UNIT 1 DAIRY DEVELOPMENT IN INDIA

Structure

1.0 OBJECTIVES

After reading this unit we shall be able to:

- state the history of dairy development in India.
- indicate the various agencies viz. the Government, NGO's and International agencies, which have contributed to the development of dairying and animal husbandry in India.
- outline the various Government run projects for dairy development.
- specify the contribution of Cooperative, NDDB and the Operation Flood (OF) in increasing the production and per capita availability of milk.
- give the present position of dairying in the country.

1.1 INTRODUCTION

Agriculture in India can be regarded as the fulcrum around which the fortunes of entire economy revolve. Agriculture accounts for 22% of the GDP and provides livelihood to 58% of the country's population. The livestock sector contributes 6.5% to the total national income (Economic Survey, 2003-04).

The origin of livestock wealth is as old as the evolution of human society. In fact this living wealth and the human society are inter-dependent. There is no denying

the fact that livestock wealth apart from being the main source of national wealth is a tool of economic prosperity especially in country like India. The union and state Government in India attach great importance to dairy development as an instrument of promoting socio-economic development of rural people, particularly the poor, landless labour and other down trodden people living below the poverty line. Milch animal rearing is directly encouraged through various dairy development programmes, government subsidy and institutional credit at subsidized rates of interest for the purchase of animals, construction of sheds and fodder, etc. The present status of livestock in general and the animal husbandry and dairying in particular has emerged out of age-old development activities. To have a clear cut idea, the dairy development activities can be studied in three phases *viz*., the Pre-plan or Pre-Independence Period, 1969-70 and post 1970.

1.2 DAIRY DEVELOPMENT IN THE PRE-INDEPENDENCE PERIOD

The history of government intervention in the animal husbandry and dairying can be traced back to the later part of 19th century, when the British troops were inducted in India. They were unable to digest the poor quality of milk. The responsibility of supplying the fresh and quality milk rested with the quarter master general. On his intervention and to meet their daily requirement of milk, various military dairy farms were set up in different parts of the country. The first such attempt to set up a military dairy farm was made in 1891 at Allahabad.

In 1920, the post of Imperial Dairy Expert was created to organize the Indian dairying on sound footing. Prior to that, the entire work of the dairy research and development was being carried out by the Imperial department of agriculture. In 1922 and 1923, diploma in dairying was started at Bangalore and Allahabad, respectively.

Dr. N. C. Wright, Director, Hannah Research Institute, Ayr. (Scotland) was invited to India in 1936 to examine the progress of dairying and to recommend as to how its tempo could be increased. He submitted his report in 1937 and recommended the appointment of Director of Dairy Research, which however was appointed 15 years later after independence in 1952. He drew most of his recommendations from the report of Royal Commission of agriculture and recommended - (i) the grading of the present cattle by better breeding with selected indigenous animals for the production of pedigree animals, for distribution to villagers, for carrying on researches on animal nutrition and for doing propaganda among the villages in the clean handling of milk and milk products. (ii) Setting up a new Dairy Research Institute close to Delhi for specialized research in various fields like Dairy Bacteriology, Chemistry, Technology and Husbandry. (iii) Utilizing existing institute at Bangalore and Anand as regional stations. (iv) Introducing investigations of dairy problems in all agriculture colleges.

An expert cattle committee appointed by the Government of Bombay in 1938 gave their recommendations on (i) cattle improvement and milk production in villages, (ii) milk production and processing, and (iii) transport of milk products and distribution to consuming areas.

National Planning Committee appointed in 1938 under the chairmanship of Pt. Jawahar Lal Nehru had also an impact on dairy development. The sub committee on animal husbandry and dairying reported that (i) There is a considerable scope of expansion in dairy industry and its retail business and as such to meet the dietic needs it must be stepped up, (ii) Development of cooperative societies for production and consumption of dairy produce, (iii) Mechanized dairy farms to substitute existing farms, (iv) Education and higher research, (v) Make cattle fodder and feed adequate.

For the development of dairy cattle, various projects were taken to improve milk production. Bulls were supplied to local bodies and rural areas but the onset of world war intervened and staggered them. After the war, these were again started. To control and develop dairy trade a major project on cooperative dairying was initiated. Three types of co-operative societies viz. milk consumers cooperative societies, milk distributors co-operative societies and milk producers co-operative societies were started. Milk consumers societies were taken up at Burnpur and Allahabad (1943). Among milk distributive societies, the Radha Swami Educational Institute, Dyal Bagh Agra was quite popular. Prominent Milk Production Societies set up were Kaira and Allahabad (1945), Anand (1946) and Banaras, Meerut, Kanpur, Nainital (1949-50). All these societies made a very significant contribution in dairy development.

During this period, many dairy projects like greater Bombay milk scheme, Kaira District Cooperative Milk Union Ltd. Anand, Polson Ltd., Talankhery Co-operative Dairy Society Nagpur, Federation of Milk Union, Calcutta, Lucknow Cooperative Milk Supply Union, Madras Milk Supply Union, Madras, Kaventers Dairy and Ksheera Kshetra came into existence.

1.3 DAIRY DEVELOPMENT FROM 1947-70

After independence too, the major objectives and how to achieve them remained almost the same as in Pre-Independence era. After independence, the Govt. of India, however realized to make a concerted effort to increase the milk production in the rural areas. To achieve these objectives, the efforts were made to develop the dairy industry in three sectors *viz.* the Government/Public Sector, Non-Government Organisations (NGO's) and MNCs.

i. Government Projects

In the Public Sector, three major schemes viz. Community Block Development Scheme, Key Village Scheme and Intensive Cattle Development Programme were launched which are being discussed below: The total outlay on animal husbandry and dairying during the period (First Plan, 2nd plan, 3rd plan and three annual plans) was Rs. 235.93 crores, but the actual expenditure was only Rs. 186.23 crores (79%). The percentage share in the outlay on animal husbandry and dairying was 63% and 37% respectively, while expenditure in the respective categories was 57% and 47%.

(a) Community Block Development Programme.

To achieve social and economic transformation of India, which was identified as the major objective of our five year plans, Community Block Development Programme was started in 55 selected blocks of the country. The importance of the project could be gauged by the fact that the project was launched from Alipore Block, near Delhi by the then Prime Minister of India Pt. Jawahar Lal Nehru on Oct. 2, 1952. The major activities undertaken in the project were in the field of (i) Agriculture, (ii) Animal husbandry, (iii) Irrigation, (iv) Communication, (v) Health, (vi) Education, (vii) Supplementary employment, (viii) Housing, (ix) Training and (x) Social welfare.

The Block Animal Husbandry Officer was appointed in each block to look after the animal husbandry programmes aimed at development of cattle by scientific breeding and disease control. Each block had a network of artificial insemination centers, where local cattle were served with quality semen of proven pedigree sires. By the end of 1968, the strength of the community development blocks went up to 52,651. In addition there were 489 Tribal Development blocks.

(b) Key Village Scheme

Key Village Scheme, a comprehensive and integrated programme of cattle improvement in the country, was launched during the First Five Year Plan. In the

project, each key village was a compact unit of contiguous villages having a population of about 500 adult cows and or buffaloes. The technical programme of cattle development included:

- designing a sound breeding policy for each state.
- enacting the livestock improvement act and the control of contagious diseases among cattle.
- establishment of Artificial Insemination Centers.
- advising the cattle breeders to solve cattle breeding problems by implementing:
  a) Castration of all unapproved bulls and breeding either by artificial insemination or by good quality bulls.
  b) Protection against contagious diseases and provision of first aid facilities for sick animals.
  c) Advise for better feeding
  d) Provision of better marketing facilities.
  e) Organization of cattle shows and calf rallies.

Regarding the progress of the project by 1959-60, a total of 3,61,064 artificial inseminations and 92,105 natural services were performed, which covered almost 25% of the population. In the key village centers, a total of 1473 bulls for AI and 193 bulls for natural service were maintained and about 1.37 lakhs scrub bulls were castrated.

(c) Intensive Cattle Development Project

Key village scheme could not bring about an appreciable impact since it could cover only about 6% population and the good work done in the area was negated by the vast area not covered by the project. In the year 1964, another ambitions project known as Intensive Cattle Development Project, which is similar to the package programme in agriculture and is regarded as an important instrument to increase milk production through intensive and integrated use of all required inputs was launched.

Each ICDP had been planned to cover one lakh cows or buffaloes of breedable age with the facilities of a Central Semen Bank, four regional A.I. centers and 100 stockman centers. Though on the eve of the fourth plan, the total number of ICDP's were 31, but this went on increasing and as per the information available the number increased to 124 by the end of 1992-93.

ii. Non Government Organizations

Not only the Government, but many Non-Government organizations being run by various philanthropic trusts and religious organizations are helping a lot in the development of animal husbandry and dairying in India, however these organizations were provided with financial support from the central and state Governments. Some of the prominent organizations working in the field are being discussed below:

(a) Gosadan Scheme

Gosadan Scheme was launched primarily with the objective to segregate old, infirm, unproductive, useless cattle so as to control indiscriminate breeding and relieving pressure on the limited resources of fodders and feeds. Gosadan are generally located either in remote forest areas or waste lands. In the first plan period, it was proposed to set up 160 Gosadans with 3,20,000 cattle. In the 2nd and 3rd plan too, 60 and 23 Gosadans were proposed to be set up, but the accomplishment fell short of targets. In the first plan only 25 Gosadans could be established.

(b) Goshala and Pinjrapoles

Goshalas and Pinjrapoles are the institutions of charity established with the close cooperation of public. The major objective of these institutions was to house

unserviceable and unproductive animals. There was a clear cut understanding that cows, calves and bullock will be kept in Goshalas while the other animals will be housed in Pinjrapoles.

Central Goshala Development Board was formulated in 1949 with the sole objective of developing existing Goshalas and Pinjarapoles having strength of about 6 lakh heads. In the second five year plan period, development activities were intensified. For the production of quality bulls, 246 Goshalas were selected. In the third plan, again 168 more Goshalas were provided with financial and technical aid and were converted into cattle breeding cum milk production units. It could well be pointed out that on several occasions, many cows belonging to these Goshalas could win the milk yield competitions at the national level.

(c) Central Council of Gosamvardhana

Central Council of Gosamvardhana came into existence in 1952 with the main aim of effecting all round coordinated cattle development at the national level. Council was reconstituted by the Government of India in 1960 and its structure as well as functions were enlarged. The activities were modified to cover organization, implementation and coordination of all programmes and policies relating to "preservation and development of cattle for the increased production of milk and the draft power. Some of the achievements of the council are as below:

- it provided a common forum for administrators, scientists, and non official workers with cattle development work.
- established a close collaboration with central and state Governments and other voluntary organization for advancement of cow and her progeny.
- council could arouse the public interest in the development of cattle by organizing "Gosamvardhana Week".
- conducted the various programmes of seminars, cattle shows and rallies.
- issued journals, books, films and pamphlets for workers.
- worked to provide a planned base for preservation and development of cattle.
- paid considerable attention on the breeding of cattle and adopted a sound breeding policy for entire country at its Mount Abu Seminar in June, 1960.
- conducted one year training course for its Goshala managers.
- Lamer reported in 1960 that there are over 3000 charitable institutions, where 10% of the cattle are estimated to be in some kind of productive activities. These charitable institutions were run by public and religious organizations, but could also muster grant from central and state Governments. Some of the other organizations working in Gujarat, Maharashtra and Bengal area are Baba Mast Ram Trust, Deen Dukhiya Mal Trust, Gandhi Samarak Nidhi and Kasturba Gandhi Trust. All these organizations were catching stray animals from the urban areas and were maintaining them on their farms.

iii. ICAR its Institutes and Agriculture Universities

Indian Council of Agricultural Research fully financed by Govt. of India is playing a crucial role in the development of dairy industry in India. ICAR is the sole body, which formulates the basic policy of dairy development, provides coordination among the various programmes and guides their execution. Various institutes of ICAR such as National Dairy Research Institute (NDRI) at Karnal (Haryana) Indian Veterinary Research Institute (IVRI) at Izzatnagar (U.P.) Centeral Institute of Research on Buffalow (CIRG) at Hissar (Haryana), Centeral Institute of Research on Goats (CIRG) at Makdoom (U.P.) and National Bureau of Animal Genatic Resources (NBGR) at Karnal (Haryana) are engaged in researh pertaining to dairy development. In addition to the above mentioned institutions various agirulture universities under ICAR are also engaged in the dairy development in the country.

Some of these institutes like NDRI and IVRI and many of the agriculture universities are also importing dairy education to create skilled manpower for dairy plants and research institutions in the country.

The policy regarding dairying is formulated and recommended by the Dairying Committee of the Animal Husbandry wing of the Board of Agriculture and Animal Husbandry. ICAR is also deeply concerned with the Dairy Education and Research in the country. It subsidizes Indian Dairy Diploma at Allahabad, publishes books on dairy science and organizes trainings programmes. It is engaged in sponsoring and giving grants to various agricultural Universities in the country for several research projects on the problems related to dairying.

iv. International and Foreign Agencies

The credit of success in the development of dairying in India partly goes to the international organization, which have provided the aid to finance the various activities from time to time. It has been estimated that out of the total amount spent in India from 1951 to 1969 on various development projects, the share of international agencies is of the order of about 20%. Out of the total aid, 58% has been received from USA alone, the share of the World Bank and IDA, Federal Republic of Germany, Britain and USSR was around 13%, 7%, 6% and 6% respectively. Canada and Japan has provided about 7% of the total aid. The remaining 3% has come from another group of 15 countries, the prominent among them being France, Czechoslovakia, Australia and Netherland. The aid received from various agencies is discussed below:

(a) United Nations International Children Emergency Fund (UNICEF)

UNICEF is a pioneer organization, which is spending on an average Rs. 15 crores per year and has contributed significantly towards the development of dairying in India. The procedure adopted to provide/sanction the aid is by approval of joint committee of UNICEF/FAO, who conducts on the spot survey and discusses it in detail with the Central/State Governments. It has helped in the construction/setting up of 17 dairies in the country. In the Rupee Reimbursable Programme, India could get Rs. 90.55 lakhs for Worli, Kaira, Rajkot, Ahmedabad, Kolkata, Aarey Milk Colony, Bangalore Dairy and National Dairy Research Institute, Karnal. In addition to this, Rs. 4.42 crore were provided for various other dairy projects. All this aid which was received from UNICEF was used for the purchase of milk powder, milk plants, equipment and machinery, planning and setting up milk plant and providing training. Apart from this, UNICEF contributed towards organizing dairy teachers tutorial workshop and T.A./D.A. for personnel attending the First Dairy Industry Conference held in India in 1964. The repayment of the aid received was in terms of supplying the milk to the children and nursing mothers in the country.

(b) Food and Agriculture Organisation (FAO)

FAO provided the experts in the implementation of dairy projects in the country. They also helped in conducting the surveys and met the expenditure of training of the Dairy Technicians deputed in the dairy developed countries. Help was also provided for conducting various programmes like Regional Dairy Course at Bombay, meeting on Dairy Problems in Asia and Far-East countries etc. A sum of Rs. 26.86 lakhs was provided for the supply of cattle feed to milk producers of Hyderabad and Delhi. In the process, Punjab was given 250 Friesian heifers from U.K.

Under the Operation Flood Programmes which will be discussed in the later part of this section, 12600 tonnes of skimmed milk powder and 42,000 tonnes of butter oil was sanctioned in 1969, which was to be received in 5 years period, but due to certain reasons, this could not be completed even in 10 years.

(c) CARE

UNICEF and CARE along with other organizations from the United States and India donated 28,000 tonnes of skim milk powder each year valued at Rs. 3 crores for free distribution among School children.

(d) Oxford Committee for Famine Relief (OXFAM)

OXFAM has donated Rs. 14 lakh for the purchase of feed mixing plant to be installed at Kaira District Milk Cooperatives Union.

(e) Heifer Project

Heifer Project Inc. was conceived in 1938 by Dan West, engaged in a church as church relief worker in distribution of milk powder to orphans and babies who were the victims of Spanish civil war. In the later stage, it was considered better to donate cows rather than milk. Under the project by 1962, it had shipped more than 25,000 farm animals and 7.50 lakh chicks and hatching eggs to over 60 countries. India also got in 1955, 6 Jersey bulls for breeding purposes. Arrangements were also made to supply frozen semen from Canada for inseminating other animals. In 1962 again, 78 Jersey bulls and 66 heifers valued at Rs. 33 crores were shipped to India in three installments. In Oct. 1969, 90 Jersey and Friesian heifers and bulls were received from New York. In Nov. 1969, 62 Jersey heifers, 21 Jersey bulls, 10 Friesian heifers and 9 Friesian bulls of top quality were supplied to India. Under this project, USA also gave a free gift of 50 American Jersey cattle (41 bulls, and 9 heifers). USA also provided Brown Swiss Frozen Semen for a cross breeding project at NDRI, Karnal. It is through this only that NDRI could develop Karan Swiss breed, which is considered as a quality breed and yields heavily.

(f) For Those Who have Less Project

Under this project, consignments of animals were received from Australia of various breeds like Guernseys, Friesian and Jersey for breeding purposes. These were distributed in various states like Tamil Nadu, Assam, Maharashtra and Kerala.

(g) International Dairy Federation (I.D.F)/Dairy Society International

International Dairy Federation and Dairy Society International has also contributed to the development of dairying in India. These two organizations discuss problems of international interest. It has set up a separate Commission in 1954 to study the problems of dairying in warm countries.

(h) Aid from other Countries.

Though not very significant (3%) aid has been received by India from various countries like Japan, Italy, France, Czechoslovakia, Australia, Netherlands, Yugoslavia, Poland, Switzerland, Belgium, Austria, Sweden, Denmark, Norway, New Zealand, Hungary and Bulgaria.

Check Your Progress 1

1. Name some of the agencies engaged in the development of animal husbandry and dairying in India?

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2. What are the major activities of community Block Development programme?

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3. Name some of the Non Government Organizations and the autonomous bodies and councils engaged in the dairy development in India?

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4. Name any five international agencies helping dairying in India to develop?

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1.4 DAIRY DEVELOPMENT FROM 1970 ONWARDS

In this country, three forms of organization *viz*. private, government and cooperatives have helped in the development of dairying and animal husbandry. The private dairies by and large have been observed to be solely interested in earning maximum possible profits and have never cared for providing the necessary incentives for milk production. Obviously, there can be no hope for improving the dairy industry by depending on private enterprises owning and operating milk plants. The performance of city milk supply schemes, managed by the Government, did not also prove satisfactory and encouraging. The experience of most successful Dairy Cooperatives such as AMUL and the results of Operation Flood programme being implemented by the erstwhile Indian Dairy Corporation (financing agency for the programme)/ National Dairy Development Board through cooperative organizations has shown that organizing dairying on cooperative lines would only yield desired results. How milk cooperatives have emerged as the most cohesive organizations of the farmers which could handle the milk procurement, transport, processing and marketing of milk on the one hand and how they can improve and enhance the milk production through an infrastructure designed for the purpose and also raise the income and social standards of the rural community in the country on the other hand are some of the important points, which need special emphasis.

i. Dairying through Co-operatives - Anand Pattern

It may be interesting to recall as to how Anand Pattern of organizations came into existence, took shape and ultimately became the model for developing dairying in the entire country. Like other places in the country, in the Kaira District in Gujarat also, milk was being purchased by private vendors. The milk vendors exploited the milk producers by low and defaulting milk price payment, incorrect weightment, and provided little incentive to improve the milk production. Ultimately, the farmers of the district had to decide, striking against these exploitative activities of the private vendors and founded the village cooperatives to procure bulk of their milk and market it. It was with the guidance from able leaders like Late Sardar Vallabh Bhai Patel and Shri Morarji Desai that this beginning could be made. Few of the village cooperatives so organized joined together and formed into a union called the Kaira District Milk Producers Co-operative union at Anand, now popularly known as AMUL.

The success of the concept of managing the milk business by milk producers themselves" at the Kaira District Milk Producers Cooperative Union also AMUL led to the emergence of the strong development tool known as Anand pattern".

The basic unit in the Anand Pattern in the village Milk Producers' Co-operative Society – a voluntary association of milk producers in a village, who wish to market

their milk collectively could become a member of the Co-operative Society. At a general meeting of members, representatives are elected to form a managing committee, which manages the day-to-day affairs of milk collection and its testing for fat content, sale of cattle feed, etc. Each society also provides Artificial Insemination (AI) Services and Veterinary First-Aid.

Each milk producer's milk is tested and paid for on the basis of the quality of milk. Usually the morning milk is paid for in the evening and the evening milk is paid for the next morning. The village societies also market nutritionally balanced compounded cattle feed produced by a cattle feed plant owned and operated by the district level union. The balanced cattle feed is sold on a no-profit-no-loss basis.

The primary milk producers' societies are affiliated to a district union, which owns and operates a feeder/balancing dairy, cattle feed plant and facilities for production of semen and its distribution. The Union also operates a network of veterinarians to provide routine and emergency services for animal health care. The village societies elect the Board of Directors of the Union, which is responsible for the day-to-day management of the union's centralized facilities for milk collection station, processing and marketing of inputs. Each union is professionally managed by a Managing Director, who reports to the elected Chairman and the Board of Directors. The dairy, owned by the Union, usually has a milk drying plant to convert the seasonal surpluses into milk powder and other conserved products. In turn, all the milk union form a federation.

ii. National Dairy Development Board

In the year 1964, the then Prime Minister of India, Late Shri Lal Bhadur Shastri desired that a 'body' should be set up, with the Government's assistance, which would help replicate the Anand pattern of Dairy Cooperatives in other parts of the country. And thus, the Ministry of Agriculture and Irrigation, Government of India, constituted the National Dairy Development Board (NDDB) in September, 1965 under the Societies Registration Act. The major objectives of the NDDB are:

- to promote projects of general public utility relating to dairying, animal husbandry, food and agriculture, fisheries and cold storages.
- to make available, on request, the information, skills and technical services needed to increase production of milk and dairy technical inputs and to speed up procurement, processing and distribution of milk.
- to prepare initial feasibility studies and to design, plan and start-up of operations.
- to provide manpower development services for dairy and allied projects by organizing technical progammes for training personnel.
- to help in the selection of equipment and undertake bulk procurement services.
- to offer consultation services on dairy and allied operations in the field of planning, control, including quality control, organization and marketing back up, wherever necessary, by research within the NDDB and outside, in other organization.
- to serve as international liaison to other National Dairy Boards and international agencies and to facilitate the exchange of information and personnel: as also to assist other countries' dairy development, and
- to conduct research in the field of dairying and animal husbandry.

iii. The Three Phases of Operation Flood (OF)

The first phase of Operation Flood (OF-I) was originally designed to be implemented over a period of five years but was extended till March 31, 1979. The main objective of OF-I was to create a virtual flood of rurally produced milk and lay a foundation for modernizing India's dairy industry. The second phase of Operation

Flood (OF-II) was launched on October 2, 1979, while OF-I was still underway and concluded on March 31, 1985. OF-II was designed to build on the foundation laid by OF-I to create a modern and viable dairy industry to meet the nation's requirements for milk and milk products. The third phase of Operational Flood (OF-III) was started on April 1, 1985 to consolidate the extensive milk procurement, processing and marketing infra-structure created under OF-I and OF-II and finally completed on March 31, 1996.

OF-I was financed by the funds generated from the sale of 126000 MT of Skimmed Milk Powder and 42000 MT of Butter Oil donated to India by the World Food Programme (WFP), an agency of Food and Agricultural Organisation (FAO) of the United Nations Organisation (UNO). In 1970, the original allocation for OF-I was Rs. 95.40 crore for a period of five years, 1970-71 to 1974-75. This was subsequently revised to Rs. 116.54 crore. The funds generated from the sale of donated dairy commodities since the inception of the programme till March 31, 1981 amounted to Rs. 114.68 crore and the actual disbursements over the same period of time were Rs. 116.55 crore. The denoted commodities were received, and sold, on behalf of the Government of India, by the IDC, which as mentioned earlier was the financing agency for the programme. The funds were disbursed by the IDC as 30% grant and 70% loan to the implementing agencies nominated by the participating State governments.

Goal of Operation Flood: This was originally conceived as a milk marketing project aimed at enabling the modern dairies to capture commanding shares of the liquid milk markets in India's four metropolitan cities of Bombay, Calcutta, Delhi and Madras. This goal was to be achieved by creating a virtual 'flood' of milk in the rural milk sheds of these four metropolitan cities and channeling the flood to the liquid milk markets of these cities through a producer-owned-and-controlled co-operative system of milk procurement, processing and its marketing. Eventually, the goal of OF was broadened to include improvements in the standards of dairy farming by introduction of improved methods of breeding, feeding, health care and management of dairy animals backed up by necessary training and extension services. Implementation of operation flood programme through an integrated approach has been taken up under various action items as follows:

- expansion of city dairies.
- new dairies in four cities.
- storage and long distance transportation
- rural dairy processing.
- resettlement of city kept cattle.
- milk production enhancement inputs.
- improved milch animals.
- organisation of rural procurement
- project planning and manpower development
- unloading, storing, transport and central pool.

Although, there were several difficulties with regard to the quality and continuity of dairy commodities received for the programme, the funds generated from their sale provided enough liquidity, buffer, and freedom to the IDC to finance the programme. The programme caused no financial strain on the Government of India's resources. Besides, the programme administrators learnt quite a few useful lessons from their experience with this form of aid and on that basis modified the procedure of receipt of donated commodities. For OF-II, donated commodities were received directly from the donors but not through any intermediaries as was the case with OF-I, and there were face-to-face and man-to-man dealings between the recipients and the donors. OF-II had an original outlay of Rs. 485.51 crore. The

European Economic Community (EEC) assisted it with a donation of 1,86,000 MT of skim milk powder (SMP) and 76,000 MT of butter oil (BO). About US $ 150 million was provided by the World Bank in the form of loans on soft terms. OF-II was approved by the Government of India for implementation during Sixth Plan period with an outlay of Rs. 273 crore. OF-III had an investment of Rs. 1303.1 crore of which Rs. 1095.4 crore was received us the external assistance from the World Bank and EEC and Rs. 207.7 crore by the NDDB's own resources.

OF-III continued to be the major dairy development programme in the Seventh and Eighth Plan period. The main thrust of this programme was the dispersal of dairy development activities on a wider scale in the country and strengthening further the National Milk Grid (NMG) for balancing seasonal fluctuations in milk procurement and marketing, some 1,108 road/rail milk tankers had been provided to meet the requirements of the four metropolitans and other big cities especially during the lean season. Adequate storage facilities were also set up (33,750 MT for milk powder and 4,280 MT for butter oil) to facilitate the operation of NMG. This grid is also helping to even our inter-regional gaps between the demand and supply of milk. With the increase in the production of milk and milk products, the Government of India recognized the NDDB as an agency to stabilize the domestic prices of milk and milk products and exploit any export potential for Indian dairy products.

At the request of the Government of India, the International Development Association (IDA) which is an affiliate of the World Bank, financed three dairy development projects in the States of Karnataka, Rajasthan and Madhya Pradesh. Like OF-I, these projects also sought to replicate the AMUL model of dairy development.

Major Achievements of Operation Flood: OF projects were well underway in 170 milksheds covering 267 districts in 23 States/Union Territories in the country by the end of 1995-96. Except Arunachal Pradesh, Meghalaya, Manipur, and Mizoram, all the states originally envisaged for coverage under the OF programme had been covered. Over 92.63 lakh milk producing families were participating in the programme and over 72.5 thousand VMPCS had been established in the country.

By March 31, 1996 (end of OF-III), the average milk procurement under OF had increased nearly two times as compared to the level of production at the end of OF-II. Almost the same rate of increase was observed during the OF-II period. The average growth in milk procurement in the OF and IDA-assisted project areas was over 20% per annum during the sixteen-year period from the base year of 1980-81. By the end of 1995-96, the total milk processing capacity in the OF milk sheds had gone up to 21.97 million litre per day with an annual growth rate of over 14% per annum since the end of OF-I (1980-81). In many milk sheds in states like Rajasthan, Maharashtra, Tamil Nadu, the capacity created has fallen short of the requirement especially in the peak flush month when milk procurement had to be discontinued to contain the flow of milk to the plants. Altogether by the end of OF-III, the dairies under OF recorded an average milk processing capacity utilization nearly 67% during the peak milk procurement month (January, 1996) and 55% on an annual basis.

Presently, OF dairies are having their milk distribution network in over 778 cities (including 175 metro and class I cities) out of the total of 3700 cities and towns in the country. The average daily liquid milk supply from all sources in the metro cities by the end of March 1995 was 9.42 million litres of which dairy co-operative sector organized through OF contributed 3.47 million litres. During the year 1994-95, OF projects produced nearly 2,68,000 MT of milk powder (including SMP, WMP, baby food), 40,000 MT of butter and 1,30,000 MT of ghee. Milk powder manufacturing capacity in the country increased form 58.50 MT per day in 1970 to 842 MT per

day in 1995-96 and use of imported SMP came down form 19.0 thousand MT in 1970 to 0.7 thousand MT in 1993.

iv. Technology Mission on Dairy Development

The Government of India launched a Technology Mission on Dairy Development (TMDD) in August 1988 to support and supplement the efforts of the OF programme thereby enhancing rural employment opportunities and income generation through dairying in 264 OF districts in the country. The objectives of TMDD were to accelerate the pace of increasing rural employment and income through dairy development on co-operative lines; to accelerate the pace of application and adoption of modern technology to improve overall dairy productivity; to ensure greater availability of milk and dairy products; to dovetail state government programmes in animal husbandry, dairying, poverty alleviation, IRDP etc. with that of the dairy co-operatives; and to dovetail research programmes of the central government research institutes, agricultural universities and NDDB for optimum results. TMDD concluded in March 1997. While the targets for the TMDD during the Eighth Five Year Plan have been achieved to a large extent, the dairy industry needs to improve its performance in many crucial areas. Increasing the productivity of Indian cows and buffaloes, control and containment of animal diseases, improving the regularity and reliability of livestock related data, enforcing high quality standards for dairy products etc. are important areas for urgent interventions.

v. BAIF Development Research Foundation

It was March, 1946 - the dawn of Indian Independence. The brief sojourn of the Father of the Nation - Mahatma Gandhi to Urulikanchan, a backward village near Pune, marked the turning point in community development. Promotion of community health through nature cure became a reality with the establishment of a Nature Cure Centre, managed by his trusted disciple Manibhai Desai.

The village presented an appalling picture to Manibhai. Unemployment and underemployment being the root causes of poverty, Manibhai decided to promote income generation activities as the main plank of development. Cultivation of high yielding varieties of food crops, vegetables and fruits was his first successful venture. However, he realized that these technologies would only benefit the well to do farmers and widen the gap between the rich and the poor.

He maintained a dairy herd consisting of an elite cattle breed - Gir. Although the herd produced several champion cows, the dairy incurred losses due to genetic limitations of this breed. This made him launch a unique experiment of breeding the Gir as well as the local non-descript cows with exotic milch breeds. The new-born crossbred cows were able to produce 10 times more milk than their mothers. Most of the poor farmers who owned non-descript cows were willing to take part in cattle development.

The encouraging response from the rural community prompted Manibhai to establish the Bharatiya Agro Industries Foundation (BAIF) at Urulikanchan in 1967, to replicate his novel experiments in rural development. Later it was renamed as BAIF Development Research Foundation.

Check Your Progress 2

1. When was the NDDB constituted? Give in brief its major objective?

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2. Name the three phases of Operation Flood and the date of start?

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3. Discuss the various action items in the implementation of Operation Flood?

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4. On which date the TMDD was started and concluded?

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1.5 PRESENT POSITION OF DAIRYING IN INDIA

With all the development activities going on in the country, India has ushered into white revolution, and has come at number one position in terms of milk production in the world.

i. Production and Import of Milk Powder

We have stopped the import of milk and milk products altogether rather we have started exporting it. The figures of the import of milk and milk products revealed that in 1960-61, India has imported 18.79 thousand MT of whole milk and commercial milk powder which increased to 53.86 thousand MT in 1961-62. It varied from 34 thousand MT to 53 thousand MT and was found to be 31 thousand MT in 1969-70. From that time onwards, import was almost negligible except for the free gift of skim milk powder and butter oil, which India could get under the Operation Flood Programme. It is worth noting that our own production started in 1967-68 (13.23 thousand MT) and went on increasing. In 1979-80, we produced 64,000 MT of milk powder.

ii. Milk Production

The total milk production in India in 1950-51 was 17.0 million tonnes, which increased to 20.0 million tonnes in 1960-61, 22.0 million tonnes in1970-71. This was 31.6 million tonnes in 1980-81. In other words the milk production increased at a growth rate of about 3.6% per year. After 1969-70, the milk production started increasing at a faster rate and more particularly after 1992-93, when the growth rate was ascertained to be 4.5% per annum. This growth rate was found to be more or less of the same order till recently. (Table 1.1)

iii. Per Capita Availability of Milk

The per capita availability of milk was only 124 g in 1950-51. But with the increase in population which was much faster than the milk population it came down to 112 g in 1970-71 and continued to slighed upto 1980-81. Thanks to the development programme initiated by the Government in the various state that the operation flood programme which showed the results and the per capita availability increased to 176 g (1990-91). Within five years period, the per capita availability increased to 223 g (2000-01). The milk production as well as the per capita availability continued to increase and in 2001-02, it touched a figure of 226 g. Assuming that it is

increasing at the same rate, the predicted figure for the year 2004-05 could be somewhere around 232 g (Table 1.1). But still we have to go a long way. The per capita availability consumption recommended by the Human Nutrition Advisory Committee of the Government of India is 250 g.

iv. Growth Pattern of Livestock Population

The increase in the production of milk and subsequently the per capita availability has been achieved through the various efforts and development programmes. Though the bovine population has also increased, but the increase in the milk production and the per capita availability is much faster. It could be observed from Table 1.2 that the growth rate in cattle was negative in 2003 over 1997. In case of buffaloes, however, it was 8.90 per cent with annual growth rate of 1.78 per cent in 2003 over 1997.

Table 1.1: Production and Per Capita Availability of Milk

Year	Milk(million tonnes)	Per Capita Availability (g/day)
1950-51	17.0	124
1960-61	20.0	124
1970-71	22.0	112
1980-81	31.6	128
1990-91	53.9	176
2000-01	81.43	223
2001-02	84.57	226
2002-03	86.7	230
2003-04	88.1	231
2004-05	91.0	232

This all goes to show that the increase in milk production is not due to increase in bovine population, rather the productivity of animals has increased, but still the productivity of the animal is much lower than the western countries.

Table 1.2: Growth pattern of Livestock Population

Sl. No.	Species	Livestock Population (in million)		Growth rate during 5 years period (%)	Annual Growth rate (%)
		1997	2003	2003 over 1997	
1.	Cattle	198.88	185.18	-6.89	-1.38
2.	Buffalo	89.91	97.92	8.90	1.78
3.	Sheep	57.49	61.47	6.91	1.38
4.	Goat	122.72	124.36	1.33	0.27
5.	Pig	13.29	13.52	1.72	0.34
6.	Others	3.09	2.55	-17.47	-3.49
	Total Livestock	**485.38**	**485.00**	**-0.08**	**-0.02**

Check Your Progress 3

1. What is the total production and per-capita of availability of milk for the year ending 2004-2005?

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2. State about growth rate of cattle and buffalo population.

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1.6 LET US SUM UP

The origin of livestock wealth is as old as evolution of human society. The share of India in the world's population is 25%, whereas the milk production is a little over 14.20%. The country has about 16% of cattle, 57% of buffalo, 17% of goat, and 5% of sheep population of the world and ranks first in respect of cattle and buffalo, second in goats, and third in sheep population. In India, the contribution of livestock sector to the total national income is around 6.5%. To have clear cut idea, the development activities can be studied in three phases *viz.*, Pre-plan, Post-Plan upto 1969-70 and after 1970. Not much work has been done in the pre-plan period except for appointment of certain commission who recommended the setting up of some military farms for the supply of quality and pure milk for the British troops/ Personnel inducted in the army. Some dairies in the Co-operative and Private Sector were also established.

In the post independence period *viz*. 1947 to 1970, various development programmes in the Public Sector *viz*. Community Development Programme, Key Village Scheme and ICDP were started. Many NGO's like Gosadan Scheme, Goshala and Pinjrapoles, Central Council of Gosavardhna contributed towards the development of dairying & animal husbandry. Many other organizations like ICAR, NDRI and IVRI also contributed significantly. The role played by various international organizations like UNICEF, FAO, CARE, OXFAM, HEIFER PROJECT, FOR THOSE WHO HAVE LESS, IDF/DSI is worth mentioning. Many other countries in their own capacities and have shown their concern and have contributed towards the development of dairying in India.

In the 3rd phase (from 1970) dairy development picked up at a much faster speed. The role played by the co-operatives and more particularly Anand Pattern Co-operatives is worth mentioning. The National Dairy Development Board formulated in 1965 took up the 'OF' programme in three phases *viz.*, OF-I, OF-II and OF-III. During this period, the number of Anand Pattern Cooperatives increased, increasing the total milk production.

Present position of dairying reveals that we are ushering into white revolution. We have stopped the import of milk products rather started exporting it. The milk production has increased form 17.0 million tonnes (MT) in 1950-51 to about 91 mt. at present. The per capita availability has also increased from 112 gms in 1968-69 to 232 gms. The strength of animals/bovines have also increased but the quality of the animals & their productivity has increased significantly.

1.7 KEY WORDS

GDP	:	Gross Domestic Project
FAO	:	Food and Agriculture Organisation
Institutional credit	:	Credit form Organised agencies.
Subsidy	:	A grant of public money in aid of some enterprise or industry.
Artificial Insemination	:	To implant or impregnate artificially
Castrated	:	To remove testicles/To make unfit for breeding
Processing	:	To prepare for market by special process or conversion into Products
Adulteration	:	Mixing with something inferior or spurious
Mandate	:	To act according to declared polices.
Dissemination	:	To propagate
Aid	:	Monetary help donated to relieve poor.
UNICEF	:	United Nations International Children Emergency Fund
OF	:	Operative Flood
Heifer	:	A young cow (2-3 yrs. age which has not yet calved)
Per Capita Availability	:	Availability for a person per day
Cooperatives	:	Association of persons for the purpose of joint trading etc.
Cattle Feed	:	Concentrated Feed for Cattle
NDDB	:	National Dairy Development Board.
Feasibility	:	Viability
Bulk Procurement	:	Procurement of Material in lump-sum
Trends	:	To have a tendency
Man Power	:	Available resources in population
BO	:	Butter Oil
SMP	:	Skim Milk Powder
EEC	:	European Economic Community
VMCCS	:	Village Level Milk Consumers Cooperative Society

1.8 SOME USEFUL BOOKS

- Khurody, D.N. (1974). Dairying in India, Asia Publishing House, New Delhi.
- John, P. (1975). Economics of Dairy Development, Parbhat Parkashan, Patna (Bihar)
- NDDB, ANAND, Extension Material/pamphlets (Published from time to time).
- Govt. of India, Ministry of Agriculture, Department of Animal Husbandry & Dairying (1998, 1999, 2000, 2001) Basic Animal Husbandry Statistics.
- Govt. of India, Five Year Plans.
- 17th Livestock Census Report. (2003). Ministry of Agriculture, Department of Animal Husbandry & Dairying.

1.9 ANSWERS TO CHECK YOUR PROGRESS

Your answer should include the following points :

Check Your Progress 1

1) i.
   - Government/Public Sector
   - Research Institutes/Agriculture Universities
   - Non-Government organizations.
   - International aid and Foreign and agencies/countries

2) i. The major activities of the Community Block Development Programme are in the field of: (i) Agriculture (ii) Animal husbandry (iii) Irrigation (iv) Communication (v) Health (vi) Education (vii) Supplementary employment (viii) Housing (ix) Training and (x) Social welfare.

3) i.
   - Gosadan Scheme
   - Goshala and pinjrapoles
   - Central Council of Gosamwardhna
   - ICAR
   - NDRI

4) i. UNICEF, FAO, CARE, OXFAM and Heifer project

Check Your Progress 2

1) i. The NDDB was set up in Sept. 1985 under the Societies registration act. The major objectives of the NDDB are:
   - To promote projects of general public utility relating to dairying, animal husbandry, food and agriculture, fisheries and cold storages.
   - To make available, on request, the information, skills and technical services needed to increase production of milk dairy technical inputs and to speed up procurement processing and distribution of milk.
   - To prepare initial feasibility studies and to design plan and start-up of operations.
   - To provide manpower development services for dairy and allied projects by organizing technical programme for training personnel.
   - To help in the selection of equipment and undertake bulk procurement services.
   - To offer consultation services on Dairy and allied operations in the field of planning, control, including quality control, organizations and marketing back up, wherever necessary by research within the NDDB and outside, in other organizations.
   - To serve as international liaison to other national Dairy boards and international agencies and to facilitate the exchange of information and personnel: as also to assist other counties dairy development and
   - To conduct research in the field of dairying and animal husbandry.

2) i. Operation Flood - I – July 1970
   Operation Flood - II– October 1979
   Operation Flood - III – April 1985
   Additonal information is given at the end of the unit

3) i
   - Expansion of city dairies.
   - New dairies in four cities.
   - Storage and long distance transportation
   - Rural dairy processing.
   - Resettlement of city kept cattle.

- Milk production enhancement inputs.
- Improved milch animals.
- Organization of rural procurement
- Project planning and man power development
- Unloading, storing transport and central poor.

4) i. TMDD was launched in August 1988 and concluded in March 1997.

Check Your Progress 3

1) i. Total Milk production – 91 million tones.

   Per Capita availability – 232 g.

2) i. The increase in the production of milk and subsequently the per capita availability has been achieved through the various efforts and development programmes. Though the bovine population has also increased, but the increase in the milk production and the per capita availability is much faster. It could be observed from Table 1.2 that the growth rate in cattle was negative in 2003 over 1997. In case of buffaloes, however, it was 8.90 per cent with annual growth rate of 1.78 per cent in 2003 over 1997. This all goes to show that the increase in milk production is not due to increase in bovine population, rather the productivity of animals has increased, but still the productivity of the animal is much lower than the western countries.

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Achievements of Operation Flood, 1970-2002

OF phases

Indicator	Phase I	Phase II	Phase III	Post-OF phase
Date Started	July 1970	October 1979	April 1985	April 1996
Date concluded	March 1981	March 1985	March 1996	March 2002
Investments(Rs. Million)	1,165	2,772	13,031	
No. of federations/apex milk unions operating	10	18	22	22
No. of milk sheds covered	39	136	170	170
No. of dairy cooperative societies set up (thousands)	13.3	34.5	72.5	74.3
No. of members (millions)	1.75	3.63	9.26	11.06
Average milk procurement (million kg/day)	2.56	5.78	10.99	17.60
Liquid milk marketing (million litres/day)	2.79	5.01	10.02	12.67
Processing capacity				
Rural dairies (million litres/day)	3.59	8.78	18.09	26.47
Metro dairies (million litres/day)	2.9	3.5	3.88	NA
Milk drying capacity (mt/day)	261.0	507.5	842.0	990.0
Technical inputs				
No. of Artificial Insemination centres (thousands)	4.9	7.5	16.8	22.0
No. of AIs done (million/year)	0.82	1.33	3.94	6.00
Cattle feed capacity (thousand mt/day)	1.7	3.3	4.9	5.2

Source: www.amul.com/achievementsdairycoop.html

UNIT 2 DAIRY CO-OPERATIVES

Structure

2.0 OBJECTIVES

After reading this we shall be able to:

- state the history and principles of Co-operation.
- outline the Anand Pattern of Co-operatives and their working.
- state how the co-operative societies are formed?
- know the Three Tier System of Co-operatives.
- understand about the Milk Federation and its role.
- indicate the role of National Co-operatives Dairy Federation of India (NCDFI), and
- specify objectives of National Milk Grid.

2.1 INTRODUCTION

The concept of cooperation has been evolved from the nature. We can observe co-operation in a body, when many different parts of the body act together and do certain task. No body can think of life without co-operation. Co-operation has been among the most honoured values throughout the history of mankind rather stressed in all the religions and moral systems of the world.

The word co-operation has been derived from the word “Co-operari”, which means to work, toil, act together and endeavour to achieve some common goal. In other

words Co-operative is a common action undertaken to fulfill the interest of all individuals. Webster Universal Dictionary defines co-operation as an association of a number of persons for a common benefit, while Chambers Concise 20th century Dictionary relates it to joint action. In International Encyclopedia of the Social Sciences, Co-operation is defined as the joint or collaborative behaviour, which is directed towards some goal/common interest or hope for reward. Social scientists have defined cooperation in several ways.

According to Fay, C.R. it is "an association for the purpose of joint trading, originating among the weak and conducted always in an unselfish spirit, or short term share in its rewards in proportion to the degree in which they make use of their association". Karve defined cooperation as a common action on equal footing undertaken to promote the legitimate interest of all concerned. It could also be defined as an ethical norm, a social process or an institutional structure known as Co-operatives.

2.2 HISTORY OF CO-OPERATIVES

The history of co-operatives is very old. In ancient times, there were four cooperative institutions known as *'KULA', 'GRAMMA', 'SHRENI', and 'JATTI'*. Our joint family system, in which all the members of the family live together for their betterment is a fine example of co-operative institution. In such a system (Joint Family System), all the members are insured against incapability, illness and old age. In the modern times, we find the cooperatives in all the fields of production, processing, marketing and distribution. Like the other industries/enterprises, in the milk trade too, we have producer co-operatives at the village level, processing cooperatives at the district level known as the Milk Union and the marketing/ distribution Co-operatives at the State level known as Federation.

i. Need of Co-Operatives

Whether it is production, processing or marketing, the producers/individuals are exploited at all levels. As the saying goes, the big fish swallows the small one. It is true in agriculture field, the traders exploit the individuals to pocket the major share of profit leaving the producers poor at the lower end. In milk trade too, the business of milk production is in the hands of innumerous producers belonging to all the category, viz. marginal, small, medium and large producers and the landless cultivators/agricultural labour and artisans. These producers individually produce a small quantity of milk. A part of it is consumed at home and only the surplus milk available with the producers goes for sale. The quantity of the product produced being very small cannot be marketed by an individual since it requires lot of time, labour and resources. With the result he has to sell his produce to an intermediary-the milk Vendor. The milk Vendor exploits the producers by giving them low prices, under weighing the product, not providing any incentive, faulty payments, lifting the milk at his convenience, and more particularly avoiding the evening procurement of milk. All this forces the producers to unite together not only to produce the product but to process and sell it unitedly. The Co-operatives have come into existence at consumers level as Consumers Co-operative Societies to get rid of exploitation from the monopolistic producers. Similarly the co-operatives have come into existence at other levels viz. processing and sales/ marketing and distribution.

ii. Advantages of Co-operatives

Co-operatives came into existence and took its roots because of the inherent advantages laid down as under:

- Prevents exploitation of the poor
- Promotes people initiative, mutual interest and self help.

- Ensure proper use of resources-human, material and financial.
- Forms effective link between producers and consumers.
- Improves production, productivity and quality.
- Provides the consumers with good quality product at a comparatively lower rate and competitive prices.
- Since the resources are pooled, the capital and other constraints are reduced to some extent.
- Many programmes like availability of inputs required for the production process can be started at the village level and can be delivered from producer to producer as per his requirements.
- Links the members of the society to outside world for increasing their benefits.

Check Your Progress 1

1. Name co-operative institutions in ancient times.

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2. List the advantages of Cooperatives.

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3. Discuss the formation of cooperatives?

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2.3 PRINCIPLES OF CO-OPERATION

The principles of co-operatives are aimed at the realization of certain moral values of life. There are four basic principles of co-operation viz.

- Open and voluntary membership.
- Democratic Governance.
- Limited return on equity.
- Equitable distribution of surplus.

Based on these principles, the organization developed the following principles:

- Co-operation between Co-operatives.
- Co-operative Education.

These principles are of universal significance and can be applied to different type of co-operatives in different situations with a considerable degree of understanding and skill. To apply these principles in the various forms and situations, it is of utmost importance to understand these principles.

i. Open and Voluntary Membership

The membership of the society should be open to any body residing in the area according to his willingness only. For it, the criteria could be that he is willing to accept the responsibility bestowed upon him. The right of membership should not be based on religion, cast, political affiliation or other artificial distinctions. The person full-filling the conditions should neither be denied nor compelled to take the membership under pressure either social or legal rather it implies freedom to join, continue or withdraw from the society.

ii. Democratic Governance

All the members of the cooperatives are the owners of the business and have the right and responsibility to govern its affairs either in their individual capacity or through the leader they choose. In case, the business of the cooperatives expands and diversifies, all the members may not get time to meet each other every day to discuss the minor details of the business and take decision. In such cases, it becomes practically difficult to involve all the members all the time. Hence the members have to choose/elect certain members from amongst them selves. The members have to delegate their powers to these elected members, known as Board of Directors, who take the decision at every moment concerning the business. If the member of the board of directors does not have the adequate time to look after the affairs of the society, the powers are delegated to the General Manager, subject matter specialists in the field or to the sub committees formed for the purpose.

iii. Limited Return on Equity

The co-operatives formed is a human association directed towards earning profits and therefore it is an economic enterprise. For starting any economic enterprise capital is required. To raise the capital for running the enterprise, every member of the society contributes his share. This shared capital of the members of the society is known as the equity. Since the money invested as equity by the members has not been paid for direct returns, a limited interest/bonus as determined by the board of directors after calculation of profits is paid to the members from time to time.

iv. Equitable Distribution of Surplus

Since the co-operative society formed is an economic enterprise running with a motto of earning profits, surplus is originated. This surplus can be used in several ways viz. capital formation and expanding the business in the same direction or starting some other business related or unrelated with this business, for common benefits or enjoyment and dividend to the members. The dividend is generally distributed on the basis of the contribution of the members or the number of shares which a member possesses in the society. Non-members who may be directly or indirectly connected with the business are not entitled to any dividend. The surplus after paying the dividend and taxes, etc. remain with the society and is at the disposable of board of directors. They can take the decision to use this surplus capital for the benefit of members, the way they like. One of the way generally used is to give the loan to the members of the society for a specific period at a certain specified rate of interest (generally the rate of interest is the same as offered by the cooperative/public sector banks).

v. Co-operation among Co-operatives

Both in the business and in protecting the interest of one another, the cooperatives work together extending the benefit of cooperation even in wider circles.

vi. Co-operative Education

Cooperative Education means providing knowledge in the principles and techniques

of cooperation to its members, officers and employees at the same time. This will facilitate the Co-operatives to run effectively and efficiently.

Check Your Progress 2

1. List the four principles of cooperatives.

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2. Who can become the member of cooperatives?

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3. What do you understand by equitable distribution of surplus?

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2.4 INDIAN CO-OPERATIVES SOCIETIES ACT

Co-operative Societies Act is a Central Act. However, 'Co-operative Societies' is a State Subject (Entry 32 of List II of Seventh Schedule to Constitution, i.e. State List). Though the Act is still in force, it has been specifically repealed in almost all the States and those States have their own Cooperative Societies Act. Thus, practically, the Central Act is mainly of academic interest. As per preamble to Act, the Act is to facilitate formation of co-operative societies for the promotion of thrift and self-help among agriculturists, artisans and persons of limited means.

The Statement of Objects and reasons states as follow- (a) Cooperative Society can be established for purpose of credit, production or distribution. (b) Agricultural credit societies must be with unlimited liability. (c) Unlimited society is not best form of cooperation for agricultural commodities. However, the provision is continued as in several provinces (now States) such societies do exist and are working. It is not intended to give them undue encouragement, but to legalise their existence. (d) Unlimited society can distribute profits with permission of State Government.

i. Registration of Society

State Government appoints Registrar of Cooperative Societies. State Government also appoints persons to assist Registrar and confer on such persons all or any of powers of Registrar (section 3). Function of Registrar begins with registration of a society. He has powers of general supervision over society. Returns of Society are to be filed with Registrar. He can order inquiry or inspection against society. He can also order dissolution of society.

ii. Societies which may be Registered

A society, which has as its object the promotion of economic interests of its members in accordance with cooperative principles can be registered as a society. Similarly, a society established with the object of facilitating operation of such a society can also be registered under the Act. The society can be registered with

limited or unlimited liability. However, unless State Government otherwise directs, (1) Liability of society of which a member is a registered society shall be limited. (2) Liability of a society of which object is to creation of funds to be lent to members, and of which majority of members are agriculturists and of which no member is a registered society shall be unlimited (section 4). Thus, a registered society can be member of another society, but liability of such other society must be limited, unless State Government otherwise directs.

iii. Who Can Form a Society?

A society can be formed with at least 10 members of age above 18 years. If object of society is creation of funds to be lent to its members, all the members must be residing in same town, village or group of villages or all members should be of same tribe, class, caste or occupation, unless Registrar otherwise directs. The provision of minimum 10 members or residing in same town/village etc. is not applicable if a registered society is a member of another society. The last word in name of society should be 'Limited' if the Society is registered with limited liability (section-6). Registrar is empowered to decide whether a person is agriculturist or non-agriculturist or whether he is resident of same town/village or whether the members belong to same caste/tribe etc. and his decision will be final (section7).

iv. Restrictions on Society with Limited Liability

If a society has limited liability, any individual member of such society cannot have share capital more than one-fifth of total capital. An individual member cannot have interest in shares exceeding Rs. 1000/-. This restriction of 20% shares or Rs. 1000/- shares value is not applicable to a registered society which is member of another society (section-5). Thus, if a registered society is member of another society, it can hold shares exceeding 20% or exceeding Rs. 1000/- in value.

v. Amendment of Bye-Laws

Any Amendment to bye-laws shall be registered with Registrar. If Registrar is satisfied that the amendment is not contrary to Act or rules, he will register the amendments.. He will issue a certificate of registration along with copy of amendment certified by him, which is conclusive evidence that the amendment has been duly registered (section 11).

vi. Rights and Liabilities of Members

If liability of members is not limited by shares, each member shall have one vote irrespective of amount of his interest in the capital [section13 (1)]. If liability of members of a registered society is limited by shares, each member will have as many votes as may be prescribed in bye-laws [section 13 (2)]. If a registered society has invested in shares of other registered society, it can vote by appointing a proxy [section 13 (3)]. A member of registered society shall not exercise his rights as member, unless he has made payment to society in respect of membership or has acquired interest in society, as may be prescribed by rules or bye-laws [section 12]. Thus, if there is any default in payment to society, the member cannot exercise his rights.

vii. Management of Society

Every society will be managed by a Committee. Committee means the governing body of a registered society to whom the management of its affairs is entrusted [section 2(b)]. Office bearers of a society includes a Chairman, Secretary, Treasurer, Members of Committee or other person empowered under rules or bye-laws to give directions in regard to business of society. [section 2 (e)].

viii. Liability of Past Members

Liability of past members towards society as on the date he ceased to be member will continue for two years [section 23].

ix. Restrictions on Loans

A registered society can give loans only to its members. However, it can give loan to another registered society with permission of Registrar [section 29(1)]. A society with unlimited liability cannot lend money on security of movable property without sanction of registrar [section 29(2)]. State Government, by issuing a general or special order, can prohibit or restrict lending of money on mortgage of immovable property by any registered society or class of registered society.

x. Inspection of Affairs of Society

Registrar can hold an inquiry or direct some person authorized by him to hold enquiry in following circumstances- (a) Of his own motion (b) Request of Collector (c) Application by majority of committed members of society or (d) At least one-third of member of society [section 35 (1)]. All officers and members of society shall furnish necessary information to registrar or person authorized by him [section 35(2)].

xi. Dissolution of Society

Registrar, after inspection or enquiry, or on application received form 75% of members of society, may cancel the registration of society, if in his opinion, the Society is to be dissolved. Any member can appeal against the order of Registrar within two months to State Government or other Revenue Authority authorized by State Government. If no appeal is filed within two months, the order of dissolution shall become effective. If appeal is filed, the order will become effective only after it is confirmed by appellate authority [section 39].

xii. Companies Act Not Applicable

Provisions of Companies Act are not applicable to registered cooperative society [section48].

Check Your Progress 3

1. Where the cooperative society should be registered?

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2. Who can from the society?

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3. How the society is managed?

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2.5 CO-OPERATIVE MOVEMENT IN INDIA

After the introduction of cooperative societies Act 1904, the cooperative movement started. Cooperatives were organized to break the poverty cycle of small farmers, which was due to the poor facilities, low productivity, famines and the heavy dependence on money lenders, who charged heavy rate of interest. The farmers were also exploited by the intermediaries engaged in the marketing of the produce. These co-operatives formed aimed to encourage thrift and wide use of credit.

In 1912, a legislation was passed to give the power to the cooperatives (other than credit cooperatives) to be incorporated. In 1918 again, the responsibility for cooperative legislation was given to state governments. During the period 1920-1940, many co-operative societies came into existence. It is interesting to note that a very large number of cooperatives were from agriculture field. The number went on increasing and more and more emphasis was laid in the formation of cooperatives in the subsequent five year plans. National Cooperative Development Corporation has reported in 1992, that there were 3,38,000 cooperatives with membership of about 15.60 crore people with 43.7% share of agricultural credit. This was an impressive achievement for a country like India in less than half a century after its independence. Again under the Operation Flood (OF) programme stress was laid on the formation of milk cooperatives.

i. Anand Pattern Co-operatives

An introduction to Anand Pattern of co-operative has been given in the Unit (1.4).

We know that the success of Kaira District Co-operative Milk Union popularly known as “AMUL” lead to the emergence of the strong developmental tool known as “Anand Pattern”. It is designed to support the production, procurement, processing and marketing/distribution of milk and milk products. It is owned by the milk producing farmers. The salient features of Anand Pattern of Dairy Co-operatives (APDCs) are as under.

- A single commodity approach
- Decentralised decision making and producers elected leadership
- A three- tier organizational structure
- Employment of professionals
- Accountability of these professional to milk producers
- Provision of providing technical inputs
- Integration of production, procurement, processing and marketing functions
- Regular audit
- Contribution to development of village

Amul pattern provides opportunity to farmers to control over the resources they create. The farmers elect those who manage their affairs and subsequently appoint professional managers and hold them accountable.

The most important factor is that the cooperatives organized both in the villages as well as the District Union are in a purely democratically knit system. The milk producers own elected representatives form the Board of Directors of the Union. The Union’s board appoint a General Manager and other professional staff for day-to-day working of the union. Thus, the institutional structure wherein the farmer producers frames the general policies for conducting the milk business through the help of professionals. They look themselves that the policies laid are pursued in the right direction in the interest of the producer members emerges and grows consistently. The Anand Union grew gradually in the 50s and 60s and developed

to become a successful model to be followed in rest of the country.

The basic unit in the Anand Pattern is the Village Milk Producers' Co-operative Society, a voluntary association of milk producers in a village, who wish to market their milk collectively. Every milk producer can become a member of the Co-operative Society. In the general meeting of members, representatives are elected to form a managing committee, which manages the day-to-day affairs of milk collection and its testing for fat content, sale of cattle feed etc. Each society also provide Artificial Insemination (A.I.) services and Veterinary First-Aid.

The primary milk producers' societies are affiliated to a district union, which owns and operates a feeder/balancing dairy, cattle feed plant and facilities for production of semen and its distribution. The Union also operates a network of veterinarians to provide routine and emergency services for animal health care. The dairy, owned by a Union, usually has a milk drying plant to convert the seasonal surpluses into milk powder and other conserved products. With the help of the dairy plant, the Union is able to ensure that the milk producers get 80-90% of the lean season price even in the flush season.

The cattle feed plant owned and operated by the co-operative union is able to provide nutritionally balanced cattle feed at prices 20-30% lower than the prices of the traditional feeds. The milk producers are therefore able to substantially increase their returns from milk production because of the better returns for their milk and lower feeding costs. Each co-operative dairy tries to market the bulk of its milk as liquid milk and converts the surplus milk into products. The profits made by the dairy are redistributed to the milk producers as a subsidiary payment. Many Societies are able to pay 12-15% bonus to their milk producers based on the business transacted with their union.

It was in the year 1964 that the Prime Minister of India Late Shri Lal Bahadur Shastri after visiting Anand and having convinced himself of the benefits that accrued to the rural Milk Producers desired that a national body should come up, which would help replicate dairying through cooperatives on Anand Pattern in the other parts of the country. Thus, came into existence the National Dairy Development Board in September, 1965. In 1969, the National Dairy Development Board formulated an integrated dairy development programme popularly known as operation Flood-I programme. The proposal envisaged 18 Anand Pattern Dairy Cooperatives in the hinter-land milk sheds of India's four major Metropolitan Cities viz. : Calcutta (Kolkata), Bombay (Mumbai), Delhi and Madras (Chennai), to provide for guaranteed investment in milk producers organization, milk production, processing and marketing. Each structure thus erected was to be handed over to the producers whose milk handled thereby put this instrument of development into the hands of rural milk producers. Concurrently in the four major cities, the urban dairy plants capacities were to be built up so that they could capture a commanding share of the market for milk. A beginning was made in the year 1970 with the funds generated from out of the conserved commodities received as gift from the World Food Programme. The funds generated provided the finances for operation Flood Programme as a whole. To handle the donated commodities, generation of funds and their disbursements for procurement, the Government of India set up the Indian Dairy Corporation which became the finance and promotion house in the country's dairy development. The NDDB became the official technical expertise body for the IDC. Now, IDC has merged with NDDB. With the implementation of this programme till March, 1981, it became possible for establishing 13270 Villages Dairy Cooperative Societies and to bring into the fold of cooperative ambit around 17.47 lakes farmers families. The capacity of the rural dairy plants was enhanced form the pre-project level of 6.6 lakh litres per day to 45.38 lakh litres per day and the throughput level raised form 4.60 lakh litres per day to 33.87 lakh litres per day. Similarly, the milk

marketing capacity of the metro dairy plants could be raised from the pre-project level of 10 lakh litres per day to 29 lakh litres per day and the throughput form 9.02 lakh liters per day to 22.76 lakh litres per day.

ii. Co-operatives in Dairy Development

According to the All India Report on Agricultural Census 1970-71, there have been some 70.50 million households cultivating around 162.12 million hectares of land in India. Of the total households engaged in agricultural farming and operating different sizes of land, approximately 70% households have been operating in less than two hectares of land. These farming families operate some 21% of the total cultivated land in India. It is significant to note that of the total agriculture farming units in India, about 33% cultivated land holding size is less than 0.5 hectares. Another 18% operated land holdings between 0.5-1.0 hectares. Those who cultivated land between 1.0-2.0 hectares were around 19% of the total cultivators in India (1970-71). The human population is increasing day by day-and –the size of land holdings are further being split into smaller size groups. Thus the role of dairying in the economy of the farmer has gained further importance in the present context.

As far as the organized attempt in dairying is concerned, in this country we have seen three forms of organization - private, government and co-operatives. The private dairies by and large have been observed to be solely interested in earning maximum possible profits and have never cared for providing the necessary incentives for milk production. Obviously, there can be no hope for improving the dairy industry by depending on private enterprises owning and operating milk plants. The performance of city milk supply schemes, managed by the governments, did not also prove satisfactory and encouraging. The experience of most successful Dairy Cooperatives such as Amul and the results of Operation Flood programme being implemented by the Indian Dairy Corporation/National Dairy Development Board through cooperative organizations has shown that organizing dairying on co-operative lines would only yield desired results. How milk co-operatives have emerged as the most cohesive organizations of the farmers which can handle the milk procurement, transport, processing and marketing of milk on the one hand and how they can improve and enhance the milk production through an infrastructure designed for the purpose and also raise the incomes and social standards of the rural community in the country are some of the important points, which need special emphasis.

Check Your Progress 4

1. What are the salient features of Anand pattern cooperatives?

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2. Who were the brains behind establishment of cooperatives?

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3. What does Amul stand for?

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4. What is the basic unit in Anand Pattern cooperatives?

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2.6 THREE TIER STRUCTURE OF DAIRY CO-OPERATIVES

Co-operatives in India are working at three stages viz. production processing and marketing. At the primary level in villages itself, the willing farmers join together to form a Milk Producers Co-operative Society. As already mentioned they form a society popularly known as Village Milk Producers Co-operative Society (VMPCS) as per the agreed principles of milk cooperatives. The secretary of the society appointed by elected representatives runs the day to day affairs of the society viz. collects the milk, tests for its quality, dispatches the milk to the Union/chilling centers, prepares the bill, draws the payment and distribute it to the producers. In addition to this he supplies the seeds and other inputs as available and required from time to time.

The second stage is the milk union at the district level (Milk District Co-operative Union). The membership of the Union consists of all the registered milk producers societies in the district or any other co-operative institution, which undertakes to supply to the Union commodities belonging to its members. The Union/chilling center collects the milk, which is processed/converted into products at the plant owned by the Union. The union at district level arranges the various facilities which other wise a society cannot arrange viz. (i) supplies the milk testing kit and the consumables required for testing, (ii) makes payment for milk procured by the society, (iii) supplies inputs i.e. fodder seed etc. for the producers, (iv) supplies milk products and concentrate feed for sale in the villages and (v) arranges for supply of semen for insemination and first aid to the sick animals in the villages and host of other facilities.

All the unions in the state form a co-operative federation at the state level (State Dairy Development Co-operative Federation). Federation appoints the Chief Executive officer to every union, who administers and runs the day to day activities of the Union, but is supervised by the Board of Directors of the Union. The Federation in turns supplies all the inputs to the Union, markets the produce for all the Unions, collects the money and gives it to the Union of onward transmission to the societies. In other words it is the three tire system i.e. village level, district level and finally the state level.

2.7 MILK FEDERATIONS

As mentioned earlier all the Unions in the state or contiguous districts form an apex body known as the Federation. The Federation, working under the Managing Director markets the products produced by various milk unions, supplies inputs and provides consultancy and supervises their activities. Federations at the level of the state is known as State Dairy Development Co-operative Federation, while at the national level, it is known as National Cooperative Dairy Federation of India (NCDFI).

i. National Co-operative Dairy Federation of India

The National Co-operative Dairy Federation of India (NCDFI) was registered in 1970. In June, 1985, the bye-laws of the NCDFI were substantially amended to

limit its membership to federal dairy co-operatives of the States and union territories and the NDDB. The amended bye- laws vest with these members- to the extent that the Multi-State Co-operative Societies Act, 1984, permits—the direction, management and control of the NCDFI. In December 1986, to gain locational advantage, the NCDFI shifted its headquarters from Delhi to Anand, the milk capital of India.

In December 1990 NCDFI included the co-operative oilseeds growers federations as its members. There are now 21 state co-operative milk producers federation apex unions and 7 oilseeds growers co-operative federations as the members of the NCDFI. These state federations comprise 170 district co-operative milk producers unions and 19 co-operative oilseeds growers' regional unions. The primary level membership comprises about 74500 villages co-operative societies and 98 lakh farmers.

Presently, the NCDFI is performing and consolidating the activities initiated during 1984 to 1987. These are: members relations, establishing a common national platform for the dairy and oilseeds co-operatives and, functioning as a single window for the coordination of purchases and supplies activities of the national level institutions and members of the NCDFI. The NCDFI is also working to improve the quality of these services by evolving an organizational climate of professionalism and excellence.

The NCDFI is managing on turnkey basis, the movement of 142 broad gauge Rail Milk Tankers in different regions of the country. There are about 24 linkages that have been established over time for the movement of liquid milk from the surplus milksheds to the demand centers. Further-more, the NCDFI has undertaken a series of measures - including a comprehensive agreement with the railways - to ensure improved turn around time and efficient utilization of the fleet.

The focus of the NCDFI is to facilitate - through co-operation and networking - a shift from:

- the restrictive and repressive co-operative laws in the country to the creation of an enabling legal environment where co-operatives can thrive and prosper.
- State owned or supported co-operatives to member-owned and controlled self reliant co-operatives.
- Political and state interference in the affairs of the co-operatives to the management of the co-operatives through enlightened membership
- Unnecessary interference in the day-to-day functioning of the co-operative by its board of directors to the evolution of true partnership and accountability between the board and a professional chief executive officer who enjoys the autonomy and power to fulfill organizational objectives.
- a policy of having chief executive officers on loan or deputation from government or other organizations to having a professional chief executive, who is a permanent employee of the co-operative and is specifically appointed by and accountable to the board of the co-operative.
- a policy of having a system of common cadre of senior officials who keep shunting between the federation and its constituent unions to the policy of having mutually exclusive and independent full time permanent employees in the unions and the federation.
- a policy where quality and excellence were viewed as a luxury policy to the policy where quality and excellence are pre-requisites for the organizations to succeed in the market place.

ii. Main Functions

National Cooperative Dairy Federation

- Develop inter Dairy Cooperative relationship
- Research, Publication and Consultancy on Dairying
- Liaison with NDDB, Government of India, etc.

State Cooperative Dairy Federations

- Production programming
- Marketing of milk products
- Coordinating bulk purchases
- Assist the Unions in input programmes
- Training, consultancy etc.

District Cooperative Milk Producers Union

- Organisation and supervision of primary cooperative societies
- Collect milk from primaries for processing and manufacturing milk products
- Ensure regular payment to DCS
- Marketing liquid milk in their area of operation
- Distribution of cattle feed
- Provide technical inputs
- Extension activities
- Arrange training of staff, DCS personnel
- Educate member farmers and farmer ladies

Primary Milk Producers Cooperative Society

- Collection and sale of milk to milk unions
- Ensure regular and remunerative payment to producers
- Help members to increase milk production
- Provide veterinary First Aid and Artificial Insemination services
- Sale of cattle feed

2.8 NATIONAL MILK GRID

The operation Flood – II, which began in 1981 aimed at building a National Milk Grid linking 136 rural milk sheds in 22 states and union territories with the Urban demand centers in the country and creating infrastructure required to support a viable dairy industry. Milk Grid takes care of the surplus milk within the State, where the milk from the surplus area/district is transferred to the deficient area. Under such a situation, it is termed as State Milk Grid. When the surplus milk from one state within the region is transferred from surplus states to the deficient state it is called a Regional Milk Grid. Transportation of milk from the surplus region to the deficient region is called National Milk Grid.

National Milk Grid now in operation in India is capable of transporting large quantities of pasteurized milk across long distances in hygienic conditions by rail or road tankers. For example, insulated rail tankers carrying 40000 litres of milk, routinely move from Anand or Guntur or Jalagaon to Calcutta, covering distances of 1500 to 2000 km. in 30 to 40 hours, with only a 2^0 C rise in the milk temperature. This takes place in a developing country where, traditionally, a paucity of transportation and infrastructure facilities has restricted the reach of fresh produce to potential markets.

At present, one rake of 60 wagons each ply milk between Anand and destinations such as Delhi, Calcutta and Guwahati each week. To that extent, the National Milk Grid exists and it connects all the four metros and about 500 towns that come in between, the nerve center being Anand in Gujarat. The milk procurement by the 12 district member unions of the Gujarat Co-operative Milk Marketing Federation Ltd. (GCMMF) stood at 44.19 lakh litres per day in 2000-01.

Check Your Progress 5

1. What is the three-tier structure?

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2. Who are the members of the district union?

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3. Explain the form NCDFI.

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4. What is the basic purpose of Milk Grid?

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2.9 LET US SUM UP

The concept of cooperation has been evolved from the nature and has been related to human body. All the parts of human body cooperate with each other to make an action. The word cooperation has been derived form the word 'Co-operari' which means to work, toil and act together and endeavour to achieve some common goal. In simple words co-operative is a common action undertaken to fulfill the interest of all individuals. Various encyclopedias like Universal Dictionary, Chambers 20th Century Dictionary, International Encyclopedia of Social Sciences have explained and interpreted the meaning of Co-operation in their own ways. C.R. Fay, Hemeik and Karve too explained the term. The History of Co-operatives is very old and is related to the institutions like *'Kula'* , '*Gramma', 'Shreni'* and *'Jatti'*. Gradually, it took the shape of 'Joint family', which served as an insurance against incapability, illness and old age. Cooperatives came into existence because the producers were exploited by the intermediaries/vendors by giving low price, incorrect weighing of the products, not making the payment at proper time and indulging in various corrupt and malpractices. The formation of cooperative could to some extent over come these things.

The principles of co-operatives are aimed at the realization of certain moral values of life. The four basis principles of co-operatives are (i) open and voluntary

membership, (ii) democratic governance (iii) limited returns to equality and (iv) equitable distribution of surplus. Based on these principles the organization developed the following principles (i) Co-operation between co-operatives and (ii) Co-operative education.

Indian cooperative societies Act is a central Act. Though Cooperative Societies is a State Subject, the central act is still in force. It has specifically been repealed in almost all the states and those states have their own cooperative Societies Act. It includes the statement of objects and gives the direction regarding the framing of rules for the Registration of Society, Who can form a society, Restriction on society with limited liability, Amendment of bye laws, Rights and liabilities of members, Management of Society, Liability of past members, Restriction on loans, Inspection of affairs of society and Dissolution of Society, etc.

Anand Pattern of cooperatives came into existence, took shape and ultimately became the model for development dairying in the entire country. The basic unit in the Anand Pattern is the Village Milk Producers Cooperative Society - a voluntary association of milk producers in a village, who wish to market their produce collectively. All the village milk producer cooperatives in a district are the members of their District Milk Cooperative Union. All the unions in the district combine together to form a Federation. Federation takes care of all the Unions in a particular state and are termed as State Milk Federation. This system of milk handling by the societies at three levels viz. procurement, processing and marketing/distribution is known as three tier system.

National Co-operative Dairy Federation of India, though registered in 1970 started functioning as an apex body of the cooperative dairy industry in 1985. There are at present 21 State Cooperative Dairy Development Cooperative Federations and seven Oilseeds Growers Co-operative Federations/Apex Unions in its fold. These State Federations are spread over 170 District Co-operative Milk Producers Unions and 19 Cooperative Oil Seed Growers Regional Unions. The primary level membership comprises about 74500 village co-operative societies and 98 lakh farmers.

2.10 KEY WORDS

Co-operative	:	To toil, work, act and endeavor together for some common goal.
Kula	:	Kin or persons of the same family, relatives and Friends.
Gramma	:	Village or Gram Sabha.
Joint Family	:	Members of the family living together for their betterment.
Exploitation	:	Act of using for selfish purposes.
Voluntary	:	Without compulsion or legal obligations.
Democratic	:	Equal right and privileges for all
Equitable	:	In accordance with Equity.
VMPCS	:	Village Milk Producers Cooperative Society.
DDCF	:	Dairy Development Co-operative Federation.
NCDFI	:	National Co-operative Dairy Federation of India.
Three tier system	:	Cooperative at three stages viz. Village level, District level and State level
Bye-laws	:	Rules and regulations

Milk Grid : Linking of Milk Shed areas with Urban Demand Centres

2.11 SOME USEFUL REFERENCES/SUGGESTED FURTHER STUDIES

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2.12 ANSWERS TO CHECK YOUR PROGRESS

Your answer should include the following points :

Check Your Progress 1

1) i. Kula, Gramma, Shreni and Jatti

2) i. Prevents exploitations of the poor.
   ii. Promotes people initiative, mutual interest and self help.
   iii. Ensure proper use of resources-human, material and financial.
   iv. Forms effective link between producers and consumers.
   v. Improves production, productivity and quality.
   vi. Provides the consumers with good quality at a comparatively lower rate and competitive prices.
   vii. Since the resources and pooled, the capital and other constraints are reduced to some extent.
   viii. Many programs like availability of inputs required for the production process can be started at the village level and can be delivered from producer to producer as per his requirement.
   ix. Links the members of the society to outside world for increasing their benefits.

3) i. To get rid from the exploitation of middlemen get timely and remunerative prices of the produce.

Check Your Progress 2

1) i. Open and voluntary membership
   ii. Democratic Governance.
   iii. Limited return on equity.
   iv. Equitable distribution of surplus.
   v. Based on these principles, the organization developed the following principles:
   vi. Co-operation between co-operatives.
   vii. Co-operative Education

2) i. Any body residing in the area according to his willingness, should be more than 18 years of age, having sound mind, good character and should not have been declared solvent.

3) i. Surplus could be reinvested in capital formation expanding the business and paying and distributing the dividend/bonus to the members on the basis of their contribution or the number of shares in the society.

Check Your Progress 3

1) i. Society could be registered under the societies act with the Registrar of cooperative societies.

2) i. A society can be formed with at least 10 members of age above 18 years residing in the same area.

3) i. Every society is managed by a committee, which means the governing body to whom the management of its affairs is entrusted under section2 (b), office bearer of the society includes chairman, Secretary, treasures and other members.

Check Your Progress 4

1) i. A single Commodity approach
   ii. Decentralized decision making and producers elected leadership
   iii. A three-tier organizational structure
   iv. Employment o professionals
   v. Accountability of these professional to milk producers
   vi. Provision of providing technical in-puts
   vii. Integration of production, procurement, processing and marketing functions.
   viii. Regular audit.
   ix. Contribution to development of village.

2) i. Sardar Vallabh Bhai Patel, Morarji Desai

3) i. Anand Milk Union Ltd.

4) i. Village Milk producers Co-operative Societies

Check Your Progress 5

1) i. Milk producers cooperative society at village level, Milk producers union at district level and milk producers federation at state level.

2) i. All the village level societies will become the member of the union.

3) i. National cooperative Dairy Federation of India.

4) i. To supply the milk form deficit area to the surplus are within the district/ state/the country.

UNIT 3 GOVERNMENT POLICIES AND INCENTIVES

Structure

3.0 OBJECTIVES

After reading this unit we will be able to:

- state the policies and incentives taken by the Government in the current plan period;
- enumerate important on-going schemes in dairy development; and
- specify the features of on-going schemes.

3.1 INTRODUCTION

The role of dairy development in increasing milk production, improving the nutritional standards of the people, generating employment opportunities (both direct and indirect) and improving income level in rural areas, especially for small and marginal farmers and agricultural labourers has been well established. We have already learnt the role of various organizations (like NDRI, NDDB, NGOs, Cooperatives etc.) and programmes (like Operation Flood) in the development of dairying in India. These institutions and programmes are directly related to the government policies and initiatives for improvement of both milk production and marketing.

Presently animal husbandry and dairying receive priority in the government's efforts for generating wealth and employment, increasing the availability of animal protein in the food basket and for generating exportable surpluses. The value of output of milk at current price (2003-04) was Rs.110085 crore, which is about 67% of the total contribution of livestock sector. Table 3.1 gives the information about the percentage contribution of livestock sector in the total Gross Domestic Product (GDP) of the country and the percentage contribution of milk in the total livestock sector. The Tenth Plan target for milk production is set at 108.4 million tonnes (MT). envisaging an annual growth rate of 6.0 per cent. Dairying plays a crucial role in rural economy and livelihood particularly for the rural women who play a significant role in dairy farming and are directly involved in major operations like

feeding, breeding, management and health care. In dairying, 75 million women are engaged as against 15 million men. As the ownership of cattle and buffaloes are more evenly distributed with landless labourers, and marginal farmers, the progress in the dairying sector will result in a more balanced development of the rural economy, particularly in the reduction of poverty ratio. Even many small and medium farmers who derive yearly savings from agriculture are dependent on livestock especially dairy and poultry for daily subsistence. The allocation for animal husbandry, dairying and fishery is Rs. 2500 crore during the tenth plan.

Table 3.1: Percentage contribution of livestock sector in the total Gross Domestic Product of the country and the percentage contribution of milk in the total livestock sector.

Year	% Contribution of livestock sector in total GDP of the country	% Contribution of milk in the livestock sector
1993-94	6.5	64.8
1994-95	6.3	66.3
1995-96	6.1	66.7
1996-97	6.0	66.2
1997-98	5.9	66.0
1998-99	5.7	67.5
1999-00	5.6	67.4
2000-01	5.7	67.5
2001-02	5.7	66.8
2002-03	5.7	66.0
2003-04	5.6	66.9

3.2 VISION AND MISSION OF THE GOVERNMENT

In the last few decades, the overall growth rate in livestock sector was steady and was above 5% per annum and this has been achieved despite the fact that investment in this sector was not substantial. But since the Ninth Plan there is some decline in the growth rate of livestock products. Total livestock output increased at 3.8% per annum during the Ninth Plan, slower than the 4.5% growth rate achieved during 1980-97. In comparison to the Ninth Plan, growth rates in the first two years of the Tenth Plan have declined quite significantly - milk (2.2% from 4.3%), egg (2.14 from 7.3%) and wool (-0.6% from 2.1%). A matter of concern is that milk and egg production has decelerated despite the latest Livestock Census showing large increase since 1997 in the number and proportion of crossbred cattle and also of poultry. Besides drought conditions, feed availability and marketing problems of livestock products appear important.

Broad frame-work of cattle and buffalo breeding policy recommended for the country since mid-sixties envisaged selective breeding of indigenous breeds in their breeding tracts and use of such improved breeds for upgrading of the non-descript stock. While the States accepted the framework, appropriate implementation of the same through field level programme could not be done. Lack of interest in promoting Breed Organization/ Societies and related farmers' bodies contributed to gradual deterioration of indigenous breeds. That there had been large deviation from the laid breeding policy is quite obvious from the fact that crossbreeding which was to be taken up in a restricted manner and in areas of low producing cattle has now

spread indiscriminately all over the country including in the breeding tracts of some of the established indigenous cattle breeds.

Investment in the dairy sector has been reduced drastically in the Ninth Plan. In comparison to Eighth Plan investment of Rs. 821.43 crore (against the plan outlay of Rs. 900 crore), the maximum investment during 9th Plan would be Rs. 130.93 crore against the plan outlay of Rs. 469.52 crore. Out of 168 Milk Unions, 119 Milk Unions (70.8 percent) were running in loss as on 31.3.1998. So far, the Government policy in dairy sector has been to give preference to the establishment of milk processing plants and selling liquid milk particularly in urban areas. This policy was guided by an overall shortage of milk and the national milk production falling short of nutritional requirement during the earlier years of planning era. But the scenario has changed from a milk shortage environment to conducive environment that will enhance demand so that growth rate of milk production is stimulated. No policy measures were undertaken so far to give a fillip to the unorganized sector involved in the production of Indian dairy products (like *ghee, paneer, channa, khoa*, etc.), which have tremendous potentiality for export market in Asian and African countries.

The major focuses of Government of India for dairy development during the Tenth Five-Year Plan are:

1) The main thrust will be on genetic upgradation of indigenous/native cattle and buffaloes using proven semen and high quality pedigreed bulls and by expanding artificial insemination and natural service network to provide services at the farmer's level. Production of progeny-tested bulls in collaboration with military dairy farms, government/institution farms and *gaushalas* will be taken up.
2) Conservation of dairy breeds should be the national priority to maintain diversity of breeds and preserve those showing decline in numbers or facing extinction.
3) After the successful eradication of Rinderpest disease, the focus would now be to adopt a national immunization program to control prevalent animal diseases. Efforts will be made for the creation of disease-free zones to boost export of milk products.
4) Development of fodder through cultivation of fodder crops and fodder trees, regeneration of grazing lands and proper management of common property resources.
5) Building infrastructure for animal husbandry extension network. Panchayats, cooperatives and NGOs should play a leading role in generating a dedicated band of service providers at the farmer's doorstep in their respective areas
6) Strengthening infrastructure and programmes for quality and clean milk production and processing for value addition.
7) An information network would be created based on animal production and health with the active involvement of Research Institutions, Government departments, private industries, cooperative, and NGOs.
8) A regular interaction between the Department of Animal Husbandry and Dairying and research institutes like the Indian Veterinary Research Institute, National Dairy Research Institute, Institutes on cattle, buffalo, sheep, goat, equine and camel.

Check Your Progress 1

1) How livestock sector plays a crucial role in the rural economy?

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2) What are the major focuses of Government of India for dairy development during the Tenth Five-Year Plan?

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3.3 SCHEMES FOR DEVELOPMENT OF DAIRYING

i. Intensive Dairy Development Programme (IDDP)

The implementation of Operation Flood (OF) program has revealed that linking of milk shed/milk production areas to the urban markets pays rich dividends through increased availability of milk to the urban consumers and remunerative return to the rural milk producers through cooperative infrastructure. During Operation Flood implementation period, the dairy development activities in the non-operation flood, hilly and backward areas, which have comparatively lesser potential for milk production, were carried out by the State Governments under the State Plan Schemes.

However, due to limited resources of the State Governments, it has been observed that there is a strong need on the part of Government of India to support efforts of the State Governments in taking up dairy development activities in these areas. Accordingly, the Department of Animal Husbandry and Dairying had launched a scheme entitled "Integrated Dairy Development Project (IDDP) in Non-Operation Flood, Hilly and Backward Areas" on 100% grant-in-aid basis during the 8th Plan period and continued during IX Plan. The proposal to further continue the scheme during the remaining period of X Plan and also in the XI Plan period has been considered by Government of India.

The Government of India has now approved the implementation/continuation of the modified scheme during X Plan period. The scheme would be entitled "Intensive Dairy Development Programme" (IDDP) and is implemented in hilly and backward areas including the districts which have received less than Rs. 50.00 lakh for dairy development activities during Operation Flood Program. The total Central Outlay of the scheme during the X Plan period is Rs. 175.00 crore.

Funding: The pattern of funding in non-operation flood areas will be on 100% grant in aid basis from Central Government to the State Governments/Union Territory Administration except for the cost of land. The pattern of funding for the districts which were covered under OF program but where investment during OF Programme was less than Rs. 50.00 lakh will be 100% grant in aid for the processing capacity up to 20,000 liters/ day. Above this capacity, OF pattern will be followed namely, 70% loan and 30% grant.

Implementation

- The State Dairy Federations/District Milk Unions in view of their expertise and professionalism will implement the project.
- The funds will be released directly to the implementing agencies to avoid delay in release of funds and speeding up the implementation of the project.
- The project will be prepared based on cluster approach in areas with better availability of water and fodder.
- Provision will be made for producing better quality milk in order to create environment for production of clean and good quality milk and adopting good hygienic practices.

- Maximum project cost will be Rs. 3.00 crore per district.
- Major components of the project will have the following ceilings:
  - Milk processing and marketing facilities (including chilling, processing, product manufacturing and marketing – not more than 60% of the total project cost.
  - Milk procurement activities including expenditure on DCS milk transportation, procurement tankers and other vehicles etc. – not more than 30% of total project cost.
  - Technical input services including breed improvement, animal health care, feed and fodder development/provision etc. – not more than 20% in areas where the breed improvement facilities are not provided under National Project for Cattle and Buffalo Breeding (NPCBB) or any other similar program and not more than 10% in areas covered by NPCBB etc.
  - Cattle induction to be restricted to only scheduled castes/scheduled tribes and BPL families subject to an overall ceiling of 10% of the total project cost and subsidy may be restricted to 50% of the NABARD cost of cattle.
  - Manpower development including training requirements of field and dairy staff as well as Management Committee of DCS and farmers training – not more than 10% of the total project cost.
  - Working capital–not more than procurement price for 21 days of the targeted milk procurement.
  - Management grants for a period of 3 years on a tapering down basis.
  - Benchmark survey and preparation of high quality Detailed Project Reports – not more than 3% of the total project cost.
  - Concurrent evaluation and in-depth independent evaluation to be undertaken– not more than 2% of the project cost.

Monitoring: The project prepared by the State Governments/Implementing Agencies within the project guidelines given in preceding paragraphs shall be considered by the Project Sanctioning Committee .The projects will be regularly monitored on quarterly basis by a Technical Management Committee headed by Secretary, In charge of Dairy Development in the concerned State/Union Territory.

ii. Strengthening Infrastructure for Quality & Clean Milk Production

Government of India has introduced a centrally sponsored scheme "Strengthening Infrastructure for Quality & Clean Milk Production" during 10th Plan period with following objectives:

- Creation of infrastructure for production of quality milk and milk products at the farmers level up to the points of consumption.
- Improvement of milking procedure at the farmers level.
- Training and strengthening of infrastructure to create mass awareness about importance of clean milk production.

Funding: The pattern of funding under the scheme will be on 100% basis, for the following components:

- Training for clean milk production to all members of the society.
- Detergent, antiseptic solutions, muslin clothes.
- Utensils and accessories for clean milk production.
- Strengthening of existing laboratory facilities.
- Planning and monitoring.

The pattern of funding under the scheme will be in the ratio of 75:25 for purchase of bulk cooler between Government of India and the respective Dairy Cooperative/ Union.

Implementation: Dairy Cooperative/Union/Federation will implement the scheme through State Government. The Project shall be prepared as per the guidelines of the scheme given below and shall be submitted through concerned state Government/ Union Territory Administration to the Department of Animal Husbandry & Dairying.

i. The first element of the project formulation would be to undertake an analysis of the proposed village to ascertain the quality standard of milk available in the village and adjoining areas both in terms of bacteriological and chemical quality. Then the status and performance of the Dairy Cooperative Society (DCS) formed in the village; its total collection and distance covered to transport the milk to the union/nearby market will be examined.

ii. While preparing the project it must be ensured that the villages and the DCS proposed for consideration under any other similar schemes on clean milk production of NDDB/Central/State Government are not covered by this scheme.

iii. While selecting DCS all such DCSs those are located in a single charged milk collection route under a Union should be covered under the scheme. In this manner all DCS of a milk route will be covered at the first stage.

iv. It should be emphasized that all DCSs, who are currently procuring more than 500 liters of milk should be considered at first priority for providing post milking chilling facilities. At second priority, all DCSs having potential of collecting 500 liters of milk per day and having no post milking chilling facilities available within a reasonable distant area but located in the same milk collection route will be selected for assistance under the scheme. In such cases, at first a DCS shall have to be organized before the village can be considered for assistance under the scheme.

v. Farmer-members who have supplied milk for a minimum of 250 days in a year to the self associated DCS or to another nearer DCS (from farmer's cattle shed/procurement spot) will be considered for assistance under the scheme. However, all farmer-members associated with the concerned DCSs shall be considered for training.

vi. Selection of DCS and selection of Farmer-members as per above shall be done by the technical/management officers involved in milk procurement and in field level extension services of Dairy Cooperative Union/Federation or Department of Dairy Development of State Government.

vii. Training program will be undertaken by 'Technical Expert Group for Training' constituted by Dairy Cooperative Union/Federation or Department of Dairy Development of the State Government or at existing training institute nearby.

viii. The training shall cover theoretical explanation as well as practical demonstration.

ix. As for the referral text material required for the theoretical training, Dairy Cooperative Union/Federation shall get this material printed and shall distribute the same to each farmer-member in local language at the time of training.

x. There will be one theoretical session and a practical demo-session in a day. Thereafter, regular field technical staff shall examine the impact of the training for seven to ten days and if needed, they shall supervise day to day activities in the field. The second theoretical session shall thereafter be taken up followed by a practical demo session.

xi. Expenditure on each farmer-member shall be @ Rs. 125/- for one day of training including referral text material contingency expenditure during the training program.

xii. The expenditure involved against the traveling expenses of the trainer experts may be met by the concerned department/Dairy Cooperative Union/Federation.

xiii. As a part of the project formulation exercise, Dairy Cooperative Union/ Federation will have to ensure that inputs relating to 25% of the financial assistance for chilling facilities will be borne by the respective society/Union.

xiv. The Project will be examined and scrutinized by Dairy Division and approval by the Department in the normal course up to cost of Rs. 5.00 crore and by a Project Sanctioning Committee (PSC) for the Project costing more than Rs. 5.00 crore.

xv. The total outlay for the scheme for 10th Plan is Rs. 30.00 crore and the budget provision of Rs. 1.00 crore for implementation of this scheme during 2003-04 as grant in aid to State Government/Union Territory.

iii. Assistance to Cooperatives

Many district level milk cooperative unions established under Operation Flood programme are running in loss and the effort to rehabilitate them through the Central Sector scheme 'Assistance to Cooperative' is also not effective in most cases. During Operation Flood Programme, about 265 districts out of over 500 (presently 600) districts in the country were covered; the remaining 250 districts will be covered by the ongoing scheme 'Integrated Dairy Development Project (IDDP)'. Due to various problems a significant number of Milk Unions created under both the Operation Flood and Integrated Dairy Development Projects are running in loss. The Government of India's 'Assistance to Cooperative' scheme supports the steps necessary to restore the financial health of some loss-making district milk unions established under Operation Flood program. The scheme provides for matching contribution of grants (50:50) from the Central and State Governments. The scheme is implemented through National Dairy Development Board (NDDB). NDDB on its part would reschedule loans, waive penal interest and freeze interest on outstanding loan.

iv. National Project for Cattle and Buffalo Breeding (NPCBB)

The NPCBB scheme is implemented by the Department of Animal Husbandry and Dairying for restructuring and reorienting cattle and buffalo breeding operations in the country with special emphasis on maintaining quality in inputs and services. The project will, over a ten year period, bring under organized breeding coverage, all the breedable female cattle and buffalo in the State through a combination of (i) a vastly improved artificial insemination (AI) network delivering AI at the farmers door step and (ii) it will strategically position bulls for natural service. The project will be implemented in two phases: I phase between 2001-2005 and II phase between 2006-2011.

Under this project, 100% grant-in-aid will be provided to the States for taking up the following activities:

- Survey work to generate relevant information.
- Conduction of Seminar and Workshop
- Computerization at state and district level.
- Strengthening of training center, bull farm and semen bank/stations etc.
- Strengthening of infrastructure for Liquid Nitrogen storage and distribution
- Training of professionals.
- Establishing of breeders association and progeny testing programme.
- Training of A.I workers (both departmental and private worker)
- Farmers training and extension program
- Conversion of static to mobile AI centers.
- Purchase of equipment for private AI workers
- Tapering grant for private AI workers

- Purchase of new bulls.
- Extension programme and farmers training.
- Equipment for AI workers.
- Strengthening of AI networks.
- Managerial grant to State Implementing Agency
- Miscellaneous

Check Your Progress 2

1) Describe the salient feature of the major scheme of Government of India for creating milk marketing infrastructure in rural India.

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2) State the features of the Central Sector Scheme for clean milk production.

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3) Explain National Project for Cattle and Buffalo Breeding (NPCBB)

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3.4 INCENTIVES SCHEMES FOR FARMERS, YOUTH AND ENTREPRENEURS

i. Dairy/Poultry Venture Capital Fund:

Small rural producers scattered all over the country accounting for about 70% of production characterize milk production in India. In India, a far larger proportion of milk continuous to be handled by the unorganized sector i.e. about 85% comprising innumerable small processors and manufacturers of indigenous milk products. But the main contention in the unorganized sector is quality, which cerates a serious threat to human health. The Government of India has introduced this scheme in the tenth plan to provide financial assistance for setting-up/modernization of dairy sector. The interventions through the scheme involve the generation of self-employment and providing infrastructure to the unorganized sector for making improvement in the quality resulting in food safety. It will help in bringing a significant portion of unorganized sector in the ambit of organized sector and will result in increasing the commercial viability of the activities.

The guidelines for the approval of the project shall be as below:

- The financial assistance of 50% of the project cost will be provided by Government of India as interest free loan while 40% of the project cost shall be provided by the financing bank at the rate of interest as applicable for agricultural activities and 10% share of the project cost shall be borne by the beneficiary. Besides this, the Government of India will also subsidize the interest component applicable for agricultural activities to the extent of 50% in case of regular/timely repayment by the beneficiary.

- The Government of India will release its share to NABARD, which will be maintained by it as revolving fund.
- The scheme will be extended to agricultural farmers/individual entrepreneurs and groups of all sections of unorganized as well as organized sector.
- The proposals will be sanctioned by the commercial banks as per the guidelines of RBI, NABARD and Government of India. The recovery of loan, when made, will be divided between the Government of India's share and the Bank's share of loan on pro-rata basis. Similarly, the loan will be disbursed simultaneously from the revolving fund as well as banker's share on pro-rata basis.

The components, which can be funded under the scheme, are given below. However, they may be funded individually or in combination.

S.No.	Component	Maximum total project cost* (Rs. In lakhs)
1.	Establishment of small dairy farms – Ten animal unit (buffaloes/cross breed cows) for milk production	Rs. 3.00 lakh per unit (up to ten animals) – Any Non Operation Flood areas. – The total cost depends on the infrastructural facilities required.
2.	Purchase of milking machines/ milk-o-tester/bulk milk cooling unit, etc.	Rs. 15.00 lakhs Milking Machine, Milk-o-tester Bulk Milk Cooling units (up to 2000 ltr. Capacity)
3.	Purchase of dairy processing equipment for manufacturing indigenous milk products.	Rs. 10 lakhs per unit – Unit cost depends upon the quantum of milk to be handled and the type of products to be manufactured. – The total cost depends upon the investment on civil structures, type and source of machinery.
4.	Establishment of dairy product transportation facilities including cold chain.	Rs. 20 lakh per unit – Unit cost depends upon the quantum of milk/milk products to be transported/handled and the type of products to be transported. – The total cost depends upon the investment on type and source of transport vehicle and machinery.
5.	Cold storage facilities for milk and milk products	Rs. 25 lakhs per unit – Unit cost depends upon the quantum of milk/milk products to be stored and the type of products to be stored. – While the cost depends upon the investment on type and source of machinery used.
6.	Establishment of private veterinary clinics	Rs. 2.00 lakhs per unit for Mobile clinics and Rs. 1.5 lakh for Stationary clinic-Area of operation from 8 to 10 villages having 5000 to 6000 cattle units.

ii. Livestock Insurance Scheme

The Department of Animal Husbandry & Dairying will introduce a Centrally Sponsored Scheme 'Livestock Insurance' in the year 2005-06.The justification given for introducing the scheme are:

- To protect the farmers and landless labour against losses, which they have to incur resulting from untimely death of livestock, owned by them.
- It is difficult for the Government to persuade the farmers to go in for genetic upgradation of their cattle through cross breeding or acquisition of high yielding milch animals unless sufficient incentive is provided by way of insuring them against losses (which will be much higher in case of crossbred and high yielding animals) caused by death of these animals.

The broad features of the proposed new scheme are:

i) While eventually all types of livestock will be brought under the scheme, it is proposed to concentrate initially on crossbred and high yielding cattle and buffaloes. Maximum 2 dairy animals per farmer will be insured under this scheme.

ii) While preference will be given to small and marginal farmers and landless labour, other farmers will not be excluded from the purview of the scheme.

iii) It is proposed to link the new scheme of livestock insurance with Centrally Sponsored Scheme of 'National Project for Cattle and Buffalo Breeding' (NPCBB) this scheme so as to ensure easy identification of animals to be insured and necessary follow-up; this will also act as an incentive for the participants in NPCBB.

iv) The insurance companies will be persuaded to apply the scheme rates (which are lower) or near scheme rates, for the animals to be covered under the proposed new scheme. The expected premium would be around 5-6% for a policy period of 3 years.

v) It is proposed that 50% of the premium should be borne by the Government (the remaining 50% to be paid by the beneficiary).

vi) To ensure active involvement of the veterinary practitioners at the village an incentive of the order of Rs. 50 per animal will have to be provided for them.

iii. Others Schemes for Dairying

Besides the Ministry of Agriculture, schemes relating to dairying are being implemented by other ministries viz. Ministry of Food Processing Industries, Department of Science and Technology, Ministry of Rural Development. During the tenth plan, Ministries of Food Processing Industries (MOFPI) had been operating many schemes for the development of food processing sector which inter alia includes setting up/expansion/modernization of food processing industries covering all segments viz. fruits & vegetable, milk products, meat, poultry, fishery, cereal, pulses, oil seeds and such other agri-horticultural sectors. During the tenth plan, these schemes were merged and one macro level scheme for 'Infrastructure Development' has been introduced with a view to enabling small and medium scale units to attain viability by defraying the cost of major facilities such as cold storage, warehousing, R&D Laboratories, power and water supply, etc. Under the scheme Food Parks will be established in different parts of the country. For packaging center, entrepreneurs will get assistance upto 25% of the total cost of plant and machinery and technical civil works (33% in difficult areas) subject to a maximum of Rs. 2 crore. The scheme has also provision for assistance for stationary/mobile pre-cooling storage, refrigerated transport system and freezer cabinets at retail outlet. Technology Information, Forecasting & Assessment Council (TIFAC) under the Department of Science and Technology also assist for projects like clean milk production and improvement of milk quality. The Ministry of Rural Development

assists in the formation of dairy cooperatives especially women dairy cooperative through the Science Technology Entrepreneurs Parks (STEP) programme. Assistance is also available for construction of milk chilling centers.

Check Your Progress 3

1. Name the major components funded under the scheme Dairy and Poultry Venture Capital Fund.

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2. Write about Infrastructure Development Scheme.

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3. State about Livestock Insurance Scheme.

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3.5 LET US SUM UP

Now, we have learnt about the policies and initiatives taken by the Central Government. The main thrust will be on genetic upgradation of indigenous/native cattle and buffaloes, conservation of dairy breeds, implementation of a national immunization programme to control prevalent animal diseases, development of fodder, building infrastructure for animal husbandry extension network and strengthening infrastructure and programs for quality and clean milk production and processing for value addition. The major Central Government Schemes for development of dairying sector are: (i) Intensive Dairy Development programme (IDDP), (ii) Strengthening Infrastructure for Quality & Clean Milk Production, (iii) Assistance to Cooperatives, and (iv) National Project for Cattle and Buffalo Breeding (NPCBB).

IDDP is implemented in hilly and backward areas including the districts, which have received less than Rs. 50.00 lakh for dairy development activities during Operation Flood Programme. The pattern of funding in non-operation flood areas will be on 100% grant in aid basis from Central Government to the State Governments/Union Territory Administration except for the cost of land. The pattern of funding for the districts which were covered under OF program but where investment during OF Programme was less than Rs. 50.00 lakh will be 100% grant in aid for the processing capacity up to 20,000 liters/day. Above this cap, OF pattern will be followed namely, 70% loan and 30% grant. The main objective of the scheme “Strengthening Infrastructure for Quality & Clean Milk Production” is to create infrastructure for production of quality milk and milk products at the farmer’s level up to the points of consumption. The pattern of funding under the scheme will be in the ratio of 75:25 for purchase of bulk cooler between Government of India and the respective Dairy Cooperative/Union. Further 100% grant is given for training of farmers for clean milk production, purchase of detergent, antiseptic solutions, muslin cloth, utensils and accessories for clean milk production and strengthening of existing laboratory facilities. District level milk cooperative unions,

which were established under Operation Flood program and are presently running in loss, are rehabilitated through the Central Sector scheme 'Assistance to Cooperative'. The scheme provides for matching contribution of grants (50:50) from the Central and State Governments and is implemented through National Dairy Development Board (NDDB). National Project for Cattle and Buffalo Breeding (NPCBB) is implemented by the Department of Animal Husbandry and Dairying for restructuring and reorienting cattle and buffalo breeding operations in the country with special emphasis on maintaining quality in inputs and services. The project will, over a ten year period, bring under organized breeding coverage, all the breedable female cattle and buffalo in the State through a combination of (i) a vastly improved artificial insemination (AI) network delivering AI at the farmers door step and (ii) it will strategically position bulls for natural service. Under this project, 100% grant-in-aid will be provided to the States for taking up the above activities.

There are incentive schemes for farmers, youth and entrepreneurs, which would help them to take up dairying as a profession. Under the Dairy/Poultry Venture Capital Fund, financial assistance of 50% of the project cost will be provided to the entrepreneurs by Government of India as interest free loan while 40% of the project cost shall be provided by the financing bank at the rate of interest as applicable for agricultural activities and 10% share of the project cost shall be borne by the beneficiary. Besides this, Government of India will also subsidize the interest component applicable for agricultural activities to the extent of 50% in case of regular/timely repayment by the beneficiary. Livestock Insurance Scheme would protect the farmers and landless labour against losses, which they have to incur resulting from untimely death of cattle and buffalo owned by them. Two animals per farmer can be insured with subsidized premium. Fifty percent of the premium should be borne by the Government and the remaining 50% to be paid by the beneficiary.

Besides the Ministry of Agriculture, schemes relating to dairying are being implemented by other ministries viz. Ministry of Food Processing Industries (Infrastructure Development Scheme), Department of Science and Technology, Ministry of Rural Development. Technology Information, Forecasting & Assessment Council (TIFAC) under the Department of Science and Technology assist for projects like clean milk production and improvement of milk quality. The Ministry of Rural Development assists in the formation of dairy cooperatives especially women dairy cooperative through the STEP program. Assistance is also available for construction of milk chilling centers.

3.6 KEY WORDS

Central Outlay : It is the allocation earmarked in the annual budget of a Central Department for particular developmental scheme(s).

Clean Milk Production : Clean Milk is generally defined as "milk drawn from the udder of healthy animals, which is collected in clean dry milking pails and free from extraneous matters like dust, dirt, flies, hay, manure etc. Clean milk as a normal composition, possesses a natural milk flavour with low bacterial count and is safe for human consumption."

Conservation of animal breed : It is the protection and management of biodiversity of different breeds within a species. There are two ways of conservation viz. Ex-situ and In-situ conservation. *Ex situ'* refers to

conservation approaches outside of a breed's natural habitat – for example, in zoos and in gene banks. *In situ'* is the conservation of ecosystems and natural habitats and the maintenance and recovery of viable populations of species in their natural surroundings. In case of domesticated species, the 'surroundings' refer to places and environment where they have developed their distinctive properties.

Gross Domestic Product (GDP) : It is the output of goods and services produced within a country including nationals and resident foreigners but excluding the remittance/profit received from other countries.

NABARD : National Bank for Agriculture and Rural Development (NABARD) was established through the Act of Parliament on 12 July 1982 for providing and regulating Credit and other facilities for the promotion and development of agriculture, small scale industries, cottage and village industries, handicrafts and other rural crafts and other allied economic activities in rural areas. NABARD serves as an apex financing agency for the institutions providing investment and production credit for promoting the various developmental activities in rural areas.

Progeny testing : It is obvious that bulls can't be tested directly for traits like milk production. This is overcome by evaluating the performance of a large number of his offspring (progenies). Progeny testing of bulls involves the mating of the bull to a number of cows in several herds using artificial insemination and recording the performance of the daughters in their first lactation.

Venture Capital : Venture capital is capital provided by outside investors/agencies for financing of new, growing businesses. Venture capital investments generally are high risk investments but offer the potential for above average returns. A venture capitalist (VC) is a person/agency who makes such investments.

Working Capital : Working capital is the capital used to meet the day-to-day business expenditure. This is used to satisfy the contingencies and uncertainties. Working capital = Current assets – current liabilities.

3.7 SOME USEFUL BOOKS

Animal Husbandry & Dairying (Chapter). Mid-term Appraisal of the Ninth Plan, Planning Commission, Government of India.

Working Group Report for the Tenth Plan (2002-07), Department of Animal Husbandry & Dairying, Government of India.

Animal Husbandry & Dairying (Chapter): Tenth Five Year Plan (2002-07), Planning Commission, Government of India.

Inter-Ministry Task Group Report on Investment, Credit and Technical Support to Promote Self-employment in Agriculture, Horticulture, Afforestation, Dairying and Agro-processing. Planning Commission, Government of India.

Annual Report (2004-05), Department of Animal Husbandry & Dairying, Ministry of Agriculture, Krishi Bhawan, New Delhi.

3.8 ANSWERS TO CHECK YOUR PROGRESS

Your answers should include following points:

Check Your Progress 1

1) i. In the livestock sector, poor people directly contribute to growth directly. As the ownership of livestock is more evenly distributed with landless laborers, and marginal farmers, the progress in this sector will result in a more balanced development of the rural economy, particularly in the reduction of poverty ratio. Even many small & medium farmers who derive yearly savings from agriculture are dependent on livestock especially dairy & poultry for daily subsistence. The rural women play a significant role in animal husbandry and are directly involved in major operations like feeding, breeding, management and health care.

2) i. The major focuses of the government are:

- Genetic improvement of cattle and buffaloes by expanding artificial insemination and natural service network so that farmers get the services at his doorstep.
- Conservation of important dairy.
- National immunization program to control prevalent animal diseases. Efforts will be made for the creation of disease-free zones to boost export of milk products.
- Development of fodder through cultivation of fodder crops and fodder trees.
- Building infrastructure for animal husbandry extension network.
- Strengthening infrastructure and programs for quality and clean milk production and processing for value addition.

Check Your Progress 2

1) i. The scheme 'Intensive Dairy Development Programme' (IDDP) is being implemented for creating milk marketing infrastructure in hilly and backward areas including the districts which have received less than Rs. 50.00 lakh for dairy development activities during Operation Flood Program. The pattern of funding in non-operation flood areas will be on 100% grant in aid basis from Central Government to the State Governments/Union Territory. Maximum project cost will be Rs. 3.00 crore per district. The State Dairy Federations/District Milk Unions will implement the scheme. Major components of the project are:

- Milk processing and marketing facilities (including chilling, processing, product manufacturing and marketing – not more than 60% of the total project cost.
- Milk procurement activities including expenditure on formation of village level dairy cooperative societies, milk transportation, procurement tankers and other vehicle etc. – not more than 30% of total project cost.

- Technical input services including breed improvement, animal health care, feed and fodder development/provision etc. – not more than 20%.
- Cattle induction to be restricted to only scheduled castes/scheduled tribes and BPL families subject to an overall ceiling of 10% of the total project cost.
- Manpower development including training requirements of field and dairy staff as well as Management Committee of DCS and farmers training – not more than 10% of the total project cost.
- Working capital and management grant.

2) i. Strengthening Infrastructure for Quality & Clean Milk Production is the major scheme of Government of India with the objective to create infrastructure for production of quality milk and milk products at the farmer's level up to the points of consumption. The pattern of funding under the scheme is in the ratio of 75:25 for purchase of bulk cooler between Government of India and the respective Dairy Cooperative/ Union. Further 100% grant is given for training of farmers for clean milk production, purchase of detergent, antiseptic solutions, muslin cloth, utensils and accessories for clean milk production and strengthening of existing laboratory facilities.

3) i. National Project for Cattle and Buffalo Breeding (NPCBB) is implemented by the Department of Animal Husbandry and Dairying for restructuring and reorienting cattle and buffalo breeding operations in the country with special emphasis on maintaining quality in inputs and services. The project will, over a ten year period, bring under organized breeding coverage, all the breedable female cattle and buffalo in the State through a combination of (i) a vastly improved artificial insemination (AI) network delivering AI at the farmers door step and (ii) it will strategically position bulls for natural service. Under this project, 100% grant-in-aid will be provided to the States for taking up activities like strengthening of bull farm and semen bank/stations, infrastructure for LN_2 storage and distribution, establishment of breeders association to undertake progeny testing program, conversion of static to mobile AI center, training and assistance to private AI workers etc.

Check Your Progress 3

1) i. Following components are funded under the scheme Dairy and Poultry Venture Capital Fund:
   - Establishment of small dairy farms for milk production with a limit of Rs. 3.00 lakh per unit (up to ten buffaloes/crossbred cows).
   - Purchase of milking machines/milk-o-tester/bulk milk cooling unit (up to 2000 lt. Capacity) etc. with a maximum limit of Rs. 15.00 lakhs.
   - Purchase of dairy processing equipment for manufacturing indigenous milk products with maximum limit of Rs. 10 lakh per unit.
   - Establishment of dairy product transportation facilities including cold chain with maximum cost of Rs. 20 lakh per unit.
   - Cold storage facilities for milk and milk products with a limit of Rs. 25 lakh per unit.
   - Establishment of private veterinary clinics at a maximum cost of Rs. 2.00 lakh per unit for Mobile clinics and Rs. 1.5 lakh for Stationary clinic.

2) i. Infrastructure Development Scheme is implemented by the Ministries of Food Processing Industries (MOFPI) for the development of food processing sector which inter-alia includes setting-up/expansion/

modernization of food processing industries covering all segments viz. fruits & vegetable, milk products, meat, poultry, fishery, cereal, pulses, oil seeds and such other agri-horticultural sectors. This scheme has also been introduced with a view to enabling small and medium scale units to attain viability by defraying the cost of major facilities such as cold storage, warehousing, R&D Laboratories, power and water supply etc. Under the scheme Food Parks will be established in different parts of the country. For packaging center, entrepreneurs will get assistance up to 25% of the total cost of plant and machinery and technical civil works (33% in difficult areas) subject to a maximum of Rs. 2 crore. The scheme has also provision for assistance for stationary/mobile pre-cooling storage, refrigerated transport system and freezer cabinets at retail outlet.

3) i. Livestock Insurance Scheme would protect the farmers and landless farmers against losses, which they have to incur resulting from untimely death of cattle and buffalo owned by them. Two animals per farmer can be insured with subsidized premium. Fifty percent of the premium should be borne by the Government and the remaining 50% to be paid by the beneficiary.

UNIT 4 MILCH BREEDS

Structure

4.0 OBJECTIVES

After reading this unit, we shall be able to:

- enumerate the names of different milch breeds of cattle, buffalo and goat;
- state the distribution of these breeds in their respective home tracts;
- describe the physical characteristics of these breeds;
- performance of these breeds;
- specify the reproduction and production; and
- indicate the concept of breed improvement.

4.1 INTRODUCTION

Cattle, buffalo and goats constituting 404.1 million population are three major domestic animal species, which contribute over 91.0 million tonnes milk in the country. The buffaloes contribute maximum (52%) to total milk production followed by cattle (45%) and goats (3%). There are large number of well descript breeds of cattle, buffalo and goats which are widely distributed under different agro-climatic regions. Besides these, there is large population of non-descript animals. A breed is a group of inter-breeding domestic animals of a species. It shows similarity among its individuals in certain distinguishable characteristics (colour, shape, size of body parts). The breeds have been developed as a result of selection and breeding based on the needs of mankind as well as adaptation to agro-climatic conditions of their native home tracts.

4.2 MILCH BREEDS OF CATTLE

There are 30 well-defined indigenous cattle breeds. These breeds can be classified into three categories based on their utility. These are (1) Milch breeds, (2) Dual purpose breeds and (3) Draft purpose breeds. The cows of milch breeds are

relatively high milk producer, but their bullocks are generally of poor quality draft. The animals of dairy breeds are generally heavy built with capacious udder, pendulous dewlap, sheath and loose skin. The important breeds of this group are Sahiwal, Red Sindhi, Gir, Tharparkar, and Rathi.

i. Indigenous Milch and Dual-purpose Breeds

i. Sahiwal: This is one of the best indigenous dairy cattle breeds. The Sahiwal cows have their native home tract in Montgomery district and adjoining places in Pakistan. The Sahiwal cows are also found in Ferozepur, Amritsar, Gurdaspur districts of Punjab in India. There are quite a good number of breeding herds in Punjab, Haryana, Uttar Pradesh, Chhatisgarh and Madhya Pradesh. The cows are red and light brown in colour, but some animals with white patches are also found. The animals have long head with medium sized forehead. The horns are short and thick emerging laterally from the polls. The cows are with long, deep, fleshy and symmetrical body with short legs, loose skin, medium sized ears, heavy and large dewlap, straight hump and capacious udder. The cows are good milk yielders and cows under village conditions yield about 1350 kg in a lactation of 305 days. Well-bred cows on institutional farms yield an average of 2000-2500 Kg/lactation. The average age at first calving is about 36.0 months which ranges from 29 to 52 months. The average calving interval, service period and dry period of Sahiwal cow are 415, 148 and 156 days, respectively. The average fat and SNF content of the milk is around 5.0 and 9.2 per cent.

Sahiwal Cow

ii. Red Sindhi: The Red Sindhi cattle have somewhat similarity in breed characteristics to that of Sahiwal but are smaller in size with compact body frame. The native habitat of this breed is Karachi and Hyderabad districts of Sindh province of Pakistan. It is an important dairy cattle breed in Indian sub-continent. Red Sindhi cattle are maintained on few organized Government farms in India. The breed has red colour, which has shades from dark to dim yellow, with white patches on some animals. Head is well proportioned with an occasional bulge on the forehead. The horns are thick at the base and emerge laterally and curve upwards. The ears are of moderate size and drooping. Dewlap and sheath are pendulous. Udder is capacious and pendulous. The cows are high milk yielders and produce milk on an average 1800 kg ranging from 1500 to 2200 kg. in a lactation of 305 days. The average age

at first calving is 42 months and ranges from 32 to 50 months. The calving interval, service period and dry period ranges from 425 to 540 days, 105 to 293 days and 112 to 179 days, respectively.

Red Sindhi Cow

iii. Gir: The cattle are found in Junagarh, Bhavnagar, and Amreli districts of Gujarat. This is one of best Indian dairy cattle breed. The Gir cattle are also widely distributed in adjoining states of Rajasthan, Madhya Pradesh and northern parts of Maharashtra. There are quite a large number of organized farms and *gaushalas* maintaining the Gir cattle. Most of the Gir cattle are purely red in colour and some are with patches of red, black and red & black on white skin. The Gir cattle have medium size and well-proportioned body with massive heads, extremely bulging foreheads, long pendulous, curling and drooping ears with notches at the tips. The

Gir

horns are thick, medium size, curve backwards, upwards and forward ending in an inward sweep. The cows have good-shaped udder with well-placed teats. The cows are very good milk yielders with an average of 1400 kg ranging from 1200 to 2000 kg in lactation. Certain outstanding cows with 26-27 kg peak milk yield in a day and lactation milk yield more than 4500 kg indicate high genetic potential for milk production. The age at first calving varies from 40 to 60 months and inter calving period from 430 to 490 days.

iv. Tharparkar: An important cattle breed raised primarily for its milking potential. The home tract of this breed is in the Tharparkar district of southeast Sind in Pakistan. In India, these animals are now found along the Indo-Pak border covering western Rajasthan and up to Rann of Kutch in Gujarat. Animals with typical characteristic of breed are found in Jodhpur, Barmer, Jaisalmer districts of Rajasthan and Kutch region of Gujarat. Animals are white or light grey. Face and extremities are of a darker shade than the body. In bulls neck, hump and fore and hind-quarters are also dark. Head is of medium size. Forehead is broad and flat or slightly convex above eyes. Face is lean, fine and slightly dished to muzzle. Ears are somewhat long, broad and slightly pendulous. Horns are set well apart curving gradually upward and outward. Dewlap is loose and flexible but not voluminous. Tail is thin and hangs loosely with black switch. Udder is large and well developed with prominent veins. Teats are long, uniform in thickness and set at even distances. Tharparkar cows calve for the first time at an average age of about 41 months (range 37 to 52 months). The average milk yield is 1,750 kg (range 900 to 2,150 kg), lactation length is 285 days (range 240 to 380 days), dry period is 140 days (range 115 to 190 days), service period is 128 days (range 108 to 190 days) and calving interval of 430 days (range 408 to 572 days). Milk fat is about 4.88 % (range 4.72 to 4.90%) and SNF 9.2 % (range 8.9 to 9.7%).

Tharparkar Cow

v. Rathi: The cattle take their name from a pastoral tribe of Rajasthan called Raths. Rathi cattle have been developed as a result of admixture of inheritance of Sahiwal, Red Sindhi and Tharparkar cattle breeds with high proportion of blood from Sahiwal breed. These are concentrated in the Bikaner district of Rajasthan.

This is a medium sized breed with symmetrical body. The animals have brown colour with white patches and some animals with complete brown or black coal

colour with white patches are also found in the tract. Horns are short to medium curving outwards, upwards and inwards, ears are of medium size, voluminous dewlap and large naval flap. Skin is loose with fine short hair. Udder and teat are well developed. The cows are docile in nature. The average lactation milk yield of Rathi cows is 1500 kg, which ranges from 1050 kg to 2000 kg. The average age at first calving ranges from 36 to 52 months and inter calving period ranges from 450 to 620 day.

Rathi Cow

vi. Deoni: This is a very popular dual-purpose breed in Marathwada region of Maharashtra state and adjoining parts of Karnataka and Andhra Pradesh states. It is also found in Parbhani, Nanded and Osmanabad districts of Maharashtra and Bidar district of Karnataka. The body colour is usually white and animals are also

Deoni Cow

black and white spotted. The ears are grey-white or complete white with black pinna. The ears are drooping and the forehead is prominent and slightly bulged similar to that of the Gir cattle. This breed is considered to have admixture of Gir, Dangi and local cattle blood. The horns emerge from the side of the poll in outwards and upwards direction, slightly backward and again curving upward. The dewlap and sheath are of medium size. The switch of the tail is black and white reaching below hock joint. Udder is moderately developed. The animals are docile and calm. The Deoni bullocks are preferred for heavy work. The age at first calving ranges from 30 to 51 months with an average of 45.5 months. The milk yield in Deoni cows ranges from 650 to 1,250 kg with an average of 950 kg. Lactation length ranges from 170 to 475 days with an average of 300 days. Calving interval averages 450 days. Milk contains 4.3% fat, 9.7% SNF and 14.0% total solids.

vii. Haryana: The Haryana is a prominent dual-purpose breed of northern India. Its native breeding tract encompasses parts of Rohtak, Sonepat, Bhiwani, Hisar, Jind and Gurgaon districts of Haryana. These animals are also reared in Jodhpur, Alwar, and Bharatpur districts of Rajasthan and Meerut, Bulandshahr and Aligarh districts of Western Uttar Pradesh. The Haryana cattle are white or light grey in colour. They have compact and proportionately built body. A long and narrow face, flat forehead and a well-marked bony prominence at the centre of the poll characterize them. They have small stumpy horns. Muzzle is usually black. Eyes are large and prominent. The legs are moderately long and lean with small, hard and well shaped feet. The udder is capacious with well-developed milk vein. The teats are well developed, proportionate and medium sized. The tail is short, thin and tapering with black switch. The age at first calving ranges from 35 to 60 months with an average of 52 months. Average milk yield is around 1000 kg with a range of 690 to 1750 kg. Lactation length is about 270 days ranging from 240 to 330 days. Average service period is 230 days (range 125 to 305 days), dry period is 255 days (range 135 to 270 days) and calving interval is 480 days (range 415 to 560 days). Milk fat ranges from 4.3 to 5.3%, with an average of about 4.5% and SNF is around 9.1%.

Haryana Cow

viii. Kankrej: The Kankrej is one of the heaviest breeds of cattle in India and is found in southeast Rann of Kutch comprising Mehsana, Kutch, Ahmedabad, Kaira, Sabarkantha and Banaskantha districts of Gujarat, and Barmer and Jodhpur districts of Rajasthan. The colour of the animal varies from silver-grey to iron-grey or steel-

black. The forequarters, hindquarters and hump are slightly darker than the rest of the body in males. The forehead is broad and slightly dished in the centre. The face is short and nose slightly upturned. Ears are large, pendulous and open. The horns are large, strong, and curved outwards and upwards in a lyre-shaped fashion. The polls, forequarters and hindquarters are rusty red in newborn calves, but the colour disappears later on. The hump is well developed. The dewlap is thin and pendulous. The average age at first calving is 47.3 months (range 34 to 56 months). The average milk yield is around 1750 kg (range 1100 to 3200 kg.). The lactation length averages 295 days (range 275 to 350 days) and calving interval is around 490 days (range 410 to 640 days). The milk fat is around 4.8% (range 4.66 to 4.99%).

Kankrej Cow

ix. Ongole: The home tract of Ongole breed is Ongole region in Andhra Pradesh which extends all along the coast from Nellore to Vizianagaram and Chittoor,

Ongole

Kurnool, Cuddapah, Anantapur, Nalgonda, Mehbubnagar and Khammam districts of Andhra Pradesh. The Ongole cattle have a glossy white coat. These cattle are large and heavy animals with loosely knit frames, great muscularity and long limbs. They have a majestic gait. The forehead is broad between eyes and slightly prominent. The face moderately long and coffin shaped. The horns are short and stumpy, growing outward and backward from the outer angles of the poll. The dewlap is large and slightly pendulous, and hanging in folds. The switch is black. The udder is well-placed with well-developed teats. The age at first calving ranges from 35 to 60 months (average 48 months). The average milk yield is 690 kg (range 475 to 1,000 kg) in a lactation period of about 230 days (range 160 to 270 days). The average dry period is 260 days (range 145 to 400 days), average service period of 190 days (range 128 to 310 days), average calving interval is 500 days (range 420 to 720 days) and average milk fat is 4.2% (range 4.1 to 4.8%).

ii. Exotic Dairy Cattle Breeds

Military dairy farms were the first to introduce crossbreeding in the country using high milk producing exotic cattle breeds like Holstein Friesian, Jersey, Brown Swiss and Red Dane for improving the milk production potential of indigenous cows. The breed characteristics of some important exotic cattle breeds have been described below.

i. Holstein Friesian: This breed was developed in the province of Friesland in Netherlands. This is the best dairy breed and is most widely distributed breed of dairy cattle in the world. Holstein cattle are heavily built and possess large udders. They are the largest dairy breed and mature cows body weight are as much as 700 kg. They have typical markings of black and white that make them easily distinguishable. The average milk production of cow is 8,000 to 10,000 kg per lactation in developed countries. However, the fat content (3.0 - 3.5 per cent) in their milk is low.

Holstein Friesian Bull

ii. Jersey: This breed originated in the Island of Jersey, one of the Channel Islands between France and England. Jersey breed is also widely distributed in Europe and America. The typical body colour of Jersey cattle is reddish brown. In India, this breed has acclimatized well and is widely used in cross-breeding with indigenous

cows in hilly areas. Jersey is relatively a smaller dairy breed and hence is more suited for cross-breeding with zebu cattle. Mature Jersey cows weigh around 450 kg. Heifers grow rapidly and mature early and calve at the age of 26 - 30 months. They have compact and angular body. The average milk production of Jersey cows is 5,000 to 8,000 kg with a fat content of 5.0 per cent.

Jersey Cow

iii. Brown Swiss: This breed originated in the mountainous region of Switzerland. The animals are quite docile and easily manageable. The colour of Brown Swiss varies from light to dark brown. Brown Swiss heifers are rather slow maturing. In India, crossbred cattle have been developed by crossing this breed with recognized Indian breeds of cattle and non-descript cattle on institutional farms and village conditions. The average production per cow is about 6000-8000 litres with an average fat content of 4 per cent.

iv. Red Dane: This breed has its home tract in Denmark. The typical body colour of this breed is red, reddish brown or even dark brown. It is also a heavy breed. The mature males weigh up to 950 kg and mature females to 600 kg. Lactation yield varies from 5,000 to 7,000 kg with a fat content of about 4 per cent.

iii. Synthetic Crossbred Cattle Strains

For bringing rapid improvement, particularly in non-descript zebu cattle, the crossbreeding of indigenous cattle using frozen semen of bulls of exotic dairy cattle breeds (Holstein Friesian, Brown Swiss, Jersey, Red Dane and Ayrshire) resulted in developing various synthetic crossbred cattle strains. Karan Swiss, Karan Fries, Frieswal, Sunandini are some of high producing synthetic crossbred cattle strains developed at organized farms and under village conditions in India.

i. Karan Swiss: A crossbred cattle strain has been developed at NDRI, Karnal by crossing Brown Swiss bulls with Sahiwal and Red Sindhi zebu cows. The frozen semen of superior Brown Swiss Bulls used for crossbreeding was imported from USA. The average age at first calving of Karan Swiss cows is 32 to 34 months (2 to 3 months less than that of Sahiwal/Red Sindhi cows). Average lactation milk yield in 305 days or less was about 3350 kg and outstanding cows with record of 305 day best lactation milk yield of 7096 kg. The average service period, dry period

and inter-calving period are 117, 85 and 404 days, respectively. The average fat and SNF content in milk is 4.16% and 9.20%

Karan Swiss Cow

ii. Karan Fries: Crossbred cattle have been developed at NDRI Karnal by crossing Tharparkar cows with the frozen semen of superior Holstein Friesian bulls. The Karan Fries cows calve for the first time at the age of 30 to 32 months and yield 3400 to 3600 kg milk in 305 days lactation. The average service period, dry period and inter-calving period are 123, 104 and 401 days, respectively. Outstanding cows yield up to peak milk yield of 46.5 kg in a day and 8338 kg in 305 days best lactation milk yield have been recorded and used for production of bulls for future breeding on institutional farms and farmers' animals. The average fat and SNF content of milk is 4.10% and 8.92%.

Karan Fries Cow

iii. Frieswal: This cattle breed is developed by crossing Holstein Friesian with Sahiwal cows at Military Dairy Farms in technical collaboration with Project Directorate on Cattle (ICAR), Meerut (UP). The breeding programme using imported semen of superior Holstein Friesian bulls and crossbred bulls has been designed in such a way that the cows are produced with 62.5 per cent inheritance of Holstein Friesian. The average age at first calving of Frieswal cows is 30 to 33 months. Average lactation milk yield in 300 days lactation ranges from 3000 to 3400 kg. The average service period, dry period and inter-calving period are 160, 115 and 425 days respectively. The fat content of milk ranges from 3.5 to 4.5%.

iv. Sunandini: As a result of crossbreeding programme launched under Indo-Swiss Project using frozen semen of Brown Swiss bulls on non-descript local or graded Red Sindhi or Sahiwal cows of rural households in Kerala, a high yielding crossbred cattle strain named Sunandini was developed. The crossbred cattle strain was further improved through introduction of exotic inheritance of Jersey and Holstein Friesian cattle breeds. Attempts were made to retain 50 to 62.5% of exotic cattle inheritance. The average production performance of recorded crossbreds in the village herds has been ranging from 1400 to 1800 kg depending upon managemental and agro-climatic condition. Age at first calving is around 35 months and calving interval averages about 450 days. *Inter-se* mated Sunandini crossbred cows are further being improved through selective breeding using superior breeding Sunandini bulls identified on the basis of their daughters' performance under field conditions.

iv. Breed Improvement in Cattle

The genetic improvement in dairy and dual purpose breeds of cattle for improving milk production can be brought about by selective breeding. Selective breeding means mating of the best males with best females. The best female means the cows yielding higher milk than the average of the population. The best male means the bull which has higher dam's milk yield, paternal grand dam's milk yield and daughters' yield compared to other bulls. Initially, the young male calves with better growth, true breed characteristics and reproductive performance can be selected as superior progenies of elite dams. The young bulls subsequently are evaluated on the basis of performance of their progenies. The females should be selected on the basis of their own growth, reproductive and productive performance.

The low producing non-descript cattle constituting about seventy-five percent (¾) of the total cattle population can be improved through **grading up.** Grading up means breeding of the non-descript females with the semen of the bulls belonging to high producing, superior indigenous dairy breeds like Sahiwal, Tharparkar, Gir, Deoni, etc. In 5-6 generations of grading up, the non-descript animals become like pure-bred indigenous breed. The grading up can be practiced in the regions with scarce availability of feed and fodder resources particularly in rain-fed conditions.

The non-descript cattle under irrigated regions with adequate feed and fodder resources can be improved through crossbreeding with exotic dairy cattle breeds like Holstein-Friesian and Jersey. Subsequently, the crossbred cattle can be improved using progeny- tested high genetic merit crossbred bulls from different farms maintaining synthetic crossbred cattle strains.

Check Your Progress 1

1) Define breed and describe the general characteristics of dairy cattle breeds.

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2) Write the home tracts of Sahiwal, Tharparkar, Gir and Ongole breeds of cattle.

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3) Give the productive performance of Sahiwal, Tharparkar, Gir, Ongole and Hariana breeds of cattle.

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4) List the names of crossbred cattle strains developed in India. Also give the names of the exotic and Indian breeds crossed for their development.

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5) How can we improve the milk production in local non-descript (Desi) cattle?

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4.3 MILCH BREEDS OF BUFFALO

India is considered as the home-tract for some of the best buffalo breeds. There are seven well-defined milch breeds of buffaloes namely Murrah, Nili-Ravi, Bhadawari, Jaffarabadi, Surti, Mehsana and Nagpuri. There are a few other lesser known breeds like Toda in Nilgiris, Parlakhemundi, Jerangi, Manda in Orissa and Pandharpuri and Marathwada in Maharashtra state. The population of these breeds is very small, and they are only found in isolated pockets but are distinct because of their morphological traits.

Apart from providing milk, the buffaloes are also used for carting, ploughing and other agricultural operations. The buffaloes are also used as meat animal. The characteristics of important buffalo breeds used as dairy animals have been discussed below.

i. Murrah: The breeding tract of Murrah breed is Rohtak, Hisar and Jind districts of Haryana state and Nabha and Patiala districts of Punjab state. The breed characteristics are massive body, neck and head comparatively long, horns short and tightly curved, udder well developed, hips broad, and drooping fore and hind quarters. The tail is long reaching up to the fetlocks. The colour is usually jet black with white switch of tail. The bullocks are good draft animals though slow but powerful. The average milk yield per lactation is 1,500 to 2,500 kg. The age at first calving is 45 to 50 months in villages but in good herds it is 36 to 40 months. The intercalving period is 450 to 500 days. The milk fat and SNF percentages are 7.0 and 9.5 respectively.

Murrah Buffalo

ii. Bhadawari: This breed is found in Bhadawar Tehsil in Agra district and Etawah district of Uttar Pradesh and Gwalior district of Madhya Pradesh. The animals have wedge shape body and are of medium size. The head is comparatively small, the legs are short and stout, the hooves are black, and the hindquarters are uniform and higher than the forequarters. The tail is long, thin and flexible with black and white or pure white markings reaching up to fetlock. The body is usually light or copper coloured which is peculiar‘ to this breed. The bullocks are reputed as good draft animals with heat tolerance. The ears are horizontal and medium in size. The age at first calving is around 50-55 months. The average milk production is 800 to 1,000 kg in a lactation period of 275-300 days. The average calving interval is 480 days (390-600 days). The breed is well known for its higher percent fat content in milk ranging from 6.5 to 12.5 per cent.

iii. Jaffarabadi: The breeding tract of this breed is Junagarh, Bhavnagar and Amreli districts of Gujarat State. This is the heaviest breed of buffaloes. The body is long and massive. The dewlap in females is somewhat loose and the udder is well developed. The head and neck are massive. The forehead is very prominent, broad and convex. The horns are heavy, inclined to droop at each side of the neck and then turning up at points, but less tightly curved than in the case of the Murrah breed. The colour is usually black. The average milk yield is around 1800 kg (1400 – 2300 kg) in a lactation period of 300 – 315 days. These animals are mostly maintained by traditional breeders called Maldharis, who are nomads. The bullocks are heavy and are used for ploughing and carting. The age at first calving is around 50-55 months and calving interval is 450 days. The average fat percentage is around 6.5 – 7.5.

Jaffarabadi Buffalo

iv. Surti: The breeding tract of this breed is Kaira, Bharuch, Vadodara and Surat districts of Gujarat. The body is well proportioned and medium sized. The barrel is wedge shaped. The head is long. The back is straight. The eyes are prominent. The horns are sickle shaped, moderately long and flat. The tail is fairly long. The colour is black or brown. The peculiarity of the breed is that there are two white bands, one round the jaw and the other at the brisket. The bullocks are good for light work. The milk yield ranges from 900 to 1300 kg. The age at first calving is 40 to 50 months with an intercalving period of 400 to 500 days. The Surti buffaloes have high fat percentage in milk (7.5 to 8.5 per cent).

Surti Buffalo

v. Mehsana: The breeding tract of this breed is Mehsana, Sabarkantha and Banaskantha districts of Gujarat state. This is considered to have been evolved out of crossbreeding between the Surti and the Murrah. The body is longer than in Murrah and the limbs lighter. The head is longer and heavier. The horns usually are less curved at the end compared to Murrah breed but are longer and could be of irregular shape. The udder is well shaped. The horns usually are less curved at the end as compared to Murrah breed but are longer and could be of irregular shape. The udder is well shaped. The colour is usually black to grey, with white markings often on face, legs or tail-tips. The bullocks are good for heavy work but rather slow. The age at first calving is around 42-48 months. The milk yield is 1,400 to 1800 kg in a lactation period of 290- 310 days. The intercalving period ranges between 450 and 550 days. The milk fat averages around 7.0 to 8.0 per cent.

Mehsana Buffalo

vi. Nagpuri: The breeding tract of this breed is Nagpur, Akola and Amravati districts of Maharashtra. This is also called as Ellichpuri or Barari. The horns are long, flat and curved, bending backwards on each side of the back almost to shoulders. The face is long and thin. The neck is somewhat long, the limbs are light. The tail is comparatively short reaching a little below hocks. The bullocks are good for heavy trotting work but slow in movement. The milk yield is 700 to 1,200 kg per lactation. The age at first calving is 45 to 50 months and intercalving period is 450 to 550 days. The milk fat averages around 7.0 to 8.5 per cent.

Nagpuri

vii. Nili-Ravi: The breed is found along with the Basins of Sutlej River in Ferozepur and of Ravi River in Amritsar districts of Punjab state and in adjoining areas of Pakistan. The head is elongate, bulging at the top and depressed between the eyes. The frame is medium sized. The peculiarity of the breed is the wall eyes. The horns are small and coiled tightly. The neck is long, thin and fine. The naval is very small. The udder is well developed. Usually the colour is black with white markings on forehead, face, muzzle, tail and legs (Panch Kalyani). The bullocks are good for heavy trotting work. The milk yield is 1700 to 2100 kg per lactation. The intercalving period is 500 to 550 days. The age at first calving is 42 to 48 months. The milk fat averages around 6.5 to 8.0 per cent.

Nili-Ravi Buffalo

Breed Improvement in Buffaloes

The genetic improvement in the buffaloes for improving milk production should be brought through selective breeding. The young male calves (future breeding bulls) with better growth, true breed confirmation and reproductive characteristics can initially be selected as superior progenies of elite dams with best lactation milk yield more than 2500 kg. The young bulls subsequently are evaluated on the basis of performance of their progenies. The females should be selected on the basis of their own growth, reproductive and productive performance.

The low producing non-descript buffaloes nearly constituting about sixty-seven percent (2/3rd) of the total buffalo population can be improved through grading up using genetically superior progeny tested bulls of pure-bred improver breeds of buffaloes.

Check Your Progress 2

1. Describe the uses of buffaloes and enumerate the important breeds of buffaloes available in India.

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2. Write the home tract of Nili-Ravi, Jaffarabadi, Bhadawari and Surti breeds.

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3. Describe the breed characteristics of famous buffalo breed of Haryana.

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4. Give the average productive and reproductive performance of Murrah, Jaffarabadi and Surti buffalo breeds.

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5. How can we improve the milk production in local non-descript buffaloes?

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4.4 MILCH BREEDS OF GOAT

Goat is regarded as "poor man's cow." The goats are adaptable to varying environmental conditions and have tremendous ability to survive on sparse vegetation unsuitable for feeding of other livestock. Goats are the source of income and occupation for a large number of rural people, specially the economically and socially backward classes of the society in India. The goat is mainly a meat animal in India and a few breeds are milch breeds which provide small quantity of milk. India possesses 22 well established breeds of goat apart from non-descript local goats. The important dairy goats are Jamunapari, Beetal, Jhakrana, Zalawadi and Surti. A few exotic dairy breeds like Alpine, Saanen, Toggenburg and Anglo-Nubian have been used in crossbreeding with local breeds of goats to improve the milk production.

i. Indigenous Goat Breeds

i. Jamunapari: This breed is found in Etawah, Agra and Mathura districts of U.P. and the tracts lying between of the Chambal and Jamuna rivers. The goats of this breed are the largest in size, tall and leggy. The breed has no uniform colour but animals having a white coat with markings of tan are common. Long pendulous ears and highly convex nose with a tuft of hair (Roman nose) are peculiar characteristics of this breed. They are dual purpose goats giving both milk and meat. The body weight of an adult male (buck) and female (doe) ranges from 50-85 and 40-60 kg respectively. The average body length and height of an adult buck and doe is 127 and 116 cm and 91 and 77 cm respectively. The average age at first kidding is 20-25 months. The kidding is once in a year with a single or twins. These goats are bred from July to October and kid from November to February. The average milk yield is around 1-2 kg per day with a maximum of 350-550 kg in a lactation period of 250 days. The lactation length varies between 210-275 days. The good animals yield 2.5-3.5 kg milk per day.

Jamunapari Goat

ii. Beetal: This breed is found mainly in Gurdaspur and Amritsar districts of Punjab. The adult buck and doe weigh around 40-70 and 35-50 kg, respectively. An adult Beetal buck measures 125 cm in body length and 90 cm in body height. The corresponding values for a doe are 105 cm and 75 cm respectively. The average age at first kidding is 20-22 months. The kidding is once in a year with a single or twins and rarely triplets. These goats are mostly bred from July to October and kid from November to February. The gestation period is five months. The ears are long and pendulous hanging like beetal leaf on both sides. The Beetal goats also have Roman nose indicating a common ancestry with Jamunapari. The bucks generally possess tuft of hair under the chin called beard. The milk yield is around 1-1.5 kg per day. The lactation length varies between 160-200 days. The maximum milk yield of 834 kg in a lactation period of 287 days has been recorded in this breed.

Beetal Goat

iii. Zalawadi: This breed is found in Zalawad district of Kathiawad. It is also found in western Mehsana and Radhanpur in Gujarat. The Zalawadi are generally large sized goats with straight screw shaped horns. The neck is long and usually two lobular appendages are found in the throat region. The coat colour is black with white spots. The skin colour is pinkish blue with black lustrous hair on the body measuring about 10-15 cm long. The average age at first kidding is 23-25 months. The kidding is once in a year with a single or twins. The adult animal weighs around 50-65 kg. This goat is a good milker and kids only once in a year. The good animals yield around 2-3 kg milk per day with an average of 200 kg in 150 days.

Zalawadi Goat

iv. Jhakrana: This breed is distributed mainly in Jhakrana and in surrounding villages near Behror in Alwar district of Rajasthan. Jhakrana goats are large-sized animals.

Jhakrana Goat

The breed is quite similar to Beetal goats in physical characteristics, but is comparatively larger in size. Coat colour is predominantly black with white spots on ears and muzzle. The forehead is slightly bulged. The body weights of adult goats are 58 and 44 kg for male and female, respectively. The average age at first kidding is 21-25 months. The kidding is once in a year with a single or twins. This goat breed is known for its milk production. The average lactation milk yield is about 120-135 kg in a lactation period of 110-125 days.

v. Surti: This breed is distributed in Surat and Baroda districts of Gujarat and Nasik and Mumbai areas of Maharashtra. The coat colour is predominantly white but often black and brown hair found in different parts of the body. This is a medium-sized white goat having well-developed udder. The ears are medium and horns are small directed backwards and slightly curved. The average body length and height is 65 and 74 cm in bucks and 60 and 70 cm in does respectively. The average age at first kidding is 21 months. The kidding is once in a year with a single or twins. The adult weight in bucks and does is around 35 and 31 kg. This is a good milch breed yielding around 1.5-2.0 kg of milk per day with a lactation yield of 120-170 kg in around 115-150 days.

Surti Goat

ii. Exotic Dairy Goat Breeds

i. Alpine: This milch breed has originated in the Alps in France. Its coat colour varies from black, fawn to white. The preferred colour is black with white markings on each side of the belly and face with white legs below the knees. The fore quarters are proportionately higher than the hind quarters. Alpine females are excellent milkers. The average body weight is 65-85 kg in the bucks and 50-65 kg in the does. The average body length of a mature buck and doe is around 88 and 72 cm while the height is around 76 and 70 cm respectively. The average daily milk yield is around 2.5 kg with an average lactation yield of 720 kg in 245 days. The good milkers yield 3-5 kg milk per day. The highest recorded milk yield is 2316 kg in 300 days. The milk butterfat is in range of 3-5 percent.

ii. Saanen: This breed has its home tract in Saanen Valley of Switzerland. It is regarded as the “milk queen” of goat world. Its coat colour is white or sometimes cream or grey and fawn at the spine. The face is straight or slightly dished. The

ears point upward and forward. The breed is normally hornless but occasionally horns do appear. The udders are usually shapely and well huge. A mature doe and a buck weigh around 55-65 kg and 70-95 kg respectively. The daily average yield is 2-5 kg per day during a lactation period of 8-10 months. The world lactation record in goats (305 days) is held by a Saanen goat in Australia with a yield of 3,084 kg milk with 3.3% fat.

iii. Toggenburg: This hardy milch breed originated in Toggenburg valley of Switzerland. The coat colour varies from deep chocolate to pale-drab. There are light fawn or white markings down on each side of the face and from the knees or hocks to the feet, around tails, rump and thighs. The ears are small and pricked. The animals are usually hornless and are very gentle and quiet in temperament. The average yield is 2.0 kg with 3.4 per cent butter fat. The lactation yield is 400 kg in 200 days. The adult female (doe) weighs around 40-50 kg and adult male (buck) weighs around 55-65 kg. The highest recorded milk yield was 2614 kg in a lactation period of 305 days in USA.

iv. Anglo-Nubian: The Anglo-Nubian breed has been evolved by crossing of Nubian of Egypt, Jamunapari of India and old English type goats. The Anglo-Nubian is usually a big animal with fine skin, glossy coat, long pendulous ears and Roman nose. There is no fixed colour. The udder is capacious but pendulous and teats are large. They are consistent milkers with higher fat (5 per cent) compared to other breeds. This breed is known as the "Jersey of goat world." On an average, they yield one kg milk per day. The lactation yield is about 300 kg in 300 days. The mature females weigh around 45-60 kg and males weigh approximately 55-80 kg. The record milk of 2124 kg was produced in 305 days by an Anglo-Nubian female in California.

iii. Breed Improvement in Goats

The best approach for bringing about genetic improvement in different dairy breeds of goats is through selective breeding i.e. mating of best females with best males for milk production. The high producing elite females (does) and elite males (progeny of elite females) can be identified in the field and retained at central nucleus farm with each animal performance recorded. Further selection can be made at the Central farm. The farm-bred males can be re-distributed in the field for improving the farmers' goats. The experiences of crossbreeding of indigenous goat breeds with Alpine and Saanen breeds of exotic goats did not yield the desired results under field condition.

Check Your Progress 3

1) Write the home tract of Jamunapari, Beetal, Surti and Jhakrana breeds of goat.

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2) Describe the breed characteristics of famous dairy breed of Punjab.

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3) Give the average productive performance of Surti, Jamunapari and Beetal goats.

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4) Describe the breed characteristics of two exotic dairy goat breeds which have been used for crossbreeding of goats in the country.

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4.5 LET US SUM UP

There are large number of well-descript breeds in cattle, buffalo and goats which are widely distributed under different agro-climatic regions of the country. Among milch cattle population, the Sahiwal, Red Sindhi, Gir and Tharparkar are prominent indigenous cattle breeds. Apart from these indigenous milch cattle breeds, Karan Swiss, Karan Fries, Frieswal, Sunandini are newly developed high yielding crossbred cattle strains resulting in fast spread of large crossbred cattle populations in different pockets of the country also significantly contribute to the total milk production. The animals of dairy breeds in general are heavy built with capacious udder, pendulous dewlap, sheath and loose skin. The average lactation milk yield of well-bred cows of important indigenous dairy cattle breeds ranges from 1500-2500 kg on institutional farms and 1350-1800 kg under village conditions. The average lactation milk production of different crossbred cattle strains is almost double. But the milk fat and SNF content in crossbred cattle are lower than that of indigenous cattle breeds. The crossbred cows have about 6-8 months lower age at first calving as compared to indigenous cows. Among buffaloes, Murrah, Nili-Ravi, Jaffarabadi, Surti and Mehsana are prominent dairy breeds. The most preferred breed among buffaloes is Murrah which yields about 1500-2000 kg milk in lactation of 305 days. The fat and SNF content in buffalo milk are highest. The goat though is regarded as poor man's cow, but it contributes very meagerly to the total milk production. The main utility of goat is meat production. The important dairy breeds of goat are Jamunapari, Beetal and Jhakrana. The genetic improvement in milch breeds of cattle, buffalo and goat for improving milk production can be brought about by selective breeding The low producing non-descript cattle, buffalo and goats constituting a large proportion of their population can be improved through grading up**.** The non-descript cattle particularly under resource rich areas with adequate feed and green fodder availability can be improved through crossbreeding with exotic dairy cattle breeds.

4.6 KEY WORDS

Dewlap : A fold of loose skin hanging from the throat of an animal.

Exotic breed : A breed having not its natural origin to the area/ country. It is introduced in the given area from other country /area.

Grading-up : Breeding of an inferior breed or non-descript animals with a superior, usually an indigenous improver breed to improve specific characteristics, e.g. milk production.

Indigenous breed : A breed which naturally originates in the area or which has occupied that area over a long period.

Kidding interval : The number of days between two successive kiddings (Delivery of kids).

Nondescript : An animal usually of inferior quality that cannot be distinguished as belonging to a specific well defined breed.

Selection : The process that makes choice of which animals in given population become parents, how many offspring they produce and how long they remain in breeding population.

Breed : A group of inter breeding animals of a species which have a common origin and similar identifying characteristics that distinguish them as belonging to a breeding group.

Zebu cattle : Humped cattle are called zebu.

Crossbred : An animal produced by crossing two or more pure breeds.

Crossbreeding : Mating systems in which hereditary material from two or more pure breeds is combined.

Dam : Female parent, the mother of an animal.

Progeny : Offspring of given individuals.

Progeny testing : A basis of selection of an animal whose genetic worth is estimated on the performance of its progenies.

Trait : Trait is observable or measurable characteristic of an individual. Coat colour, body weight, milk production of animal is trait.

Breeding value : The genetic worth of an animal for a specific trait.

Habitat : Habitat of the breed is the physical environment in which it is originated and developed.

4.7 SOME USEFUL BOOKS

Singh Harbans and Moore Earl N. (1982). *Livestock and Poultry Production*, Prentice Hall of India Private Limited, New Delhi -110001.

Sastry N S R, Thomas C K, and Singh R A (1982). *Farm Animal Management and Poultry Production*, Vikas Publishing House Private Limited, New Delhi -110002.

Animal Genetic Resources in India by Bhat P N, Bhat P P, Khan B U, Goswami O B and Singh B. IVRI, Izatnagar – 243122

Handbook of Animal Husbandry. Publications and Information Division, Indian Council of Agricultural Research (2002), Krishi Anusandhan Bhawan, Pusa, New Delhi 110012.

4.8 ANSWERS TO CHECK YOUR PROGRESS EXERCISES

Your answers should include following points:

Check Your Progress 1

1) i. Give the definition of a breed as a group of inter-breeding individuals of a species having many common characteristics.

ii. Cows of dairy breeds are high milk producers.

iii. The male of dairy breeds are poor work animals.

iv. These are heavily built animals with capacious udder, pendulous dewlap, sheath and loose skin.

2. i. Sahiwal - Montgomerry district now in Pakistan and Amritsar, Gurdaspur and Ferozpur districts of Punjab in India.

ii. Tharparker – Tharparker district now in Pakistan and along Indo-Pak border regions in western Rajasthan particularly in Barmer, Jaisalmer and Jodhpur districts.

iii. Gir - found in Junagarh, Bhavnagar, and Amreli districts of Gujarat

iv. Ongole – Ongole region in Andhra Pradesh.

3. Write the average lactation milk production, lactation length, dry period and the fat and solids-not-fat percentage in the milk of these breeds.

4. i. Important crossbred strain developed in India are Karan-Swiss, Karan Fries, Frieswal and Sunandini

ii. Karan Swiss was developed by crossing Brown Swiss bulls with Sahiwal and Red Sindhi zebu cows

iii. Karan Fries was developed by crossing Tharparkar cows with the frozen semen of superior Holstein Friesian bulls.

iv. Frieswal was developed by crossing Holstein Friesian with Sahiwal cows at Military Dairy Farms

v. Sunandini was developed using frozen semen of Brown Swiss bulls on non-descript local or graded Red Sindhi or Sahiwal cows of rural households in Kerala

5. i. By grading up low producing local non-descript cows.

ii. Explain grading up as breeding of the non-descript females with the semen of the bulls belonging to high producing, superior indigenous dairy breeds like Sahiwal, Tharparkar, Gir, Deoni etc

iii. In 5-6 generations of grading up, the non-descript animals become like pure-bred indigenous breed.

iv. The non-descript cattle under irrigated regions with adequate feed and fodder resources can be improved through crossbreeding with exotic dairy cattle breeds like Holstein-Friesian and Jersey.

Check Your Progress 2

1. i. Buffalo being a triple purpose animal used for milk, meat and draft.

ii. Give the names of 6 important breeds of buffaloes.

2. i. Nili-Ravi – Basins of Sutlej River in Ferozepur and of Ravi River in Amritsar districts of Punjab and in adjoining areas of Pakistan.

ii. Jaffarabadi – Junagarh, Bhavnagar and Amreli districts of Gujarat.

iii. Bhadawari – Bhadawar Tehsil in Agra district and Etawah district of Uttar Pradesh and Gwalior district of Madhya Pradesh.

iv. Surti - Kaira, Bharuch, Vadodara and Surat districts of Gujarat.

3. i. Massive body, neck and head comparatively long, horns short and tightly curved, udder well developed, hips broad, and fore and hind quarters drooping.

ii. The tail is long reaching up to the fetlocks.

iii. The colour is usually jet black with white switch of tail.

iv. The average milk yield per lactation is 1,500 to 2,500 kg with 7.0 % fat.

4. i. Give the productive performance of these breeds in terms of average

lactation milk production, lactation length, dry period and fat & SNF % in milk.

ii. Give the reproductive performance of these breeds in terms of Age at first calving, service period and calving interval.

5. The low producing non-descript buffaloes can be improved through grading up using genetically superior progeny tested bulls of pure-bred improver breeds Such as Murrah, Mehsana or Surti.

Check Your Progress 3

1. i. Jamunapari –Etawah, Agra and Mathura districts of U.P. and the tracts lying between of the Chambal and Jamuna rivers.

   ii. Beetal –Gurdaspur and Amritsar districts of Punjab.

   iii. Surti –Surat and Baroda districts of Gujarat and Nasik and Mumbai areas of Maharashtra.

   iv. Jakhrana - Jhakrana and in surrounding villages near Behror in Alwar district of Rajasthan.

2. i. The ears are long and pendulous hanging like beetal leaf on both sides.

   ii. The Beetal goats have Roman nose indicating a common ancestry with Jamunapari.

   iii. The bucks generally possess tuft of hair under the chin called beard.

   iv. The kidding is once in a year with a single or twins and rarely triplets

   v. The milk yield is around 1-1.5 kg per day. The lactation length varies between 160-200 days.

3. i. Give the daily and lactation milk production of these breeds

   ii. Give the lactation length of these breeds.

4. i. Alpine and Saanen are the most extensively used exotic breeds of goat in India.

   ii. Give the name of place of origin, body characteristics and productive performance of Alpine and Saanen breeds.

UNIT 5 ANIMAL HUSBANDRY PRACTICES AND HEALTH CARE

Structure

5.0 OBJECTIVES

After reading this unit, we shall be able to:

- describe the management and feeding practices of dairy calves, heifers, milking and dry cows and buffaloes.
- explain the estrus cycle, symptoms of heat, methods of heat detection and artificial insemination in dairy animals.
- outline the common diseases of dairy animals and measures for their prevention and control.

5.1 INTRODUCTION

The animal husbandry or the rearing of animals for their economic utilization is as old as human civilization. The Neolithic (New Stone Age) man first domesticated the various present-day animal species and started practicing animal husbandry. Under domestication, the animals are dependent on humans for their sustenance and performance. They need to be provided with appropriate levels of feeding, suitable housing, breeding, timely healthcare and management so as to obtain desired productivity.

The cattle and buffaloes are the two major milk producing species in India. The cattle initially domesticated primarily as draft animal and later on some of the cattle breeds were developed as milch animals through selection. The buffalo, though domesticated much later, is the most important milk producing species in India.

Together they contribute more than 95 per cent of 91.1 million tonnes of milk currently produced in India. Therefore, their feeding, housing, healthcare and routine management based on scientific recommended practices is essential for obtaining higher profit from dairy farming. The care and management of a dairy farm starts with the birth of a healthy calf. The healthy female calves born have to be fed and cared well to grow at a faster rate and become a producing cow or buffalo at an early age. Once in production, the dairy animals are managed for breeding regularly and to produce milk at higher level so that their rearing becomes profitable to the dairy farmer.

5.2 MANAGEMENT OF DOWN CALVERS AND CALF RAISING

The dairy farming starts with the birth of a healthy and vigorous calf. The care of calf starts in the womb of cow itself. The cows during last 6-8 weeks of pregnancy, called "down calvers" become slow and gentle separating themselves from the general herd and avoid fights so as to guard against any injury to the fetus inside the womb. Therefore, the advanced pregnant cows especially during the last 15 days of pregnancy need special care and attention of the dairyman.

i. Care and Management of Down Calver Cows and Buffaloes

a) **Shifting the cows and buffaloes to the calving pens:** The advance pregnant cows should be separated from the general herd and should be shifted to individual calving pens (maternity pens) about 1 to 2 weeks before the expected date of calving. The keeping of down calver cows and buffaloes individually in calving pens provide the pregnant cows with better climatic protection and the disturbance from other cows is avoided. The cows in these pens are given individual attention and kept under the watch round the clock. These pens can be disinfected which prevent chances of infection gaining entry at the time of calving. Chances of contamination of the general herd by infected cows and healthy cows contacting diseases of genital tract are minimized.

   Small farmers who have only one or two animals must tie the cow in advanced pregnancy separately in a clean area where it will not be disturbed. Good straw bedding should be provided. In farms where abortions and calf diseases are common, the calving pen should be sterilized regularly. The floor and walls should be scraped and scrubbed with 4 per cent washing soda in hot water and disinfected before the cows are brought in. Once in the calving pen, the cows should be provided a good quality laxative feed and ample amount of clean drinking water.

b) **Care at calving:** The cow should be kept under constant watch for the signs of parturition like swelling of the udder, swelling of the vulva and drooping away ligaments around the tail head. At the first sign of calving, the first two fore feet followed by the muzzle will appear after the water bag has burst. Birth usually takes place 2 to 4 hours. If the labour prolongs for more than four hours, abnormal presentation may be suspected and veterinary aid may be called for immediately.

   After parturition wash the udder and hindquarters with lukewarm water containing an antiseptic and dry with a clean cloth. Watch for the expulsion of afterbirth (placenta). It will be expelled within 2 to 4 hours after the calving. If it is not expelled within 8 to 12 hours, help of a veterinarian may be sought.

ii. Care and Management of Calf at Birth

a) **Attending to the newly born calf:** Immediately after the birth of the calf, all phlegm (mucus) sticking in the nostrils, mouth and on the body should be removed and the calf should be wiped dry with a clean cloth. Normally the calf starts respiration immediately after birth on its own. However, sometimes the

respiratory tract of the calf may be blocked by mucus and the calf may not start breathing. Under this situation, hold the calf head down by lifting it holding the back. The mucus may flow off and the calf may start breathing. The new born calf should be protected from inclement weather conditions especially during winter months and be provided with plenty of dry bedding like straw.

b) **Disinfecting the navel cord:** The navel of the calf should be painted with antiseptics like tincture of iodine soon after birth to prevent infection gaining entry through the navel. If the umbilical cord is not broken, a ligature may be put 2-3 cm away from the body with a sterile thread and cut 1 cm distal to the ligature with a clean sterile scissors. A small amount of antiseptic lotion may be painted at the cut end and protected from flies.

c) **Colostrum feeding:** The calf should be fed with colostrum (first milk of cow after calving) for the first 3 to 4 days of its birth. The feeding of colostrum is very essential as the antibodies present in colostrum provide passive immunity to the calf against many diseases. It should be fed within half to one hour after birth of the calf at the rate of 1/10 of its body weight per day. In conditions where there are no facilities to weigh the calf, a quantity of 2.5-3.0 kg colostrum per day per calf may be offered. So as to reduce the feeding and labour costs, the calves of crossbred cows may be weaned at birth and maintained in an individual pen for the first few weeks. In case weaning is not practiced, the calves should be allowed to suckle for 5 minutes 4-5 times a day.

iii. Management and Feeding Practices for Growing Calves

The husbandry practices and feeding of the calves born at the farm are aimed at attaining a higher rate of growth with a lower morbidity and mortality.

a) **Management practices:** The new-born calves should be provided with individual housing for 4-6 weeks after birth for better protection and care. These houses should have the provision for warming in winter season and cooling in summer season along with the provision of a good bedding on the floors. Later on they may be kept in small groups. The new born calves are given an identification number during the first 3-4 days generally by tattooing the number in the left ear or by tagging. At large farms, dehorning of crossbred calves may be done by removing the horn buds with an electric dehorner within 1 to 2 weeks of birth. Any extra teats present on the udder of female calves called “supernumerary teats” are removed within first 1 to 2 months after birth.

b) **Feeding of growing calves:** The feeding of weaned calves after initial colostrum period shall be as per the following feeding schedule: (Table 5.1)

Table 5.1: Feeding schedule for calves

Age	Whole milk	Skim milk	Concentrate mixture (kg)	Green fodder
5-30 days	1/10th b.wt*.	—	—	—
1-2 month	1/15th b.wt.	1/25th b.wt.	0.120	*ad libitum*
2-3 months	1/25th b.wt.	1/15th b.wt.	0.250	-do-
3-4 month	—	6.5 kg	0.650	-do-
4-5 month	—	6.5 kg	1.000	-do-
5-6 month	—	5.0 kg	1.500	-do-

* body weight

From 6 months onwards, the calves may be offered a good quality green fodder free choice along with the supplementation of 1.0 to 1.5 kg of concentrate mixture per calf daily. The deworming of the growing calves is to be done regularly. The following calf deworming schedule may be followed at the dairy farm (Table 5.2).

Table 5.2: Deworming Schedule for Calves

Age of calf (day)	Name of medicine	Dosage
3rd	Piperazine adipate	1 gm/4 kg Body weight
7th	-do-	-do-
8th	Sulmet course for 3 days	1st day — 30 ml
		2nd day — 15 ml
		3rd day — 15 ml

Later on whenever infection of endoparasites is suspected broad spectrum anthehelmintic drugs like albendazole, fenbendazole or thiobendazole should be used at the rate of 5-10 mg/ kg body weight depending on the severity of infection. The growing calves may also need to be protected from ectoparasites click, tick by periodically spraying of animals and calf houses.

Check Your Progress 1

1) Why the down calvers should be housed separately?

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2) What care and management should be provided to the down calvers in the calving pen?

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3) List the practices for care and feeding of a new born calf.

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4) Give the feeding schedule of weaned calves.

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5.3 HEIFER MANAGEMENT AND FEEDING PRACTICES

Heifer is a female animal of cattle and buffaloes from one year of age up to first calving. Thus, heifers are future cows of the herd. On most dairy farms, 20-25

per cent of the cows are replaced every year with freshly calved heifers. Therefore, proper nutrition and management of heifers are necessary to provide adequate number of healthy and genetically superior herd replacements. Under Indian conditions the goal of dairy farmer should be raise well grown heifers that calve at an average age of about 30 months in case of crossbred cows, 36 months in indigenous cows and about 40 months in case of buffaloes.

The nutrition during this period shall mainly comprise *ad libidum*. feeding of good quality green fodders supplemented with some amount of concentrate mixture so as to obtain a daily growth rate of 500-550 gm in crossbred heifers and 450-500 gm in heifers of indigenous cattle breeds and buffaloes. The heifers may be fed mostly on roughages and allowed to remain lean until pregnancy. During the last half of pregnancy, they can be fed at a higher plane of nutrition to achieve rapid growth which could cause maximum development of ducts and alveoli in the heifer's udder.

The loose system of housing for heifers is generally followed through out the country except in heavy rainfall and coastal areas. For better growth, the heifers need to be protected from summer stress especially under North Indian conditions. Water sprinkling or splashing during hotter parts of the day twice or thrice daily, provision of ceiling fans in the sheds, provision of mist cooling devices and wallowing especially in buffalo heifers are some of the practices to be followed for the protection of heifers from heat stress. For protection from cold stress in winters, the heifers are offered a well balanced nutritious diet. In severe cold weather conditions, the allowance of concentrate mixture may be increased by 0.5 to 1.0 kg per heifer daily so that their growth is not adversely affected. Provision of adequate bedding is essential during winter.

Heifers having stunted growth, late maturing, anatomical defects or bad disposition should be regularly culled from the herd. They need to be protected against ectoparasites such as ticks, lice, etc. by spraying with insecticides like 1 % malathion at monthly intervals. The floors, walls and roofs of the heifer sheds should also be sprayed to make them free from these ectoparasites. The heifers at the age of puberty should be observed for signs of heat every day and should be inseminated with the semen of superior bulls. Attainment of 60 per cent of mature body weight (about 300 kg) is the stage at which the heifers should be bred. The advance pregnant heifers should be trained for milking by taking them to the milking parlour along with the milking cows and allowed to go through the milking routine. This will give them an opportunity to get adapted to the milking routine. Such heifers will not get excited and thus will not give any difficulty in milking after calving.

5.4 BREEDING MANAGEMENT OF DAIRY ANIMALS

After milk production, reproduction is the most economically important trait in dairy animals. Therefore, the maintenance of high fertility rate is basic to the success of any dairy farming enterprise. The practices adopted for the breeding management of dairy cows and buffaloes should aim at bringing about higher breeding efficiency. The breeding efficiency is the measure of the capacity of an adult cow or buffalo to reproduce. It can be measured in terms of number of services taken by a cow or buffalo per conception, length of calving interval, percentage of non-returns and percentage of pregnancies in a breedable period.

i. Sexual Maturity and onset of Estrus Cycle

a) **Puberty and sexual maturity:** The stage of life in which animals become sexually mature and the secondary sexual characteristics first become clearly visible is known as "puberty." In cow and buffalo heifers, this is the stage of first estrus (heat), and in the bull calf it is the stage when it starts giving semen with viable sperms. The term "sexual maturity" means that the heifers are

capable of reproduction. At this stage, reproductive organs undergo a marked increase in size.

Puberty occurs before mature body size is attained. Under good feeding, a calf attains puberty approximately at 66 per cent of adult body size. Breed, genotype, climate and level of feeding influence the age at puberty. The time of onset of puberty appears to be a function more of body size than of age. The sudden increase in size and weight of reproductive tract associated with puberty involves hormonal action.

b) **Estrus cycle:** Every 21±3days from the time of puberty, the cow prepares for a pregnancy. A mature ovum is liberated from the ovary, the cervix becomes receptive to the spermatozoa, the female exhibits behavioural adjustment and attraction to receive the male in copulation, the uterus and fallopian tubes produce the secretions which are conducive to the transport of ovum and sperms and the endometrial lining of the uterus prepares to receive and nourish a fertilized ovum. The events listed above in sum total are known as "estrus cycle."

The estrus cycle has two major phases *viz.* estrogenic phase and progestational phase. The estrogenic phase or the period of follicle includes the proestrus and estrus and lasts for about 4 days of the cycle. The progestational phase or the luteal phase includes the metestrus and the diestrus and lasts for about 17 days.

ii. Symptoms of Heat and Heat Detection

The estrus or the heat is the period in which the animal exhibits sexual desire. The length of estrus period is between 8 to 24 hours in cows with an average of 18 hours. In buffaloes, the estrus period varies between 5 to 27 hours with an average of 20 hours. During summer the buffaloes have very short estrus period.

a) **Symptoms of Heat:** The cows in early stages of heat will show activities like smelling other cows, attempting to mount other cows and bellowing. They will be restless and their vulva will be moist, red and slightly swollen. After a time lapse of 6 to 8 hours, the heat will become more pronounced. The cow will stand to be mounted by other cows or bulls. Due to this, this period is termed as 'standing heat'. This extends for 14 to 16 hours and shows other symptoms like bellowing, nervousness, anorexia, reduction in milk yield, clear mucus discharge and dilated pupil of eye.

b) **Detection of Cows in Heat:** The heat detection work may be carried out twice daily, once early in the morning and once in the evening. Disturbances like noise, visitors or other activities on the farm may be avoided at the time of detecting heat. Use of heat detection chart and breeding history of the cow should always be made while detecting heat. Parading of a teaser (vasectomized) bull amongst the cows in early morning and evening hours by a skilled person will greatly enhance the heat detection rate. Also keenly observing the expected cows and buffaloes while milking and while leaving the milking barn can improve heat detection rate. The other aids suggested to improve heat detection include the use of chin ball markers, heat mount detectors and pedometers.

iii. Artificial Insemination (AI) and Time of Breeding

a) **Artifical Insemination:** AI is the technique in which semen with living sperms is collected from the male animals and introduced into the female genital tract at proper time by mechanical means. The semen is collected from the bulls commonly by the artificial vagina technique. Then it is examined to judge its suitability for insemination by physical, microscopic, chemical and bacteriological tests. The good quality semen is extended further with an appropriate diluent to increase its utility in fertilizing more females. The freshly diluted liquid semen is then used for inseminating the cows and buffaloes in heat or preserved in frozen state for future use.

Advantages of AI: The AI technique offers many advantages over natural mating. It enables an individual bull to sire a large number of progeny. This reduces the number of bulls required for breeding purpose. The services of superior bulls are greatly extended allowing for the genetic evaluation of bulls through progeny testing. It is a major aid in crossbreeding work and in preventing the spread of genital diseases. Due to economic reasons, small farmers may not be in a position to maintain a bull. They can avail AI services at nominal cost.

b) **Time of breeding:** The time of breeding cows naturally or by AI is very important as it greatly influences the conception rate. The best time to breed cattle is from the middle of standing heat and six hours following that. Three or four hours perceeding or succeeding this excellent period also gives good results. As a routine practice, if a cow is seen showing early heat in the morning, it may be inseminated in the evening. If heat signs are first manifested in the evening, the cow may be bred next day morning. A cow is expected to show heat in 30-40 days after calving. Cows that fail to show heat even after 50 days have generally some problems and need examination.

Check Your Progress 2

1) What do you understand by estrus cycle?

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2) What are the symptoms of heat in cows and buffaloes?

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3) Describe artificial insemination (AI). Also give its advantages.

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5.5 MANAGEMENT AND FEEDING PRACTICES FOR MILKING COWS & BUFFALOES

The freshly calved cows should be shifted to the milking herd after 4-5 days of colostrum period. The management and feeding during the lactation is of paramount importance as the level of production and profitability from dairy farming depends largely on the amount of care and judicious feeding provided during this period.

a) **Housing:** The milking cows should preferably be housed in loose houses having a covered area of 3.5-4.0 sq. m. and an open area of 7-8 sq. m. per cow. The floors of these loose houses should be non-slippery and a good dry bedding material should be provided especially in rainy and winter seasons. All the milking cows should be divided into 2-3 groups depending on their level of production as high, medium and low producers. When housed in groups, the number of cows in each paddock should not be more than 50. Frequent shifting of the animals between different groups should be avoided.

The loose housed milking cows and buffaloes need to be protected against the

summer heat stress especially in Northern Indian conditions by suitable means. Water splashing / sprinkling on the animals body for 5-10 minutes twice or thrice daily during the hotter parts of the day, provision of ceiling fans in cow sheds or installation of mist cooling devices specially for crossbred cows and wallowing of buffaloes twice daily for a period of about 1 hour are some of such means. During winter the cows need to be protected against direct cold drafts especially during nights.

b) **Feeding:** The feed and fodder requirements of dairy cows and buffaloes are calculated based on their dry matter (DM) content. The dry matter requirement of milking dairy animals varies between 2.5 to 3.5 per cent of their body weights depending on the level of milk production. Two-thirds of the total requirement of DM of the milking animal should be met through a mixture of cereal and leguminous green fodders and dry roughages. The remaining one-third of DM should be fed through concentrate mixture. As a thumb rule the producing cows should be fed concentrate mixture at the rate of 1 kg for every 2.5 kg of milk produced and buffaloes at the rate of 1 kg for every 2 kg of milk produced over and above the maintenance requirement of the animal.

c) **Milking:** The milking of the dairy animals should be done at the same time daily as per the routine. The buffaloes and low producing cows are milked twice daily and high producing crossbred cows thrice daily maintaining a constant interval between each milking. For better milk production, the milking should be done gently, quietly, quickly and completely. For clean milk production, the milking should be done at a clean place or in a separate milking parlour. Before milking, the cow or buffalo should be washed with water and the udder and teats should be wiped dry with a clean cloth. The milker should also wash his hands and milk the cow after proper let down of milk in clean dry narrow mouthed milking bucket. Milking should be completed within 5.7 minutes.

   All milking animals should be observed for signs of heat from 45 days after calving and should be bred by 60 days of calving. Cows not coming into heat after 60 days of calving should be examined for any reproductive problems.

5.6 MANAGEMENT AND FEEDING PRACTICES FOR DRY COWS AND BUFFALOES

The day from which the cow stops giving milk to the day it calves is called as dry period. A normal dry cow does not give milk but it should be in advance pregnancy. The importance of dry period is to give rest to the cow's udder. It also gives an opportunity to the cow to recuperate its body condition lost during the lactation. Allowing dairy cows a dry period thus results in higher milk production in the succeeding lactation.

An ideal length of dry period is about 60 days. However, in Zebu cattle and buffaloes it is much higher. These animals do not normally need to be dried as they are low milk producers and have shorter lactations which end on their own accord. The high producing crossbred cows and purebred exotic cows need to be dried by using a suitable method.

a) **Methods of drying-off cows:** There are three methods of drying cows viz. abrupt cessation of milking, intermittent milking and incomplete milking. In abrupt cessation method, the milking of cows is stopped all of a sudden. The build up pressure of milk in the udder causes regression of milk secretary cells. This method is suitable for low to medium milk producing cows. In intermittent milking method, the cows are milked once every second or third day till milk production completely ceases. In incomplete milking, the cows are milked gradually, smaller and smaller quantities of milk spread over a week or so. This method is preferred for high yielding cows.

b) **Feeding and management of dry cows:** The feeding of the dry-pregnant cow should be aimed at making up the condition of the cow lost during the lactation. Cows that have been properly fed during the dry period produce up to 25 per cent more milk than the cows which have not been conditioned. Cows which gain about 500 gm of body weight per day during dry period have high milk production in the ensuing lactation. The feeding of cows during dry period should mainly comprise of good quality *ad libitum* green and dry fodders which may be supplemented with 1-2 kg of concentrate mixture per cow per day depending on the condition of the cow.

The dry-pregnant cow should be housed in a separate comfortable paddock at a lesser stocking rate than for the milch or growing stock. About 15 days before the expected date of calving, the pregnant cows should be transferred to maternity pens for better care and feeding.

Check Your Progress 3

1) Briefly describe the housing, feeding and milking management practices of lactating cows and buffaloes.

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2) What is dry period? Describe its importance and list methods of drying off.

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5.7 HEALTHCARE PRACTICES OF DAIRY ANIMALS

Maintaining dairy animals in proper health is essential for obtaining desired productivity and higher profitability from dairy farming enterprise. Animals can be kept healthy if they are purchased from the healthy herd and are quarantined for 45 days before entry into the herd. Further, they are to be kept under proper sanitation, management and feeding and use of appropriate vaccines for the prevention of diseases should be made so that losses from diseases could be minimized.

i. Signs of ill health

The animals that are not in good health, will show several behavioural changes and other symptoms which can be observed by any experienced person. Every farmer should be aware of the common signs of illness of dairy animals so that he/she is able to identify the unhealthy animals at an early stage. Some of such symptoms are described below:

a) The general posture of the animal, its movement and behaviour will change in case of illness. The animals separating from the herd, showing weariness, lack of alertness and keeping head down are likely to be sick.

b) Stoppage of rumination and off-feed are the earliest signs of ill-health. The muzzle and nostrils will be moist and devoid of any discharges in healthy animals. Sunken eyes with fixed staring look, redness in the eyes, paleness or yellow colouration of eye membrane are indicative of disease.

c) The dung in healthy animals is semi-solid in consistency with a dark green colour. Urine of healthy animals is clear and straw coloured. If variation to deep yellow, bloody or coffee colour is noticed it can be a sign of disease.

d) The skin of healthy animals should be soft, elastic and pliable and the hair coat should be glossy and lustrous.

e) Change in quality and quantity of milk produced is an early indicator of disease. Milk yield in dairy cows fall when they are sick. The purulent and creamy discharges from the reproductive tract are indicative of diseased reproductive tract.

f) Change in the normal rectal temperature indicates illness. The average normal rectal temperature of cattle is 101.5 ºF and in buffaloes it ranges from 98.3 ºF in winter to 103 ºF in summer.

g) Variation in the nature and rate of pulse can be indicative of disease. The normal pulse rate varies from 50-60 counts per minute in cattle and 40-50 counts per minute in buffaloes.

h) The rate of respiration and the manner of breathing deviate in disease conditions and ailments of respiratory system. The normal respiration rate varies from 20-25 counts per minute in cattle and 15-20 counts per minute in buffaloes. Incidence of coughing, whistling, crackling and grunting with pain are the signs of diseases of the respiratory system.

ii. Common Diseases and Control Measures Against them

The disease conditions commonly affecting cattle and buffaloes, their causes, modes of transmission, symptoms and the measures for their prevention and control are given in table 5.3.

Table 5.3 Common Diseases and their Control

Name of disease	Cause	Mode of transmission	Principal symptoms	Prevention and control
Foot-and-mouth disease (Muh-khur)	Small filterable virus of 7 types	Contact with infected animals or material contaminated with discharge from lesions	Principal symptoms Salivation, sores on feet, tongue and inside of mouth, stamping of feet, lameness, off-feed, drop in milk production	Seggregation and other sanitary measures, pre-seasonal vaccination with polyvalent vaccine.
Haemorrhagic septicaemia (galghotu)	A bacteria - Pasteurella boviseptica in Cattle and Pasteurella bubalisepta in Buffaloes	Ingestion through contaminated feed, water and pastures, contact with infected animals, organism usually present in the respiratory tract of apparently healthy animals and cause disease when the animal's resistance is lowered.	Sudden attack, high fever, painful, hot swellings on throat, neck and dewlap, swollen tongue and laboured breathing.	Segregation,avoidance of infected pasture, feed and water sources, pre-monsoon vaccination, adequate sanitation.
Black Quarter or Black Leg (sujua)	Bacteria-Clostridium chauvoei	Water and food contaminated with blood and excretions.	Lameness, swellings over shoulders and thighs, high temperature, death in three days.	Annual vaccination before rainy season
Brucellosis	Bacteria - Brucella abortus	Feed, water etc. contaminated by discharge and aborted foetus.	Incidence of abortions during 7th to 9th month of pregnancy, full-time still-births, retained placenta etc. in the herd.	Elimination from herd of carriers, calfhood vaccination at 6 months of age
Anthrax (Gorhi)	Bacteria - Bacillus anthracis	Water and food contaminated with blood and excretions or by wound infection	History of sudden death, high fever, rapid breathing, swelling over body especially around neck.	Annual vaccination before rainy season

Mastitis (Than pakka)	Infectious mastitis is due to the entrance of bacteria into the gland. Non-infectious mastitis is due to improper milking, injury, burns, chilling etc.	Bacteria from dirty floor, milker's hands, cow's body etc. enter into udder through injuries on udder and teats.	Uneasiness in cow when milked, udder swollen, hot and painful in acute cases, milk whey-like with milk clots or even blood clots, temperature of animal rises.	Follow proper dry hand milking, washing or wiping of udder and teats with mild antiseptic before and after milking. Clean barns and sheds, prevent overcrowding in cow sheds
Milk fever (Zichighi-ka bukhar)	A metabolic disorder - due to acute fall in calcium (and magnesium) level possibly due to draining of the same at the onset of lactation through milk.	Occurs generally during the early stages of lactation	Loss of appetite, constipation, general depression, animal lies with its head resting on the chest wall and the nose pointing towards the flank, temperature sub-normal, animal may develop nervousness and die in 6-24 hours if unattended.	Feed mineral supplements to high yielders during late pregnancy and early lactation. To prevent further secretion of milk - stop milking.
Tuberculosis (Kashaya rog)	A bacteria - Mycobacterium tuberculosis	Infection occurs either directly or indirectly from infected animals, their secretions or excretions -bacteria enter system by ingestion or inhalation.	Usually lungs and lymph glands are affected. In cows, the udder becomes infected sometimes There may be loss of weight, swelling of joints, a chronic cough and laboured breathing	Seggregation and other sanitary measures.
Calf scour	Mostly Escherichia coli	Overfeeding, underfeeding, feedeing from dirty pails, feeding milk at temperature below body temperature, housing in unclean pens are predisposing factors.	Severe diarrhoea with light coloured, foul smelling, watery or foamy faeces. Many calves are affected at a time and may die quickly.	Hygienic calf feeding practices, clean calf pens, segregation of infected calves and disinfection of premises
Pneumonia	Many micro-organisms, inhalation of water or medicine drenched by untrained person, exposure to cold drafts	Generally pneumonia occurs when animals are exposed to unfavourable weather conditiond and when their resistance is lowered.	Initially chill followed by high temperature, breathing becomes faster and laboured, dry and painful coughing, watery or mucus like discharge from nostrils.	Avoid sudden exposure to cold or rain. Avoid overcrowding of animals. Keep animals in neat, clean and dry houses.
Bloat (Aphara)	Accumulation of gas / foam in rumen	Greedy feeding on lush green fodders, obstruction in oesoghagus.	Greatly distended abdomen especially on the left side.	Care in feeding green fodders, feeding after wilting, feeding dry fodders with green fodders.
Retention of placenta	As a consequence of abortion, difficult parturition etc.	----	A portion of membrane hangs out from the vulva, chocolate coloured discharge with foul smell, milk yield goes down.	Clean the hind quarters of cow with warm water and take care that the hanging part of the membrane does not get pulled out. Seek veterinary aid.

iii. Vaccination for the Prevention of Diseases.

Vaccination is a procedure for artificially inducing active immunity in animals against specific infectious diseases by introducing biological agents called vaccines into their systems. The vaccine is an antigenic substance from a particular microorganism. A vaccine when introduced into the animal system produces antibodies in the animal against the disease and thus protects the animal from the attack of that disease. A chart showing the programme for vaccination at a dairy farm is presented in Table 5.4. Vaccination is carried out routinely on animal farms so as to prevent the outbreak of diseases in the herd. The vaccination is not done at a locality where the disease has already broken out.

Table 5.4 Vaccination schedule

Name of the disease	Type of vaccine	Time of vaccination	Duration of immunity imparted
Foot and mouth disease	Polyvalent tissue culture vaccine	At about 6 months of age with a booster dose 4 months later. Thereafter, yearly once in the month of September-October	One season
Haemorrhagic Septicaemia	Oil adjuvant vaccine	Once in a year (pre-monsoon)	One season
Black Quarter	Polyvalent vaccine	Once in a year (pre-monsoon)	One season
Tuberculosis	B.C.G. vaccine	At about 6 months of age to be repeated every 2-3 years	One to two years
Brucellosis	Strain - 19	Calfhood vaccination, in case herd is suspected of infection	Life long

Check Your Progress 4

1) Enumerate major signs of ill health in dairy animals.

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2) List the common diseases of dairy animals. Also describe their symptoms and control measures.

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3) What is vaccination? Give a schedule of vaccination to be followed at a dairy farm.

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5.8 LET US SUM UP

The dairy business comprises of performing several practices in a synchronized fashion. These include feeding, breeding, housing, healthcare and day-to-day management of all categories of dairy animals such as calves, heifers, lactating as well as dry cows and buffaloes. The feeding of a balanced ration comprising both fodders and concentrates in required quantities and at proper time shall result in better health and growth performance. Likewise, proper heat detection and insemination of estrus cows at the right time shall result in higher breeding efficiency and better reproductive performance. For better productive performance, the dairy animals are to be kept in sound health by practicing regular deworming and vaccination and attending to the sick animals promptly. Proper care and management of lactating cows and buffaloes and following of a good milking routine shall result in higher milk production which ultimately determines the profitability of dairy farming.

5.9 KEY WORDS

Herd	:	A group of cows or buffaloes.
Umbilical cord	:	A band of tissue connecting the foetus with its placenta.
Placenta	:	An organ that attaches the foetus to the wall of uterus.
Colostrum	:	The first secretion (milk) produced by mammary gland in each lactation.
Alveoli	:	The cells responsible for the secretion of milk in the mammary gland
Weaning	:	Separating the calves from their mothers at their birth or later and rearing them artificially.
Mortality	:	The incidence of death in a population in a given period.
Morbidity	:	The state of being diseased.
Tattooing	:	A method of identifying individual animals by the use of numbered pins and indelible ink.
Breeding	:	The mating (artificial insemination) of animals to produce young ones under controlled circumstances.
Anorexia	:	Complete loss of appetite.
Conception rate	:	The number of animals pregnant as a proportion of the total number mated or inseminated.
Ad libitum	:	Free choice
Zebu cattle	:	The humped cattle breeds of Indian origin.
Skim milk	:	The milk from which fat has been separated.
Genotype	:	The genetic constitution of an individual or group as determined by the particular set of genes it possesses.
Teaser bull	:	A vasectomized bull used for estrus detection.
Purulent	:	Containing pus.

5.10 SOME USEFUL BOOKS

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5.11 ANSWERS TO CHECK YOUR PROGRESS EXERCISES

Yours answers should include following point

Check Your Progress 1

1) i. For better climatic protection and avoidance of disturbance from other cows
   ii. For giving them individual attention and keeping under constant watch.
   iii. For preventing the chances of infections to cows and calves at the time of birth.
   iv. For preventing the injury to the new born calves and cows
2) i. Provision of bedding and laxative feed.
   ii. Watching for the signs of approaching parturition
   iii. Assisting the cow in delivery if needed
   iv. Washing the udder and hindquarters and their drying
   v. Watching for the expulsion of placenta
3) i. Care of new born calf: Removal of mucus and drying of calf, ensuring normal respiration, protection against extreme weather conditions, disinfection of the navel
   ii. Feeding of new born calf: Time and amount of colostrum to be fed D duration of colostrums feeding
4) i. The feeding schedule for growing calves including the feeding of whole milk, skim milk, concentrate mixture and fodders.

Check Your Progress 2

1) i. Attainment of puberty D onset of estrus D showing of physiological and behavioural symptoms of heat D shedding of ovum from the ovary D repeating of estrus after about 21 days if case the cow has not conceived D called estrus cycle.
2) i. Cows will be restless, their vulva swollen, red and moist, eyes dilated.
   ii. Bellowing and mounting by cows with mucus discharge from vulva.
   iii. Nervousness with reduced feed intake and milk yield.

3) i. Semen collection from bulls D its quality evaluation D semen dilution insemination with liquid semen '! freezing for future use.

ii. a. Reduces the requirement of bulls

b. Aid to crossbreeding programme of cattle

c. Reduces the spread of diseases

d. Small farmers can avail breeding services at low cost

Check Your Progress 3

1) i. Type of housing D space requirements D grouping of animals D summer and winter protection measures. ii) Dry matter (DM) requirement D DM to be fed through concentrate mixture, green & dry roughages D thumb rule of concentrate feeding. Ii) Regularity of milking D cleanliness of cows, milkers and milking utensils.

2) i. Definition of dry period ii) Giving rest to cow's udder D improving the body condition of cow D higher milk yield in next lactation iii) Abrupt cessation of milking intermittent milking and incomplete milking D suitability of each method.

Check Your Progress 4

1) i. The posture of the animal D condition of the muzzle, nostrils and eyes D consistency and colour of dung and urine D Change in milk production and quality of milk D change in body temperature, pulse rate and respiration rate D loss of appetite.

2) i. Name various diseases of cattle and buffaloes D give their major symptoms and the steps to be taken for their control.

3) i. Introduction of vaccines into the animal body D production of antibodies against the disease D protection of the animal against that disease.

ii. Give the chart showing the vaccination programme to be followed at a dairy farm.

UNIT 6 CLEAN MILK PRODUCTION

Structure

6.0 OBJECTIVES

After reading this unit, we shall be able to:

- state the meaning of the clean milk production
- describe the importance of clean milk production
- specify the measures to produce clean milk at farm level
- enlist the constraints in clean milk production

6.1 INTRODUCTION

The dairy industry is an important segment of food industry in India as it plays a significant role in the national economy and socio-economic development of the country. It is an important source of self-employment and subsidiary occupation to the rural and semi-urban population of India. Milk provides relatively quick returns for small-scale livestock owners. It is a balanced, nutritious food and a key element in household food security. Over 80 per cent of milk consumed in developing countries is handled by informal market traders, with inadequate regulations. Dairy industry is an integral part of livelihood of million of people thriving on scarce resources. Dairying, as a subsidiary source of income, is a real relief to most of the weaker section in the society who depend on agriculture. Undoubtedly, the major challenge of the dairy sector in India is to increase the milk production in order to meet the increasing demands resulting from population explosion. Under such prevailing circumstances, the maintenance of high quality of milk production at farm under most hygienic conditions and bringing it to milk plant is a most challenging job. Ultimately, the quality of milk and milk products have to be evaluated based on the final products that are going to be utilized by the end users. Hence,

the dairy industry is passing through a very critical phase of quality upgradation to place the best quality of milk and milk products in the market.

6.2 CONCEPT OF CLEAN MILK PRODUCTION

Quality initiatives need to be made strong by introducing concept of clean milk production at the village level. “Clean milk” may be defined as “ milk drawn from the udder of healthy animals, which is collected in clean, dry milking pail and free from extraneous matter like dirt, dust, flies, hay, manure etc. Clean milk has a normal milk flavour with low bacterial count and is safe for human consumption.”

Milk secreted from the udder under normal conditions is almost sterile. It contains many essential nutrients such as protein, lipid, lactose, minerals and vitamins and therefore, acts as an ideal medium for rapid proliferation of micro-organisms. Milk needs to be protected from all possible sources of microbial contamination and various types of pathogenic organisms. The employment of hygienic practices at the time of milking is therefore one of the first and foremost important step in clean milk production.

Clean milk production is always beneficial/profitable for both the producers and the consumers because of the following reasons:

- Safe for human consumption
- Better keeping quality and chances of spoilage minimized
- High commercial value
- Renders protection against diseases like typhoid, dysentery, etc. which are transmitted to the milk through human contact
- Helps to produce good quality dairy products or value added products
- Transportation over long distance

Quality of product encompasses safety, hygiene, reliability, wholesomeness and acceptance by consumers. Quality conveys different meaning to different people”.

“Milk quality is not an option but it’s an obligation”. Milk quality is the most important factor in dairying today; quality is a result of totally integrated approach, from the dairy farm environment to cooling and storage of bulk milk on the farm.

6.3 SIGNIFICANCE OF CLEAN MILK PRODUCTION

Milk production which was almost stagnant between 1947 and 1970 with an annual growth rate of merely one per cent has registered a significant growth during the last two decades. The annual milk production has increased from 17 million tonnes in 1950-51 to 91.1 million tonnes during 2004-05 in a period of over 50 years which amounts to one and a half million tonnes increase per year. With the present growth rate of 5.5 percent per annum, India is expected to produce 220 to 250 million tonnes of milk by the year 2020 which would be more than one third of the projected global production.

Dairy industry has its own peculiarities unlike other industries. Manufacturing a good dairy product is not enough but it must be free from harmful additives and microbes till it is consumed. The implementation of hazard analysis critical controls points (HACCP) in dairy industry would provide a competition edge to milk and milk products supplies in the international market. The objective of clean milk production can be achieved by judicious application of the principles and practices of HACCP, which is a scientific based system and systemically identifies specific hazards and provides measures for their control to ensure safety of milk and milk products. It is a tool to assess hazards and establish control system that focuses

on prevention rather than relying mainly on end product listing. Therefore, successful and effective implementation of HACCP system requires the use of risk-based decision-making in identifying significant hazards at different points in the food chain from producer to dairy docks and to ultimate end users as well as establishing critical limit at specify critical points.

The dairy sector is poised to play a significant role in the process of diversification and commercialization of agricultural production in our country. In spite of enormous breakthrough in milk production, India's global participation in milk trade is negligible. Milk and milk products produced in our country reaches domestic consumers to fulfill an enormous need of people. Export of milk and milk products is very low which possesses large potential for export especially to third world countries, if we are able to achieve and sustain the quality of milk and milk products.

6.4 FACTORS AFFECTING CLEAN MILK PRODUCTION

Milk is one of the main sources of proteins and calcium for a largely vegetarian population. Around 63 per cent of the available animal protein comes from milk. Milk is the most easily contaminated and perishable commodity as it is an ideal medium for bacterial growth. Hence, the employment of hygienic practices right from milking at the farm level to the factory is essential. The causes of high bacterial load in milk and the factors affecting the clean milk production are presented in Figure.6.1 and 6.2, respectively.

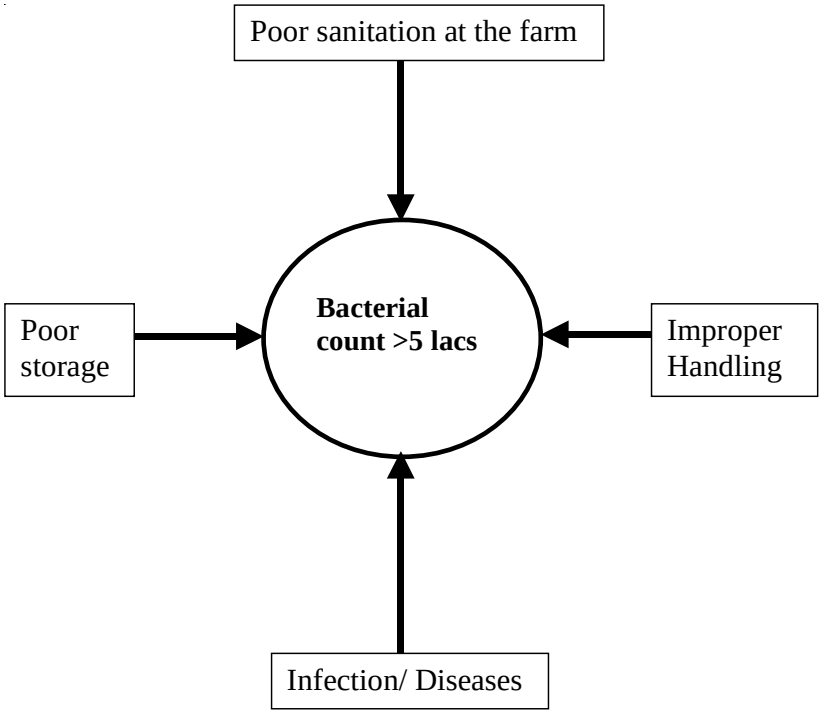

Figure 1: Causes of high bacterial load in milk

The factors affecting the production of clean and safe milk can be classified into two catagories: internal and external factors.

i) Internal factors includes:
   - Udder infection – Mastitis
   - Foremilk – First few streams of milk contains a large number of bacteria

ii) External factors includes:
   - Cow/animal's body – especially dirt and dung from hind quarters and tail

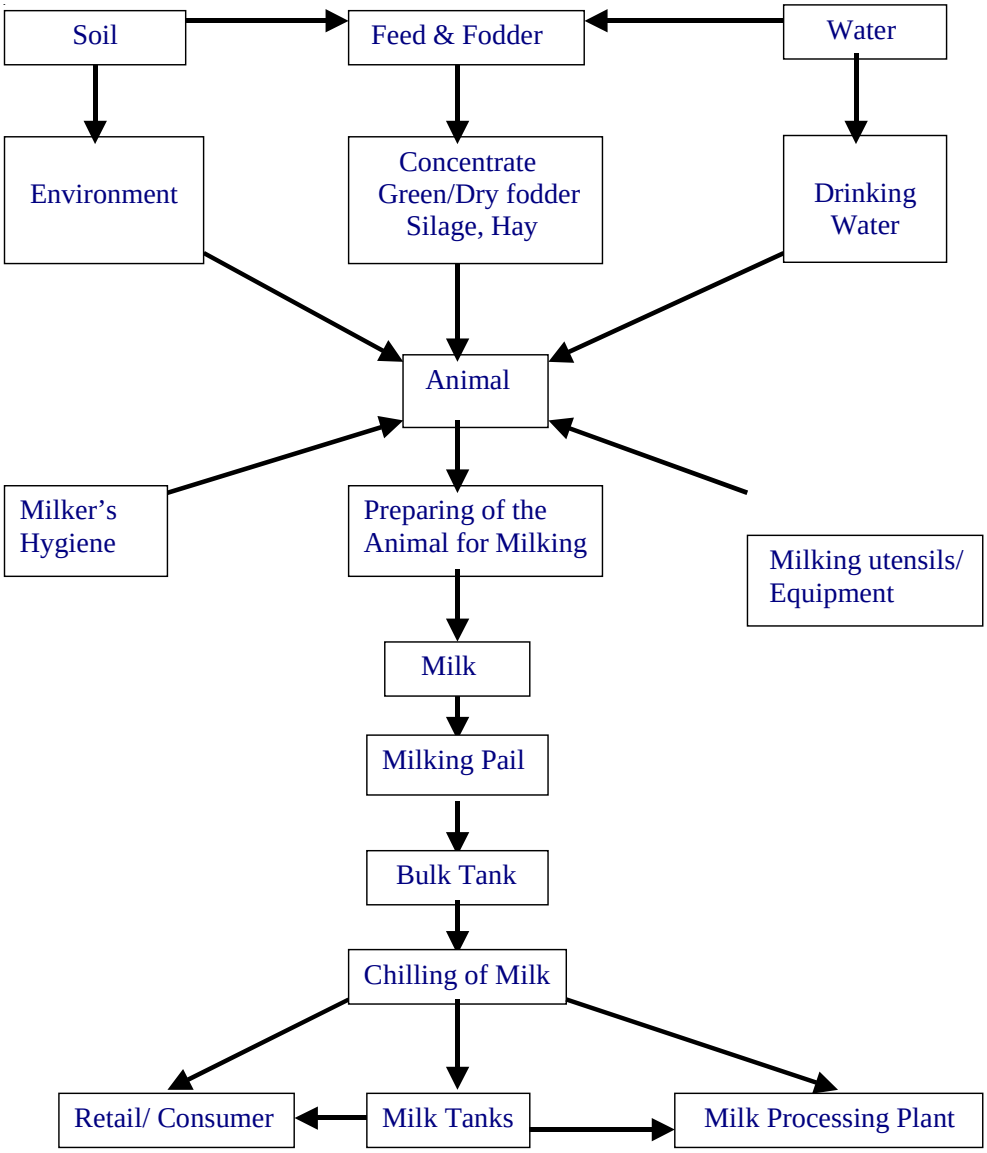

Figure 2: Factors affecting Clean Milk Production

- Udder and teats
- Milker – hygiene and habits
- Milking and storage utensils
- Method of milking
- Feed and Water
- Milking Environment

However, contamination of milk can be corrected at various levels as follows:

- The animal management- includes feeding, housing and health
- Hygiene of milking equipment and utensils
- Milker and milking practices
- During storage and transport
- Personal hygiene of those who are involved in production, processing and delivery activities related to milk and milk products

Check Your Progress 1

1) Describe Clean Milk. How does it facilitate value addition to milk and milk products?

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2) Write the causes of high bacterial load in milk.

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3) Enumerate the factors affecting Clean Milk Production at farm level.

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6.5 MEASURES FOR CLEAN MILK PRODUCTION

In order to bring out considerable change in the prevailing situation throughout the country, a systematic approach is required for milk production and manufacturing of different products. Therefore, a multidimensional team work should be initiated in which the team workers will look into the areas of animal management, nutrition, health, microbiological aspects of the milk and milk products as well as the residues of other unwanted contaminations in the milk. This should first generate information on the base line for each aspect and identify the critical points during the process of milk production and processing.

The following measures should be taken care for the production of clean milk:

i. Animal Management at Farm Level

When milk leaves the healthy udder, it is relatively free from bacteria. While some contamination with bacteria from the milking environment and the equipment is inevitable, the total bacterial count should be lower than 3 million/ml or otherwise, it will lead to significant degradation of the fat, protein and lactose causing off-flavour and would significantly reduce the flexibility in processing the milk. Although pasteurization reduces the bacterial count, it can not destroy the bacterial spores, which germinates again. Moreover, there are some bacteria producing toxins that survive even at pasteurization temperature and remain in the milk products too.

The animal management involving the feeding aspects of the animal as well as health and practices related to housing and environment at farm level are very important.

a) **Feeding:** Feeding of milch animals should be done an hour before milking. At the time of milking, for the purpose of keeping cows busy, provide only concentrates which are less dusty. Feed and feed ingredients should meet minimum safety standards. These should only be produced, stored, marketed and used if they are safe and suitable. The presence of unsuitable substances such as industrial and environmental contaminants, pesticides, radionuclides, persistent organic pollutants, pathogenic agents and toxins/mycotoxins in the feed should be identified. Feed additives and veterinary drugs used in medicated feed should be critically assessed for safety aspects before using. Therefore, improper procurement, manufacture and handling of animal feed can result in the introduction of pathogens and chemical hazards, which can affect the safety and sustainability of milk.

Balanced feeding with appropriate quantities of green fodder, straw and concentrates having all essential nutrients and minerals is another important aspect required for quality milk production.

The points to be considered while feeding the milch animal are:

- Feeds and fodders should be free from pesticides, insecticides, fungicides, herbicides, fumigants, aflatoxins as well as heavy metals.
- Feed ingredients should be stored in moisture-free conditions. Rodenticides should be carefully handled.
- Silage and wet crop residues should not be fed at milking place as it may impart foul odour to the milk.
- Good quality straw and supply of adequate minerals and vitamins in feeds should be given high priority.

b) **Housing:** The housing and its environment are most often forgotten. Therefore, we need to look at where the cow is milked, where she is housed, and how she gets back and forth between these areas. The animal shed is one of the main sources of contamination. At the same time, a good shed protects animals against micro-organism as it keeps out other animals, people, wind, rain and excessive heat, all increasing the danger of contamination. Mud, urine, faeces and feed residues should regularly be removed from the shed. The shed should have proper drainage, sufficient lighting and ventilation. In very wet areas, sprinkling slaked lime over the surface will help to dry it out quickly. The milking area of the shed needs special hygienic attention. The floor of the milk shed should be swept with clean water and disinfected with one per cent bleaching powder solution. Facilities should be provided for a sufficient supply of safe and potable water for drinking, washing udders and flanks of the animals, utensils and milker's hand etc.

The farmer needs to be educated to know how a well-constructed animal shed and well maintained surrounding help in keeping his animal disease-free.

- The cattle shed should be well-roofed, sufficiently lighted, well ventilated, dry and comfortable with adequate elevation to avoid stagnation of water. It should not be a breeding place for pathogens, flies and mosquitoes.
- There should be appropriate arrangement for disposal of animal waste in a manure pit or a biogas plant. Care should be taken to remove left over fooder and fodder lying on floor.
- Proper arrangement of doors and windows with wire mesh.
- Barns and holding pens have to be properly located.
- Piggery and poultry farming should be avoided in the premises of animal shed.
- Control of flies and insects is important as they are potential source of transmitters of disease causing organisms.

Tips to evaluate a good housing system

- Housing must be kept clean and dry 24 hours a day.
- Proper ventilation and lighting
- Controlling the environment during summer and excessive winter.
- Allotment of proper space for each animal.

c) **Animal Health:** The pre-requisite of clean milk production is a healthy herd. The farmer should be educated and trained to adopt improved health care practices because only a healthy and clean animal can produce contamination free milk.

- Routine examination of cattle is necessary to assure that they are disease-free (TB, Brucellosis etc.)

- The animals suffering from contagious disease must be kept separate from healthy herd. Sanitary precaution to prevent and control the disease should be adopted.
- Using inducer drugs should be avoided.
- Check for udder wounds and mastitis. Avoid pooling of milk of the animals on drugs with the bulk milk until the animal fully recovers from illness.
- Vaccination of animals against FMD, Anthrax, Hemorrhagic septicemia etc. should be done at least once a year.

ii. Somatic Cell Counts (SSC)

Mastitis is one such infection, which not only alter the composition of milk but also reduces the milk yield. Mastitis milk has low lactose, casein, fat and calcium and high amount of immunoglobulins and sodium. Such milk contains high number of somatic cell and pathogenic bacteria. Mastitis renders the milk unsuitable for human consumption and for production of cultured and fermented milk products. Infected udder can be source of a wide variety of micro-organisms.

Somatic cell count (SCC) is being used as an index of the udder health and quality of milk. Any inflammation or injury to the mammary gland will increase SCC of milk. Due to this reason the monitoring of somatic cell secretion in milk helps to detect the sub-clinical mastitis. In addition, SCC in bulk milk samples also indicates the level of hygiene maintained at the farm. The milk having high SCC indicates some disturbance in the udder and should be discarded. To effectively monitor the udder health and the quality of milk, the milk samples should be checked at least at fortnightly intervals and if SCC values are found more than the prescribed standards, the necessary treatment of the quarter should be immediately given. Somatic Cell Count is influenced by number of factors such as management of animal, health of animal and surrounding environmental of the animal. Milk is considered normal, if SCC are $1x10^6$ cells/ ml or lower. The detailed criteria of normal and abnormal milk is given in Table 6.1.

Table 6.1: Criteria to determine the normal or abnormal milk

S.No.	Somatic cell	Status of the counts	Status of the milk udder
1.	Up to 2.5 lakhs	Normal	Normal
2.	2.5 to 4.0 lakhs	Sub-clinical mastitis	Slight change in milk
3.	>4.0 lakhs	Clinical mastitis	Visible change in milk

In order to reduce effectively the SCC in milk, cleaning and regular removal of waste should be done so that the chances of bacterial growth and pests are minimized. Milk from the animals showing clinical symptoms of diseases should neither be mixed in bulk milk nor used for human consumption. The milking byres should have provision of fans and proper ventilation so that light does not become a limiting factor in milking operations.

iii. Cleanliness of Milking Equipment and Utensils

Milking equipments and utensils used at farm include a variety of equipment and containers including milk pail, milking machine, teat cup clusters, cans, milk pipeline, recorder, bulk tank, strainer, cooler, milk flow indicators, etc. These equipment pose a serious threat. The residual milk solids on such equipment sustain the growth of micro-organism and colonization of such micro flora results into formation of biofilm. These biofilms can result into heavy contamination of milk during subsequent operation or use. Milk cans generally contribute thermoduric organisms while bulk tank and storage tank may facilitate the proliferation of psychrotrophs due to prevalence of cold temperature during holding of milk in these tanks.

Therefore, proper cleaning removes most of germs and parasites along with the dirt. The equipment and vessels coming in contact with milk should be thoroughly cleaned.

- The milk vessels must be cleaned before and after each milking thereby rendering these bacteria free.
- Detergents/chemicals used for cleaning of vessels, must be non-injurious to health like teepol. Use of ash or mud is not recommended.
- The cleaned and sanitized vessels must be kept in an inverted position in a space.
- Milking pail with dome shaped top should be used instead of open buckets or vessels by which milk contamination can be nullified to a great extent.

iv. Hygienic Milking Practices

Hygienic conditions of storage and transport equipments and storage temperature are the two key factors, which play a great role in deciding quality of raw milk. Air posses a lesser threat as a source of contamination in comparison to other sources like teat surfaces. Some organisms may enter during hand milking (falling in the milk pail) and machine milking (sucked along with air). In addition, the personal hygiene of the worker either at cattle yard or dairy dock must be taken into consideration to produce clean milk.

Hygienic practices during milking contribute to production of safe and suitable milk.

- There should not be any floor sweeping (disturbances, noise etc.) at the time of milking for preventing pollution of air by dust/bacteria.
- Milker's should be free from communicable diseases and should wear clean clothes, nails trimmed and should neither eat or spit anything nor clean his nose.
- Before starting the milking operation, the milker should clean his hands with soap, potable water and then wipe them with clean towel.
- Clean the udder and teats with lukewarm water using a cloth before each milking.
- The fore stripping should be collected in separate utensil/cup and should not be thrown on the floor, so as to avoid infections by the flies.
- After milking the teats have to be dipped into a bacteriocide to minimize the risk of infection. The practice of dipping of fingers into milk and then wetting the teats to soften them is not recommended.
- Milking should be completed within 6-8 minutes.
- Wet milking (moistening the hand with milk or oil or water) is not encouraged.
- Milk should be strained using a clean cloth or a strainer to remove sediment and other foreign materials. If cloth is used, it should be washed and dried daily.

v. Cooling of Milk

The provision of bulk cooling facilities at each centre under clean milk production programme encouraged by NDDB has been assured in order to have the bulk milk cooling tank for maintaining the bacteriological quality of raw milk by adopting clean milk production practices and immediate cooling of milk for onward journey to dairy dock. The reduction of time between milking and reception at the center, maintenance of low temperature of milk till it is received at dairy/chilling center through chilling interventions by providing bulk milk cooling tanks enhances the safety of quality milk.

The strategic advantage of producing clean milk is lost entirely if post milking handling is not carefully managed. The microbiological contamination is the major source of continuous deterioration of milk.

- To preserve the keeping quality of milk, it has to be cooled as soon as possible to a temperature below 5°C by storing in refrigerator or can be kept at cooler place.
- The sooner the milk is cooled after removal from the udder, the better is the quality.
- Bacterial growth is retarded by cooling and storing milk at 10°C or below within 2 hours of milking.
- Delivery of milk to the factory should be as frequent and as early in the day as possible.

6.6 STRENGTHENING INFRASTRUCTURE FOR QUALITY & CLEAN MILK PRODUCTION

Government of India has introduced a centrally sponsored scheme "Strengthening Infrastructure for Quality & Clean Milk Production" during 10th Plan period with following objectives:

- Creation of infrastructure for production of quality milk and milk products at the farmers level up to the points of consumption.
- Improvement of milking procedure at the farmers level.
- Training and strengthening of infrastructure to create mass awareness about importance of clean milk production.

Funding: The pattern of funding under the scheme will be on 100% basis, for the following components:

- Training for clean milk production to all members of the society.
- Detergent, antiseptic solutions, muslin clothes.
- Utensils and accessories for clean milk production.
- Strengthening of existing laboratory facilities.
- Planning and monitoring.

The pattern of funding under the scheme will be in the ratio of 75:25 for purchase of bulk cooler between Government of India and the respective Dairy Cooperative/ Union.

Implementation: Dairy Cooperative/Union/Federation will implement the scheme through State Government. The Project shall be prepared as per the guidelines of the scheme and shall be submitted through concerned state Government/Union Territory Administration to the Department of Animal Husbandry & Dairying.

6.7 STRATEGIES TO IMPROVE THE QUALITY OF MILK

If the dairy industry in India has to gear up to be considered as one of the best in the world, the stress should be emphasized on "Quality of raw milk". To achieve this goal, it is imperative to have comprehensive extension efforts to impart knowledge on clean milk production practices to the dairy farmers. The strategies to be employed for this are:

1. Identification of coalition or interest groups in the rural communities involved in community development activities.
2. Work with the group to get information on the needs, priorities and constraints in the various aspects of clean milk production.
3. Designing and developing new Information and Communication technologies like Interactive Multimedia on clean milk production practices as it fulfills the

need for the interaction in the communication process as compared to other media.

4. Education and training of the milk producers on hygiene, house keeping, clean methods of milking and collection of milk and good animal husbandry practices. Educational programmes should be organized for farmers for making them aware of clean milk production practices.
5. Posters/charts/video films on clean milk production can be displayed at village level, society level as well as at milk collection centers.
6. Mass media programmes should be initiated with regular visits of experts, in relation to comprehend the clean and hygienic practices by the farmers.
7. Villager should be made aware about fast multiplication of bacteria at various stages of milk handling by testing of bacteriological quality of milk from udder to milking point, society and ultimately reception dock.
8. There is a need to identify the information needs of the target group on various aspects of clean milk production practices and data base computer information system to improve the efficiency of standard practices.

6.7 PRESENT STATUS OF CLEAN MILK PRODUCTION IN INDIA

The present status of India's dairy sector has distinct advantage being the largest producer of milk in the world from a large base of livestock. The pressure of competition is such that Indian dairy industry has no option but to launch a vigorous campaign to produce clean milk. Efforts are continuing by the National Dairy Development Board in collaboration with different cooperatives and dairy federations to introduce the practices at the village level to produce clean and hygienic milk to meet the present day challenges faced by it. It is important not only in order to sustain the present level of milk production and continue paying the remunerative price presently being paid to farmer producers, but also it helps in reducing wastages and producing more value added milk products.

It is well known that the quality of milk is affected due to the contamination from feed, veterinary drugs, fertilizers and environment in the milk at the farmer level. The microbiological quality of milk is affected by general health of animals and milk handling practices subsequent to milking. In fact, the bacteriological quality of raw milk in India is similar to that of any developed countries at the cattle udder level.

The status of raw milk produced in India is reflected in its bacterial quality (Table 6.2). A comparison of status of raw milk quality in India vs. International quality standards (1000-1,00,000 SPC cfu/ml) indicates that the bacteriological quality of raw milk is almost similar at the udder level (Table 6.3). Thus, the way of milk handling subsequent to milking affects the quality of raw milk.

Studies conducted by the author at nearby villages from National Dairy Research Institute (NDRI) related to the knowledge level of farmers on clean milk production practices revealed the following aspects scoring very low:

- Drying of udder with clean dry cloth after washing
- Udder cleaning with lukewarm water
- Shape of milking pail
- Clean and sanitized animal shed
- Teat dipping
- Sub-clinical mastitis and it's diagnosis

Table 6.2: Bacteriological status of raw milk produced under different Indian conditions

Source of sample	Age of milk from time of production (h)	Colony forming units (10^6/ml)*					
		CENTRE A			CENTRE B		
		Winter	Summer	Monsoon	Winter	Summer	Monsoon
		15-25°C	22-25°C	20-32°C	9-25°C	28-45°C	23-40°C
Fresh milk	0	0.10	0.17	0.18	0.40	0.91	0.99
Village Produced	2	0.34	0.58	0.47	0.74	2.62	1.10
Private Dairies	4-5	3.41	3.68	1.47	0.19	9.80	1.30
Milk Vendors in towns	4-5	1.59	1.99	3.75	1.21	6.66	2.45

*Average data for 200-300 samples in each category.
Centre A – South India (Characterized by a fairly temperate climate)
Centre B – Typical north Indian Town (Characterized by extremes of temperate)

Table 6.3: Comparative statement of Standard for Bacterial Load in raw milk

India (BIS)			USA (cfu/ml)		UK (cfu/ml)		IDF (cfu/ml)	
Grade	**SPC (cfu/ml)**	**MBRT (hr)**						
Very good	<2X10^5	5.5	**Liquid milk grade**	<1X10^5	**Grade A**	<2X10^4	**Min (cuf/ml)**	<1000
Good	2X10^5 - 1X10^6	3-4	**Manu-factured production grade**	d”3X10^6	**Grade B**	2X10^4- 1X10^5	**Max (cuf/ml)**	1X10^6
Fair	1X10^6 to 5X10^6	1-2			**GradeC**	>1X 10^5		
Poor	>5X10^6	30 min.						

The results of the study reveals the grim knowledge of milk producer’s and therefore calls serious attention upon the contemporary situation in clean milk production. Hence, there is virtually an urgent need to disseminate knowledge regarding the benefits of adopting clean milk production among the farmers.

6.8 CONSTRAINTS IN ADOPTION OF CLEAN MILK PRODUCTION PRACTICE

The main constraints in adoption of different measures for clean milk production are:

- Level of awareness among rural population producing milk.
- Low threat perception
- Lack of quality norms or legislation
- Milk procurement is obligatory irrespective of quality

- Low level of mechanical processes to collect the milk from farm to dairy dock
- Poor technical knowledge and available infrastructure facilities for collection and chilling of milk.

Check Your Progress 2

1) Enumerate the constraints in clean milk production system.

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2) What is Somatic cell count? Give classification of normal and abnormal milk based on SCC.

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3) Discuss in brief strategic view points for Clean Milk Production.

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6.9 LET US SUM UP

We can understand from this unit that as milk is a highly perishable agricultural commodity, it is necessary to produce clean milk for safe human consumption. Clean milk is the milk drawn from healthy animal, collected in a clean, dry milking pail, possessing good flavour, free from extraneous materials like dirt, dung, dust, flies, hay etc. containing a relatively small number of bacteria, essentially free from pathogens and safe for human consumption. The main sources of contamination of milk are animals' body, udder, milker, milking equipment and utensils and milking environment. Proper animal management, cleanliness of milking equipment and utensils, hygienic milker and milking practices and proper storage and transportation of milk is necessary for clean milk production. There is also an urgent need to disseminate knowledge regarding the benefits of Clean Milk Production among the farmers.

6.10 KEYWORDS

Clean Milk : The milk drawn from the udder of healthy animals, which is collected in clean milking pail and free from extraneous matter like dirt, dust, flies, hay, manure etc. having low bacterial count, free from off- flavour and safe for human consumption.

Quality : Quality encompasses safety, hygiene, reliability, Wholesomeness and acceptance by consumers

Pesticides Residues in milk : The chemical residues which originates in milk and milk products from insecticides, fungicides, herbicides etc.

Insecticides	:	This is a chemical compound, which kills the insects and pests on agricultural commodity/ veterinary drugs etc.
Fungicides	:	The chemical compounds, which kill the fungus, mainly used to protect the fungal diseases of plants.
Herbicides	:	The chemical compounds, which kill the weed/ unwanted plants/ vegetation.
Rodenticides	:	The chemical compounds, which are used to kill rodents in agriculture field/ food grain storage.
Fumigants	:	It is a chemical compound, which are available to produce fumes for treating against insects and pests of food grains during storage.
Mycotoxins	:	Mycotoxins are a group of toxins originate from fungal origin.
Mastitis	:	It is a disease condition of udder due to bacterial infection resulting in swelling, pain and hardening of udder thereby affecting the quality and quantity of milk

6.11 SOME USEFUL BOOKS

Codex. **(**1997). General Requirements (Food Hygiene), Supplements to Vol. 1B. FAO/WHO. Rome.

Ganguli, N.C. (1999)**.** Sustainable milk quantity – A pre-requisite to go global. *Indian Dairyman*, **51** (6): 21-29.

Heeschen, W. H. (1996). Bacteriological quality of raw milk: Legal requirements and payment systems. IDF Publication.

Sohrab. (1997). HACCP Through ISO 9000 Quality Management System. *Indian Food Industry*. May-Jun, 1997. **16**(3).

6.12 ANSWERS TO CHECK YOUR

Your answer should include the following points:

Check Your Progress 1

1) i. "Clean milk" may be defined as " milk drawn from the udder of healthy animals, which is collected in clean, dry milking pail and free from extraneous matter like dirt, dust, flies, hay, manure etc. Clean milk has a normal milk flavour with low bacterial count and is safe for human consumption."

   It facilitates:

   - Safe for human consumption
   - Keeping quality
   - Commercial value
   - Quality base product for processing
   - Transportation to far places

2) i. Poor sanitation at the farm

   ii. Improper handling of milk

iii. Poor storage of milk

iv. Infection/disease of animal milked

3) i. Internal factors includes:

- Udder infection – Mastitis
- Fore milk – First few streams of milk contain a large number of bacteria

ii. External factors includes:

- Cow/animal's body – especially dirt and dung from hind quarters and tail
- Udder and teats
- Milker
- Milking and storage utensils
- Method of milking
- Feed and Water
- Milking Environment

Check Your Progress 2

1) i. Awareness of people producing milk

ii. Low threat perception

iii. Lack of quality norms or legislation

iv. Milk procurement is obligatory irrespective of quality

v. Lack of mechanical processes

vi. Lack of technical knowledge and available infrastructure facilities for collection and chilling of milk

2) i. Somatic cell count is a measure of number of somatic cells or leucocytes in one ml of raw milk. Somatic cell count (SCC) is being used as an index of the udder health and quality of milk. Any inflammation or injury to the mammary gland will increase SCC of milk. Due to this reason the monitoring of somatic cell secretion in milk helps to detect the sub-clinical mastitis. Milk is considered normal, if SCC is $1x10^6$ cells/ml.

Sl.No.	Somatic cell	Status of the counts	Status of the milk udder
1.	Up to 2.5 lakhs	Normal	Normal
2.	2.5 to 4.0 lakhs	Sub-clinical mastitis	Slight change in milk
3.	>4.0 lakhs	Clinical mastitis	Visible change in milk

3) i. Displaying of posters/charts/video films on clean milk production at village level

ii. Development of database computer informations

iii. Training of milk producers on house keeping hygiene and animal husbandry practices

iv. Use of mass communication and multimedia techniques.

v. Testing of bacteriological quality of milk at various stages of milk handling.

UNIT 7 MILK PROCUREMENT AND MODES OF PAYMENT

Structure

7.0 OBJECTIVES

After reading this, we shall be able to:

- state the milk disposal and procurement systems;
- comprehand the economics of milk procurement; and
- give the basis of pricing of milk and modes of payment.

7.1 INTRODUCTION

India has attained number one position in the world in milk production. The country produces about 91.0 million tonnes of milk annually and it has been increasing by about 5 per cent annually. Milk production is one of the largest single enterprises in India with an annual output valued at Rs. 90360 crores. One of the significant features of dairying in India is that it is basically a small holders' enterprise. Milk production is still in the hands of small holders who are spatially scattered. Majority of them maintain small herd of one to two milch animals. The productivity of these animals is also relatively low.

Prior to Operation Flood, dairying in the country was largely unorganized and left

in the hands of middlemen, vendors and halwaiis. There was little emphasis to link milk production in the rural areas with urban demand for milk and milk products. In the subsequent periods, the organized dairy sector in the co-operative, private and state domain has come up in a big way. The organized dairy sector vertically integrates the process of milk procurement, processing and marketing of milk and milk products. It has successfully reduced the role of middlemen in the dairy industry. At present there are 865 dairy factories in this sector in the country that procure milk and convert it into value added products for delivering to the consumers in the form consumers want.

There is huge demand for milk and milk products in India. About 15.51% of total expenditure on food items is spent on milk and milk products in rural areas whereas in urban areas it is still higher at 18.19%. To fulfill this huge demand of people for milk and milk products, organization of milk procurement is a first step in this direction. It is indeed a tremendous task to organize milk procurement from millions of tiny milk producers scattered all over the country side and transport it to the dairy factories for the manufacture of different dairy products. What type of the organizational structure is best suited to accomplish this task? What should be the price of milk to be paid to the producers and the selling price of milk and milk products by the dairy plants are some of the other relevant questions that need serious considerations?

7.2 MILK DISPOSAL PATTERN

Procurement covers collection of milk from rural producers or contractors, including setting up of chilling centres, provision of laboratory equipments and supplies, milking machines, cattle welfare including feed and fodder and transportation. What are the factors that affect milk procurement and or its constituents? It can be answered properly if we have some information about milk disposal pattern adopted by the milk producers in the area as they are the suppliers of milk from whom the milk is to be collected. In other words, it is concerned about knowing how much milk do the milk producers retain at home and how much do they sell after meeting their own requirements? To whom do they sell their milk and at what price? It is estimated that out of the total milk production, 40 per cent of the milk is retained at home either for self consumption and or conversion into few dairy products at household level in the rural areas. The rest 60 per cent of total production is marketed. Out of this marketed surplus, the share of traditional sector is about 78 per cent whereas the share of organized sector is 22 per cent. The quantity of milk which is surplus after meeting household requirements depends upon host of factors such as milk production per household per day, size and composition of the family, preferences of family members for milk and milk products, education level, economic conditions etc. Marketed surplus as a percentage of milk production may be as low as zero per cent i.e. no sale of milk at all and can go up to 100 per cent depending upon the above mentioned factors. Selling of milk provides cash to the farmers for meeting other needs. The milk producer may, in certain cases resort to distress sales, though he may not have any marketable surplus of milk. We have observed that many factors affect marketable surplus, thus all these factors directly or indirectly influence milk procurement.

7.3 MILK MARKETING SYSTEMS

How the link between the producer of milk and consumer is established? Or what are the channels of milk disposal available to the milk producers? Figure 7.1 given below illustrates that milk generally reaches the consumers through the following channels.

S.No	Milk Marketing Channels
1	Producer ——————————————————▷ Consumer
2	Producer ———▷ Vendor ——————————————▷ Consumer
3	Producer ———▷ Halwaii ——————————————▷ Consumer
4	Producer ———▷ Vendor ————————▷ Processor ———▷ Consumer
5	Producer ———▷ Middlemen/Milk Producers Cooperative Society —▷ Milk Plant ——▷ Consumer

Figure 7.1: Milk Marketing Channels

The above Figure reflects the prevailing milk marketing systems in the country. The first four channels pertain to the unorganized sector while the fifth one is generally adopted by the dairy plants in the private/co-operative sector. To dispose off the surplus milk, the producer has choice of selecting the agency to whom he can sell his milk. The milk producer has the option of selling milk to the consumer directly either in the village itself or in the town/urban area as depicted in Channel-1. The milk producer can also sell milk to the vendor (Channel-2) who in turn sells it to the consumer. The Channel-3 connects milk producer to the Halwaii (sweet maker) and ultimately the consumer whereas in Channel-4 the first contact point is milk vendor in addition to the other marketing functionaries in milk trade as is evident in Channel-4. Milk producer can also deliver milk at the collection center of Milk Producers Co-operative Society in the village itself (if there is any such center) or in some nearby village where there is a milk collection center. Milk producer is at liberty to patronize one or more than one milk marketing agency depending upon his individual preferences, terms of payment settled and commitments between the seller and the purchaser. It is generally found that milk vendor collects the major share in the milk business in comparison to other agencies involved in the milk trade.

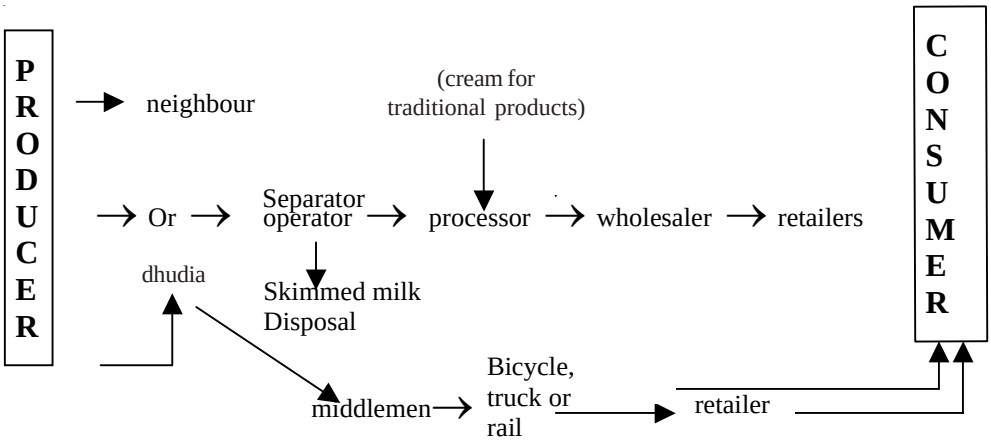

Fig. 7.2: Traditional Channel of Milk Transport

The flow chart in the figure 7.2 depicts the typical traditional channels of milk transportations from the producer to the consumer through the retailers.

7.4 MILK PROCUREMENT

We know that dairy industry is dependent on a perishable raw material i.e. milk which is subject to wide seasonal fluctuations. How and from where do the dairy plants collect milk to meet their daily requirement? Or what are the factors that influence milk procurement? The organized dairies collect their milk supplies from milk shed area.

A milk-shed area is the geographical region from which a marketing agency secures its fluid supply. The size of the milk shed area is primarily determined by the demand of the dairy plant. The larger the dairy plant the larger the milk shed and more costly the supply. If a dairy plant is large enough the milk shed may overlap of other cities. The number of milk collection centre, the number of milk producers pouring milk at the collection centre, distance of milk collection centres, price paid by different milk procurement agencies, regularity of payment are the other considerations that determine milk procurement.

The systems of milk procurement, which have grown in the organized sector of dairying, can be depicted as following (Fig. 7.3).

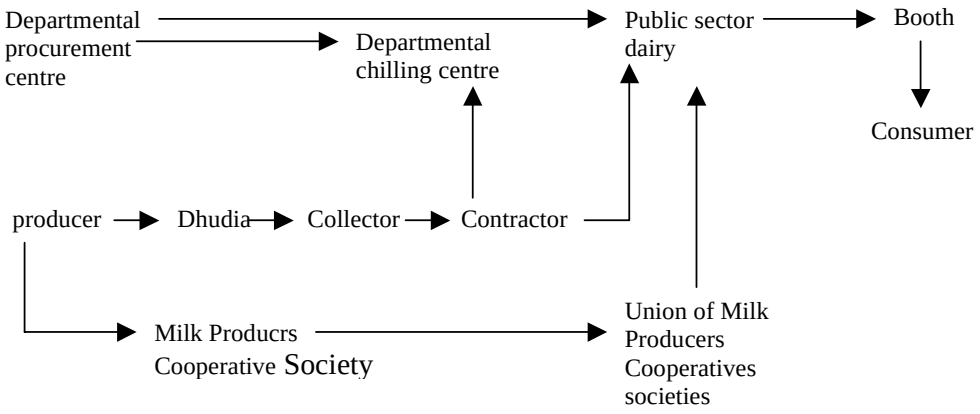

Fig. 7.3 : Milk Procurement by Organized Sector

How milk is procured by the dairy plant? As can be seen from the flow chart, the organized dairies collect milk through one or combination of the following systems:

i. Direct System

In this system the plant collects milk directly from the producers by establishing its own village procurement centres. The milk producers deliver their milk supplies at the collection centres. The payment for milk to the milk producers is made according to pre-specified rate based on quantity and quality of milk supplied.

ii. Agent System

The dairy plant appoints agents to procure milk in the specified area. Payment for the milk is made directly to the producers while the agent gets the commission on pro-rata basis.

iii. Contractor System

The plant purchases milk from the contractor according to terms of the contract. The details in respect of quality, quantity of milk in the flush and learn season, price and the payment etc. are specified in the contract.

iv. Co-operative System

The plant accepts milk from Milk Producers Co-operative Societies (MPCS) established and functioning at the village level. The milk producers in the villages give surplus milk to MPCS. The payment for milk is made according to quality and quantity of milk. The rates for fat and SNF are made known to the milk producers.

The co-operative sector has made tremendous progress in the organization of dairy co-operatives at the grass-root level in the villages and milk procurement in sizeable quantities. The extent of their reach can be judged from the number of dairy co-

operatives, their membership, quantity of milk procured and sold in different states under the co-operative sector during the year 2003-04 as given in Table 7.1.

Table 7.1: Milk Procurement in Different States under Co-operative Sector as on 31-03-2004

S.No.	Name of the Sates	DCS Organized	Farmer Members	Rural Milk Procurement (000Kg/Day)	Liquid Milk Sale (000L/Day)	Processing Capacity (000L/Day)
1	Andhra Pradesh	5590	785	953	898	2150
2	Assam	65	2	3	8	60
3	Bihar	4621	239	402	447	666
4	Delhi	-	-	-	1937	1350
5	Goa	169	19	43	89	75
6	Gujarat	12112	2580	5052	2107	6720
7	Haryana	4257	230	326	152	530
8	Himachal Pradesh	235	17	25	16	40
9	Karnataka	9311	1741	2243	1517	2530
10	Kerala	3218	706	614	740	905
11	Madhya Pradesh	5089	250	313	323	1000
12	Maharashtra	18349	1583	2683	2648	4650
13	Nagaland	76	3	2	4	10
14	Orissa	1654	122	127	132	185
15	Pondichery	93	30	55	52	50
16	Punjab	7283	404	745	496	1545
17	Rajasthan	9643	534	1035	855	1295
18	Sikkim	189	7	9	7	15
19	Tamil Nadu	7578	1988	1664	1206	2601
20	Tripura	84	4	2	9	10
21	Uttar Pradesh	17826	778	797	436	1670
22	West Bengal	2287	172	327	823	1600
	Total	**109729**	**12194**	**17420**	**14902**	**29657**

It is made clear at the outset that the dairy plants in the co-operative and public sector domain have adopted dairy co-operatives structure as a system not only for milk procurement but also for dairy development as well.

It may be emphasized that no city dairy can function properly unless it is linked up with a proper milk procurement organization preferably located at a distance from the urban consumption centers. Dependable sources of milk supply would be distant milk production centers rather than close peri-urban areas.

In the past, city dairies were established without much thought on the milk procurement arrangement. When the city dairies were commissioned there was immediate need for milk. Milk contractors and middlemen were ready to supply milk. The milk contractor supplied milk to the dairy when they found it more profitable to do so. This happens in milk surplus season when milk prices in the rural areas and consumer prices in the cities are low. During lean season the contractors take advantage of the high market price in the cities and divert the milk directly for sale through traditional milk vendors. Many dairies had to remain at the mercy of milk traders and contractors facing the problem of more milk than what they can

sell during flush season and less than what they need during lean season. The system of milk procurement through contractors and middlemen neither helps the producers nor the consumers.

The milk producer's interests shall be served best when he gets remunerative price for milk, the payment is regular and timely, incentives for higher milk production like availability of veterinary services free or at a nominal costs, readymade feed mixture at subsidized rates, supply of improved seeds and other technical services are provided to him.

On the dairy development aspects, National Commission on Agriculture had observed the weaknesses of agent system and the contractor system. It recommended establishing the milk co-operatives all over India on Anand Pattern as these societies serve the best interests of milk producers. These societies appoint their own employees, equip the centre with testing, measuring or weighing facilities and operate the collection centers. The chances of malpractices by the paid employees are reduced as they work under the constant watch of the milk producers. Moreover the price of milk is based on the two-axis pricing policy, calculated by fixing a pre-determined rate for fat and solids-not-fat. Milk producers are generally better off in this type of system of payment.

The most common system of procurement of milk now being followed by most of the government dairies is through establishment of milk collection centers and the collection-cum-chilling centers. The simplest form of milk chilling station is where milk can be chilled by ice. A chilling plant handling about 10,000 litres of milk per day is reported to increase cost roughly by 30 paise per litre to the cost of milk. A chilling plant handling smaller quantity of milk increases the cost further. In order to reduce the cost per litre, the chilling plant should be of a size giving the optimum economic returns. Generally speaking the minimum size of a chilling plant should have a handling capacity of 10,000 liters/day. The selection of the size of the chilling plant quite often poses a difficult problem for the dairy organization. Though the operational cost per litre of milk is lower with bigger sized plant but while taking a decision on the size of the chilling plant, the extent of availability of milk is also a determining factor. A decision of the capacity of the chilling station should, therefore, be taken in all cases after carefully weighing various factors and keeping in view the primary consideration of economy.

With good and reliable transport agencies, it should be possible to transport milk in fresh condition from village collection centers to a dairy plant located 50 to 60 km away. Chilling centers may, however, become unavoidable under certain situations e.g. where milk is to be procured from far away places and where transport facilities are not satisfactory. Actually it is the time lag between milking and its receipt at the dairy plant and the associated risk of spoilage of milk that would determine the requirement or other wise of a chilling centre. While it is necessary to maintain the quality of milk, it is equally necessary that procurement cost is kept as low as possible.

The dairy industry is also faced with the problem of uneven supply of milk during different months of the year whereas the demand of milk and milk products does not depict wide fluctuations. How to meet such situations to balance supply with the demand so that the wide gap between them is narrowed down? Sometimes large dairies requirement cannot be met from one source and that too from a nearby source of milk production. A large dairy has to be linked up with more than one milk shed. It is with these objectives that helped in establishment of rural feeder/balancing dairies to meet the milk requirement of new dairies set up in the metropolitan cities. Each feeder/balancing dairy was to be owned and operated by the milk producers themselves. The role and objectives of feeder/balancing dairies are elaborated below.

v. Feeder/Balancing Plants

To ensure a year-round steady and uniform supply of milk for city milk projects there is need to establish feeder/balancing plants. The feeder function of the plant is confined to the dispatch of chilled/pasteurized milk in bulk to the city distribution system whereas the balancing function of the plant is to balance the year round supply of the required quantity of milk to the cities and conserve the remaining quantity of milk procured in the form of milk products. It is generally observed that procurement of milk during the lean season declines to nearly one-third of that of the flush season whereas the year-round demand for milk in the city remains almost constant. One of the measures to meet this demand is to conserve surplus milk during the flush season in such a way that it can be utilized during the lean season. The surplus milk may either be converted into products ready for direct marketing or for reconstituting into fluid milk during the lean season.

The farmers should be provided with a guaranteed market throughout the year. It is, therefore, necessary to build up processing facilities that are large enough to process the entire marketable surplus milk during the flush seasons. This can be achieved with establishment of what has come to be known as Feeder/Balancing Plants as an integral part of a large city milk supply project.

vi. State Milk Grid and National Milk Grid

With the establishment of a number of fully functional feeder/balancing plants of adequate size in suitable locations within a state, it would be desirable to establish a State Milk Grid that would ensure steady milk supply all through the year in different parts of the state. Similar developments in the adjoining states may enable the creation of a regional milk grid and with progressive development it should be possible to establish a national milk grid for the whole country. Creation of the milk grid would require besides establishment of functional feeder/balancing plants, the building up buffer stocks of products like skim milk powder, white butter, butter oil and frozen cream.

Milk, after collection at the village collection centre needs to be transported as early as possible to the dairy plant or milk chilling centre for processing/cooling. Fast moving vehicles can be used to transport milk by road. The dairy organization has to decide whether to own its own fleet or hire it on contract basis. Further it requires schedules of the timings to be maintained at the collection centres to clearly demarcate the responsibilities to the village society, truck operators and the dairy plants. Road milk tankers are more economical and satisfactory for collection milk from chilling centres provided adequate quantity of milk is available for a single trip. The biggest size road milk tanker can carry about five times milk quantity in comparison to a truck which can carry about 75 cans of 40 litre capacity each.

7.5 ECONOMICS OF MILK PROCUREMENT

Milk and its procurement is the base on which the structure of dairy Industry is built. The efficiency with which milk procurement activities are undertaken affects the costs and returns of the dairy plants. The efficiency of procurement operations namely milk collection, chilling and transportation of milk has deep impact on the cost of milk procurement. The total cost of procurement of milk in addition to payment for milk, include milk collection cost, transportation cost, chilling cost and other procurement overheads. Generally it is found that milk collection cost per litre bears a negative relationship with the quantity of milk collected. As the quantity of milk increases the per litre cost of milk collection is decreased. It may be pointed out that there are seasonal fluctuations in the milk production which give rise to lean and flush seasons. It also affects the cost of milk collection. The density of

milk produced in the vicinity, quantity of milk supplied per household, proximity of the milk shed area to the plant, organizational set up, location of collection centres, milk losses at the collection centres are the other factors which influence milk procurement cost.

i. Milk Transportation Cost

Milk may be hauled from collection centres to the plant directly or to the chilling centre first and then transported to the plant after it is chilled at the chilling centre to avoid its spoilage. Depending upon the mode of milk transport used by the plant and or the transporter, the cost of milk transportation may vary depending upon quantity of milk transported. Due to economies that accrue when larger quantity of milk is transported, milk transportation cost per litre generally shows a decreasing trend. In addition to quantity of milk to be handled, system of transportation whether bulk or in cans, type of trucks used, distance of milk collection area from the plant, routes followed, road conditions, weather conditions are other determinants of transportation cost. The average transportation may come about around 50 paise per litre of milk transported. This cost may increase further if milk is taken to the chilling plant first and then transported subsequently after chilling at the chilling centre. Under the contractual arrangement made for haulage of milk from co-operative societies/collection centres to the chilling centres and or the reception dock of the dairy plant, then transportation cost per litre of milk generally behaves more or less like as depicted in Fig. 7.4.

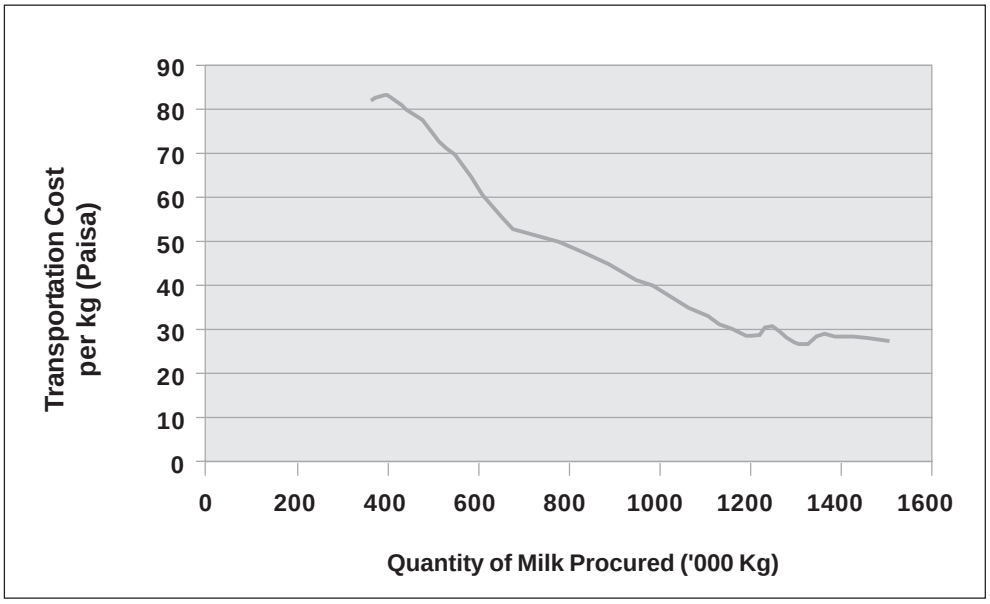

Figure 7.4: Cost of Transportation per Kg. of Milk

The above diagram is illustrative only indicating the underlying phenomenon. The actual cost may vary from plant to plant depending on the factors discussed above.

ii. Milk Chilling Cost

The mode of chilling, type of chillers used, efficiency of chilling machine, quantity of milk chilled, ambient temperatures are some of the significant factors which affect milk chilling cost. Chilling cost per litre during summers is relatively high partially due to high ambient temperature and also on account of relatively low volume of milk handled. As milk quantity increases the fixed cost is shared by larger volume resulting in lowering of overall average chilling cost/litre.

In addition to above activities of milk collection, transportation and chilling milk is to be received at the dock of the plant. Expenditure on the use of fixed assets which include depreciation and interest on fixed assets, salaries and wages of staff

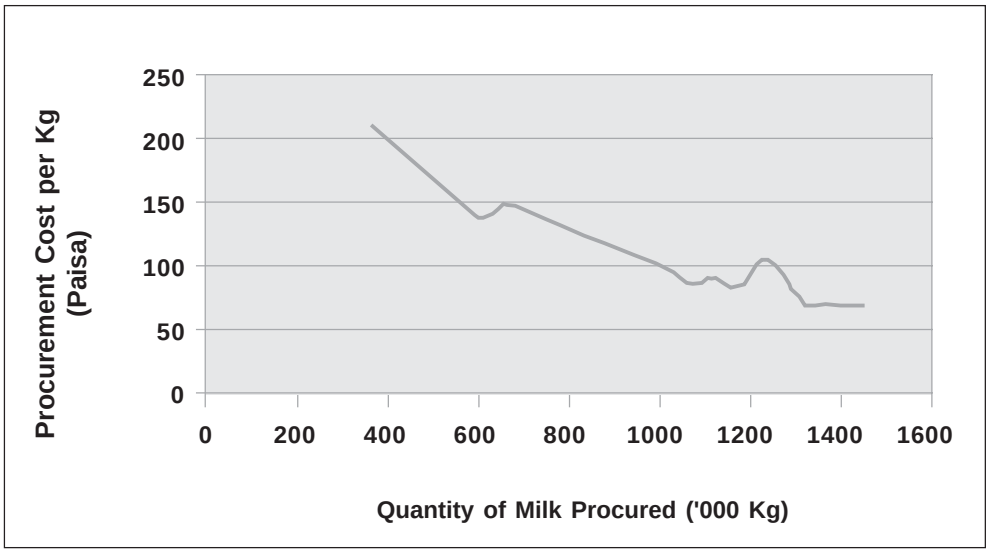

Fig. 7.5: Cost of Milk Procurement at Various Levels

involved in the milk reception, electricity cost, consumables, repairs & maintenance of machinery and other miscellaneous expenses add to total milk procurement cost to determine the cost of milk at the dock of the dairy plant. The cost of milk procurement excluding the payment made to the milk producers at various levels is illustrated in Fig. 7.5.

Check Your Progress 1

1. What are different methods of milk procurement? Discuss their relative merits and demerits.

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2. What is the necessity of feeder/balancing dairies and State/National Milk Grid? What role do they perform?

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3. Discuss the factors that affect milk procurement cost.

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7.6 PRICING OF MILK AND MODES OF PAYMENT

Milk thus procured is to be utilized in most efficient way in the production of different dairy products according to the consumer demand. The dairy plants have to look after the interests of milk producers as well as the consumers. It demands a rational pricing policy to meet the objectives of serving both these entities and at the same time to see that the plant's own economic viability and growth prospects are not lost sight of.

Price is one of the most effective means of achieving organizational objectives. Pricing can effectively serve as an instrument of supply and demand management. It has a significant role to develop and influence the structure of any segment of the economy including dairying. Most marketed milk is a joint product of mixed farming. For successful purchase pricing it is necessary that the purchase price should be such that it attracts the inputs required for milk production such as labour and cultivable land for growing fodders. The sufficient conditions for success include the competitiveness of the purchase price i.e. its absolute value v/s other prices offered, timing and reliability of payment.

The selling price for milk and milk products must be competitive with others selling prices, consistent with the objective of social justice, relative consumer preferences and techno-economics of dairying.

Determination of a pricing structure for milk has not only to be based on the demand-supply equilibrium but also on the compositional quality of milk. The market forces will determine the base price for milk. The dairy plants should decide what price is to be paid to the farmers on the basis of quality of milk. Most dairy plants have some kind of a purchase pricing policy, which has some kind of relationship to what the plants get from the sale of their milk and milk products. In the interest of the organized sector, the milk pricing system has to be such that it becomes instrumental in increasing milk production by ensuring lucrative returns to the milk producers.

A rational pricing structure should ensure that :

- Milk production is encouraged.
- The farmers get a fair return.
- Producers should get the incentives to supply better quality and larger quantity of milk.
- It should ensure the maintenance of an even supply of milk throughout the year.
- Consumers should get wholesome milk at reasonable rates.
- An attractive margin of profit to processors of milk and milk products.

A faulty pricing policy can lead to a combination of the following undesirable effects:

- Encourage adulteration with water or with fat and solids not fat from non-milk sources.
- Discourage production of one kind of milk while encouraging the production of other kind.
- Encourage mixing of cow milk with buffalo milk or vice versa.
- Encourage malpractices in payment for milk.

The pricing systems that are operative in the country for milk procurement are of the following type:

i. Pricing on Fat Content

Under this system milk is paid on the basis of its fat content alone.

- This system discourages adulteration with water or mixing cow and buffalo milk with a view to gain an economic advantage.
- This system involves relatively simple accounting.
- This system encourages partial skimming and adulteration with cheaper fats.
- Production of cow milk is discouraged, as milk is valued only on fat basis, completely disregarding the SNF contents. According to this system, cow milk containing 3.5% fat will be paid at half the rate for buffalo milk containing 7%

fat, even though the solids-not-fat (SNF) content of both the milk is nearly the same.

ii. Pricing on the Species Source

Milk pricing is made on the consideration of the species from which milk is drawn i.e. cow or buffalo. Usually a minimum fat standard for the different types of milk is adopted for acceptance or rejection of the product. Milk that meets the minimum fat standards is usually paid a flat price without regard to its compositional quality.

Such system provides no incentives for production of richer milk. The producers, therefore, under this system, would not get any extra payment for extra fat in their milk during lean season. Generally in the lean season milk production goes down while fat percentage goes up.

iii. Pricing on the basis of a Minimum Fat Percentage plus Premium for Fat

Under this system a minimum fat standard is laid and a base price is fixed for the minimum fat standard. Fat over and above the minimum standard is paid premium on pro-rata basis. It discourages the production of cow milk.

iv. Pricing on Total Milk Solids

This system is mostly adopted by traditional milk traders. Milk is paid on the basis of yield of *Mawa or Khoa*.

- Fat & SNF are priced at the same level which in fact is not rational.
- This system discourages the production of high fat milk.
- It encourages partial skimming & adulteration of milk with cheaper non-milk-solids.

v. Two Axis Pricing of Milk

National Commission on Agriculture recommended that dairy industry should adopt two axis pricing policy for milk procurement as it is rationally based on evaluation of both fat and solids-not-fat contents of milk. According to the two-axis pricing policy, the price of milk is calculated by fixing a pre-determined rate for fat and solids-not-fat. In this system fat and SNF are, generally, given equal value and per kg. price for fat and SNF are fixed in that ratio at which these occur naturally i.e. round 2/3 of fat price per kg. for each kilogram of SNF. In actual practice incentive for higher than the minimum SNF and penalty for supplying lower grade of milk by way of deducting the amount at a higher rate otherwise payable for good quality milk is well specified.

This type of raw milk pricing automatically discourages adulteration. This system does not discriminate against the cow or the buffalo milk. To minimize the effect of seasonality on milk procurement seasonal price premium can be paid up to 30% of flush season rate during lean months as it will increase average plant utilization and reduce the cost of processing.

vi. Pricing of Milk Products for Sale

The sale price of milk and its products should be fixed in a manner that would enable the organized dairy industry to pay remunerative price to the milk producers and meet the cost of collection, processing and distribution of milk and milk products. The sale prices should also cover the cost of services rendered in connection with channellizing the inputs for milk production, keep a fair margin of profit and yet make the price of the commodities competitive.

In case of milk schemes sponsored by the Government, the consumer's price is

administered so as to keep it as low as possible. It becomes difficult to pay remunerative price to the producer and thereby induce more production and procurement. Commercial consideration of profit and loss should be the guiding policy to help and develop the dairy industry so that it becomes viable and commercially profitable. However, Govt. may have differential pricing of dual-price policy for milk distributed through milk supply schemes to render assistance to weaker sections of the community.

The only method for maintenance of the competitiveness of consumer price without reducing the remunerative price for producers is to keep marketing cost as low as possible. This can be done by attaining greater efficiency in procurement, processing and distribution of milk and milk products.

The Committee on Pricing of Milk set up by the Government of India detailed the criteria for a rational pricing policy. It recommended that a Milk Pricing Committee should be appointed at (a) each dairy plant, (b) in each state and (c) an inter-state authority should be set up to coordinate the activities of the dairy plants that collect milk from more than one state to fix the producer and consumer prices of milk from time to time. The Milk Pricing Committee of the state and dairy plants should be sensitive to the variations in the prices of various inputs for milk production and the benefits that the farmer can obtain so that milk production is not discouraged by the pricing structure. The committees should also keep in view the interests of the consumers and should critically examine the overhead charges for collection, processing and administration so that the gap between the producer and the consumer price is kept to the minimum.

Check Your Progress 2

1. What is Two-Axis Milk pricing? How do you consider this pricing system better than any other pricing system for milk payment.

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2. Tick the correct answer for the following statements.

   (i) Milk producers sell milk to the Milk Producer Co-operative Society only

   (ii) The share of milk vendors in milk collection is lowest among all the milk collection agencies.

   (iii) Marketed surplus as a percentage of milk production may range from 0 to 100 per cent for an individual milk producer.

   (iv) Milk Producer Co-operatives Societies (MPCS) procure milk from the members of MPCS only.

   (v) Dairy Co-operatives Societies on Anand Pattern serve best the interests of milk producers.

   (vi) While deciding the size of the chilling plant, major consideration should be given to economy of operations.

   (vii) In India there is even supply of milk throughout the year.

   (viii) The major objective of Feeder/Balancing plants is to compete successfully with the larger city dairies.

(ix) Milk transportation cost per litre increases with the increase in milk quantity transported.

(x) Two-Axis pricing policy is better than the other systems of milk payment.

7.7 LET US SUM UP

Milk is a critical input for any dairy plant and needs to be collected for the supply of fluid milk and milk products. The efficiency with which milk procurement activities are undertaken affect the costs and returns of the dairy plants. In the unorganized sector milk vendors command major share in milk collection. The organized dairies collect their milk supplies by one or combination of the methods comprising of direct system, contractor system, agent system and the co-operative system. The dairy plants under the co-operative and the public sector rely mainly on the co-operative structure of milk procurement.

To ensure a year-round steady and uniform supply of milk for large city milk projects there is need to establish feeder/balancing plants followed subsequently by establishing State Milk Grid for the state and National Milk Grid for the country.

Milk procurement cost is affected by various factors such as density of milk production, quantity of milk supplied per household, size and proximity of the milk shed area to the plant, organizational set up, location of collection-cum-chilling centres, milk losses at the collection centres, mode of milk transportation, and quantity handled, etc. Among the various methods of payment for the milk, two-axis pricing policy is rational one and has been accepted by the dairy industry by and large. The sale price of milk and its products should be fixed in a manner that would enable the organized dairy industry to pay remunerative price to the milk producers and meet the cost of collection, processing and distribution of milk and milk products and a fair margin of profit.

7.8 KEY WORDS

Milk-shed area : A milk-shed area is the geographical region from which a marketing agency secures its fluid supply.

Procurement : It comprises collection of milk from rural producers or contractors, including setting up of chilling centres, provision of laboratory equipments and supplies, milking machines, cattle welfare including feed and fodder and transportation.

Marketed Surplus : It is the quantity of any commodity that is actually sold in the market.

Two-Axis Pricing : It is a system of milk pricing which takes into account the compositional quality of milk and makes a rational evaluation of market realizations for fat and SNF.

7.9 SOME USEFUL BOOKS

Report of The National Commission on Agriculture 1976, Part VII Govt. of India, Ministry of Agriculture and Irrigation, New Delhi

Special Number ‘Dairying in India-1980’, XVI Dairy Industry Conference, Pune.

7.10 ANSWERS TO CHECK YOUR PROGRESS

Your answers should include following points:

Check Your Progress 1

1) i. Discuss all the systems of milk procurements, i.e. direct system, agent system, contractor system and the co-operative system. Elaborate the strengths and weaknesses of each system.

2) i. Highlight the prevalent uneven supply of milk in the country during different seasons and state how establishing of feeder/balancing dairies can be instrumental in solving the problem. At the state/national level the role of State/National Milk Grid is to be explained.

3) i. We know what constitutes total milk procurement cost. Discuss the factors that affect various constituents of milk procurement cost. In other words, elaborate the factors that affect milk collection cost, milk transportation cost, milk chilling cost and milk reception cost.

Check Your Progress 2

1) i. The student is expected to discuss Two-axis pricing policy and highlight its advantages vis-à-vis other systems of milk payment.

2) (i) False (ii) False (iii) True (iv) False (v) True (vi) True (vii) False (viii) False (ix) False (x) True.

UNIT 8 MILK COMPOSITION, ITS CONSTITUENTS AND NUTRITIONAL IMPORTANCE

Structure

8.0 OBJECTIVES

After going through this unit, we shall be able to:

- enumerate chemical constituents of the milk;
- specify milk composition of different species;
- identify factors associated with composition of milk;
- give chemical nature of flavour and off-flavour related to milk; and
- indicate nutritional importance of milk.

8.1 INTRODUCTION

Living beings require food for various purposes like growth, reproduction, supply of energy, maintenance and recovery from diseases at different stages of their life. These functions are met from foods of different sources. Amongst different foods milk is a mixture par excellence which contribute towards nutrition of human beings. Milk is taken by the infant from birth to weaning, by the adults as well as old and sick. Some of the dairy products are also recommended as a part of the diet of such persons. The need and function of food varies as per the requirement of the individuals. Thus an infant requires food for growth and maintenance while a pregnant and lactating woman nutrient function is for the development of foetus and synthesis of milk. Food must also meet sense of taste and appetite. Milk and milk products have an unique position as a source of nutrients. Each of the milk constituent plays an important role in the life span of an individual.

8.2 MILK COMPOSITION

Mammary gland is the symbol of milk for all mammals. Milk is required by young ones for energy and growth. Milk constituents are important as human food. Utilization of milk for the manufacture of various dairy products and the problems arising during their production has led to the need to study milk composition, its constituents and factors which affect the composition of milk.

Milk is an important food for mankind and young ones of all mammals as a liquid food. Milk contains water, fat, protein, lactose, vitamins and minerals. Unravelling the composition of milk and its constituents has been a challenging problem for scientists due to its complex nature. These constituents are present in three phases viz; true solution collodial dispersion and fat-in-oil type emulsion. A knowledge of the composition of milk, lead to the understanding of physico-chemical nature of this complex biomolecule. It will also add to the knowledge needed for the preparation and manufacture of milk and its products.

i. The Gross composition of milk

Milk is the liquid secreted by the mammary gland with broad components consisting of a mixture of water, fat, proteins, lactose, minerals and vitamins as the nutrient. On an average cow milk contains 87 per cent water, 3.9 per cent fat, 4.9 per cent lactose, 3.5 per cent protein and 0.7 per cent minerals and vitamins and other minor constituents. Chemical composition of milk of different species varies considerably (Table 8.1). The composition of milk varies with the species to ideally suit the need of new born infants. However, milk from cow, buffalo and goat ideally meet the requirement of human beings as liquid milk or its products.

ii. PFA definition of milk

There are several definitions for milk. As per PFA (1976) milk has been defined as the lacteal secretion obtained by the complete milking of one or more healthy milch animals, which is free from colostrum. Cow milk shall contain not less than 8.5 per cent of solids-not-fat and not less than 3.5 pre cent of milk fat while buffalo milk shall contain not less than 9.0 per cent solids-not-fat and not less than 6.0 per cent milk fat.

Table 8.1: Chemical Composition of milk of different Species

	Name	Water %	Total Solids %	Fat %	Lactose %	Protein %	Mineral %	SNF (Solid Not Fat) Minimum %
1	Cow	87.2	12.8	4.0	4.7	3.4	0.7	8.8
2	Buffalo	83.5	16.5	7.2	4.8	3.8	0.7	9.3
3	Human	87.4	12.6	4.3	6.8	1.25	0.2	8.3
4	Goat	86.9	13.1	4.0	4.6	3.7	0.8	9.1
5	Sheep	81.5	18.5	8.6	4.7	4.5	0.7	9.9
6	Mare	90.1	9.9	1.7	5.7	2.2	0.3	8.2
7	Donkey	91.5	8.4	0.6	6.1	1.4	0.3	7.8
8	Camel	86.5	13.5	3.0	5.6	4.0	0.8	10.5
9	Elephant	67.8	32.2	19.5	8.8	3.2	0.6	12.7
10	Dog	75.5	24.5	9.5	3.3	11.1	0.6	15.0
11	Cat	82.1	17.9	3.3	4.9	9.0	0.6	14.6

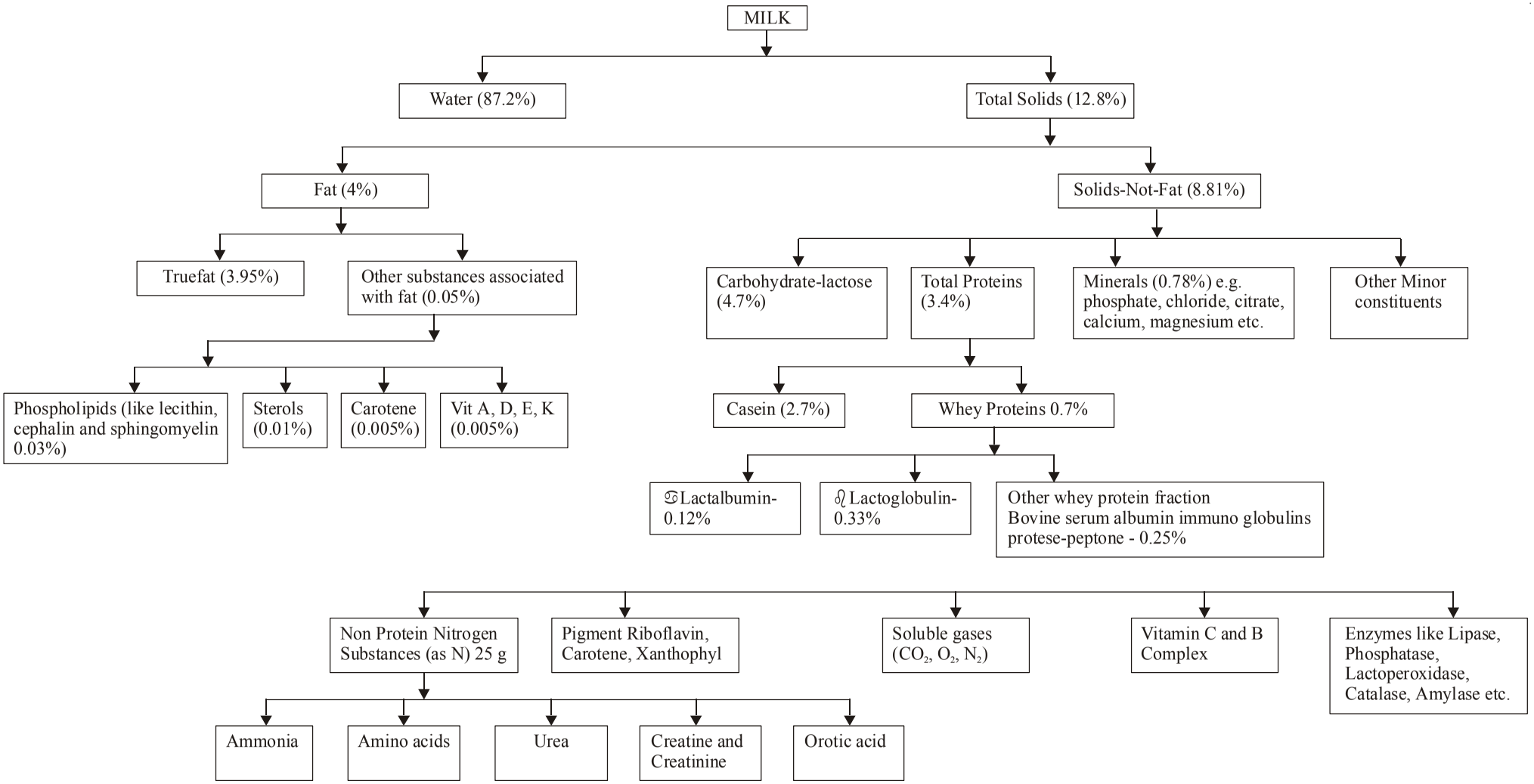

Fig 8.1: Distribution of Constituents of cow milk

Check Your Progress 1

1. Give the composition of cow and buffalo milk.

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2. Name the highest component other than water present in human milk.

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3. State the level of protein in sheep milk.

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8.3 MILK CONSTITUENTS

Milk is a complex mixture of various constituents. On keeping at room temperature milk separates into fat as cream, curd or casein and whey. Curd and whey separates on curdling of milk. However, the constituents of milk include water, fat, proteins, lactose, minerals, enzymes and vitamins. Distribution of constituents of cow milk is given in the Fig 8.1.

A detailed study of the constituents of milk is essential to understand the nature of milk, its physico-chemical characteristics and nutritive value. The constituents have an important role in the preparation of milk products. Study of each constituent helps in understanding its chemical microbial and technological behavior.

Physical States of Constituents of milk

The main constituents of milk, namely, fat, sugar, protein, minerals, vitamins and other minor constituents are present in three states. The three physical states are true solution, colloidal dispersion and fat in oil-type emulsion follows:

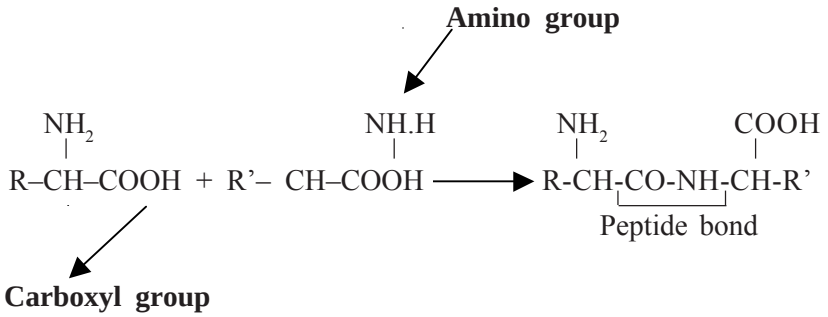
There are always a state of equilibrium between colloidal state and true solution in normal milk.

i. Milk Proteins

Proteins are present in milk in colloidial state. Important proteins found in milk are casein and whey proteins. Description of these proteins is presented here:

i) **Casein:** Casein is the major proteins which contribution at 80% protein. It is present in milk in colloidal state in the form of Calcium caseinate phosphate complex. The micellar particles of casein are spherical in nature and exist in milk as distinct particles. Each micelle of casein is bridged with various submicelles. The submicelles within casein micelle are held together by calcium phosphate by an ester linkage with the serine hydroxyl group. The calcium phosphocaseinate are rather large in size, as seen by electron microscope ranging in size between 30-300 millimicrons in diameter.

Definition of Casein: Casein may be defined as phosphoprotein obtained from raw milk at pH 4.6 at 20^0C. Casein is made up of amino acids forming a polymeric chain through a peptide bond $(-CO-NH_2-)$. This linkage is established by reaction of an amino and a carboxyl group.



With difunctional units such as the amino acids, long chain polymers can be built in this way.

Heterogeneity of Casein : Based on its primary structure, electrophoresis, chromatography and solubility in salts such as urea, casein is classified in the form of its fractions namely,

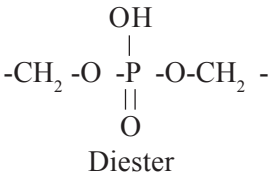
a_{s1} – Casein
a_{s2} – Casein
b – Casein and
k – Casein

These main fractions are themselves variable because of genetic polymorphism involving deletion or substitution of amino acids within the polypeptide chain of each fraction.

β

Elementary Composition: Casein contains the following elements (in percent) – Carbon 52.6-54.0, Hydrogen 6.75-7.10, Nitrogen 15.51-15.91, Sulphur 0.71-0.83 and Phosphorus 0.71-0.85.

Since casein is a phosphoprotein the phosphorus is bound chiefly if not entirely in ester linkge with the - OH group of amino acid serine or threonine



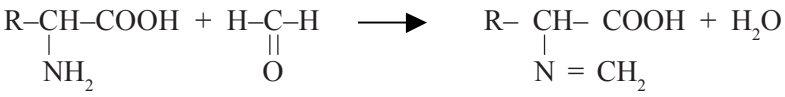
Diester

Electrical Properties: The isoelectric point of casein is pH 4.6 i.e. at this pH it has a zero net change. Above this pH it carries a negative charge while below this pH it is positive in nature. Thus at the pH of milk (pH 6.6 to 6.8), casein carries negative charge and, therefore, migrates towards anode in an electric field.

Solubility: Both α -and -casein are insoluble at isoelectric point (pH 4.7 and 4.9) but dissolve readily on either side of pH, a-casein is less soluble at pH 4.2 at 2^0C while b - casein is more soluble at pH 4.2 at 2^0C causing their separation. Casein also binds calcium ions above isoelectric point causing aggregation of casein, which lowers its solubility.

Other Properties : Casein also posseses other properties such as optical rotation, suggesting globular nature, oxidation and reduction due to its amino acids, and reacts with formalin/ formaldehyde. This reaction with formalin takes place through

amino or amide groups of amino acids of casein. During this reaction with formalin an equivalent amount of protons (H^+ions) are released which is then titrated against an alkali. The amount of proton released are equivalent to the amount of protein present. This is the basis for estimating protein in milk quickly by titration with NaOH.



Amino acid Formaldehyde → Complex

ii) **Whey Proteins:** Lactalbumin and globulin fractions of whey proteins are two proteins together which form about one-eighth of the total protein of milk and are described as soluble protein. Both albumin and globulin are soluble in milk/ whey but they differ in that while albumin is soluble in water, globulin is insobule in water but soluble in dilute salt solutions. Both are coagulated by heat, the extent of which is governed by temperature and time of holding, salt concentration and pH of the solution (e.g., pH 4.5). Whey proteins are the native proteins present in whey or serum and are a constituent of whey, which is prepared after removal of casein through acidification at pH 4.6 or by rennet action during preparation of cheese. b-lactoglobulin is the major whey protein of milk. b-lactoglobulin is globular in nature. It has a molecular weight of 36,000 daltons with an iso-electric point of 5.2. It is a heat labile protein and gets denatured on heating. It is soluble in salt solution. It has a high nutritive value. It possess free – SH group in its structure through amino acid cysteine.

Alpha-lactalbumin is the second most abundant whey protein after b lactoglobulin. It is rich in human milk. This protein is involved in the bio-synthesis of lactose. It has a molecular weight of 16,000 daltons with an iso-electric point of 4.2. It contains no phosphorus or carbohydrate. This protein is very rich in the amino acid tryptophan and sulphur containing amino acids cystine and cysteine. Due to the presence of essential amino acids this protein is nutritionaly important whey protein.

Table 8.2 Properties of whey proteins

Property	b-Lacto globulin	a-Lactalbumin	Blood serum albumin	Lactoferrin
Molecular weight	36,000 Daltons	16,000 Daltons	65,000 Daltons	80,000 Daltons
Isoelectric point	5.18	4.2	4.72	8.2

iii) **Immunoglobulin:** Globulin of milk and blood are identical. In colostrum and milk both are present but globulin in the form of immunoglobulin is found in much higher amounts in colostrum. In milk, globulin is present to the extent of only 0.1 percent, while in the colostrum it is 6 per cent. This concentration is so high that it causes coagulation of colostrums on heating. This property of colostrum being lost as the globulin declines to the normal level in milk. Both albumin and globulin proteins possess a high nutritive value and supply all essential amino acids. Moreover, albumin rectifies the low sulplur content of

casein in the form of alpha - lactalbumin and beta - lactoglobulin in normal milk. Thus they are complementary in that the value of the three milk proteins is larger in presence of each other than when measured separately. Molecular weight of immunoglobulins is very high ranging between 1,80000 to 8 lac daltons.

Traces of certain other proteins are also present in milk. These include proteose-peptone, iron-containing protein lactoferrin, fat globule membrane protein, lactollin, free secretory component, folate and vitamin B_{12} binding protein along with various milk enzymes, which are more than 30 in number.

iv) **Non protein nitrogenous substances:** Milk contains various nitrogen containing substances, which are not true protein. Their amount is 5 percent of the total nitrogen found in milk. These are popularly referred as NPN or non protein nitrogenous constituents of milk. They are present in four forms as (a) amine (e.g., ethanol amine, choline) (b) amino acids (e.g., free amino acids such as lysine, leucine, etc) (c) amino acid derivatives (e.g., creatine, creatinine) and (d) other compounds (such as morphine and milk oligosaccharides). NPN varies from season to season and has no biological value as that of protein.

v) **Enzymes in Milk:** Enzymes are organic catalyst, which are found in plant and animal cells. They bring about most complex chemical reactions but they themselves do not enter into chemical change. They are colloidal and proteinous. They are classified as per the chemical changes they bring about, such as hydrolase (hydrolysing enzymes), oxidase (oxidizing enzymes), reductase (reducing enzymes). They are also classified on the type of substrate they attack e.g., protease (protein splitting enzymes), lipase (fat splitting enzymes), amylase (starch splitting enzymes) etc.

Enzymes are susceptible to heat, light and pH changes. There are substances, which enhance the activity of various enzymes and are known as co-enzymes and those, which inhibit the activity, are called as anti-enzymes.
Enzymes in milk occur in 4 phases. They are:

- water soluble
- casein bound
- lipid bound and
- present in microsomal particles
- These enzymes are in a state of equilibrium in milk and can change their state due to agitation, homogenization, heating, etc.

a) **Peroxidase:** Peroxidase enzyme liberates oxygen from hydrogen peroxide. Lactoperoxidase is the principle enzyme present in fresh milk. Activation of lactoperoxidase result in enhancing the keeping quality of raw milk for longer period. It is destroyed at a temperature above 80^0C.

b) **Amylase (diastase):** This enzyme hydrolyses starch to dextrin. It is present in milk in small amount. It is destroyed at 60-65^0C.

c) **Lipase:** It is a hydrolytic enzymes. It hydrolyze fat into the corresponding fatty acids and glycerol. It causes butyric or hydrolytic rancidity in milk, cream, butter, ghee and enhances acidity. It is destroyed on heating at 63^0C for 20 minutes.

d) **Catalase:** Catalase decomposes hydrogen peroxide into oxygen and water. It is present in small amount in milk. However, on contamination of milk its concentration increases in milk. It is destroyed when heated above 90^0C for 20-25 minutes.

e) **Phosphatase:** This enzyme hydrolyze phosphoric acid esters. During pasteurization of milk this enzyme is destroyed. This enzyme is thus used as a marker to check proper pasteurization of milk and milk products.

f) **Proteases:** These are proteolytic enzymes and hydrolyze protein into simpler compounds such as proteose, peptone and amino acids. These enzymes are

involved in the hydrolysis of milk proteins i.e. casein and whey proteins. Proteases enzymes are destroyed at a heating temperature of 80^0C.

g) **Reductases:** These enzymes help in reduction of certain organic compounds. They reduce methylene blue added to milk and make it colourless.

h) **Lactases:** They hydrolyze lactose into glucose and galactose. The principle enzyme is beta glycosidase. The above emzyme hydrolyze lactose, which is finally converted into lactic acid.

ii. Milk Carbohydrates

The principal sugar of milk is lactose, which is present to the extent of 4.8-5.0 percent in milk. In addition milk also contain traces of bound carbohydrates. Human milk is a rich source of lactose and oligosaccharides. Human milk contains about 6.3-7.0 percent lactose and between 0.3-0.6 percent oligosaccharides.

Lactose: Lactose is the sugar which is found exclusively in the milk of mammals. Lactose is present in true solution. On crystallization lactose crystallizes with one molecule of water of crystallization ($C_{12}H_{22}O_{11}.H_2O$). These crystals are gritty in nature and sometime give gritty or sandy taste to some milk products like concentrated milk and ice-cream.

Structurally lactose consists of glucose and galactose molecule which together form the lactose molecule. Thus lactose is a disaccharide because it is made up of two monosaccharides. On hydrolysis of lactose by the enzyme lactase found in small intestine, lactose splits into glucose and galactose.

$$C_{12}H_{22}O_{11}+H_2O \xrightarrow{\text{Lactase}} C_6H_{12}O_6+C_6H_{12}O_6$$

Mineral acids such as hydrochloric acid also possesses the hydrolyzing capacity to split lactose into its two sugar units viz. glucose and galactose. Certain yeasts and enzymes have the ability to ferment lactose to alcohol and lactic acid which impart acid or alcoholic taste to fermented milk products.

$$\underset{\text{Lactose}}{C_{12}H_{22}O_{11}}+HOH \longrightarrow \underset{\text{Glucose}}{C_6H_{12}O_6} + \underset{\text{Galactose}}{C_6H_{12}O_6}$$

$$2C_6H_{12}O_6 \longrightarrow 4\ \underset{\text{Lactic acid}}{CH_3CHOHCOOH}$$

The conversion of lactose to lactic acid is favoured by microorganisms as lactose is a good substrates for their activity. This causes sour taste to milk. At an acidity of 0.18 to 0.20 per cent milk curdles on heating. Lactose is faintly sweet, about one-sixth the sweetness of cane sugar.

Lactose is a reducing sugar due to the presence of a free aldehyde group. It thus reduces fehling solution. Lactose is insoluble in alcohol and ether but is soluble in hot acetic acid. On oxidation lactose is oxidized to formic acid or carbonic and oxalic acid depending upon the oxidizing agent used. On heating above 150^0C lactose turns yellow and at 175^0C it turns brown and form caramel. Slight burning and cooked milk odour is due to caramel, though milk and milk products are never treated to such high temperatures under ordinary processes. Thus individual milk constituents have different property rather than when they are present in a complex system like milk.

Lactose is involved in Maillard reaction with ammonia, amino acids or amines forming brown coloured pigments as complexes. Lactose helps in assimilation of calcium and phosphorus from small intestine and has a beneficial effect.

iii. Milk Fat

In milk, fat is present in the form of fat globules with an average size of 3 micron. If cool raw milk is kept for sometime without mixing there is tendency for the fat globules to cluster and rise at the surface forming cream layer. However, these globules are independent due to the presence of a protective fat globule membrane layer. Fat is distributed in continuous aqueous phase as an oil-in-water type emulsion. The membrane prevents the merging of fat globules and formation of a continuous fat phase.

Nature of protective fat globule membrane layer: On examination of the protective fat globules layer it is found that a variety of substances are present in it. These include protein, phospholipids, phosphatase, complex of vitamin B_{12} binding proteins and a complex of riboflavin- phosphoric acid protein. There are also metals like copper, iron and zinc. In the presence of copper it causes oxidation of fat.

Physico-chemical nature of milk lipids: Milk lipids are present in three phases in milk, namely, the fat globule, the membrane surrounding the globule called fat globule membrane (FGM) and the milk serum. Fat globules are entirely made up of triglycerides coated with FGM containing complex lipids, phospholipids and proteins (Table 8.3).

Table 8.3: Various lipid material present in milk

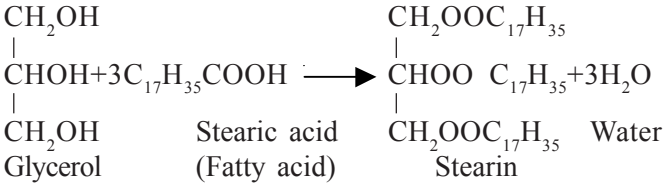
Constituents	Location in milk
Triglycerides	Fat globules
Phospholipids (lecithin, cephalin and sphingomyelin	Fat globule membrane and serum
Sterols (cholesterol)	Fat globule, FGM and serum
Free fatty acids (various)	Fat globules and serum
Waxes	Fat globule
Squalene	Fat globule
Fat soluble vitamins such as Vitamin A, Carotenoids, Vitamin E, Vitamin D and Vitamin K	Fat globule

Source: Principles of Dairy Chemistry by Jennes & Patton

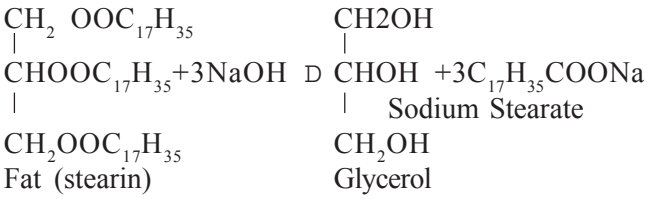
Physical properties of milk fat: The physical properties of the milk fat are determined by the nature and proportion of its consitituents. The colour varies from yellow (due to carotene) to whitish light blue tinge due to bilirubin. The melting and setting of the fat takes place over a considerable range of about 5^0C. The ranges are 28-33^{0}C and 24-29^{0}C as the melting and setting points, respectively. This shows that fat is made up of several components which is a mixture where different constituents at different temperatures have their own melting point and other physical properties.

Milk fat has a specific gravity range of 0.936-0.946 at 15^0C. Milk fat has a refractive index of 1.459-1.462 at 15^0C. It is slightly soluble in ethanol but is readily soluble in hot amyl alcohol.

Chemical Properties of Milk Fat: True fats are glyceride esters of higher fatty acids.



During hydrolysis of fat it is resolved into its components i.e. glycerol and the corresponding fatty acids. This hydrolysis occur naturally by the enzyme lipase. The hydrolysis can be brought about also by superheated steam or alcoholic NaOH.



All fats react in this manner but differ only in the number and relative proportion of fatty acids that are united to glycerol. If milk fat is treated in the above manner, about 16 fatty acids are obtained, some of them are soluble in water but most of them are insoluble and appear as white precipitate oleic, polmitic, butyric, stearic and myristic acids are the five major fatty acids.. While many of these fatty acids are odourless and almost tasteless some of them such as butyric acid possess strong odour. The libration of butyric acid leads to rancidity of fat caused by hydrolysis.

Milk fat also contains oleic and palmitic acids like other fats representing one-third and one-fourth of total fatty acids, respectively. However there are the minor constituents, which distinguish milk fat from other fats. Nearly 43 percent of the milk fat is unsaturated which give chemical activity to fat.

With glycerol about eighteen compounds are formed if fatty acids are attached. But the glycerides present in milk fat are compounds of glycerol with two or even three different fatty acids. Thus, a large number of compounds are present in milk fat.

iv. Milk Salts

In milk, salts are represented by the "non-combustible matter" known as "ash". The ash constitute the mineral matter of milk which is present to the extent of 0.7 per cent. The ash content is normally constant in milk. A higher value indicate an abnormal condition of the mammary gland. The important salt constituent present in milk ash are calcium, phosphorus, magnesium, sodium, potassium chloride, citrate and sulphur. Calcium and phosphorus are the pre-requisite for bone formation in the body. Milk is a very rich source of calcium. Average content of milk salts present in milk is presented below: (Table 8.4).

v. Milk Vitamins

Milk is a very rich source of most of the vitamins except vitamin C. Almost all the vitamins are present is milk. Milk contains both fat soluble and water soluble vitamins (Table 8.5).

Table 8.4: Salt contents in Milk

S.No.	Constituents	Average content mg/100 ml
1.	Sodium	50
2.	Potassium	145
3.	Calcium	120
4.	Magnesium	13
5.	Phosphorus (total)	95
6.	Chloride	100
7.	Sulphate	10
8.	Carbonate (as carbon dioxide)	20
9.	Citrate (as citric acid)	175

a) Fat soluble vitamins
   i) Vitamin A
   ii) Vitamin D
   iii) Vitamin E
   iv) Vitamin K

b) Water soluble vitamins
   i) B_1 (Thiamine)
   ii) B_2 group- This group consists of Riboflavin, Nicotinic acid, Pyridoxine, Pantothenic acid, Biotin, Vitamin B_{12} and Folic acid
   iii) Vitamin C or Ascorbic acid.

Table 8.5: Quantity of vitamins present in milk

Vitamins	Amount
Fat Soluble:	
Vitamin A	20 I.U. per g of fat
Carotene	5 mg/g of fat
Vitamin D_3	1 I.U. per g of fat
Vitamin E	28 mg/g of fat
Vitamin K	Traces
Water Soluble:	
Vitamin B_1	37 mg
Riboflavin	140 mg
Pantothemic Acid	400 mg
Nicotinic acid	63 mg
Pyridoxine	37 mg
Biotin	1.6 mg
Vitamin B_{12}	0.3 mg
Folic acid	0.3 mg
Ascorbic acid (Vitamin C)	2.0 mg

Source – Ling, E.R. (1956) Volume 1

Note 1 mg= one millionth of a gram

Though all the above mentioned vitamins are present in milk, but those present in appreciable amounts to make milk a valuable source are vitamin A and B_2 group as far as human nutrition is concerned.

Check Your Progress 2

1. Name the three states in which constituents of milk are present.

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2. Give the range of size of casein micelles.

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3. State the pH at which casein coagulates from milk.

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4. Give the molecular weight of beta lactoglobulin.

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5. Which protein is present in highest amount in colostrum?

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6. True fats are made up of glycerides of fatty acids. True or False.

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8.4 FACTORS AFFECTING THE COMPOSITION

The main constituents of milk are fat, protein, lactose and ash. The proportion of these constituents varies with type of milk. This variation in composition of milk is due to several factors such as species, breed, stage of lactation, feeding, etc. Cow, buffalo, goat and sheep milk are often consumed and have been studied in detail. Some of the factors which affect the composition of milk are:

1. **Species:** The milk from various species of manmals have different composition (Table 8.6). This variation in milk composition is due to species effect.

Table 8.6: Difference in milk composition due to species

Species	Water %	Fat %	Sugar %	Protein %	Ash %
Cow	87.54	3.71	4.70	3.31	0.76
Goat	85.58	4.93	4.78	4.11	0.89
Buffalo	82.90	7.50	4.70	4.10	0.80
Human	88.50	3.30	6.80	1.30	0.20

2. **Breed:** Like species composition of milk is also determined by breed. Exotic as well as indigenous breeds differ somewhat in their composition. Within the different breeds fat is the major constituent, which is affected most. This variation in fat content in different breeds is evident from the data in Table 8.7. Generally milk containing a higher percentage of fat is also rich in solids not fat as vice versa Table 8.7, 8.8 and 8.9.

Table 8.7: Variation in the composition of milk of exotic breeds

Breed	Fat %	Protein %	Lactose %	Ash %	Total solids %
Holstein	3.55	3.42	4.86	0.68	12.50
Brown Swiss	4.01	3.61	5.04	0.73	13.41
Ayrshire	4.14	3.58	4.70	0.68	13.10
Jersey	5.18	3.86	4.94	0.70	14.09
Guernsey	5.19	4.02	4.91	0.74	14.87

Adopted from- Principles of Dairy Chemistry, R.Jenness & S. Patton 1959

Table 8.8: Variations in composition of milk amongst Indian breed of cows

Breed	Fat %	Protein %	Lactose %	Ash %	Total solids %
Gir	4.73	3.32	4.85	0.66	13.30
Red-Sindhi	4.90	3.42	4.91	0.70	13.66
Sahiwal	4.55	3.33	5.04	0.66	13.37
Tharparkar	4.55	3.36	4.85	0.68	13.25
Crossbred	4.50	3.37	4.92	0.67	13.13

Table 8.9: Variation of composition of milk according to the breed of buffalo

Breed	Fat %	SNF
Murrah	6.8	10.1
Jaffarabadi	7.3	10.1
Surti	8.4	10.3

Source: Indian Dairy Products, Rangappa and Achaya

3. **Individuality of Animal:** Under identical condition of management and feeding, within the same breeds, individual variations in the composition of milk always exist. These may affect milk components like fat or protein, which may be high or low. These variations have been attributed to the individuality of the animal.

4. **Milking Intervals:** Milking intervals also affect the composition and yield of milk. As a rule longer the milking interval lower is the fat content, which is compensated with a higher milk yield. However, variation in the fat content of both the individual and herd milk between the morning and evening bulk milk samples occur (Table 8.10).

Table 8.10: Variation in fat content of milk due to the time of milking (fat percent)

Time of milking	Red Sindhi	Gir cow	Buffalo
Morning	6.0	6.0	7.1
Evening	6.3	6.2	7.9

Source: Indian Dairy Products, Rangappa and Achaya

5. **Milking Efficiency:** Milking efficiency is a very important factor to obtain high milk yield and fat. As the udder is emptied during milking fat also increases. No appreciable differences other than in milk fat have been found between fore milk and strippings. The fore-drawn milk contain about 1 to 2 percent fat and as the milking progresses the fat content increases upto 6 percent or more in strippings. However, there seems to be a general relationship between fat percentage and solids-not-fat. The first portion is poorest in fat but richest in solids-not –fat but later portion is poorest in S.N.F. and vice versa (Table 8.11).
6. **Stage of Lactation:** The composition of milk varies with lactation. The first secretion after parturition, namely the colostrum is totally different from milk in its composition and general properties (Table 8.12). Colostrum is very thick in nature with a high viscosity. It has a high concentration of immunoglobulin, lactoferrin, chloride and low lactose content. Its fat content may be higher or lower than that of milk. Colostrum from different cows and buffaloes varies much more in composition than does milk. With successive milking, the composition rapidly approaches that of milk, and the variability decreases.

Table 8.11: Variation is composition of different portions of milking

Portions	Fat %	S.N.F %
1	1.04	8.64
2	1.42	8.63
3	3.02	8.57
4	4.40	8.37
5	5.32	8.15
6	7.63	7.77

Source: Indian Dairy Products, Rangappa and Achaya.

Table 8.12: Composition of colostrum

Colostrum	Total Solid %	Fat%	Total Protein %	Lactose %	Ash %	Specific Gravity
Ist milking	24.55	3.89	16.76	2.50	1.33	1.0604
2nd milking	18.00	3.84	9.33	3.52	0.97	1.0437
3rd milking	16.79	3.11	7.06	3.85	0.96	1.036
4th milking	15.21	3.82	6.17	4.23	0.88	1.0372

The transition from colostrum to a composition within the range of variation of normal milk is complete in about 4 days, the protein content being slowest to complete the transition. The yield of milk increases to a maximum in early lactation and than falls to normal. When yield of milk increases, fat and solids-not-fat decreases and vice versa. This decrease is between 0.2 to 0.4 percent. The only change in lactose percentage attributable to stage of lactation is a slight decrease towards the end.

Because of low lactose concentration the osmotic pressure also remain low and in order to rectify the low osmotic pressure, the concentration of chlorides, sodium and soluble non-protein nitrogenous compounds, which restores the osmotic pressure to its normal level increases. Due to an increase in calcium towards the end of lactation it is a common experience that a salty taste may be detected in the milk of cows in advanced lactation. Calcium decreases to a minimum concentration and then increases, whereas total phosphorus remains constant throughout.

7. **Feeds and Nutritional Level:** Excessive feeding of fooder and concentrate is known to slightly increase solids-not-fat content in milk. Excessive protein in the feed does affect the protein content but may increase non-protein nitrogen content and sometimes fat. On feeding on pastures solids-not-fat content increases. The lactose content is not changed.

   Rations low in roughages lower the fat content by 0.5% with no change in milk yield. Additional feeding with palm oil, butterfat, lard and coconut oil increases the fat percentage while cod liver oil lowers the same. Food fats modify the composition of milk fats to a limited extent. Feeding of minerals such as calcium and phosphorus does improve their level in milk.

8. **Season:** Seasonal variations are directly related to temperature, humidity, sunshine and drought. In summer months drop in milk yield occur with slight decrease in fat content. However, vitamin D content increases due to exposure to sunlight. During rainy season when green fodders are available in plenty carotene and riboflavin level increases. During the period of drought the solids-not-fat content decreases while there is no change in fat percentage. Fat content is highest in May and minimum in November while S.N.F is highest in October and lowest in July and September.

9. **Disease:** Disease adversely affect the composition. During infection of the udder with mastitis or foot and mouth disease there is lowering of lactose and casein. There is an increase in chloride content, increase in soluble nitrogen and reduction in natural acidity. There is also an increase in ash content.

10. **Age of the Animal:** With the advancement of age there is a slight decrease in fat content. An irregular decline in S.N.F also occurs. Within S.N.F, lactose and casein are the main components, which are affected. Maximum milk yield in milk occur from fifth to the ninth month of lactation. Age factor is highly effective with advancement of lactation.

11. **Hormones:** Injections of hormones such as prolactin and oestrogen is known to have a favourable role in enhancing milk production, fat and solids-not-fat content. However, excessive dose has a negative effect with depression of milk. These hormones enhance the metabolic activity of the body but excessive dose have a deleterious effect.

12. **Heat or Oestrum:** During the heat period the yield of milk and fat is slightly affected. This is due to the excitability and nervousness of the animal due to heat or hormonal secretion. Variations in fat occur due to the holding up of the milk by the animal.

13. **Gestation:** During the gestation period especially towards the end of lactation changes in milk composition occures. These variations are reflected in solids-not-fat content, which is increased. The composition is affected from fourth month onward.

Check Your Progress 3

1. Amongst cow, buffalo, goat and human, name the species which has lowest percentage of protein.

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2. Explain how colostrum milk is different from normal milk?

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3. Give in brief role of age in affecting the composition of milk.

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8.5 FLAVOURS AND OFF-FLAVOURS RELATED TO MILK

Flavours of foods can be divided into two categories. Natural, good or normal flavour which are desirable, or essential flavours. The other category is off-flavour which are undesirable and are not natural or normal flavours.

For consumer acceptance of any food including milk, flavour is of primary importance. Even if the food is wholesome, nutritious, attractively packaged, reasonably priced, but if its flavour is poor it will be rejected by the consumers. Milk and milk products are in the top list of foods where flavour plays most important role. Right from production of milk at the farm to the point of processing of milk into milk and milk products needs proper handling of milk to avoid flavour contamination and deterioration. Thus knowledge of flavour is indispensable in the production of milk and milk product that are consistently acceptable to consumers.

Studying flavour involves study of three fields together. These include dairy technology, chemistry and physiology. Dairy technology involves control of flavour, chemistry deals with micro-chemical changes involved in flavour development including the chemistry of compounds involved. Physiology, deals with sensory evaluation which includes odour and taste of milk and milk products.

The nature of flavours: Three basic sensory aspects are involved in flavour. They include olfactory, gustatory and tactual components. On tasting, food vapours go into the olfactory area which is related with odour of milk. Taste is concerned with sensation in the mouth and tongue. These include sweetness, sourness, saltiness and bitterness. Sensation is detected by taste buds. Actual sensation gives an index of the milk feels in the mouth. This aspect deals with the feeling aspects such as tender, grainy, etc.

Measurement of flavour: Flavour is measured psychometrically and by chemical analysis. Chemical analysis only shows the nature of component responsible for flavour. However, chemical methods cannot evaluate like or dislike of flavour. They can be differentiated only by psychometrically as stated above.

Flavour identification: Compounds responsible for a given flavour needs identification. This is essential so that off flavours may be prevented and desirable flavours can be preserved.

Flavour components are present in minute amount in (parts per million or parts per billion). These components can be isolated and identified chromatographically involving TLC (Thin Layer Chromatography), GLC (Gas Liquid Chromatography), HPLC (High Pressure Liquid Chromatography) and often combined with mass spectrophotometery. Infrared (IR) is also used in flavour analysis.

i. Flavour of milk

Flavour of milk can be divided into two categories, normal and natural flavour that are desirable. Milk should be free from oxidized, rancid, feed/weed, unclear, malty and other off flavours.

On tasting milk, one finds milk sweet and slightly salty. Normally it is neither bitter nor sour. However, these variations differs with individuals. Some detect milk as sweet, others flat and still others a slight salty. Sweet-salt taste varies with individuals. Milk has sweet taste due to the presence of sugar lactose (4.8-5.0%). Salty taste is observed in mastitis milk due to its high chloride content. This is also true for late lactation milk.

Normal milk has a sweet characteristic flavour, which is faint in nature. At present it cannot be said conclusively what compounds cause natural flavour of milk. However, some low weight compounds definitely contribute to the flavour of milk though they are present in trace amount. They include acetone, acetaldehyde, butyric and certain other free falty acids contributing towards the flavour of milk. A high predominance of these compounds gives abnormal flavour to milk. Normal milk has smooth feeling in mouth.

A notable compound methyl sulphide present in p.p.b (parts per billion) level up to 12 p.p.b in water gives flavour similar to that of milk. This compound is present in milk and cow's breath and significantly contributes towards the flavours of milk.

Off-flavours are referred to the flavours, which are not typical of the food such as milk and are considered undesirable. These undesirable flavours are often off shoot from undesirable compounds generated generally as post contamination.

Milk is particularly susceptible to off-flavours. These generally start from the milking animal such as cow or buffalo and include feed and fodder, weeds and barn contamination. These factors may create problem for flavour of milk**.** Contaminations such as bacteria, metals etc., also contribute towards off-flavours. Problems of off-flavours can be eliminated or avoided by carefully considering the above factors.

ii. Chemical flavour deteriorations

a) **Oxidized flavour:** Oxidized flavour is one of the most important aspect of flavour deterioration of milk and milk products. It is perhaps one of the single most important factor of off-flavour of milk. Oxidized flavour is a general term and include off-flavours such as cardboard, metallic**,** oily and tallow.

Cause of off-flavour of milk: The component responsible for off-flavour is the fat or lipid part of milk which undergo oxidation and generates off-flavours. Phospholipids of milk serve as the origin of oxidized flavour of milk. During milk fat separation one third of the phospholipids are found in skim milk. Sweet cream buttermilk is highly susceptible to off-flavour due to high content of phospholipids in butter milk.

Mechanism of oxidized flavour development in milk: Oxidized flavour is

produced from hightly unsaturated fatty acids such as linoleic acid present in phospholipids. Oxygen from the air attacks the methylene group adjacent to the double bond present in these acids, resulting in the formation of peroxides, hydroperoxide and breakdown products such as various aldehydes and ketones. One compound 2-octenal and 2-nonenal has the most characteristic oxidized property.

b) **Rancid Flavour (hydrolytic rancidity):** Hydrolytic rancidity is caused by natural milk enzyme lipase present is milk. Lipase releases free fatty acids from glycerides of milk fat. One of the most notable fatty acid butyric acid when released causes rancid flavour

Glyceride D Glycerol +Butyric acid

Lipase is inactive in the freshly drawn milk because it is present in the serum phase of milk. However, during handling of milk lipase is absorbed on the fat which can cause lipolysis and produce rancid flavour. Amongst the factors which cause and enhance rancidity are homogenization, vigorous agitation, warming and cooling of milk.

Prevention of Lipolysis: Problems of lipolysis is the release of lower chain fatty acids of milk fat such as butyric acid which renders it unacceptable for human consumption.

Lipolysis can be reduced or avoided by inactivating lipase. For this the following parameters should be considered:

1. Pasteurization of milk destroys lipase in milk
2. Avoid excessive agitation which should not be prolonged for a long period especially accompanied by foaming
3. Homogenization of milk
4. Separation or clarification.
5. Warming milk to 80-90^{0}C and cooling again to low temperature
6. Secretion of milk during advanced stage of lactation
7. Freezing and thawing of milk
8. Mixing of raw milk with cream or homogenized milk should be avoided.

c) **Sunlight Flavour:** When milk is exposed to direct sunlight it leads to the development of sunlight flavour which is undesirable. Sunlight off-flavour is caused due to two-reasons which are -

- Development of oxidized flavour as a result of light exposure.
- Sunlight flavour as such which is sometime refered as burnt flavour.

Methional is the sunlight off flavour compound produced due to direct exposure of sunlight. It gives off-flavour to as low as 1 part in 20 million. It is formed due to the reaction of **methionine** released from hydrolysis of protein in the presence of **riboflavin.**

Methionine + Riboflavin D Methional

Prevention: Avoid exposure of milk to direct sunlight or artificial light.

iii. Heated Flavours

Milk is always subjected to heating to preserve the same. Heat is required in the preparation of milk products. Heating process involve pasteurization, forewarming, boiling, superheating and sterilization of milk.

Pasteurization: Pasteurization whether holder or short-time process has hardly any effect on the development of flavour in milk. However, pasteurization is now an acceptable process for milk preservation without any change in flavour

Pre-heating/Forewarning: At or above 74^0C distinct flavour changes occur in milk. Notable amongst is the development of cooked flavour caused by the formation of H_2S. Hydrogen Sulfide (H_2S) is formed by the amino-acid methionine with a lowering of oxidation-reduction potential of milk.

Superheating: When heating is carried out for 75^0C for long period cooked flavour is changed to caramelized flavour. Chemical nature of caramelized flavour is not known. Since caramelized flavour is absent in whey it appears that casein plays an important part in caramelization.

Browning: However, caramelizing is accompanied by browning reaction. The reaction is known as Stecker degradation. This reaction occurs between the amino group of a basic amino acid such as lysine with free aldehyde group of sugar resulting in browning.

iv. Other off - flavours

Coconut Flavour: Coconut flavour originates from milk fat. Recent research shows that a compound delta lactone is formed from milk fat. It is a storage related defect and is favoured at high storage temperature rather than cooling.

Microbial flavour: Milk is a favourable medium for the growth of microbes particularly bacteria. These microbial changes are also accompanied by chemical changes. Such types of flavour changes are encountered with defects including bitter, fruity, rancid, stale and putrid-type of off-flavours.

Absorbed flavour: Absorbed flavours are those, which are other than those off-flavour caused by microbial or chemical action. These off-flavours are accidentaly absorbed in milk from several sources. These flavours can absorb either before or after milking. These flavours can enter through milking animals by the nose or mouth, to the lungs, to the blood stream, to the udder cells, and into the milk. Feeds and fodders fed to the animal are the main cause of absorbed flavours. Thus if a cow eats onion or garlic the flavour is transfered to the milk within 20 to 30 minutes. Milk can also absorb flavour from the atmosphere, improperly clean utensils and equipments. Residual disinfectant or any other odorous substance sticking to the metal surface has the potential to cause off-flavour in milk.

Check Your Progress 4

1. What are three basic sensory aspects of flavour of milk?

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2. Why flavour is important to a consumer?

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3. Name the components linked with natural flavour of milk.

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4. Name the notable compound responsible for flavour of milk.

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5. Explain off- flavour.

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6. Name the major off-flavours of milk.

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7. Name the compound responsible for oxidized flavour of milk.

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8. State hydrolytic rancidity and its control.

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8.6 NUTRITIVE VALUE OF MIL AND MILK PRODUCTS

Newly born infant is unable to ingest and assimilate nutrients from any food source other than milk. Consequently, milk has to provide all the growth, in an easily acceptable form. The nutrients present in milk and milk products are present in the form of carbohydrates, proteins, enzymes, minerals, vitamins, etc., which provide these nutrients in an easy and palatable manner. They not only provide a nutritious diet but also give energy and meet the day to day nutritional needs.

Role of constituents of milk and milk products

- Growth
- Supply of energy
- Maintenance of body
- Recovery from disease
- Reproduction
- Provide taste and appetite and palatability.

Milk and milk products in the form of food not only meet the nutritional requirement but also supplement the above requirements. Apart from birth of the infant these requirements are fulfilled by milk and milk products from growth phase to adult stage. Composition and nutritive value of milk and milk products are given in Table 8.13.

Table 8.13: Nutritive components in milk and milk products (100 g)

Product	Calories	Water g	Protein g	Fat g	Ash g	Carbo-hydrate g	Calcium mg	Phosphorus mg	Iron mg
Whole milk (cow)	68	87.0	3.5	3.9	0.7	4.9	118	93	0.1
Skim milk	36	90.5	3.5	0.4	0.8	5.1	123	97	0.1
Evaporated milk	138	73.7	7.0	7.9	1.5	9.9	243	195	0.2
Condensed milk	320	27.0	8.1	8.4	1.7	54.8	273	228	0.2
Skim milk (dry)	362	3.5	35.6	1.0	7.9	52.0	1300	1030	0.6
Butter	716	15.5	0.6	31.0	2.5	0.4	20	16	0
Butter milk	36	90.5	3.5	0.1	0.8	5.1	118	93	0.1
Cheddar cheese processed	370	40	23.2	29.9	4.9	2.0	673	787	0.9
Cottage cheese	95	76.5	19.5	0.5	1.5	2.0	96	189	0.3
Cream	204	72.5	2.9	20.0	0.6	4.0	97	77	0.1
Ice cream	207	62.1	4.0	12.5	0.8	20.6	123	9	0.1
Dried whey	344	6.2	12.5	1.2	7.7	72.4	679	576	-

Product	Sodium mg	Potassium mg	Vitamin A mg	Vitamin B1 mg	Vitamin B2 mg	Nicotinic acid mg	Vitamin C mg	Niacin mg
Whole milk (cow)	50	140	160	0.04	0.17	0.1	1.0	0.1
Skim milk (cow)	52	150	Traces	0.04	0.18	0.1	1.0	0.1
Evaporated milk	100	270	400	0.05	0.36	0.2	1.0	0.2
Condensed milk	-	-	430	0.05	0.39	-	1.0	0.2
Skim milk (dry)	77	1130	40	0.35	1.96	1.1	7.0	1.1
Butter	980	23	2300	Traces	0.01	0.1	0	0.1
Butter milk	130	140	Traces	0.04	0.18	0.1	1.0	-
Cheddar cheese	700	92	1400	0.02	0.42	Traces	0	Traces
Cheddar cheese processed	1500	80	1300	0.02	0.41	Traces	0	-
Cottage cheese	290	72	20	0.02	0.31	0.1	0	-
Cream	-	-	830	0.03	0.14	0.1	1	-
Ice cream	100	90	520	0.04	0.19	0.1	1	0.1
Whey dried	-	-	50	0.49	2.5	0.8	-	-

Source: Principle of Dairy Chemistry, R. Jenness and S. Patton (1959)

Products like condensed and evaporated milk are also easily digestible which flocculates the protein during heating thus improving digestibility. Likewise, fermented milk products such as dahi, yoghurt, lassi etc., have high therapeutic value because of microbial population which degrade milk components including protein. They also enhance the digestibility of these products.

i. Fat

Lipids are one of the most important constituents of milk. They have an important bearing on the economics of milk and milk products although this picture has changed somewhat due to the importance being ascribed to solids-not-fat also. Nutritive value of milk fat is due to its high calorie value of 9 kilocalories per gram. Second, it serves as a carrier of the fat soluble vitamins A,D,E and K. Milk fat also contains significant amounts of so called essential fatty acids (linoleic and arachidonic acids).

Major role of milk fat in milk and milk products is that it is linked with their flavour. There are no other fats, which can replace this role. The rich and pleasant flavour of milk fat cannot be duplicated. Milk fat in the form of butter, ghee, ice cream, coffee and whipping cream has its own flavour, taste and nutritive value.

The main function of milk fat is to supply energy. However, excessive intake of milk fat often leads to obesity, which leads to deposition of fat in the adipose tissue of the body. Thus there is a trend to consume milk and milk products with low fat. During starvation the body fat is utilised for energy.

Like essential amino acids of proteins there is a body requirement and need for essential fatty acids which cannot be synthesized as such. These are three unsaturated fatty acids, namely, linoleic, linolinic and arachidonic acids, Nearly 99 percent of the milk fat is present as triglycerides of fatty acids. Major portion of these triglycerides is lower chain fatty acids. They are responsible for the pleasant aroma, flavour and taste of milk fat. Amongst these fatty acids butyric acid is the major saturated fatty acid. Emulsifying properties of milk fat are related to phospholipids which are present to the extent of 1 per cent of total milk fat. A discouraging factor for milk fat is the presence of cholesterol in milk fat which accounts for 0.40 percent of total milk fat. Cholesterol is implicated in heart disease called artheroschlerosis and its awareness has led to lower milk fat consumption. However, milk fat remains the costliest constituent of milk because of its additional secondary role by imparting flavour to milk and milk products. Milk fat enhances their palatability and acceptability leading to enhanced consumption of milk and milk products

ii. Milk Protein

Milk contains proteins in the form of casein and whey proteins. The amino acids of these proteins are released during digestion in the stomach. These serves as structural building blocks of other body proteins. Our body is able to synthesize some amino acids but others have to be supplied by foods. Twenty amino acids are required by our body for growth and synethesis of proteins. Of the twenty amino acid 10 are not synthesized by our body. They are known as essential amino acids. They have to be supplied through diet. Milk is a rich source of essential amino acids, which comprises tryptophan, phenylalanine, lysine, threonine, valine, methionine, leucine, arginine and histidine.

Whey proteins have very high nutritional value for youngsters, adults and geriatric people, which acts as a tonic for body health maintenance. Whey protein concentrates are used as supplements in the preparation of high protein foods, low fat foods, low salt food etc. Low lactose intolrence food, geriatric food formulation for old age person with low digestibility, pregnant, lactating and nursing women foods for children

(Pediatric foods) for growth, anaemia and memory boosting foods are now available. For general vitality sickness or convalescence when most other form of foods are unacceptable dairy products provide the required nutrition.

Whey protein concentrate have been used as biopreservative and antioxidants. They are also used as functional foods due to their high emulsification, gelation, whipping etc., properties. Whey protein concentrate differs somewhat due to processing variables, pretreatment given to whey during handling and manufacture.

Biological value (B.V) of cow's milk is 90, which is an index of nutritive value of milk proteins. Biological value of milk proteins increases when it is mixed with cereals. Biological value refers to the quality of protein or nitrogen protein that may have participated in tissue construction or the percentage of nitrogen absorbed that is made use of by the body.

B.V of egg protein is 96, goat meat 76 and raw soyabean 57. Milk proteins have high buffering effect on stomach and is a remedy for excessive stomach acidity. Milk and milk products are, therefore, used in the dietary therapy for person suffering from acidity and gastritis. Milk proteins readily blend with other proteins or foods and provide supplementary dietic foods. On the negative side milk proteins have allergic property, which can be avoided by taking other proteins.

Nutritive value of products like cottage cheese, channa, rasogolla etc., is largely due to its curd, which is easily digestible. The curd is also a concentrate of casein which is a source of high quality protein.

iii. Carbohydrate

The main carbohydrate of milk is lactose, which is present at a concentration of about 5 percent. Carbohydrate provides energy at the rate of 4.0 kilocalories per gram. Lactose plays an important role as a source of energy. It has other nutritional functions as a sugar enhancing taste of milk and as a sweetener enhancing palatability.

Lactose performs several functions in the body. During intake of lactose through milk it takes a longer time for ingestion than the common carbohydrate cane sugar or sucrose. The increased ingestion time in the stomach favours the growth of desirable bacteria, namely, lactobacillus species preventing undesirable organisms damaging putrefactive in the gastro intestinal tract. Lactose helps in the absorption of calcium by its chelating action. This action of lactose is through the absorption of calcium as calcium lactate. Lactose intolerance is one undesirable property of lactose in some individuals. During the ingestion of lactose in small intestine it is broken down to glucose and galactose by the enzyme lactase, also called -glycosidase. The enzyme may be destroyed during illness or genetic disorders. This may result in non-breakdown of lactose to its monosaccharides units i.e. glucose and galactose. This defect is known as lactose intolerance. This intolerance can be overcome by either avoiding taking milk or consuming hydrolytic milk products such as dahi, yoghurt, lassi etc.

iv. Vitamins

Milk and its products contain both water soluble and fat-soluble vitamin. Their role is summarized as follow:

1. **Vitamin A:** Retina of eyes, mucous membrane infection prevention, night blindness, maintenance of good health
2. **Aneurin, thiamine (vitamin B_1) :** Anti beri-beri, polyneuritis, body maintenance
3. **Riboflavin (vitamin B_2):** Oxidation-reduction changes in milk
4. **Nicotinic acid:** Skin disorder e.g. Pellagra disease

5. **Pyridoxine:** Anti pellagra factor
6. **Biotin:** Promotes skin development
7. **Folic acid:** Prevent pernicious anaemia
8. **Vitamin C:** Prevent scurvy
9. **Vitamin D:** Prevention of rickets (bone disease)
10. **Vitamin E:** Anti sterility

A summary of the distribution of vitamin in milk and dairy products is given in the Table 8.14.

Table 8.14: Distribution of vitamin in milk and milk products.

Milk and milk products	A	B1	B2	C	D
Raw whole milk	Fair good	Very fair	Good	Very fair	Very fair
Pasteurized milk	Good	Slight	Good	Slight	Very fair
Sterilized milk	Good	Very	Good	Very slight	Very fair
Dried whole milk	Good	Slight	Good	Slight	Fair
Evaporated whole milk	Good	Very slight	Good	Very slight	Fair
Condensed whole milk sweetened	Good	Slight	Good	Slight	Fair
Separated milk Butter milk	Absent	Very fair	Good	Very fair	Absent
Cream	Good	Slight	Slight	Slight	Fair
Butter	Good	—	—	—	Fair
Cheese	Good	Slight	Very fair	—	Fair

Source: Dairy Chemistry and Animal Nutrition, M.M. Rai (1964)

v. Minerals

Milk and milk products are a good source of minerals, especially calcium and phosphorus. Our body requires various minerals such as calcium, phosphorus, magnesium, sulphur, nitrogen, sodium, potassium and chlorine (as chloride). There are certain trace elements, which too are needed by individuals in traces. These include iron, copper, zinc, cobalt and iodine.

Milk contains calcium and phosphorus in the ratio of 1.3:1 required for optimum growth. This ideal ratio meets the need of a growing child and different individuals with varying age groups.

Trace elements are required by our body in traces. They are needed in ppm or in small quantity. Their nutrition role is as important as of major elements. For example iron is an integral part for the formation of blood protein haemoglobin needed to prevent anaemia. Likewise Cobalt is required for vitamin B_{12} molecule which contains cobalt in its structure. Hormone thyroxine secreted by thyroid gland is secreted as thyroxine. Iodine deficiency leads to enlargement of thyroid gland.

Except for iron, milk is a good source for trace elements especially zinc, nickel, molybdenum which are considered important for nutrition and proper functioning of certain specific enzyme activities. Milk is an excellent source for calcium and phosphorus. Calcium is an integral part of bones and teeth. Along with phosphorus they are involved in the formation of teeth and bones. Milk meets the entire need of these minerals.

Finally it may be concluded that milk is good source of all the minerals except iron and iodine.

Check Your Progress 5

1. Explain why milk is essential for infant.

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2. State caloric energy of lipids.

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3. Name the fat-soluble vitamins.

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4. Name the mineral for which milk is an excellent source.

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8.7 LET US SUM UP

Food is required for growth, reproduction, supply of energy, maintenance and recovery from diseases at different stages of life. These functions are met by milk and milk products. Milk and milk products meets the nutritious needs of infants, adults, old and convalescence. The functions of milk are served through its constituents including protein, fat, lactose, vitamins, and minerals. Milk contains 20 amino acids. Milk is a source of high quality proteins, which have a high biological value of 90. Milk is a rich source of calcium.

Unravelling the composition of milk and its constituents has been a challenging problem due to the complex nature of milk. A knowledge of the composition of milk, its constituents and factors affecting the composition of milk lead to the understanding of the physico-chemical nature of this complex biomolecule. The average gross composition of milk varies due to several factors, which affect the composition of milk. There are several factors including species, breed, stage of lactation, feeding etc.

Flavour and off-flavour are important from the point of view of consumer and food acceptance, and palatability. Flavour is affected by heating, contamination and various other factors. There are several components, which are responsible for flavour and off-flavour.

Milk and milk products play an important role in nutrition. This has resulted in the preparation of several food products especially whey protein concentrate.

8.8 KEY WORDS

SNF	:	Solids-not-fat
Kilocalorie	:	A unit of heat energy
Nutrional	:	Needed for nutrition
Triglyceride	:	Constituent of fat made up of glycerides of fatty acids
Fortify	:	To add or enhance a nutritive quality of food.
Essential amino acid	:	Amino acids which can not be synthesised by body.
Lactose	:	A disaccharide sugar of milk
Hydrolysis	:	Chemical break down of complex compounds into simple one.

8.9 SOME USEFUL BOOKS

Jenness R and Patton S. (1959) Principles of Dairy Chemistry, John Wiley's, USA.

Ling E.R. (1956) A text Book of Dairy Chemistry Vol 1 & 2, Chapman and Hall, London.

Webb B.H. and Johnson, A.H (1979) Fundamentals of Dairy Chemistry, AVI Publishing Co, Connecticut, USA

Rai, M.M.(1964) Dairy Chemistry and Animal Nutrition, Kalyani Publishers, New Delhi.

Mathur M.P. Datta Roy, D, and Dinakar (1999) Test Book of Dairy Chemistry I.C.A.R. New Delhi.

8.10 ANSWER TO CHECK YOUR PROGRESS

Your answers should include following points.

Check your Progress 1

1) i. The composition of cow and buffalo milk is as follow (As percent)

		Water	TS	Fat	Lactose	Protein	Minerals	SNF (Minimum)
1.	Cow	87.2	12.8	4.0	4.7	3.4	0.7	8.8
2.	Buffalo	83.5	16.5	7.2	4.8	3.8	0.7	9.3

2) i. Lactose is the highest constituent of human milk with a level of 6.8%

3) i. Level of protein in sheep milk is 4.5 %

Check Your Progress 2

1) i. The three different states in which milk constituents are present are:
   a) Fat is present as an emulsion
   b) Protein along with a portion of mineral matter is present in colloidal state
   c) Remainder of mineral matter and lactose and present in true solution
2) i. The range of size of casein micelles is between 30-300 millimicron
3) i. Casein coagulates at pH 4.6.
4) i. The molecular weight of beta lactoglobulin is 36,000 dalton
5) i. Immunoglobulin
6) i. True

Check Your Progress 3

1) i. Human milk has lowest percent of protein, which is 1.30 percent
2) i. Colostrum is different from normal milk because of its high concentration of globulin protein, namely, immunogobulin which is present in very high concentration in colostrum.
3) i. With advancement in age there is a slight decrease in fat content. An irregular decline in S.N.F. also occur. Within S.N.F casein and lactose are the main components which are mainly affected

Check Your Progress 4

1) i. The three basic sensory aspects of flavour in milk are
   - olfactory
   - gustatory
   - tactual
2) i. Flavour is important to the consumer because if the flavour is poor milk will be rejected inspite of the fact that the food is wholesome, nutritious or reasonably priced.
3) i. Components linked with flavour of milk are acetone, acetaldehyde, butyric and certain other free fatty acids. Methyl sulphide also contributes towards the flavour of milk.
4) i. Notable component is melthyl sulphide upto 12 p.p.b
5) i. Off - flavour are referred to the flavours which are not typical to the food such as milk and are considered undesirable.
6) i. Major off- flavours of milk are oxidized, lipolytic or rancid, sunlight, heated, coconut and absorbed flavour.
7) i. Compound responsbile for oxidized flavour is 2-octenal and 2- nonenal.
8) i. Hydrolytic rancidity is the rancidy caused by lipase through the release of butyric acid. It can be prevented by pasteurization, avoiding excessive agitation of milk, homogenization, warming to 80-90^{0}C, freezing and thawing, mixing of raw milk with cream.

Check Your Progress 5

1) i. Milk is essential for infants as they are unable to digest any other food other than milk which is readily digestible and meets its nutrition requirement
2) i. Lipids gives 9 kilocalorie energy/g
3) i. The fat soluble vitamins are vitamin A,D,E & K
4) i. Calcium is the mineral for which milk is an excellent source

Check Your Progress 6

1) i. Living being requires food for various purposes. These include food for growth, reproduction, and supply of energy, maintenance and recovery from diseases at different stages of life. These functions are met from foods from different sources. Milk is an extremely useful food, which contributes towards nutrition of human being.

2) i. The main constituents of milk which perform nutritional functions are lactose, milk proteins, lipids or fat, enzymes, minerals, and vitamins.

3) i. Twenty essential amino-acids are required by our body of which 10 are essential amino acid.

4) i. Lactose is retained for a longer period in our body because of its greater resistance towards microbial fermentation.

UNIT 9 PHYSICO-CHEMICAL PROPERTIES OF MILK

Structure

9.0 OBJECTIVES

After studying the unit we shall be able to:

- enumerate important physico-chemical properties of milk;
- specify their role in the processing of milk and milk products;
- describe the methods used to measure the important physico-chemical properties;
- indicate their impact on quality of milk and milk products; and
- test the purity and quality of milk and milk products.

9.1 INTRODUCTION

Certain physical and physico-chemical properties of milk like density, viscosity, acidity, pH etc., are important characteristics of milk with a very narrow range of variation in these properties. Knowledge of physico-chemical properties of milk is essential for identification and effective quality control of milk. In many cases processing parameters can be selected or modified depending upon the nature of the physico-chemical properties of fluid milk for manufacturing purposes e.g. in the processing of milk for ice cream, condensed milk, dried milk, butter, whey protein concentrate, etc. The selected physico- chemical parameters result in the production of the final product with desirable properties and characteristics. Important physico-chemical properties of milk are described here.

9.2 DENSITY

We know that density is defined as mass per unit volume. It is expressed in gm/ml at a given temperature.

Density = weight/volume

Density is a characteristic property of milk. Though the composition of milk is variable but the density of milk remain within a very short range. Same is true for various constituents of milk e.g. milk fat. Density is an absolute value i.e. absolute density. When density is related with a standard material e.g. water it is termed as specific gravity (sp.gr).

Specific gravity=density of substance/density of water

Generally density of water at 4^0C is used as the standard for specific gravity for liquid and solids. Since the absolute value of water at 4^0C is unity, the numerical values for absolute density and sp.gr. are identical. The density of any substance including water varies with temperature, it is therefore necessary to specify the temperature when reporting density or specific gravity.

Determination of Density of Fluid milk: Density of milk is determined by the following methods:

i) **Pycnometer/ Specific gravity bottle:** Pycnometer is a simplified form of specific gravity bottle. Density is determined by weighing milk in the pycnometer with a specific volume generally at 20^0C.

ii) **Lactometer**: Lactometer is used as an instrument for rapid determination of density of milk. The density is determined with a glass instrument called lactometer. It is based on the principle of floatation which displaces specific volume of milk on floatation. The lactometer is graduated in such a manner where each graduation is called as lactometer reading of the scale. Each division is graduated as lactometer degree. The average lactometer reading for normal cow whole milk is between 26-30. For buffalo milk the range is between 28-32. The lactometer reading can be changed to sp. gr. by prefexing 1.0. Thus a reading of 32 indicates a sp.gr. of 1.032. The specific gravity of cow milk ranges from 1.028 to 1.032 and that of buffalo milk from 1.030 to 1.034. Skim milk ranges from 1.034 to 1.036.

Check Your Progress 1

1. Give the normal range of lactometer reading of cow and buffalo milk.

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2. Convert the lactometer reading 28 to its specific gravity.

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3. Define density. Write the unit in which it is expressed.

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9.3 VISCOSITY

Viscosity of a fluid (liquid or gas) is a measure of its resistance towards flow. This resistance is due to internal friction within a liquid as they slide each other. The unit of expression of viscosity is poise (named after Poiseuille). A poise is the force of one dyne acting on area of one square centimeter between two parallel planes one centimeter apart, to produce a difference in flow rate between the planes of one centimeter per second.

In milk centipoise is commonly used to express viscosity, which is one hundreth of a poise.

Principle of Viscosity: Viscosity can be measured both in absolute or relative terms. Absolute viscosity is the viscosity in poise or centipoise. Relative viscosity is the rate of flow of liquid. It is either volume flow during a fixed period of time or time for a fixed volume under specified conditions. The absolute viscosity of water is 1.005 centipoise at 20^0C. Thus centipoise is the viscosity exhibited by water at 20^0C**.**

Viscosity can be measured by the following methods

i) **Ostwald pipette** which is based on the principle of time of flow under a fixed pressure

ii) **MacMichael Viscometer**-Measuring the force required to move two layers of liquid past each other.

iii) **Falling Ball Viscometer**-by measuring the fall of a ball through a column of liquid e.g. Hoeppler viscometer.

Viscosity of Milk: Viscosity of milk ranges between 1.5 to 2.0 centipoise at 20^0C. Due to fat emulsion and colloidal particles milk is viscous than water. Any alternation in the physical nature of fat or protein hydrolysis, cooling or heating of milk affects proteins and fat and thus the viscosity. Clustering of fat globules affects viscosity e.g. cream where viscosity increases due to clustering of fat globules. Likewise homogenization of milk results in the state of sub-division of dispersed constituents e.g. fat. Thus homogenization of milk increases the viscosity. Viscosity increases also due to heating and concentration e.g. condensed milk due to increased total solids and changes in milk constituents.

Check Your Progress 2

1. Define viscosity.

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2. Explain why homogenized milk is more viscous than unhomogenized milk.

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3. Name the methods employed for measuring viscosity.

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9.4 SURFACE TENSION

A molecule in the interior of a liquid is attracted in all directions because it is surrounded by molecules equally in all directions. However, the molecules at the surface of the liquid are attracted sideways and downwards but not upwards. The cohesion or tension of molecules at the surface, resulting from imbalance of forces acting on them, convert the surface to act as though covered with a film or skin. This, phenomenon is known as surface tension. Surface tension can be demonstrated by carefully horizontally placing needle at the surface of the water where it will float due to the forces of surface tension.

Surface tension is expressed is dynes per centimeter (dynes/cm). In simple words surface tension is defined as the force in dynes acting at right angles to any line, 1 cm of length on the surface of a liquid.

Surface tension in milk can be measured any of the two methods:

i) **Ring Detachment or Tensiometer method:** This is based upon the principle of force required to pull a metal ring free from the surface of a liquid.

ii) **Drop Weight method:** Here the number of drops formed when a given amount of liquid is allowed to fall from a pipette is measured. The instrument used to measure drop weight is known as stalagmometer. It consists of a glass tube with a uniform diameter of 1-3 mm with a small bulb which is sharply grounded so that the liquid drops from the tube in an almost spherical form. The tip of the tube can be enclosed in a circulating water bath to control the temperature. Droplets falling from the tube are collected and weighed.

The Surface tension of milk: Surface tension of milk falls in the range of 40 to 60 dynes/cm. A value of 50 dynes is commonly taken as surface tension of milk at 20^0C. Water has a surface tension of 72.75 dynes/cm at 20^0C. The lower value of milk compared to water is due to substances which lowers the surface tension of milk. Notably, these include fat and protein. Fat significantly lowers the surface tension of milk as cream has a surface tension value of 39-40 dynes/cm. Lipolysis also lowers down the surface tension of milk.

Check Your Progress 3

1. Define surface tension along with its unit of expression.

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2. Name the two methods commonly used to measure surface tension.

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3. Explain why the surface tension of milk is lower than that of water?

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9.5 REFRACTIVE INDEX

Definition

The velocity of light varies with density of the medium through which it passes. Thus when light passes from a less denser medium such as air into a more dense medium water it is bent or refracted. The magnitude of this bending when expressed as a ratio of sines of the angles of incidence and refraction of the light, is the refractive index. It is designated by the letter *n*.

$$n = \frac{\sin i}{\sin r}$$

Where i = angle of incidence

r = angle of refraction

n=refractive index constant

Refractive index of milk and ghee: Refractive index of milk has a range between 1.3440 to 1.3480. The refractive index of water at 20^0C with the D line of sodium spectrum (589.3 mm) is n_D^{20} = 1.33299. The refractive index of material such as milk is higher than water due to dissolved material in milk. The dissolved material includes salts, lactose, etc. The refrecture index is used to measure the concentration of dissolved solids like sugar in food industry e.g. jams, jellies, syrups, etc., to estimate sugar. A butyro refractometer (B.R. Index) reading between 40-42.5 is the index of purity of ghee. Ghee exhibiting a refractive index of 1.4545 corresponds to a B.R. index of 43 at 40^0C.

Measurement of Refractive Index

i) **Immersion refractometer:** It is used for measuring refractive index of milk. Milk serum is prepared with the help of copper sulphate. The proteins are removed by filtration. A drop or two is placed on the prism of refractometer and the refraction is measured

ii) **Abbe's refractometer:** Abbe's refractometer is a modified version of refractometer. It is provided with a narrower range for measuring RI for fats and oils. There is an arrangement for circulation of water so that fat remains in a melted state and temperature can also be controlled. The scale is usually graduated in numbers (e.g. 43 which corresponds to *n* = 1.4545). Abbe's refractometer is used to measure purity of ghee. A drop or two of ghee drop -lets are placed on the surface of Abbe's refractometer prism, which is heated at 40^0 C through water circulation. The refractometer reading called as butyro refractometer reading (B.R) is recorded on the scale. A B.R reading between 40-42.5 is taken as the criteria for purity of ghee. This is commonly known as the B.R. index of ghee. An increase in B.R. shows the adulteration of ghee with vegetable oil/animal body fat.

Refractive index is used to measure

- Total solids in milk and condensed milk
- Sugar content
- Purity of ghee
- Adulteration of milk with water

Check Your Progress 4

1. Define refractive index

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2. Name the instruments used to measure R.I.

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3. Name the applications where R.I. can be applied

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9.6 FREEZING POINT OF MILK

Freezing point of water is a constitutive property i.e. it depends upon the nature of the molecules of the liquid i.e. water. But the freezing point of a solution or a liquid such as milk is a colligative property which depends on the total number of solute particles. If the solvent content is the same any variation in the solute concentration will affect freezing point of the solutions. The solvent of milk is water while solute consists of molecules like sugars, minerals, proteins, milk fat in suspension, etc. When ice and water are in equilibrium with one another that is called freezing. At this temperature they have the same vapour pressure. The addition of solute to water lower the vapour pressure. The reason is that it delays the escape of the vapours from the surface. Thus the freezing of a given solution is always lower than that of water. The amount of depression of the freezing point is proportional to the fraction of the total number of solute particles, which are solute molecules. Also freezing point depression is a function of the osmotic pressure of the solution. The osmotic pressure of milk is believed to be the same as that of blood physiologically.

Freezing point of milk: Freezing point of milk ranges from $– 0.530^0$ to $- 0.550^0$C. In order to obviate negative sign the term freezing point depression is used. Thus 0.540 refers to the freezing point depression of milk. This eliminates the negative sign. Addition of water lowers this value. Values below 0.530 indicate the addition of water. Since skim milk also has the same freezing point as milk adulteration of skim milk cannot be detected by this method.

Souring of milk lowers the freezing point as the number of molecules increases due to breakdown of lactose, which affect the osmotic pressure of milk. This results in an increase in freezing point depression

Determination of freezing point depression of milk: Freezing point is a fairly sensitive and constant property of milk. It is principally used to detect adulteration of milk with water. Since the freezing point depression of milk differs from water with only 0.5^0C, highly sensitive and accurate thermometers are required for its measurement, which can read up to 0.001^0C. Two methods are used to determine freezing point of milk

1. **Hortvet Cryoscope method:** It was one of the earliest method to determine freezing point of milk by an instrument called Hortvet cryoscope. It was developed and used as early as 1923. This instrument has a number of drawbacks. Major difficulty being the cumbersome of the operation of cryoscope and limitations in getting reproducibility of results. This instrument uses ordinary thermometer called freezing point thermometer.

2. **Thermistor Cryoscope method**: Due to the development of special type of thermometers called thermistor probes, thermistor cryoscope has been developed which has replaced Hortvet cryoscope in determining freezing point of milk. Thermistor probes are special type of thermometers based on the measurement of changes in electrical resistance with variation in temperatures. Thermistor cryoscope are vary popular in determining freezing point depression of milk. "Fiske Cryoscope" and "Advanced Milk Cryoscope" are the important cryoscope instruments which are used for determining freezing point of milk. Official methods of Analysis of the Association of Official Analytical Chemists (AOAC) has recommended the method for determining freezing point depression of milk using thermistor probes.

   In order to determine percentage of water added it can be calculated by the formula -

   Minimum percentage of added water by mass = $\text{F.P.} = \frac{0.530 - \Delta T}{0.530} \times (100 - \text{SNF})$

   Where WT is the freezing point of sample

   F.P = Freezing point

   SNF = % Solids- not-fat of milk sample

   (0.530^0 is the freezing point depression of genuine milk)

Check Your Progress 5

1. Name the methods used for freezing point determination of milk

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2. Give the freezing point range of pure milk.

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3. Give the formula for detecting water by F.P. method

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4. Explain why freezing point of milk is lower than that of water?

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5. Name the two instruments to measure freezing point of milk

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9.7 BOILING POINT

A solution always boils at a higher temperature compared to a pure solvent. This depends on the concentration of the dissolved substances or the solute concentration. Milk contain several constituents such as protein, fat, minerals, etc. These constituents are responsible for elevating the boiling point above 100^0C. Value of 100.15^0C is taken as the boiling point of milk but actual boiling points is 100. 45^0C. The reason for this discrepancy is an alteration of the normal ionic and molecular colloidal equilibrium as a result of heating.

Milk boils more quickly than water. The reason is not that milk boils at a lower temperature but it requires less heat to raise its temperature than water does. The boiling point of milk, in fact, is slightly higher than that of water. Milk contains a number of easily heated solids. Therefore, if the same amount of heat is applied to equal quantities of milk and water the temperature of the milk will be raised more than that of water.

As a conductor of heat milk is poorer than water. Addition of water lowers the concentration of the dissolved substances responsible for elevating the boiling point of milk. Though boiling point is lowered by addition of water it can be used as a method of water adulteration in milk. However, there are practical difficulties in determining the boiling point of milk.

Check Your Progress 6

1. Explain why the boiling point of milk is higher than that of water?

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2. Give the boiling point of the milk.

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9.8 SPECIFIC HEAT OF MILK

The specific heat of a substance is the amount of heat required to raise the temperature of a given mass of the substance one degree centigrade, compared with the amount of heat required to raise an equal mass of some standard substance one degree centigrade. Water is taken as a standard and its specific heat is 1. Compared to water specific heat of milk is 0.9454 which is lower than that of water. Thus it requires less heat to raise the temperature compared to same quantity of water. It also takes less ice to cool a certain volume of milk one degree than it does to cool the same quantity of water through one degree.

The specific heat of skim milk is lower than milk. This is due to the absence of fat from skim milk. Skim milk has a value of 0.933 to 0.954 cal $g^{-1}C^{-1}$. Fat has a higher specific heat of about 0.52 cal $g^{-1}C^{-1}$. The specific heat of milk and cream depend strongly upon the fat content.

Specific heat is measured easily with the help of a calorimeter with an electric heater. With the help of calorimeter energy used to raise the temperature can be easily measured. Specific heat of milk varies with the temperature. Specific heat

of warm milk is the same as that of normal milk. This is due to the fact that fat is in the liquid state. This value is however, lower of milk as milk is cooled below 19^0C. At this temperature some of the heat supplied to the milk system at a temperature near the melting point of the fat is used by the fat for its melting.

Table 9.1: Specific heat of milk and milk products

Milk and milk products	At 60^0F	At 40^0F
Milk	0.94	0.93
Whey	0.98	-
Butter	0.53	-
Cream (30% fat)	0.98	0.85
Cream (60% fat)	1.05	0.72
Cheese	0.64	-

Check Your Progress 7

1. Define specific heat of milk.

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2. Give value for specific heat of milk, skim milk and cream.

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3. Why the specific heat of milk is higher than skim milk?

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9.9 ACIDITY

Natural acidity of milk: Freshly drawn milk is slightly acidic in nature. This is due to the presence of natural constituents of milk. These include various salts such as phosphate, citrate, carbonate, etc. Also milk constituents like casein, albumin, non-protein nitrogenous compounds and various acids which contribute towards the natural acidity.

Developed acidity of milk: During storage of milk acidity develops due to the fermentation of milk lactose to lactic acid and other acidic components, primarily due to microbial effect. Beyond an acidity of 0.18% as lactic acid milk coagulates on boiling.

COB Test for detection of coagulation of milk: The developed acidity along with natural acidity, which is refered as total acidity, gives positive reaction on boiling milk. A platform test named COB test called clot-on-boiling test is used to detect coagulation of milk. Formation of clot on boiling is an index for acidic abnormal milk.

Measurement of acidity: Acidity of milk can be determined against a standard alkali such as 0.09 N NaOH or 0.1N NaOH solution in the presence of phenolphthalein indicator. On complete neutralization of acidity phenolphthalein indicator changes its colour in milk to faint light pink. The following reaction occurs during titration.

$$CH_3CHOHCOOH + NaOH \rightarrow CH_3CHOHCOONa + H_2O$$

Lactic acid **Sodium lactate**

The titratable acidity is expressed as lactic acid per 100 ml of milk.

$$TA = 0.9 \times V_1 \times N_1$$

Where V_1 = Volume in ml of the standard

NaOH solution required for titration

N_1 -= Actual normality of the NaOH solution

TA = Titratable acidity

Note: The calculation becomes simpler when 0.09N $(\frac{N}{9})$ NaOH is used for titration as titre value is direct reading of acidity.

Check Your Progress 8

1. What is the natural and developed acidity of milk? Name the constituents responsible for developed acidity of milk.

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2. What is COB test and its relation to acidity.

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3. Why is it easier to use $\frac{N}{9}$ NaOH to calculate acidity of milk ?

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9.10 pH OF MILK

pH refers to the hydrogen ion concentration (C_H+). Mathematically, pH = -log C_H+

pH is an index of the true acidity or alkalinity of the system. pH is expressed in the form of pH scale which is 1 to 14 pH units. pH of 7.0 is called as neutral pH. pH below 7.0 is acidic while above 7.0 it is basic or alkaline.

pH of normal fresh milk is between 6.6 to 6.8. The slight lower side of pH is due to natural acidity as a function of natural milk constituents contributing towards acidity. During titration of milk with alkali to measure developed acidity induces

shifting of pH through hydrogen ion equilibrium due to the buffering action of milk. Buffer action simply indicates a state of resistance to a change in hydrogen ion concentration of a solution i.e. milk. The buffer compounds present in milk are the acids, proteins, salts of acids such as phosphate, citrate, carbonates and dissolved CO_2.

Measurement of pH

pH of milk can be determined mainly by the following two methods:

i) **Indicator Paper Strip Method:** With indicator paper strip method pH can be easily determined within few seconds. However, this method gives less accurate results compared to electrometric method. In this method help of pH paper strip is taken. The pH of the strip is so choosen so that it is nearest to the expected pH. On dipping the pH paper strip colour of strip changes. The pH of milk is equal to that of standard pH colour scale to which the dipped paper compares.

ii) **Electrometric method:** Electrometric method is based on the principle of potentiometer, which measures electromotive force (emf) of the system, the difference of emf is measured with the help of two electrodes. One of the electrode is known as reference electrode which has potential independent of the solution,. The other electrode is pH dependent. It generates emf when dipped in a solution. This emf is generated by H^+ ion concentration in the solution, which causes emf generation. It is directly related to pH. Due to emf generation by two electrodes and along with the emf of the reference electrode causes electric current to flow. The magnitude of the electric current flow can be measured accurately and rapidly with modern electromotive devices.

Measuring pH of milk: pH meter is standardized with a standard pH solution e.g pH 4.0, .6.0 or 9.0. After standardization, milk is taken in a beaker and the electrodes are dipped in milk. This results in pH measurement, which can be obtained directly from the pH meter.

Check Your Progress 9

1. Define pH. What is the natural pH of milk?

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2. Give the range of pH scale. Give the neutral value of pH scale.

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3. Name the two methods commonly used to measure pH.

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9.11 BUFFERING ACTION OF MILK

There are several constituents of milk which act as a buffer i.e. they give resistance towards change in pH. These include carbon dioxide, proteins, phosphate, citrate and a number of minor constituents. Due to microbial action additional components

are introduced in milk, which include lactate and many other organic anions. Titration of milk in the pH range of 4.8 to 8.3 has been used to assess the behaviour of milk during titration in the presence of phenolphthalein indicator. When milk is titrated against an alkali maximum buffering occurs at a pH range of 4.8 to 6.8 but at pH 8.0 to 8.3 very little alkali is required resulting in lower buffering. Titration of fresh milk over pH 6.6 to pH 8.3 requires 13 to 20 ml of 0.1 NaoH per 100 ml (1.3 to 2.0 meq. per 100 ml). Most fresh milk samples fall in the range of 1.5 to 1.8 meq. per 100 ml.

Buffering of milk varies between samples and breeds. Some of the constituents responsible for buffering of milk are given here.

i) **Carbon dioxide**: Milk contains 20 mg CO_2 per 100 ml of milk or 10% by volume. CO_2 behave like an acid in the form of carbonic acid. This on titration offers a titration value of 0.5 meq/100 ml between pH 6.6 and 8.3 out of the total value of 1.3 to 2.0

ii) **Proteins:** Milk contain around 2.5% casein and 0.6% whey proteins. Casein contributes to a titration value of 0.8 meq/100 ml and whey proteins 0.1 to 0.2 meq/100ml.

iii) **Phosphate:** Presence of phosphate in milk has three buffering ranges. In the presence of calcium it forms a complex of calcium phosphate. During titration precipitation of calcium phosphate occurs as the pH is raised e.g. pH 6.0 About 0.6 meq of alkali is needed around pH 6.0

$$3Ca^{++} + 2H_2PO_4^- \text{ D } Ca_3 (PO_4)_2 \text{ F } + 4H^-$$

$$4H^+ + 4OH^- \text{ D } 4H_2O$$

iv) **Citrate:** Citric acid as citrate ions has very little buffering capacity of 0.1 meq per 100 ml. However, it complexes with calcium as calcium citrate. This delays the precipitation of calcium phosphate and affect the titration indirectly.

v) **Lactate**: Lactic acid also delays the titration as it also forms a complex with phosphate ion.

$$CH_3 \text{ CHOH COOH } + HPO_4^{--} = \text{ D } H_2PO^-_4 + CH_3 \text{ CHOHCOO}^-$$

Lactic acid **Lactate ions**

Check Your Progress 10

1. Explain buffering.

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2. Name the constituents of milk responsible for buffering of milk.

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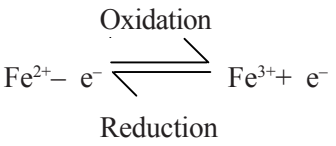
9.12 OXIDATION-REDUCTION POTENTIAL (Eh)

Definition: Oxidation may be defined as the uptake of oxygen or the loss of hydrogen or the loss of electrons. Likewise reduction is defined as the loss of oxygen or the uptake of hydrogen or the gain of electrons. These process of oxidation and reduction go simultaneously in a system composed of more than one

substance constituting the system which involve exchange of electrons simultaneously in the system.

Theory: Exchange of electrons generates an electromotive force i.e. emf in the system which indicates the direction in which processes proceeds. This is illustrated with the equation



Method of determining oxidation-reduction potential: Method of determining oxidation-reduction potential is based on the principle of oxidation-reduction. Substances giving or taking electrons in a solution creating potential difference can be measured using electrodes. Potential difference can be measured by platinum electrode (e.g., donating or accepting electrons) and a reference calomel electrode in the presence of a potentiometer. The voltage measured under these conditions gives the oxidizing or reducing capacity of the system. This is simply called as oxidation-reduction potential and is designated by the symbol E_h. A positive potential involving loss of electrons from the platinum electrode is indicative of oxidizing properties, whereas a negative potential, which involves gain of electrons at the platinum electrode, gives reducing capacity.

The Oxidation-Reduction Potential of milk: Milk has a positive oxidation-reduction potential. It ranges between +0.2 and +0.3 volt for cow milk with an average value falling between +0.23 and +0.25 volt. This is primarily due to the presence of dissolved oxygen in milk. Flushing of oxygen of milk with nitrogen decreases the oxidation - reduction potential of milk. Heating of milk such as HTST Pasturization milk or preheating prior to making milk powder produces reducing substances in milk. This lowers E_h values in heated milk or dried milk. Thus superior quality with higher storage capacity milk powders can be prepared by increasing reducing substances in it.

Bacterial contamination of milk affects E_h of milk. A lowering of E_h occurs due to consumption of oxygen by microorganisms. Also reducing substances are formed during the course of bacterial **metabolism.** Methytane blue reaction is based on E_h. A negative E_h is obtained when the dye becomes colourless.

Presence of copper in milk also influences E_h. Copper acts as an oxidizing agent with very strong electron acceptance. Presence of copper raises E_h of milk.

Check Your Progress 11

1. Define oxidation-reduction potential.

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2. Briefly describe the E_h

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3. Give two application of E_h in relation to milk and milk products

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9.13 ELECTRICAL CONDUCTIVITY

Solutions of electrolytes can conduct electric current due to the presence of electrolytes under the influence of an electric field.

Definition: Electrical conductivity may be defined as a measure of the ability of a solution to carry electric current. This conductance is obeyed by ohm's law and is measured by specific resistance.

Theory: Specific resistance is defined as resistance in ohms of a column of solution 1 cm long and 1sq cm in cross-section. The conductivity or specific conductance is the reciprocal of specific resistance. It is expressed as reciprocal ohms (i.e., $ohms^{-1}$ or mhos)

Measurement of Electrical Conductivity: The electrical conductivity is measured in terms of specific conductance which is reciprocal of specific resistance. The specific conductance is estimated from the resistance obtained from the filled solution in the cell. The electric resistance of milk is measured by placing milk in a cell, between two platinum electrodes fixed at a distance. The electrical resistance is measured with the help of Wheatstone bridge. The specific conductance is calculated from the measured resistance of the cell filled with solution e.g. milk. Thus

$$\text{Specific conductance} = \frac{K}{R}$$

Where K= cell constant determined with cell of solutions of known conductance and R = measured resistance in ohms.

Specific Conductance of milk: The specific resistance of milk is low with an average value of 0.005 ohm^{-1}. During **mastitis** the value increases due to the presence of various ions of milk. The various ions responsible for the conductivity of milk are sodium, potassium and chloride ions. In mastitis and colostrum milk these ions are abnormally high. .

Check Your Progress 12

1. Define electrical conductivity

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2. Explain specific conductivity. Name the ions responsible for specific conductivity of milk.

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9.14 LET US SUM UP

Milk possess characteristic physico-chemical properties which are specific in nature. These are due to the constituents present in milk. These physico-chemical properties include specific gravity/density, pH, buffering, viscosity, surface tension, freezing point, oxidation-reduction, specific heat, boiling point and electric conductivity. Understanding these properties can be used advantageously for processing of milk & milk products. Such properties have great potential for detecting the adulteration. For example adulteration of milk can be detected by specific gravity, freezing point and refractive index. Likewise, adulteration of ghee can be detected by refractive index. Some of these properties have been discussed.

9.15 KEY WORDS

Ions	:	Negatively or positively charged particles.
Calorimeter	:	An instrument for determining heat of energy on burning the substance.
Buffer	:	A substance which resist changes in pH.
Carbon dioxide	:	CO_2 gas present in air
Lactic acid	:	An acid developed in milk through the action of microbes on lactose.

9.16 SOME USEFUL BOOKS

Jenness R and Patton S, (1959). Principles of Dairy Chemistry, John Wiley, New York

Ling, E.R. (1956). Text Book of Dairy Chemistry, Vol 142 Chapman and Hall, London.

Webb, B.H. and Johnson, A.A. (1965). Fundamentals of Dairy Chemistry, AVI Publishing Co., Connecticut, USA

9.17 ANSWERS TO CHECK YOUR PROGRESS

Your answers should include following points.

Check Your Progress 1

1) i. The normal range of lactometer reading for cow milk is between 26-30 and 28-32 for buffalo milk

2) i. It is 1.028

3) i. Density is mass per unit volume. It is expressed in gm/ml

Check Your Progress 2

1) i. Viscosity is nothing but resistant of a liquid or gas towards flow. It is expressed in centipoise which is one hundredth of a poise.

2) i. Homogenization results in sub division of fat which increases viscosity.

3) i. Method employed for measuring viscosity are

- Ostwald pipette
- MacMichael viscometer
- Falling ball viscometer

Check Your Progress 3

1) i. Surface tension is expressed as the force acting at right angles to any line one cm of length on the surface of a liquid. Surface tension is expressed in dynes/cm.

2) i. Ring and drop weight method.

3) i. It is due to substances present in milk. Notably they are fat and protein which lower down the surface tension of milk compared to water.

Check Your Progress 4

1) i. When light passes from a less denser medium such as air to a more denser medium such as water it is bent or refracted. Magnitude of this bending when expressed as a ratio of sins of the angles of incidence and refraction of the light, is the refractive index.

2) i. Immersion refractometer and Abbe's refractometer

3) i. Sugar content, purity of ghee, adulteration of milk with water.

Check Your Progress 5

1) i. Thermistor cryoscope and Hortvet cryoscope method

2) i. 0.530 to 0.550.

3) i. $\frac{0.530 - \Delta T}{0.530} \times (100 - SNF)$ = Freezing point or F.P.

4) i. Due to dissolved substances of milk notably milk salts and sugars etc. These substances affect the F.P of milk and lower down the freezing point of milk.

5) i. Fiske cryoscope and Advanced milk cryoscope

Check Your Progress 6

1) i. Boiling point of milk is higher than that of water because of the presence of dissolved substances in milk which raises the boiling point.

2) i. Boiling point of milk is 100.45^0C

Check Your Progress 7

1) i. The specific heat of a substance is the amount of heat required to raise the temperature of a given mass of the substance one degree centigrade, compared with the amount of heat required to raise equal mass of some standard substance one degree centigrade. Water is taken as a standard and its specific heat is 1

2) i. Specific heat of

Milk – 0.9454

Skim milk –0.933 to 0.954

Cream (30% fat)- 0.85 at 40^0F, 0.98 at 60^0F

3) i. The specific heat of skim milk is lower than that of milk. This is due to higher specific heat of fat.

Check Your Progress 8

1) i. Acidity due to natural components such as phosphate, citrate and proteins, etc., is called natural acidity. Acidity due to lactic acid is called developed acidity. The constituent for developed acidity are mainly lactic and some organic acids.

2) i. Clot on boiling test. It is related to developed lactic acid acidity, which makes the milk to clot at 0.18% lactic acid acidity to clot on heating milk.

3) i. It is easier to calculate acidity using NaOH because titre value is directly related to acidity of milk.

Check Your Progress 9

1) i. pH refers to H^+ ion concentration, pH= — log C_H+. Natural pH of milk is between 6. 6 to 6.8

2) i. Range 1 to 14, pH 7.0

3) i. pH paper and electrical method.

Check Your Progress 10

1) i. Buffering may simply be defined as resistance towards changes in pH.

2) i. Constituents of milk responsible for buffering of milk are

- CO_2
- Phosphate
- Citrate
- Proteins
- Lactate

Check Your Progress 11

1) i. Oxidation- reduction potential is the process of loss or gain of electrons with the development of a potential.

2) i. E_h involve measuring the potential. A+ ive potential is the loss of electrons. A-ive potential is gain of electrons. Exchange of electrons generates an electromotive force i.e. emf in the system. This is simply called as oxidation-reduction potential.

3) i. Bacterial metabolism, presence of Cu

Check Your Progress 12

1) i. Electric conductivity may be defined as a measure of the ability of a solution to carry electric current as obeyed by ohm's law.

2) i. Specific resistance is defined as the resistance in ohms of a column of solution I cm long and 1 sq cm in cross-section. The electric conductivity is a measure of specific conductance, which is reciprocal of specific resistance. The ions responsible of specific conductance are sodium, potassium, phosphate and citrate.

UNIT 10 THERMAL PROCESSING OF MILK

Structure

10.0 OBJECTIVES

After reading this unit, we shall be able to:

- name various heating processes used in dairy industry.
- explain effect of heat on milk.
- define freezing of milk.
- enumerate important enzymes and their role in processing of milk

10.1 INTRODUCTION

The main purpose of application of heat is preservation of milk and milk products. In some cases controlling microbial contamination is the primary criteria. In products like dried milk main purpose is to preserve the product from chemical deterioration apart from microbial spoilage. The purpose of heat is to meet public health requirements such as pasteurization and sterilization, to remove water, to destroy enzymes, to facilitate mixing and blending processes, such as in ice cream mix, processed cheese and cultured dairy products and to impart desirable properties such as development of flavours.

10.2 HEAT PROCESSING OF MILK

There are several processes in which the main purpose of heat application is to make milk safe for human consumption and increase its keeping quality. Common process in which heat is applied are as follows:

i) **Pasteurization:** The main aim of pasteurization of milk is to kill all pathogenic microoganism and make it safe for human consumption. Pasteurization of milk is done either by High temperature short time (HTST) or Low temperature long time (LTLT) process. In Holder process milk is heated for not less than 30 minutes at 63^0C while in HTST pasteurization heating not less than 71.7^0C for 15 seconds is used. Pasteurization of milk is done to meet the public health requirement. Pasteurization leads to the destruction of pathogenic bacteria, e.g. Mycobacterium tuberculosis and most of the non-pathogenic organisms and the enzymes present in milk. Both in Holder and HTST process alkaline phosphatase activity is taken as an index of destruction of Mycobacterium tuberculosis.

ii) **Sterilization**: The purpose of heat sterilization is to destroy all micro-organisms and their spores in milk. Sterilization is primarily employed for the preparation of sterilized milk. In the preparation of evaporated milk sterilization at temperature

of 116^{0}C for 15 minutes is employed. Sterilized milk can be stored at room temperature for longer period.

ii) **Forewarming or Preheating:** Forewarming or preheating is applied for the manufacture of condensed or evaporated milk and dried milk. Temperatures between 88^{0}C to 100^{0}C are employed for forewarning. Present trend is to heat milk above 100^{0}C to give maximum heat stability.

iv) **Condensing:** In condensing heating is carried out under vacuum to remove water. In a single effect vacuum evaporator the temperature ranges between 43 to 55^0 C. With the widespread use of multiple effect evaporators for condensing milk, it is not possible to specify precisely the degree of heat treatment which may be subjected in condensing operation.

v) **Drying**: The purpose of drying is to completely remove water with minimum physico-chemical changes in the dried product. The temperature employed in spray drying process ranges between 71 to 177^{0}C in terms of air inlet temperatures. The precise temperature conditions vary with the particular drying equipment.

vi) **UHT Process:** In the ultra high temperature process for preparing UHT milk, the milk is heated at a high temperature of 135^{0}C – 150^{0}C with holding time of few (1 to 8) seconds. This is a microbially safe milk. UHT milk can be stored at room temperature for further use

vi) **Homogenization:** Homogenization is carried out to break down the fat globules into a smaller size, resulting in stable state of dispersion. Though homogenization can be carried out without heating but heating is generally required for proper and satisfactory homogenization. Before homogenization heating facilitates melting of fat and inactivation of the enzyme like lipase. If heating is not done it leads to the development of hydrolytic rancidity with the liberation of lower chain fatty acids. Heating destroys lipase and thus prevents lypolysis. Non-heating and homogenization will result in fast lypolysis by lipase resulting in rancid flavour by liberation of lower chain fatty acids from the glycerides. It is desirable to heat the milk before homogenization. Other due to heating and homogenization there are other physico-chemical changes which occur in milk. These include easy digestibility of milk, soft curd formation and tasteful products. However, homogenization results in difficulty in cream separation. Homogenization is primarily employed in the preparation of flavoured milk, ice cream mix and evaporated milk.

10.3 EFFECT OF HEAT ON MILK

I) **Effect on salt system:** The heat-induced changes in the milk salt system can be covered under three cateogories:

- Readily reversible shift in salt balance by changes in temperature
- Irreversible shift in salt balance.

Variations in temperature and concentration adversely affect salt balance. Calcium phosphate is less soluble at high temperature than at low temperature. Thus, the concentration of soluble calcium and phosphate is decreased during heating. Dissolved or soluble calcium and phosphate during heating is transferred to the colloidal state. This transfer action occurs on the colloidal micelles of caseinate phosphate. This transfer of soluble calcium and phosphate causes extensive changes in the structure of the micelles produced by heat treatment. Dissolved calcium and phosphate tend to revert to the original system but it is not completely transferred to the original structure after heat treatment. At the same time aggregation of the caseinate-phosphate micelles may occur (reversibly or irreversibly).

II) **Effect on Acidity:** During heat treatment CO_2 is removed from the milk system. This causes a decerase in acidity of milk. The effect is through the release of H^+ions. This process is affected by the insolubilization of calcium and phosphate.

$$3Ca^{++} + 2HPO_4^- \rightarrow Ca_3(PO_4)_2 + 2H^+$$

On the basis of available data, heat treatment lead to an increase in the dissolved citrate in milk.

III) **Effect on the milk proteins:** The heat-induced changes in milk are of great practical importance to the dairy industry. During denaturation the original three-dimensional structure changes. Denaturation consists of non-proteolytic changes in the structure of protein. Amongst the heat induced changes caused by denaturation of whey proteins are:

- Development of cooked flavour
- Development of anti-oxygenic properties
- Impairment of clotting properties
- Imparting of soft curd characteristic to milk
- Prevention of age-thicking in evaporated milk
- Improvement in the baking quality for non-fat dry milk in the bakery industry

These changes are related to whey proteins. The whey proteins are present to the extent of 0.6 to 0.7% in milk. Beta-lactoglobulin is the major whey protein of milk accounting for 50 percent of the total whey proteins. The observed changes in milk are: release of H_2S production, of cooked flavour, development of anti-oxygenic properties and lowering of curd tension. All these changes are related to whey proteins.

a) **Heat denaturation of whey proteins:** Heat denaturation of whey proteins occur between 68^0C to 80^0C. Heat denaturation starts from 68^0C onwards when milk is heated for 30 minutes or 71^0C for 15 minutes. The denaturation of whey proteins occurs at a higher temperature than pasteurization. The order of denaturation of whey proteins are immunoglobulin, blood serum albumin, beta-lactoglobulin while alpha-lactalbumin is the most heat resistant whey protein.

b) **Changes associated with whey protein denaturation:** Above 75^0C –SH groups are released from whey protein, which are highly reducing in nature. These groups are susceptible for oxidation. The activation of-SH groups accompanies by an important phenomenon of anti -oxygenic property of heat-induced changes in whey protein. Sulphahydryal (-SH) groups are powerful reducing agent. The ability of these groups to bind oxygen results in anti-oxygenic property. As a result it lowers the oxidation-reduction potential of milk, which shows the activation of these groups. Formation and activation of -SH also results in the liberation of volatile sulphides. These volatiles also include H_2S. The release of H_2S is one of the most important component responsible for cooked flavour of milk. Cysteine amino acid containing maximum number of -SH group is responsible for producing H_2S. Whey proteins are a rich source of cysteine and are a main cause of cooked flavour. Beta-lactoglobulin is very rich in -SH group.

Another important change resulting, as a function of heat denaturation of whey proteins is the soft curd forming property of milk. It is accompanied by two important changes in curd. These are the development of a soft curd characteristic in the curd and partial loss of clotting property in cheese manufacture. These are related to changes in the flocculation of serum protein particles. The impairment of milk clotting property seems to be due to interaction of casein with whey protein (beta-lactoglobulin). The denatured whey proteins bind with casein and thus affect its clotting property.

Milk contains a factor, which affect the loaf volume of bread when milk is added during bread making. As a result volume of bread is depressed and slackens dough is produced. This defect can be overcome by heating milk. This is supported by the role of added skim milk powder to dough during bread making, which contain heat denatured whey proteins. Heat denaturation of whey proteins in skim milk powder is thus used as an index of baking quality.

There is loss of creaming property and increase in whitening of milk due to denauration of whey protein. Loss of creaming property has been attributed to the interactions between whey proteins notably immunoglobulins which interact with proteins of fat globules. This interaction affect the creaming ability. Cream layer formed in such milk is shallow and indistinct from normal milk. Reflectance or improvement in whitening has been attributed to a heat denatured state of milk proteins just before browning. At this stage flocculation of whey protein occur, along with aggregation of casein and conversion of soluble calcium to insoluble salt.

c) **Destabilization of caseinate system:** Caseinate-phosphate particles in milk exist in a precarious equilibrium with soluble Ca^{++} and Mg^{++}, dissolved salts and whey proteins. Slight changes occurring as a result of heating or changes in ionic environment through pH will alter this equilibrium. Casein binds Ca^{++} and Mg^{++} ions very strongly. Casein is stabilized in the system by charge it carries. Heating causes pH changes which affect this process. The caseinate particles are very sensitive to changes in pH. Casein start precipitating below pH 6.0 and micelles precipitation starts at pH 5.2 to 5.3 where they still contain Ca^{++} and Mg^{++} attached to them. The manufacture of cottage cheese is based on the phenomenon of caseinate system by heat and acidity. During this process the destabilization of the caseinate particles leads to the formations of a smooth gel occupying the entire volume originally occupied by the milk. In this system a three-dimensional type network is formed that entraps the liquid along with gel structure formation or a network and a semi-solid system is formed. On applying heat to this system at cooking stage of the process, the caseinate particles become more closely knit together, water is expelled, and the clot shrinks. A desirable product is obtained by judicious use of pH and proper heat treatment.

The calcium caseinate phosphate micelles are readily precipitable by addition of various salts such as ammonium sulphate and urea. Heating hastens the process. This is the basis of producing various fractions of casein. The effects of heat and divalent cations are important from the view point of rennet action and heat. In this phenomenon ionic concentration and heat play an important role in the stability of casein micelles. Phosphate and citrate ordinarily exert an opposite effect over Ca^{++} and Mg^{++} because they form undissociated complexes with Ca^{++} and Mg^{++}.

Some milk apparently are stabilized by added calcium and destabilized by ions such as phosphate and citrate that sequester calcium. Observations of this type are the basis of the well-known salt balance theory first suggested by Sommer and Hart (1926). This theory holds that optimum stability depends on a certain ratio of calcium and magnesium ions to those of phosphate and citrate. The concept has been of great practical utility in developing practical procedures for controlling the stability of evaporated milk during heat sterilization. In practice evaporated milk to be sterilized is treated, as a series of samples on a pilot scale with graded level of phosphate or Ca the later being rarely if ever necessary. The samples are then sterilized and after cooling the minimum level of added salt that imparted satisfactory stability is noted and used to stabilize the lot of milk to be sterilized.

IV. **Forewarming process and heat stability:** Before sterilization in the preparation of evaporated milk forewarming of milk provides heat stability to milk. Generally, heating milk at 95^0C for 10 minutes provide heat stability to milk. It has been shown that a high temperature short time process of heat treatment provides

a better heat stability. However, it may be stated that this phenomenon of heat stability is complex and depends upon other factors such as quality of milk, storage temperature of milk, etc.

V. **Browning of milk:** Browning reactions in milk and milk products are the manifestation of heat induced processing of milk. Browning reaction occur due to changes related with pH, storage conditions, moisture content, relative humidity and temperature of processing and storage of milk and milk products. Browning reaction is absent in pasteurized milk but is evident in highly heated sterilized milk on storage. Browning reaction occurs in two forms on heating. The two types of browning in relation to heating are (a) amino sugar or Maillard browning and (b) non-amino browning or caramelization.

a) **Amino Sugar or Maillard browning:** Two components are responsible for this browning reaction. They are milk protein particularly casein and lactose present in milk and milk products. Phosphate salts and whey proteins make minor contribution in browning reaction. Browning reaction is complex. The reaction occurs between aldehyde groups (-CHO) of sugars and amino groups ($-NH_2$) of amino acids. They together start the browning reaction which ultimately lead to the formation of brown pigment melanoidin.

CHO l H–C–OH l	+	$H_2N - R$	D	RNH l H–C–OH l
Sugar (Lactose) with aldehyde group		Amino group of amino acid of the protein		Complex ultimately leading to the formation of melanoidin

b) **Caramelization or non-amino browning:** Caramelization or browning may be defined as the heat decomposition of sugar as a function of pH and buffers in the absence of amino compounds. It requires a relatively high order of heat energy. On the other hand, Maillard type browning requires a relatively low order of energy for its initiation and exhibit autocatalytic qualities once it has started. Caramelization is desirable in milk based products such as caramelized flavour which is desirable and liked.

c) **Changes related to browning:** Along with browning many complex reactions also occur with the formation of various compounds. In addition, fluorescent and reducing substances, various sugar fragments and flavour compounds are formed. Many of these are detected before browning starts. These changes have great practical utility. Notable amongst these is the development of flavour especially caramelized flavour. Following changes related to browning can occur:

- **Compound formation:** A large number of lactose degradation compounds are formed. These include furfuryl alcohol, furfuryl aldehyde, maltol, acetol, acetaldehyde, acetic, formic and pyruvic acid, NH_3, H_2S and CO_2
- **Reducing substances:** Heated and dried milk contain's a complex reducing system involving –SH compounds, ascorbic acid and substances associated with browning reaction. Heating concentrated milk for a similar period has a significant effect on browning reaction.

d) **Factors affecting browning of milk:** The principle factors responsible for browning in milk are:

i) **pH:** A pH above 6.8 favours browning reaction. This defect is predominant in evaporated milk where pH of milk plays an important role. Due to variations in pH and protein concentration in different

milks browning is affected due to these variations. This is due to release of protons during heating. As the pH is raised above pH 6.6 browning reaction occurs at a faster rate.

ii) **Storage and temperature:** Higher temperature and prolonged storage period favours browning. These changes are favoured in the presence of increased humidity and moisture. Colour intensity increases with storage time and is highest at a storage temperature of 40^0C.

iii) **Total solids concentration:** During concentration of milk total solids concentration increases. As the total solids concentration in milk increases the browning reaction also gains momentum. Lactose plays a major part of total solids concentration along with casein. The interaction results in increased browning.

iv) **Heat treatment:** Heating milk as a pre-heat treatment between 85-100^0C for 30 minutes or more favours browning. It is one of the most important factors of browning. Reducing the heating time such as with HTST process will reduce the browning of milk products.

v) **Oxygen:** Oxygen favours browning as it reacts with –SH groups released during heating. Presence of oxygen destroys these reducing groups. Problem can be reduced by replacing O_2 with N_2 while storing heated and dried milk products.

e) **Prevention of Browning:** Browning can be prevented to a great extent by storing milk and milk products at low temperatures and short period of storage. In dried products moisture should be below 5%. Also N_2 packing helps in reducing browning due to replacement of oxygen. Strong and long duration heating should be avoided.

10.4 FREEZE PROCESSING OF MILK

Freezing has been suggested as a means for tansporting frozen concentrated milk. This is to co-ordinate supply to those areas, which are not adequately covered to supply liquid milk. The objective of freezing is to prepare frozen concentrated milk to replace liquid milk supply to distant areas, which are not well connected.

Freezing of milk and its effect on milk system: To manufacture frozen milk, the milk is first concentrated and then frozen stored. During frozen storage of milk and its subsequent thawing very fine milk particles called flocculates are formed. Initially flocculates are readily dispersible but prolonged storage period makes them difficult to disperse.

Effect of freezing on lactose and caseinate system: Lactose is the first component of milk which is affected during frozen storage. Frozen storage results in crystallization of lactose especially at very low temperatures. Lactose is present in milk in a highly supersaturated state which readily crystallize on storage. Lactose binds calcium from milk but calcium is released on crystallization. In the dissolved state lactose binds calcium but releases calcium upon crystallization. No change in protein denaturation occurs on storage even though flocculation occurs. The reason for destabilization is calcium. It has been seen that frozen stored casein remains unchanged in terms of solubility. Casein isolated from frozen stored milk has the same sensitivity to calcium precipitation as casein isolated from fresh milk. Although casein flocculates on frozen storage but protein seems to be unchanged.

Check Your Progress 1

1. Define denaturation of protein. Name some of the major proteins affected by denaturation.

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2. What is the reason for development of cooked flavour during heating?

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3. Name the agents of browning reaction.

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4. Discuss the role of ions during heating.

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5. How lactose affect frozen storage of milk?

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10.5 ENZYMES IN RELATION TO PROCESSING

Enzymes are organic catalytst, which are found in plant and animal cells. The enzymes bring about metabolic reactions but they don't undergo any chemical change. They are colloidal and proteinous in nature and are classified as per the reaction performed e.g., lipase, the fat splitting enzyme. The activity is affected by pH, heat, light etc. Enzyme in milk gain entry via udder or externally.

Milk enzymes are technologically important. They are related with flavour (e.g., lipase). Study and knowledge of these enzymes is essential to understand their role.

Functions of enzymes

The following functions are related to enzymes.

- Oxidising enzymes (e.g., peroxidase)
- Lipolytic enzyme hydrolyzing fat (e.g., lipase)
- Decomposing H_2O_2 (e.g., catalase)
- Decomposes phosphorous esters.(e.g., phosphatase)
- Lactose hydrolyzing enzyme (e.g., lactase)
- Reductase as reducing enzyme (e.g., MBR test)
- Proteolytic enzymes hydrolyzing protein (e.g., protease)
- Hydrolysing aldehyde (e.g., xanthine oxidase)

Peroxidase, lipase, catalase, reductase, phosphatase, xanthine oxidase, lactase are all present in freshly drawn milk. Other enzymes enter via bacterial contamination.

i) **Peroxidase:** Peroxidase is present in milk as lactoperoxidase enzyme. The enzyme is destroyed between 70-80^{0}C. Lactoperoxidase enzyme act on H_2O_2 in the presence of thiocyanate ions, forming hypothiocyanate ions ($OSCN^-$) are lethal to microbes. This enzyme has been used in milk to improve shelf life during transportation of milk from distant places to milk plant. The enzyme is also used as an index of detecting proper heating of milk as it is destroyed at 70^{0}C, especially for detecting high temperature heat treatment of milk.

ii) **Phosphatase:** Phosphatase catalyse the hydrolysis of phosphate esters. Alkaline phosphatase is the most important milk enzyme. It is destroyed by pasteurization of milk. At the temperature of pasteurization of milk tubercle bacili bacteria present in milk are also destroyed. The inactivation of this enzyme is thus taken as the process of destruction of TB organisms. Under health consideration pasteurization of milk is mandatory in various countries. Phosphatase test has been developed to ascertain if the milk has been properly pasteurized. So as to ensure the destruction of Micobacterium tuberculosis which is destroyed at a temperature wherein alkaline phosphatase is inactivated.

iii) **Lipases:** Lipases hydrolyse milk fat into corresponding fatty acids and glycerol. In milk they are linked with hydrolytic rancidity of milk fat releasing butyric acid. Excessive presence of butyric acid in milk causes rancid flavour defect. This defect may also be present in butter. They are destroyed at 63^{0}C when heated for 20 minutes.

iv) **Proteases:** Proteins are hydrolysed by proteases to simple compounds such as proteose, peptone, amino acid and other compounds. They are inactivated in the presence of salt or preservative. Proteases are destroyed by heating milk between 70-80^{0}C. Proteolytic enzymes have been employed externally for preparing different varieties of cheese. These enzymes primarily hydrolyze casein.

$\xrightarrow{Catalase}$

v) **Reductase:** Reductase are enzymes of bacterial origin. These enzymes are capable of reducing certain dyes to their colourless leuco-compounds. It has been shown that generally speaking the reduction time at 38^0 C is approximately proportional to the number of bacteria.. They are used as measure of microbial population and determine the extent of contamination of milk by bacteria. This is possible through methylene blue reduction test (MBRT). The blue dye is reduced to a colourless compound in the presence of reductase. The earlier the dye lost its blue colour greater is the contamination.

vi) **Catalase:** Catalase catalyses the decomposes hydrogen peroxide as per the following reaction

$$2H_2O_2 \qquad 2H_2O+O_2$$

Catalase content varies in milk from different animals and within the same species. It is also affected by feed given to the animal. Catalase content is high in colostrum, mastitis milk and milk contaminated with mastitis or colostrum milk or bacterial contamination. It tends to parallel leucocyte count. It increases with multiplication of bacteria in milk. It is destroyed when milk is heated to about 65^{0}C or over.

vii) **Xanthine oxidase:** A variety of substances are oxidized by this enzyme including xanthine, hypoxanthine, aldehyde, oxypurines, etc. Thus in the presence of O_2 and an aldehyde following reaction takes place:

$$RCHO + H_2O + O_2 \xrightarrow{Xanthine\ oxidase} RCOOH + H_2O_2$$

Xanthine oxidase is a prominent enzyme of milk and was discovered as early as 1902.

Xanthine oxidase content varies from cow to cow and increases with stage of lactation. It is associated with fat globules. It can be isolated from cream or buttermilk. The following table gives the data for inactivation of the enzymes in milk.

Table 10.1: Inactivation temperature of enzymes

S.No.	Enzymes	Inactivation temperature (^{0}C)
1.	Lipase	80^{0C} (weakend at 60^0C)
2	Peroxidase	72^{0C} (for 30 minutes)
3	Reductase	Above 80^{0C}
4	Catalase	65 to 70^{0C}(for 30 minutes)
5	Phosphatase	62.5^{0C} (for 20 minutes)
6	Lactase	75 to 80^{0C}

Check Your Progress 2

1. What are enzymes?

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2. Name some of the enzymes present in milk.

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3. Name the enzyme responsible for hydrolytic rancidity and cause for rancid flavour.

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10.6 LET US SUM UP

Thermal processing of milk is an important aspect. The milk industry will come to a standstill if heat is not applied. This is because milk is a highly perishable commodity. Also heat is necessary to evaporate water to prepare dried milk and related products. Preservation of milk and milk products is the primary objective of heat.

Heat treatment consists of several processes such as pasteurization, sterilization, forewarming, condensing, drying and UHT processing. Heat treatment causes changes in milk in terms of denaturation of proteins including whey proteins, altering of salt balance, browning reaction, caramelization, development of flavour and compounds formed from lactose. Heating also results in changes in various other properties including development of cooked flavour, anti-oxygenic property, clotting and soft curd characteristics and baking quality of milk.

Freezing of milk results in lactose crystallization, Ca^{++} binding and flocculation of milk particles. Various enzymes are present in milk. They have been involved in processing of milk such as pasteurization e.g., phosphatase and lactopeoxidase, catalase as index of mastitis or leucocytes, lactoperoxide system for milk preservation.

10.7 KEY WORDS

Enzyme : Organic proteinous catalyst involved in metabolic raction

Pasteurization : A process of heating milk to kill pathogenic organisms

Amino group : A group present in amino acid

Denaturation : A process by which structure is changed e.g.,enzyme or protein

Cations : Positively charged ions e.g., Ca^{++}

Anions : Negatively charged ions e.g., Cl^{-}

Melanoidin : A brown coloured pigment

Reducing sugar : Sugar with free aldehyde or ketonic group

10.8 SOME USEFUL BOOKS

Jenness, R and Patton, S. (1959). Principles of Dairy Chemistry, John Wiley and Sons. Inc. New York

Webb, H.H., Johnson, A. and Alford, J.A. (1978). Fundamentals of Dairy Chemistry. The AVI Pub, Co. Inc. West Port, Connecticut.

Ling, E.R. (1956). A Textbook of Dairy Chemistry, Vol. 1& 2, Chapman and Hall, London, UK

10.9 ANSWER TO CHECK YOUR PROGRESS

Your answers should include following points

Check Your Progress 1

1) i. Denaturation may be defined as the change in the original native three-dimensional structure of protein. It consists of non-proteolytic structural changes of protein. The major proteins responsible for denaturation are whey proteins such as immunoglobulin, beta – lactoglobulin, alpha – lactalbumin and serum albumin.

2) i. The reason for cooked flavour development in milk is release of H_2S. It is liberated from sulphur containing amino acid cysteine.

3) i. The two reactants of browning reaction are – CHO or aldehyde group of reducing sugar lactose and $-NH_2$ or amino group of basic amino acids such as lysine.

4) i. Frozen storage results in crystallization of lactose at low temperature. Lactose binds to Ca^{++} and release calcium upon crystallization

Check Your Progress 2

1) i. Enzymes are organic catalysts which are found in plant and animal cells. The enzymes bring about metabolic changes but they do not undergo any chemical change.

2) i. The enzymes present in milk are -

- Peroxidase
- Lipase
- Phosphatase
- Lactase
- Reductase
- Protease
- Xanthine oxidase

3) i. Lipase is responsible for hydrolytic rancidity in milk by releasing butyric acid from milk fat.

UNIT 11 PRESERVATIVES, NEUTRALIZERS AND ADULTERANTS IN MILK AND THEIR DETECTION

Structure

11.0 OBJECTIVES

After studying this unit, we shall be able to:

- enumerate common preservatives used by the unscruplous person in milk;
- detect preservatives used in milk by simple tests;
- test neutralizers added in milk;
- specify adulterants used in milk; and
- check the purity of milk.

11.1 INTRODUCTION

Preservatives, neutralizers and adulterants are often added in milk with several different aims. However, it may be emphasized that addition of these components is strictly prohibited under PFA Act. This act does not allow the addition of any external agent to milk and is punishable under law. Preservatives are also prohibited in milk except during sampling and subsequent analysis.

Preservative may be defined, as a substance which when added to food is capable of inhibiting, retarding or averting the process of fermentation, acidification or spoilage or decomposition of food. The initial quality of milk is poor in India which leads to a high bacterial load. Moreover, it takes a long time with a time gap of several hours before milk reaches the consumers or individuals and dairy plants for processing. Under such circumstances there is a tendency to use preservatives to delay or prevent microbial proliferation and spoilage of milk. Let us know more about preservatives, neutralisess and adulterants.

11.2 PRESERVATIVES

It is a common practice by unscrupulous persons to add preservatives to liquid milk. The addition of preservatives is not permitted under law. Freshly drawn milk get contaminated with microorganisms which proliferate and multiply rapidly in milk. The growth of these microorganisms leads to an increase in acidity and souring of milk, which leads to spoilage. The problem is acute during summer months due to high temperatures. Their use is permissible under law only where sample is stored

for testing. The common preservatives added to milk are:

i) Formalin

ii) Boric acid and borates

iii) Benzoic acid and sodium benzoate

iv) Salicylic acid

v) Mercuric chloride

vi) Potassium chromate

vii) Hydrogen peroxide

i. Formalin

Formalin is a solution of 40% formaldehyde in water. By Hehner test formalin/ formaldehyde can be detected in milk. Formalin is a strong preservative which is very effective even in small dose. Formaldehyde (HCHO) is a gas. Its 40 percent solution in water is known as Formalin. It contains 10% methanol to prevent polymerization. Milk samples for analysis are preserved with 0.1 ml (two drops) of formalin per 25 gm/ml samples. Formalin can be detected by three tests namely, Hehner test, Hehner-Fulton test and Chromotropic test.

i) Hehner Test

Hehner test is a very simple and quick test for detecting formalin. It can be detected with concentrated sulphuric acid in the presence of an oxidizing agent $Fecl_3$. It gives intense violet colouration with this test. The detection is very easy and simple. Even a very small quantity of preservative can be detected by this test.

- Take 5 ml sample of milk in a test tube and gently add 2 ml concentrated sulphuric acid (H_2SO_4) containing a trace of $FeCI_3$. Care should be taken that while adding acid it forms a separate layer at the bottom of the tube. The acid should not mix with milk
- A coloured ring is formed at the junction of the two liquids. Note the colour of the ring formed at the junction of the milk and acid. A voilet to purple coloured ring indicates the presence of formalin/formaldehyde.

ii) Chromotropic Acid Test

Chromotropic acid test is a colour reaction test with formalin. In the presence of formaldehyde chromotropic acid develops a purple colour. The coloured reaction of Chromotropic acid test is due to reaction between chromotropic acid and formalin.

Chromotropic acid solution-is prepared as a saturated solution of chromotropic acid (1,8- dehydroxy napthalene-3, 6-disulphonic acid). The solution is prepared by stirring 0.5 g of chromotropic acid in 100 ml 72% H_2SO_4 (150 ml concentrated H_2SO_4 in 100 ml water-mixed in cold). The solution is straw yellow in colour.

- 5 ml reagent and 1 ml milk distillate is taken in test tube. Distillate is prepared from H_3PO_4 acidifred milk.
- The test tube is placed in a boiling water and the developed colour is noted.
- Development of light to deep purple colour indicates the presence of formalin. The colour intensity depends upon the amount of formalin present in sample.

ii. Boric Acid and Borates

Like formalin, boric acid and sodium borates are also common preservatives. They are available in the form of either boric acid (H_3BO_3) or its salt as sodium borate (Na_3 BO_3) as commercial chemicals. In acidic medium they can be conveniently detected with the help of turmeric paper. In the presence of boric acid and borates the paper turns red in acidified medium. This is due to the formation of ferric benzoate.

- Take 20-25 ml milk in a porcelain basin. Acidify milk by adding 1.5 ml concentrated hydrochloric acid.
- Take a strip of turmeric paper and carefully dip in the milk. Remove the strip from acidified milk and dry it in the air.
- Presence of boric acid or borates is confirmed by noticing the change in colour of the strip. The strip changes its colour from yellow to a red colour which is characteristic for the presence of boric acid or borate.
- On exposure of the paper strip to ammonia vapours or ammonia solution the colour changes to bluish green but reappears on re-acidification with HCl.

iii. Benzoic Acid and Sodium Benzoate (E)

These are food grade preservatives. Benzoic acid and its salt sodium benzoate are stable preservative. Benzoic acid is commonly used in the form of its sodium salt because it is more soluble than the acid but later is the active form. Sodium Salt is converted to the free acid when used as preservative. The optimum PH range for anti microbial activity of benzoic acid is 2.5 to 4.0. Benzoic acid is detected by extracting with ether from milk serum, as benzoic acid is soluble in ether. In alkaline medium with $FeCI_3$ it gives salmon red precipitate. In modified Mohler test a red brown ring is formed.

- Benzoic acid is extracted from serum of milk by removing casein. Collect the clear filtrate or serum.
- As benzoic acid is soluble in ether it is extracted by adding 50 ml diethyl ether and shaking it. The water and ether layer is allowed to separate in a separating funnel. If emulsion is formed and layers do not separate 10-15 ml petroleum ether (b.p. 60^0C) is added. Alternatively, separate the layers by a centrifuging at 1200 r.p.m.
- The etheral layer is carefully removed in a porcelain dish.
- The etheral layer is carefully evaporated on a boiling electric water bath.
- The residue so obtained is dissolved in 5 ml portion of water and divided it into two parts equally. There are two tests for detection, namely, FeCI3 test and modified Mohler test.

i) **$FeCI_3$ Test:** Make one portion of the above extract alkaline by adding a few drops of NH_4OH solution, expel the NH_3 by evaporation and dissolve the residue in a few ml hot water. Filter if necessary and add a few drops of 0.5% neutral $FeCI_3$ solution. Note the change in colour. A salmon red precipitate indicates the presence of benzoic acid.

ii) **Modified Mohler Test:**
   - In another portion of the extract add 1-2 drops of 10% NaOH solution and evaporate to dryness.
   - To the residue add 1 ml conc. H_2SO_4 and a crystal of KNO_3. Heat for 20 minutes on a boiling water bath.
   - Cool and add 1 ml water and mix. Make ammonical by adding NH_4OH. Boil to break any ammonium nitrate that may have formed.
   - Transfer the solution to a test tube; add a drop of freshly prepared ammonium sulphide solution without mixing.
   - Formation of a red brown ring indicates the presence of benzoic acid. The colour diffuses on mixing and give greenish yellow colour on heating.

Note: Salicylic acid also gives a reddish brown colour. However, this colour remains unchanged after heating.

iv. Salicylic Acid

Salicylic acid is an organic preservative. Like benzoic acid it is extracted from milk serum with the help of ether in which salicylic acid is soluble. To the residue in the presence of salicylic acid ferric chloride gives a voilet colour.

- To the residue obtained after extraction add 1 drop of 0.5% neutral $FeCI_3$ solution and observe the colour produced.
- A voilet colour indicates the presence of salicylic acid.

v. Mercuric Chloride

Mercuric chloride is a heavy metal salt and is highly toxic. It is also used as a preservative. Mercuric chloride is detected from milk serum by adding stannous chloride solution. A white precipitate is formed in the presence of mercuric chloride.

Prepare the extract of milk as is followed for benzoic acid.

- Dissolve the residue in 1-2 ml water. Filter if necessary.
- Transfer the solution to a test tube and add to it 15% stannous chloride in 1:1 HC1 solution and mix it simultaneously.
- A silky white precipitate appears which turns grey on further addition of $SnCI_2$ solution if mercuric chloride is present confirms its presence in milk.

vi. Potassium Chromate

Potassium chromate is used as a preservative only for storage of milk for analysis. Its solution is yellow in colour due to chromate ions. Potassium chromate is detected by a simple test using barium chloride. Yellow precipitates are formed due to barium chromate in the presence of potassium chromate.

- Prepare ash from 50 ml of milk by first drying on boiling water bath and then heating it in a muffle furnace at 550^0C for two hours.
- Add to ash 3-4 ml dil HCl and dissolve by warming.
- To 1 ml ash solution add 2 N NaOH solutions dropwise till the solution is alkaline (test with pH paper).
- Add 1 ml acetic acid and then 0.5 ml $BaCI_2$ solution and mix.
- Formation of a yellow precipitate indicates the presence of dichromate in milk.

vii. Hydrogen Peroxide

Hydrogen peroxide is a very strong oxidizing agent, and is an efficient preservative in small quantities. It breaks into water and oxygen in the presence of natural catalase present in milk. Hydrogen peroxide plus thiocyanate also activates the native lacto- peroxidase system which can be used for prolonging shelf life of milk. The use of hydrogen peroxide is prohibited. With paraphenylene diamine test hydrogen peroxide present to the level of 1:40,000 can be easily detected. It gives dark blue colour with paraphenylene diamine. Hydrogen peroxide can also be detected by vanadium pentoxide test which forms pink to red colour with this reagent.

i) Paraphenylene diamine test

- 5 ml milk is taken in a test tube.
- 5 drop of 2% aqueous solution of paraphenylene diamine is added and mixed in milk.
- Formation of deep blue colour indicates the presence of H_2O_2

ii) Vanadium Pentoxide (V_2O_5) Test

Vanadium pentoxide test gives pink to red colour in the presence of H_2O_2. It is a simple test and test is carried out in acidic medium first.

Vanadium pentoxide reagent is prepared by mixing 1 g vanadium pentoxideV_2O_5 in 100 ml H_2SO_4 (6 vol conc H_2SO_4 + 94 vol H_2O)

- To 10 ml milk in a porcelain dish add 10-20 drops of V_2O_5 reagent and mix carefully with a glass rod.
- Formation of pink to red colour indicates the presence of H_2O_2.

Check Your Progress 1

1. Name the preservatives which are commonly added to milk.

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2. Name the test by which boric acid is detected.

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3. Hehner test is used for the detection of which preservative?

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11.3 NEUTRALIZERS IN MILK

Neutralizers are added to neutrilize the acidic sour milk. The addition of alkalis is not permissible under law. Some of these alkalis are highly injurious to health. To overcome this problem by means of a few simple test they can be detected in milk added as neutralizer. Freshly drawn milk has an acidity of 0.12-0.16 per cent expressed as lactic acid. With the passage of time the acidity increases during souring of milk. Any acidity above 0.18 per cent lactic acid coagulate milk. This is due to the formation of lactic acid from lactose. Neutralization of milk is illegal under the P.F.A act. Unscrupulous milk producers and farmers tend to neutralize the milk to avoid rejection of milk with increased shelf-life at the milk collection centers and at the dairy plants. The common neutralizers which are added to milk are caustic or sodium hydroxide, baking soda or sodium bicarbonate and washing soda or sodium carbonate. They are detected by determining the alkalinity of ash and carbonate or bicarbonate by rosalic acid test.

i. Rosalic acid test for the detection of carbonate and bicarbonate in milk

Rosalic acid test is used for the detection of carbonate and bicarbonate in milk. This is a very simple, reliable and quick test for their detection. Rosalic acid reacts with carbonate and bicarbonate and give rose red colour in their presence. The intensity of colour depends upon the amount of these chemicals present.

- Take 5 ml sample of milk in a clean and dry test tube.
- Add 5 ml ethanol 95% and mix
- Now add 2-3 drops of rosalic acid solution prepared in 1% ethanol to the mixture and mix well. Note the colour change.
- A rose red colour develops.

- Formation of rose red colour in milk indicates the presence of carbonate or bicarbonate added as neutralizer.

  Note: Pure milk gives only a brownish red colour.

ii. Alkalinity Test

The presence of neutralizers can generally be detected by determining the alkalinity of ash. A known quality of milk is heated and converted into ash. The alkalinity of ash is estimated by titration against a decinormal standard hydrochloric acid in the presence of Phenolphthalein indicator. Values abnormally high would indicate neutralization of milk. To carryout this test first ash is prepared from milk so as to obtain added alkali in a concentrated form.

- Pipette 20 ml milk in a porcelain dish and evaporate to dryness on a boiling water bath.
- Prepare ash by keeping it over a burner or muffle furnace at 550^0C for 1 hour. When using burner heat till ash becomes grey white in colour.
- Cool the basin. Add water and mix the contents with a glass rod.
- Titrate the ash solution using standard O.1N HCl in the presence of 4-5 drops of phenolphthalein indicator solution. Note the volume of HCl solution used till a pink colour is obtained.
- If the volume of O.1N HCl exceeds 1.20 ml the milk is suspected to contain neutralizers.

Check Your Progress 2

1. Which test is used for the detection of carbonates and bicarbonates?

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2. Which substances are added as neutralizers?

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11.4 ADULTERANTS IN MILK

The ease with which milk can be adulterated has always attracted unscrupulous persons to adulterate the same with numerous compounds. The most common of them include starch or cereal products, cane sugar, glucose, urea and ammonium sulphate. Tests for their detection are now available which can easily detect these compounds. Some of these compounds are highly injurious to the health of individuals. Laws are now available which can lead to the punishment for adding these prohibited substances. These compounds are primarily added to raise the density of milk.

i. Starch or cereal flour (*atta*)

Starch is a tasteless, odourless and cheap adulterant which is readily available. It is often added as an adulterant because it is not sweet like sugar. It is difficult to be detected organoleptically in small quantities. Starch can be easily detected as blue coloured starch iodide complex on heating and cooling with 1% iodine solution. The demand for liquid milk is far greater than the availability of milk. This forces the adulteration with a view to make quick profits. A large volume of milk is

supplied to the consumer directly by the producers through vendors at the door step without any sort of processing, packaging or quality control. The milk supplied to the consumers is most prone to adulteration, as they do not bother about such adulteration and are under the impression that they are getting pure milk. However, such milks are often maximum adulterated. Compared to vendors the milk supplied in the organized sector is tested for the adulterants by random analysis of procured samples. The easiest way is to adulterate the milk with water and keep the fat within the PFA limit. The addition of water, however, decreases the SNF content and is compensated by adulterating milk with cheaper solid ingredients like sugar, starch, urea etc.

Starch is detected by a very simple and quick test using 10% iodine solution. In the presence of starch a voilet blue colour of starch iodine complex is obtained on boiling.

- Take 5 ml milk in a test tube. Boil the milk over a flame. Cool the milk.
- Add 1 to 2 drops of iodine solution.
- Formation of voilet blue colour indicates the presence of starch or cereal flour.

ii. Cane Sugar

Cane sugar is added to raise the total solids content in milk. This adulterant is readily available and is cheaper than milk solids. When added in large quantity it is detected by sweet taste imparted to milk. It can also be detected by resorcinol reagent, which gives redish brown colour in the presence of sucrose.

- Take 5 ml sample in a clean test tube
- Add 5 ml resorcinol reagent and mix well
- Place the tube in a boiling water bath for five minutes or heat directly on the flame to boiling
- Development of red colour with or without the separation of brown red precipitate indicates the presence of cane sugar in milk.

iii. Glucose

Glucose is added to milk to increase its density. It is odorless, colourless and is not as sweet as cane sugar. It is detected by modified Barfoed's reagent either directly from milk or clean filtrate of milk. In the presence of glucose Barfoed's reagent gives a deep blue colour. To detect glucose in milk.

- Take 1 ml milk sample in a test tube.
- Add 1 ml Barfoed's reagent. Heat for 3 minutes in a boiling water and then cool.
- Now add 1 ml phosphomolybdic acid reagent and mix.
- A deep blue colour shows the presence of glucose. Pure milk only gives a faint blue colour.

iv. Urea

Urea is available readily as chemical fertilizer with farmers. It is often used as an adulterant to boost total solids after dilution with water or skim milk. Urea is detected in serum part of milk after removing casein from the filtrate in alkaline medium. In alkaline medium in the presence of phenol a bluish green colour indicates the presence of urea.

- Take 5 ml milk in a 50 ml conical flask and add 1 ml acetic acid or TCA 24% solution and heat for 3 minutes in boiling water both. Filter the precipitate. Collect the filtrate
- Take 1 ml filtrate, add 1 ml NaOH solution, followed by 0.5 ml sodium hypochlorite

solution mix and finally add 0.5 ml phenol solution.

- A bluish green colour is formed with phenol in the presence of urea.

v. Ammonium Sulphate

Ammonium sulphate is also a fertilizer, it addition boosts the solids content of milk. Detection of ammonium sulphate is carried out on casein free filtrate prepared as per urea detection.

- Take 1 ml filtrate, add 0.5 ml NaOH, 0.5 ml sodium hypochlorite solution and mix. Now add 0.5 ml phenol and heat for 20 seconds in boiling water bath.
- Formation of a bluish colour which changes to dark blue shows the presence of ammonium sulphate. The colour is stable for over 12 hours.

  Note: In pure milk only salmon pink colour is formed, which gradually changes to bluish in course of about 2 hours.

vi. Partial Removal of Fat by Skimming

An indication of the removal of excess fat from milk give the following changes to milk:

- Lowering of fat percentage in milk
- Higher density of milk sample at 27^0C
- Higher ratio of solids-not-fat to fat in milk

vii. Addition of Skim Milk

Addition of separated milk or skimmed milk results in following changes in the milk:

- Addition of skim milk results in lowering of fat in milk
- Higher density of toned milk sample at 27^OC
- Higher percentage of solids-not-fat
- Higher ratio of solids-not-fat to fat.

viii. Dilution of milk by addition of water

Milk is commonly adulterated by adding water as it is highly profitable. It causes following effects:

- Fat percentage is lowered
- Density of milk is lowered at 27^OC
- Lowering of solids-not-fat content of milk
- Lowering of freezing point depression of milk

i) Determination of Specific Gravity of Milk by Lactometer

In routine analysis of milk the density in determined with the help of a lactometer. The lactometer is graduated at a temperature of either 15.5^0C or 27^0C. Lactometer consists of a long, slender glass stem of uniform diameter connected to a larger glass chamber that facilitate lactometer to float. Lower end of the lactometer is filled with synthetic material which makes the lactometer to float and also keeps it in upright position.

- Warm the milk to 40^0C for 5 minutes
- Cool the milk near the temperature of 27^0C, the temperature of lactometer graduation.
- Pour gently the milk in a 250 ml cylinder avoiding air bubbles and place the lactometer so that it floats freely.
- Take the lactometer reading and note the temperature

- Take the average of two readings
- Correct the lactometer reading from the table.

Lactometer reading for genuine cow milk is between 26-30 and 28-32 for buffalo milk. These readings are converted to specific gravity by prefixing 1.0 for lactometer readings e.g. a reading of 28 will give a specific gravity of 1.028.

Calculation

$$\% \text{ TS} = \frac{C.L.R.}{4} + 1.2 \text{ F} + 0.14$$

$$\% \text{ S.N.F.} = + 0.2 \text{ F} + 0.14$$

Where TS = Total solids in milk sample

S.N.F. = solids-not-fat in milk sample

F = Fat Percentage in sample

C.L.R.= corrected lactometer reading at 15.5^0C

Note: If the temperature is above 15.5^0C then to each 1^0C rise in temperature add 0.2 to each lactometer reading. On the other hand if the temperature in below 15.5^0C then to each 1^0C lowering of temperature subtract 0.2 from the lactometer reading. For example, if the temperature is 16.5 and reading is 30 then the C.L.R reading will be 30.2 (30+0.0.2). On the other hand if the temperature is 14.5^0C and the lactometer reading in 29 then the C.L.R. will be 28.8 (29.0-0.2).

ii) **Fat Determination**

a) **Gerber Method:** For routine fat analysis of milk Gerber method is commonly followed for fat estimation. It is a rapid method and results are available in short time. Gerber method is volumetric method for fat analysis.

b) **Roese-Gottlieb method:** In this method fat is extracted from milk with the help of fat extraction reagent i.e. solvent ether. Ammonia and alcohol are added to facilitate fat extraction. Ammonia dissolves the fat globule membrane and alcohol helps in the passage of the fat globules in the aqueous phase. This is a gravimetric method of fat estimation.

iii) **Freezing Point (FP)**

Milk contains upto 85 percent water and varies widely in composition. Thus a constant parameter of milk is difficult to assign for milk. As such freezing point is a fairly constant property with a freezing point value between 0.530 to 0.555^0C. Freezing point is a colligative property which depends upon the number of solute particles present in the system or solution. The solvent is water and its freezing point is always constant. On addition of water in milk the solute particles in the solvent are diluted which affect the freezing point of milk. This results in an increase in freezing point depression of milk. With cryoscopy the percent water added is calculated as percent-added water

Check Your Progress 3

1. Name the methods used for detection of water in milk.

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2. Why starch or cered flour (*atta*) is added to milk?

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3. Which constituent of milk is analysed by Gerber test?

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4. Cane sugar is detected by which reagent?

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11.5 LET US SUM UP

External agents in the form of adulterants, neutralizers and preservatives are added for many purposes. Each has its own role. The adulterants in the form of water, starch or flour (*atta*), sucrose, glucose, ammonium sulphate, urea etc., are primarily added to adulterate milk. While water addition give a larger volume of milk, role of other compounds is to raise the density of milk. Some of these components are hazardous and injurious to health. Neutralizers are primarily added to neutralize or decrease the acidity of milk. Some preservatives are added to preserve milk samples for analysis. However, they are added to slow down microbial growth so as to avoid spoilage of milk which is not permissible under PFA. Different tests are now available to detect them in milk.

11.6 KEY WORDS

Adulterant	:	An external substance added to milk for raising density or to increase volume with water
Freezing point	:	A characteristic ice forming property of milk
Rosalic acid	:	A dye used for the detection of neutralizer
Neutralizer	:	A substance which neutralizes the acidity
Hazardous	:	Poisonous
Injurious	:	Harmful

11.7 SOME USEFUL BOOKS

Mathur, M.P., Dutta Roy, D and Dinakar P.(1999), Text book of Dairy Chemistry, Indian council of Agricultural Research, New Delhi.

Roy, N.K. and Sen, D.C (1991) Text book of Practical Dairy Chemistry, Kalyani Publisher, Ludhiana.

11.8 ANSWERS TO CHECK YOUR PROGRESS

Your answers should include following points:

Check Your Progress 1

1) i. The preservatives commonly added to milk are- formalin, hydrogen peroxide,

boric acid/borates and potassium dichromate.

2) i. Boric acid in milk is detected by Turmeric acid paper test

3) i. Hehner test is used for the detection of formalin in milk.

Check Your Progress 2

1) i. Rosolic acid is a test, which is used for the detection of neutralizers containing carbonate and bicarbonate.

2) i. Substances which are added as neutralizers are caustic and caustic soda.

Check Your Progress 3

1) i. Water adulteration is detected by estimating the fat, density of milk and the freezing point of milk.

2) i. Starch or atta is added to raise the density of milk.

3) i. By Gerber test fat is estimated.

4) i. Cane sugar is detected by resorcinol reagent.