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Value Addition of Milk and Meat: A Push to Entrepreneurship

Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana
&
National Institute of Agricultural Extension Management (MANAGE), Hyderabad

GADVASU, Ludhiana & MANAGE, Hyderabad

Value Addition of Milk and Meat: A Push to Entrepreneurship

Programme Coordination

Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana, Punjab

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MANAGE, Hyderabad

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Editors: Dr. Parkash Singh Brar, Dr. Nitin Mehta, Dr. Amandeep Singh, Dr. S. Sivakumar and Dr. Shahaji Phand

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This e-book is a compilation of resource text obtained from various subject experts of GADVASU, Ludhiana & MANAGE, Hyderabad, on "**Value Addition of Milk and Meat: A Push to Entrepreneurship**". This e-book is designed to educate extension workers, students, research scholars, academicians related to veterinary science and animal husbandry about the value addition of livestock products and their potential in creating entrepreneurial opportunities. Neither the publisher nor the contributors, authors and editors assume any liability for any damage or injury to persons or property from any use of methods, instructions, or ideas contained in the e-book. No part of this publication may be reproduced or transmitted without prior permission of the publisher/editors/authors. Publisher and editors do not give warranty for any error or omissions regarding the materials in this e-book.

Published for Dr.P.Chandra Shekara, Director General, National Institute of Agricultural Extension Management (MANAGE), Hyderabad, India by Dr. Srinivasacharyulu Attaluri, Program Officer, MANAGE and printed at MANAGE, Hyderabad as e-publication.

MESSAGE

National Institute of Agricultural Extension Management (MANAGE), Hyderabad is an autonomous organization under the Ministry of Agriculture & Farmers Welfare, Government of India. The policies of liberalization and globalization of the economy and the level of agricultural technology becoming more sophisticated and complex, calls for major initiatives towards reorientation and modernization of the agricultural extension system. Effective ways of managing the extension system needed to be evolved and extension organizations enabled to transform the existing set up through professional guidance and training of critical manpower. MANAGE is the response to this imperative need. Agricultural extension to be effective, demands sound technological knowledge to the extension functionaries and therefore MANAGE has focused on training program on technological aspect in collaboration with ICAR institutions and state agriculture/veterinary universities, having expertise and facilities to organize technical training program for extension functionaries of state department.

In India, livestock products contribute widely to the livelihood of the masses. Apart from domestic consumption, export of these products is contributing to National income. However, potential of value addition and processing of livestock products, particularly, milk, meat and egg has not been realized to its maximum and there is a dire need to push entrepreneurial outlook amongs youth through channel of value addition. It will help them in establishing themselves in a much better way and they can be job creators than job seekers. Further, this would help in increasing their income beyond regular direct sale to market.

It is a pleasure to note that, SAU- Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana, Punjab and MANAGE, Hyderabad, Telangana is organizing a collaborative training program on “Value Addition of Milk and Meat: A Push to Entrepreneurship” from 2-5 August, 2021 and coming up with a joint publication as e-book on “Value Addition of Milk and Meat: A Push to Entrepreneurship” as immediate outcome of the training program.

I wish the program be very purposeful and meaningful to the participants and also the e-book will be useful for stakeholders across the country. I extend my best wishes for success of the program and also I wish SAU- Guru Angad Dev Veterinary and Animal Sciences University (GADVASU), Ludhiana, Punjab many more glorious years in service of Indian agriculture and allied sector ultimately benefitting the farmers. I would like to compliment the efforts of Dr. Shahaji Phand, Center Head-EAAS, MANAGE and the Director, SAU-GADVASU, Hyderabad for this valuable publication.

Dr. P. Chandra Shekara
Director General, MANAGE

FOREWORD

For a country, the entrepreneurs are the key component in holistic development which is further linked to socio economic progression. The current scenario in India reveals that it is practically impossible for government to provide wage employment to everyone. At this juncture, it is imperative to divert the focus of youth towards self-employment and entrepreneurial ventures. Livestock Products industry, particularly milk, meat and egg, in India is in progressive mode and provides avenues for the people to start up their enterprise in a scientific and profitable manner. Apart from providing regular nutrition, livestock products provide ample opportunities for entrepreneurial ventures. GADVASU has always been on forefront in providing the knowledge and training on processing and value addition of livestock products to the young entrepreneurs and farmers. I am really delighted that our university is conducting a free online training program on "Value Addition of Milk and Meat: A Push to Entrepreneurship" sponsored by the National Institute of Agricultural Extension Management (MANAGE), Hyderabad for the Extension officials of state/central animal husbandry departments, veterinarians, faculty of SAUs/KVKs/ICAR institutes, etc. during 02-05 August, 2021 through Cisco Webex Online Platform. The lectures of this online course are exactly designed to expose the participants to various aspects of processing and value addition of animal products highlighting scope for entrepreneurship. I hope that the participants from different parts of the country would be immensely benefitted from this online course by interactions with the expert resource persons selected for this training. I have no doubt that the course will be intellectually rewarding the participants.

The compendium for the above said training programme has been designed to provide firsthand knowledge to the readers. I extend a warm welcome to all the trainees and wish them to have a fruitful and informative interaction.

Dr. Parkash Singh Brar
Director of Extension Education,
GADVASU, Ludhiana

PREFACE

This e-book is an outcome of collaborative online training program on **"Value Addition of Milk and Meat: A Push to Entrepreneurship"** conducted from 02-05 August,2021. This book is intended is to provide insights to all extension workers, faculties, researchers and students about the value addition of milk and meat. This book focuses on entrepreneurship development through value addition of livestock products. The readers shall get latest information on contemporary livestock processing techniques after reading this book. The current information in product development will help themto do well in the entrepreneurial and extension field.

In present times, the share of livestock and livestock products is increasing in the agriculture driven economy. Milk has been the highest grossed commodity in the agriculture sector and the meat consumption is increasing day by day. Moreover, the value added products have also emerged as sought-after products in agriculture market. Keeping in mind, the need to understand value addition and develop the same on entrepreneurial lines for income generation and livelihood sustainability, experience ofthe resource persons are clubbed and edited to give it the form of this book. Coordinating the prepositions of dairy science and meat science from the entrepreneurial point of view was indeed a challenging job. However, the experts and resource persons contributed immensely and tirelessly to develop various chapters of this e-book in very short span of time and are highly acknowledged. The editors extendtheir sincere thanks to all the experts who have devoted valuable time and efforts to produce this e-book.

The editors also thank MANAGE, Hyderabad for the financial support to the training program. The editors express gratitude towards the Honourable Vice- Chancellor, GADVASU Ludhiana, Dr. Inderjeet Singh for the constant encouragement forthis training and e-book creation for the participants. The editors hope that this e-book will help participants as well as other extension people across the country to gain valuable information on value addition of milk and meat.

The valuable suggestions for future improvements are always welcome.

August, 2021

Dr. Parkash Singh Brar
Dr. Nitin Mehta
Dr. Amandeep Singh
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Chapter 1

Extension Network and Activities of Veterinary University

Parkash Singh Brar and Jaswinder Singh

Guru Angad Dev Veterinary & Animal Sciences University, Ludhiana, Punjab 141004.

"Give a man a fish, he will eat for a day, teach him how to fish, he will eat for a lifetime"

India being "The Livestock Giant" possess the largest livestock population (535.82 million) in the world, with the highest cattle (192.52 million), buffalo (109.85 million), and bovine population (302 million) which in turn make the country highest milk producer of the world (BAHS, 2019). Punjab, located in the northwest part of the country (31.1471° N, 75.3412° E), is home to 69.92 million livestock including 2.47 million cattle and 4.01 million buffaloes and currently producing 12.6 million tons of milk per year. Further, 80% of the bovine and ovine population and nearly 90% of the pig and poultry population are reared by marginal (0.002-1 ha) and small farmers (1-2 ha) (NSSO 2013), who are generally knowledge and resource-poor. These farmers remained glued to age-old traditional practices of rearing animals, which hinder them to exploit the maximum potential of these livestock farmings. These farmers need to be made aware about latest scientific practices to improve their income and living standards through extension services.

The extension means stretching out the information from the source of origin to the end-users. Different countries have different terminologies for extension service but motive remains same as below

- Arabic: *Al-Ershad* (“guidance”)
- Dutch: *Voorlichting* (“lighting the path”)
- German: *Beratung* (“advisory work”)
- French: *Vulgarisation* (“popularization”)
- Spanish: *Capacitación* (“training” "capacity building")
- Thai, Lao: *Song-Suem* (“to promote”)

Till few years back, livestock extension services were provided mainly by agricultural sector. But, sensing the potential of the livestock sector and tapping the hitherto untapped potential, the govt started focusing on this sector. As a result, many new veterinary universities/institutes were carved

out from the existing agricultural institutes or were established as new with the sole motive to promote the livestock sector at the regional level. Guru Angad Dev Veterinary and Animal Sciences University started functioning in the year 2006 at Ludhiana after upgrading the college of veterinary science. Since its establishment, University has toiled in all possible ways to reach the livestock, poultry, and fisheries farmers for creating scientific awareness. Unlike agricultural extension service, livestock extension service is not season-specific rather it is household-specific. Every household has different type of animals, different numbers, different microenvironments, different feeding and management practices, etc. and hence require different types of extension services. But reaching every household personally to provide livestock extension service seems impossible. So, the university strives its best by choosing blends of methods to reach the end-users.

Technology dissemination: Research has no meaning if it does not reach end users. Being the mouthpiece of the university, the extension wing disseminates all technologies/ scientific recommendations developed by the university to the end-users through all possible means as discussed below.

1. **Literature:** Printed information is a permanent source of knowledge with the readers, while oral information vanishes quickly if not applied in routine use. Information once learned can be precisely and quickly recapitulated with the help of books. So, the university puts efforts to bring the published literature on the different species viz Dairy, goat, poultry, fish, dog, etc in different languages for the livestock farmers. Till now the university has published 18 books in Punjabi, 4 in Hindi, and 8 in the English language. These books can be purchased from the Farmers Information Centre of the university on any working day at very nominal charges.

2. **Monthly Magazine:** Since 2007, the university is regularly publishing the monthly magazine "Vigiyanik Pashu Palan" in the Punjabi Language. Any person can avail of its subscription by paying Rs 1000 for five years. This magazine intends to provide the latest and recommended practices to the readers besides providing the motivational and innovative stories of successful Livestock farmers in the different fields on monthly basis.

3. **Handy Tools:** In livestock farming, many operations are time-specific like when to inseminate, expected parturition date after successful pregnancy, booster vaccination etc. So, for the ease of

livestock farmers, the university has developed many handy calendars like reproduction calendar for dairy animals, goats, pigs, female dog, calf calendar, vaccination calendar, feed calendar, month wise operations calendar, etc. These are very handy can be kept/hanged/placed in the shed itself so that when needed, a farmer can seek the exact information.

4. Capacity Building: Organization of training programs, seminars, workshops, interface, exposure visits, awareness day, etc for different stakeholders is a routine feature of the university. Following trainings are organized on regular basis.

1. Dairy farming
2. Poultry Farming
3. Goat Farming
4. Pig Farming
5. Fish farming
6. Value addition of milk and meat

Usually, the duration of Dairy and Poultry training is 2 weeks and 1 week for the rest of the trainings. Depending upon the situation, these trainings can be conducted in online or offline mode. Besides these, universities also organize tailor-made training programs as per the demand of farmers.

5. ICT tools: Information and communication technology has brought a new revolution in the country. It provides quick information round the clock. Today almost all farmers have a mobile phone and the majority have smartphones. So to provide scientific information through this platform university has developed various android mobile apps such as

i) Precision dairy farming (English and Punjabi)
ii) Dairy reproduction (Punjabi)
iii) Pig farming (Punjabi and Hindi)
iv) Goat farming (Punjabi)

Anyone can download these apps from the google play store. Many more apps are in pipeline. Recently, University started one digital newsletter for the farmers namely “Pashu Palan Sunehe", published after every two months. This newsletter provides interesting and recent news/ happening in the livestock sector across the globe to the farmers. It is circulated among farmers through certain social media platforms. It is also available on the university website www.gadvasu.in .

6. Youtube channels: Looking at the popularity of youtube among the masses, the university recently started one channel exclusively for the farmers namely "**GADVASU farmer-friendly e - extension".** Till now more than 80 videos on different aspects of livestock, poultry, and fish farming have been uploaded and the same has been viewed by more than twenty thousand farmers. New videos are being uploaded from time to time to up breast the viewers with the latest knowledge. The viewer's quarries are also responded from time to time. Any farmer or interested person can subscribe to this channel.

7. Pashu Palan Melas: To reach a large number of farmers to demonstrate and show all the scientific and latest advances done by the university is a very daunting task. So University thinks other way and exhibit all the scientific and latest technologies in a single place and invite the farmers to visit the campus on said dates. This event is popularly known as Pashu Palan Mela. University organizes two such melas every year, one in the month of September and the other in the month of March. Lakhs of Farmers across the northern states of India usually visit this gala event. Mini replicas of this event are also organized at the regional stations from time to time. During the COVID -19 pandemic the university organized virtual Pashu Palan Mela for the cause of the farmers.

8. Regional Research and Training Centre (RRTC). To reach every nook and corner of the state, the university has opened its regional outstations at different places. Three Regional Research and Training Centres, one each at, Talwara (Hoshiarpur), Booh (TarnTaran)n and Kaljharani (Bathinda), three Krishi Vigyan Kendras(KVK's) one each at Handyia (Barnala), Majra (Mohali) and Booh (Tarn Taran) are presently working to cater the need of regional farmers. One more center namely will start functioning soon at village Sappanwali (Fazilika).

9. Awareness Campaigns: "*Learning by doing and seeing is believing*" is the basic principle of extension. To aware the livestock farmers, the university regularly organizes awareness camps, field/farm days, farmers-scientist interfaces, demonstrations, hands-on training, field training, etc. at the field level. Exposure visits of farmers to the farms of progressive farmers, scientific institutes are undertaken to provide first-hand knowledge to the farmers.

10. Mass Media: TV, radio, and newspaper are the mass medium having the ability to reach the hitherto unreached farmers/area. So university regularly provides scientific information to the farmers through Doordarshan Kendra, Jalandhar, Fastway channel, All India Radio, Jalandhar, Ludhiana,

Patiala &, Bathinda etc. More than 100 radio/TV talks/year are delivered. Likewise, articles, stories, news are published in the leading daily papers. Advisories for livestock farmers, selective articles, digital newsletters are also available on the university website. Online webinar/seminars for the farmers have also become a regular feature.

11. Chief Minister awards. To pat the innovative and progressive farmers and to motivate the other farmers to replicate the same, the university confers the Chief Minister awards annually to the farmers on a competitive basis. Seven Chief Minister awards, one each to Cattle farmer, buffalo farmer, Goat farmers, Pig farmer, Poultry farmers, Fish farmers, and farmer/Entrepreneur venturing in value addition of livestock produce.

12. Farmer Associations: As the famous quote said "*Coming together is a beginning, staying together is progress, and working together is success*", University work in close proximity with livestock farmers. Different farmers Associations like Progressive pig farmers association, Progressive Goat farmers association, Innovative Fish farmers association, Progressive poultry farmers association are working under the aegis of the university. University provides technical support in terms of organizing regular seminars of these associations and further united farmers group work more vigorously for the upliftment of their respective sector.

13. Farmer Information Center: To provide all the facilities available for the farmers under one roof, University has established one Farmer Information Centre near the University Veterinary Hospital. Farmers can purchase books, magazine calendars, mastitis diagnostic kits, Ruminal Magnets etc. Similarly, information related to different training programs will be provided. Any farmer can enquire about any services of University by calling 01612414026. Soon university is going to start a tele advisory service also for livestock farmers.

14. Studies on Livestock sector: Different departments especially the extension department of the university regularly conducts studies on the livestock sector, farming practices, diseases incidence, biosecurity, constraints faced by stakeholders, the adoption rate of scientific practices, value chain analysis, social issues related with livestock/poultry etc., so that more focus can be given on the weak parts. These finding further helps the think tanks and policymakers to develop more suitable policies.

Market-oriented extension is the need of the hour. Market demand, is very crucial for the survivability and profitability of farmings. Till now university extension service was mainly focused on production services both in terms of quality and quantity but now university also includes marketing aspect. University is also in the process to start a business incubator for facilitating the start-up entrepreneurs and providing them to the required impetus to cross the breakeven.

Pluralism in livestock extension services envisaged the need for coherence between the different extension agencies to cater to the need of diverse livestock farmers. The University works with the line agencies to provide concrete and uniform information to the end-users. ATARI, Ludhiana, PAU, Ludhiana, CIPHET, Ludhiana, Milkfed, NABARD, MANAGE, PAMETI, State Animal husbandry Department, State Dairy Development Department, State Fisheries department, ATMA, Banking sectors, NGO, etc are some examples with whom university work in tandem. Internationally, University also developed a strong liaison with PUM senior experts, Netherland and already availed the services of seven PUM experts on different livestock farming's. University also provides technical support to various Farmers Clubs, NGOs, FPOs, etc who are working for the cause of farming community.

This is not the end, the University remains eager to explore new and latest technologies to reach the farmers in every nook and corner of the state to inculcate scientific awareness in them to promote livestock sector.

Chapter 2

Scope of Meat Processing Sector in India: A Push to Entrepreneurship

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Introduction

Meat is an excellent source of high quality protein and is considered as a vital part of human diet. Constituting around 20–24% protein, most of which is of high biological value, supplying essential amino acids, meat is gaining position in India food basket. Meat is also an important source of the vitamins, particularly B_1 (thiamine), niacin (nicotinic acid), B_2 (riboflavin), B_6 and B_{12} (cyanocobalamin), and vitamin A (retinol). It is a major source of valuable minerals like iron, copper, zinc and selenium. Fresh meat provides key avenues for the producers and manufacturers, however, for boosting their income and profitability, value addition has been looked upon as a promising solution.

Value addition of meat is referred to the enhancing nutritional value, economic and health benefits through the processing into various designer and health oriented meat products by incorporating various functional ingredients and with use of other techniques such as tenderizing the tough meat, preparation of cut of parts and utilization of slaughter house byproducts to develop valuable products. The economic value of product is increased by changing its current place, time, and form characteristics to characteristics more preferred in the marketplace. With rapid industrialization, urbanization, increase in disposable income, nuclear family, education and awareness, the market for value added products has seen an increasing trend. These market forces have led to greater opportunities for product differentiation and added value to raw commodities thus ensuring increasing profitability and viability of industry in addition to catering increased consumer demands regarding health, nutrition, and convenience. Addition of non-meat, functional ingredients offer possibilities to lower formulation cost by means of adding water to the meat, increase processing yield along with additional health benefits by lowering the salt, fat, cholesterol, nitrites and calories in meat products along with the supply of dietary fiber, antioxidants, Calcium and other nutrients. Meat processing

industry has been continuously improving productivity and efficiency by applying various latest technologies. Producers have a challenge to be responsive to consumer demands by producing what is desired by the consumers and market response. Hence, the concept of value addition is not only improving the functionality of meat products for enhancing nutritional value but increasing profit margins of the producers with a great deal. India is a leading exporter of fresh bovine meat and most of the income (95%) is generated through the same. This can be visualized as a profitable venture with interventions of value addition methodologies. Processing of meat into various value added products for domestic consumption and export can really benefit economically. As per estimates, only 3% of total meat produced in our country is processed into value added meat products, thereby the scope for expansion seems to be immense.

Advantages of value addition to meat

- Increased convenience to consumer through reduced preparation time and minimizing processing steps.
- Sustainable demand for the products, improvement of safety and product attributes such as appearance and taste.
- Cost reduction, competitive pricing and byproducts utilization.
- Sustainability to meat industry.
- An overall increase in the value of product.

Approaches for Value Addition

- Value is added to raw chilled meat by changing the form or utility.
- Meat properties and preservation are changed by many single or combination unit-processing operations.
- Primary processing operations include tenderization, grinding, flaking, freezing, and case-ready fabrication and packaging, whereas examples of further processing are curing, smoking, marinating, emulsifying, forming, and cooking.
- Irradiation and processing of healthy meat products also comes under value addition.

Various common procedures adopted for value addition to meat and meat products

1. **Combination of Meat:** In order to compliment and supplement qualities and availability of different meat and their byproducts combination of meats is desirable to produce value added products. Blends of mutton and chicken or chicken byproducts (skin, gizzard and heart) or chicken fat resulted in highly acceptable products such as nuggets, patties and sausages. Eggs possess several functional properties which may compliment meat proteins in meat products. Highly acceptable meat products of relatively lower cost were produced incorporating eggs up to 30% in the formulation.

2. **Utilization of non-meat ingredients:** Different non-meat ingredients are added during processing of meat for different purposes. Some ingredients enhance the functionality of muscle proteins while others help in retention of moisture and provide characteristics texture, flavour and colour. These ingredients are selected based on economic, raw materials availability, consumer preferences, food safety concerns etc. The most common non-meat ingredients utilized in meat products preparation are salt, phosphate, nitrite, ascorbate, sugar, soya, whole egg liquid, refined wheat flour, skimmed milk powder etc. to impart different properties in developed products. These may protect or modify flavour, may act as fat replacers. Other ingredient functions include improved tenderness, juiciness, cohesiveness, water binding and emulsion stability, along with colour stabilization and preservation. Many of the ingredients exhibit multifunctional properties.

3. **Incorporation of Vegetables in Meat Products:** Incorporation of seasonal vegetables such as cabbage, cauliflower, carrot, bottle guard, pumpkin, etc. in meat products would be advantageous to reduce cost of meat products, to provide fiber and flavonoids in meat products, to facilitate consumption of vegetables and to provide balanced and healthful diet meat products. Meat products added with vegetables may find wide popularity among Indian consumers.

4. **Formulation of cut-up-parts:** Instead of selling whole intact carcass, formulation of different cut-up parts are found to be more profitable and yield greater economic benefits e.g. Poultry carcass consists of major six cuts - Whole leg (Drum sticks + Thigh meat), Breast, Neck, Wings and Back. The cut-up-parts including whole leg and breast are considered as prime cuts due to their juiciness and tenderness, which can fetch more price in the market. When these cuts are sold separately the profit margin of the farmer can be increased in comparison to sale of whole carcass.

5. **Emulsion technology for meat products:** Emulsion type meat products are the most popular processed meat products. When lean muscle tissue, fat, water and salt are mixed together and subjected to high speed cutting and shearing action, a batter is formed. This batter is called emulsion. Special equipment called "bowl chopper" is used for preparation of emulsion. Meat emulsions are prepared using lean meat, water, other curing ingredients and fat. Different popular emulsion based meat products includes value added products such as meat balls/koftas, meat burger patties and meat nuggets etc. Meat balls/kofta is a traditional Indian comminuted meat product. These are widely used as snack items and culinary preparations. It can also be served after enrobing to provide it better appearance and flavour. Meat patties are emulsion based ready-to-eat meat product, can be utilized as fillings in burgers, rolls and sandwiches for packed lunch or can be served as snack. These are prepared by moulding the emulsion into circular shape/tikki, thereafter cooked in oven. Meat nuggets are ready-to-eat meat product which can be used as a base for various recipe or preparation of meat products. For the preparation of meat nuggets, the chilled meat blocks are sliced into pieces of 15mm thickness in a meat slicer and cut into nuggets of almost uniform size.

6. **Enrobed or coated meat products:** Enrobing/coating of meat products with edible materials in the form of batter using flours, whole eggs liquid and other additives is a method of value addition, which enhances the acceptability of meat products. Enrobing imparts the products a crispy texture and increase the pleasure of eating with more desirable colour.

7. **Restructuring of meat:** Restructured meat products are generally prepared from less expensive cuts, tough cuts, meat trimmings or combination of these. Restructured meat products are becoming an important component of the meat industry due to benefits like convenience in preparation, less demanded meat trimmings, different shapes product with improved tenderness, juiciness and flavour characteristics at economic cost. Moreover, restructured meat products can be formulated as per the requirement of a specific group of consumers seeking low fat, low salt, high dietary fibre and antioxidants in meat products.

8. **Curing and Smoking of Meat:** Curing process involves addition of curing agents to the meat cuts for enhancement of colour, flavour and preservation. It is the treatment of meat with preservative chemicals that restrict or prevent the growth of spoilage bacteria and food poisoning bacteria. It is

used together with processes that use heat, smoke or low temperatures to give the required shelf life of cured meats.

9. Retorting: Thermal processing of meat destroys microorganisms and enzymes responsible for food spoilage. Thermal processing of foods refers to application of heat to improve digestibility, texture, flavour and destruction of enzymes and microbial population there by increasing the storage life. Thermal processing in metal cans or retort pouches increases shelf life of products and decreases 50% processing time.

10. Improving tenderness of meat: Tenderness of spent animal's meat can be improved by electrical stimulation, proper hanging of carcass, use of chemicals and artificial tenderizers. A variety of products such as sausage, patties, nuggets, balls, slices can be developed utilizing meat and byproducts from spent animals and birds. Electrical stimulation (ES) of carcass muscles soon after slaughter accelerates their normal decline in pH and may enhance tenderization during conditioning. A number of organic acids such as acetic, citric and lactic have been used to tenderize meat.

11. Fermentation of meat: Meat fermentation is a preservation method which results in unique and distinctive meat properties such as flavour and palatability, colour, microbiological safety, tenderness, and a host of other desirable attributes of this specialized meat item. It is influenced by many environmental pressures that need to be controlled to produce a consistent product. Fermented meat products rely on microbial fermentation and dehydration to develop their specified flavour and texture. In the production of fermented meat products, selected bacterial culture is added to the minced meat. These are called starter culture. Dry Sausages (Pepperoni, Genoa Salami, Dry Salami, etc.) and Semi-dry Sausage (Summer Sausage, Lebanon bologna, etc.) are important fermented meat products.

12. Effective utilization of slaughterhouse byproducts: Non-utilization or underutilization of by-products not only lead to loss of potential revenues but also lead to the added and increasing cost of disposal of these products. Besides pollution and hazard aspects, in many cases meat, poultry and fish processing wastes have a potential for recycling raw materials or for conversion into useful products of higher value. By-products such as blood, liver, lung, kidney, brains, spleen and tripe has good nutritive value. Technologies have been developed for number of high value products like collagen

sheets, tallow, keratin hydrolysates, ossein, pet foods, animal feeds etc. from different slaughter house byproducts. Other important product that can be prepared slaughter house byproducts include leather, carcass meal, rendered fat, sausage casings, blood meal, horn and hoof meal etc.

Major Limitations of Value addition of meat

- ✓ Value addition is a capital intensive activity.
- ✓ Less preference for frozen meat by the consumer.
- ✓ Insufficient cold chain infrastructure facilities.
- ✓ Lack of well-organized marketing system.
- ✓ Less domestic demand for value-added meat products.
- ✓ Non-availability of adequate technology and manpower, fluctuating export trade, high import duty and strict sanitary and phyto-sanitory norms by importing countries.

Conclusions

Meat processing sector in India is a sunrise sector with immense potential. Adequate support to this sector at various levels and forms is needed for its overall development. Adequate financial and technical assistance from government and non-government agencies is equally important for the promotion of meat processing sector. Value addition of meat is possible through the different methods discussed above. It is the need of the hour to make the enterprise of meat production and processing economical viable through generating more profit. Department of LPT, College of Veterinary Science, Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana has developed many technologies for the preparation of value added and functional meat products such as omega-3 enriched low-fat chicken meat patties, fiber and bioactive compound enriched low-fat chicken meat nuggets, low-fat buffalo meat patties, fibre enriched meat biscuits, chicken snack sticks, meat samosa, meat cutlets, chicken croquettes, chicken kurkure, meat mathi, meat wadi, chicken noodles, meat papad etc. Value addition to meat and meat products also help in boosting entrepreneurial attitude amongst youth, wherein they can generate resources of their own. All they need is adequate support and hand holding through programmes like Entrepreneurship Development Programme (EDP) and specialised trainings.

Chapter 3

Innovation and Opportunities of Traditional Dairy Products (TDP) With SpecialEmphasis to Composite Dairy Products

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1. Introduction

India has been ranked in frontiers in developing national food and nutrition records, undertaking research studies and surveys detailing the ongoing agriculture, food and nutrition and health changeovers. However, despite of all the efforts the major concern related to combating with the needs of micronutrients deficiencies are still can be said as half job done. Therefore, during the past decade, micro or macronutrient deficiencies in toto, have been attracting attention of both academicians and administrators. Achieving the targets and ranked first position in production of food crops goes waste when a huge amount i.e. 30-40 per cent of produce is dumped during post-harvest operations and accounts for an enormous number of populations still suffering from malnutrition. However, owing to certain socio-cultural behavior and trends, highest rate of malnutrition is prevailing among children and women. The fact is quiet simple which simply illustrates that consuming one specific type of food cannot compensate the nutrients requirements of the body. Therefore, nutrition delivery via means of common food items is the most sought way to fight hidden deprivation, undernutrition and ill-health especially under the circumstances when almost half of the population is spending almost or even higher than 50 percent of their hard-earned to buy the food for their survival. Also, seeing the list of innumerable benefits of milk, milk is the best entity to fight against such malnutritional cases.

Milk being a perfect vehicle and a source of various valued macronutrients like fat, protein, & milk sugar -lactose, vitamins and micronutrients; available in the form of minerals, and is considered a complete food, a balanced or a ‘nutritious food’ as it contains all the vital nutrients required by the body for its proper functioning but it lack certain essential components such as micronutrients (iron, copper etc.) and fiber and milk in itself has certain limiting factors such as it is a cause of allergenicity for many, inability of lactose digestion for lactose intolerance population, presence of cholesterol and

saturated fat content, etc. To combat the voids of the milk, with the help of advancements in expertise and tools available, numerous components obtained through milk are being used in combination with other non -milk components for preparing versatile range of food products with enhanced nutritional output in the form of '**value-added'** products with better assimilability and superior functionality along with the benefits of wholesomeness. In this context, milk in its desiccated form is an epitome where the nutritional profile is at par along with the desired sensory appeal. Desiccation where at one point removes unwanted moisture from the milk, also roots to the concentration of valuable nutrients of the milk. Herein it is worth to mention that the lacking components of the milk can be excellently compensated if different sources can be included at this point. This particular brainstorm idea gave birth to a newer dominating category of Indian dairy products – i.e. **Composite dairy foods**. Such combinations always create nutritionally far superior category which otherwise single ingredient cannot serve at all. For population with milk allergenicity or lactose intolerance problems, various other additives can be added to the milk so that a complete food in real sense can be prepared out of it, and therefore supplementation and complementation of various micronutrients derived and obtained from adding various cereals, millets, fruits, vegetables and legumes is now in practice.

Also, non-dairy components play an important role in increasing acceptability of composite foods by participating in various chemical reactions and mingling well with elements of milk foods. This approach not only yields improved sensory and nutritional profile of the resultant product but also leads to decreased cost. Therefore, visualizing all these facts and figures regarding rising costs, demands for the development of healthy yet cheaper products is increasing. Hence, there is a need to fuse the combination of ingredients derived from other sources other than milk with milk- based ingredients so that objective to lower down the rate of malnutrition, hidden hunger and various issues can be taken up. However, these composite foods are not very popular in India and some of them are even regional specific. Therefore, due to lack of technical know-how and scientific technologies to prepare the same, commercialization at wider scale of these products is a challenging task.

2. Definition

Indian dairy products or Indian Indigenous milk products can be defined as all milk products which are native of India and which were evolved over ages utilizing locally available fuels and cooking ware, whereas the Codex standards (1999) define composite dairy product is a food product from milk and/or its constituents, milk products, with or without addition of milk processing by-products and non-dairy components (expect non-dairy fats) included in as individual ingredients,

added for purposes other than substitution of milk constituents.

3. Composite dairy foods

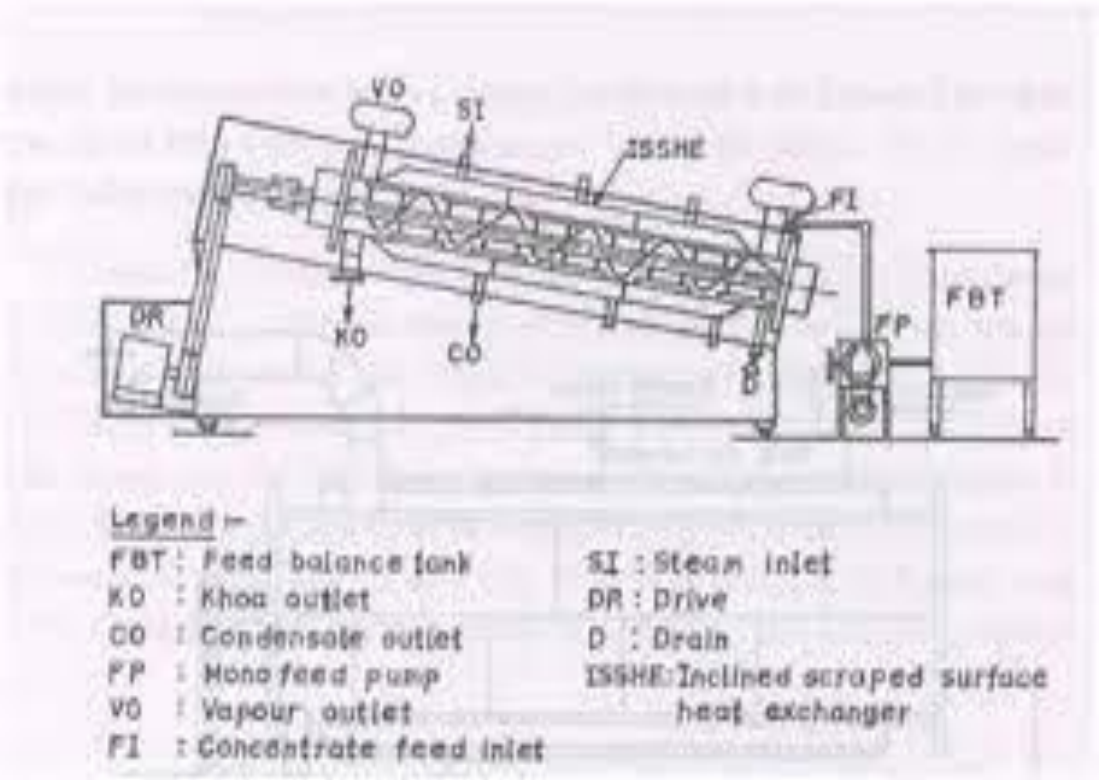
Earlier the aim of substitution of non-dairy ingredients in composite foods was dependent upon improvement in sensory characteristics and on the product integrity but now days it also takes into account the targeted benefits to be derived from the product. Also, as few people are conscious and doubtful with respect to consumption of milk and milk products either due to certain health related issues or considering the presence of saturated fats, cholesterol, lactose in the milk, etc. Therefore, keeping in mind the demands laid by today's consumers as per their needs of lifestyle, statistics, social, financial & developmental background, an entire range of innovative and novel products have grown to suit the palate of the diverse customers. The concept of composite foods is well appreciated by researchers, academicians and dairy technologists as the matter of fact, combining non-dairy functional entities into milk-based foods, increases the consumption and consequently production of such foods.

4. Innovations and opportunities

Traditional Indian dairy products owing to their huge market potential are increasing in number and so as their product portfolio due to upcoming newer innovations. However, these innovations and modernization become an integral part of our lives, when it fully exhibits the advantages over the increasing costs compared to conventional technologies. Also, with a dual earners concept, and demand in intact nutritional profile products, manufactures are bound to look for certain innovative methods to cater the demands of the customers. Following are the ways by which organization can manufacture wholesome traditional dairy products at competitive prices (Patil, 2006).

4.1 Mechanization

- Khoa using SSHE (scraped surface heat exchanger)
- Using Inclined SSHE



Mechanization is the one of the most reliable and advocated tool by many researchers and scientists in the growth of food processing sector. This not only enables continuous production but also offers advantages such as uniformity and reproducibility. Such an innovation in the field of TDP with special reference to composite foods can be seen as SSHE or ISSHE wherein continuous *khoa* production can be seen. The machine has numerous advantages like continuous khoa dispensing system, uniformity in granular size and reproducible process for larger systems.

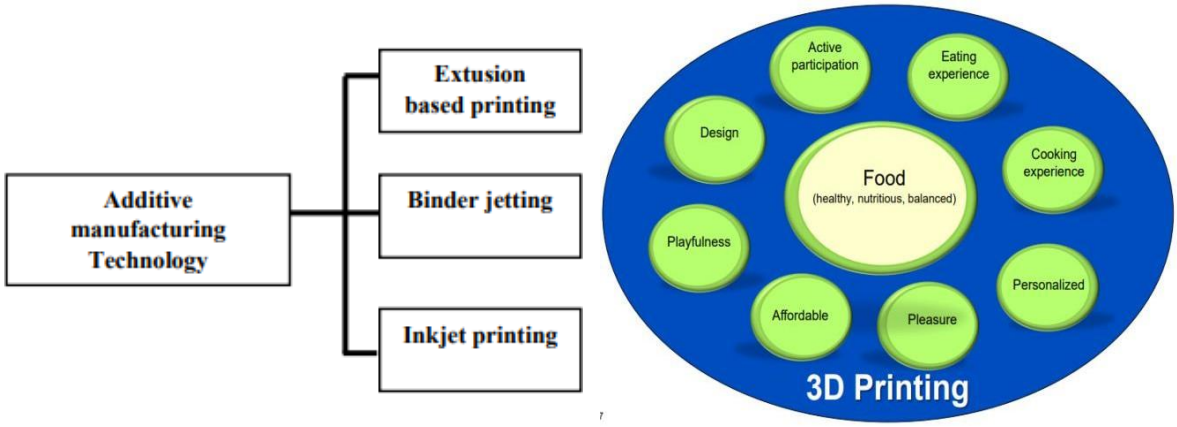
4.1.1. 3D printing (video: https://www.youtube.com/watch?v=_wZnTYUeb5A)

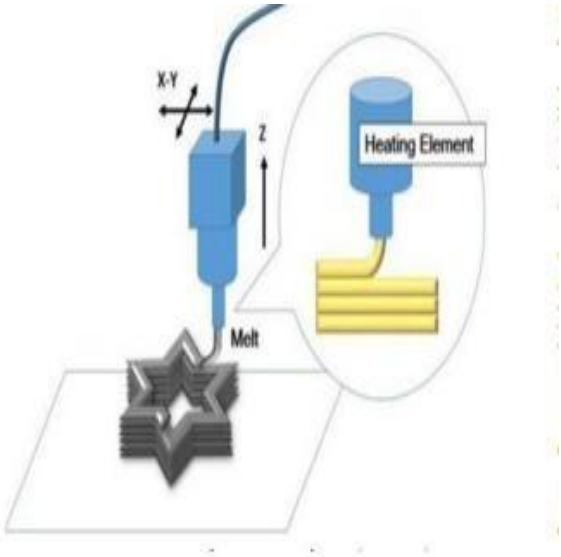
3D food printing is the process of manufacturing variety of food products using a variety of additive manufacturing techniques. With this method, various customized shapes, colors, texture, flavor or nutrition, can be sought off and is not only limited to foods products but is also having applications in space exploration and healthcare. Classically, it is "The process of joining materials to make objects from 3D model data, usually layer upon layer, as opposed to subtractive manufacturing methodologies" (ASTM F42 Committee).

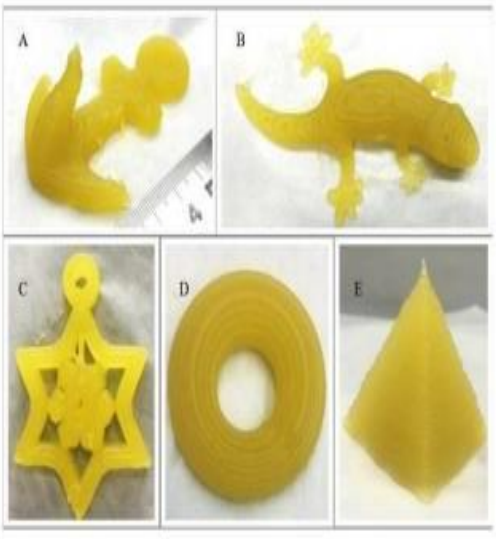
Varietal variants can be prepared using three different technologies naming, extrusion wherein a nozzle opening is used to give a layer-by-layer effect. The advantage of this technique lies in low cost of the entry-level machines, availability of variety of raw materials which are easy customizable while

the low level of precision and long build time are the disadvantage of extrusion-based printing. The other method in additive manufacturing is binder jet system. Herein food materials are successively deposited on to the powder bed surface through nozzle. Based on the low viscosity, surface tension and ink density, the suitable material in this technique are liquid based or powder-based.

The third system employs an electrically heated print head carrying food material which pushes the droplets via established pulse pressure from the nozzle in Inkjet printing. Benefits include high resolution, accuracy and use of multiple materials while post-processing may damage thin and small features, which is disadvantage of inkjet printing.







4.2. Membrane technology

A wide range of membranes are available in commercial plants and their utilization can be opted depending upon the retentate or permeate portion to be recovered. It is a pressure driven filtration process which discriminate the molecules primarily on the basis of size and to a lesser extent on shape and chemical composition. The main membrane systems widely used, in the ascending order of pore size, are reverse osmosis (RO), nano-filtration (NF), ultrafiltration (UF) and microfiltration (MF). In the consumer driven globalized world, with an immense application of these membrane systems, variety of products can be prepared and is highly beneficial in modernization and upgradation of the technologies of our traditional dairy products.

A majority of water can be removed with the help of RO systems wherein other heat driven processes cause a huge destruction to the vital nutrients. Several attempts have been made to develop new methods including the use of scraped surface heat kettles or heat exchangers for commercial production of khoa. The use of concentrated milk having up to 30% TS has produced khoa of highly satisfactory quality. Similarly, from milk, UF produces a permeate containing water, lactose, soluble minerals, non-protein nitrogen and water-soluble vitamins. This can be successfully employed to prepare khoa from the cow or buffalo milks. On similar grounds, MF can be used for separating colloidal and suspended particles in the range of 0.05-10 microns. Use of MF milk for preparation of products is a boon wherein extended shelf life can be expected without the fear of unwanted microbial proliferation. The system also cuts down the requirement of any preservatives synthetic or natural and enhances the life of the product.

4.3 Developments in preservation

Inclusion of synthetic and natural preservative system is been a practice since older times in traditional Indian dairy products. Though the desiccation process itself requires no preservation system owing to the lowering of water activity. However, to further extend the life, various synthetic additives like sorbates, ortho- phosphates or other organic acid like citrates can be added to the product matrix to extend its shelf life. With an unprecedented surge in natural preservatives, the synthetic preservation system is currently overhauled by natural preservative systems like use of bacteriocins naming a few as: microgard, nisin and natamysin. Their promising results are another factor for its wider publicity and popularity amongst consumers.

4.4 Developments in packaging

- Modified Atmospheric Packaging (MAP)
- Vacuum packaging
- Edible packaging
- Edible Antimicrobial packaging

Packaging has surpassed the simple role of containing and carrying the goods to a level beyond a stage wherein it serves as a vehicle for extending the produce's life. Now, the concept of conventional and traditional packaging is getting obsolete, and a new era of smart and intelligent packaging is heading to the market. A flood of terms like edible packaging, edible antimicrobial packaging, active and passive packaging, smart or intelligent packaging, and terms of the same origin have captured the market and the articles thereon. The increasing occupancy of such products in the market can be due to the consumer's expanding knowledge and interest towards shelf-stable products, choice and demand of nutritious products with supplemented safety.

Employing vacuum has advantages in the products wherein oxygen has negative role in modifying properties of the food by either carrying out certain oxygen mediated processes or participating in the reaction like oxidation and rancidity. Mere application of vacuum can extend the life of product many folds depending upon the nature and properties of food product under consideration. Modification of atmosphere within the package is one of the most suitable alternatives with other options such as vacuum packaging or any of these, to alter the inner atmosphere to lead towards an active system. However, this modification is especially relevant to minimally, pre-cut fruits, and vegetables to delay browning reactions, lowering respiration rate, and ethylene biosynthesis. Modified atmospheric packaging (MAP) can further be distinguished as active or passive wherein, in the prior oxygen and carbon dioxide concentration is modified initially within the package which changes dynamically depending upon the uptake of respiration, whereas in the later produce is placed in the modified atmospheric package, sealed with gas-permeable layer, allowing respiration and the consequent change in the composition of package till a steady-state equilibrium is achieved.

In response to the growing demand for sustainability and ecological safety, recently, many investigations have been focused on the development of effortlessly degradable and biocompatible food packaging materials commonly referred as edible packaging. These biopolymer-based packaging materials can be simply disposed of after use in bio-waste decomposition centers for further

degradation, releasing organic byproducts like carbon dioxide (CO_2) and water (H_2O). However, the application of biodegradable polymers in food packaging systems is often restricted due to various shortcomings like poor mechanical, barrier, and thermal characteristics compared to the conventional non-biodegradable petroleum-based plastics.

To further enhance the applications of edible packaging, antimicrobial packaging is an excellent alternative technique to reduce, restrict, or inhibit the growth of spoilage and pathogenic microorganisms in food products, and has received significant attention from the packaging industry for its beneficial effect on food quality and safety as well as shelf-life extension. The antimicrobial agents are amalgamated in a polymer matrix to produce antimicrobial packaging films that help suppress targeted microbial growth whose activity otherwise causes food contamination.

Conclusion

With the ever-growing demand and significant expansion of innovative technologies in the market for TIDP's, composite dairy products become an integral part of our lifestyle and food habits. Therefore, application of above-mentioned technologies and systems can help in various ways. However, taking considering the complexities associated with composite being a mixture of two different commodities,

careful use of technologies is of paramount importance. Therefore, due care is required while designing such products and to promote their potential market share, the strengths and weaknesses of the product under consideration should be carefully examined and reworked.

Chapter 4

Scientific and Hygienic Processing of Poultry for Human Consumption

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The term poultry meat refers to the edible portion of any domesticated avian species, mainly comprising poultry birds such as chicken, duck, turkey, geese, guinea fowl, Japanese quail. Poultry meat is very popular among consumers due to absence of any social or religious taboos associated with poultry meat consumption, wholesome, nutritious, low in fat and higher content of desirable unsaturated fatty acids, light flavour, low fat in meat, quick and better economic returns of the poultry due to better feed conversion ratio, rapid growth, uniformity of size and specialized breeding making automation very easy, better biosafety measures due to application of All-in-All-out concept, small body size of poultry, more uniformity in composition and colour, low cost of production, vertical integration and automation, etc.

For, the production of good quality broiler meat, not only the rearing/ managemental condition but various pre-slaughter precautions should be taken during feed withdrawal period, catching of live birds, loading, transport, ante-mortem inspection, slaughtering procedure, post-mortem examination and chilling. The various steps in hygienic processing of poultry are as follows

A. Pre-slaughter operations

1. Harvesting of birds

Harvesting of birds refers to catching of bird from farm and placing these birds into containers for transport. Usually majority of broilers are slaughtered at the age of 6-7 weeks and turkeys are slaughtered at the age of 14-20 weeks. This optimum age of slaughter also varies with breeds. The harvesting comprises various steps such as preparation of birds for catching, catching birds and finally placing these birds into crates/coops/ containers for transport.

a. Feed withdrawal

The first step in harvesting of birds is stop access to feed to birds just prior to harvesting. Feed withdrawal as total duration for which bird is kept without feed before slaughter. This duration comprises time spent at farm without feed, transit and holding area. The feed withdrawal period should be minimum time required for evacuation of gastrointestinal content in birds. For broiler and turkey, a feed withdrawal period of 8-12 h and 6-12 h, respectively is recommended based on several studies that found this interval needed to ensure that maximum birds from a flock reaching slaughter had their stomach empty at that time. This facilitates easier evacuation of intestinal content at the time birds reach at poultry processing plant. Feed withdrawal period comprises time spent during feed withdrawal at farm, transit time from farm to processing plant and holding time at processing plant. The feed withdrawal period should be as short as possible and just sufficient for clearing gastro-intestinal content before processing. It is recommended to provide at least 4 h of light after feed withdrawal to ensure maximum evacuation of gastrointestinal content in birds. Adequate drinking water should be provided before catching of birds and start of feed withdrawal process. The water keeps birds hydrated and facilitates cleaning of gastrointestinal contents. It also affects the colour and appearance of carcass and quality of dressed poultry carcasses.

b. Catching and loading

Catching of birds in small farm is usually done manually, whereas large farms employ automation. Sufficient manpower is employed to catch birds depending on the farm size. The whole process of catching birds should not cause unnecessary stress and injuries to birds. Birds should be caught at cooler temperature such as early morning or in the evening by the expert/ trained personnel's under supervision to avoid injuries and later downgrading of carcasses. At that time birds are usually calm, easier to catch, struggle less and settled down in the coops faster.

c. Transportation

Birds are transported from farms to processing plant. The time spent during transport should be minimum and proper care should be taken to minimize transport stress and ensuring proper animal welfare. Variation in environmental temperature is the major factor causing stress during transportation. Proper ventilation should be ensured at motion and at rest. Proper attention should be given while opening curtains if the outside environment is having high temperature and higher humidity. The various factors such as vibration, motion, acceleration, temperature fluctuation, feed and water deprivation, noise level and separation from original groups also increase the stress levels in birds.

d. Unloading

Unloading of birds is done at the processing site after receiving birds at the end of transport. There is a provision of conveyor belt for unloading of the loose crates from transport vehicle. To facilitate proper loading operations, a loading platform is placed to the side of vehicle. The coops of birds are removed from vehicle and either put on conveyor belt or manually unloaded. In manual systems, crates are unloaded and picked by workers. These birds are placed on the moving shackle line. Automated unloading is also used in large processing plants where the birds are unloaded from modules on conveyor belts and are able to walk on the belts. The lairage should have sufficient space and should be properly covered to provide protection against harsh climatic conditions and proper ventilation system to control relative humidity below 70%.

2. *Pre-slaughter inspection*

Birds should be thoroughly checked for any injuries and body conditions after removal from crates or modules. In lairage the condition of every consignment is checked to assess the body conditions of poultry birds and to ensure that head, legs and wings of birds were not trapped during transit. This examination is done by a qualified veterinarian. The inspection are should have proper lighting for efficient visualization.

3. *Shackling*

After pre-slaughter inspection at lairage, birds are shackled for slaughter. Birds usually became calm after some time of wing flapping at the time of shackling (12 second for broiler and 20 seconds for turkey). The broiler should not be shackle for more than 2 minutes and turkey for less than 3 minutes. The broilers are suspended by 2 point suspension whereas turkeys are suspended by 3 point suspension (2 legs and head).

4. *Stunning*

Stunning is a humane method of poultry slaughter. It makes the bird unconscious during slaughter and avoids undue stress and pain during humane slaughter of poultry. In religious slaughter, birds are slaughtered under fully conscious state and stunning is not mandatory to stun birds.

Electric stunning is preferred method during slaughter of birds as it improves killing efficiency, better blood loss and easier feather removal during picking. The most common method of slaughter of birds is by using electric shock. In this stunning method, birds are placed in inverted positions above water bath by hanging upside down and feet having been positioned in well-designed species specific shackle. The water bath has 1% NaCl (sodium chloride) solution and electric current is passed through it from head of bird to body to feet and shackle line. In proper conditions, birds will become unconscious within 60-90 sec and it is unable to move or stand after removal from shackle. The level

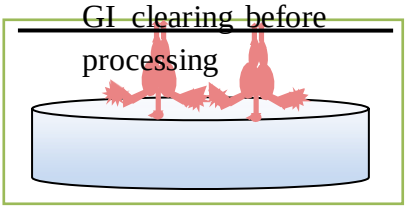
of water should be properly maintained in stun bath and it should not be overflown otherwise causing pre-stun shock to birds at inlet chute. This causes birds to raise their head and thus avoid proper stunning in stun bath. A 50 Hz alternative current with 148 mA current per bird is sufficient to stun or kill nearly all birds. However a current of 105 mA is preferred for stunning broilers if these birds are bled within 15 seconds. During electric stunning, 10-20 mA current is passed through each broiler for 10-20 seconds.

- No abnormal fat colour
- No abnormal size internal organs
- Colour of breast and thigh should have similar bloom

- No abnormal growth
- No fluid accumulation in body cavity
- Both sides of bird should be similar

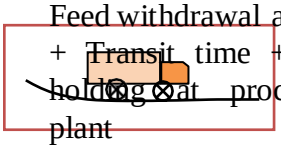
Selection of live birds

Length of feed withdrawal = shortest time for GI clearing before processing

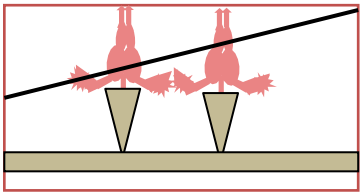


Feed withdrawal
(8-12 h, water ad-lib)

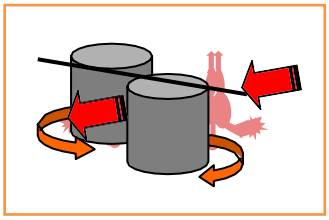
Feed withdrawal time = Feed withdrawal at farm + Transit time + Live holding at processing plant



Catching & loading

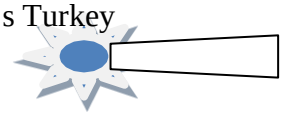


Transit



Unloading

Electrical stunning 12 s Poultry 20 s Turkey



Stunning

Bleeding time 2-5 m

Bleeding

Scalding

Plucking/ defeathering

5-10 s

Singeing

Blow torch

90 s

Electrical stimulation

Removal of internal content i.e. viscera

Evisceration

Chilling

Packaging

Chilled in slush

Fig 1: Flow chart of primary processing of poultry (Source: Akhilesh K Verma, Pramila Umaraw, VP Singh, Pavan Kumar (2020). Every step of the way ensures quality: Good quality broiler carcasses can only be obtained from birds with good health and proper growth. Fleischwirtschaft International. 1:34-43).

B. Post-slaughter operations

1. Killing

The stunned birds are moved by shackle conveyor to killing machine where head is cut by using circular cutting blades by incising jugular veins and carotid arteries of one or both side of neck while holding the wattles and lower neck skin by rotating bars. The cut of jugular vein and carotid artery should be proper. The circular blades should not make deep cut as it may cut spinal nerve cord resulting in nervous stimulation and hardening of feathers making them hard to pick.

2. Bleeding

Cutting of the blood vessels (jugular vein and carotid artery) in the neck region of birds is carried out for removal of blood (bleed-out). Modified Kosher is the one of the most commonly used method in which jugular vein is cut just beneath the jowls and leaving the trachea and oesophagus intact. These trachea and oesophagus are later pull out by use of automatic apparatus. This method is widely used method in modern operations as it is easy to carry out in both manually or with automated machine, causes excellent bleed out and leaves the head, trachea and oesophagus intact with carcass. Birds are bleed for 90 sec in ritually killed or automatic cutting severing carotid arteries and jugular veins on both sides and 150 sec for automatic cutting severing carotid artery and jugular vein of one side.

3. Scalding

Properly bled poultry carcasses are dipped in hot water to loosen hair follicle, facilitating easier removal of feathers. It can be carried out by a single stage or multistage scalding bath while the stunned poultry are suspended from a moving shackle line. Scalding at higher temperature helps in easier removal of feathers but at the same time damage skin. The scalding at high temperature (hard scalding, 59-61^{o}C for 45-90 seconds) resulted in separation of epidermis on rubbing of rubber knobs/ fingers to poultry carcass used for removal of feathers. This damages *statum corneum* or cuticle, a waxy and yellow pigmented layer. During chilling process, skin of such carcasses are dehydrated and discoloured. Thus hard scalding is used to assist defeathering in avian species whose skin is thick and feathers are very tightly attached to skin and difficult to remove at low temperature scalding such as waterfowl and

duck. Waterfowl has comparatively thick skin than other poultry and thus hard scalding causes less damage to skin colour and dehydration. Medium scalding or sub-scalding (54-58ºC for 60-120 seconds) may also damage the epidermis of skin and makes it sticky. The skin discolouration/ barking in such carcass can be controlled by keeping the scalded bird under moist conditions to prevent dehydration. It is mostly followed for scalding of moisture birds. Soft or semi-scalding (50-53ºC for 60-180 seconds) is usually used followed for scalding of young chicken and turkey birds as it does not cause much damage to the outer layer of skin. Soft or semi-scalding allows for comparatively simple removal of the feathers from the hair follicle. The presence of cuticle, waxy and yellow pigmented layer on carcass gives better appearance and consumers consider it carcass from healthy bird.

During scalding process, the temperature of water in tank should be uniform and there should be sufficient stirring or agitation to ensure uniform temperature. The birds should be scalded for proper time and its whole body should be immersed in water. The hygienic quality of scalded water should be properly checked and there should be proper design of scalding tank or equipment for regular replacement of water and removing the dirty/ soiled water.

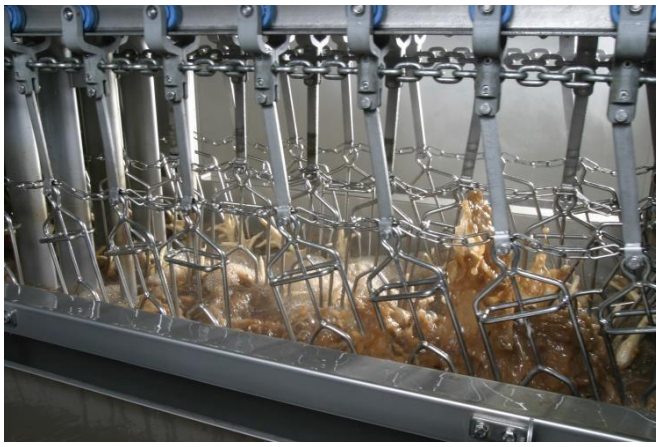


Fig 2: Scalding of poultry carcasses

5. *Plucking/Defeathering*

Defeathering is carried out with the help of electrically or hydraulically driven automatic machine having rubber fingers (with various levels of lubricating agent affecting elasticity and hardness) placed on belt or gear driven contra-rotating discs (defeatherer). This equipment is installed adjacent to the scalding operation to facilitate carcasses of slaughtered birds remain warm at the time of feather removal. As the distribution and strength of feathers varies on the body of birds, more rubber fingers should be placed in machine for removal of feathers in these parts such as bottom part,

high force needed in femoral area than pectoral area etc. The plucking machine has a series of rows of rotating groups of flexible, ribbed rubber fingers directing at different region of birds. These rubber fingers rub against the carcass and pull out feathers in scalded birds while rotating. The relative position of rubber fingers and birds in machine is very important .

Fig 3: Defeathering of poultry (Courtsey: Marel Poultry)

6. Singeing

Singeing is passing of blue flame for 5-10 second over poultry carcass to remove hair like appendages (filo-plumes). Some poultry processors used a propane torch for burn of filo- plumes. Pinfeathers are the immature hair like appendages and still present in the feather shaft can be very difficult for the removal during mechanically process. The presence of hair like filo-plumes is considered as carcass defects and gives offensive appearance to poultry carcass. Proper precautions should be taken not to burn skin of the birds. The slaughtered poultry birds are singed for the removal of hair and feather which are left during the defeathering process.

7. Evisceration

Evisceration comprises various processes involving separation of edible and inedible internal content from poultry carcass. This process is done by synchronized sequence of vastly automated operations that vary considerably in series and designs from processor to processor and from one equipment manufacturer to another manufacturer. In broiler birds, evisceration basically comprises three main processes-

i. Opening of body cavity by cutting starting from the posterior tip of the breastbone to cloaca.

ii. Scooping of viscera (as gizzard, gastrointestinal tract, related organs, kidney, reproductive organs, heart, and lungs) from carcass.

iii. Separation of giblets (heart, liver, gizzard and neck) from scooped viscera and removal of adhering connective tissues, fat followed by cleaning with potable water.

Neck is severed just before shoulder by a blade by putting enough pressure to break spine and cut dorsal skin while leaving ventral skin, trachea and oesophagus intact followed by dragging the partially severed neck from carcass. Preen /oil gland is cut by blade on dorsal surface of tail as the oil present in preen glands may lead to offensive flavour in poultry carcasses and meat. Vent is opened by vent cutter/ buttonholer by placing a probe against vent opening and holds the surrounding skin through vacuum followed by cutting of skin around vent by circular blade and pulling the terminal part of lower intestine from carcass and releasing it by discontinuation of vacuum.

Abdominal cavity is opened through machine by inserting large blade in abdominal cavity and skin is cut by pressing outward from spine to the tip of keel, thus facilitating removal or scoop of intestinal content from the carcass along with gizzard and heart by evisceration machine or drawing machine.

8. Chilling

In high processing plants, there is very less heat loss from the carcasses and its temperature usually ranges above 30°C. Prompt and efficient chilling is very critical to control growth of psychotropic microbes and other microorganisms of public health concern. Chilling of poultry carcass is done to control microbial load and ensuring safety during marketing. Poultry carcasses are chilled at 4°C or lower within 1-2 h after evisceration. In some countries, this temperature requirement is attained within 4 h in broilers and 8 h in turkey carcasses. Carcasses coming for chilling are washed with fresh and clean water by following counter-flow principle for removal of blood and small pieces of tissues attached with carcass. In post-chilling, cold water is used to cool the carcass.

Fig 4: Immersion chilling of poultry carcasses

C. Post-mortem Inspection

Post-mortem inspection is carried out by trained veterinarian. The bird carcasses are moved to inspection area along with their viscera and abdominal fat for easy viewing of these parts by the post-mortem personnel's and identification of any internal lesions especially in liver, intestine and air sacs. If the birds are unfit for human consumption, then such carcasses are disposed hygienically in designated cans. After inspection is over, viscera package are removed by pack puller from the carcasses and sent for harvesting of giblet. The carcasses passed the inspection are sealed/ stamped and sent for further processing or in marketing channel.

Do not use broiler birds for human consumption that have any of the following condition:

1. Presence of abnormal growth lumps/spots of any size on the surface of the liver.
2. Presence of high quantity of fluid in the body cavity.
3. Presence of fat in a poorly fleshed/emaciated bird. The colour of the fat should not be abnormal colour rather than yellow or white.
4. The unusual growth of any individual internal organ twice or more times larger than normal size (compare with similar size of bird).
5. Colour of breast meat should be normal and should not have similar coloration/bloom as meat of the thighs and legs.
6. Broiler muscle should not exhibit white streaks or an area of abnormal enlargement when compared to the same area on the opposite side of the bird.

Chapter 5

Processing and Value Addition of Meat and Meat products

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Introduction

Meats constitute a dietary food group, that contributes to the intake of different nutrients necessary to meet the metabolic requirements and, thus, is an important factor in the achievement of adequate nutrition. Meat is a concentrated source of nutrients. It is an excellent source of high quality protein. Lean meat contains on average 20-24% protein, most of which is of high biological value because its composition matches closely that of our own proteins. It contains all the amino acids essential for human health. Meat is also an important source of the B vitamins, particularly B1 (thiamine), niacin (nicotinic acid), B_2 (riboflavin), B_6 and B_{12} (cyanocobalamin), and vitamin A (retinol). It is a major source of iron, copper, zinc and selenium. Iron in meat has high bioavailability, the main reservoir being as a component of the haem-protein myoglobin (Warriss, 2010). On the other hand, it also contributes to the intake of fat, saturated fatty acids, cholesterol, salt and other substances that can have negative health implications. Therefore, the meat processing industry is driven by increasing consumer demand for healthier meat products which includes enriched products with fiber and omega-3 fatty acids and reduced levels of fat, cholesterol, sodium and nitrite as there is increasedawareness about the effect of food on human health in terms of incidences of coronary heart diseases, hypertension, and cancer.

Value addition of meat products via incorporation of novel components and processing technologies are being seen as an opportunity to improve the image of meat and address consumer needs. Value addition to meat is referred to the enhancing nutritional value, economic and health benefits through the processing into various designer and health oriented meat products by the incorporation of various functional ingredients and other techniques such as tenderizing the tough meat, preparation of cut of parts and utilization of slaughter house byproducts to develop valuable products. Non-meat, functional ingredients offer possibilities to lower formulation cost by means of adding water to the meat, increase processing yield along with additional health benefits by lowering

the salt, fat, cholesterol, nitrites and calories in meat products along with the supply of dietary fibre, antioxidants, Calcium and other nutrients.

Processed, convenient and value added meat products sector has a very good potential in developed and many developing countries like India due to changing lifestyle, increase in double income families, increase in disposable income and less time availability for cooking. At present India has a large population of over 250 million economically strong consumers having an adequate purchasing power for buying food, as a result of which the domestic demand for the value added livestock and poultry product is poised for rapid growth. The number of consumers seeking low fat, high fibre, nutrient enriched and other functional meat products that enhance their health is also growing very fast in India.

Advantages of Value addition to meat

- ✓ It increases demand and marketability and meet life style requirements-Healthy meat products.
- ✓ Value addition provides variety of meat products
- ✓ Value addition utilizes different carcasses beneficially and to utilize different by-products
- ✓ Value addition leads to incorporation of non-meat ingredients for quality and economy.
- ✓ Value addition provides aid in the preservation, transportation and distribution to larger populations.
- ✓ Value addition provides and promote entrepreneur ventures and employment.
- ✓ Value added products are further processed products that provide convenience to consumer through reduced preparation time and minimizing processing steps.
- ✓ Value added products are produced to ensure sustained demand for the products, improve safety and product attributes such as appearance and taste.
- ✓ Value added products facilitate diverse products, cost reduction, competitive pricing and byproducts utilization.
- ✓ Value addition to processed meat is also essential to provide shelf stable, nutritious and designer products to the consumers.
- ✓ Production of value added meat products is an important avenue for sustainable meat industry.

Importance of value addition to meat and meat products

Indian meat production can be described as “production by masses rather than mass production”. In India, sizeable quantity of meat is produced from aged animal at the end of their

productive life. Meat from such animals is usually tough and fibrous and has poor sensory characteristics. Thus the value addition of such type of meat is necessary for effective and efficient utilization of low quality meat. Processes such as cutting, deboning, ageing, tenderization, tumbling, mincing, restructuring, emulsion preparation, fermentation, curing, smoking, drying, battering, breading and a variety of cooking methods are utilized to produce a variety of value added products.

A number of traditional meat products are being prepared and consumed at household or at restaurant levels. Now-a-days exotic meat products are also being served in selected hotels and restaurants. These exotic meat products have number of advantages over traditional meat products like higher yield, longer shelf life and superior sensory characteristics. As the process for most of these exotic products have been mechanized, it is easy to manufacture large quantity with minimum labour. These products have tremendous scope in our country.

In processed meat sector, there is need to develop economic formulations, processing, bio-preservation and eco-friendly packaging conditions for convenience, value added, traditional, designer and shelf stable meat products from spent animal's meat. Inedible offal's and animal wastes from the meat plant can be rendered for the preparation of economically useful products. Great potential exists for processing animal tissues for valuable proteins/materials which have global market and most of them are imported to India.

Some of the important procedures adopted/recommended for value addition to meat and meat products are:

Value addition can be defined as "a change in the physical state or form of the products and production of a product in a manner that enhances its value as demonstrated through business plan". Meat processing and value addition involves a wide range of physical and chemical treatment methods, normally combining a variety of methods.

Based on their processing type, meat products may be roughly classified into following types:

Emulsion based meat products	Grinding/chopping/cutting of meat with water, common salt (NaCl) and other non-meat ingredients until a fine, protein-rich slurry is formed. After cooking, the salt soluble proteins are coagulated and this results in an	Ex. Nuggets, Meat Balls/kofta, patties**,** Sausages

	immobilization of the fat, water and other constituents	
Restructured meat products	Chunks of meat are partially disassembled and then reassembled to form products resembling intact meat cuts	Ex. Turkey rolls, meat slices
Cured and smoked meat products	During curing, meat pieces or bigger cuts are dipped /injected with curing brine/pickle solution consisting of salt, phosphate, nitrate/nitrite, ascorbate, sugar dissolved in potable water to give a characteristic color/flavor Hardwood smoke gives a typical surface color, flavor and preservative effect in smoked meat	Ex. Ham, Bacon
Enrobed meat products	Coating of meat products with edible materials to preserve nutritive value, reduce moisture loss, improve juiciness, and enhances the acceptability	Ex. Enrobed drummettes, wings,
Designer meat products	Functional properties of meat products are improved by adding ingredients considered beneficial for health (ω-3 fatty acids, fiber) or by eliminating components that are considered harmful to health (saturated fatty acids, cholesterol).	Ex. Low salt, low fat and high fiber meat products

Process involved in development of processed meat products

All processed meat products have been in one way or another physically and/or chemically treated. These treatments go beyond the simple cutting of meat into meat cuts or meat pieces with subsequent cooking for meat dishes in order to make the meat palatable. Meat processing involves a wide range of physical and chemical treatment methods normally combining a variety of methods.

- ✓ Meat processing technologies include:
- ✓ Cutting/chopping/comminuting (size reduction)
- ✓ Mixing/tumbling
- ✓ Salting/curing

- ✓ Addition of spices/non-meat additives
- ✓ Stuffing/filling into casings or other containers
- ✓ Fermentation and drying (if applicable)
- ✓ Smoking (if applicable)
- ✓ Heat treatment

Equipment's required for meat processing

Most of the meat processing steps can be mechanized. In fact, modern meat processing would not be possible without the utilization of specialized equipment. Such equipment is available for small-scale, medium-sized or large-scale operations. The major items of meat processing equipment needed to fabricate the most commonly known meat products are listed and briefly described here as follows.

- **Meat grinder/Meat Mincer**

A meat grinder is a machine used to force meat or meat trimmings by means of a feeding worm (auger) under pressure through a horizontally mounted cylinder (barrel). At the end of the barrel there is a cutting system consisting of star-shaped knives rotating with the feeding worm and stationary perforated discs (grinding plates). The perforations of the grinding plates normally range from 1 to 13 mm. The meat is compressed by the rotating feeding auger, pushed through the cutting system and extrudes through the holes in the grinding plates after being cut by the revolving star knives. Simple equipment has only one star knife and grinder plate, but normally a series of plates and rotary knives is used. The degree of mincing is determined by the size of the holes in the last grinding plate.

- **Bowl cutter (bowl chopper)**

The bowl cutter is the commonly used meat chopping equipment designed to produce small or very small ("finely comminuted") lean meat and fat particles. Bowl cutters consist of a horizontally

revolving bowl and a set of curved knives rotating vertically on a horizontal axle at high speeds of up to 5,000 rpm. Many types and sizes exist with bowl volumes ranging from 10 to 2000 liters. The most useful size for small- to medium-size processing is 20 to 60 liters.

In bigger models bowl and knife speed can be regulated by changing gears. Bowl cutters are equipped with a strong cover. This lid protects against accidents and its design plays a crucial role in the efficiency of the chopping process by routing the mixture flow. Number, shape, arrangement, and speed of knives are the main factors determining the performance of the cutter. Bowl cutters should be equipped with a thermometer displaying the temperature of the meat mixture in the bowl during chopping.

- **Filling machine/sausage stuffer:**

These machines are used for filling all types of meat batter in containers such as casings, glass jars, cans etc. The most common type of filling machine in small and medium size operations is the piston type. A piston is moved inside a cylinder forcing the meat material through the filling nozzle (funnel, stuffing horn) into the containers.

Piston stuffers are either attached to the filling table or designed as floor models. In small-scale operations manual stuffers are usually sufficient, sometimes even simple hand-held funnels are used to push meat mixes into casings. Modern filling machines for larger operations are designed as continuous vacuum stuffers. During the filling process a substantial part of the enclosed air is removed from the product, which helps to improve colour and texture of the finished products. These models are usually equipped with a portioning and twisting devise and have a casing grip devise attached for filling of "shirred" (folded) uncut collagen and plastic casings. This type of continuous filling equipment is relatively expensive and is thus not used in small- to medium-size operations.

- **Patty making and meat ball forming machines:**

Meat emulsion of fixed weight/shape will be moulded in the form of patty or meat ball in continuous operations.

- **Meat Tumbling machine:**

It helps in penetration of curing ingredients and extraction of meat proteins to the surface of meat chunks through fragmentation of meat fibers due to the pressure impact caused by dropping of the meat chunks.

It consists of a drum with paddles inside. When the cylinder rotates with the meat in it, the impact caused by falling will help in mixing and penetration of cure ingredients. Use of vacuum tumblers will minimize the lipid oxidation. Tumbler is an important requirement for preparation of restructured meat products.

- **Meat Smokehouses:**

Meat smokehouses are used for smoking only. In traditional and smallscale operations the most common methods of smoke generation include burning damp hardwood sawdust, heating dry sawdust or heating pieces of log. But technological progress has changed the smoke generation and application techniques.

Methods used in modern meat processing include the following: In modern smokehouses (1), smoke generation takes place outside the smoking chamber in special smoke generators with electrical or gas ignition (4). Separate smoke generators allow better control of the quantity and temperature of the smoke produced. The sawdust or chip material (3) is moved from the receptacle to the burning zone (4) by a stirrer or shaker (3). It is ignited by means of an electrically heated plate or by gas flame.

Non-meat ingredients for development of meat products

Changes in consumer demand of meat products as well as increased global competition are causing an unprecedented spur in processing and ingredient system developments within the meat manufacturing sector. Consumers demand healthier meat products that are low in salt, fat, cholesterol, nitrites and calories in general and contain in addition health-promoting bioactive components such as for example carotenoids, unsaturated fatty acids, sterols, and fibers. On the other hand, consumers

expect these novel meat products with altered formulations to taste, look and smell the same way as their traditionally formulated and processed counterparts. At the same time, competition is forcing the meat processing industry to use the increasingly expensive raw material "meat" more efficiently and produce products at lower costs. Different non-meat ingredients are added during processing of meat for different purposes. Some ingredients enhance the functionality of muscle proteins while others help in retention of moisture and provide characteristics texture, flavour and colour. Original meat products can be extended up to 200% by use of nonmeat ingredients. These ingredients are selected based on economic, raw materials availability, consumer preferences, food safety concerns etc.

The most common non-meat ingredients utilized in meat products preparation are salt, phosphate, nitrite, ascorbate, sugar, soya, whole egg liquid, refined wheat flour, skimmed milk powder etc. to impart different properties in developed products. These may protect or modify flavour, may act as fat replacers. Other ingredient functions include improved tenderness, juiciness, cohesiveness, water binding and emulsion stability, along with colour stabilization and preservation. Many of the ingredients exhibit multifunctional properties.

Salt

Salt (sodium chloride) is the most commonly used non-meat ingredient in the preparation of meat products. It is used for flavour with microbial inhibition, extension of shelf-life and increased protein hydration. Microbial inhibition and extended shelf-life from salt addition are achieved by reducing the water activity and in some cases by increasing the chloride ion content in the product. Salt concentrations of 1.5 to 2.5% are common for processed, ready-to-eat meat products.

Phosphate

Phosphates used in meat processing are usually alkaline Polyphosphates which raises the pH away from the isoelectric point of meat proteins and increases the tendency for water binding. Polyphosphates are also able to chelate metal ions that might otherwise catalyse lipid oxidation and acts as anti-oxidant. Cooked meat products containing alkaline polyphosphates exhibit less lipid oxidation and flavour loss during storage than similar products without phosphate.

Nitrite

Sodium nitrite is a highly reactive chemical that reacts with meat to produce nitric oxide (NO) which replaces the oxygen molecule in the meat pigment structure (heme) yielding the typical cured "pink" colour when the meat product is heated. Nitrite also functions for meat flavour, helps provide microbial stability and acts as a potent antioxidant.

Ascorbate/Erythrobate

These chemical along with ascorbic acid, sodium acid pyrophosphate, chemical acidulants, etc., are reducing agent used in cured meat products to facilitate the reduction of nitrite to nitric oxide. Erythorbic acid or ascorbic acid may be used as oxygen scavengers to slow down light-induced fading of cured meat colour.

Sugars

Sugars are commonly used as sweeteners in manufactured meat products. These carbohydrate materials are usually included to impart a desired degree of sweetness. However, properties such as surface browning, water binding, mouthfeel or smoothness, and ability to be fermented by microorganisms are also important. Surface browning of meat products during cooking is a desirable process involving the sugars in the product. Caramelization of sugars may lead to surface browning if very high temperatures, greater than 190 °C, are achieved as with radiant heat cooking. However, the Maillard browning reaction between protein and a reducing sugar is much more common in meat products.

Soya

A number of additives are permitted and used as binders, extenders or fillers in emulsion products. Soya due to its high protein content and meat like texture is a product of choice to be incorporated in different meat products. Soya grits with low protein (50%) often have a bean-like flavour; protein isolate (90% protein) has less flavour problems; hydration rate is usually 2.5 to 1).

Whole egg liquid

Egg proteins, derived from whole egg, yolk or whites, are available in different forms for use in processed meat products for their functional properties, such as foaming, binding and thickening ability, emulsifying ability and moisture retention. Whole egg and egg white have been used in the formulation of normal and low-fat meat products (meat patties, bologna and others) and have proved very effective as binders for meat. They also have excellent nutritional properties.

Processed products meat products

Meat from spent animals and birds are generally tough and not liked by consumers for use as fresh meat can be profitably utilized to prepare further processed meat products. There are different categories of processed meat products like emulsion based, restructured, enrobed, fermented, cured and smoked etc. These products have advantages of convenience, taste and shelf life. Simple technologies developed for most of these products require very nominal capital cost but can ensure handsome returns to the processor.

Emulsion based meat products

Emulsions are colloidal two-phase systems, in which a liquid is dispersed in another liquid of different composition, the second liquid forming the continuous phase. The dispersed phase is also called internal phase, and the continuous phase is referred to as the external phase. In many emulsions, there is an aqueous phase and a hydrocarbon or oil phase. Emulsion type meat products are the most popular processed meat products. When lean muscle tissue, fat, water and salt are mixed together and subjected to high speed cutting and shearing action, a batter is formed. This batter is called emulsion. In emulsion, lean meat and other ingredients like free fat and added water form a matrix. Thus, fat and water do not separate during cooking. Special equipment called "bowl chopper" is used for preparation of emulsion. Different popular emulsion based meat products includes value added products such as meat balls/koftas, meat burger patties and meat nuggets etc.

Meat balls/koftas

Meat balls/kofta is a traditional Indian comminuted meat product. These are widely used as snack items and culinary preparations. It is a ready-to-eat, convenient product suited for the restaurants, working couples etc. It has storage life of about three weeks at refrigerated temperature. It can also be served after enrobing to provide it better appearance and flavour. **Meat *Patties***

Meat patties are emulsion based ready-to-eat meat product, can be utilized as fillings in burgers, rolls and sandwiches for packed lunch or can be served as snack. These are prepared by moulding the emulsion into circular shape/tikki, thereafter cooked in oven.

Meat Nuggets

Meat nuggets are ready-to-eat meat product which can be used as a base for various recipe or preparation of meat products. For the preparation of meat nuggets, the chilled meat blocks are sliced into pieces of 15mm thickness in a meat slicer and cut into nuggets of almost uniform size.

Restructured meat products

Restructured meat products are generally prepared from less expensive cuts, tough cuts, meat trimmings or combination of these. In this technology, small pieces of meat or meat trimmings are joined together to get bigger pieces. The bigger pieces can be again cut into smaller pieces. Thus, we can get meat pieces/products of desirable shapes and sizes. During the process of binding small pieces, sensory qualities are improved by use of different additives. These types of meat product have sensory characteristics between ground meat and intact muscle steaks. Conventional restructured meat products depend upon hot-set binding of meat proteins extracted with the combined effects of salt, phosphate and mechanical action. This technology limits the marketing of the product to either the

precooked or frozen state. Many restructured meat products have been developed by various agencies/departments such as Low-salt restructured cooked hams (Pietrasik et al., 2014), restructured chicken slices (Najeeb et al., 2014), restructured chicken blocks (Malav et al., 2014), meat rolls, meat loaves, chicken sticks etc.

Fermented meat products

Meat fermentation is a low energy, biological acidulation, preservation method which results in unique and distinctive meat properties such as flavour and palatability, colour, microbiological safety, tenderness, and a host of other desirable attributes of this specialized meat item. Changes from a raw meat to a fermented product are caused by "cultured" or "wild" microorganisms which lower the pH. Since this is a biological system, it is influenced by many environmental pressures that need to be controlled to produce a consistent product. Fermented meat products rely on microbial fermentation and dehydration to develop their specified flavour and texture. In the production of fermented meat products, selected bacterial culture is added to the minced meat. These are called starter culture. Dry Sausages (Pepperoni, Genoa Salami, Dry Salami, etc.) and Semi-dry Sausage (Summer Sausage, Lebanon bologna, Cervelat, etc.) are important fermented meat products.

Cured and smoked meat products

In curing, generally intact muscle is subjected to some process to ensure distribution of salt (NaCl) and other curing agents throughout the product. Curing is mainly done in ham and belly portions of pork and large cuts of beef. After curing, smoking of meat is done to preserve and provide characteristics aroma and flavour to meat products. For smoking, meat cuts or products are kept in the atmosphere of smoke generated from saw wood.

Conclusions

Value addition of meat is possible through the different methods discussed above. Value addition is the need of the hour to make the enterprise of meat production and processing economical viable through generating more profit. The meat sector when organized on scientific lines can generate more employment in rearing of animals, production of hygienic meat, processing of meat into meat products and processing of slaughter house by-products for allied industries. Value addition to meat and meat products may open the new era of low cost, convenient and ready to eat and health oriented products with more profit to farmers/entrepreneurs.

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Chapter 6

Advances in Preservation and Packaging of Meat for Food Safety

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In the last few decades, India has made great strides in the production of milk, meat, and eggs, etc. and there is semblance of self-sufficiency, albeit fragile in view of the burgeoning population. Even then, the net amount of the fresh produce for consumption is further reduced due to insufficient storage and processing. So, adoption of appropriate processing and storage technologies of these food products are become imperative. Further consumer demand, regulative pressure to improve food processing towards better environmental performance, and the economic need to reduce waste or by-products stimulated the quest for innovative food processing techniques. In the recent years, consumers have become more health conscious in their food choices but have less time to prepare healthful meals. As a result the market demand for "minimally processed" or "lightly processed" animal products has rapidly increased. Food processing industry is one of the largest manufacturing industries worldwide and possesses global strategic importance. With the advancement of science and technology, new food processing technologies are capturing the attention of many scientists in academia and industry. Consumers prefer high-quality foods which not only taste better but also retain their natural flavour, colour and texture and contain fewer additives such as preservatives.

The market for processed livestock products is changing day by day. Unlike many industrialized countries Indian consumers no longer require a shelf stable animal product. This is due to changes in family lifestyle, and increased ownership of freezers and microwave ovens, are reflected in demands for animal foods that are convenient to prepare, are suitable for frozen storage or have a moderate shelf life at ambient temperature. There is also an increased demand by some consumers for foods that have fewer changes during processing and thus either closely resemble the original material or have a healthy image. New preservation technologies, such as high pressure processing (HHP), ultrasound (US) treatment, infrared (IR) heating, microwave (MW) cooking, use of radio frequency (RF), radiation treatment, osilitating magnetic field (OMFs) and use of active and intelligent packaging offer advantages in meeting consumer demands of freshness, convenience and safety.

Minimally processed foods

Minimal processed foods have been defined as products that include all the operations which add some value to conventional food preservation processes like washing, selecting, peeling, slicing, chopping, coring and packaging that cause fewer possible changes in food quality and maintain their quality attributes similar to those of fresh produce, but at the same time provide the food enough useful life to transport it from production site to the consumer. Minimal processed foods may be meant for direct consumption or can be later transformed in to the final products by any conventional techniques (Misha, 2011)

The demand for minimally processed, easily prepared and ready-to-eat 'fresh' food products, globalization of food trade, and distribution from centralized processing pose major challenges for food safety and quality. Recent food-borne microbial outbreaks are driving a search for innovative ways to inhibit microbial growth in the foods while maintaining quality, freshness, and safety. One option is to use packaging to provide an increased margin of safety and quality. The next generation of food packaging may include materials with antimicrobial properties. These packaging technologies could play a role in extending shelf-life of foods and reduce the risk from pathogens. Antimicrobial polymers may find use in other food contact applications as well.

High hydrostatic pressure (HHP) processing

Various physical and chemical changes result from the application of high pressure treatment. Generally, physical compression during pressure treatment results in a volume reduction and increase in the temperature and energy (Heremans, 2003). In HHP processing, food is subjected to very high pressure (up to 8.4 kg/cm^2) to kill bacteria present in the raw food. High pressure works like heat to kill bacteria. For HPP, pre-packaged raw product is placed in a pressure chamber and subjected to very high pressures for specific time (< 10 minutes). There are three general principles of the application of HHP in food processing: Le Chatelier's principle, principle of microscopic ordering and Pascal's isostatic rule (Zhang and Mittal, 2008). The Le Chatelier's principle states the phenomena of phase transition; chemical changes etc which are accompanied by a decrease in volume are enhanced by pressure and vice-versa. The principle of microscopic ordering explains at constant temperature, an increase in pressure increases the degree of ordering of a given substance. Therefore, pressure and temperature exert antagonistic forces on molecular structure and chemical reactions (Balny and

Masson, 1993). The isosatatic principle indicates that pressure is instantaneously and uniformly transmitted throughout a sample, whether in direct contact with the pressurized medium or insulated from it in a flexible container. Thus, the pressurization process is independent of sample volume, product size, and geometry, in contrast to thermal processing. Processing by high hydrostatic pressure is usually carried out in a low compressibility liquid such as water. Pressure influences most biochemical reactions occurring in foods since they often involve a change in volume. Presently, with the growing demands of consumers for natural, fresh, safe, and "minimally processed" food products, HHP is currently of great interest in meat research, primarily as an alternative to thermal processing (Sun and Holley, 2010).

Ohmic heating

Ohmic heating (OH), also called Joule heating, electrical resistance heating or electroconductive heating, is based on the principle that most food products have the ability to resist to the passage of an electrical current. Heating occurs when an alternating electrical current is passed through a food resulting in the internal generation of heat, due to the electrical resistance of the food. Ohmic heating is somewhat similar to microwave heating but with very different frequencies. The advantage of this technique is that it uniformly heats food with different densities such as chicken soup. The quality product with minimal structural nutritional and organoleptic changes can be produced. Potential application of this technique includes blanching, evaporation, dehydration, fermentation and extraction.

The principal mechanisms of microbial inactivation in OH are thermal in nature. Recent research indicates that OH may present mild non-thermal cellular (electroporation mechanism) may occur during ohmic heating. The principal reason for the additional microbial inactivation effect to heating of ohmic treatment may be its low frequency (50 – 60 Hz), which allows cell walls to build up charges and form pores. The main limitation of ohmic heating is the heterogeneous nature in composition of the food products and their corresponding electrical conductivities that leads to differences in the conversion of the electrical current into thermal energy. As in microwave heating, in ohmic heating, thermal runaway can also occur, because electrical conductivity, which is the property that influences electrical energy dissipation, usually increases with increasing temperature. Therefore, especially in stationary (i.e., not moving in a stream) solid products, there may be areas that are very hot (usually areas close to the electrodes), which in some instances may even be burned, while in other areas (with initially lower electrical conductivities, or farther away from the electrodes) almost

no heating occurs. Uniform heating with ohmic processing is theoretically possible, but at the same time challenging due to the various factors impacting on the slowest heating zone and the time – temperature history throughout the products.

Ultrasound treatment

Ultrasound is defined as sound waves with frequencies above the threshold for human hearing (>16 kHz and in its most basic definition, refers to pressure waves with a frequency of 20 kHz or more. Generally, ultrasound equipment uses frequencies from 20 kHz to 10 MHz. Higher power ultrasound at lower frequencies (20 to 100 kHz), which is referred to as "power ultrasound," has the ability to cause cavitations. The bactericidal effect of ultrasound is attributed to intracellular cavitation, that is, micro-mechanical shocks that disrupt cellular structural and functional components up to the point of cell lysis. Critical processing factors are the nature of the ultrasonic waves, the exposure time with the microorganisms, the type of micro-organism, the volume of food to be processed, the composition of the food, and the temperature.

The ultrasound induced cell damage is primarily explained by cavitation phenomena such as shear disruption, localized heating, and free radical formation. Cell wall and membrane of biological cells can be damaged by surface rubbing, leading to fracture and leakage. Equally, separation of the cytoplasmic membrane due to ultrasonic treatments has been reported, and free radicals are assumed to cause DNA damage.

Oscillating magnetic fields

The strong static (SMF) or oscillating (OMF) magnetic fields (5–50 Tesla) have the potential to inactivate vegetative microorganisms. The impulse duration is between 10 ms and several milliseconds. The frequencies are maximally 500 MHz, because above that value the items begin to warm up noticeably. Preservation of foods with OMF involves sealing food in a plastic bag and subjecting it to 1–100 pulses in an OMF at temperature of 0 to 50°C for a total exposure time ranging from 25 to 100 ms. However, the effects of magnetic fields on microbial populations have produced controversial results. So, before considering this technology for food preservation purposes consistent results concerning the efficacy of the method are needed.

Irradiation

Preserving meat to maintain its quality and safety is challenging task by the food industry. For centuries, great efforts have been devoted to finding ways of preserving foods and protecting them against physical damages, chemical changes and further microbial contaminations and spoilage. Food irradiation is a controlled treatment of food with ionizing energy, a part of the electro-magnetic energy spectrum that also includes radio or television waves, microwaves, infrared radiation, visible light and ultraviolet radiation. Ionizing radiation has a shorter wave length and consequently higher energy than other radiation in the spectrum. Levels of absorbed radiation are measured in kilo grays (kGy). Radiation may be defined as the emission and propagation of energy through space or material medium. Radiation destroys microorganisms without appreciable raising temperature is called cold sterilization. Two types of radiations are used for food preservation i.e. Ionizing radiation and non-ionizing radiations. The FDA has approved medium dose treatments for fresh and frozen meat.

*Non-ionizing radiations***:** UV light for meat processing has been investigated for many years but is still considered as an innovative technology. In this technology, UV - C light (wavelength of 254 nm) is predominantly being used as a disinfection method to inhibit or inactivate foodborne microorganisms. Fresh produce can be processed using UV light, which has a germicidal effect on many types of microorganisms like bacteria, viruses, protozoa, molds, and yeasts. UV light in meat processing can be used for surface sterilization of meat animal carcasses because of it less penetrative power. The most effective wavelength of UV rays is 2600Å. The germicidal properties of UV irradiation are mainly due to DNA damage induced through absorption of UV light by DNA molecules. This mechanism of inactivation results in a sigmoidal curve of microbial population reduction. In general, wavelengths ranging from 100 to 400 nm are suitable for UV light processing.

Microwaves cause oscillation of molecules in the food system. The molecules oscillate about their axes while attempting to go proper positive and negative poles; intermolecular friction is created and manifested as a heating effect. Microwave frequencies viz. 915 and 2450 megacycles are commonly used with wavelength of 32.8 and 12.25 cm respectively. Although most commonly available microwave ovens operate at 2450 MHz, there is great interest in the 915 MHz frequency. This frequency produced two peaks on at surface and other at the centre, while 2450 MHz frequency produces only the surface peak. The generator or power tube of conventional microwave oven is called magnetron. Cooking processes in microwave are associated with exposure of meat products at high temperature (e.g. grilling, baking, etc.) which may induce the production of potential carcinogens. So, there have been concerns that microwave cooking may also increase the production of carcinogens

or mutagens in foods. However, the degradation rates of nutrients depend on the heating time and temperature.

Ionizing radiations: This radiation rays have primary interest due to its high penetration power in to the products where it directly kills microbes without appreciable raise of heat. There are three main types of ionizing radiation. This includes (Wavelength < 2000 Å) e.g. α-particles, β-rays, γ-rays, x-rays and cosmic rays. Gamma rays (γ-rays) emitted from ^{60}Co and ^{137}Cs are the cheapest form of radiation for food preservation (^{60}Co have t ½ is 5 years and ^{137}Cs t ½ is 30 years) γ -rays have very good penetration power. In the case of gamma facility, the meat is exposed to an ionizing energy source contained in stainless steel tube. In the case of linear accelerator facility, the meat is exposed to electrons or X-rays, which is delivered in rapid pulses. The irradiator emits short wavelengths of energy that pass through the meat. Some electron accelerator can be designed to generate only electrons and thus can be used as an online process inside a meat processing plant with just a few inches of shielding surrounding the source. High energy ionizing radiation produces positive and negative charges that disabled bacterial DNA, thereby eliminating the threat to the human health. The process of meat irradiation often called "cold sterilization" because it kills most bacteria without the use of heat. This means that food can be irradiated within its packaging and remain protected against recontamination until open by user.

Membrane technology

With the inception of new composite membranes and tubular system, reverse osmosis (RO) and ultra-filtration (UF) are being used extensively in food and dairy industries. RO is a single phase concentration process which uses a pressure gradient across a semi permeable membrane to squeeze water through membrane. RO process is extremely energy efficient compared to both evaporation and freeze concentration. Ultra filtration uses much lower pressure 1 to 10 bars and much more open membranes, which pass salts, sugars and organics in the molecular range typically from 5,000 to 1,00,000 depending on the membrane type. It is limited by osmotic pressures, since the sugars are not concentrated. Both RO and UF have promising uses in food industry as a unit operation for concentration or aroma recovery and clarification.

Plasma treatment

Plasmas can be described as quasineutral particle systems in the form of gaseous or fluid-like mixtures of free electrons and ions, frequently containing neutral particles, with a large mean kinetic

energy of the electrons and/or all of the plasma components and a substantial influence on the charge carriers and their electromagnetic interaction on the system properties. Plasma systems are two major categories: thermal and non-thermal plasmas. Thermal plasmas usually arcs or radiofrequency (RF) inductively coupled plasma discharges are associated with Joule heating and thermal ionization, and enable the delivery of high power (to over 50 MW per unit) at high operating pressures. Very high gas temperatures limit their applicability to food systems. In non-thermal plasmas, the electron temperature is much higher (several ten thousands K) than the bulk gas temperature (below 40°C). The non-thermal plasmas may be produced by a variety of electrical discharges at different pressure levels. The most suitable system for food processing is an atmospheric-pressure plasma device in which no extreme conditions are required and low temperatures can be realized. Atmospheric pressure plasma is commonly generated by corona discharge, dielectric barrier discharge (DBD), or plasma jet. For the treatment of non-uniformly shaped products, the application of plasma jets offers advantages due to various options regarding design and construction.

Pulsed electric field (PEF)

It was in US where in 1920s first attempt to treat milk with electro impulse was made. Further, experimentations followed in the 1960s primarily with in molecular biological research for incorporation of foreign gene materials into microorganisms. This technique involves application of pulse of high voltage (typically 20-80 KV/cm) to foods placed between two electrodes. Only pumpable food products like milk, liquid eggs etc can be treated. This is the more novel process. PEF imposes a strong electric field on a flowering fluid for a very short time. Above critical field strength of about 15,000 V/cm, vegetable cells are killed.

Generally higher field strength up to about 35,000 V/cm for disinfection like destruction of bacteria, fungi and other microbes. When exposed to high electric field pulses, cell membranes develop pores either by enlargement of existing pores or by creation of new ones. The pores increase membrane permeability allowing loss of cell contents or inclusion of surrounding media either of which can cause cell death. It has limited effect on pores and only appears to affect a few enzymes. PEF offers a five log reduction of most pathogens and is considered as a pasteurization process so products must be refrigerated. It kills live cells and reduces their ability to retain water, greatly improves filtration. The important process variables of PEF include the electric field, temperature, pressure and time of exposure

Modified atmosphere packaging (MAP) and controlled atmosphere storage (CAS)

The main objective of modified atmosphere packaging (MAP) is to interrupt or slow down the derivative processes and also to prevent the attack of pathogens until the food is consumed. Controlled atmosphere (CA) is the alteration of the natural gaseous environment and maintenance of this atmosphere at pre specified conditions throughout the storage time. Modified atmosphere (MA) is the initial alteration of the gaseous environment in the immediate vicinity of stored and packaged product. These are used for retail distribution and for consumer product packages. The CA and MAP extend the shelf life of the product. Lot of work has been carried out and further research is on.

Retort processing technology

Retort processing of foods in rigid, semi rigid and flexible packaging systems is the most acceptable form of food preservation. It represents a unique combination of product, process and package technologies with potential, functional, quality and economical benefits. The increasing consumer awareness and inhibition/dislike to accept other methods of food preservation such as use of chemical preservatives, irradiation etc. has offered a vast scope for retort processed foods.

Although retort pouch processing of foods is similar to conventional canning, it has certain major advantages like (i) Consumes less energy for processing (ii) enhances the quality attributes and (iii) reduces the cost of transportation and storage. Retort processing is generally carried out for low acid foods with a pH more than 4.5 at a temperature of 121.1ºC using moist heat. During heat treatment, undesirable spoilage as well as pathogenic microorganisms is inactivated / killed and thereby the food products become commercially sterile.

Thermal destruction of microorganisms is measured and monitored by time-temperature history, lethality and F_0 value. Despite distinct advantages, retort pouch processing of foods till recent years did not become popular in India as compared to countries like Japan mainly because of the high cost of processing equipment and non-availability of indigenous multi layer flexible packaging materials. DFRL, Mysore has been a pioneer in developing the retort processing technology indigenously in the country. Over the past two decades, research and development work has been carried out in developing multilayer flexible packaging materials as well as designing a simple low cost retort (semi-automatic and automatic) amenable to Indian food industry. Due to continuous efforts,

DFRL has so far successfully transferred the retort pouch processing technology to 40 firms for commercial exploitation (Bawa, 2011).

Active packaging and intelligent packaging

*Active packaging***:** Active packaging allows packages to interact with food and the environment and play a dynamic role in food preservation. So, *Active packaging* refers to the incorporation of additives into packaging systems with the aim of maintaining or extending meat product quality and shelf-life. Developments in active packaging have led to advances in many areas, including delayed oxidation and controlled respiration rate, microbial growth, and moisture migration. Other active packaging systems include carbon dioxide absorbers and emitters, odour absorbers, ethylene removers, and aroma emitters. While purge and moisture control and oxygen removal have been prominent in active packaging, purge control is the most successful commercially. For example, drip absorbing pad used in the poultry industry.

The presence of oxygen in package can trigger or accelerate oxidative reactions that result in food deterioration: oxygen facilitates the growth of aerobic microbes or molds. The use of scavengers led to faster reduction and to lower levels of residual oxygen, as compared to nitrogen flushing. Ferrous oxide is the most commonly used scavenger (Kerry *et al*., 2006). Others include ascorbic acid, sulfites, catechol, some nylons, photosensitive dyes, unsaturated hydrocarbons, ligands, and enzymes such as glucose oxidase. They are available in the market in various forms (sachets in headspace, labels, or direct incorporation into package material and/or clousers) and names. Ageless^{R} is an iron and ascorbic acid containing oxygen scavenger. The FreshPax^{TM} has packets configuration with absorbing capacities ranging from 10 to 2 000 cc of oxygen.

Carbon dioxide may be added for beneficial effects like to suppress microbial growth in certain products such as fresh meat and poultry. Carbon dioxide is also used to reduce the respiration rate of fresh produce and to overcome package collapse or partial vacuum caused by oxygen scavengers, and thus increasing the product shelf-life. Carbon dioxide is available in various forms, such as moisture activated bicarbonate chemicals in sachets and absorbent pads. Since the permeability of carbon dioxide is 3/5 times higher than that of oxygen in most plastic films, it must be continuously produced to maintain the desired concentration within the package.

Control of moisture is important for food preservation. Soaking up moisture by using various absorbers is very effective at maintaining food quality and extending shelf life by inhibiting microbial growth and moisture related degradation of texture and flavour. In addition to moisture absorber

sachets for humidity control in packaged dried foods, several companies manufacture moisture drip absorbent pads, sheets and blankets or liquid water control in high a_W foods such as meats, fish and poultry. Basically they consist of two layers of a microporous non-woven plastic film, such as PE or PP, between which is placed a superabsorbent polymer that is capable of absorbing up to 500 times its own weight with water. Typical superabsorbent polymers include polyacrylate salts, carboxymethyl cellulose (CMC) and starch copolymers, which have a very strong affinity for water (Reynolds, 2007). Moisture drip absorber pads are commonly placed under packaged fresh meats, fish and poultry to absorb unsightly tissue drip exudate. Commercial moisture absorber sheets, blankets and trays include Toppan Sheet™, Thermarite™, Luquasorb™ and Fresh-R-Pax™.

Antimicrobial packaging is a promising form of active packaging especially for meat products. Limitations antibacterials include neutralization of compounds on contact with the meat surface or diffusion of compounds from the surface into the meat mass. Incorporation of bactericidal agents into meat formulations may result in partial inactivation of the active compounds by meat constituents and therefore exert a limited effect on surface microflora. Antimicrobial food packaging materials extend the lag phase and reduce the growth phase of microorganisms in order to extend shelf life and to maintain product quality and safety. Coating of films with antimicrobial agents can result in effective antimicrobial activity.

The use of ethanol as an antimicrobial agent, particularly for surface sterilization and disinfection, is well known. It acts against vegetative cells of microorganisms in high concentrations, and it also has a preserving action in low concentrations. Ethanol creates an anti-mold atmosphere, particularly effective in extending the shelf-life of high water activity baked products. The use of ethanol generating sachets or strips avoids the ethanol spraying directly onto the product surface prior to packaging. The ethanol is absorbed or encapsulated in a carrier material enclosed in sachets of selective permeability to ethanol. These allow for the ethanol vapour to be released into the packaging headspace. The packaging material should have high barrier characteristics to ethanol, preferably below 2 g/m^2 day according to suppliers' recommendations, to allow for ethanol accumulation in the headspace.

In packaged products , flavour and odour absorbers take in unwanted gaseous molecules such as volatile package ingredients, chemical metabolites of foods microbial metabolites, respiration products, or off-flavours in raw foods. During storage various sulphurous compounds and amines produced biochemically from protein degradation, aldehydes and ketones produced from lipid oxidation or anaerobic glycolysis, and that are removed by use of flavour and odour absorbing systems

employing mass transfer mechanisms. They are typically available as films, sachets, tapes/labels, and trays.

*Intelligent packaging***:** Intelligent packaging systems are those that monitor the condition of packaged foods to give information regarding the quality of the packaged food during transport and storage. The potential of biosensor technologies like freshness indicators and time-temperature indicators (TTI) and radio frequency identification (RFID) are evaluated for potential use in food products. These smart devices may be incorporated in package materials or attached to the inside or outside of the package. Recognition of the benefits of active and intelligent packaging technologies by the food industry, development of economically viable packaging systems and increased consumer acceptance is necessary for commercial realization of these packaging technologies (Kerry *et al.,* 2006). Some indicators are freshness indicators, TTI's etc.

Conclusion

Development of innovative technology not only improves health, but reduces poverty. When animal food products are safe, nutritious, well marketed, and competitively priced thanks to efficient manufacturing, they attract consumers. Rising consumer demand, in turn, expands a nation's entrepreneurial base in food products, creating jobs and raising family incomes. Larger family food budgets then contribute to a further drop in malnutrition. New preservation technologies, such as high pressure processing and pulsed electric fields offer advantages in meeting consumer demands of freshness, convenience and safety. There is no single process that will allow the high-quality production of every food product while ensuring safety; all of these processes, as well as thermal processing, have their own set of limitations and advantages.

Chapter 7

Management of Slaughterhouse By-Products for Environmental Sustainability ***Om Prakash Malav, Nitin Mehta, Rajesh V. Wagh, Mehak Jandyal and Ashlesha S. Ranade*** *Department of Livestock products Technology,*

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1. Introduction

The slaughtering and other meat processing operation results in production of valuable by-products in addition to main product i.e. meat. It may be defined as every part of a slaughtered animal except dressed carcass (also called as offal or fifth quarter). It may range from 40-60% of the total weight of the animal and normally not utilized to its full potential. India is bestowed with vast livestock resources of 535.78 million comprising of Cattle-192.49 million, Buffalo-109.85 million, Mithun- 0.38 million and Yak- 0.06 million, 74.26 million sheep, 148.88 million goats, 9.06 million pigs and 851.81 million poultry (Livestock census, 2019).

According to BAHS (2018-19) total meat production in our country is 8.11 million tonnes. The proportion of meat produced by different animal species is as follow: Poultry-50% buffalo-19.05%, goat-13.53%, sheep-8.36%, pig-4.98% and cattle-4.02%. Annual growth rate of meat production is about 5%. Large number of animals and birds are slaughtered to produce the meat for domestic consumption and export. It leaves huge loads of by-products. Efficient utilization of animal by-products has direct impact on the economy and environmental pollution of the country. Non-utilization or under-utilization of by-products not only lead to loss of potential revenues but also lead to the added and increasing cost of disposal of these products along with major aesthetic and serious health problems. It has been estimated that 11.4% of the gross income from beef and 7.5% of the income from pork come from the by-products.

It is an astonishing observation that the livestock sector alone contributes nearly 29.82% of value of output at current prices of total value of output in Agriculture, Fishing and Forestry sector (National Accounts Statistics-2019). The overall contribution of Livestock Sector in total GDP is nearly 5.10% at current prices during 2018-19. This contribution would have been much higher had the animal by-products been also efficiently utilized. The economic analysis has been carried out and it was observed that the financial loss to nation through none or underutilization of animal byproducts is around Rs. 1000 crores/ annum.

Table 2: Common Meat Processing Industry By-products and their general uses (Ockerman and Hansen, 2000; Chatli et al., 2005; Jayathilakan et al., 2012; Irshad et al., 2015)

By Product	% of live weight	Raw by products	Processed by products	Uses
Blood	7	Edible raw blood	Plasma and Red blood corpuscles	Adhesives for sausages, pharmaceutical products, blood sausages or pudding
Bones	20-30	Inedible raw blood	Blood meal, poultry feed, blood albumen	Additives for livestock feed, leather finishing agent, plywood adhesive, fertilizer, mordant
		Raw bone classified as edible	Edible fat pieces	Shortening, bone gelatine, bone meal, livestock and poultry feed
		Raw bone classified as inedible	Inedible fat pieces	Lubricant gelatine: photographic, pharmaceutical, printing. Tallow: soap, cosmetics, food, bone ash, ceramics. Glue: adhesive, abrasive.
Hide	6-8	Hides	Preserved hide, hair and wool	Leather products, falls, upholstery
		Hide and pelt	Trimmings for inedible rendering	Fertilizers and textiles. Collagen: cosmetics, face creams, shampoo, detergents
		Pig skin	Edible	Used in various comminuted meat product up to 7-10%.
		Pig skin	Tanned skin	Leather products
Intestines	2		Sausage casings	Sausage skins, edible, Surgical sutures, sports guts, musical

				strings, prosthetic materials, collagen sheets, burn dressing, dialyzing membrane, animal feed, heparin, protein meal
Horns and hooves	0.6	Cattle feet	Neat's foot oil	Fine lubricant
		Horns & hoofs	Gelatin extracted protein	Gelled food products, foaming in fire extinguishers, felt, upholstery, brushes
		Toe nails	Meal	Mixed with livestock feed or fertilizers
Hair, Bristles and Wool		Hair		Pelting, fabrics and pillow
		Bristles		Brushes
		Wool		Yarn, blankets, carpet, lanolin, fertilizer
Stomach	2		Pharmaceuticals	Trypsin, bate, insulin pharmaceuticals
Liver	1.2		Edible	Direct consumption, variety meat, sausage ingredient
Fat	Variable	Edible raw fat	Edible fat oleostearein cracklings	Fatty acids, frying purpose, margarine, shortening, candy chewing gum, pet foods or meat meal
		Inedible raw & mixed condemned materials	Inedible fat, meat and bone meal	Lubricants, soaps, candles, glycerin additives for livestock and poultry feed
		Inedible raw fat	Inedible (rendered) fat	Lubricants, soap, candles, glycerin, additive for livestock and poultry feed

Glands	Variable	Discussed in Table: 5

The by-product management is in turn is associated with environmental sustainability. The animal industry by-products are potential environmental polluters if are not used adequately and disposed without any treatment as they are very rich in non-biodegradable organic matter. There has been a lot of hue and cry in public about installation of any slaughter house in their vicinity as foul and stinking smell emanates from decaying organic by products. The important environmental impact of the animal processing industry results from the discharge of wastewater. The animal industry has operations which demand a lot of water for the different operations such as washing, cleaning the excreta, cleaning the slaughter house flour, drinking water for animals etc. The discharge of waste waters having high polluting potential may result in depletion of oxygen leading to death of aquatic life through eutrophication.

The disposal of animal byproducts without utilization also results in loss of animal proteins and other nutrients that could have been utilized for human and animal consumption. So, it becomes imperative that all the wastes and by products generated from slaughtering needs to be converted into valuable commodities.

2. Utilization of Meat Processing Industry By-products

As mentioned above, the utility of animal industry byproducts is immense and technological intervention is always required for effective utilization of these by products. The general uses of animal byproducts in various forms have been described in Table 2. Value addition of animal byproducts is seen as a promising approach for efficient utilization without compromising the environmental health. Value addition is economically improvement of a commodity and inculcating characteristics that makes it more favourable to a market. Though the consumption of by products are not to the level as that in other countries but the insistence on value addition can Create a preferred market. A number of technologies for value addition of animal industry byproducts like emulsification, restructuring and enrobing are now commonly used. Processing of meat along with by products in a stipulated ratio is also being tried in steaks, chops, cutlets etc. This helps in increasing value and palatability of spent meat and reduction in price of meat product too.

Other important uses of meat processing industry by-products are given as follow:

2.1 Livestock Feed

Animal by products including condemned carcass can be utilized as feed supplement for livestock and poultry. Animal blood is a source of quality protein and is an important edible byproduct. It is frequently used in preparation of blood pudding, blood sausages, biscuits etc. But it is employed in development of livestock feed in form of blood meal. The advantages of using these byproducts as feed for livestock ensure better health and productivity. Addition of 10% level in feed helps in meeting out the essential requirements of amino acids like lysine, tryptophan and methionine. The meat meal can be included in diets of pigs and poultry of any ages. Other than that, bone meal is mixture of crushed bones which is used for feeding livestock. It is a source of phosphorus and calcium which in present in a ratio of 1:2. Meat-cum-Bone meal is also prepared which can be fed to animals. Poultry industry byproducts like feathers can be used for preparation of feather meal. This not only helps in better utilization of feathers but also prevents environmental degradation as feathers are potent pollutants. The feathers are having keratin which are hard to degrade at lower temperature. So the digestibility is somewhat questionable. A technological intervention that can be employed is biodegradation of feathers by keratinolytic microorganism like *Bacillus linciformis*. Rendering is frequently used for preparation of the livestock feed from byproducts and it will be discussed in detail in forthcoming sections.

2.2 Pet foods

Utilization of offals and slaughter house by-products for the production of pet foods may fulfil the nutritional requirement of all categories of pets (i.e. different age groups and physiological conditions) which have absolute requirement of animal proteins in diet along with sparing the grains for human consumption. It will also help in minimizing the economic losses and environmental pollution resulting from discard of animal by-products. Slaughter house byproducts utilization in pet food formulation will give more ingredient option to the pet food manufacturers. This will open gates for employment generation as well as growing income for the slaughter house owners and pet food manufacturers. Common pet treats from the byproducts are Abomasums, Achilles Tendon, Bone Chews, Braided Skin, Omassum, Muzzle chew, Heart, Hock Tendon, Head skin, Intestine Braid, Intestine Knott, Intestine Plain, Intestine Twist, Knee Tendon, Knotted Bone, Lamb Ears, Lamb Heart, Lamb Legs, Lamb Trachea, Lamb Tripe, Liver, Liver Bites, Lolly Pop, Lung Sliced, Lungs, Dried tail, Smoked Bones, Dried ear, Dried braided pizzle, Schaslik atc.

Slaughterhouse waste or meat processing industry by-products such as liver, lung, kidney, gizzard, bones, brain, spleen and tripe has high nutritive value and these can be efficiently utilized for the production of pet foods as the animal proteins are the integral part of their diet.

- Pork tail: highest fat and lowest moisture content of all meat byproducts.
- The liver, tail, ear and feet of cattle has equivalent protein content as that of lean meat.
- The vitamin content much higher than lean meat tissue.
- Kidneys and liver contain 5- 10 times more riboflavin (1.69-3.63 mg/100g) as compared to lean meat.
- Pork liver, lungs and spleen are rich sources of iron. Also, they contribute 90-350% RDA for copper.
- Thymus and sweetbreads contain highest levels of phosphorus (393-558 mg/100g) and potassium (360-433 mg/100g) amongst meat by products.

2.3 Fertilizers

After rendering, the finished product can be either used as livestock feed or fertilizer but it depends on the nature of the material. Clean and fresh material is used to make good stock feed while material which is contaminated and decomposed is suitable for fertilizer preparation. Animal by-products can be used as a valuable resource as agricultural fertilizer and soil conditioner. Their application improves the soil health through addition of carbon and nutrients that feed the microorganisms or through better plant growth, which in turn adds the organic matter. Their application leads to higher infiltration, better moisture and nutrition retention. The disadvantage associated with the application is that soil structure may get damaged during application by compaction and other contaminants like salts and metals may be added. However, these risks can be reduced by good management practices.

2.4 Pharmaceutical by-products

Animal by-products like glands provide many chemical extracts having pharmaceutical and cosmetic applications. These glands like pituitary gland, adrenals, liver, lungs etc. secrete many enzymes and hormones. The glands/tissues are collected only from healthy animals and locating the glands requires experience because some of the glands are often small and are often encased in other tissue. Different animals have different glands that are important, and their function is dependent on the species, sex, and age of the animals. The best method of preserving most glands is by quick freezing

without any degradation of their active principle. Before freezing, the glands must be cleaned and trimmed from surrounding fat and connective tissue. After careful wrapping, they are stored at -18 °C. Then the glands are dried and defatted and converted to powder form which is later on dispensed as capsules or tablets. Various glands and products of pharmaceutical value derived there from are presented in Table 4.

Table 3: Slaughter house By-Products of pharmaceutical value and their uses

Glands/organs	**Active compounds**	**Use**
Adrenal gland (suprarenal capsules)	1. Adrenal cortex – Corticosteroids (cortisone) 2. Adrenal medulla i. Epinephrin ii. Norepinephrine	✓ Addison's disease- progressive anemia, low blood pressure, loss of weight, dark skin pigmentation, diarrhea, loss of strength and a depletion of sodium.; anti-neoplastic and anti-inflammatory agents, and for treating shock. ✓ To arrest hemorrhaging, shirk blood vessels, prolong the effects of local anesthetics, stimulate heart action, and overcome shock. ✓ Shrink blood vessels, reduce peripheral blood flow, and slow the rapid heartbeat.
Arteries (bovines)	Carotid arteries	✓ Implantation into humans as a femoropopliteal or iliofemoral substitute.
Bile	1. Ruminants gall i. Cholic acid ii. Deoxycholic acid 2.Pig gall i.Chinodeoxycholic acid	✓ In synthesis of corticosteroids-prednisone, prednisalone and progesterone. ✓ Treatment of human gall stone to suppress cholesterol synthesis.
Bone cartilage	1.Xiphoid and xiphisternal cartilage from young cattle	✓ To replace facial bone of human.

Heart	1.Pigs heart valves (young)	✓ Implantation into the human heart in place of defective valves.
Intestine	1.Heparin (pork and beef)	✓ In the treatment of frostbite and burns.
Liver	1. Vitamin B12 2. Heparin 3.Catalase enzyme (hog)	✓ Pernicious anemia and sprue ✓ Anticoagulant and the treatment of frostbite and burns. ✓ Cold sterilization of milk for cheese making.
Lungs	1.Heparin	✓ Anticoagulant and the treatment of frostbite and burns.
Ovaries (sow)	1. Estrogen 2. Progesterone 3. Relaxin (corpora lutea)	✓ Treatment of menopausal syndrome. ✓ Prevent abortion ✓ Used in child birth.
Pancreas (pork)	1. Insulin (β-cells) 2.Glucagon (α-cell) 3.Pancreatin 4. Trypsin 5. Chymotrypsin	✓ Treatment of diabetes. ✓ To elevate blood sugar and treat insulin over dose ✓ Intestinal disorders and cystic fibrosis. ✓ Remove death tissue and speed healing after surgery or injury. ✓ Milk curdling proteolytic enzyme.
Parathyroid	1.Parathormone	✓ To treat human parathyroid deficiency.
Pineal gland	1.Melatonin	✓ For the treatment of Schizophrenia, mental and physical development problems, and mental retardation.
Pituitary (pork)	1. ACTH 2. Oxytocin 3. ADH	✓ In the treatment of rheumatism, arthritis, eye inflammation some skin disorders

	4.Prolactin hormone	and multiple myeloma (a form of leukemia). ✓ Use to assist child birth and in obstetrical complication, let down of milk. ✓ In the treatment of diabetes insipidus ✓ Use to stimulate milk secretion from mammary gland.
Seminal vesicles	1.Postaglandins	✓ To induce parturition and in large doses induce abortion.
Testes	1.Hyaluronidase 2.Androgen	✓ Spreading factor-has ability to digest mucoplolysaccharides, and thus increase the rate of absorption. ✓ Control male characteristics.
Thymus	1. Thymosin	✓ Helps the body in resisting infection, calcification of bone and prevent rickets.
Thyroid (hog)	1. Thyroxin 2. Calcitonin	✓ To treat cretinism in (infant) and myxoedema (in adult). ✓ In the treatment of 'Pagets disease'.

2.5 Tallow and Lard

Animal fats are important byproducts of animal industry and the major edible fats are lard and tallow. Tallow is the rendered fats of cattle or sheep while lard is rendered fat of pig. These are obtained by dry and wet rendering procedures. Animal fats provide important amounts of fats used in the world today, both for foods and for many non-food applications. Animal fat is a versatile, sustainable and natural basis for many products. Worldwide, they are used in explosives, paints, soaps, lubricants, insecticide, wax etc. Prior to its use as a food ingredient, the lard or tallow is often bleached and deodorized. Wordwide, 172 million tonnes of vegetable and animal oils and fats are produced annually, from which approximately 25 million tonnes (14%) are estimated to be of animal origin (REA, 2013). These animal fats are mainly categorized as tallow, lard, fish oil, and butter.

3.6 Biodiesel Production

The energy sources especially petroleum based products are depleting vary fast due to rapid utilization without due replenishment. This has led to a search of alternative sources and biodiesel presents a potential substitution. It is produced from the fat extracted from byproducts after rendering operation. It is biodegradable and nontoxic which emits lesser obnoxious chemicals when burnt as compared to petroleum based products. The technology that is adopted for converting rendered fat to biodiesel is trans esterification. It reduces the viscosity of oil /fat to a range of (4-5mm^2/s) closer to that of petro diesel. The use of biodiesel is getting popular throughout the world. It is generally blended with diesel at the level of 20 percent. No modification in design of engines is required for this substitution.

3.7 Biogas Production

Animal waste like GI tract contents are digestible and can yield biogas. The waste product is utilized effectively and contributes to the continuous generation of an efficient energy source. The animal wastes constitutes a good substrates for biogas production with methane potential of 619 dm^3kg^{-1} from mixed animal wastes, which is much higher than simple manure (20- 30 dm^3kg^{-1}) (Hejnefelt and Angelidaki, 2009). Power plants have been designed to produce biogas (60% methane, 30% carbon dioxide and traces of hydrogen, carbon monoxide etc.) by digestion of animal waste (Sharma, 2003). Biogas is produced from animal wastes due to their anaerobic fermentation in airtight tanks called digesters. The resulting gas is then compressed in tanks and distributed for consumption. It is used for steam production and utilized to force turbines and create electricity. It can also be used to cooking, heating, lighting and even power car engines.

2.8 Leather

Hide constitutes around 6-8 % of live animal weight whereas the skin from sheep and goat constitutes around 12-15 % of live animal weight. Leather is prepared after the processing of hide and skins through tanning. India's leather industry has grown drastically, transforming from a mere raw material supplier to a value-added product exporter. The Indian leather industry accounts for around 12.93 per cent of the world's leather production of hides/skins. Leather is one of the most widely traded commodities globally. The growth in demand for leather is driven by the fashion industry, especially footwear. Apart from this, furniture and interior design industries, as well as the automotive industry also demand leather. The leather industry has a place of prominence in the Indian economy

due to substantial export earnings and growth. Exports of Leather & Products in India averaged Rs 11.90 Billion from 1991 until 2017, reaching an all-time high of Rs 36.46 Billion in August of 2014 and a record low of Rs 1.81 Billion in June of 1991.

During Apr-Jun 2017, the major markets for Indian leather products were US (14.66 per cent), Germany (11.22 per cent), UK (10.05 per cent), Italy (7.03 per cent), Spain (4.63 per cent), France (5.15per cent), Hong Kong (4.52 per cent), UAE (5.04 per cent), China (3.09 per cent), Netherlands (3.05 per cent), Poland (2.23 per cent) and Vietnam 1.88 (per cent). At 47.54 per cent, footwear (leather and non-leather) and footwear components accounted for the lion's share of leather exports in April-June 2017, followed by leather goods and accessories with 23.34 per cent share, finished leather with 16.77 per cent share, leather garments with 9.79 per cent share and saddlery & harness with 2.56 per cent share.

The Indian Leather Industry holds a noticeable place in the Indian economy. This particular sector is known for its consistency in the high export earnings and is also among the top ten foreign exchange earners for the country. The export market for leather and leather products have increased over the past decades and touched to around US$ 5.91 billion during 2013-14, recording a growth rate of about 14.77% in 5 years. Kanpur is the largest center of the leather industry, other top 7 leather centers in India are Unnao, Chennai, Ambur, Kolkata, Agra and Ranipet. Chennai contributes far more than 50 percent of India's total leather exports. It also has a CSIR research institution named the Central Leather Research Institute. According to the CLRI survey on capacity utilization, there are 2091 tanneries in the country out of which 1803 units are in the small scale sector and 288 are DGTD units. Tamil Nadu with 934 units, West Bengal with 538 units and Uttar Pradesh with 378 units, account for 89 percent of the tanneries in the country.

The Council for Leather Exports (CLE) is an autonomous non-profit organization, which is entrusted with export promotion activities and the development of the Indian leather industry. About 3,500 companies manufacturing/exporting leather and leather products are members of the Council.

2.9 Bone meal

Bones constitutes around 20-30 % of live body weight of animals. Important products prepared from bones are gelatin, glue, bone meal, fertilizers etc. Bone meal is mixture of crushed bones which is used for feeding livestock. It is a source of phosphorus and calcium which in present in a ratio of 1:2. Major manufacturers/suppliers of bone meal are Aarti Traders Delhi, Andhra Agro-Vet Associates Pvt. Ltd. Himayatnagar, Hyderabad, Frigorifico Allana Ltd. Allana House, Allana

Road, Colaba Mumbai, Maharashtra, Frigorifico Allana Ltd. Paithan Road Aurangabad, Maharashtra, Hindustan Crushers & Fertilisers Co. Agra, Uttar Pradesh, Jas Agro Vet – Industries Khaderpet Vaniyambadi, Tamil Nadu, Kerala Chemicals & Proteins Ltd. Ernakulam Kochi, Kerala, Khatauli Manure Mills (P) Ltd. Meerut, Uttar Pradesh, Mount Wool Growth & Exports Ltd. Gujarat, Nandyal Aqua Feed Pvt. Ltd. Kurnool, Andhra Pradesh, Parle Chemicals, Mani Majra Chandigarh, Rupa Poultry Enterprises, Warangal, Andhra Pradesh, Shaw Wallace Gelatines Ltd. Calcutta, West Bengal Standard Agro Vet Industries Unnao, Uttar Pradesh, Vet Chem Industries Kanpur, Uttar Pradesh, Vetstar Agros Pvt. Ltd. Hyderabad.

2.10 Gelatin

Gelatin is important product prepared from bones. Gelatin is broadly classified as edible and inedible. Inedible gelatin is used is cosmetics manufacturing industry such as nail polish and in photographic papers and film. The edible variety of gelatin is used in different manufacturing industry like food processing and pharmaceutical. Global production of gelatin is 4,00,000 tons per annum while India accounts for 5% of the total production at 20,000 tons. In India, bulk of the gelatin is consumed by pharmaceutical industry but worldwide, it is more consumed by the food industry. The global market is growing at a rate of 4% per annum while in India it is growing at a rate of 10%. The major players for the gelatin production in India are- Nitta Gelatin India Ltd (BSE: 506532), India Gelatines & Chemicals Ltd (BSE: 531253) and Narmada Gelatines Ltd (BSE: 526739).

Table 4: Export of slaughter house products from India

Sr No.	Products	**2017-18**	**2018-19**
		Value (Rs)	**Value (Rs)**
1	Edible offals (Fresh, Chilled/frozen)	12923744063	16293367066
2	Raw hides and skin of bovines	14724126	15186251
3	Raw skin of sheep and lambs	2429911	1057998
4	Other raw hides and skins	864001	---
5	Tanned/crust hides and skin of bovines	41332465	135547185
6	Tanned/crust skin of sheep and lambs	394032	31543267
7	Tanned/crust hides and skin of other animals	21732354	272167172

8	Leather from bovines	36184134662	30612525049
9	Leather from sheep and lamb	5420145290	6248504021
10	Leather from other animals	14292663204	12865493605
11	Laminated leather/metallized leather	363434604	275061948
12	Casings	32744360000	48066260000

Source: DGCI&S Kolkatta

3. Constraints: Indian meat industry has inherent handicaps which hamper the proper utilization of the meat industry by-products. At present we have very limited number of industries based on by-products processing. The major constraints are:

- Lack of collection and transportation of byproducts
- Lack of cold storage facilities
- Poor facilities for the collection of bones
- Unorganized/non-scientific slaughtering
- Poor collection facilities for dead and fallen Animals/Birds
- Lack of by-products processing facilities
- Lack of trained/skilled human resources
- Lack of research in the area of byproducts utilization
- Synthetic Substitutes
- Agitation by ethical groups
- Identification of markets

Conclusions

The byproducts from the meat processing industry are of great importance. Efficient utilization of animal by-products has direct impact on the economy and environmental pollution of the country. Non-utilization or under-utilization of by-products not only lead to loss of potential revenues but also lead to the added and increasing cost of disposal of these products along with major aesthetic and serious health problems. Various important value added edible, inedible and pharmaceutical value products can be prepared from the meat industry byproducts such as leather, animal feed, pet food, neat's foot oil, gelatin, hormones, enzymes etc which may generate extra income to the meat processors. There is an urgent need to create the facilities for timely collection, transportation and processing of the slaughter house byproducts.

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Chapter 8

Dairy Industry By-products: Hidden Treasure for Dairy and Food Industry

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Introduction

In the dairy industry, several by-products are produced out of which a major part is covered by skim milk, buttermilk, whey, and ghee residue. Casein, caseinates, lactose, and whey proteins are the derived by-products. Due to its excellent nutritive value, several attempts were made by academia and industries for the utilization of by-products at the global level. But, to date, it is a major challenge for the Indian dairy industries to utilize the dairy by-products, especially, whey and ghee residue economically and effectively. The western dairy industries developed efficient technologies for the economical utilization of dairy by-products in an effective manner.

Continuous efforts in the direction of process automation for the production of dairy by-products, like, casein, caseinates, co-precipitates, whey powders, whey protein concentrate, low lactose powder, etc. have also been made by the Indian and western dairy industries for the efficient and valuable production. As per the dairy market review report, in April (2021) global milk production reached nearly 906 million tonnes in 2020, and in India, milk output reached 195 million tonnes. Due to higher milk production, consumption of milk and milk products in the world increased continuously. Due to increased consumption of dairy products especially, cheese and butter results in the production of whey and buttermilk in higher proportion. Due to the increased production of dairy by-products, utilization of these products is also a major challenge for the dairy industries (Ahmed and Razig 2017). Additionally, a higher proportion of buffalo milk, higher cost of adoption of novel technology, lack of sophisticated research and development facilities are also the major obstacles in the utilization of by-products for a country like India. With the advancement in the field of novel technology, the use of membrane technology also increases at the global level which also enhances the application of dairy industry by-products, especially, skim milk, and whey.

Skim milk and its by-products

Skim milk is a valuable by-product obtained during the manufacturing of cream. It is not considered a by-product when used in the manufacturing of casein, caseinates, or any other valuable product. However, if utilization is not effective, then it comes under the category of by-product. Due to higher solid-not-fat content, it is majorly used for standardization purposes like, for the production of cheese and other varieties of milk.

Casein and caseinates

Casein is the major milk protein present in milk. It contributes around 80% of total milk proteins. Casein is generally produced using isoelectric precipitation of milk proteins at pH 4.6 and temperature 20°C (Fox, 2001). Two basic types of clotting agents (rennet and acid) are used for the production of casein with higher functionality. Treatment of casein with suitable alkali results in the production of caseinates (sodium, calcium, potassium, etc.) (Badem and Uçar, 2017). Skim milk is generally used for the production of casein with the addition of acid (mineral or biological acid). Both casein and caseinate contain nearly 90% of protein on a dry matter basis. Casein products are mainly used to improve the physical properties of food products and also provide superior nutritive value. Acid or rennet casein can be used as a protein source in the preparation of cheese analogs and baked products. Sodium caseinate can be used as an emulsifying agent (coffee whitener), textural agent (in confectionery), thickeners (soups and gravies), fat emulsifier (whipped toppings), etc. Along with the food applications, casein and caseinates have emerging industrial applications in industries like paper, textile, leather, rubber, etc. Caseinates provide water resistance, structure, and thickening effect in glues. Caseinates and acid casein are also used as thickeners and emulsifying agents in the paint industry Rennet casein help in the structure formation when used with plastics, and acid casein acts as a jointer in cement (Badem and Uçar, 2017).

Co-precipitates

Co-precipitates are also known as total milk protein (TMP), as it contains both casein and whey proteins. These are generally produced by a combination of heating and acidification with or without the addition of calcium salts. Heating of milk at 90°C results in the formation of the casein-whey protein complex. Heating and holding time determines the amount of calcium addition. There are three major categories of co-precipitates- high (2.5-3.0%), medium (1.5%), and low calcium co-precipitates (0.5-0.8%) (Muller et al., 1967). Calcium concentration is the major determinant of the functionality of co-precipitates. Co-precipitates contain around 92-95% of milk proteins on a dry

matter basis. The ratio of casein and whey proteins largely determines the functional properties of co-precipitates (Mulvihill 1992, Badem and Uçar, 2017, Stathopoulos 2008). Major advantages of co-precipitates over casein are the higher product yield, superior functionality, and higher nutritional value. Co-precipitates are mainly used in meat products, desserts, baked goods, and confectionery products as a nutritional and functional ingredient (Badem and Uçar, 2017, Mulvihill 1992, Stathopoulos 2008).

Milk protein hydrolysates

Casein is the major milk protein that contains several hidden peptides in the amino acid sequence that has several health benefits. To transform the hidden peptides into the active form, milk protein is subjected to enzymatic treatment. Protein hydrolysates due to their nutritional health benefits are widely used in the formulation of various nutritional and therapeutic foods. Casein contains various peptides like antithrombotic, antihypertensive, opioid (agonistic and antagonistic activity), caseinophosphopeptides, glycomacropeptide, immunomodulating, and antimicrobial peptides. Protein hydrolysates are boon for the peoples having problems of protein allergy, stomach disorder, and having poor digestibility (Silva and Malcata, 2005).

Buttermilk

Buttermilk is a by-product produced during the manufacturing of butter. As a result of the churning of cream, the disruption of the phospholipid/ protein layer occurs. Membrane material along with water-soluble components released into the aqueous phase called buttermilk. As per Eurostat (2016), the production of buttermilk in the EU is around 2 million tonnes in 2015. Buttermilk has excellent nutritional status due to higher phospholipid content, as phospholipids exhibited higher biological activity like anticarcinogenic potential, protective effect against bacterial toxins and infection (Dillehay et al., 1994; Schmelz et al., 1996, 1998; Rueda et al., 1998; Sprong et al., 2002). Buttermilk contains 7 times more phospholipids than whole milk, with concentrations equal to 0.89 mg/g and 0.12 mg/g, respectively (Elling et al., 1996; Malmsten et al., 1994; Sachedva and Buchheim, 1997). Buttermilk has an approximately similar composition as that of skim milk. About 80% of protein present in buttermilk is major milk protein along with 20% from milk fat globules membrane (MFGM) origin. The fat content of buttermilk differs significantly from skim milk. Buttermilk also exhibited similar physical and chemical characteristics as that of skim milk (O'Connell and Fox, 2000). Buttermilk processing is one of the economic sources for the dairy industries. As per USDA report

2001, production of buttermilk powder (2-2.5 million kg) with the production of 50 million kg butter per month in the USA. Production of buttermilk powder along with butter manufacturing is a valuable source of money and also enhances its utilization. A major portion of buttermilk is converted into dried form. Buttermilk powder is used in various food formulations to provide desirable characteristics, like, improving crumb texture in bakery products (Madenci & Bilgiçli, 2014) and texture improvement of yogurt (Le et al., 2011). Buttermilk contains a valuable component MFGM which has superior health benefits can be separated using a microfiltration process to produce MFGM isolates (Corredig, Roesch, and Dalgleish, 2003). Hickey et al., (2018) produced cheddar-style cheese by incorporating 10% of buttermilk powder. Buttermilk incorporated cheese had a similar textural profile, sensory profile with a higher level of phospholipids content.

Ghee residue

Ghee residue is the by-product produced during the manufacturing of ghee. Ghee, clarified milk fat, has a wide variety of applications. In India, around 30-35% of milk of total milk production is converted into ghee (112 million tons in 2009-10; Gandhi et al., 2013). The solid non-fat part of cream during heating settles down and the blackish-brown residue obtained is known as ghee residue (Janghu et al., 2014). The amount of ghee residue depends on the method adopted for ghee manufacturing. The highest yield of ghee residue is obtained using the direct creamery method (12%). The yield obtained in the creamery butter method and desi method is almost the same (3.7%). Cream ripening results in the reduction of ghee residue yield (Santha and Narayanan, 1978). Ghee residue contains around 32% of fat which can be further utilized for the production of lipase (Sahasrabudhe et al., 2012). Ghee residue also contains part of milk proteins along with lactose and minerals. During heat processing in ghee manufacturing, part of phospholipids retained in ghee residue due to the formation of a complex with proteins. The addition of 0.1% of ghee residue to ghee increased the oxidative stability of ghee. Heat processing of ghee residue along with solvent extraction can be used to extract phospholipids from ghee residue (Pruthi, Narayanan, and Bhalerao, 1971). Ghee residue has various food applications like preparation of burfi (Verma and De, 1978), soups, food supplements, candies (Galhotra and Wadhwa, 1993), bakery products, and flavor enhancers (Tamine, 2009).

Whey and its products

Production and processing of milk increase day by day with a rate of 10% every four years (FAOSTAT, 2017). With increasing production and processing of milk, consumption of milk and milk

products (especially cheese and butter) increased at the global level. Out of total milk production, around 37% of milk is converted into cheese and 30% converted into butter. Around 80-90% of the total processed volume of milk is obtained in the form of whey and other by-products, with 10-20% recovery of the original product (Mirabella et al., 2014). Whey is the by-product of the cheese and casein industry. It has relative importance due to its larger produced volume along with incredible nutritional composition. A major portion of whey produced from milk industries is discarded. Whey is a greenish translucent liquid obtained after the removal of a coagulated mass in the casein and cheese production process (Mazaheri Assadi et al., 2008). Only 50% of the total volume of whey produced is utilized efficiently. Out of which, half of the volume is consumed directly in liquid form while 30% volume is converted into powdered form. 15% of the total volume is utilized for lactose production and the remaining volume is converted into whey protein concentrates and isolates. Surplus of whey is discarded, which raises serious environmental issues due to its high chemical oxygen demand of 100,000 mg O_2/L, along with higher economical loss (Carlini et al., 2015; Panghal et al., 2018).

Whey contains around half of the total solids as present in milk, 20% of milk proteins, 70% of lactose, and almost all soluble vitamins, and minerals (Mollea, Marmo, and Bosco, 2013; Panghal et al., 2018). Whey proteins contain a higher proportion of beta-lactoglobulin (β -lg) 65% and alpha-lactalbumin (α-la) 25% with the minor concentration of bovine serum albumin (BSA), lactoferrin, lysozyme, glycomacropeptide (GMP), immunoglobulin, and phospholipoproteins. Due to higher concentrations of sulphur containing amino acids whey proteins have higher nutritional status [13]. Whey protein has a high biological value (110), protein efficiency ratio (3.6), and net protein utilization (95) (Macwan et al., 2016).

Constituents of whey proteins and their biological properties

β-lactoglobulin (β -lg)

β -lg is the major whey protein (58%) present in ruminant species that belongs to the lipocalins family but not present in human milk. β -lg A is the major genetic variant present in cow milk. Cow milk produces 2-3g/l of β -lg (Kontopidis, Holt, and Sawyer, 2003; Madureira et al., 2007). It is present in globular form contains 162 amino acid residues with a molecular weight of 18,362 g/mol. Variation in pH conditions results in the conformational transformation of β -lg. At pH 5.2-7.0, 5.2-3.5, and below 3.0 and above 8.0 it is present as a dimer, octamer, and monomer with molecular weight 36,700 kDa, 140,000KDa, and 18,350 kDa, respectively (Apenten, Khokhar, and Galani, 2002). β -lg is a rich source of cysteine, which is an important substrate for glutathione synthesis (De Wit, 1998). β -lg

facilitates the fatty acid digestion through the binding of fatty acids and released the pre-gastric lipases (Pérez and Calvo, 1995). β -lg contains the ligand sites which bind with the hydrophobic molecules like, fatty acids, retinoids, and cholesterol (KUSHIBIKI et al., 2001). β -lg is the most allergic milk protein. Conjugation of β -lg with acidic oligosaccharides reduces its allergic response (Yoshida et al., 2005; Krissansen, 2007). β -lg contains several bioactive peptides like, lactokinins, β -lactorphin, β -lactotensin which provides several health benefits like, angiotensin-I-converting enzyme (ACE) inhibitor, improved vascular relaxation, reduces stress and hypertension, cholesterol level reduction, etc. to the body.

α-lactalbumin (α-la)

α-la is the important fraction of whey protein synthesis during lactogenesis, and also actively participates in lactose synthesis. α-la contains several types of essential amino acids that provide superior health benefits (like, defensive action contrary to mucosal injury, immunomodulation, antihypertensive, etc.) (Stănciuc and Râpeanu, 2010; Matsumoto et al., 2001). Human milk contains α-la as a major whey protein (1.7 mg/mL). Bovine originated α-la has a molecular weight of 14.2 kDa contains 123 amino acid residues with higher content of minerals and acidity (isoelectric pH 4.8) (Lien, 2003). α-la present in the α- helical and β-sheet structure stabilized with four disulfides linked with calcium ion (Wijesinha-Bettoni, Dobson, and Redfield, 2001; Pettersson-Kastberg et al., 2009).

Bovine Serum Albumin (BSA)

BSA is the whey protein fraction (5% of total whey proteins) which is not synthesized in mammary glands; present in milk due to leakage from the blood stream (Madureira et al., 2007; Krissansen, 2007). BSA is a high molecular weight (66,267 kDa) whey protein that contains 582 amino acids residues, present in α-helical form with heart shape structure (Huang, Kim, and Dass, 2004; Fox, 1989). Due to its higher size, BSA easily binds with fatty acids. BSA has several biological functions like, anti-carcinogenic, anti-oxidant activity, opioid, ACE inhibitory action) (Tong et al., 2000; Choi et al., 2002; Laursen, Briand, and Lykkesfeldt, 1990).

Immunoglobulins (Ig)

Ig is the composite group of elements present in three forms in whey (IgG, IgA, and IgM) having a concentration of 0.7g/l which are produced by β-lymphocytes. A major part of Ig is contributed by IgG (IgG1 and IgG2) around 80% of total Ig in milk and whey (De Wit, 1989;

Madureira et al., 2007). Ig exerts several biological benefits like, antimicrobial and antiviral, immunomodulation, lowering of blood pressure, hypercholesterolemic effect (Sharpe, Gamble, and Sharpe, 1994; Loimaranta, 1999).

Lactoferrin (LF)

LF is a glycoprotein synthesized by glandular epithelial cells and mature neutrophils belong to the transferrin family and present in a concentration of 0.02-0.35 mg/ml in bovine milk. It is a high molecular weight glycoprotein (80000 kDa) that is present in milk, saliva, seminal fluid, intestinal secretion. (Krissansen, 2007; Adlerova, Bartoskova, and Faldyna, 2008). LF placed an important role in iron metabolism and it also affects iron absorption in infants. It contributes towards several other biological functions like antibacterial and antiviral activity, inhibits tumor growth, growth factor activator, etc (Legrand et al., 2005).

Lactoperoxidase (LP)

LP belongs to the mammalian peroxidases family, present mainly in animal secretion having oxido-reductase nature. It contributes around 1% of total whey proteins having a concentration of 0.03g/l in whey (Dunford, 1991). The concentration of LP varies with species, breed, stage of lactation, etc. LP has a well-known preservation effect in raw milk (activation required). It has inhibitory action against Gram-negative catalase-positive organisms, like, pseudomonas, coliform, etc. (Tenovuo, 2002; Dunford, 1991).

Different products from Whey

Plain condensed whey, Sweetened condensed whey, and whey powder

Consumption and utilization of whey solids are majorly in liquid and dried form. Due to higher water activity, preservation of whey in liquid form is quite difficult. To preserve the whey and utilization of whey solids in an effective manner concentration, demineralization followed by drying of whey solids is done to form dried whey powders. With the advancement in membrane technology, for concentration purposes reverse osmosis is generally used. By employing reverse osmosis concentration up to 28% TS can be achieved without affecting the functionality of whey proteins. Concentration using reverse osmosis requirement 3 times less energy as of 7 effect evaporator. Further required concentration is achieved by using a multiple-effect evaporator. A degree of concentration greater than 55% TS results in the crystallization of lactose in the vapor separator. For the preparation

of plain condensed whey, the desirable degree of concentration is 35-50% TS. Sweetened condensed whey is prepared by using sweet cheese whey along with the addition of sugar and concentrate the whey up to 76% TS, followed by cooling and crystallization. Plain and sweetened condensed whey is generally used in the manufacturing of candies like whipped whey fudge, whey taffy, etc.

Whey powder is manufactured using condensed whey (up to 60% TS for crystallized with 85-90% degree of crystallization and 42-45%TS for non-crystallized). Lactose crystallization is an essential step to avoid the caking of whey powders. Single-stage or multiple-stage drying is used for the production of whey powder.

Whey protein concentrates (WPC) and isolates (WPI)

With the advancement in novel technology, it makes it possible to produce highly soluble and functional whey protein powders with higher protein content. Whey protein concentrate contains protein content up to 85% and whey protein isolates contain protein content greater than or equal to 90%. Various processes like, membrane separation, chromatographic techniques are used to produce WPCs and WPI. WPCs are produced by employing an ultrafiltration process followed by diafiltration and spray drying. The heating of concentrated whey is undesirable as it causes the denaturation of whey proteins which harms the functionality of proteins. (Panghal et al., 2018). A higher concentration factor is required to increase the protein content and reduce the concentration of lactose and minerals in the manufacturing of WPI. WPCs and WPI exhibited superior water binding capacity, with good emulsifying activity, gelling and thickening behavior under acidic conditions (Westergaard, 2004; Jelen, 2009). Due to superior functionality, these are widely used in product formulations like infant formula, high protein nutritional bars, sports beverages, etc.

Whey Beverages

Consumption of whey in the form of whey beverages is widely increased. Both fermented and non-fermented beverages are produced from whey. Whey beverage is light, refreshing, less acidic, and nutritious as compared to fruit juice. By using the appropriate amount of fruit juice along with whey and pulp fruit flavored whey beverages can be formulated (Panghal et al., 2018). Various types of whey-based beverages were formulated by the researchers like, carbonated (Pareek, Gupta, and Sengar, 2014), fruit and vegetable-based (Panghal et al., 2017), fermented (Saha, Ray, Hazra, 2017), probiotic (Sasi, 2015). By optimizing the ionic environment, pH, and acidity functional whey-based

beverages can be formulated (Panghal et al., 2018). Commercial production of whey beverages starts in the 1970s to utilize the whey effectively and economically.

Whey Lactose

As per CODEX lactose is a normal constituent of milk generally produced from whey having anhydrous lactose content not less than 99% on a dry matter basis. Industrial production of lactose starts from 1880-1890 (Paterson, 2009). Lactose production from whey is an effective and efficient method of whey utilization. Both pharmaceutical and food-grade lactose can be produced from whey. The production process of lactose contains the concentration, nucleation, growth, and harvesting. Whey contains around 95% of the total lactose present in milk. The different processes like, microfiltration, ultrafiltration, ion-exchange/demineralization, concentration, and drying are used for the production of lactose. For maximum recovery of lactose with high purity (99.8%), ultrafiltration (molecular weight cut off 5kDa, pore size 0.2 micrometer) can be used (De Souza Araki et al., 2010). The concentration of whey up to 58% using reverse osmosis and evaporators, followed by cooling and crystallization of lactose (between 15-25°C), and then harvesting of lactose. Lactose has limited applications in food formulations due to inferior functionality and higher mineral content.

Conclusion

The utilization of by-products is useful for dairy industries as it strengthens the economic scenario of industry along with less environmental pollution. Skim milk and buttermilk are utilized efficiently in India and abroad and valuable products are produced like, high protein dairy powders, buttermilk powder, etc. Attention is still needed for the utilization of whey so that valuable products from whey can be produced at an industrial scale.

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Chapter 9

Role of Egg in Human Nutrition and Its Value Addition for Enhanced Profits

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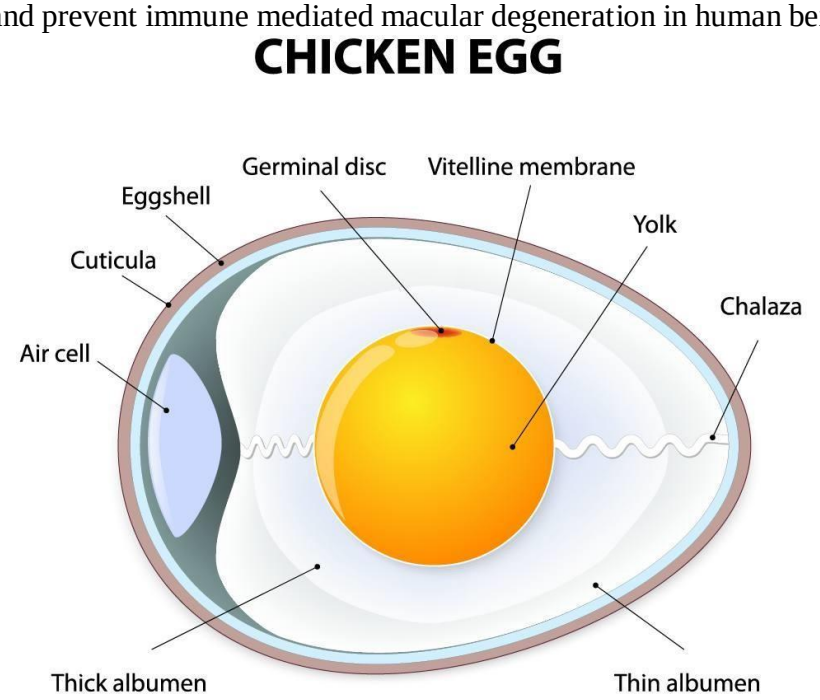
An encapsulated source of micro and macro nutrients, egg is often referred to as 'nature's perfect food'. It is a good source of high-quality protein, vitamins and minerals, yet contain only about 70 calories. One large egg contains about 6.3g of protein, the protein in egg contains all the essential amino acid. This perfect balance and diversity in terms of nutrient composition along with high digestibility and affordability places eggs as a basic food for humans. In 1968, American Heart Association recommended people to consume less than three whole eggs per week linking its consumption to high blood cholesterol and consequently higher cardiovascular disease risks. It was a big blow to egg industry as a whole and also partly influenced people's dietary habits depriving them from an affordable food of high nutritional interest. Later, the studies denied such association and proved increased bioactivity of eggs in human diet. People can consume eggs taking into consideration the dietary intake of cholesterol from other food sources. Eggs have been identified as lowest cost animal source for proteins, vitamin A, iron, vitamin B complex and second lowest cost source for zinc and calcium. In addition, eggs also contain biologically active components which are distributed in different components within the eggs. These components have a key role in prevention and therapy of many diseases and have antimicrobial, immunomodulator, antioxidant, anti-cancer or anti-hypertensive properties. Lysozyme, ovomucoid, ovoinhibitor and cystatin are biologically active proteins in egg albumen. Additionally, eggs are an important source of lecithin and are one of the few food sources that contain high concentrations of choline. Lecithin is a functional and structural component of all biological membranes. Another important nutritional component from eggs is phosvitin, which is present in egg yolk and represents about 7% of yolk proteins. It is a strong metal chelator and acts as an important melanogenesis inhibitor to control excessive melanin synthesis in human skin. Carotenoids are natural pigments present in hen egg yolk that confer its yellow color and

it represents less than 1% of yolk lipids, and are mainly composed of carotene and xanthophylls (lutein, cryptoxanthin and zeaxanthin). Lutein and zeaxanthin are not endogenously synthesized by the human body and tissue levels therefore depend on dietary intake. They are important in maintaining macular pigmentation and prevent immune mediated macular degeneration in human beings.



Source: https://www.chickens.allotment-garden.org/eggs/structure-egg/

Nutritional composition of egg (Miranda et al. 2015**)**

Component (Unit)	Amount	Component (Unit)	Amount
Egg shell (%)	10.5	Calcium (mg)	56.0
Egg yolk (%)	31	Magnesium (mg)	12.0
Egg white (%)	58.5	Iron (mg)	2.1
Water (g)	74.5	Phosphorus (µg)	180.0
Energy (Kcal)	162	Zinc (mg)	1.44
Protein (g)	12.1	Thiamine (mg)	0.09
Carbohydrates (g)	0.68	Riboflavin (mg)	0.3
Lipids (g)	12.1	Niacin (mg)	0.1
Saturated fatty acids (g)	3.3	Folic acid (µg)	65.0
Monounsaturated fatty acids (g)	4.9	Cyanocobalamin (µg)	66.0
Polyunsaturated fatty acids (g)	1.8	Pyridoxine (mg)	0.12
Cholesterol (mg)	410	Retinol equivalents (µg)	227.0
Iodine (µg)	12.7	Potassium (mg)	147
Tocopherols (µg)	1.93	Carotenoids (µg)	10
Selenium (µg)	10	Cholecalciferol (µg)	1.8

Quantities represent an edible portion of about 100 g.

Why value addition to eggs?

The technological improvements and the desirability of high-quality shell eggs often led to an increase in off grade eggs and fetch a lesser price in market. Moreover, the sale of eggs is largely dependent on the season resulting in market fluctuations e.g. during the summer season, the marketability of these eggs are greatly lowered resulting in fall in the egg price. Value addition to eggs may help in bailing out the producers from the loss. In addition, the lack of cold chain transport system in the country is a major bottleneck in transportation of high quality poultry products. The keeping quality of eggs is greatly compromised by the continuous handling and the non-availability of continuous cold chain system. As a result of which, the eggs cannot be stored more than 10-12 days on an average. The production facilities and methodologies are not in line with the international standards and the quality of eggs in terms of size is also greatly compromised. The best solution for uniform price fixing of these off grades and unsold eggs is to convert them into value added products. The term "egg products" has been generally used to refer the eggs that has been removed from the egg shell and may be in the form of frozen, liquid or dried form. Many a times, food processing unit prefer to use egg liquid as the labor cost to break the egg is reduced and the pasteurized liquid are 'Salmonella free', hence adds to the ease of use and safety. Egg is a common vehicle for several spoilage and pathogenic organisms such as Salmonella, and sometimes pasteurization and conversion into value added egg products helps in ensuring the safety of products.

Types of value addition in eggs

Most of the eggs in India are consumed as table egg that are transported in open condition and in unrefrigerated vehicles and being sold in open without consideration for preservation of their quality. Adoption of processing technologies may provide newer avenues, easy distribution and marketing, and higher revenue generation for the producers. Egg Processing is a new area and is showing good sign of growth, especially marketing of branded eggs and designer eggs. A number of products can be developed during value addition of eggs that may help in enhancement of profits of the farmers.

Liquid whole egg: As soon as the eggs are broken, the liquid egg must be pasteurized to reduce the possibility of contamination and proliferation of food borne pathogens such as *Salmonella*. As per the USDA, it is required that liquid whole egg must be heated to at least 140˚F and held for no less than 3.5 min, or at least 134˚F and held for no less 3.5 min, or at least 132˚F and held for 6.5min for egg

white. Additives such as sucrose, glucose or fructose or salt may be added at 10% level to protect heat damage. The solid content of liquid egg is usually standardized to 43-44% and the pH of liquid whole egg may vary from 7.0 to 7.6. UHT treatment of liquid egg require higher temperature for a shorter period of time. Usually eggs are heated to a temperature of 70˚C for 1.5 min, the aseptically packaged final products can have a shelf life of 24 weeks under refrigerated condition. Many functional ingredients such as omega-3 PUFA, lutein, vitamins and minerals can be used to enriched and make a functional food.

Table: Minimum Requirement of Composition for Liquid Egg Products (FSSAI, 2016)

Composition	**Liquid egg white**	**Liquid egg yolk**	**Liquid whole egg**
Min solids matter content (%)	10.5	40.0	22.0
Min fat content (%)	0.05	25.0	9.8
Min protein content (%)	10.0	15.0	10.5
Extraneous matter	No particles over 1 mm in 100 g and should not exceed 100 mg/kg	No particles over 1 mm in 100 g and should not exceed 100 mg/kg	No particles over 1 mm in 100 g and should not exceed 100 mg/kg
Min. concentration of hydrogen ions (pH)	8.5	5.9	7.0
Max. β-hydroxybutyric acid (mg/kg)	10	10	10
Max lactic acid (mg/kg)	1,000	1,000	1,000
Max succinic acid (mg/kg)	25	25	25

Dehydration/ egg powder: Egg powder is a dried product with similar texture as that of milk powder that retains all the nutritional value even after drying. Changing food habits and increased awareness has led to increase in eggs and egg products consumption in India and there has been a huge demand for egg powder. This technology houses many advantages as in contrast to shelled eggs which are easily broken and perishable, egg powder has relatively a longer shelf life. Egg powder processing in highly industrialized countries is done using sophisticated technologies. When it is produced with

fewer regulations, such countries are able to export this product at lower prices compared to domesticated markets. Egg powder is one of the most common products in poultry industry in the country. Transportation of eggs is difficult as chances of breakage during transportation are higher and it is costly also. Egg powder is comparatively easier to transport and there is no question of any breakage during the transit. The major market is defense exports, establishments, various government and non-government nutritional programmes, bakeries and all such areas like hills or forests where transportation is difficult. Removal of moisture from liquid egg after pasteurization results in efficient storage and transportation, and they are easy to handle and to formulate. Different drying methods can be used to accomplish the drying although spray drying is the most common method and the flowability in the product can be achieved by adding a free-flowing agent such as sodium silicoaluminate or silicon dioxide. The egg liquid must be desugarised before drying either by yeast or bacterial fermentation to prevent Maillard reaction during drying.

Flowchart for the production of whole egg/ egg yolk powder

Whole eggs or egg yolk: Homogenization

↓

Filtration: to remove membranes and fragments of shell pieces

↓

Pasteurisation @64-66˚C/ 2-4 mins

↓

Spray drying

↓

Whole egg/ egg yolk powder (moisture: 2-4%; bulk density: 0.3-0.35g/cm$^{3)}$

Refrigerated/Frozen egg products: The white and yolk of an egg is pasteurized separately to destroy *Salmonella* and other bacteria and kept frozen or under refrigeration to increase its shelf life. The liquid eggs are kept under refrigeration at a temperature 40˚F (4˚C) or below, and frozen products are stored at 0˚F (-17˚C). The frozen egg products must be thawed at refrigeration temperature for 2-3 days before use, and must be used within 4-5 days once thawed. These frozen and liquid may be further used in bakery industry or other in fast food outlets.

Liquid egg, egg powder and frozen egg products being produced at large quantity in industrial scale. But beside these products, several other convenience or processed form of eggs are also being produced; specialty egg products such as egg crepes, egg rolls, egg omelets, scrambled eggs, quiches

and others. Research on egg and egg products has been going on widely in Department of Livestock Products Technology, GADVASU, and several products are developed and technologies are already transferred to entrepreneurs. Some of the technologies developed in the same are discussed further.

Egg Jam: Jam is a nutritious and tasty product liked by the kids is mainly prepared from fruits. It has high sugar content and no protein content. Egg jam is developed from whole egg liquid and is considered as tastier, sweet with excellent spreadability. It is a superior nutritive alternative to fruit-based jams in market. Egg jam contains high biological value protein (14-16%), contains all essential amino acids and fatty acids. Various flavoured egg jams such as Mango, pineapple and plain were developed. Diabetic egg jam or high protein, sugar free egg jam was also developed.

Egg chutney: It is a whole egg liquid product that us sweet, salty and tangy in flavor similar to fruit-based chutney and has a protein content of about 15-17%. The product is free from artificial color and flavor and can be stored at refrigeration temperature for up to 6 months.

Egg cutlets: It basically is a novel product obtained by uniform mixing of whole egg liquid and mashed potato avoiding the formation of clumps and cooked in a pre-heated oven at 155˚C for 15 min followed by deep frying. Preparation of egg cutlets enable protein enrichment of commercially available fast foods**.**

Egg drink: Egg drinks are refreshing drink with a protein content of 4-6gm/100ml, fat 2-3g/100ml and energy 68-80 Cals/100 ml, most suitable for summer months. It is prepared by mixing egg drink concentrate and chilled water in the ratio of 1:4 and available in six different flavors i.e. mango, banana, lemon, orange, pineapple and coconut.

Egg parantha: It is a ready-to-cook product having protein content of 12-14g, Moisture: 40-43g, Fat: 10-12g. The egg parantha can be stored under frozen condition in laminated pouch with outer aluminium layer and require a cooking time of 3 min (max) prior to consumption.

Ready omelette mix: It is a ready-to-cook product prepared by dehydrating whole egg liquid by mixing with other ingredients. The mixture can be easily mixed with water in 1:3 ration and cook on a hot pan. It is a shelf stable egg product and estimated storage life is 6 months at room temperature.

Egg Pickle: The less desirable small size chicken eggs or quail eggs can be suitably used to prepare egg pickle in the market. The pickle can be stored at room temperature for 1½ -2 months. Two varieties are available in market: vinegar based or oil based.

Egg Paneer: Egg based paneer was developed from whole egg liquid and it is similar in texture to soya and milk paneer. It can be used base material to develop various culinary dishes and various snack-based products. Various varieties such as Egg Albumen paneer free from fat and cholesterol, low calories. It has storage life of 7-10 days at <4ºC under aerobic packaging condition whereas 4week at 4ºC under Vacuum packaging.

Egg industry by-products: As egg shell constitutes about 11% of the total egg weight, the main by-product of egg processing plant is the egg shell that can be used to prepare granular egg shell meal and utilized as dietary calcium source for laying hens. Egg shell and egg shell membrane has been widely studied for their efficiency as non-toxic and versatile adsorbents for removal of organic and inorganic hazardous chemicals, especially from waste water. The egg shells having the same chemical composition as lime can be used as plant fertilizers and soil fertilizers. In artistry, the artist use egg shell for mosaics and texture paints for 3D effects in artwork.

Poultry production in India is witnessing a double figure growth rate in the last decade. It has transformed poultry rearing from back yard farming system to the systematic organized poultry industry. This sustained increase is indeed a boon to meet the growing domestic market for eggs and egg products and ensure that India remains self-sufficient in poultry and poultry products. We should analyze the growth in terms of supply, demand and price of egg as well price and buffer stock to maintain the price at consumer and farmer end. Therefore, the processing of eggs into value added egg products is not only a profitable business, but also improves the availability of high quality protein to the masses. The product market can be divided into ready-cooked egg meals, pasteurized liquid white, liquid egg, hardboiled egg, pasteurized liquid yolk, and dehydrated egg. Adoption of processing technologies may provide newer avenues, easy distribution and marketing, and higher revenue generation for the poultry farmers. Further, the fortification of products to develop either omega-3 fatty acid enriched eggs, iron enriched, low-cholesterol, low-calorie egg products are easier to develop by the processing interventions. Branding or designer eggs market is catching up fast in Metro and Tier -1 cities at an annual rate of more than 20 per cent. Apart from the omega-3 fatty acid enriched,

micro nutrient fortified eggs etc., Organic Eggs have come up as a big sector. Potential of Cage free eggs, vegetarian eggs, free range eggs etc. can be tapped to increaser the farmers' income and it can be realized as a promising solution to build up entrepreneurial set up even at micro scale.

Chapter 10

Microbiology in Dairy Processing: Significance, Challenges and Future Prospects

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Introduction to Microorganisms

Microorganisms are the tiny living creatures invisible to naked eyes. Even though it took time to discover microbes in real sense; they have existed and felt their existence even before science evolved. According to traditional beliefs and early mythology, several mystical powers *viz*. spirits, evils and demons were responsible for disease, death and decay. It was Roger Bacon (1220-1292), Girolamo Fracastro (1483-1553), Anton von Plenciz (1762), and A. Kircher (1658), who introduced the concept of role of invisible living creatures in disease, death and decay of bodies, meat etc. Later, the science of microbiology evolved with the marked contributions of Robert Hooke (1635-1703, UK), Anton van Leeuwenhoek (1632-1723, Netherlands), Louis Pasteur (1822-1895, France), Robert Koch (1843-1910, Germany) and many other eminent researchers. Microbes of current era could only find their current existence due to constant efforts of researchers, coupled with advent of newer technology. Microscopy has been the propelling force that has helped microbiology evolve, exist and address several oppositions by supporters of spontaneous generation. Microscopy in itself has evolved over centuries from notable contribution of Leeuwenhoek, the first simple microscope to current day electron and confocal microscopy. Different forms of these tiny invisible creatures, referred to as microorganisms, have been differentiated into diverse forms *viz*. bacteria, archaea, fungi, algae and protozoa. Viruses, recognized as connecting link between living and dead and one of the most talked, discussed and researched organism in past two years (2019-21) due to global impact in form of SARS-Cov-2 (COVID-19) are also studied under microbiology. Bacteria, the most commonly studied form, including archaea are unicellular and prokaryotic forms i.e. bears primitive nucleus lacking a defined nuclear membrane. Fungi and protozoa are multicellular eukaryotic forms having a defined nuclear

membrane. Microorganisms are present in almost every part of the biosphere, including soil, hot water springs, inside rocks, depth of ocean, and in the atmosphere. They can even thrive in the vacuum of outer space. Microorganisms have been observed in the Mariana Trench, the deepest spot in the Earth's oceans. They thrive inside rocks up to 580m. Recently, their existence has been confirmed 800m below the ice cover of Antarctica. It can be stated that microbes can be found almost everywhere as they are extremely adaptable to conditions, and survive against the odds.

Microorganisms – Human-Animal-Environment Interface

Microorganisms play varied roles in ecosystems, including nutrient recycling, decomposition, nitrogen fixation, precipitation and weather. They are also exploited in traditional food and beverage preparation, and in modern technologies based on genetic engineering and recombinant DNA technology. This literature will mostly refer to the significance of bacteria, fungi and viruses in dairy; as both spoilage and health promoting agents. However, it is also important for readers to understand the role of microbes at Human-Animal-Environment interface. In brief, microorganisms are among the man's best friends and also worst enemies. Knowledge about them has grown at fast pace; since their discovery by Leeuwenhoek and other eminent scientists, recognizing them as an agent of infection and disease. It took time to establish their role in food and fermentation and later their positive impact over human health, as proposed by Dr Ellie Metchnikoff. Exploitation of microbes for their useful applications in food, feed, dairy, fermentation, pharmaceutical and other areas is practiced since centuries now. However, besides having beneficial roles, their impact as a threatening agent against humans, animals and vegetation persists in form of many infections, spoilage and epidemics, adding considerable load on individual and global economy. Microorganisms in environment regulate decay, decompose and recycle of vast amount of household and industry waste. Industrial effluent treatment is usually carried out using bacterial super-bugs. Microorganisms are usually recognized for their negative impact, especially in context to animal husbandry and food processing industry. There is a long list of animal diseases, spoilage and infections associated with microorganisms, which henceforth requires concerted efforts by researchers, animal welfare workers, veterinarians and food processors, for their quick identification and prevention.

Microorganisms in Dairy

Food quality is chiefly determined by the overall consumer acceptability based on physical characteristics, color, taste, texture, flavor etc. In true sense the quality of any food including milk and

milk products is based on its purity i.e. free from any adulteration, and its microbiological profile. A food product otherwise of high nourishing value and certified purity can be non-edible or unsuitable for consumption based on its microbial inhabitants. It becomes important for any dairy entrepreneur to put a routine check on the overall microbial load of raw and pasteurized milk and milk products to ensure that the product meets its expected shelf life besides maintaining characteristic flavor and consumer safety. Microbiology is the branch of science that studies creatures invisible to naked eyes. Among them bacteria, yeast, and fungi are primarily important for milk and milk products. Dairy farmers adopting milk processing as a business avenue face problem with overall quality of developed product besides having inconsistent quality/sensory characteristic leading to customer/consumer dissatisfaction and economic losses. Both quality and over the time consistency of milk products depends on microbiological attributes of raw milk and final products. Basic knowledge of microbiology and establishment of routine facilities can help entrepreneurs to maintain the quality of products at par to the standards, leading to high economic benefits and establishing products in market with some signature characteristics. Microbes making their way to raw or processed milk products can lead to several defects making the product unacceptable. Common microbial defects and their causative organisms are tabulated below:

Table: Common microbial defects of milk and milk products and causative organism

Products	**Defects**	**Causes**
Milk	Ropiness	*Alcaligenes viscolactis, Achrobacter lacticum*
	Proteolysis	*Pseudomonas fluorescens, P. fragi, Achromobater, Enterobacter*
	Sweet-curdling	*Bacillus cereus, S. liquefaciens*
	Stormy fermentation	*Clostridium perfringens*
	Alkali production	*P. fluorescence* and *A. viscolactis*
	Musty potato flavour	*P. taerolens*
	Medical flavour	*Aerobacter aerogens*
	Soapiness	*P. sapolactic*
	Earthy flavour	*Actinomycetes*
	Blue milk	*P. syncyaneum*
	Yellow milk	*P. synxantha* and *Flavobacterium*
	Red milk	*Serratia marcescencs* and *Micrococcus roseus*

	Brown milk	*P. putrefaciens* and *P. fluorescens*
Cream	Sweet-curdling/ high coarse acid cream	Milk clotting enzyme by *Bacillus cereus*
	Bitterness	Proteolytic and lipolytic organisms (*Pseudomonas, Proteus*), aerobic sporeformers (*B. substilis*) and yeast *(Rhodotorula mucilaginosa*)
	Rancidity	*Pseudomonas* species (*P. fluroscens and P. fragi*), Lipolytic psychrotopic bacteria, mold (*Geotrichum candidum*) and yeast (*Candida lipolytica*)
	Fruity flavour	*P. fragi*
	Cheesy/ putrid flavour	*P. putrefaciens*
	Slimy/ ropy cream	*A. viscolactis*
	Malty taint	*Streptococcus lactic* subsp. *maltigenes*
	Blackish discoloration	*P. nigrifacies*
	Yeasty flavour	*Candida pseudotropicalis* and *Torulopsis sphaeica*
	Soapiness	*P. sapolactic*
Butter	Black discoloration	*P. nigrifaciens*
	Brown	*Aspergillus* spp. and *Phoma* spp.
	Green and blue green	*Penicillium* and *Aspergillus* spp.
	Orange and yellow	*Geotrichum candidum*
	Reddish pink	*Fusarium*
	Black (yeast origin)	*Torula*
	Pink	*Rhodotorula*
	Rancid flavour	*Pseudomonas* species (*P. fluorescens and P. fragi*), *Achromobacter*, Lipolytic pschrotopic bacteria, mold (*Geotrichum candidum, Penicillium* and *Aspergillus* spp.) and yeast (*Candida lipolytica, Torula*)
	Putrefactive taint / surface taint	*P. putrefaciens*
	Skunk-like flavour	*P. mephitica*

	Fishy taint	*Proteus ichthyomia* and *G. candidum*
	Musty flavour	*Achrobacter spp.*
	Ester like flavour	*P. fragi*
	Apple like aroma	*Flavobacterium lactis*
Evaporated milk	Gassy fermentation / bloat	Anaerobic sporeformer like *Clostridium foetidum*
	Sweet coagulation	*B. subtilis*
	Sour coagulation	*B. coagulans, B. simplex, B. cereus*
	Bitterness	*B. amaruss*
	Fishiness	*Proteus ichthyosmius*
Sweetened condensed milk	Gassy fermentation	Yeast (*Torulopsis lactis condense, Torulopsis globose*) and *B. cereus, B. butyricum, B. coagulans*
	Bacterial thickening	*M. pyogegns, S. aureus, S. albus, B. substilis*
	Mould button formation	*Aspergillus repens, A. glaucus, Penicillium*
	Peculiar odour	*Thermobacterium mathiacelle*
Yoghurt/Dahi	Slimy/ropy/stringy	Leuconostocs and lactobacilli
	Unclean and bitter flavour	Some strains of *L. bulgaricus*
	Yeast/cheesy	Contaminating yeast growth
	Rancid flavour	Lipolytic organisms
	Slow acid production	Phage attack on *S. thermophilus*
Cheese	Putrefaction	*Clostridium*
	Malty off flavour	*Aspergillus, Cladosprorium , Mucor, Penicillium*
	Early blowing	*E. coli*
	Late blowing	*Clostridium butyricum, C. tyrbutyricum*
	Black spots	*A. niger*
	Green coloration	*Penicillium puberulum*
	Red spots on blue cheese	*Sporendonema casie*
	Rusty spots in chedder cheese	*L. plantarum, L. brevis*
	Colored spots on swiss cheese	*P. rubrum*

Regulatory standards

Different national and international regulatory bodies publish standards for milk and milk products. The Food Safety and Standards Authority of India (FSSAI) published its notification on revised standards for milk and milk products in the Official Gazette of India. The implementation date for the revised standards is scheduled for July 1, 2020. The Regulatory standards laid down by FSSAI for checking microbes in milk and milk products are tabulated below:

Table: Regulatory standards laid down by FSSAI (2015) for checking microbes in milk and milk products

Products	SPC (cfu/mL)	Yeast and Mold	Coliform	*E. coli*	*S. aureus*	*Salmonella* and *Shigella*	*L. monocytogenes*	*B. cereus*
Pasteurized Milk/ Boiled / Pasteurized Flavoured milk	$30x10^3$-$50x10^3$	-	Absent in 0.1ml	Absent in 0.1ml	-	Absent in 25ml	Absent in 25ml	-
UHT Milk / UHT flavoured Milk	Nil	Absent in 1 ml	Absent in 0.1 ml	Absent in 1 ml	Absent in 1 ml	Absent in 25 ml	Absent in 1ml	-
Sterilized Milk / Sterilized Flavoured Milk	Nil	Absent in 1 ml	Absent in 0.1 ml	Absent in 1ml	Absent in 1 ml	Absent in 25 ml	Absent in 1ml	-
Pasteurizd cream	$50x10^3$-$70x10^3$	-	10/gm	Absent in 0.1gm	-	Absent in 25gm	Absent in 25gm	-

Pasteurized Butter	$25x10^3$-$50x10^3$	20-50/gm	Absent in 0.1gm	Absent in 0.1gm	10-50/gm	Absent in 25gm	Absent in 1gm	-
Butter Oil / Butter Fat / Ghee	Not more than 5000 / gm	Absent in 1 gm	Absent in 0.1 gm	Absent in 1 gm	Absent in 1 gm	Absent in 25 gm	Absent in 1gm	-
Khoa	$25x10^3$-$50x10^3$	10-50/gm	50-100/gm	Absent in 0.1gm	10-100/gm	Absent in 25gm	Absent in 1gm	-
SCM	$5x10^2$-$1x10^3$/gm	10/gm	absent in 0.1gm	Absent in 0.1gm	10/gm	Absent in 25gm	Absent in 1gm	-
Evaporated milk	-	-	-	-	-	Absent in 25gm	-	-
Milk powder Cream Powder / Whey powder	$30x10^3$-$50x10^3$/gm	50/gm	50/gm	Absent in 0.1gm	1-100/gm	Absent in 25gm	Absent in 25gm	$1x10^2$-$1x10^3$/gm
Infant milk powder	$5x10^2$-$5x10^3$/gm	Absent in 0.1gm	absent in 0.1gm	Absent in 0.1gm	Absent in 0.1gm	Absent in 25gm	Absent in 25gm	$1x10^2$-$5x10^2$/gm
Edible Casein Products	Not more than 50,000 / gm	Absent in 1 gm	Absent in 0.1 gm	Absent in 1 gm	Absent in 1 gm	Absent in 25gm	Absent in 1 gm	-
Ice cream/ Frozen	$1x10^5$-$2x10^5$/gm	-	10-100/gm	Absent in 1gm	10-100/gm	Absent in 25gm	Absent in 25gm	-

Dessert / Milk Lolly / Ice Candy / Dried Ice Cream mix								
Cheese / Processed Cheese / Cheese Spread / All other Cheeses	Not more than 50,000 / gm	Absent in 1 gm	Absent in 0.1 gm	Absent in 1 gm	Absent in 1 gm	Absent in 25gm	Cheese other than hard cheese: Absent in 25 gm Hard cheese: Absent in 1 gm	-
Paneer	$15x10^4$-$35x10^4$/gm	5-150/gm	10-100/gm	Absent in 0.1gm	10-100/gm	Absent in 25gm	Absent in 25gm	-
Yoghurt /Dahi	-	50-150/gm	10-100/gm	Absent in 1gm	10-100/gm	Absent in 25gm	Absent in 25gm	-
Chakka / Srikhand	Not more than 50,000 / gm	Chakka: Not more than 10 / gm Shrikhand: Not more	Not more than 10 / gm	Absent in 1 gm	Not more than 100 / gm	Absent in 25 gm	Absent in 1 gm	-

		than 50 / gm						

FSSR (2009 and 2015). Revised standards for milk and milk products. In The Gazette of India, extraordinary Part-III, section 4 Published by Food Safety and Standards Authority of India.

Testing of milk and milk products

***Direct Microscopic Count*:** It is based on the examination of stained thin film of a measured volume of milk spread over a specified area on a glass slide. The method is useful for rapid estimation of the total bacterial population (including live and dead cells) of milk sample. In this test, milk smear is prepared on one square centimetre area. The smear is stained with a special stain called Newman's stain and examined under microscope. Each microscopic field examined represents a quantitative aliquot of the milk sample. The average number of clumps per field are calculated and multiplied by the microscopic factor to get the DMC per millilitre of milk. As per BIS, clump count of <5,000,00 per mL signifies good bacteriological quality of milk. The alternate culture based method is Standard Plate Count, where the milk samples is serially diluted and plated over nutrient medium. Each bacterial colony developing after 24-48h incubation is presumed to have grown from single bacterium. A colony count of <2,000,00/mL in raw milk indicates Very Good quality.

***Methylene Blue Reduction Test* (MBRT):** The methylene blue reduction test is based on the fact that the color imparted to milk by the addition of methylene blue dye will disappear more or less quickly. The removal of the oxygen from milk and the formation of reducing substances during bacterial metabolism cause the color to disappear. Milk, as it exists in the udder has a sufficiently low redox potential to reduce the methylene blue immediately. The processes like milking, cooling, dumping etc. raise the oxidation reduction potential of milk to +0.3V, because of the incorporation of atmospheric oxygen. At this particular O-R potential, methylene blue is in oxidized state. When bacterial cells multiply in milk these, consume dissolved oxygen and as more and more oxygen is used and gets depleted, the dye starts acting as electron acceptor instead of oxygen. As the oxidation reduction potential decreases from + 0.06 to – 0.01 V, methylene blue gets reduced. One atom of hydrogen is taken up by the double bonded nitrogen of the dye that converts it into colourless state. The greater is the number of microorganisms in milk, the greater is the metabolic activity and the faster is the reduction of methylene blue. Methylene blue reduction time of 5h and above indicates very good quality of raw milk.

Estimation of *Coliform, Yeast and Mold and other target pathogens*: Serially diluted samples are plated over selective/differential agar based media and allowed to incubate at target organism optimum growth temperature conditions. Coliforms are detected over EMB and MacConky agar media; while yeast and Molds over Potato Dextrose or Malt Extract agar media. Baird Parker agar base is commonly used for detecting *Staphylococcus aureus*.

Identification and characterization of target pathogens in milk is primarily carried out on basis of characteristic morphological and biochemical properties. Isolation involves initial enrichment in common enrichment media. Colonies displaying typical colony characteristics over differential media are subjected to morphological and biochemical identification. Rapid detection of any potential food pathogen with high sensitivity and reproducibility is of significance for ensuring food quality and safety. Polymerase Chain Reaction (PCR) methods (PCR, Real Time Quantitative PCR) offers ability to rapidly identify pathogens on basis of unique DNA sequences targeted *via* single-plex and multi-plex PCR reactions. In recent years, Loop mediated isothermal amplification (LAMP) assay has emerged as a simple, rapid and cost-effective DNA based tool for detection of pathogens. Although the DNA based identification is quick, sensitive and reproducible; it requires skills, high-end infrastructure; besides need for enrichment, growth in liquid or solid media, and selection of pure colonies followed by DNA isolation, PCR amplification and electrophoresis (not required for RTqPCR) steps, which compromises the rapid identification, especially when it comes to a perishable commodity, such as milk. Some other rapid identification strategies (eg. ELISA, BAcT/ALERT, fluorometric strategy (Target Inhibited Fluorescence Signal Recovery), Phage endolysins, flow cytometry) have been proposed and are likely to have application in early pathogen detection in milk. Bioluminescence based ATP determination approach is becoming increasingly common in HACCP program in situ hygiene monitoring. ATP bioluminescence has often been used for the investigation of microbial contamination of food contact surfaces and for measuring the efficiency of cleaning procedures. This method can monitor the presence of microorganisms and can easily be applied to determine both somatic cell counts (SCC) and microbial counts for controlling raw milk production quality.

Control of Microorganisms

Thermal processing of milk is carried out to minimize the microbial count and to qualify the regulatory microbial standards. Thermal processes include thermization (sub-pasteurization),

pasteurization, and sterilization (UHT). Thermization (57-68°C for 15 sec) is applied to extend the shelf life before further processing of milk. This treatment inactivates pyschrotrophs such as *Pseudomonas* sp. to prevent them to produce spoilage enzymes followed by cold storage of milk until further processing. Pasteurization (63°C/30min, 72-74°C/15-30s) targets typically the most heat resistant pathogens like *Coxiella burnettii* and *Mycobacterium tuberculosis*. Inactivation of alkaline phosphatase enzyme determines pasteurization efficacy. UHT processing (135-140°C/3-5s) combined with aseptic packaging produce sterile milk.

Processes have been developed to minimize the losses and saving nutritional qualities of milk. Radiation is used as the main mechanism of heat transfer**.** Microwave heating is a form of non-ionizing, electromagnetic radiation with wavelengths between 300 MHz and 300 GHz. Microwave pasteurization can be applied to the packaged foods, and thus prevent the post treatment contamination. Radiofrequency**,** another form of non-ionizing radiation has a wavelength between 3 kHz and 300 MHz. Modified Atmosphere Packaging further effectively prolongs the shelf-life of some foods.

Future Prospects

There is still a need for rapid methods that can indicate product microbial quality, sterility and detect pathogens, so that food-borne pathogen outbreaks can be minimized, consumer confidence can be strengthened and losses at producer, processor and consumer level can be minimized. The detection methods need to be rapid, user friendly and easy to operate without need for any specific infrastructure. Developing antimicrobial resistance, ability to form resistant biofilms and reports of emerging heat resistance are the major concerns that needs to be addressed for ensuring food quality and consumer safety. Application of living microorganisms and their metabolites as bio-therapeutics and pharmaceuticals further presents an important avenue for both processors and consumers.

Chapter 11

Fish Processing Industry: A Lucrative Entrepreneurial Venture

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Abstract

Fisheries sector plays a significant role in the Indian economy and nutritional security. This sector is expanding very fast due to introduction of new species, expansion of cold chain, processing and value addition. Fish processing and value addition activity has huge scope to reduce the problem of unemployment and at the same time provides a tool of livelihood. Consumers get healthy, clean and convenient form of fish in their surrounding areas. Fish processing sector have tremendous scope for the entrepreneurial activities and to adopt as a business.

Fisheries sector plays an important role in the Indian economy and occupies a paramount position in the socioeconomic development of our country. Fisheries, aquaculture and fish based enterprises are considered as 'sunrise sectors' in India, providing food and nutritional security, employment generation and earning of foreign currency through its export. Fish, being an economical and rich source of nutrients in the form of animal protein, it is one of the healthiest options for reducing hunger and malnutrition. It is available in every region, geographical conditions and water bodies of the country. Fish farming is a profitable venture moreover it has capability to support other ancillary industries including feed, medicine, nets fabrication and fish processing. In recent times, the demand for processed fish has increased significantly due to the increase in consumption internationally as well as within the country, although the introduction of new species, their processing and value addition have acted as a catalyst to make it more popular. A large number of 'Ready to cook' or 'Ready to eat' are designed and developed according to consumer's preference and convenience, such as fish finger, ball, nugget, cutlet, wafer, papad, sausage, soup powder etc. There is an immense potential in fish processing sector to enhance income and usher in economic prosperity to stakeholders including fish processing.

Health Benefits of Eating Fish

In recent times, consumption of fish and fish products has witnessed a significant growth due to various reasons including change in life style, work culture, perception about fish as a healthy food. Fish accounted for about 17% of total animal protein, and 7% of all proteins, consumed globally (FAO. SOFIA, 2020). Such protein is considered as high quality protein and ranges between 10-22%, moreover it is highly digestible and its biological value is also high. Protein from fish contains all essential amino acids in good quantity. Fat present in fish meat is also of good quality and ranges between 2-20% moreover it contains high amount of Poly unsaturated fatty acids (PUFA) especially Ecosapentaenoic acid (EPA) and Decahexaenoic acid (DHA), which is quite helpful to reduce blood cholesterol, helps in brain development. Fish meat is rich in minerals and contains calcium, phosphorus, iron, manganese, zinc, sodium, potassium, copper and selenium in good quantity and possesses Vitamin A, D, E and B12 in good quantity.

Economic Importance of Indian Fisheries Sector

India ranks the second largest producer of fish and also second largest aquaculture nation in the world. In India, the total fish production during 2019-20 was recorded at 14.16 Million Metric Tonnes (MMT), of which inland capture fisheries accounted for 10.43 MMT and the share of marine fisheries sector was 3.72 MMT. (Handbook on Fisheries Statistics, 2020, Dept of Fisheries, GOI) (Table 1). Marine fish production in India witnessed an increase by 7.75%, while the inland fish production increased by 58.2% during the span of last six years. During 2018-19, contribution of Indian fisheries sector in Indian economy was 1.25%, while percentage contribution of fisheries sector in agricultural economy of the country was 7.28%. In country, both domestic consumption as well as export of fishes has witnessed a strong growth. In recent past, Indian seafood industry has become one of the leading suppliers of quality seafood and exporting the sea produce to almost all major markets of the world. During 2019-20, export of fishery items from the country valued Rs. 46,662.85 crore and further Government of India has decided to increase the export the fishery items more than 1.0 lac crore Rs. by 2024 -25 (PMMSY, Operational Guidelines, 2020, Dept of Fisheries, GOI).

Table 1: Fish production status in India (2019 – 20)

Total Fish production	**14.16 MMT**
Marine fish production	3.72 MMT
Inland fish production	10.43 MMT

Source: Handbook of Fisheries Statistics, Dept of Fisheries, GOI, 2020

Export Scenario of Fish and Fish Products

Commercial fish processing activities in India is mainly export driven with minimum emphasis on domestic market. The major processed products being exported from India include frozen, breaded and battered shrimp individually quick frozen (IQF) products, pre-cooked products, accelerated freeze dried products (dehydrated), cooked and stuffed meat, surimi and surimi based value added products.

India has emerged as the largest exporter of shrimp in the world, though in terms of total marine products exports India has ranked at sixth position. Frozen shrimp continued to be the major export value item accounting for a share of 66% of the total US$ earnings. There was all time high growth in unit value realization of frozen shrimp at 35.05%.The overall export of shrimp during 2019-20 was to the tune of 12,89,650.90 tonnes worth Rs 46,662.85 crore US$ 6,678.69 million (Handbook of Fisheries Statistics, 2020, Dept of Fisheries, GOI) (Table 2). Frozen shrimp continued to be the major item of export in terms of quantity and value, accounting for a share of 50.58 % in quantity and 73.21% of the total USD earnings. Shrimp exports during the period increased by 6.04% in USD value and 6.20% in quantity (Annual Report 2019-20, MPEDA 2020)

Table 2: Status of India's fisheries export (2019 – 20)

TITLE	QUANTITY
Total value of fisheries Export	Rs. 46.662.85
Total quantity of fisheries export	12,89,651 tonnes

Source: Handbook on Fisheries Statistics, Dept of Fisheries, GOI, 2020

Important Activities in Fish Processing

Fish Handling

Fish is a highly perishable food item, which requires proper handling during preprocessing and processing activities. Proper handling, processing and preservation helps in maintaining quality, nutritional value, shelf life, better economic return and reduced post-harvest losses. Typical handling process includes sorting and grading, bleeding, gutting and washing, chilling and storage at desirable temperature. Stored fish can be further dispose off for its consumption as fresh, preservation (traditional or modern methods) or through value added products. Fish processing, particularly seafood processing and marketing have become highly complex and competitive and exporters are trying to develop diverse value added fish products at low cost.

Processed Fish Products

In general, value-added food products are raw or pre-processed commodities whose value has been increased through the addition of ingredients or processes that make them more attractive to the buyer and/or more readily usable by the consumer. It is a production/marketing strategy driven by customer needs and perceptions. Fish processing serves two important purpose i.e. preservation (enhanced shelf life) and convenience (vale added fish products as per consumer's preference).

Fish Preservation

Preservation is mainly associated with to store fish for longer duration for human consumption. Many of the preservation techniques are being employed since ancient time though with technological support product quality has been improved a lot. However choice of preservation methods depends on the type of product, desired properties to be maintained in the product, storage conditions, energy source, packaging methodology, intended use and cost. Common methods used to preserve fish are discussed below.

A. Salting: Salting is widely used, cheapest method to preserve fish and requires no energy. Addition at 6-10% salt in fish flesh helps to prevent the fish from most of the spoilage bacteria (*Pseudomonas, Achromobacter, Clostridium botulinum*) as well as decomposition process (Abolagba, 2011 and Balachandran, 2016). Moisture comes out from flesh through the process of osmosis and remaining (20-30%) moisture is further reduced by sun drying. Salted products are shelf stable at room temperature and possess reasonable quality, long storage life with high nutritional value. Dry (Kench) salting, wet salting (pickling) and brining alone or with slight modifications, combination (mona curing, pit curing, Colombo curing etc.), are the diverse practices of preservation; however selection of process and method depends on the fish species and the final product. The product contains comparatively high amount of salt. Quality is major issue in salted fish, particularly if fish is processed in crude way.

B. Drying: Drying is another low cost, rational and widely adopted practice (Mansur *et al*. 2013) and the dried fish are in great demand in many parts of the country and abroad. Traditionally, sun drying alone or in combination with salting results in to a shelf stable product, which is highly relished by people who prefer its characteristic flavor, taste and texture developed during drying

process (Paul *et al*., 2018). Sun drying is an old age, inexpensive method to preserve fish and requires no energy in traditional methods, however using modern instruments and techniques; dryer running by electricity are being used for moisture removal purpose. The quality, nutritional value and storage life of processed fish using solar/electric dryers is better than the fish dried under direct sun light in open areas.

C. Smoking: Smoking is another popular traditional method to preserve fish, which imparts not only the peculiar smoky flavor, taste, aroma, colour to the product but also helps to increases the shelf life by dehydrating it and deposition of chemical containing antimicrobial and antioxidant produced during the process of smoke generation. Smoke produced during smoldering of wood results into formation of complex mixture of aliphatic and aromatic compounds and is responsible to give a distinct flavour to the product, simultaneously bactericidal and antioxidant compounds during same process helps in maintaining the quality for long duration. Based on temperature maintained during smoking process, it can be cold smoking (30^oC) or hot smoking (80^oC). Smoking can be done either hanging the fish on iron rod or placed over wire mesh in smoker of traditional or modern design (Adeyeye, 2019). Now days, commercial smokers are also being used to impart smoky flavor into fish. Among modern method, liquid smoking in which condensed smoke dissolved in solvent are used directly on products by dipping or spraying, where as in electrostatic smoking is another rapid way to smoke fish, in which fish is sent into a tunnel where electrostatic field is created. A positive charge is given to smoke particles which get deposited on to the surface of the fish which is negatively charged.

D. Fermentation: Fermentation is a process through which complex organic molecules including protein are broken down into simpler molecules by the action of organic catalysts (enzymes or ferments). Degree of fermentation depends on factors such as preprocessing of fish, salting, biochemical composition of fish, additives used along with environmental conditions such as temperature and humidity. Fish sauce is one of the most popular fermented products and is mainly prepared in Asia from the fermentation of fish such as sardines, anchovies or mackerel (Quija, 2020).

Fermented fish products: Process employed for the fermentation of fish yields three distinct types of products:

1. **Products in which the fish substantially retains its original form:** Herring and Anchovies are popular species to ferment by this method, however it can be produced by many other species also. Makassar (Indonesia), Buro (Philippines) or Pekasam (Malaysia) are the important products produced under this process. Colombo-cured fish is well known product of India.
2. **Products in which the original fish is reduced to the form of a paste:** Popular in many Asian countries. Fish paste is dried after mixing salt, and sealed in containers. Moisture content in final product is in the range of 30-40%.
3. **Fish sauces in which the fish meat is reduced to a liquid:** Fish and salt mixture is allowed to stand for extended periods until the whole flesh is converted into liquid containing amino acids and other protein breakdown products which is water soluble.

E. Canning/ retort pouching: Canning/ retort pouching techniques are based on thermal sterilization concept. Can/ retort pouches containg food material in hermetically sealed (air tight) containers/ pouches and treated with heat under steam- pressure for destroying the microbes present inside. The heat treatment and sudden cooling (pasteurization) at desired temperature and duration inactivates makes the enzymes inactive and kills the microorganisms responsible for spoilage and hence maintains the shelf life for prolong duration until can is not opened. Cans are metal container of single or combination of different metals, which consists of two or three piece as per fabrication process. Commercially, cans are available in different sizes and shape and are denoted by trade name followed by their dimensions, diameter and height. Retort pouches are flexible in nature and comprise compressed laminates of generally 3 ply (polyester/ aluminum foil/ cast polypropylene (Gopakumar 2002). The main advantage of canned/ retort pouch product is that they can be stored at ambient (room) temperatures and its nutritional value is also maintained good. If the thermal processing is carried out properly, they remain in good condition even for years. Another advantage of canning is that the process is amenable automation.

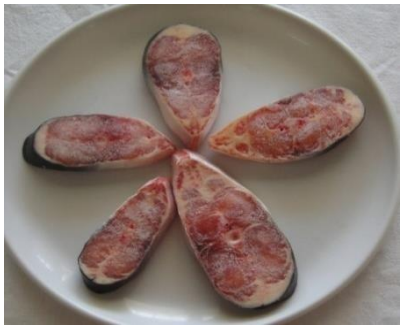
F. Freezing: Freezing is a process to get cool down the product at zero or any temperature set below freezing point. Initially, products are frozen at -40^{o} C, while it is stored at -20^{o} C to maintain its quality for long duration. Freezing may be carried out in two ways: quick and slow manner, however commercially quick freezing method of preservation is always preferred due to various advantages like, it restricts proteolytic degradation due to self-enzymes and bacterial contamination is also inactivated or destroyed up to great extent. The rest of them get immobilized

due to non-availability of free water, low temperature etc. Thus as long as the fish is maintained under freezing temperature it will be preserved in the fresh form. Freezers such as horizontal plate freezer, vertical contact-plate freezer, tunnel/air blast freezer, immersion freezer and fluidized bed freezer are most commonly used for freezing at commercial level.

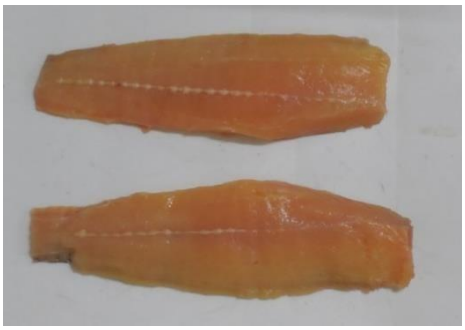
Canning/ retort pouching and freezing are possible at commercial level which requires high input and skilled training.

Value Added Fish Products

Cutting activities, processing techniques can be categories into two major categories; first one is primary processing in which fish is cut into its basic form like fish steaks, fillets and cut fillets, while preparing 'Ready to Eat' or 'Ready to Cook' value added products is called secondary or advance processing. Among primary processed fish products steak cutting/ filleting of fish are most common. Steak is a round cut of fish containing vertebrae in the center, while fillets is meat cut into rectangular or ribbon shape. Fish steaks/fillets (Fig.1) in its frozen form is convenient trade commodity, which is used to prepare verity of recipes like fish curry, pakoda, pickle etc. Marinated fillets/ steaks are already very popular as street food and are becoming popular as snack food. Steak and fillets can be prepared from any table size fish but presently catfish, murrels are preferential freshwater species for fillet production in the country, however demand for carp fillets and steaks are also increasing.



Fish Steak



Fish Fillet

Fig. 1. Fish Steak and fillet of pangas prepared locally

Coated products: Battered and bearded products are the modern day's technological intervention which improves the appearance, texture, flavour and makes it convenient food from consumer's consumption point of view. It is the combination of activities like coating, combination of ingredients, processing, technological innovations and convenient presentation. A variety of fish and shellfish meat based products prepared as batter and breaded or coated products offer a 'convenient food', with

distinct flavor and texture. Production of battered and breaded products involves several stages like: Portioning/forming, Pre-dusting, Battering, Breading, Pre-frying, Freezing, Packaging and cold storage

Popular Battered and Breaded Fish Products: A wide variety of value added products fish product produced commercially or local manufacturing are available in the market like fish fingers, balls, nuggets, cutlets, sausage, fish cakes etc. (Fig. 2).

Fish Fingers **Fish Balls** **Fish Cutlets**

Fig. 2. Fish finger, balls, cutlets prepared at small scale

Other than above mentioned products, fish burger, surimi, cake, patty, high pressure extruded products, etc. are other popular value added products, can also be prepared from fish meat.

Processed shrimp

Shrimp and prawns form the major item of frozen trade. During the processing of shrimp, it is washed in potable water and according to type of product head, telson is removed. As per product specifications with or without peeling, vein is removed or kept intact, with or without cooking shrimp is processed. Sometimes shrimps are enrobed or stretched. Some most common processed shrimp are: Headless shell-on or Raw headless/ HL, Peeled and deveined/P&D, Fan-tail/Butterfly, Peeled undeveined/ PUD, Whole/Head-on, Cooked and peeled, Cooked, peeled and deveined/CPD, Peeled, deveined & cooked/PDC and Coated stretched shrimp also known as *Nobashi*

Headless shell-on or Raw headless

Peeled and deveined/P&D

Coated shrimp

Fan-tail/Butterfly shrimp

Peeled, deveined & cooked/PDC shrimp

Fig. 3. Different form of processed shrimp

Packaging and labeling: To maintain quality of the product, packaging method, material play crucial role and it must be selected select according to type of product, storage condition and shelf life. Libeling helps to boost the confidence among consumers regarding authenticity, shelf life, nutritional value and storage condition and brand promotion. Labeling should be done in compliance of Food Safety and Standards Authority of India (FSSAI) guidelines.

The frozen coated fillets are immediately packed in thermoformed containers or pouches made of 12μm plain polyester laminated with 118μm LDPE. A specified number of such consumer packs are then packed in master cartons and further cartons of frozen coated fillets are stored in a cold storage maintained at -20°C. Shrimps are arranged in PVC/polystyrene trays and vacuum pack in laminated pouches.

Fish waste management

Fish generates good amount of waste in the form of head, viscera, skin, scale and fins and is considered as no value biomass and causes unhygienic condition along with pollution, if it is thrown untreated.

This waste is a good source of protein and can be easily converted into economically important by-products like fish meal, fish oil, bone meal and silage and processor can fetch additional profit.

Market opportunities

Markets are the final destination of the product (fish and seafood products). These can be defined either by location, domestic or international, or type of end-user (e.g. human consumption, industrial use). However supply side of the fish and fishery products gets affected by different factors like market demand, prices, season, climatic conditions, population dynamics, economics status, fuel prices, policy and legal environment etc. The number of fish eaters is increasing day by day, as a result the demand for fish and marine products is also increasing, and consumers are looking for clean processed fish in convenient places, hence restaurants, hotels, railways & flights kitchens, defense departments, retail suppliers like shopping malls, bazars and stores have now emerged as a new option to sell products.

Food quality and safety measures

Quality and Food Safety have become competitive edge in the global market for food products. For the all-round development of the food processing sector in the country, various aspect of Total Quality Management (TQM) such as quality control, quality system and quality assurance should operate in a horizontal fashion. To ensure food safety, adoption of food safety and quality assurance mechanisms such as TQM including ISO 9000, ISO 22000, Hazard Analysis and Critical Control Point (HACCP), Good Manufacturing Practices (GMP), Good Hygiene Practices (GHP) and all precautionary measures including sanitary and phyto-sanitary, from the procurement of raw material, processing, product preparation, packaging, storage and distribution of raw material, will be performed because , there is a need to ensure that the quality food products manufactured and sold in the market meet the stringent parameters prescribed by the food safety regulator

Scope of Business in Fish Processing Sector

In India, fish production particularly Inland fish production is continuously increasing due to adoption of 'Best Management Practices' (BMPs), including stocking of quality seed, providing balanced feed as per growth requirement, prophylactic measure to minimize disease risk along with increase in the fish farming area. To utilize such increased fish produced in better and efficient manner and to minimize post harvest losses, its processing could be the only solution. Moreover availability

of fish in plenty at nearby area act as catalyst to processing unit because regular supply of raw fish is one of the bottle neck to run fish processing unit successfully.

With rising awareness about health consciousness, people have started paying attention towards healthy processed food. Hence, establishment of fish processing unit can help to reap humongous economic profit by through fulfilling the demand of such section of the society. However, still carp is the dominating fish species in inland farming system but now a day due to technological interventions such fish species can be easily processed into a wide variety of value added fish products like fish fingers, balls, nuggets, cutlets, sausage, pickle, etc. More over during its processing the generated waste can also be converted into byproducts like fish meal, bone meal, oil etc.

Conclusion

Fish processing especially the seafood industry has opened up new frontiers to top high income from foreign markets in many industrialized nations. The seafood industry is growing into a multibillion dollar industry with immense potential for the future.

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Chapter 12

Engineering Interventions in Dairy Processing: Entrepreneurial Initiative toStart Small Scale Milk Plant

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On-farm processing of raw milk is done to harness the most quality attributes of milk and then to transform the freshly harvested milk into variety of milk products. Milk products likewise milk cake, peda, curd, lassi, ghee, sterilized flavored milk/ whey drinks are generally processed at farm level. Since, a long time, milkman, middleman and class contactors are managing the most of the supply of raw milk, to processing plants and thus many stakeholders are involved in entire milk supply chain. Every stakeholder earns their own share during the handling and storage of milk thus the handling, transportation and storage is contributing in production cost of milk and milk products and it greatly affected the consumer at large. A small dairy processing plant is a timely initiative which is established with a clear mandate to process the milk of dairy farmers at small scale food processing units at own level and within their premises. Due to ease of availability of quality fresh raw milk and installation of milk processing machinery, milk products of utmost quality could be economically manufactured and sold in the market. Therefore, freshly harvested raw milk of premium quality with the advent of engineering & technology could be converted into arrays of value added good quality milk products.

Raw milk is converted with advent of small scale milk processing plants. Milk processing plant involves various operations namely; milk reception at raw milk reception dock (RMRD), bulk milk cooler (BMC), standardization equipments (cream separator and standardization tanks), homogenizer, pasteurizer (PHE) and packaging unit (FFS) to process and pack the milk into different forms of milk variants namely; likewise full cream, standardized, toned and double toned milk (DTM) packed with variable fat and solid-not-fat (SNF) content in different color codes (red, green, blue & orange), to capture the changing habits and needs of fat and SNF content. Design of the plant depends up on the capacity decided for processing the milk, type of products to be processed, land available, demographical & climatic conditions and most important the budget allocated for the processing plant. Milk processing plants are classified as small scale, medium enterprises and large scale plants. Mainly, liquid milk (LP), composite milk plant (CMP) and creameries type of milk processing plants

is characterized depending upon the capacity and type of product processing. Generally, mini to small dairy processing plant varies from 500 to 10000 LDP.

Dairy industry is amongst most perishable food industries which require a comprehensive quality criterion for achieving the safe and quality production of food products. Quality plays a vital role in production of quality milk and value added milk products. Quality of the processed milk and milk products depends on type of animal, feed, breeding techniques, clean milk practices. Production of first quality milk begins from good agricultural practices coupled with clean milk production practices. Dairy industry milk quality is determined by microbial and chemical quality related attributes examination and is addressed by good laboratory practices. We know poor quality of milk impact the entire segments of dairy industry. So, it is imperative to maintain the quality of milk during the whole supply chain starting from milk production, handling of milk, cold chain storage, processing, packaging, distribution and including retailing need due consideration to maintain the overall quality of food product. Improving the safety and quality of milk products definitely fetch good price for the milk produced by the dairy farmers as well as benefit the milk processors. Therefore, high production of premium quality milk is very important including emphasizing the good manufacturing practices (GMP) to achieve by overall quality of milk and milk products from the "field to fork".

Engineering interventions

Engineering interventions in dairying sector largely executed in dairy farming (DF), fresh milk reception (FMR), milk processing (MP) during value addition, cleaning to maintain the hygiene is conditions, quality control and packaging of products manufactured **(IA Chauhan, AtanuJana, AK Mackwana and AG Bhadania 2016)**. Mechanization of dairy farm is done with an aim to facilitate the human to feed, grow and finally to ease the harvesting of milk from the animal. Sheds layout, design including feeding system, floor type, ventilation to the animal, watering system are the basis of establishing good dairy farming practices which help in clean milk production (CMP) **(Robert AG. 2002).** In addition, manure scrapping and collection system, grooming system and robotic milking parlour are the finest interventions at dairy farm level. Conventional system of dairy farming is now being replaced by robotic arms to complete the milking by robotic type engineering interventions. Premium quality of milk is harvested with the help of automation at dairy farm. In milking robotic system, milk is simultaneously checked for analysis and if found suitable, milk is pumped to milk cooler. Milk here is kept cool and then transferred to refrigerated milk van and is taken to factory for further processing in to varied milk and milk products. Milking robot is retro fitted with existing milk

parlour system with a cleaning system to clean the teats and therefore reduces the labour cost, fasten the milking operation, reduce the bacterial contamination and also ensure good milk yield and food safety. **(**http://rotec-engineering.nl/en/portfolio-item/voluntary-milking-system**).** Milk cooling and short-period storage is generally done in bulk milk coolers (BMC) at milk cooperative societies and the collected milk is transferred to refrigerated milk vans. Mobile BMCs are used to immediate collection of milk. Tankers are installed tag indicators to check the history of temperature during transportation and interlocked with the refrigeration unit to automatically start the cooling process if suitable temperature is not achieved by milk during transportation. Location of the tankers could be tracked with sensors and GPS systems to monitor the unwanted stay of milk tanker (**Krish Industries Pvt., Ltd., Bulk Milk Coolers automation pamphlet).**

New equipments likewise bactofuse, cream separator for in line standardization and self-cleaning clarifiers are used to remove of bacteria and spore, for instant standardization of fat and de-sludging of extra materials deposited to bowl of the clarifier. Automatic closing and opening of valve for automatic standardization of milk is done. Milk processed by bactofuse is processed into cheese and ultra-high temperature milk. Cream separator, also use drive and integrated drives with variable frequency drive to enhance the overall efficiency of cream separator. Scrapped surface heat exchangers (SSHE) are also used to develop the heat desiccated viscous type of milk products. (**Lanjewar P. et al. 2014)**. Importance of cleaning is well known in liquid & product milk processing to maintain the quality of products manufactured. Cleaning-in-place (CIP) is the most crucial process to clean the equipments and maintain their hygienic quality. Most typical process in dairy industry is CIP circuits and their operations to recover the adhered biological material/ biofilms in milk pipelines (**Rao BP, 2014**).

Therefore, a fully automated CIP system is required to ensure the complete hygiene of the dairy equipments. During the distribution of liquid milk, automatic milk vending machines are used to sell pasteurized loose milk in the market to reduce the excessive load of plastic waste which is generated as of plastic bag packaging **(Christian I, Andreas Mansson, 2006**). This system is reliable, very compact and its installation is easy on a carrier vehicle to avail the milk at any time.

Small dairy processing plant is established to facilitate the entrepreneur to on-farm processing of milk so that value added milk products of premium quality could be manufactured. Small scale processing plant are mainly established to start new dairy processing ventures, reduce the delay in milk processing, to help the dairy farmers to earn the profit while processing in their own premises and moreover, scale dairy processors got the recognition and brand of their products. Mini-to-small milk processing plant

capacity ranged from 500 to 10,000 LDP (max.) are recommended for better plant economics and profitability however plant may be in modules of different capacities. Mini dairy processing plant is generally established by individuals, societies and shelf help groups depending on amount of milk available. Generally, For 2000 LDP plant module, 500 sq. feet area with building either single or multi story with power requirement of 20 KW and water requirement of 1000 LPD are required. The site should be cool and well-ventilated. Sometimes not all these conditions can be met. The most important factor is availability of water. It should be remembered that on average five litres of water are required to process one litre of milk. Milk is highly perishable commodity and gets influenced by environment conditions. Milk quality and shelf life depend largely on the surroundings in which milk is manufactured, packaged, transported and finally stored. Fig 1 is shown the different sections for processing of liquid milk and other milk based products. The milk processing plant should be established at appropriate site, and plant layout should be considered in relation to reception, processing, storage, parking area and roads connectivity to plant.

Dairy Processing Plant

Dairy processing plant, generally involved unit operations likewise cooling, heating, mixing, pressing, cutting and packaging of composite dairy products. At dairy farm level ensure milk is cooled or delivered for processing within the specified time. Cool milk as soon as possible after milking to the required storage temperature and within the specified time. Cooling times and storage temperatures should conform to limits set by the relevant authority. The storage equipment should be capable of holding milk at the required temperature until collection, and be constructed of materials that do not taint the milk. Liquid milk processing section involves procurement of milk from the villages and from dairy farm level thus chiller, tanks for standardization, homogenizer, pasteurizer, farm and fill machine (FFS) for market milks of different variants namely; whole, standardised, toned and double toned, milk is required. In this type of plant usually standardization of liquid milk into standardization milk, toned milk and double toned milk is done. The cream separated after standardization could be distributed as it in market after packaging and could also be processed to ghee by electric kettles. Processing of milk required processing building which includes raw milk reception dock (RMRD), main processing hall, provision for manufacture of other products, cold storage, clean in place (CIP), laboratories (chemical and microbiological analysis), quarters, office, garages, security post etc. The factory building for the milk reception, quality control, processing, packing and storage of milk require about 500 sq. ft. (46.45 sq. meters) area for handling 500 to 2000 litres of milk **Fig 1.** The essential

sections of a milk processing plant raw milk reception dock (can washer, weighing balance, dump tank etc.), processing hall (cream separator, chiller, homogenizer, pasteuriser and other related machinery, milk storage tanks, finally, packing area for packing of liquid milk, milk products, utilities area-for generator set, water treatment plant for treating the dairy effluents, maintenance area and office area-for all the administration.

A cream separator has to be used to skim the milk received in the processing plant. Standardization is an operation producing milk with constant butterfat content through partial, manual skimming. The operation makes it possible to standardize the composition of the finished product and to set aside part of the cream for butter. There are several possibilities for heat treatment, depending on the available power source. Plate heat exchanger (PHE) type pasteurizer (HTST; High Temperature for Short time at 71℃ for 15sec.) is used for heat treatment of milk capacity over and above of 2000 litre. For 100–500 litre quantities of milk, milk pasteurization with a plate pasteurizer is not recommended. For batch type pasteurizer, a minimum temperature of 63°C for 30 minutes is recommended to destroy pathogenic germs in milk by heating. Batch pasteurization could also be done in tank by circulating hot water of desired temperature for required time and immediately cooled. The milk is cooled in a jacketed vat have circulation of cold water. Milk cooled by cold water circulating within its jacket up to 500 litres, a multipurpose vat could be designed for cooling purposes. Electricity supply is required for milk processing plants; standby generators may be in connection with processing and storage section sections. A milk processing plant requires the water for cleaning of equipment's, cold storage and drinking purposes. Accordingly, water facility can be created. Depending upon the requirement of the plant and expansions the number of vehicles is purchased for distribution of milk. To measure milk density: lacto-densitometers with glass cylinders, to test milk acidity; Pipettes and Fat content of milk; Manual Centrifuge is required. Hence, an effort is being made to calculate the modalities for setting up of a milk processing unit for handling of milk per day ranging from 500 to 2000 litre for making products such as liquid milk in different variants, flavoured milk, paneer, yoghurt, dahi, lassi, paneer and whey drinks, etc.

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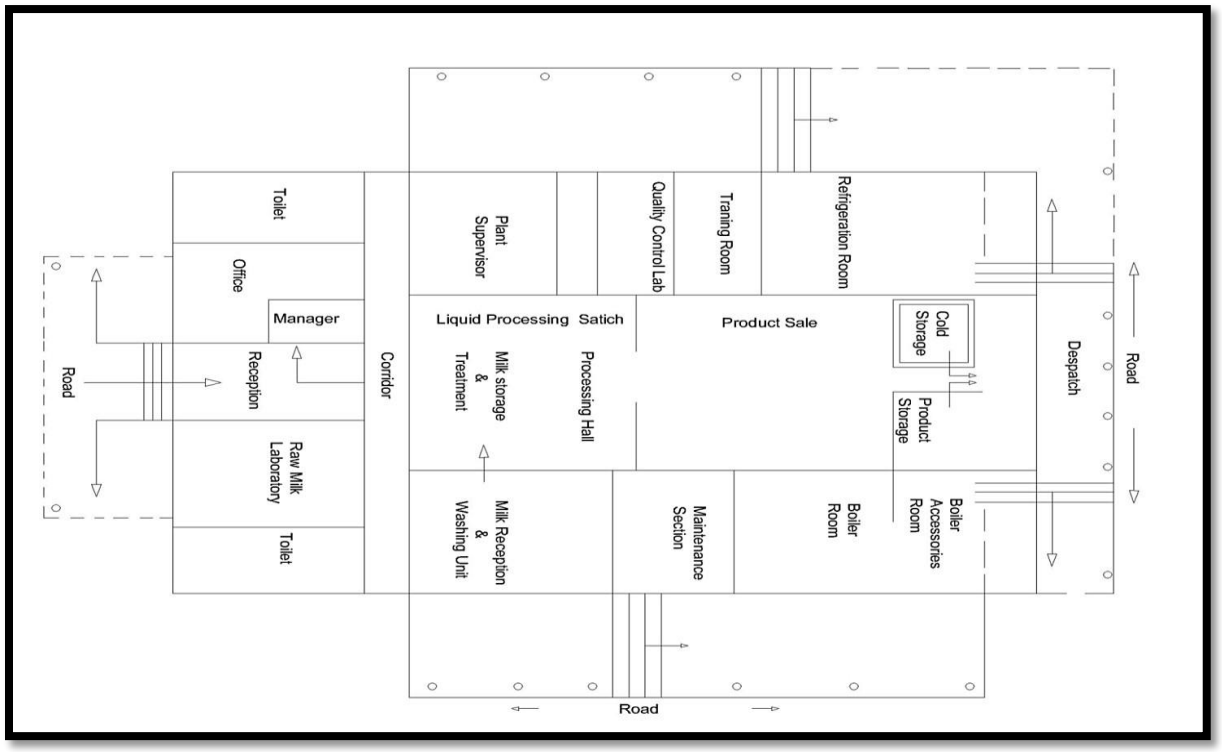

Fig 1. Small milk processing plant layout design for 2000 to 5000 LPD capacity

Chapter 13

Quality and Safety Aspects of Adulteration in Milk and Its Detection

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Adulteration in Milk

Milk in its natural form has a high nutritive value as it is a good source of quality proteins, fats, carbohydrates, vitamins and minerals. It is easily digestible and hence is readily absorbed and thus is especially important for infants, nursing women, children and elderly people. Milk proteins also supply amino acids needed for the proper growth of adults and infants.

Nowadays milk is being easily adulterated throughout the world. The practice of adulteration of milk invariably reduces its quality and may introduce hazardous substances into the dairy supply chain jeopardising consumers' health. Adulteration of milk is an act of intentionally reducing its quality, offered for sale either by admixture, substitution of inferior substances or by removal of some valuable ingredient. The Food and Drug Administration defined the 'Economically Motivated Adulteration' as the 'fraudulent, intentional substitution or addition of a substance in a product for the purpose of increasing the apparent value of the product or reducing the cost of its production that is for economic gain'. Thus, from the point of view of the dairy industry as well as consumers, it is necessary to have proper methods to differentiate between adulterated and clean milk and to provide consumers with pure and wholesome milk.

Quality and Safety Aspects

The key motive for adulteration of milk and milk products, a very common problem, is for deriving undue economic benefits. Adulteration includes masking the poor quality of product by increasing the fat and/or solids not fat (SNF) content. The complex colloidal mixture of several constituents in milk, the high-water content and opacity, render milk as a commodity in which adulterants are not visible and therefore easy to adulterate.

The fraudulent practice of adulterating milk as well as preparing synthetic milk, with some of the common practices being addition of water along with starch of skimmed milk powder, removal of fat etc. is rampant among the milk vendors. Synthetic milk, which is mixed with natural milk,

contains hazardous chemicals like urea, laundry detergents, pulverized soap, boric acid, hydrogen peroxide, starch and neutralizers (caustic soda or sodium hydroxide, sodium carbonate and sodium bicarbonate.

Sometimes natural milk is adulterated with low value ingredient like water, whey etc. and is known as 'economic adulteration.' It is a very common practice by the milk supplier to add water or 'liquid-whey' to milk to increase the volume of milk. Diluted milk reduces its nutritional value, and contaminated water causes serious health problems. This fraud can be concealed by adding substances classified as thickeners, such as sodium chloride, starch or sucrose (Gondim et al. 2015). Since milk fat is very expensive, some manufacturers of milk and dairy products remove milk fat for additional financial gain and compensate it by adding non-milk fat such as vegetable oil. Detergents are added to emulsify and dissolve the oil in water giving a frothy solution, which is the desired characteristics of milk (Singuluri and Sukumaran, 2014).

Adulterants are added in milk either to increase fat, solid-not-fat (SNF) or protein percentage, thereby increasing the milk quality in dishonest way. For example sugar, starch, sulfate salts, urea and common salts are added to increase SNF. Urea, being a natural constituent of raw milk, has a maximum limit imposed by FSSAI (Food Safety and Standards Authority of India) Act 2006 which is to be 70 mg/100 ml. Commercial urea is added to milk to increase non-protein nitrogen content. Similarly, melamine is added in milk powder to increase protein content falsely. Soy, rice and almonds are intentionally processed into milk-like products for supplementing the protein source in milk. Ammonium sulphate is added to increase the lactometer reading by maintaining the density of diluted milk. Ammonium sulphate could also come into milk due to the addition of ammonium compounds to animal feed and fodder/silage.

Poor milk quality is related to microbial count, which can be reduced by adding preservatives such as formalin, hydrogen peroxide, salicylic acid, benzoic acid or sodium hypochlorite and thus increase the shelf life of milk. Quality problems due to high acidity levels are related to failures in good manufacturing practices. When this occurs, the acidity can be reduced by fraudulently adding common neutralizers, such as bicarbonate, carbonate, hydroxide or citrate.

There are some hazardous chemicals added in milk to improve the physical appearances and shelf life. Some of those are very hazardous and can lead to fatal diseases in long run consumption of such milk. Table 1 represents the some of the common adulterants and their health effects in human being.

Table 1. Common adulterants in milk and their health effects

Type of adulterants in milk	Purpose of adulteration	Health effects
Melamine	➢ Increase the apparent nitrogen or protein content of milk and milk products	➢ Renal failure and death of infants when ingested at levels above the safety limit
Detergents	➢ Emulsify and dissolve the oil in water	➢ Gastro-intestinal complications, gastritis and inflammation of the intestine
Starch	➢ Increase the SNF content in milk	➢ Excessive starch in the milk can cause diarrhea due to the effects of undigested starch in colon
Urea	➢ Increasing the consistency of milk ➢ Standardizing the solid-not-fat content to that expected for natural milk	➢ Overburdens the kidneys ➢ Health hazards associated are acidity, indigestion, ulcers and cancers
Neutralizers (caustic soda, carbonate and bicarbonates	➢ Neutralizes the developed acidity in milk	➢ Disruption in hormone signaling that regulate development and reproduction. ➢ High intake of sodium acts as slow poison for those suffering from hypertension and heart ailments. ➢ Carbonates in milk produce gastrointestinal problems including gastric ulcer, diarrhoea, colon ulcer and electrolytes disturbance.
Formalin, Salicylic acid, Benzoic acid and Hydrogen	➢ Acts as preservatives and increase shelf life of milk	➢ Peroxides damages the gastro intestinal cells which can lead to gastritis and inflammation of the intestine

Peroxide		➢ Formalin develops abdominal pain, diarrhea, vomiting and other poison related symptoms

The report of 'National Milk Quality Survey, 2018', released in the month of November, 2018 by the FSSAI reveals that milk in India is largely safe, even though quality issue persists. The scope of this survey is to assess the quality and safety of milk across the country taking into consideration the possible impact of seasonal/demand supply situation on the quality of milk. The survey conducted over a period of about 6 months (7 May to 31 Oct 2018) on milk quality addressed 2 quality parameters (fat and SNF), 13 adulterants (vegetable oil/fat, detergents/caustic soda, hydrogen peroxide, sugar, glucose, urea, starch, Maltodextrin, boric acid, ammonium sulphate, nitrates, cellulose, and neutralizer) and 3 contaminants (18 pesticide residues, aflatoxin M1 & 93 antibiotic residues), however, this survey did not include microbiological parameters. Sample size comprised of 6432 (out of which 3825 raw milk and 2607 processed milk) samples and were collected from all major towns covering 29 states and 7 union territories and tested on-the-spot for qualitative parameters. The key findings of the survey shows that only 12 samples had adulterants and 638 samples (<10%) had contaminants (Pesticide residues-1; Antibiotic residues-77; Aflatoxin M1-368) (out of a total of 6,432 samples) that affect the safety of milk or unsafe for human consumption. The survey also reveals that 1261 (19.6%) and 2165 (33.7%) of the samples did not meet standards of fat and SNF, respectively and total of 234 samples (3.4% of the total samples) were found to be added with sugar and maltodextrin.

Detection of adulteration in milk

Qualitative detection of adulterants in milk can be easily performed with chemical reactions while quantitative detections are complex and diverse. Type of quantitative detection techniques depend on the nature of adulterants in milk. The classical qualitative tests for detecting milk adulteration, which are established as official methods by regulatory authorities in several countries (FSSAI in India), include independent determinations of different analytes.

Qualitative detection of adulterants in milk is simple colour based chemical reactions. These can be performed in any Biosafety Level 1 Laboratory with availability of chemical reagents and necessary precautions. Qualitative detections are advantageous because these are simple, rapid and very easy to perform. Major drawbacks of these techniques are the facts that these are valid for a limited range of concentrations and are not sufficiently precise. Moreover, requires a large number of

tests and reagents and a great deal of time and generate large amounts of waste. Presence of common adulterants in milk can be detected rapidly as shown in Table 2.

Table 2. Rapid qualitative detection of common adulterants in milk

Adulterants	Procedure	Observation
Sugar	Take 5 mL milk sample in a test tube. Add 1 mL conc. HCl and 0.1 g resorcinol solution. Place the test tube in boiling water bath for 5 min.	Appearance of red color indicates the presence of added sugar.
Starch	Take 3 mL sample in a test tube. After boiling it thoroughly, cool it to room temperature. Add 1 drop of 1% iodine solution.	Appearance of blue color indicates the presence of starch
Glucose	Take 1 ml of milk sample in a test tube. Add 1 ml of modified Barfoed's reagent. Heat the mixture for exact 3 min in a boiling water bath. Rapidly cool under tap water. Add one ml of phosphomolybdic acid reagent to the turbid solution.	Immediate appearance of deep blue color indicates the presence of glucose
Common salt	Take 5 ml of milk sample into a test tube. Add 1 ml of 0.1 N silver nitrate solution. Mix the content thoroughly and add 0.5 ml of 10% potassium chromate solution.	Appearance of yellow color indicates the presence of added salts, whereas, brick red color indicates the milk free from added salt.
Hydrogen Peroxide	Add to 5 mL of suspected milk sample in a test tube and 5 drops of 2% solution of paraphenylenediamine.	Appearance of blue color indicates the presence of hydrogen peroxide in milk.
Maltodextrin	Boil 20 ml of milk in a beaker and cool. Coagulate the milk using 10% TCA solution. Filter through Whatman filter paper no. 42 and collect the filtrate. Add 2 ml barium chloride solution (2%) to the filtrate and mix.	Appearance of blue color indicates the presence of maltodextrins.

Formalin	Take 10 mL milk sample in attest tube. Add 5 mL conc. sulfuric acid with a little amount of ferric chloride without shaking	Appearance of violet or blue color at the junction of two liquid layers indicates the presence of formalin
Urea	Take 1 ml of milk sample into a test tube. Add 1 ml para-dimethylamino benzaldehyde (1.6% in ethanol added with 10 ml conc. HCl) and mix	A distinct yellow color is observed in milk containing added urea.
Ammonium sulphate	Take 2 ml milk in a test tube and add 0.5 ml NaOH (2%), 0.5 ml sodium hypochlorite (2%) and 0.5 ml phenol (5%). Heat in boiling water bath for 20 sec	A bluish color, which turns deep blue, indicates the presence of ammonium sulphate
Nitrates (Pond water)	Take 2 ml of milk in a test tube. Rinse the tube with the milk and drain the milk from the test tube. Add two-three drops of the diphenylamine reagent (2% in conc. H_2SO_4) along the side of the test tube.	A deep blue color on the walls of the tubes as well at bottom portion indicates the presence of nitrate in the milk sample.
Neutralizer	Take 5 ml milk in a test tube. Add 5 ml 95% ethyl alcohol and mix well. Add of 2-3 drops of Rosalic acid solution (1% in ethanol (30%)).	The appearance of a rose-red color indicates the presence of neutralizer
Detergent	Take 5 ml of the milk sample test tube. Add 0.1 ml (1 to 2 drops) of Bromocresol purple solution (0.5%) and mix	A violet to purple color indicates presence of detergent in milk.

Source: FSSAI (2017); Azad and Ahmad, 2016

Now a days, these procedures are being replaced by instrumental techniques that consume less solvent and can detect many analytes simultaneously. With the advancement of technology, newer techniques have been invented to detect different kinds of milk adulterants, but in the same pace the complex methods of milk adulteration and varieties of milk adulterants have been evolved. There are several sophisticated methods such as chromatography, spectroscopy etc. are used to detect milk adulteration. Other analytical techniques are freezing point, capillary electrophoresis, thermometric sensors, mass spectrometry, DNA based methods, differential scanning colorimetry, ELISA for detection of adulterants in milk and milk products.

Recently infrared spectroscopy is widely used in the food industry for detection of adulteration. Its advantages include the analysis of samples with little or no preparation, ease of use, rapid data collection and use as a 'fingerprint' technique. Untargeted and targeted approaches have been successfully applied to detect common adulterants in milk including water, vegetable proteins (soy, pea and wheat isolates), thickeners (starch, sugar and sodium chloride), preservatives (formaldehyde, hydrogen peroxide and sodium hypochlorite) and neutralizing agents (carbonate, bicarbonate and hydroxide).

Different types of chromatographic techniques in association with mass spectrometry (MS) and other detection systems have been regularly used for the detection of various adulterants in milk. RP-HPLC has been used to separate and detect the presence of soy and extraneous whey proteins in milk. HPLC coupled with tandem mass spectrometry is used for the routine detection of melamine in adulterated milk. Gas chromatography has been used for the analysis of the fatty acid and triacylglycerol profile as well as total sterol fraction of vegetable oils, milk fat or mixtures, to detect vegetable oil adulteration in milk fat.

E-nose and E-tongue has become an interesting tool to detect milk adulteration. E-nose contains ten different metal oxide semiconductor sensors which can monitor the adulteration of milk by water (Yu et al. 2007). E-nose can monitor the aging of milk and can detect milk volatile compounds. The E-tongue has been used to detect hydrogen peroxide, fat content of the milk and also detect the goat milk adulteration with bovine milk (Dias et al. 2009).

A biosensor is an analytical tool that in intimate contact with a transducer converts a biological signal into a measurable electrical signal. Based on the transducer system employed, the biosensors can be of optical, piezoelectric, calorimetric and electrochemical type. The biosensors are used for the detection of various milk adulterants such as melamine, urea, non-milk fat, exogenous proteins, preservatives like formalin etc.

These instrumental method of analysis yield high accuracy of detection but they suffer from some distinctive shortcomings as the methods are time consuming, tedious, expensive and requires elaborate sample preparation and expert manpower.

Table 3. Adulterants in milk and methods used to detect those adulterants

Sr. No.	Adulterants	Methods of detection
1	Water	Lactometer (by specific gravity)

		E-nose Electrical conductivity Freezing point Ultrasonic transmitter receiver system Near-infrared (NIR) spectroscopy
2	Rennet whey	NIR spectroscopy Reverse phase- High Performance Liquid Chromatography (RP-HPLC) Capillary electrophoresis ELISA Immunochromatographic assay Phosphor partition Blot Immunoassay
3	Urea	Infrared spectroscopy Raman spectroscopy Potentiometric biosensors Colorimetric method HPLC-MS/MS HPLC-UV Gas Chromatography/Isotope Dilution Mass Spectrometry
4	Melamine	Surface Enhanced Raman Spectroscopy Laser Raman spectroscopy Single Bounce Attenuated Total Reflectance - Fourier transform infrared spectroscopy Atmospheric Pressure Chemical Ionization-Mass Spectroscopy (MS) Extractive Electrospray Ionization Mass Spectrometry LC-MS/MS Gold nanoparticles GC-MS
5	Glucose	Mid-Infrared (MID) spectroscopy Biosensors

6	Neutralizer (NaOH, Na_2CO_3, $NaHCO_3$)	Conductivity Ultrasonic method Flame photometer Atomic absorption spectroscopy Mid-Infrared (MID) spectroscopy
7	Non-dairy proteins (Soy, wheat, pea and brown rice proteins)	Polarimetric method Isoelectric precipitation, Sodium Dodecyl Sulfate Polyacrylamide Gel Electrophoresis (SDS-PAGE), RP-HPLC Immunodiffusion method ELISA Biosensor immunoassay Optical biosensor Capillary electrophoresis
8	Vegetable oil and animal fat	Matrix-assisted Laser Desorption/Ionization Quadrupole Time of Flight Mass Spectroscopy Gas chromatography High-performance thin layer chromatography
9	Hydrogen peroxide	E-tongue Mid-Infrared (MID) spectroscopy

Source: Das et al. (2016); Poonia et al. (2016)

Summary

Milk adulteration has become a common practice over the years. One of the major reasons for milk adulteration is considered to be financial gain. Due to lack of adequate monitoring and law enforcement, the problem is more acute in developing and under developed countries. The chemical adulterants added in milk cause serious health implications. Existing common detection techniques are not always convenient and accessible making it difficult to address the diverse ways of fraudulent adulteration in milk. This calls for combined efforts from scientific communities and the regulatory bodies through the development, implementation and dissemination of better techniques for the detection of milk adulteration (Azad and Ahmad, 2016). Awareness of milk adulteration in public and access to information can play a pivotal role to overcome this issue.

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Chapter 14

Artificial Intelligence in Livestock Sector: Today and Tomorrow

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Introduction

Improving rural livelihoods through Information and Communication Technology (ICT) is one of the key areas, which has potential to change the economy of livestock, agriculture, and rural dwellers in India. Information and Communication Technology (ICT) is basically an umbrella term that encompasses all communication technologies such as internet, wireless networks, cell phones, satellite communications, digital television etc. The advent of artificial intelligence (AI) has further boosted the utility of ICTs and created a tech-revolution in almost all the sectors in which it is being implemented. Since 2017, AI has witnessed massive growth in its application. Livestock sector being a no exception has also witnessed the use of artificial intelligence mediated ICTs. Massive growth in the mobile and internet users has led a revolution in the research and development of artificial intelligence based ICTs. We would not be wrong if we call this era as "Era of ICTs". With Government of India's Digital India Mission and by the provision of economical tariffs by telecom providers to the users have paved way for the internet technology at everyone's doorstep, thus boosted internet of things (IoTs). All of these technologies together weave an 'Information Web' for the farmers and is responsible for dissemination of timely information for livestock development. With the enormous growth in the world population, the farmers are switching to smarter techniques that can aid in regulating the proper use of land, water, and energy to feed the planet and evade the global food crisis. The AI technology has been successfully adopted by several industries, and now it is set to revolutionize the future of farming with drones, robots and intelligent monitoring systems.

According to NASSCOM (2017), the present share of AI in case of Agriculture and Allied Sectors in India is only 5 per cent but it is estimated that by 2030, it will be doubled. There are so many ways by which AI can be used for farmers like development of learning simulations for the farmers who want to switch to livestock farming, deriving algorithms for ascertaining the animal production, deriving algorithms to understand the pattern and the amount of losses due to animal diseases and mortality, development of AI-Based Livestock Expert Systems, etc. Although, AI has

both pros and cons but it is also a true saying that robots cannot replace humans. Humans are blessed with the power of creativity which will always be lacking in robots. This chapter details the artificial intelligence based ICTs which are being used in livestock sector with special emphasis on the technologies used for livestock products.

Do you know?

Artificial learning (AL) is a specific field of computer engineering that focuses on creating systems capable of gathering data and making decisions and solving problems.

Artificial Intelligence (AI) is usually defined as the science of making computers do things that require intelligence when done by humans.

Machine learning (ML) is the process by which an AI uses algorithms to perform artificial intelligence functions.

Deep learning (DL) is what happens when a neural network gets to work, as the layer process data, the AI gains a basic understanding.

Natural language processing (NLP) is the process when an AI is trained to interpret human communication. E.g. chatbots like Alexa and Siri.

Transfer learning or inductive transfer is a research problem in machine learning that focuses on storing knowledge gained while solving one problem and applying it to a different but related problem.

Turing test was developed by Alan Turing in 1950, is a test of a machine's ability to exhibit intelligent behaviour equivalent to, or indistinguishable from, that of a human.

Big data usually includes data sets with sizes beyond the ability of commonly used software tools to capture, curate, manage, and process data within a tolerable elapsed time.

Internet of Things (IoT) is the network of physical devices, vehicles, home appliances and other items embedded with electronics, software, sensors, actuators, and connectivity which enables these objects to connect and exchange data.

Cloud computing is an information technology (IT) paradigm that enables ubiquitous access to shared pools of configurable system resources and higher-level services that can be rapidly provisioned with minimal management effort, often over the internet.

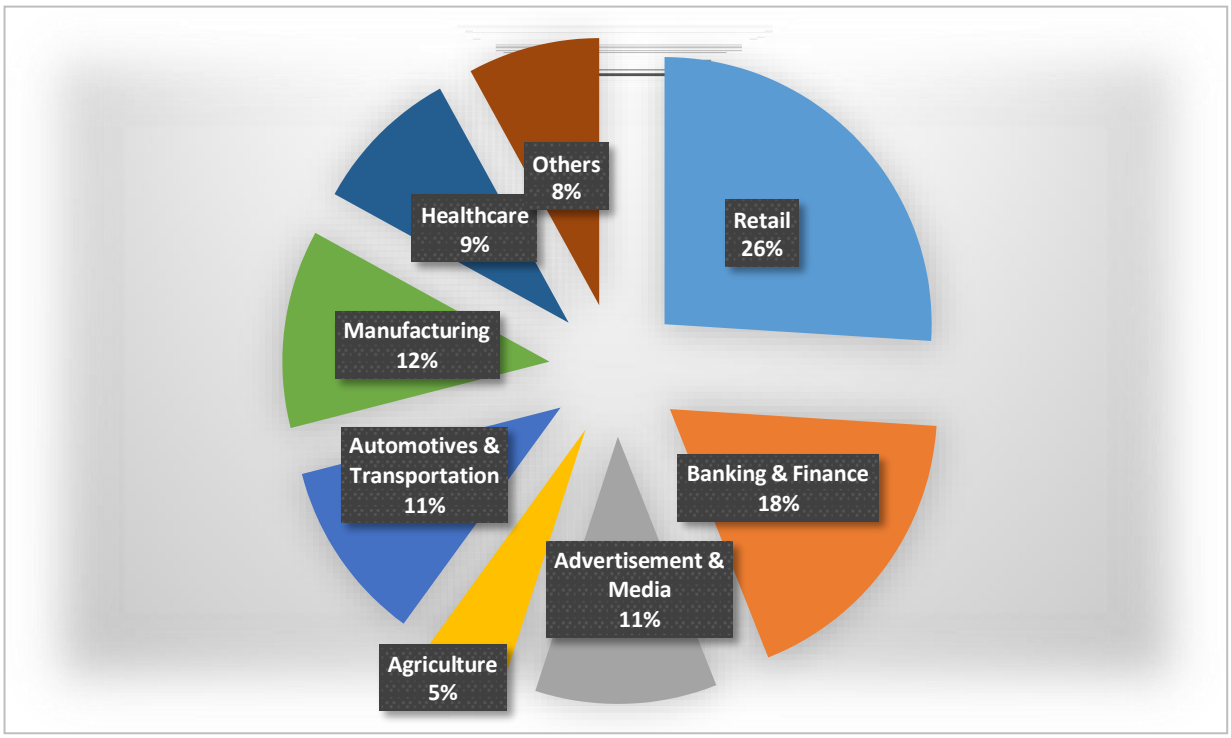
Sector wise breakup of Artificial Intelligence in India

Narendra Modi-led government has taken a leap into artificial intelligence and training its gun to counter China's thrust towards artificial intelligence. Though we have made a modest beginning

and have allocated $480 million to promote artificial intelligence, machine learning and IoT this year, but India badly lags behind its neighbouring country China. Surprisingly, nearly 14.42 per cent of research is done by the industry, compared to 85.58 per cent at universities, a Scopus Analysis by Neel Shah claims. Scopus Analysis shows, about 70 per cent of the AI research is at non-Indian companies' headquarters in India. Google and IBM have published almost 62 per cent of all industry research publications, while there is only one Indian company in the top 10 – TCS with 13 per cent of all publications (Sinha, 2018).

In terms of the number of engineers graduating every year, India is among the top countries. But sadly, the engineering talent in India is largely focused on IT and not research and innovation. The Scopus analysis shows that, out of 129 deemed universities, 67 public institutions, 700 degree-granting institutions, 35,539 affiliated colleges, there are only 15 universities that contribute to almost 42 per cent of all research publications. IIT Kharagpur, which is known as the research hub of the Indian IT sector contributes to just 2.86 per cent of research publication. Scopus Analysis shows that India's research is not matching the world's trend. The country produced less than 600 papers on AI in 2016, which is likely due to the complexity of research and lack of financial support from the government. However, there is an exponential growth in Computer Vision research. Additionally, the average citation of a top researcher in the world and Indian researcher in India is almost same (Sinha, 2018).

According to a report by National Software and Services Association (NASSCOM, 2017), the retail sector of the country employs highest number of start-ups related to AI. The agriculture sector on which 48 per cent of our population depends have market share of only 5 per cent. The following pie-chart shows the per cent share of the sectors in India related to AI ventures.



(Source: NASSCOM, 2017)

Applications of Artificial Intelligence in Livestock Sector

Applications for Livestock Health

Robotic Imaging

Penn Vet is the first veterinary teaching hospital in the world using the EQUIMAGINE robotics-controlled imaging system, which has clinical and research applications for both animal and human medicine.

New Bolton Center now offers robotics-controlled computed tomography (CT) scans of the following body parts in the standing patient:

- Head
- Cranial cervical spine
- Distal limb

Obtaining CT scans with New Bolton Center's EQUIMAGINE system offers several advantages:

- The patient is awake and standing, unencumbered by an enclosed gantry.

- Obtaining the scans with sedation instead of anesthesia saves time and money, and decreases risk to the patient.
- Acquiring a scan takes only about 30 seconds.
- The modality produces high quality, multi-planar reconstructions and 3D images.
- The system enables our radiologists to diagnose conditions difficult to detect with other imaging modalities.
- New Bolton Center's board-certified radiologists interpret the scans and are available to assist in the image acquisition (Penn Vet, 2016).

Canine Patient Simulator

What started in 2010 with the world's first robotic dog simulator for veterinary training has evolved into the opening of a new simulation center at Cornell's College of Veterinary Medicine. Its new, advanced pet simulators are allowing the simulation learning model to spread throughout the veterinary curriculum and paving the way for other institutions to follow suit.

Cornell's new simulation center includes two fully equipped exam rooms, two rooms for live video-feed observation and debriefing, and space for storage and developing new models, like a new robotic cat and a more advanced dog (Hodes, 2013).

Thermal Imaging Cameras

According to Vainionpää a thermal imaging camera is a very useful tool for veterinary examinations. "The use of thermal imaging cameras is a quick and reliable non-contact method. You don't have to sedate the animal, you don't have to touch it and using a thermal imaging camera doesn't expose the animal to potentially harmful radiation." An additional advantage of using a thermal imaging camera in relation to other diagnostic tools, such as X-ray, ultrasound and MRI scanners, is that immediately result can be shown to the owner of the animal the initial results (FLIR, 2018).

Anti-Stress Ear Tag for Cattle

The anti-stress ear tag boosts herd-wide productivity with powerful, real-time animal status monitoring. It analyse 200 parameters at a time and helps in the following

- Unmatched heat detection accuracy, with precise insemination timing guidance
- Early detection of health issues for proactive, individualized health management
- Insight into ration and nutrition issues

- Detection and analysis of environmental factors for optimal decision making
- Enhanced herd-wide monitoring
- Rich, customizable reporting and cow card management
- Integration with third-party herd management software
- Seamless integration to a complete parlor management system (SCR Dairy, 2018).

Pig Respiratory Disease Package

Pig respiratory disease package consists of a microphone installed in the piggery and a sound analyser fitted with the computer. Any change in the voice of the pigs, coughing, and respiratory distress is caught by the microphone and send to the analyser. Any diversion from the normal sound is detected. It is helpful to diagnose diseases 7-10 days before its onset as it is very effective in catching even a minor change in the sound of the respiration of pigs.

Applications for Livestock Production

Automatic Feed Manager

The major feed companies are using artificial production enabled predictive data analytics and a robust data infrastructure to predict the digestive process and its fermentation products based on sensor analyser information, batch conditions and other process data available in the data infrastructure. Any change in the quality of the feed can be detected using the system. One can also make animal specific diet based on the metabolic trials conducted on the animal and its metabolic energy requirements (Abel, 2017).

3D Cameras to assess Beef Cattle

The development of a 3D imaging system is showing potential. To help graziers accurately and objectively assess carcases for live cattle, the DPI is working on a research project to use X Box cameras in the yards to record 3D information on the animals. It'll help producers to work out when it's better to move their animals off-farm and into slaughter processing or to hold them back for a bit to get them to meet market specification. They can be set up on-farm with instantaneous results as animals come into the race or in situations where animals are walking through. We'd be able to assess the amount of muscle on the rear end of cattle as they walk through. That information is recorded. It goes into computer algorithms and then it estimates what that muscle score value is (Herbert 2015).

Robo-Cams for Poultry

A commercially available ground robot outfitted with 2D and 3D sensors and cameras nicknamed GOHBot, the Growout House Robot was initially manually operated in an experimental growout house at the University of Georgia (UGA) to establish the feasibility of operating robots in poultry houses. Results of this testing showed there to be no negative impact on the birds due to robotic systems operating in the flocks. Having established the feasibility of operating a robotic vehicle in the house, the team set out to determine if autonomous navigation was possible. Autonomous navigation could open the door for robotic handling of tasks ranging from automatic removal of floor eggs in breeder houses to constant monitoring of birds for disease and well-being (Poultry Tech, 2016).

Virtual Fences for Controlling Cattle

The application of smart collars is to control cattle in fragile riparian environments. There are experiments in which cattle could be kept out of a region by remote manually applied audible and electrical stimulation. They noted that cattle soon learn the association and keep out of the area, though sometimes cattle may go the wrong way. Cattle learn to associate the audible stimulus with the electrical one and they speculate that the acoustic one may be sufficient after training. The idea of using GPS to automate the generation of stimuli was proposed by Marsh, 1999. GPS technology is widely used for monitoring position of wildlife. On the work of Marsh to include bilateral stimulation, different audible stimuli for each ear so that the animal can be better controlled. The actual stimulus applied consists of audible tones followed by electric shocks.

The Dutch Cattle Expert System (veePRO)

Dutch organisation Veepro created an artificial intelligence expert system which is able to prescribe feed rations, medications, health and welfare conditions for livestock. It can recommend the mating partners for improving genetic potential of offspring. The expert system is able to perform complex analysis of health, reproduction status of individual or groups of animals, to keep track of production and recommend operational measures to be taken in order to improve the farm performance.

Veepro gives information about dairy cattle improvement and health care, supports dairy husbandry, dairy cattle improvement and health care. The system can develop and implement fine-tuned breeding programs. The most important selection criteria are milk production, fat and protein percentage, age durability, functional traits (udder, feet and legs), fertility, health, calving ease, and

type. The indexes for calculating the breeding values are constantly updated according to the newest scientific insights (AI., 2016).

Applications for Animal Reproduction

Smart Neck Collar

With the use of smart collars positive results are seen not only health management but fertility as well. After putting faith in Silent Herdsman, the information one receives is more accurate and reliable. "We don't intervene and induce heats, but we still want to calve them at 24 months old. Heifers are served with sexed semen and the timing of insemination is highly important. The collars have been a huge help," says Blackburn. As a result of the system, average calving interval has decreased significantly – from 430 to less than 400 days and projected to decrease even more. Conception rates have risen from 23% to over 35% (Afimilk, 2016).

Face Recognition Systems

The image-recognition system is able to recognize a cow using both the animal's pattern of spots and the cow's actual face. The system takes a few seconds to recognize an individual cow, the companies said. Giving computers the ability to monitor just how much food and water each cow receives turns what would be a several week manual process into something that happens almost in real time, according to the companies. With that information, dairy farmers can anticipate issues and use the information to adjust feeding — all factors that can help increase a farm's efficiency, along with preventing animal loss. Software features are Maintain information of the cattle, owners, and doctors and Keep a track of cattle information from it heat period to delivery (Digital Trends, 2018).

Cow Gait Analyzer or Pedometry

Female fertility cannot be easily defined as a single trait as it comprises different aspects. Some of these aspects are related to the prompt resumption of cyclicity and the showing of recognizable estrous behavior, while others are related to the ability of the cow to become (and remain) pregnant with a limited number of inseminations. Cow gait analyser analyses the cow in heat as it moves more often than normal days.

Intelligent Dairy Assistant

A Dutch company has developed technology to follow the movements and activities of cows. The high-tech system, powered by AI and motion sensors, is called "The Intelligent Dairy Farmer's Assistant." The company, Connecterra, launched the system in the United States in December 2017 after several years of testing and operations in Europe. A device is put around the neck of the cow to record its movements. This information is then processed by a computer that uses AI to learn about the animal's behavior over time. The system can tell farmers what the cow is doing in real time. This information can help predict when cattle get sick, become less productive or are ready for mating (Harvell, 2018).

MSUES Cattle Calculator

The MSUES Cattle Calculator app has many calculations available to the user relating to beef cattle operations. The app has a reproductive calculator, which can provide calving and breeding dates as well as the breading season. There is also a calculator for animal performance. This tells the user adjusted weight amounts mainly pertaining to birth, weaning, and yearling. The final calculator is for management to make proper decisions on dosage amounts for medication, frame scoring, and much more. This app is free to download and is available to IOS operating systems (farms.com).

Applications for Livestock Products

Robotic Milking Systems or Automatic milking systems (AMS)

Since the 1970s, much research effort has been expended in investigating methods to alleviate time management constraints in conventional dairy farming, culminating in the development of the automated voluntary milking system. There is a video of the historical development of the milking robot at Silsoe Research Institute. Voluntary milking allows the cow to decide her own milking time and interval, rather than being milked as part of a group at set milking times. AMS requires complete automation of the milking process as the cow may elect to be milked at any time during a 24-hour period. The milking unit comprises a milking machine, a teat position sensor (usually a laser), a robotic arm for automatic teat-cup application and removal, and a gate system for controlling cow traffic. The cows may be permanently housed in a barn, and spend most of their time resting or feeding in the free-stall area. If cows are to be grazed as well, using a selection gate to allow only those cows that have been milked to the outside pastures has been advised by some AMS manufacturers.

When the cow elects to enter the milking unit (due to highly palatable feed that she finds in the milking box), a cow ID sensor reads an identification tag (transponder) on the cow and passes the cow ID to the control system. If the cow has been milked too recently, the automatic gate system sends the cow out of the unit. If the cow may be milked, automatic teat cleaning, milking cup application, milking, and teatspraying takes place. As an incentive to attend the milking unit, concentrated feedstuffs needs to be fed to the cow in the milking unit. The barn may be arranged such that access to the main feeding area can only be obtained by passing the milking unit. This layout is referred to as forced cow traffic. Alternatively, the barn may be set up such that the cow always has access to feed, water, and a comfortable place to lie down, and is only motivated to visit the milking system by the palatable feed available there. This is referred to as free cow traffic. The innovative core of the AMS system is the robotic manipulator in the milking unit. This robotic arm automates the tasks of teat cleaning and milking attachment and removes the final elements of manual labour from the milking process. Careful design of the robot arm and associated sensors and controls allows robust unsupervised performance, such that the farmer is only required to attend the cows for condition inspection and when a cow has not attended for milking. Typical capacity for an AMS is 50–70 cows per milking unit. AMS usually achieve milking frequencies between 2 and 3 times per day, so a single milking unit handling 60 cows and milking each cow 3 times per day has a capacity of 7.5 cows per hour. This low capacity is convenient for lower-cost design of the robot arm and associated control system, as a window of several minutes is available for each cow and high-speed operation is not required.

AMS units have been available commercially since the early 1990s, and have proved relatively successful in implementing the voluntary milking method. Many of the research and developments have taken place in the Netherlands. The most farms with AMS are located in the Netherlands, and Denmark. A new variation on the theme of robotic milking includes a similar robotic arm system, but coupled with a rotary platform, improving the number of cows that can be handled per robot arm (Wikipedia, 2017).

Robotic Hide Puller

- This machine is used to remove the hide in a downward pulling motion.
- It pulls the hide from the tail area down along the back and finally over the head.
- The two main operations of the machine are controlled via metered hydraulic pedals.

- The drum is rotated by a hydraulic motor and the main carriage is moved up and down by two hydraulic cylinders (one mounted on either side) actuating simultaneously.
- The hide puller incorporates its own stainless steel stand complete with built in apron washes, knife/whizzer sterilisers drip trays and drainage system
- Both the hydraulic power unit and electrical control panel are built onto the machine frame meaning only electrical power and air supplies are required from the customer.
- The chains detach themselves from the hide automatically when the drum is unrolled.
- This machine is hydraulically powered (GM Steel).

Smart Packaging

Officially called the AMP Cortex system, the robot is nicknamed Clarke, named after science fiction author and futurist Sir Arthur C. Clarke. Cortex uses a camera, much like the one on a typical smartphone, to scan materials as they pass through a conveyor belt on the recycling line. It uses AI that learns from experience to be able to identify the thousands of food and beverage cartons from the other materials on the line.

Cortex is also able to identify the different kinds of carton packaging, from knowing the difference between gable-top and aseptic cartons to being able to differentiate a broth or almond milk carton to knowing a package is not a carton and should therefore not be sorted with them. In fact, Cortex has learned to identify more than 150 carton variations and is constantly learning more (Brown & Horowitz, 2017).

Applications for Animal Welfare

Robot Fish

A robot fish is a type of bionic robot, which has the shape and locomotion of a living fish. Since the Massachusetts Institute of Technology first published research on them in 1989, there has been more than 400 articles published about robot fish. According to these reports, approximately 40 different types of robot fish have been built, with 30 designs having only the capability to flip and drift in water. Most robot fish are designed to emulate living fish which use Body-caudal fin (BCF) propulsion. BCF robot fish can be divided into three categories: Single Joint (SJ), Multi-Joint (MJ), and smart material-based design. The most important parts of researching and developing robot fish are advancing their control and navigation, enabling them to 'communicate' with their environment,

making it possible for them to travel along a particular path, and to respond to commands to make their 'fins' flap (Yu & Tan, 2015).

Protection Assistant for Wildlife Security (PAWS)

PAWS, which stands for Protection Assistant for Wildlife Security, is a newly developed AI that takes data about previous poaching activities and outputs routes for patrols based on where poaching is likely to occur. These routes are also randomized to keep poachers from learning patrol patterns. Using machine learning, a branch of AI, PAWS can continually find new insights as more data is added. Milind Tambe, a professor of computer science at the University of Southern California, became interested in working on an AI solution for poaching after he went to a Global Tiger Initiative conference, where he says his eyes were opened to the threat of extinction for animals like the tiger and elephant (Snow, 2016).

Man's Best Friend 2.0

While PAWS is doing its part to save the lives of threatened animals, one Beijing start-up is taking a more light-hearted approach by creating an artificially intelligent "pet" dog.

This summer, China's ROOBO shared its latest creation with the world: Domgy. The pup bot can roll around a house, navigating obstacles, and it even knows to return to its charging station when battery power is low. Domgy can be controlled via smartphone and is equipped with facial recognition software that allows it to identify and greet individual family members, learn how they like to be entertained, and follow that owner's specific rules and preferences. Aside from offering companionship and a laugh, Domgy can serve as a smart controller for all of its owner's IoT devices, turning on electronics, adjusting the thermostat and acting as an alternative to the standard alarm clock.

It is also a security system thanks to a 5M camera in the device's head. Owners can check in on what their "guard dog" is seeing as it patrols an empty house, and Domgy will even alert family members when it discovers a stranger in the home, according to ROOBO's Marketing Director Anthony Chen. While Domgy isn't directly impacting the lives of animals, it could serve as a stepping stone of sorts to pet adoption, building an affinity for all creatures great and small in the children who grow up around the device. It also enables parents to assess how their kids may react to the introduction of a live pet (Houser, 2016).

Minimizing Drug Testing on Animals

A hard truth about medical innovation has long been the necessity for animal testing before a drug could be approved for human use. One big data analytics company is finding a way to replace live animal subjects with artificially intelligent substitutes.

From its headquarters at John Hopkins University in Baltimore, Insilico Medicine develops new drugs and researches techniques to combat aging and disease. Instead of using live animals or humans, they use computers to test clinical trials through analysis and deep learning methods. "At Insilico, we have not sacrificed a single mouse yet," said the company's CEO Alex Zhavoronkov. "All of our predictions were made on human data and on data obtained from human cells, tissues and organoids." Given enough data, the systems are able to make accurate predictions without the need for animal testing, though Zhavoronkov acknowledges that traditional testing methods are still needed in some cases. He also believes, however, these methods are overused and often not particularly accurate.

"Clinical trials in humans fail over 90 percent of the time after therapies have been tested in mice," he said. "And the animals are often sacrificed in vain without all possible and relevant data collected." Ultimately, Insilico's goal is to create intelligent algorithms capable of developing drugs for humans. If they're able to reach that goal, animal experimentation in healthcare could become a thing of the past (Houser, 2016).

Applications for Livestock Statistics

- Vetel's Diagnostic Software
- IBM's Vet Computing Tool
- Sofie Cognitive Computing Tool
- Deep Mind for Record Keeping
- Deep Genomics

The Way Forward

The booming increase in the internet users in the country shows the promising role of AI based ICTs in livestock development, provided that this potential should be tapped efficiently and on time. The issues like digital illiteracy is still a challenge for the technological interventions in livestock sector but this can be overcome by implementing need based digital literacy programs for the livestock owners. There is a need for the capacity building of stakeholders as well as livestock farmers for

development and use of AI based ICTs. Artificial Intelligence based ICT tools show a promising future but there is a need to check them for their cost effectiveness and there perceived utility in the Indian rural conditions.

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