of about Rs 17,371 crore, the Plan has three major components — enhancing milk production through increased productivity; substantially strengthening/expanding the infrastructure for procurement, processing, marketing and quality assurance through existing institutional structures and by promoting new ones; and, human resource development.

The share of the organised sector has meanwhile doubled—from 15 per cent a decade back to around 30 per cent now. This is seen as an encouraging sign, with most big players assuring quality checks at multiple points. The fast expanding private sector investment and entry of global players is also intensifying competition. In the last 5 years, USD 150 mn has been invested by private equity investors in the Indian dairy industry, of which USD 125 mn has come in the last 18 months. The capital raised has largely been invested in backward and forward integration of the private dairy companies. Private equity investors are encouraging Indian companies to move up the value chain. There is a big Business Prospects and Investment Opportunities in the Dairy Industry in India.

MINI SOLAR POWER GRID: AN EXCELLENT ENERGY OPTION FOR DAIRY AND FOOD PROCESSING PLANTS

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Introduction

Solar energy has experienced an impressive technological shift. While early solar technologies consisted of small-scale photovoltaic (PV) cells, recent technologies are represented by solar concentrated power (CSP) and also by large-scale PV systems that feed into electricity grids. The costs of solar energy technologies have dropped substantially over the last 30 years. For example, the cost of high power band solar modules has decreased from about $27,000/kW in 1982 to about $4,000/kW in 2006; the installed cost of a PV system declined from $16,000/kW in 1992 to around $6,000/kW in 2008 (IEA-PVPS, 2007; Solar buzz, 2006, Lazard 2009). The rapid expansion of the solar energy market can be attributed to a number of supportive policy instruments, the increased volatility of fossil fuel prices and the environmental externalities of fossil fuels, particularly greenhouse gas (GHG) emissions. Theoretically, solar energy has resource potential that far exceeds the entire global energy demand (Kurokawa et al. 2007; EPIA, 2007). Despite this technical potential and the recent growth of the market, the contribution of solar energy to the global energy supply mix is still negligible (IEA, 2009).

Solar energy represents our largest source of renewable energy supply. Effective solar irradiance reaching the earth's surface ranges from about 0.06kW/m2 at the highest latitudes to 0.25kW/m2 at low latitudes.. Even when evaluated on a regional basis, the technical potential of solar energy in most regions of the world is many times greater than current total primary energy consumption in those regions. (de Vries et al. 2007).

On a country-wise basis, growth in solar capacity hasbeen mainly driven by Spain, Germany, Japan, the US andItaly. Germany has seen remarkable growth in the solar PVmarket and has reached a capacity of 5,337 MW.The geographical focus of solar PV manufacturing is thusgradually shifting towards developing countries such asChina, India, Malaysia and Taiwan. Among other things,this is due to the perceived advantages of technicalmanpower and labor costs that these regions offer. In the area of solar energy, India has today achieved a leading position in the world in the development and use of technology. It is the second largest manufacturer in the world of crystalline silicon modules. Solar device based industrial production has touched a level of 7 MW/year.

Under solar photovoltaic programme 792,285 numbers of solar lanterns, 88,297 numbers of solar street lighting systems and 5, 50,743 numbers of solar homelighting have installed. Besides these achievements 7247numbers of solar water pumping installed for the benefit ofagrarian society. More than 12.67 MW have so far been installed for voltage support for weak grids, for peak load saving and as diesel saving. This shows solar device technology not only entered into heating and lighting but also it extends its possibility in the area of water pumping and power producing through grid and off-grid.

Mini solar grid is an effort to improve the overall utilisation of solar energy for different industrial or non industrial applications. Government schemes for subsidy on equipments or installations, easily available equipments, assistance for installation and growing pressure to adopt green energy technologies have played a significant role in promoting private players and investors to step into solar energy based commercial power plants business. The option for selling the produced electricity to state electricity board or to any nearby industry has made the mini solar grid, an attractive business with a very good monetary return along with appreciations for reducing carbon emissions.

Table 1: Achievement of solar based power plants in india (1996 TO 2010)

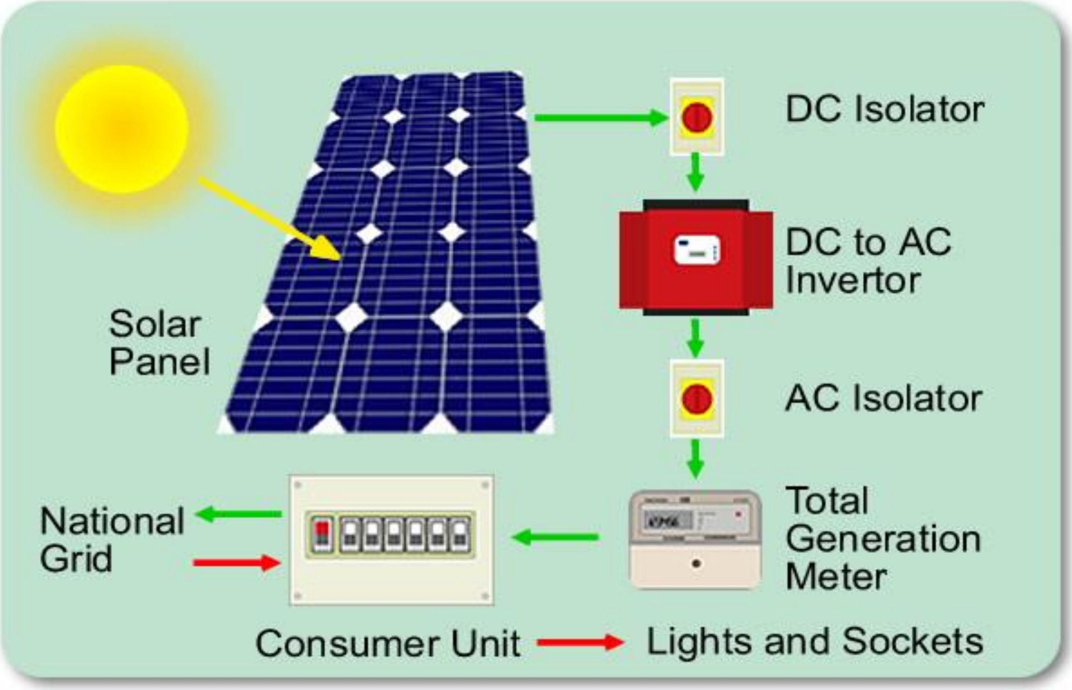
systems	1996	2005	2007	2010
(a) Gridconnected	---nil---	---nil---	2.12 MW	10.28 MW
(b)Stand alone	909.3 KWp	1566 KWp	2.18 MW	2.39 MW

Source: Annual reports of MNES, Government of India' 1996, 2005, 2007&2010.

There is a vast scope for industrial application of mini grids which can be installed with various power pack plans depending upon the current investment capabilities of investor. Mini solar grids provide leverage in selection of total power output plan with an option for easy expansion in total electricity generation capacity in future. One can select power plans with battery setup or without battery, which facilitates direct power generation and simultaneously supplying it to the customer (to an industry or to the electricity board).

Silent features of installing Mini solar grids:

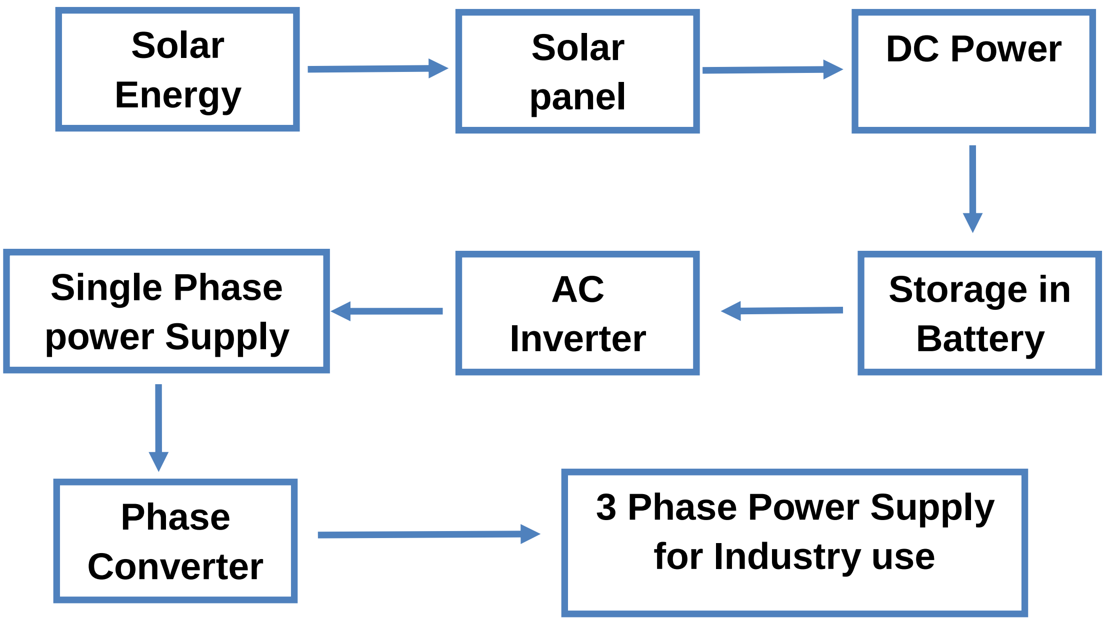
- Government appreciation in form of subsidy is easily available.
- Easily available equipments at subsidised rates.
- Low maintenance cost.
- Only one time investment required.
- Attractive return on investment.
- Productive life of the installation is 25 years or more.
- Can be started with small capacity power generation and easy expansion.
- Payback period is reasonably small.
- A no recession business.
- Environment friendly.



(Source: http://www.spectrumrenewables.co.uk/AboutPV.aspx)

Fig. 1: Schematic diagram for Conversion of Solar energy to Electrical energy

After getting the Single Phase AC power from Solar Grid, we can convert this power into 3 phase AC power by using Phase Converter. After getting 3 Phase AC power, we can use it for the different operation in dairy plants.



The different types of Phase Converters are:

1) Rotary Phase Converter: RPC is an electrical machine that produces three-phase electric power from single-phase electric power. This allows three phase loads to run using generator or utility-supplied single-phase electric power. A rotary phase converter (RPC) may be built as a motor-generator set. These completely isolate the load from the single-phase supply and produce balanced three-phase output. However, due to weight, cost, and efficiency concerns, most RPCs are not built this way. Instead, they are built out of a three-phase induction motor or generator, called an idler, on which two of the terminals (the idler inputs) are powered from the single phase line. The rotating flux in the motor produces a voltage on the third terminal. A voltage is induced in the third terminal that is shifted by 120° from the voltage between the first two terminals. In a three-winding motor, two of the windings are acting as a motor, and the third winding is acting as a generator.

2) Digital phase Converter: A digital phase converter creates a three phase power supply from a single phase supply. A digital signal processor (DSP) is used to control power electronic devices to generate a third voltage, which along with the single-voltage from the supply creates a balanced three-phase power supply. AC power from the utility is converted to DC, then back to AC. The power switching devices used in this process are insulated gate bipolar transistors (IGBT).

Utilization of SPV in Dairy Industry

We can utilize SPV 3 Phase Power Supply for various operations in dairy industries. We can use a Switching controller which automatically connect the supply to equipments as soon as it get the supply from Solar Power grid. As in the evening, the power output from the solar grid decreases from a particular level, it automatically connect equipments to the State discoms supply.

Solar Power Grid for Milk Homogenizer:

S. No.	Pariculars	
1)	Type	**APV Gaulin 2642MC45-4TPS Homogeniser**
2)	Capacity	10000 LPH
3)	Rated power consumption	90KW
4)	SPV grid Installation capacity	100KW
5)	Cost of SPV grid	1 crore
6)	Optimum Usage Time period	9:00-16:00
7)	Battery requirement	No

8)	Life of SPV	25 Years
9)	Optimum Saving of money (approx.)	8 Crore

Solar Power Grid for Milk Cream Separator:

S. No.	Pariculars	
1)	Type	**Tetra Centri hot milk separators**
2)	Capacity	10000 LPH
3)	Rated power consumption	15KW
4)	SPV grid Installation capacity	15KW
5)	Cost of SPV grid	15 Lakh
6)	Optimum Usage Time period	9:00-16:00
7)	Battery requirement	No
8)	Life of SPV	25 Years
9)	Optimum Saving of money	120 Lakh

Solar Power Grid for Milk Pasteurizer:

S. No.	Pariculars	
1)	Type	Nichrome Filpack CMD Plus
2)	Capacity	6000 Pouch/ hr
3)	Rated power consumption	8KW
4)	SPV grid Installation capacity	10KW
5)	Cost of SPV grid	10 Lakh
6)	Optimum Usage Time period	9:00-16:00
7)	Battery requirement	No
8)	Life of SPV	25 Years
9)	Optimum Saving of money	80 Lakh

Solar Power Grid for Pasteurizer:

S. No.	Pariculars	
1)	Type	Tetra Pak Pasteurizer
2)	Capacity	10000LPH
3)	Rated power consumption	15KW
4)	SPV grid Installation capacity	15KW
5)	Cost of SPV grid	15 Lakh
6)	Optimum Usage Time period	9:00-16:00
7)	Battery requirement	No
8)	Life of SPV	25 Years
9)	Optimum Saving of money	100 Lakh

Mini Solar Power Grid for Boiler:

S. No.	Pariculars	
1)	Type	Shellmax Oil fired Boiler (SM-10DH)
2)	Capacity	1000Kg/hr
3)	Rated power consumption	16-17KW
4)	SPV grid Installation capacity	18KW
5)	Cost of SPV grid	18 Lakh
6)	Optimum Usage Time period	9:00-16:00
7)	Battery requirement	No
8)	Life of SPV	25 Years
9)	Optimum Saving of money	144 Lakh

Case Study: Visakha Dairy

With the Port City already bearing the brunt of frequent power cuts a couple of months prior to the onslaught of summer, Visakha Dairy has gone ahead and installed solar power panels with a capacity of 1.15 MW to reduce its dependency on the power grid. Visakha Dairy managing director S V Ramana said, "We want to reduce our dependence on power. Since our industry caters to highly perishable goods, power is an important factor for us." Pointing out that the frequent power cuts and restrictions imposed during peak hours were also key factors that drove the dairy to take up solar power, he said, "Even though we have diesel generators, it is a cause of pollution and involves high maintenance. When the central and state governments are giving subsidies for encouraging solar power, we thought we should take the lead. We have about 5 acres of space adjacent to our dairy so we invited tenders and set up the solar plant." Claiming that Visakha Dairy is the first dairy in the entire state to set up a solar plant for captive use, Ramana said: "We have got a warranty of five years and guaranteed power generation of 80 lakh units in five years or about 16 lakh units per annum. In addition, we will get the benefit of renewable energy certificates (REC), which are tradable." Even though the price of RECs has dropped from Rs 13 per unit to Rs 9 per unit over the last couple of years, the dairy can still save a huge amount of money and get back its return on investment in 3-4 years, he said, adding that Renen Solar Private Limited from Hyderabad installed the solar plant for the dairy. Mentioning future plans, he said, "We are planning to increase capacity, but the cost of land plays an important role. So we are searching for land near the grid so that we can reduce the cost of laying power cables and enjoy the benefits of solar power."

STRATEGIES TO INCREASE PROFITABILITY OF DAIRY PROCESSING UNITS

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India is the largest producer of milk with around 133 Million MT of milk production in 2013. This milk is produced at around 75 million dairy farms with captive holding of two cows per farm with an average yield of around 1000 liters per day. Out of this almost half of the milk is consumed at the production level and balance comes to the market for direct sales and processing. The ratio of unorganized to organized sector in milk procurement and trading is 60:40.

If we compute it on daily basis then around 18 crore liters of milk comes to the market daily out of which around 11 crore is handled by unorganized and 7 crore liters to the organized sector. Cooperatives and government dairies process close to 45 % of it and 55 % is being handled by the private sector as per latest media reports.

The milk coming to organized sector is processed in close to 1400 dairy processing plants with an installed capacity of close to almost 13.5 crore liters per day. The average capacity utilization isaround 60 % in the organized sector’s plant.The processing capacity in India is growing at a high rate of 20-25 % in last 3-4 years. There have been both inorganic and organic growth being considered by the investors from India and abroad.

While the milk production is growing at slightly above 4.5 %, the demand is showing slightly edge over it at around 6 %. Now the market is becoming conscious about the quality of milk and ready to pay more for better quality and varieties of packed milk and milk products . The competition is becoming fierce and gone are the days when the processors were minting high value on basic products like pasteurized milk in poly-packs. With Food safety laws becoming more stringent and covering cover cold chain also, the overheads of all the dairies on supply chain from farm to table is moving north.

In this context let us explore the ways in which the profitability of processing plants could be improved. I would like to suggest the following strategies to improve profitability in processing plant.

A. Establishment of own milk procurement through VLC and latest technologies for maintaining high quality of milk across the supply chain.
B. Modular designs of plants in terms of milk processing and utilities.
C. Use of heat exchanging technologies for maximum energy recoveries.
D. Better production scheduling to avoid rerun of process for product making and standardization.
E. Use of automatic milk heating system for indigeneous milk products like dahi, panir, rasogollaetc so as to reduce costs.
F. Developing more and more variants in different packaging of milk products so as to add value and provide convenience and reduce discontent of consumers.
G. Planning CIP systems with recycling of chemicals as well as recirculation of water.
H. Setting targets for better recovery in all the products by using appropriate technologies say for panir, cheese etc.
I. Finding ways of recovery from whey, butter milk, ghee residues etc.
J. Maintaining the plant and machineries to avoid breakdowns and reduce idle hours.
K. Maintaining packaging machineries so as to limit the packaging loss.
L. Creating a system of recording energy consumption both at Motor control center level specific to respective sections of the dairy plant.

M. Developing a robust recording systems for all processing and utility parameters and control all parameters through close monitoring.
N. Set standard temperatures for processing and emphasize more on controlling finished quality through high quality raw milk rather than by elevating the processing temperatures, say in pasteurization.
O. Use of allowed chemicals to effect better recoveries in fermented and coagulated milk products.
P. For larger plants selection of technology in utilities for low cost of power through turbine, HVAC, AAS etc as well as selection of low cost fuel with local availability.
Q. Avoiding any kind of leakages in pipes or any other machine as saving losses is the simplest route to added profitability.

Dairy operations are cross functional and ownership of profitability needs to be taken up by everyone.

These are indicative strategies only but for long run a separate council or team should be formed in the organization which only looks after cost management through performance improvements at all levels of production. This team might comprise of one member each from cost accounting, quality control, production, maintenance , marketing and procurement.

ABSTRACTS

MOISTURE SORPTION ISOTHERM OF DAIRY WHITENER

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ABSTRACT

The sorption isotherms describe the equilibrium relationship between water activity (aw) and moisture content of the food, at constant temperatures and pressures. The knowledge of sorption isotherm of a food product is essential for product and process development in solving engineering problem such as equipment design, drying and storage condition selection as well as predicting the shelf life of food. The sorption isotherm of dairy whitener was measured at the three different temperatures of 30, 40 and 50°C. A gravimetric static method was used under 11–92% relative humidity for the determination of sorption isotherms that were found to be typical type- II sigmoid. There was a negative effect of temperature on equilibrium moisture content at a given water activity and a positive temperature effect on water activity at a given equilibrium moisture content. The equilibrium moisture content of dairy whitener decreases with increase in temperature at same water activity and increase in equilibrium moisture content with water activity at all three temperatures. The EMC at 30°C was higher than as compared at 40oC and 50°C. The experimental data were fitted to five mathematical models viz. Modified Mizarhi, Caurie, Oswin, Hasley and Guggenheim–Anderson–de Boer (GAB). It was found that GAB models were acceptable in describing equilibrium moisture content–equilibrium relative humidity (EMC–ERH) relationships for dairy whitener over the entire range of temperatures. The value of monolayer moisture content of dairy whitener decreases from 3.355 to 2.199 g/100g solids with increase in temperature from 30 to 50⁰C. Thermodynamic property of the product i.e the isosteric heat of sorption was determined as a function of moisture content of product. The isosteric heat of adsorption for dairy whitener ranged from 15.798 kJ/mol at 5% moisture content (d.b.) to 1.414 kJ/mol at 30% (d.b.) moisture content.

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DESIGNING APPROACH OF FARM MILK CHILLER

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ABSTRACT

Being world's largest milk producer as well as consumer, milk and milk products play significant role in Indian diet and is the only acceptable source of animal protein for large vegetarian segment of Indian population. Effective milk cooling on farm and holding the raw milk at low temperature while transporting it from milking centre to collection centre is very important to ensure the quality of the milk and thus of the dairy products. To design an effective cooling system for cooling milk on farm, there is a need to focus on some parameters like cooling rate, hygiene conditions, ergonomic features, etc. In past years, several researchers have tried to design a system to deal with the problem of milk cooling on farm but due to various reasons these systems could notbe adopted. The present paper is an attempt to discuss the approach for designing of a workable, easy to handle, low cost and sturdy farm milk chiller for maintaining the milk quality and cool chain during the initial stage of milk handling.

INVESTIGATIONS OF FLOW BEHAVIOR, TEMPERATURE EFFECT AND PASTING CHARACTERISTICS OF BARNYARD MILLET WORT-MILK BLENDS FOR SPRAY DRYING

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ABSTRACT

Barnyard millet based wort and milk blends were prepared, and their flow behavior was studied. The grains were malted, de-vegetated and wort was prepared using double mash technique with addition of α-amylase enzyme at different levels (0.5, 1.0, 1.5 and 2.0 mL). The optimum level of enzyme addition for complete hydrolysis of starch in wort was 2.0 mL. The compositional and physicochemical analyses of wort revealed that it had protein (9.80 %), pH (6.7), total acidity (0.24), free amino nitrogen (128 mg/L), specific gravity (1.029) and ash (3.20%). Flow behaviour of pure wort and wort blended with milk at different ratios (1:1, 1:1.5 and 1:2) were determined using an Anton Paar MCR52 rheometer (Courtesy: Anton Paar India, Bangalore). The blends showed shear thickening behaviour at constant temperature (30°C) and shear rate (500 s-1). Amongst five different models tested, Hershel Bulkley and Cross models showed better fitting with higher co-efficient of determination (R^2= 0.9942) and lower RMSE values. Temperature ramp of all samples showed pseudoplastic behaviour over the temperature range of 30 to 100°C without any significant gelatinization, except for control which showed rapid gelatinization and swelling after 70°C with a peak viscosity of 523.3 mPa.s at 93.3°C.

STUDY OF BULK DENSITY, POROSITY AND TEXTURAL PROFILE PROPERTIES OF PANEER WHILE VARYING THE PRESSURE APPLIED OVER THE HOOP-CUM-PRESS

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ABSTRACT

Paneer is a popular indigenous dairy product and can be produced by heating the milk 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 paneer. It has great value in Indian food because it is a rich source of high quality proteins, fat, minerals and vitamins. It is prepared by coagulating cow or buffalo or a blend of cow and buffalo milk and pressing the coagulum. Initially the raw milk was tested for the fat and SNF content by Gerber solution method on which the total quantity of the paneer extracted depends. The average values of fat and SNF were found 3.8% and 9.2% respectively for the raw cow milk procured from the cattle yard. Milk was boiled to the temperature of 90 oC and the solution of citric acid (2 g per liter) is poured in the milk. Coagulation started and the whey was filtered out and the coagulum was placed in the paneer hoop of the dimension 9.5×9.5×12 cm. The different pressure applied on the coagulum for the different amount of time and the textural profile, moisture content, bulk density and the porosity of the paneer prepared were evaluated using the standard methods and TPA. About 650 g (3.8+9.2=13 g of paneer per 100 ml of milk) of paneer was prepared from the 5 liter of milk. Average value of porosity was found to be 20.29 % and the bulk density 1.0926 g/cc. A reduction on porosity value was observed as the pressure applied on the paneer hoop was raised while the bulk density was increased to about 1.32 g/cc. In textural profile analysis it was found that the cohesiveness and gumminess were increasing with the increasing the pressure.

AUTOMATED TEMPERATURE CONTROL FOR MOISTURE CONTENT ANALYSIS BY GRAVIMETRIC METHOD OF PANEER

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ABSTRACT

The important application of instruments is in automatic control systems and has been employed for the moisture content measurement of paneer. Measurement of a variable and its control are closely associated for maintaining the quality of the prepared paneer. To control a process variable, e.g., temperature, pressure or humidity etc., the prerequisite is that it is accurately measured at any given instant and at the desired location. Paneer should not contain moisture more than 70 g per 100g paneer as per the PFA regulations (1987). The moisture content of paneer was determined by gravimetric method for which the 2 g of sample was taken in peltry dish, added distilled water, smashed sample into tiny pieces. The weights were taken before and after putting the sample inside the hot oven whose temperature was set at a temperature of 102± 2 ºC. The temperature value was set by using the PID control programming for the period of 4 hours which controlled the temperature of the sample within the set value inside the hot oven and cut the supply as and when it goes up. The samples were weighed after 4 hours and kept it again in the oven and weighed in ½ hour difference until the consecutive measurements gave a difference of ± 5 mg. This weight was taken as final weight (Wfinal) of the samples. The moisture content can be obtained using the following formula, Moisture content (%) = (W_initial- W_final)/W_initial × 100. The average values of moisture content for the two samples prepared at different applied pressure of 7 and 13 kg were found to be 52.5 % and 49.35 % on paneer hoop respectively. For production of paneer, 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. Recovery of milk solids in chhana varies between 63% and 67%. When chhana is pressed, matting of the coagulum takes place due to change in visco-elastic properties of casein under pressure.

PERFORMANCE EVALUATION OF THREE STAGE SCRAPED SURFACE HEAT EXCHANGER FOR CONTINUOUS MANUFACTURE OF *BURFI*

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Indigenous Dairy Products are very popular in India. About 50- 55% of total Indian milk production is converted into traditional Indian milk products. Burfi is among one of the traditional milk products, which is very popular all over India. Feasibility studies and process optimization has also been done for manufacture of Burfi in relation to sensory and organoleptic quality. It has been proved very successful for continuous manufacture of Khoa and Basundi in three stage scraped surface heat exchanger. Burfi was manufactured by adding sugar directly into pasteurized milk by varying scraper speed all three stages. The performance was evaluated in terms of quality of *Burfi* manufactured, steam and electricity consumption. Effect of scraper speed on performance was checked in different 27 scraper rpm combinations.

RHEOLOGICAL CHARACTERISTICS OF MILK-CEREALS BASED MICRONUTRIENT FORTIFIED COMPLEMENTARY FOOD

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ABSTRACT

The rheological properties of the milk-barley-pearlmillet based complementary porridges were evaluated through dynamic oscillatory and steady shear tests at six different temperatures viz. 5, 20, 35, 50, 65 and 80 °C by using controlled stress rheometer. The dynamic oscillatory test was conducted at the angular frequency (ω) varied from 0.1-100 rad/s with an aim towards the estimation of storage modulus (G'), loss modulus (G''), Damping factor ($\tan\delta$) and complex viscosity (η*). Similarly, steady shear test was conducted at the shear rate (γ) varied from 0.1-100 rotations within 5 min to estimate the shear stress (τ) and apparent viscosity (η_a). The steady shear test revealed that τ and η_a decreased with increase in temperature and Hershel bulkey model found well fitted to experimental data. The Hershel bulkey parameters like *n* and *k* values decreased with increase in temperature, however *k* value reached equillibrium after 50 °C. whereas, the yield stress didn't showed any temperature dependency. The dynamic oscillatory test revealed that G' and G'' increased with increase in frequency and both have decreased with increase in temperature except at 5 and 80 °C. However, the great loss in elasticity and increment in viscosity found with increase in temperature showed product turned more towards liquid consistency. The modified Cox-Merz rule found fitted well upon insertion of shift factor (k). But goodness of fitting was not satisfied by other statistical criterions (*RMS %*, *P* and χ^2). The thermal characteristics evaluated through differential scanning calorimetry found good agreement with the rheological characteristics. The results obtained in this study will help in the process development of complementary porridges.

DEVELOPMENT OF VEGETABLE BASED DRIED *KHEER* MIX

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ABSTRACT

Kheer, one of the most widely consumed traditional dairy products of Southeast Asian nations including India. Because of poor shelf life, which hinders commercialization and product is confined to cottage level. The object of this study was to develop the process for vegetable based dried *kheer* mix using five treatments T1 (Pumpkin flesh kheer), T2 (1 per cent pumpkin powder + 43 per cent skim milk powder), T3 (2 per cent pumpkin powder + 42 per cent skim milk powder), T4 (3 per cent pumpkin powder + 41 per cent skim milk powder) and T5 (4 per cent pumpkin powder + 40 per cent skim milk powder). In addition to this all the treatments were added sugar 36 %, rice 10 %, nutmeats 2.1 %, cardamom 0.7 % and 0.2 % color. The dried *kheer* mix was testing moisture 3.65 %, fat 7.06 %, protein 15.47 %, lactic acidity 0.59 %, reducing sugar 11.09 %, total sugar 59.89 % and ash 1.44 %. The *kheer* obtained from dried kheer mix was compared with pumpkin flesh *kheer* (T1). Statistical analysis revealed that, score assigned for color varied significantly for T1 (7.30) and T5 (6.80), yellow color of *kheer* decreases with the increase in level of pumpkin powder. The average values for flavor score ranging from 6.36 to 7.32. Body and texture score decreases in order of T2 > T3 > T4 >T5. As regards appearance score, all treatments were non-significant. The score recorded ranged between 6.40 ± 0.77 and 7.30 ± 0.79 for overall acceptability. Dried kheer mix with 1 % dried pumpkin was accepted.

CROSS CONTAMINATION OF PASTEURIZED MILK - PREVENTING BY PRESSURE DIFFERENCE IN PASTEURIZER

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The purpose of the differential pressure in pasteurizer is to ensure the maintenance of higher pressure of pasteurized milk in comparison to unpasteurized/raw milk/heat exchanging media. When milk is in forward-flow, the pressure on the pasteurized milk side of the regeneration and raw milk/heat exchanging media zones shall not be less than 10 kPa above the pressure of raw milk/heat exchanging media. The pressure drop (0.2-0.3bar) across regeneration zone rises, so the product pressure before the heat exchanger must be increased to force the product through the plates of heat exchangers by installing a booster pump at heating zone inlet. The back pressure valve (installed at chilling zone outlet) throttles the flow of milk, resulting in pressurized pasteurized milk line and this increased milk pressure will be uniformly distributed in pasteurized milk zones in the regenerators (approx. 3.5bar). During diversion, milk is diverted back to balance tank by flow diversion valve. Thus pasteurized milk will not enter in the regeneration zones. Raw milk pressure in regeneration zone increases vs pasteurized milk. This may lead to possible cross-contamination of pasteurized milk due to hair line cracks or gasket failure. To prevent this, Hygienic bypass assembly is used mainly during start-up of high capacity HTST systems. The purpose is to bypass raw milk going in the Regeneration zone. This will help to maintain differential pressure in regeneration section as well as to achieve pasteurization temperature at holding coil outlet in short time. Components of Hygienic bypass are feed pump, booster pump, stuffing pump and pipe work. Hygienic regeneration bypass assembly helps to maintain positive pressure in the pasteurized milk side during start-up, low temperature diversion and power failures. This also prevents contamination of pasteurized milk by raw milk as well as heat transfer media. Hygienic regenerator bypass assembly also minimize steam and energy consumption during start-up/diversion mode.

FOOD EXTRUSION TECHNOLOGY – A TOOL FOR VALUE ADDITION IN DAIRY PRODUCTS

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ABSTRACT

Extrusion process has become very popular and is being increasingly used for the manufacture of various 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. Its main advantages include improvement in starch or protein digestibility, homogenous and consistent product quality, minimum reduction of nutrients and enhanced product characteristics and range. A food extrusion machine consists of tightly fitting screw rotating within a stationary barrel. The food extruder use single or twin screws to transport, mix, knead, shear, shape and cook multiple ingredients into a uniform food product by forcing the ingredient mix through shaped dies to produce specific shapes and lengths. Their main use in dairy industry has been in the manufacture of processed cheese, mozzarella cheese, casienates, texturizing butter grains, sandesh, etc. Extrusion process is a very useful technology for dairy processing operations involving conveying, mixing, kneading, cooking, shearing and shaping which is yet to be exploited by Indian dairy industry.

DEVELOPMENT AND PERFORMANCE EVALUATION OF FRUSTUM CONE SHAPED BUTTER CHURN

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ABSTRACT

India has emerged as largest butter producing country in the world, with annual production of 4.52 million metric tons in 2012. In India, per capita consumption of butter is 3.6 kg which is low as compared to the other developed countries so it is being imported annually. In the present research, the frustum cone shaped butter churn at the capacity of 10 liters with working capacity of 5 liters was developed. The body of churner was insulated with a thermal insulation of foamed polyethylene over it to maintain the churning temperature. The performance was conducted at three different churning temperatures of 8, 10 and 12˚C and churn speed of 35, 60 and 85 rpm. The reduced churning time and with good consistency of butter was obtained at churning temperature of 10˚C and churn speed of 60 rpm. The optimum moisture content (16%) and fat content (82.7%) was obtained at churning temperature of 10˚C and churn speed of 60 rpm. The highest overrun of the butter was recorded to be 24.46% at higher churning temperature (12˚C) and higher churn speed (85 rpm), however butter formed was weak and leaky. The optimum overrun of 19.49% was obtained, with good body and texture at churning temperature of 10˚C and churn speed of 60 rpm. However maximum yield was obtained at higher temperature and churn speed, but with respect to the body of butter best yield was obtained at churning temperature of 10˚C and churn speed of 60 rpm of 1.57 kg on weight basis.

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COMPUTER VISION TECHNOLOGY FOR QUALITY EVALUATION OF FOOD

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ABSTRACT

Computer Vision Technology (CVT) becoming one of the most important non destructive, rapid, economic, consistent and objective inspection and evaluation technique in the dairy and food industry. Computer Vision (CV) based on image processing/analysis techniques have been increasingly employed in the food industry for quality inspection, classification and evaluation, with great advantages in its objectiveness, efficiency and reliability. The food industry now ranks among the top ten industries using computer vision technology. Computer vision systems can perform repetitive tasks faster, more accurately, and with greater consistency over time than humans. They can reduce labor costs, increase production yields, and eliminate costly errors associated with incomplete or incorrect assembly. Especially computer vision has recently been investigated as a tool to evaluate the functional properties of cheddar and mozzarella cheeses, topping percentage and distribution of pizzas and quality attributes such as shrinkage, pores size and distribution, texture and colour of cooked meats, which has significantly expanded its possible application in the food industry. The technology is also used in a variety of different application to automate the production, increase production speed and yield, and to improve product quality. The most recent progress in the application of computer vision in the food industry for quality evaluation including meat, poultry, fish, fruit and vegetables, grains, bakery and confectionary and other foods.

ELECTRONIC NOSE, ELECTRONIC TONGUE AND ELECTRONIC VISION (ENTV) TECHNOLOGY FOR MEASUREMENT OF QUALITY OF FOOD PRODUCTS AS A NOVEL ARTIFICIAL ELECTRONIC SENSING TECHNOLOGY

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ABSTRACT

For a very long time the human being has been superior to the machines when it comes to the ability to see, hear, smell, feel or taste. Since time immemorial, five physiological sensory organs of the humans have been in use for detection and identification of parameters relevant and significant to societal and individual perspective. Today there are sensor systems that imitate the five human senses in a way that makes it possible to in some extent replace for example a human taster at a food-industrial company, with an artificial sensing system. Sensing and perception through these organs are done through biological, physiological, chemical processes involving finally the brain as the Central Processing Unit. Now, many of the food industries are looking forward for the non destructive food quality analysis techniques. The emerging non destructive food quality analysis techniques are capable of evaluating the finished products quality by analyzing their sensory outputs which may be in the form of flavor, odor, color, texture and taste. One of the signs of this care is development and optimization of monitoring and control methods of both, food materials and their processing. The taste or smell of end-products manufactured in the food, beverage or dairy industries can be of vital importance to the commercial success of the product. The expectations of consumers regarding the quality of products in these fields are continually increasing as a result of greater range of choices in the marketplace together with targeted advertising, which emphasizes product quality. Competition for market share and the added emphasis on quality have increased pressure on product development and rigorous QA/QC to meet consumer expectations. Ideally taste analysis, both in the development of new products and their routine production, should be carried out by tasting panels composed of human experts. In practice such panels are extremely expensive and especially problematic when used for production control purposes. With rapid growth in electronic hardware technology and spurt of software-based computation and processing, standardized identification through artificial sensors like E-Nose, E- Tongue and E- Vision etc. have been recently used. ENTV technology has generated a lot of interest recently because of its versatile applicability in terms of identification and classification of processed food and consumer items.

FLOW PATTERN, FRICTION FACTOR AND RESIDENCE TIME DISTRIBUTION OF HORIZONTAL LIQUID -- FULL SCRAPED SURFACE HEAT EXCHANGERS USING WATER

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ABSTRACT

Flow pattern, friction factor and residence time distribution of horizontal liquid full scraped surface heat exchangers (LF-SSHEs) as influenced by mass flow rate, rotor speed, number of blades, ratio of diameter of rotating cylinder to that of inner stationary cylinder and pressure of liquid were investigated using tap water as test fluid. A saturated sodium chloride solution as a tracer of residence time was injected through an injector at the inlet of LF-SSHE flowing with tap water at steady state. The samples were collected after every 15 sec at the outlet and the conductivity of collected samples were measured. Due to higher range of Re_r/Re_{rc} from 21.30 to 220.57, the experiment had a combined axial and Taylor vortex flow away from transitional zone of rotational flow i.e. from vortical to turbulent. For small rotor assembly (d_s/d_t as 0.16) with set of 4 blades, the friction factor varies from 0.5807 to 1.2291, however, for large rotor assembly; it varies from 0.0661 to 0.1514. This indicated that friction factor and power consumption is lower in large rotor assembly than that in small rotor assembly. With the increase of mass flow rate, d_s/d_t , pressure of liquid and number of blades, the value of mean residence time (t_{cbar}) and variance were decreased ($P\leq$ 0.01). With the increase of rotor speed from 2.33 to 7.00 rps, the t_{cbar} and variance were increased, resulting in decreased in Peclet number ($P\leq 0.05$).

PHYSICOCHEMICAL PROPERTIES OF CONCENTRATED MILK MADE FROM STEAM JACKETED KETTLE

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ABSTRACT

Physicochemical characteristics of concentrated milk made from steam jacketed kettle at steam pressure of 2.0 Kg/cm^2 were analysed. The properties analysed were pH, Colour, HMF, viscosity, FFA and density. Two concentrations of concentrated Milk i.e. 30% TS and 45% TS were taken for analysis. pH was measured with help of Eutech Instruments pH/mV/cm/$^oC/^oF$ meter with RS-232. Colour was measured with help of Hunter LAB colorimeter. HMF was measured by Spectrophotometric method (Keeney and Bassette). Viscosity was measured with help of Anton Par Rheometer. Free Fatty acid was measured by method given by deeth *et al.* (1975) and density was measured with the help of pycnometer. The measured pH values of 30% TS and 45% TS concentrated milk were 6.156 and 6.521. The measured colour values in terms of L, a ,b of 30% TS and 45% TS concentrated milk were L=86.18 a=-1.21 b= 12.28 and L=84.24 a=-2.33 b= 8.36. The measured HMF values of 30% TS and 45% TS concentrated milk were 3.93 and 7.5 micromole/lit. The measured viscosity values of 30% TS and 45% TS concentrated milk were 15.7 Pa-s and 16.8 Pa-s. The measured FFA values of 30% TS and 45% TS concentrated milk were 0.52 and 0.80 microequivalent /ml. The measured density values of 30% TS and 45% TS concentrated milk were 1.08 and 1.07 gm /ml.

STUDIES ON APPLICATION OF SOLAR WATER HEATING SYSTEM ASSISTED SHELL AND TUBE HEAT EXCHANGER FOR PASTEURIZATION OF MILK

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ABSTRACT

India is the largest milk producer in the world and FAO reported that the present production of milk is about 139.68 MT in 2013-14. Heat exchanger is used for processing milk and milk products in the dairy and food industry. Heat exchangers are devices which commonly used to transfer heat between two or more fluids of different temperatures. Traditionally, fossil fuels are utilized to generate heat to produce steam/hot water. The present investigation is aimed to evaluate the performance of solar water heating system assisted 1-2 pass shell and tube heat exchanger, to prepare pasteurized milk using solar heated water and to assess the chemical and microbial qualities of pasteurized milk prepared using solar heated water. The performance of shell and tube heat exchanger was evaluated considering solar water flow rates of 3, 5, and 7 l/min at 83 to 85^{0}C and cold water flow rates at 0.5, 1.0 and 1.5 l/min at 34-36^{0}C. The values of heat exchanger effectiveness, number of transfer units, heating efficiency and tube wall temperature were found to be maximum in combination of flow rate of hot water at 7 l/min and flow rate of cold water at 0.5 l/min. The milk was pasteurized with this combination of flow rates. The pasteurized milk was evaluated for its chemical and microbial qualities and was compared with raw milk. The pasteurized milk had 0.15, 3.49, 8.44 and 11.93 per cent acidity, fat, solid not fat and total solid, respectively and was found similar with raw milk. The alkaline phosphatise test was found negative for all samples of pasteurized milk. Methylene blue reduction time was found 5.40 h for pasteurized milk. The total counts were found 4.27 log 10 cfu/ml and coliform was found to be absent in 0.01 dilution for pasteurized milk and was within the BIS microbial standards specified for pasteurized milk. Solar water heating system assisted shell and tube heat exchanger system could be used to produce properly pasteurized milk with acceptable quality without using non-renewable energy source for heating.

DESIGN OF AN INTERMITTENT VAPOUR ABSORPTION REFRIGERATION SYSTEM USING SOLAR TROUGH CONCENTRATOR FOR SMALL SCALE APPLICATIONS

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ABSTRACT

Use of Solar concentrators is becoming more common and simpler and smaller designs are now in the public domain. Application of this for small scale applications of cooling milk or making ice is possible with minimum of investment and technical skill, if some procedure are followed. The paper presents such unit in details of fabrication. With very little modification, the same can be used for chilling milk or producing chilled water.

BIOLOGICAL TREATMENT OF DAIRY WASTEWATER IN AN ANAEROBIC BIOREACTOR FOR METHANE GENERATION

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ABSTRACT

Dairy Industry serves as a breeder of huge quantities of wastewater with very high Biological Oxygen Demand and Chemical Oxygen Demand. The strict legislations regarding the disposal of wastewater leads to development of bioreactors which converts the organic wastes into Methane gas and hence providing a cleaner environment along with a sustainable and renewable source of energy. One of the focal ecological difficulties of todays is the constantly cumulative production of organic waste material in the solid, liquid and in gaseous phases. Numerous countries demonstrating a significant part of the mutual determinations to diminish pollution and greenhouse gas discharges and to moderate worldwide climate variations. Abandoned waste removal is no longer suitable today and even precise landfill disposal and burning of organic wastes are not measured ideal practices, as environmental principles hereof are gradually severer and energy retrieval and reutilizing of nutrients and organic matter is meant.

COLD PLASMA TECHNOLOGY IN FOOD PROCESSING

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ABSTRACT

Plasma, the fourth state of matter, is an ionized state of matter similar to a gas, consisting of positive ions and free electrons in proportions resulting in more or less no overall electric charge, typically at low pressures or at very high temperatures. Based on the relative temperatures of the electrons, ions and neutrals, plasmas are classified as "thermal" or "non-thermal". Cold or Non-thermal plasma (NTP) is a novel food processing technology that uses energetic reactive gases to inactivate contaminating microbes on the surface of fresh and processed foods and even packaging materials at or near room temperature. Devices that have been used for plasma generation include corona discharges, micro hollow cathode discharges, gliding arc discharge, one atmospheric uniform glow discharge, dielectric plasma needle, barrier discharge and atmospheric pressure plasma jet. The combination of electron and ion bombardment, thermal effects, free radical and local exposure to UV all act in concert to disrupt bacterial cell membranes, denature proteins and damage bacterial DNA. This technology is increasingly finding acceptance among food processors for the surface sterilization and combating biofilm formation. Application of this technology for processing dairy products and studying the combined effect of cold plasma with other processing technologies offer immense potential for research.However, only limited information is available about the nutritional and chemical changes in food products treated with this technology.Hence this is a promising technology which is the subject of active research to enhance the safety of foods.

DESIGN AND DEVELOPMENT OF BALL FORMATION MACHINE FOR *PINNI* PRODUCTION

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ABSTRACT

India's milk production is highest in the world for last few years. A larger proportion of milk in India is used to produce traditional dairy products. Pinni is one of the traditional and popular dairy composite product of northern India. Pinni is prepared by roasting dal peethi(paste) in ghee and then adding sugar, khoa and is moulding into round shape. The ball formation process is done by hand which is time consuming , unhygienic and laborious. Also the temperature of the product of the material is high at the time of ball formation, so it poses difficulty to the person involved in this. To overcome these entire difficulties ball formation unit was designed for pinni production. It consist of a hopper of capacity 4 kgs, a screw of 75 mm diameter and 35.5 cm long through which material oves and reaches the die for cutting .A pneumatic cylinder is attached at the end of the die which is further attached to knife for cutting of material when 45 gram material comes out. This compressed cylindrical mass falls onto twin rollers. Twin rollers (150 mm diameter) and 61 cm in length to perform the rolling action which changes the shape of mass from elliptical to spherical. The power transmission mechanism is chain and power was given with 0.5 hp a.c. motor

TECHNOLOGICAL AND ENGINEERING ASPECTS OF COLOSTRUM PROCESSING

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ABSTRACT

"Colostrum" means the fluid secreted by the mammary glands of milk-producing animals up to three to five days post parturition that is rich in antibodies and minerals. Owing to the nutritional benefits and ability to inhibit viral and bacterial pathogens, colostrum products have been growing in popularity as a human food. Early studies on pasteurization of bovine colostrum using the same time-temperature combination recommended for milk resulted in a thick, denatured product that clogged pasteurization equipment, with reduced Ig concentration. However recent studies show that when colostrum is heat treated at a lower temperature (60^{O}C) for 60 min, the IgG concentration or fluidity do not change significantly when compared to raw colostrum. Freeze-drying and low temperature spray-drying technology can be adopted to produce colostrum powder.However freeze drying has high capital and process costs. Generally colostrum is spray dried using indirect steam and with low pressure and temperatures (less than 63°C) to produce a high quality powder while protecting the colostral proteins. In spray drying of colostrum, it has been reported that moisture content and solubility are inversely proportional to inlet air temperature, drying air flow rate, compressed air flow rate and the bulk density increases as compressed air flow rate and drying air flow rate increase, as inlet air temperature decreases. Studies have also been reported on processing colostrum usingmembrane technology, UV, High voltage pulsed electric field and High pressure processing. Most of the researches carried out in relation to the processing of colostrum have been on the effect of processing on the bacterial count and IgG concentrations. Hence there is immense scope of further study regarding the effect on other parameters and engineering interventions.

IN-LINE PRODUCTION OF KHOA THROUGH COMBINATION OF SSHE WITH CONICAL PROCESS VAT

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ABSTRACT

The Indian dairy industry is fastest growing, trying to keep pace with the galloping progress around the world with, with more than 4% annual growth. Since immemorial time traditional Indian milk products have been an inseparable part of the socio-cultural life of India. Significant portion of milk produced in India is used to manufacture a wide variety of indigenous milk sweets. Khoa is an important indigenous milk product used as a base material for a variety of sweets, such as *burfi, peda, gulabjamun*, milk cake *kalakand, kunda* etc. having annual market share of Rs. 375 billion. The Indian dairy is considered as A tool for socio-economical up-liftment for rural poor people of India. With a view to mechanize the process of making traditional products various efforts has been carried out for design and development of new equipments and methodology.

In the present Investigation systematic attempt has been made for continuous production of khoa with desirable texture by integrating a scraped surface heat exchanger(SSHE) with Conical Process Vat, by using three variables at different levels such as steam pressure of SSHE (3 kg/cm^2, 4 kg/cm^2, and 5 kg/cm^2) ,scraper speed of SSHE(50 rpm,100 rpm, and 150rpm) along with steam pressure of Conical process vat (2.5 kg/cm^2, 3 kg/cm^2, and 3.5 kg/cm^2). Product obtained was subjected to sensory evaluation using a panel of judges. Texture profile analysis was done by using a texture analyzer. Instrumental texture profile analysis was used to compare the subjective sensory assessment of the textural attributes of the product. On the basis of sensory attributes, and texture analysis the operational parameters were optimized by using Central Composite Rotatable Design (CCRD) popularly known as response surface methodology (RSM) in realistic vicinity to locate the true optimal value of multiple compositional variables. Using RSM it was predicted that Khoa produce by using 4.32 kg/cm^2 steam pressure and 107.26 rpm scraper speed of SSHE along with 2.99 kg/cm^2 steam pressure of conical process vat was gives maximum sensory and textural score among all combinations. It was observed that khoa produced by using 4.0 kg/cm^2 steam pressure and 100 rpm scraper speed of SSHE along with 3.0 kg/cm^2 steam pressure of conical process vat gives average sensory score like flavour, body and texture, colour and appearance as 43.22, 33.15,and 13.24 respectively, and average textural attributes score like hardness, gumminess ,chewiness value as 25.96,3.680and 0.557 respectively, which are highest among all combinations. The Predicted score and observed score of all sensory as well as textural attributes were compared, and statistically analysed by Student's t test.

Statistical analysis shows that there wasn't significant difference between predicted and observed value at optimum parameters at $p \leq 0.05$ at all degree of freedom. Based on statistical analysis it was concluded that, for continuous production of good textural quality khoa using 4.32 kg/cm^2 steam pressure and 107.26 rpm scraper speed of SSHE along with 2.99 kg/cm^2 steam pressure of conical process vat were considered as the optimized parameters of the integrated unit.

PROCESS OPTIMIZATION FOR IN-LINE PRODUCTION OF *RABRI*

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ABSTRACT

In the present study, scraped surface heat exchanger (SSHE) was integrated with conical process vat (CPV) for in-line production of rabri. Response surface methodology was applied to optimize the process parameters on the basis of sensory score, color & textural attributes. The four factors considered for optimization were initial concentration of milk in SSHE, final concentration of milk in CPV, ratio of clotted cream layer (CCL) to sweetened concentrated milk (SCM) and steam pressure of CPV during removal of CCL. Optimum parameters predicted for rabri production were 30 % total solids (TS) initial concentration of milk in SSHE, 40% TS final concentration of milk (before sugar addition) in CPV, 0.167 CCL/SCM ratio and 0.8 kg/cm2 steam pressure of CPV during removal of CCL. The observed values for flavour, body & texture, color & appearance, overall acceptability, firmness, L*, a* and b* were 7.97, 7.93, 8.23, 8.067, 0.3540, 75.907, 01.14 and 16.3197 respectively.

AUTOMATION AND INSTRUMENTATION IN DAIRY INDUSTRIES

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ABSTRACT

The term automation generally refers to the science and technology to carry out the process which maximum accuracy and efficiency. Automation and instrumentation has become an essential requirement in all fields such as medical, defense, household appliances, industries, communication, transportation, etc. The basic aim of having automation in various fields is to achieve higher precision and efficiency in all operations and processes. Automation can be achieved by adopting various types of automation tools such as numerical control, CAD, CAM software, CHI, PLC etc. In view of the volume of the milk to be handled and the requirement of food safety standards, the use of automation in all dairy processing operations has become a necessity today. The control of process parameters in processing of milk and manufacture of different products is one of the essential requirements to achieve desired quality product. The transfer function of each element involved in process controllers in important to achieve optimum performance of the control system. In addition to consistency in product quality, automation also provides scope for operational flexibility, energy conservation and safety in the plant. Automation has done wonder in the field of packaging of dairy and food products. The dairy equipments such as milk reception and processing equipments, 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. Automation in dairy industries is presently viewed as a versatile tool for solving crucial problems of the process and production control, plant supervision and management as well as for solving the accompanying financial and organizational problems. The basic objective of dairy plant automation is to identify the information flow and to manipulate the material and energy flows of a given process in a desired optimal way.

ECO-FRIENDLY BIO-DETERGENTS: A SOLUTION FOR EFFICIENT CLEANING

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Abstract

Cleaning is essential prerequisite for maintaining hygienic conditions in the dairy and food plants. This can be performed using various chemical and physical treatments with or without use of the chemical agents. The industries have problems for the biofilm formations (biofouling) and proteinaceous milk stones on the surface of equipments. This can be eliminated using the formulated detergents with added enzymes called bio-detergents. Enzymes can reduce the environmental load of detergent products, since they save energy by enabling a lower wash temperature to be used; allow the content of other, often less desirable, chemicals in detergents to be reduced; are biodegradable, leaving no harmful residues; have no negative impact on sewage treatment processes; and do not present a risk to aquatic life. Detergent enzymes must be cost-effective and safe to use. A potential application for bio-detergents includes cleaning of UF and RO membrane, reduce and control of biofilm formation on the equipment surfaces, removal of milk stone from the pasteurizers. The Bio-detergent which is bio-degradable, less toxic, non-corrosive, prevents environmental pollution, enhance cleaning properties, have increased efficiency and stability. Bio-detergents involving enzymes are affected by High temperatures, pH conditions, Ionic strength, Composition matrix as they are action specific. Therefore, these are referred as “green chemicals” and are becoming an ideal consumer choice. There is a need to increase production of Bio-detergent in our country so that import can be reduced. Also, there is need of awareness among people especially in dairy and food industry so that hygienic conditions in plant can be maintained leads to production of quality products.

DEVELOPMENT OF VEGETABLE BASED DRIED *KHEER* MIX

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ABSTRACT

Kheer, one of the most widely consumed traditional dairy products of Southeast Asian nations including India. Because of poor shelf life, which hinders commercialization and product is confined to cottage level. The object of this study was to develop the process for vegetable based dried *kheer* mix using five treatments T1 (Pumpkin flesh kheer), T2 (1 per cent pumpkin powder + 43 per cent skim milk powder), T3 (2 per cent pumpkin powder + 42 per cent skim milk powder), T4 (3 per cent pumpkin powder + 41 per cent skim milk powder) and T5 (4 per cent pumpkin powder + 40 per cent skim milk powder). In addition to this all the treatments were added sugar 36 %, rice 10 %, nutmeats 2.1 %, cardamom 0.7 % and 0.2 % color. The dried *kheer* mix was testing moisture 3.65 %, fat 7.06 %, protein 15.47 %, Lactic acidity 0.59 %, reducing sugar 11.09 %, total sugar 59.89 % and ash 1.44 %. The *kheer* obtained from dried kheer mix was compared with pumpkin flesh *kheer* (T1). Statistical analysis revealed that, score assigned for color varied significantly for T1 (7.30) and T5 (6.80), yellow color of *kheer* decreases with the increase in level of pumpkin powder. The average values for flavor score ranging from 6.36 to 7.32. Body and texture score decreases in order of T2 > T3 > T4 >T5. As regards appearance score, all treatments were non-significant. The score recorded ranged between 6.40 ± 0.77 and 7.30 ± 0.79 for overall acceptability. Dried kheer mix with 1 % dried pumpkin was accepted.

PHYSICO-CHEMICAL PROPERTIES OF RECONSTITUTED *KHEER* OBTAINED FROM VEGETABLE BASED DRIED *KHEER* MIX

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ABSTRACT

The objective of this study was to determine physico-chemical properties of reconstituted *kheer* obtained from dried *kheer* mix using five treatments T1 (Pumpkin flesh *kheer*), T2 (1 per cent pumpkin powder + 43 per cent skim milk powder), T3 (2 per cent pumpkin powder + 42 per cent skim milk powder), T4 (3 per cent pumpkin powder + 41 per cent skim milk powder) and T5 (4 per cent pumpkin powder + 40 per cent skim milk powder). In addition to this all the treatments were added sugar 36 %, rice 10 %, nutmeats 2.1 %, cardamom 0.7 % and 0.2 % color. Samples were studied for physico-chemical properties viz. moisture, fat, protein, acidity, reducing sugar, total sugar and ash. The results revealed that the increased level of pumpkin powder leads to decrease in moisture content. T1 showed 64.62 % moisture content while T5 recorded minimum moisture content 58.02 % and all the treatments were statistically significant. T1 showed 3.61 % while T3 recorded lowest 2.59 % fat content, all the treatments were statistically non-significant. The protein content ranging from 4.30 to 5.06 and recorded significant difference among treatments. Statistical analysis for Lactic Acidity showed that treatments T1, T3, T4 and T5 are at par with each other and the difference is non-significant. Reducing and total sugar content recorded non-significant difference for all treatments. There was decrease in ash with the increase in proportion of pumpkin powder. The highest ash value 1.72 % was recorded for T2 and lowest 1.21 % was found with T5.

DEVELOPMENT OF COLOUR, TEXTURE AND CRUMB GRAIN FEATURES IN *CHHANA PODO* DURING BAKING

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ABSTRACT

Chhana podo is a popular dairy product of Southern India. It is probably the only milk-based indigenous dairy product that is prepared by baking. Preparation involves mixing *chhana*, sugar and semolina in 20:6:1 ratio, and kneading for 2-5 min using a planetary mixer attached with a hook-type beater to smooth consistency and baking the dough. Baking, the key step in the preparation of *chhana podo*, involves simultaneous heat and mass transfer that induces physico-chemical and structural changes in the product. In this study, podo was baked at 120, 135 and 150°C for a period of 120 min. The effects of baking conditions on colour, texture and crumb grain development of the product were evaluated. The surface colour of *chhana podo* was measured using image analysis technique using Adobe Photoshop software. The texture profile analysis of *chhana podo* was analysed using texture analyser. The crumb grain features were measured using image analysis technique using ImageJ software. Results indicated that the browning index of baked *podo* increased from the initial value of 15.7 to 95.4, 101.5 and 112.1, at 120, 135 and 150°C, respectively. Browning kinetics followed the logistic model (R^2>0.98) with an activation energy of 17.8 kJmol^{-1}. In general, crumb grain characteristics such as mean cell area, air cell density and cell to total area ratio increased with increase in baking time and temperature. Textural attributes such as hardness, chewiness and gumminess increased with baking time and temperature while springiness, cohesiveness and resilience increased up to 40 min due to filling up of pores by melting fat and expanding water, and decreased thereafter. The results on physical properties of *chhana podo* could be useful for modeling the heat and mass transfer during baking. The method of crumb structure evaluation by image analysis is simple and can be used for quality assessment of several foods.

VACUUM BAND DRIER: AN OVERVIEW

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ABSTRACT

Vacuum band driers are used with high-moisture foods that can be slurried. The product is spread over a steel band which passes over two hollow drums in a process that occurs under partial vacuum. The first drum is heated internally with steam and radiant heaters are positioned above the band to facilitate the evaporation of water. The partial vacuum of the atmosphere accelerates the evaporative process. The band then passes to the second drum with is cooled and the product is scraped from the band. Shelf driers more closely resemble a batch process. The product is spread onto trays that are heated in a partial vacuum chamber to facilitate evaporation. Later, the dried product is scraped from the trays Vacuum band driers can be used to produce a range of products, however their most common application is in the production of puff-dried foods. The disadvantages of the process are high capital costs and relatively low production rates.

POTENTIAL OF VAPOUR ADSORPTION SYSTEM IN DAIRY PROCESSING PLANTS

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ABSTRACT

The Industrial design and development of adsorption cooling systems started in the 1920s by using silica gel and sulfur dioxide. This system is a way of decreasing dependence on electricity for cooling and to use environmental friendly system, thermally –powered cooling system such as physical adsorption systems. Basically in an adsorption cooling cycle the mechanical compressor of conventional vapour compression system powered by electricity is replaced with a thermal compressor driven by low grade thermal energy like solar energy. Because of high prices of fossil fuel and environmental concerns have drawn attention to the need for reliable, pollution free and low energy cost refrigeration. Adsorption refrigeration is a thermal driven refrigeration system, which can be powered by solar energy as well. The use of thermal driven systems helps to reduce the carbon dioxide emission from combustion of fossil fuels in power plants. Another advantage for adsorption systems compared with conventional vapor compression systems is the working fluid used. Adsorption systems mainly use a natural working fluid such as water and ammonia, which have zero ozone depletion potential.

OPPORTUNITIES FOR CONDENSATE HEAT RECOVERY IN DAIRY & FOOD PROCESSING INDUSTRIES

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ABSTRACT

Steam is usually generated for one of two reasons : 1) To produce power, as in power stations and co-generation plants, 2) To carry energy for heating and process systems. An efficient steam distribution system will make good use of this condensate. Failure to do so makes no financial, technical or environmental sense. Heat carrying capacity of steam, total enthalpy, is divided in two components, ie, latent heat and sensible heat. When steam starts condensing from Vapour State, latent heat is transferred to the cold source with which steam has contact. When the steam condenses, heat energy available in the liquid state of steam is called sensible heat. Sensible heat energy available in the condensate is proportional to the temperature at which steam is used for heating purpose. Recovering the condensed steam or the condensate, saves the heat energy and additional cost of water and chemicals used to treat the waste water. Practically, all process industries are trying to improve the condensate recovery. Steam, used for heating, gives up its latent heat, which is a large proportion of its total heat. The remainder is held by the condensed water. As well as having heat content, the condensate is also a distilled form of water, which is ideal for use as boiler feed water. An efficient installation will collect condensate and either return it to the deaerator, boiler feedtank, or use it in another process. Only when there is a real risk of contamination should condensate not be returned to the boiler. But then it may be possible to collect the condensate and use it as hot process water or pass it through a heat exchanger where its heat content can be recovered before discharging to drain. Condensate is discharged through traps from a higher to a lower pressureCondensate and flash steam discharged to waste means replacement feed water, more fuel, and increased running costs. The recovery of condensate in dairy and food processing plant has a great potential of cost saving.

OPPORTUNITIES OF HEAT RECOVERY FROM EXHAUST AIR OF SPRAY DRIER

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ABSTRACT

Spray drying is a commonly used method of drying a liquid feed through hot gas in the production of powders. This technique is widely used in food and pharmaceutical manufacturing and presents not only a low operating cost, but also a short contact time. This wide application of spray drying in research of new products increases the need for engineers to better understand energy calculation with mass and heat balance concerning the spray drying process. With the scarcity of energy and its rising cost, it is important to evaluate energy consumption on the drying process. Heat recovery from milk powder spray dryer exhausts has proven challenging due to both economic and thermodynamic constraints. Integrating the dryer with the rest of the process (e.g. evaporation stages) can increase the viability of exhaust recovery. Several potential integration schemes for a milk powder plant have been investigated. Indirect heat transfer via a coupled loop between the spray dryer exhaust and various heat sinks were modeled and the practical heat recovery potential determined. Hot utility use was reduced by as much as 21% if suitable heat sinks are selected.

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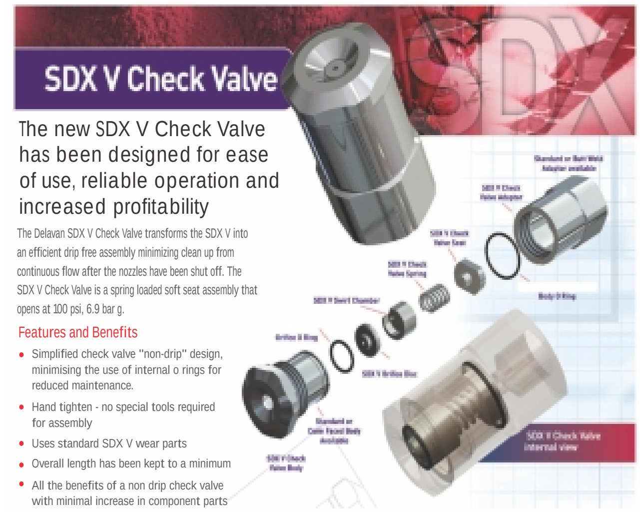

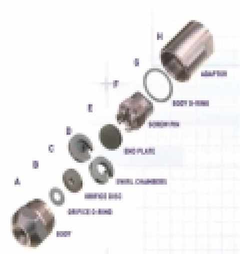

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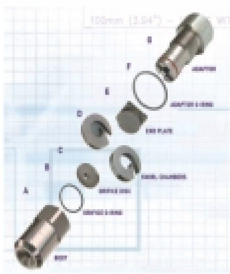

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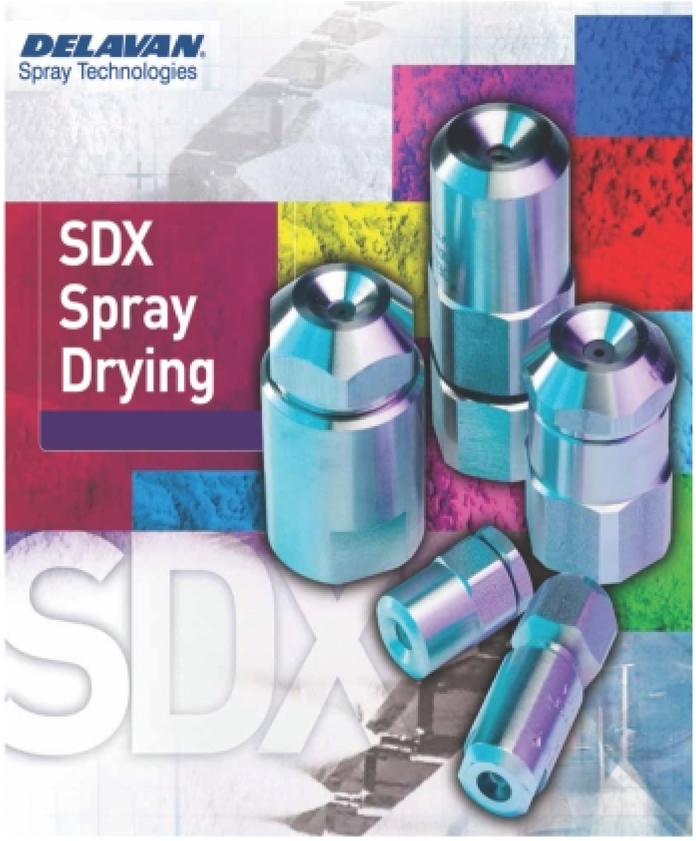

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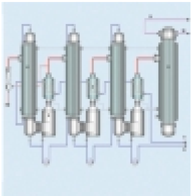
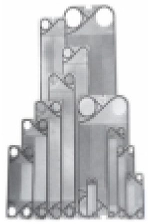
Depotal Hose Pipe

Powder Blender



Evaporators



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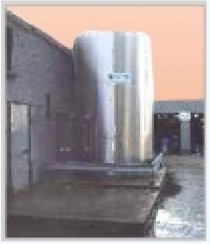


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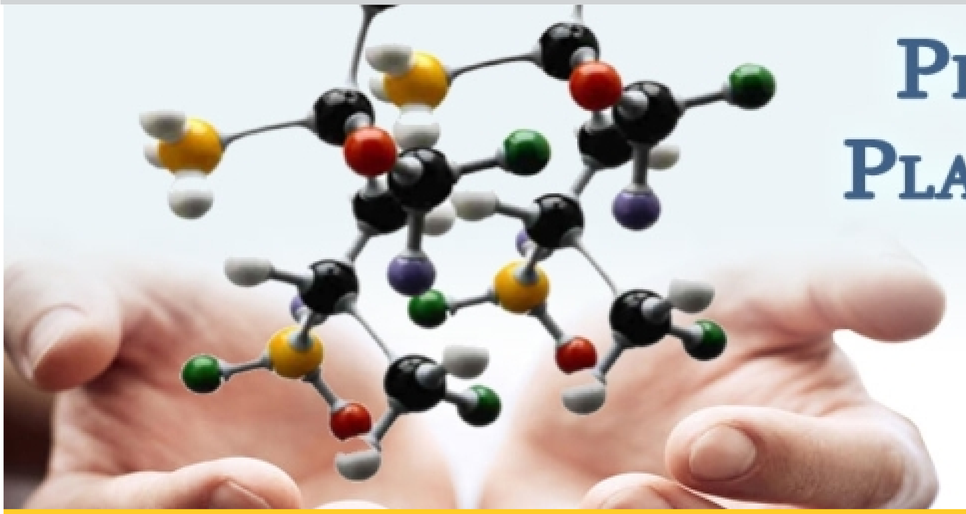

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