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① Kharde-D.N. (mother of Dairy)

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Portion of milk which reaches to consumer is called cream

Theory Notes on

Course Title : Technology of Milk and Milk Products

**Course No. : ASDS – 353
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INDEX

Lecture No.	Topic to be covered	Page No.
1	Present status of dairy industry in Maharashtra and India	02
2.	Definition and composition of milk	06
3	Physico chemical properties of milk	08
4	Microbial quality of raw milk. Factors affecting composition of milk	11
5	Physico chemical and microbial standards for different types of milk	16
6	Nutritional importance of milk and its constituents	20
7,8 and 9	Reception and processing (platform test, chilling, standardization, homogenization, pasteurization, storage and marketing) of milk	24
10,11 and 12	Classification and composition of milk products (heat coagulated, heat and acid coagulated, evaporated, fermented frozen and fat riched products)	37
13	ISI, PFA and AGMARK standards for milk products	53
14	International requirement for export of dairy products	58
15	Preservation of milk and milk products by bio, herbal, chemical and physical preservatives in use	64
16	Utilization of dairy by products whey and high acid milk	67
17	Packaging of milk and milk products with modern techniques.	71
	Syllabus	76
	Question Papers	78

Lecture No. 1

Present status of Dairy Industry in Maharashtra and India

DAIRY INDUSTRY IN INDIA

Market Milk :

Market Milk refers to fluid whole milk that is sold to individuals usually for direct consumption. It excludes milk consumed on farm and that used for Dairy products.

Dairying – A Major Enterprise :

Milk forms an important food since ancient times. Processing and distribution of milk can be treated as a separate enterprise. Indian Dairy Industry (Market Milk) may be regarded as of recent origin as compared to that of USA. Indian cities reached high population levels in the middle of 19th century.

Family Cow :

'Family cow' concept was prevalent earlier upto late 19th century. However, space and sanitation problems enhanced due to that the cows / milch animals were sent back to rural areas. Milk from rural areas was needed to be transported by well connected routes – from fluid milk sheds i.e. villages and adjoining producing zones. There was a lack of transportation facilities and also refrigeration earlier.

Indian Milk Industry :

Indian Milk Industry got a boost due to the development of factory system wherein the rural population started gradually migrating to major cities including Bombay (Mumbai), Calcutta (Kolkata), Madras (Chennai) and Delhi.

In 1900 Refrigeration was developed in U.S.A.

In 1951, Central Dairy Plant was started at 'Aarey'

(1889 – Oldest Military Dairy Farm was developed at Allahabad)

Bombay Milk Scheme was initiated in 1950. Next to that Kurla Dairy was established, Worli Dairy in 1961, Calcutta (Haringatta) in 1959, Delhi Dairy in 1959, Madras Dairy in 1963 were developed.

Five Year Plan periods which contributed to Indian Dairy Industry were

Five Year Plan	Year	Expenditure in Rs. crores
I	1951-56	Rs. 7.8 crores
II	1956-61	Rs. 12.0 crores
III	1961-66	Rs. 36.6 crores

The average contribution to milk marketing forms Cow milk 33.6 %, Buffalo 63.6 %, Goat 2.8 %. Fluid milk was registered at 44.5 % and Manufactured milk @ 55.5 %.

Major products included Ghee 32.7, Dahi 7.8, Butter 6.3, Khoa 4.9, per cent respectively.

Operation Flood :

It was a planned strategy for Dairy Development in India. The central idea was to flood the milk supply of the country.

During the year 1970 WFP (World Food Programme) supplied free of cost to India 1.26 lakh tonnes of skim milk powder and 0.42 lakh tonnes of Butter oil. This was to be reconstituted to milk in 4 metropolitans of Bombay, Calcutta, Madras and Delhi. Programme was planned to increase milk processing facilities. Procurement of milk was strengthened from 'milk sheds' in 10 states. Facilities were created to 'salvage' one lakh high yielding milch animals from the metropolises. The funds generated by the sale of milk out of this were to the tune of Rs. 95 crores. This was given in the form of loan assistance as 30 % of state share and 70 % central aid for the expansion and milk processing facilities.

~~Father~~ **Dr. Werghese Kurien** pioneered the, Anand Milk Cooperative of Anand. 'Amul' was the Promoter of Operation Flood.

The important mile stones of Indian Dairy Industry Development may be outlined as :

- I. Bombay Milk Supply Scheme - establishment of milk colony at 'Aarey', Government Dairies were developed during First Five Year Plan at Pune, Hubli and Dharwad and Milk Schemes started functioning.
2. Cooperative Dairy Processing Plant for processing of milk and milk products was set up at 'Anand' in Gujarat.
3. Second Five Year Plan witnessed the development of Delhi Mil Scheme, Ahmedabad Milk Scheme, and Milk processing facilities were developed at Amritsar and Rajkot.
Rural creameries were set up at Bavauni, Aligarh and Junagarh. Around 1959 - 2257 Cooperatives (Dairy) and 77 Milk Supply Schemes came in to existence.
4. Third Five Year Plan stimulated the enhancement of Rural Milk Production. Dairy plants were developed at Kaira, Mehsane and Delhi. Cattle Feed Plant was set up at Anand.

Salient Features were to set up cooperative dairies for :

- i) Organising Dairy Extension Service to set up Rural Milk Production.
- ii) To organise cooperative milk unions for collection and distribution.
- iii) Arrange loans to farmers to purchase good animals.



- iv) Establishment of Rural creameries for inducting untapped surplus area of milk production.
- v) Development of Cooperative 'Salvage farms' up to 1968-69 there were 91 dairy plants in the country.

5. **Fourth Five Plan** – Government of India launched 'Operation Flood' during 1970 up to 1984-85 238 Dairy plants with an average capacity of 86.5 lakh litres/day did exist milk powder infant milk food malted milk and condensed milk plants is set up. During 1986 – liquid milk plants numbered were 137 whereas, product factories were at 39, pilot dairy projects as 74 with an overall capacity of 16282 (000) litres/day.

National Dairy Development Board (NDDB) :

National Dairy Development Board (NDDB) was instituted with the Head quarters at Anand. It encouraged integrated activity with milk plant, cattle feed plant and setting up of farmers organisations. It contributed to provide technical inputs for rural milk production, procurement and marketing. Package of practices were developed by NDDB. Dairy Cooperatives were encouraged to carry procurement processing and marketing of milk and milk products.

Indian Dairy Corporation (IDC) :

Indian Dairy Corporation (IDC) – A Government Body was formulated during February 1970. It negotiated the Terms of India with WFP (World Food Programme) and during 1970 India – WFP Project 618 came in to existence as 'Operation Flood'.

Main objectives were :

- i) To promote Dairy Industry in India.
- ii) To assist State Government and Cooperative organizations to meet requirements of milk and milk products to vulnerable groups.
- iii) To promote cattle husbandry for increasing milk production.
- iv) To prevent pre-mature destruction of high yielding milch cattle and calves due to urban areas there was a shifting of cattle to rural areas.
- v) Develop expand Delhi, Bombay, Calcutta, Madras dairies.
- vi) To establish liquid milk plants chilling centres, feeder dairies balancing dairies (Additional milk processing and handling capacity).
- vii) To assist manufacture of SMP, Butter oil, milk products and by products.
- viii) Creating storage and transport facilities for milk and milk products.
- ix) To work as an agent of Central Government for negotiating World Food Programme and International Agencies.

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DAIRY INDUSTRY IN MAHARASHTRA

In Maharashtra for increasing the productivity of local cows, cross breeding programme is in operation from last 25 years. Today the production of milk is 160 LLPD. Of the 60 LLPD milk procured, about 14 to 15 lakh litres comes from Government sector, and 25 to 26 lakh litres comes from cooperative sector. The remaining about 15 to 20 lakh litres of procured milk is utilized for milk products by the projects / organizations registered under MMPO, 1992.

For increasing the milk production the focus is on the following points :

1. Bulls of high foreign breeds were utilized for cross breeding.
2. Calves of high class breeds (of one year) were distributed in rural areas to the milk producers.
3. The scheme of cross breed pregnant cows / buffaloes distribution was operated.
4. Rates of milk purchased to be fixed keeping in view the production cost of milk producer.
5. Guarantee given by Government for purchase of all milk produced by the milk producer.

In Maharashtra State cow milk accounts for 53 % of total milk production and buffalo milk 43 %. As compared to other states, cow milk production in Maharashtra State is quite high (53 %). There is difference between fat and SNF (Solid Not Fat) of cow milk and buffalo milk. For cow milk the fat and SNF should be not less than 3.5/8.5 and for buffalo milk it should be 6.0/9.0. The figures of milch cattle and production of milk in Maharashtra is as follows :

No. of Milch animals and production of Milk in Maharashtra

Sr. No.	Year	Cross breeds cows			Indigenous cows			Buffalo			Goat			Total production
		Total in lakhs	Production In kg		Total In lakhs	Production In kg		Total In lakhs	Production In kg		Total In lakhs	Production In kg		
1	2	3	4	5	6	7	8	9	10	11				
1	1995-96	5.770	14272.210	18.610	9965.800	18.740	23447.220	33.400	2226.030	49911.250				
2	1996-97	5.820	14422.590	18.550	10126.170	18.800	24407.850	33.190	2309.480	51266.190				
3	1997-98	5.900	14670.900	18.530	10161.690	18.870	24716.550	34.720	2379.120	51928.260				
4	1998-99	5.250	16143.270	18.790	10569.110	19.620	26485.370	36.400	2587.490	55085.240				
5	1999-00	6.440	16693.960	18.800	10841.270	19.690	26813.910	38.760	2712.280	57061.420				
6	2000-01	6.580	17052.660	18.940	11126.580	20.120	27551.760	37.080	2768.270	58491.270				
7	2001-02	7.430	16680.330	22.060	11551.690	21.640	27918.890	38.450	2880.150	60931.060				
8	2002-03	7.700	19146.090	22.260	11826.410	21.980	28592.890	39.120	2848.230	62513.620				
9	2003-04	7.910	19549.130	22.580	12065.260	22.370	29148.610	39.580	3008.480	63771.480				
10	2004-05	9.480	23118.500	19.130	10144.600	22.670	29618.300	36.580	2788.500	65689.900				

Lecture No. 2 :

Definition and Composition of Milk

Definition of milk :

Milk may be defined as the whole, fresh, clean, lacteal secretion obtained by complete milking of one or more healthy milch animals, excluding that obtained within 15 days before or 5 days after calving or such periods as may be necessary to render the milk practically colostrums-free, and containing the minimum prescribed percentage of milk fat and milk-solids-not-fat.

COMPOSITION OF MILK

Chemical composition of milk :

Milk freshly drawn from udder of cow has a amphoteric reaction i.e. it turns red, litmus paper to blue and blue to red. This reaction is principally caused due to protein, which can function either as acids or base.

Milk composition :

Major constituents of milk are water, fat, proteins lactose and ash (Mineral matters).

Minor constituents are phospholipids, vitamins, enzymes, pigments etc.

True constituents are milk fat, casein and lactose.

Colostrum :

It is the first secretion obtained after parturition, for the nourishment of calf concentrated food first given to calf. It is thick, yellowish in the colour, viscous and sticky. Contains same ingredients that of milk but in differential proportion. It contains more fat, protein, vitamin D, and copper. **It has got 12 times more lactoglobulin than the normal milk.** It has got disease resistant power - Immunity in calves.

Composition of colostrums

Sr. No.	Components	Per cent
1	Water	73.01
2	Fat	5.10
3	Casein	5.08
4	Albumin and Globulin	11.34
5	Ash	1.54
	Total	95.54
	Specific gravity	1.067
	Lactose	4.5 or less to 21.48

Characteristics of Colostrum:

- i) Highly coagulated by heat due to high Albumin and Globulin.
- ii) It contains more iron i.e. 17 times more than normal Milk.
- iii) Albumin / Globulin content steadily decrease and Lactose content increases.
- iv) The fat of colostrum contains eight times more vitamin 'A' and twice the Vitamin 'D' of the normal butterfat.
- v) It contains antibodies, which protect the calf from pathogenic organisms.
- vi) It is laxative in nature and so removes accumulated excreta.

constituents present in milk

(A) major constituents:

- ① water.
- ② fat.
- ③ proteins.
- ④ lactose.
- ⑤ ash (mineral matters).

WFPMA

(B) minor constituents:

- ① phospholipids.
- ② vitamins.
- ③ enzymes.
- ④ pigments.
- ⑤ casein.
- ⑥ lactase.

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Lecture No. 3

Physico chemical properties of Milk

A) Physical state of milk:

Water is the continuous phase in which other constituents are either dissolved or suspended. Lactose and a portion of the mineral salts are found in solution. Proteins and the remainder of the minerals in colloidal suspension and fat as an emulsion.

B) Acidity and pH of milk:

i) Acidity:

Fresh milk is amphoteric to litmus (red-blue, blue-red). However, it has some acidity i.e. Natural due to presence of casein, acid phosphates and citrates. The natural acidity is much more uniform. Higher the SNF content higher the Natural acidity (N.A.) and vice-versa.

Developed or real acidity (D.A.) is due to lactic acid formed as a result of bacterial action on lactose in milk. Hence Titratable acidity is the sub total of N.A. + D.A. and expressed as per cent lactic acid.

T.A. }	Cow milk ranges	0.13 to 0.14 %
}	Buffalo milk	0.14 to 0.15 %

ii) pH:

The pH normal fresh milk varies from 6.4 to 6.6 for cow milk and 6.7 to 6.8 for the buffalo milk. Higher pH values for fresh milk indicates udder infection (Mastitis) and lower values due to bacterial action (More T.A.) This is called Hydrogenion concentration in milk.

iii) Density and Specific gravity:

Density = Mass (weight) per unit volume.

Specific Gravity = is the ratio of density compared with water

As density varies according to temperature. It is necessary to specify temperature (e.g. water at 4 °C milk sp. gr. is determined at 60 °F / 15.6 °C). It is determined by Lactometers (Zeal, Quevenne and ISI lactometers).

Milk is heavier than water.

S.N.	Particulars	Specific gravity
1.	Cow milk	1.028-1.030
2.	Buffalo milk	1.030-1.032
3.	Skim milk	1.035-1.037

The specific gravity of milk is influenced by the proportion of its constituents (i.e. composition).

S.N.	Particulars	Composition
1.	Water	1.000 sp.gr.
2.	Fat	0.93
3.	Protein	1.346
4.	Lactose	1.666
5.	Salts	4.120
6.	SNF	1.616

Though buffalo milk has got higher fat but its sp. gravity is more than cow milk because it contains more SNF.

1. Addition of water or cream -- Lower the Specific Gravity.
2. Addition of skim milk or removal of fats -- Increase the Specific Gravity.

The percentage of total solids (T.S.) and solids not fat (SNF) in milk is calculated by using following formula. IS 1183 (1965).

$$\text{T.S. \%} = 0.25 D + 1.22 F + 0.72$$

$$\text{SNF \%} = 0.25 D + 0.22 F + 0.72$$

Where,

$$D = 1000 (D-1)$$

$$D = \text{Density of sample of milk at } 20^{\circ}\text{C}(68^{\circ}\text{F})$$

$$F = \text{Fat \%}$$

iv) Freezing point of milk :

Milk freezes at temperature slightly lower than water due to the presence of soluble constituents such as lactose soluble salts etc. which lowers the freezing point.

$$\text{Freezing point of cow milk} = -0.547^{\circ}\text{C} (31.02^{\circ}\text{F})$$

$$\text{Buffalo milk} = -0.549^{\circ}\text{C} (31.01^{\circ}\text{F})$$

A freezing point depression lower than this indicates added water. Water freezes at $32^{\circ}\text{F} (0^{\circ}\text{C})$.

By addition of salt to water, its freezing point can be reduced to exceedingly low temperatures. The fat and protein have little or no effect on the freezing point of milk. Since the soluble constituents, lactose and ash vary in milk so slightly. The freezing point remains almost constant. This fact makes it possible to determine whether or not milk has been watered.

It has been shown that the addition of one per cent water to the milk, the freezing point rises approximately $0.0099^{\circ}\text{F} (0.0055^{\circ}\text{C})$. The fresh milk should

be used for this test as increased acidity results in lowers freezing point due to increase in the amount of soluble molecules.

Mastitis milk shows a normal freezing point. The Freeing point (F.P.) test is highly sensitive and even up to 3% of watering can be detected.

Boiling and sterilization increases F.P. but pasteurization has no effect.

Draw backs of this test:

1. It does not detect the addition of skim milk or removal of fat.
2. Watered milk which is subsequently soured may pass the test.

v) Boiling point of milk :

Milk boils at a temperature slightly above the water (As it is dependable on soluble constituents as that of sp.gr.).

Water boils at 212 °F (100 °C) at sea level.

Water boils at 212.3 °F (100.17 °C) at normal place.

vi) Viscosity :

Viscosity of any liquid is the resistance to flow.

Milk is slightly more viscous than water. It is 1.5 to 1.7 times more viscous. The viscosity of fluid is its resistance to flow, it is measured in centipoises by viscometer.

Viscosity of water is 1.005 cp.

Viscosity of milk is 1.5 to 1.7 cp

vii) Colour of milk : The colour is a blend of the individual effects produced by

- A) 1. Colloidal casein particles.
2. Dispersed fat globules. both of which scatter light
- B) Carotene and to some extent the Xanthophyll which imparts yellowish tint.

Cow milk	=	<u>Yellowish creamy</u>
Buffalo milk	=	<u>Creamy white</u>
*Skim milk	=	<u>Bluish</u>
*Whey	=	<u>Greenish yellow colour</u>

* This colour was marked by other constituents in milk.

viii) Flavour :

This is composed of smell (odour) and taste.

Sweet taste – due to lactose

Salty taste – due to minerals.

Phospholipids, fatty acids and fat also contribute to the flavour. Sulfydryl compounds significantly contribute to the cooked flavour of heated milk.

Lecture No. 4

Microbial quality of Raw milk, Factors affecting composition of milk

Microbial quality of Raw milk

Introduction :

Nearly all the changes which take place in the flavour and appearance of milk, after it is drawn from the cow, are the result of the activities of micro-organisms. Of these, the most important in dairying are bacteria, mould, yeast and virus- the first one predominating. Micro-organisms are visible only with the aid of a microscope. A few are desirable, while most cause undesirable changes; a relatively small proportion are disease producing types, and are called 'pathogens'. In the dairy industry considerable effort is expended in controlling microorganisms which cause spoilage. The greater the bacterial count in milk i.e. the greater the number of bacteria per ml of milk, the lower is its bacteriological quality.

Bacteria are microscopic, unicellular fungi (plants without chlorophyll) which occur principally in the form of spherical cylindrical or spiral cells and which reproduce by transverse fission. In milk and its products, the spherical and cylindrical forms are predominant. Most bacteria vary from 1 to 5 microns in size. Although individual bacterial cells are invisible to the naked eye, they form bacterial colonies which are visible. Bacteria are found nearly everywhere in nature. They are found in large numbers in the soil, sewage, decaying plants or animals and are also present in air, water etc. Under favourable conditions, bacteria multiply very rapidly and may double their number in 15 minutes or less. Some bacteria also form spores, which are tough resistant bodies within the bacterial cell. Spores when placed in an environment favourable to growth, form new vegetative cells. **Spore-forming bacteria cause trouble in the dairy industry because of their resistance to pasteurization and sanitization procedures.**

Moulds are multi-cellular, differing greatly in most respects from bacteria. Although the individual cells are not visible to the naked eyes, at maturity they may be observed readily as 'Mycelium'. They are found in soil, feeds, manures and poorly washed utensils. Most spores of moulds are destroyed by pasteurization. They are of considerable importance in cheese making and are responsible for some defects in butter and other milk products.

Yeasts are unicellular but are somewhat larger in size than bacteria. Spores of yeasts are readily destroyed during pasteurization.

Viruses include all ultra-microscopic forms of life. In the dairy industry, only those viruses that are parasitic on lactic acid bacteria and known as **Starter Bacteriophage** (or simply phage) are of special importance. The viruses range in size from 0.22 to 0.23 microns. The lactic phages are usually not destroyed by normal pasteurization of milk employed for cheese and cultured buttermilk, but they can be destroyed by higher heat treatment.

Bacteriological standards of raw milk

SPC ml (or g)	Grade
Not exceeding 200,000	Very good
Between 200,000 and 1,000,000	Good
Between 1,000,000 and 5,000,000	Fair
Over 5,000,000	Poor

B) Factors affecting Composition of Milk

Milk differs widely in composition. All milk contain the same kind of constituents i.e. water, fat, protein, sugar and ash but varying amounts. It will be noted that fat percentage varies widely, protein considerably but less than fat, while variation in lactose and ash is relatively narrow. Variations in milk composition of milk are quantitative and rarely qualitative.

1) Species :

Each species yields milk of a characteristic composition. See table of composition of milk of different species:

Table : Chemical composition of milk of human and different species of animals

Sr No.	Species	Per cent composition				
		Water	Fat	Protein	Lactose	Ash
1	Human	87.7	3.6 ↓	1.8	↑ 6.8	0.1
2	Cow	86.6	4.6	3.4	4.9	0.7
3	Buffalo	84.2	6.6	3.9	5.2	0.8
4	Goat	86.5	4.5	3.5	4.7	0.8
5	Sheep	79.4	8.6 ✓	6.7	4.3	1.0
6	Mare	89.1	1.6	2.7	6.1	0.5
7	Ass.	90.0	1.3	1.7	6.5	0.5
8	Elephant	67.8	19.6	3.1	8.8	0.7
9	Reindeer	68.2	17.1	10.4	2.3	1.5
10	Whale	70.1	19.6	9.5	-	1.0

specific gravity
 cow - 1.28 - 1.30
 buffalo - 1.30 - 1.32

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2) Breed :

It is well known fact that the breed is one of the important factors influencing the composition of milk, (See table). Holstein-friesian contains lower percentage of fat and protein, while Jersey cow milk contains higher fat and protein and Brownswiss stand intermediate. Jersey milk is intensive yellow in colour as compared to Holstein Friesian and Brown Swiss milk.

Chemical composition of milk of Breeds of cow

Sr. No.	Particulars Breed	Water %	Fat %	Protein %	Lactose %	Ash %
1.	Holstein Friesian	87.74	3.40	3.22	3.87	0.68
2.	Jersey	85.09	5.37	3.92	4.93	0.71
3.	Brownswiss	86.59	4.01	3.61	5.04	0.73
4.	Red Sindhi	86.07	4.90	3.42	4.91	0.70
5.	Gir	86.44	4.73	3.32	4.85	0.66

It is clear from the table that human milk is lower in protein and fat whereas higher in lactose than cow milk. Buffalo milk is higher in fat, protein, lactose and ash than cow milk, while cow milk contains more water than buffalo milk. Mare's milk is low in dry matter (TS).

73%

3) The Stage of Lactation : (सूत्रावली)

The first secretion after calving i.e. colostrum which is very different from milk in composition. It is lower in water, sugar and fat and higher in protein and ash than normal milk.

After 1-2 months fat % become normal and continued to normal and increase near the end of lactation. Milk protein also follows the same trend.

S.N.	Constituents	Colostrum %	Milk %
1	T. S.	28.31	12.90
2	Fat	3.37	4.00
3.	Protein		
a)	Casein	4.83	
b)	Albumins and Globulin	15.85	3.10
4.	Lactose	2.48	5.00
5.	Minerals/Ash	1.78	0.70

3) Age:

The fat percentage of milk increase from 2nd to 3rd lactation and remains same until the advance age begin. The milk fat per cent declines slightly as the cows grows older. Example : Fat % of jersey cow is 5.2 at the age of 6-8 years and 4.5 % at the age of 15 years.

4) Milking intervals :

The fat content of milk of a particular cow may show considerable variation from milking to milking. When the animals are milked twice a day, morning milk has different composition than evening milk. Such variation is due to interval between two milking and the environmental differences and greater sensibility of fat to metabolic activity. Fat is inversely proportion to the length of milking period.

5) Portion of milking :

The first milk drawn (fore milk) during milking is low in fat (less than 1.0%) as compared to last milk drawn (strippings) (10 % fat).

6) Season:

The percentage of fat and SNF show slight but well defined variation during different season of the year. Cows receiving the same ration through out the year shows tendency to decline fat and SNF during summer and increased again in winter.

7) Yield:

For individual cow fat per cent is depend on the yield of milk. Yield of milk is inversely proportional to the fat per cent of milk.

8) Health of the animal at parturition:

Health of animal at parturition has significant effect on the composition of milk. Those animals which are in good condition at parturition, produce more milk with higher total fat. Animals which are weak at calving produce milk with less fat.

9) Feed :

It affect the composition of milk to great extent. When animals fed concentrate especially oil cake or cotton seed, they produce milk with higher fat and SNF. Animals receiving green fodder only produce more milk with less fat per cent.

10) Individuality of the Cow :

Animals belonging to a particular breed and maintained under identical condition produce milk with different composition. It is due to individual variations. It could be due to genetic variation. (See table below) :

Sr. No.	Particular	TS %	Fat %	Protein %	Sugar %
1. Holstein Friesian					
A)	Cow	12.12	3.23	3.0	5.05
B)	Cow	10.73	2.93	2.70	4.26

11) Completeness of milking:

If the cow is completely milked, the test is normal, if not, it is usually lower.

12) Irregularity of milking:

Frequent changes in the time and interval of milking result in lower tests. So adopt uniform milking interval.

13) Disease and Abnormal condition :

These tend to alter composition of milk especially when they result in a fall in yield.

14) Excitement:

Both yield and composition of milk are liable to transient fluctuation during the period of excitement for whatever reason.

15) Administration of drugs / hormones :

Certain drugs may effect temporary change in fat. Infection/feeding of hormones result in increase both yield and fat.

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Lecture No. 5

Physico chemical and microbial standards for different types of milk

PHYSICAL STANDARDS:

A number of ratios of chemical constituents and physical values of milk proposed by workers for detecting adulteration have been considered. Those are

1) Specific gravity :

Average specific gravity of cow milk is 1.028 - 1.030 and Buffalo is 1.030 - 1.032.

It should not less than 1.028 at 15.5°C / 60 °F. The range of this value, as pointed out earlier is neither distinctive, nor tight enough to prevent gross adulteration when considered itself.

2) Freezing point :

No standard has been fixed in India for the freezing point of milk although it has been investigated widely by a comparatively by many workers. The test is more sensitive than all to adult ration with pure water is commonly adopted. The average freezing point is - 0.530 °C. It is a time consuming procedure and up to 4-5 % adulteration with water can be checked with this test.

3) Refractive constant : (A combination of refractive index and sp.gr.):

Unlike other physical value, it takes into account every single constituent of milk without exception colloids. Crystalloids andand is an expression at once of the sum of the contribution of individual constituents towards the total value of the refractive index, as well as of the complex ratios obtaining among them.

Refractive Index for cow milk is 0.2065 to 0.2075 and Buffalo is 0.2076 to 0.2086

Watering of milk or defatting buffalo milk to the level of cow milk, is expressed by the disturbance of the correlation between the Refractive Index (R.I.) and Refractive constant to each type of values.

Pocket refractometer for milk can be useful to detect adulteration with water more than 10-15 % and defatted by more than 25 %.

The minimum standards prescribed by the PFA (1976) for cow milk are 3.0 to 4.0 % fat and 8.5 to 9.0 % SNF, while these for buffalo milk are 5.0 to

6.0% fat and 9.0% SNF throughout the country with a view to encouraging milk production through high yielding indigenous and cross breed cows. It is necessary to adopt a pricing policy which would provide an adequate incentive for production of cow milk.

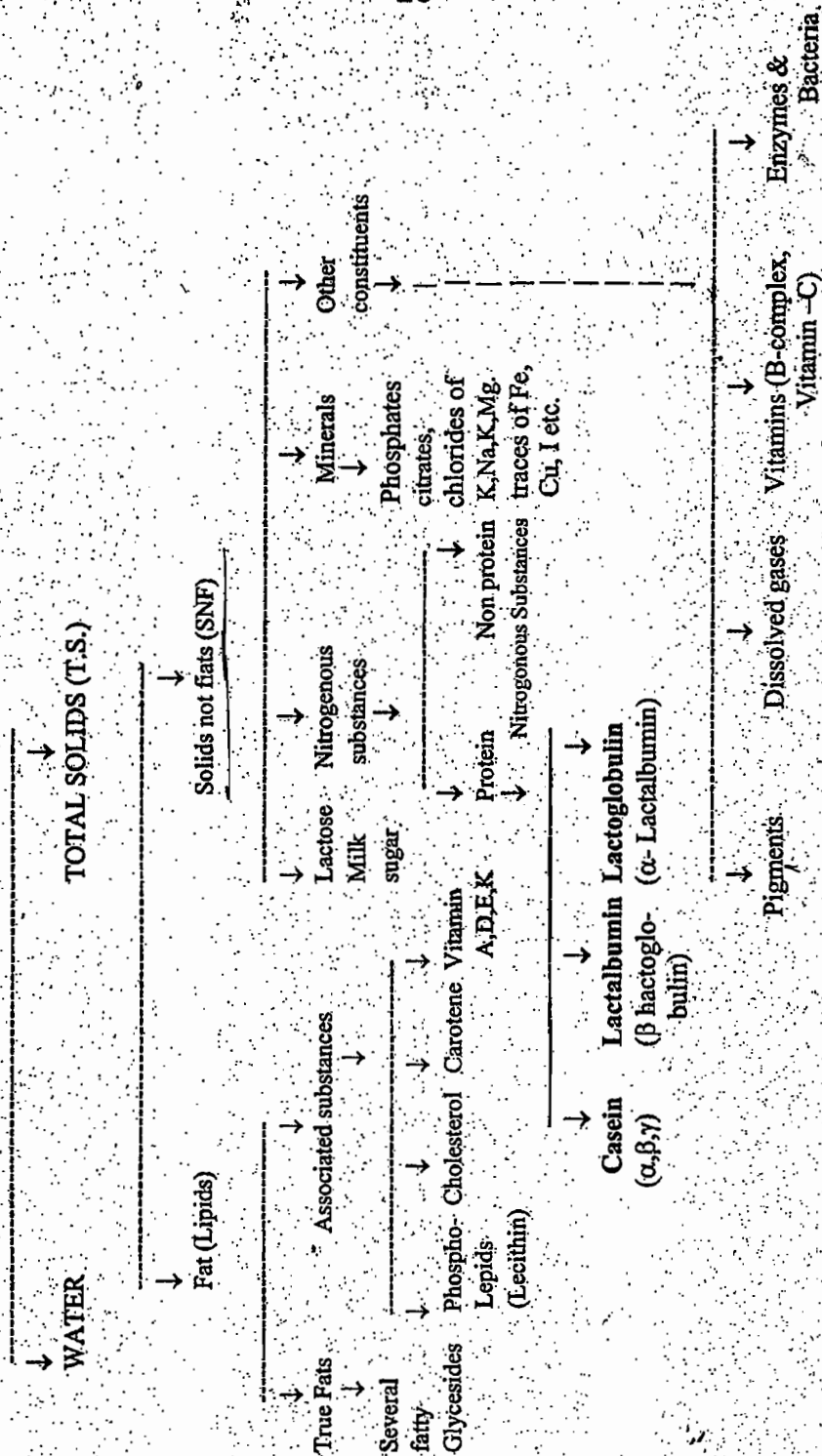
In this context N.D.D.B. has suggested the two axis milk pricing policy. Such a policy ensures payment for milk on its compositional quality evaluated rationally on its fat and S.N.F. components. This would discourage adulteration of buffalo milk and at the same time ensure a common pricing approaches to cow and buffalo milk. But it needs accurate testing of milk.

Legal standards

According to the Prevention of Food Adulteration (P.F.A.) Rules, 1976, the standards for different classes and designations of milk in India are as follows:
Standards for different milks in India.

Sr. No.	Class of milk	Designation	Minimum	
			% MF	% MSNF
1	Buffalo milk	Raw, pasteurized, boiled, flavoured and sterilized.	6.00	9.0
2	Cow milk	-do-	3.5 - 4.0	8.5
3	Goat or sheep milk	-do-	3.0-3.5	9.0
4	Standardized milk	-	4.5	8.5
5	Recombined milk	-	3.0	6.5
6	Toned milk	-	3.0	8.5
7	Double Toned milk	-	1.5	9.0
8	Skim milk	-	Not more than 0.1	8.7

Constituents of Milk



Microbiological standards for Raw milk

1) Direct microscopic count

Sr. No.	Count per ml	Bacteriological quality / Grade
1.	< 5,00,000	Good
2.	5,00,001 – 4,00,000	Fair
3.	4,00,001 – 20,00,000	Poor
4.	> 20,00,000	Very poor

2) Standard plant count (SPC)

Sr. No.	Count per ml	Quality
1.	Not exceeding 2,00,000	Very good
2.	Between 2,00,001 and 1,00,000	Good
3.	Between 1,00,001 and 5,00,000	Fair
4.	Over 5,00,000	Poor

3) Mattujline Blue Reduction Time (MBRT) :

Sr. No.	MBRT (hour)	Quality
1.	5 and above	Very good
2.	3 and 4	Good
3.	1 and 2	Fair
4.	½ and below	Poor

4. One hour Resazurin Reduction Test (RRT)

Sr. No.	Disc No.	Quality
1.	4 or higher	Good
2.	3 ½ to 1	Fair
3.	½ to 0	Poor

5. 10 Minute RRT

Sr. No.	Disc No.	Quality
1.	6, 5 or 4	Satisfactory
2.	3 ½ to 1	Doubtful
3.	½ to 0	Unsatisfactory

Pasteurized milk :

1. SPC	Count / ml < 30,000	Quality Satisfactory
2. Coliforms	Count / ml Absent	Satisfactory

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Lecture No. 6

Nutritional importance of milk and its constituents

Milk is an almost ideal food. It has high nutritive value. It supplies body building proteins, bone-forming minerals and health-giving vitamins and furnishes energy giving lactose and milk fat. Besides supplying certain essential fatty acids, it contains the above nutrients in an easily digestible and assimilable form. All these properties make milk an important food for pregnant mothers, growing children, adolescents, adults, invalids, convalescents and patients alike.

(a) Proteins :

Milk proteins are complete proteins of high quality, i.e. they contain all the essential amino-acids in fairly large quantities.

(b) Minerals :

Practically all the mineral elements found in milk are essential for nutrition. Milk is an excellent source of calcium and phosphorus, both of which, together with vitamin D, are essential for bone formation. Milk is rather low in iron, copper and iodine.

(c) Vitamins :

These are accessory food factors which are essential for normal growth, health and the reproduction of living organisms. Milk is a good source of Vitamin A (provided the cow is fed sufficient green feed and fodder), Vitamin D (provided the cow is exposed to enough sunlight), thiamine, riboflavin etc. However milk is deficient in vitamin C.

(d) Fat :

Milk fat (lipid) plays a significant role in the nutritive value, flavour and physical properties of milk and milk products. Besides serving as a rich source of energy, fat contains significant amounts of so-called essential fatty acids (linoleic and arachidonic). The most distinctive role which milk fat plays in dairy products concerns flavour. The rich pleasing flavour of milk lipids is not duplicated by any other type of fat. Milk fat imparts a soft body, smooth texture and rich taste to dairy products. Lastly, milk lipids undoubtedly enhance the consumer acceptability of foods; they also serve the best interests of human nutrition through the incentive of eating what tastes good.

(e) Lactose :

The principal function of lactose (carbohydrate) is to supply energy. However, lactose also helps to establish a mildly acidic reaction in the intestine (which checks the growth of proteolytic bacteria) and facilitates assimilation.

(f) Energy value : The energy-giving milk constituents and their individual contributions are as follows :

Milk fat	9.3 C/g
Milk protein	4.1 C/g
Milk sugar	4.1 c/g

(where 1 C (Food Calorie) = 1000 c (small calorie).)

(g) Effect of processing :

i) Pasteurization carried out with reasonable care has no effect on Vitamin A, carotene, riboflavin and a number of remaining vitamins B, and Vitamin D. Of the remainder, a 10 per cent loss of thiamine and a 20 per cent loss of ascorbic acid may be expected.

ii) Sterilization increases the losses of thiamine and ascorbic acid to 30-50 % and 50 % respectively, though the remaining vitamins are but little affected.

(h) A balanced diet :

A balanced diet is essential for proper health and growth. The role of milk and milk products in providing the nutrients required for a balanced diet is indicated below given table.

Role of milk and milk products in a balanced diet

Sr. No.	Nutrients	Purpose	Sources
1.	Proteins	Essential for muscle building and repair; give the body energy and heat.	Meat, poultry, fish, milk, cheese, beans, peas, nuts
2.	Carbohydrates	Body energy and heat	Bread, cereals, pastry, sugar, vegetables, fruit
3.	Fats	Body energy and heat	Butter, ghee, oils
4.	Minerals	Bone, teeth, body cells	Dairy products, fruit, vegetables
5.	Vitamin A	Growth, health of the eyes, structure and function of the skin and mucous membrane	Fat-rich dairy products, eggs, spinach, carrot, tomatoes, fish liver oils
6.	Vitamin B ₁ (Thiamine)	Growth, aids appetite, prevents beri-beri, function of the nervous system	Whole grains, eggs, green vegetables, yeast, liver, kidney
7.	Vitamin B ₂ (Riboflavin)	Growth, health of skin and mouth, functioning of the eyes	Milk, cabbage, carrots, spinach, liver, eggs, yeast, lean meat, prunes.
8.	Niacin	Functioning of the stomach, intestines and nervous system	Meat, heart, kidney, liver, eggs, fish, milk, peanuts, yeast
9.	Vitamin C	Aids bones and teeth, prevents scurvy	Citrus fruit, maize, tomatoes, lettuce, cabbage.
10.	Vitamin D	Aids in calcium-absorption which strengthens bones, prevents rickets.	Eggs, Milk, fish liver oils.

MILK CONSTITUENTS :

A) Major Milk Constituents :

1) Water:

Ⓐ major constituents of milk

✓ ① Water

22

It constitutes the medium in which other milk constituents are dissolved or suspended. Most of the portion of water is in free form, very small portion is in bound form with milk proteins, phospholipids etc.

✓ 2) Milk-fat (Lipid) :

Exists in the form of small globules. Average size 2-5 microns. This is present in emulsion form, just oil in water type emulsion. Each globule is covered with a membrane containing phospholipids and proteins called fat globule membrane. Due to this fat globule keeps separated from each other. Due to agitation, heating and freezing the emulsion is broken. When milk stands / undisturbed cream layer at top is formed having higher fat with large fat globules.

Chemically milk fat is composed of a number of glyceride esters of fatty acids, on hydrolysis; Milk fat-furnishes a mixture of fatty acids and glycerol. The fatty acids are saturated or unsaturated. Saturated fatty acids are stable while unsaturated fatty acids are unstable and PLAY an important role in the physico-chemical properties.

✓ 3) Milk proteins:

Most complex organic substances. They are vital for living organisms, as they constitute an indispensable part of the individual body cell.

They are composed of large number of (22-23) amino acids (essential and non-essential). The essentials are necessary in the diet for the formation of body proteins. On hydrolysis of proteins furnishes a mixture of amino acids,

It consists mainly casein, β lactoglobulin and α -Lactalbumin.

Casein exists in the form of Ca-caseinate phosphate complex, present in colloidal state. The casein forms about 78-80% of total protein. It may precipitated by acid, rennet, alcohol, heat and concentration. It has got α , β , γ fractions.

β - Lactoglobulin and α Lactalbumin :

These are known as whey proteins or serum proteins. They are also present in colloidal state. Easily coagulated by heat.

Lactoglobulin	18%	} Total protein
Lactalbumin	27%	

4) Milk sugar or lactose :

This exists only in milk. It is in true solution form. On crystallization forms gritty crystals. It is 1/6 as sweet as sucrose. The sandiness defect in ice-cream and sweetened condensed milk is due to lactose.

Lactose is composed of one molecule each of glucose and galactose.

Lactose occurs in two forms α and β both the form occurs as hydrate or unhydrate unhydride.

Due to fermentation of lactose by bacteria - Lactic acid and other organic acids are formed.

Due to undesirable fermentation i.e. spoilage of milk occurs due to this constituent.

5) Mineral matter and ash :

Salts of milk present in small quantities. Major salts are K, Na, Mg, Ca, P citrates, phosphates etc. Trace elements are Fe, Cu etc.

B) Minor milk constituents :

a) **Phospholipids** : Example : Lecithin, Cephalin etc. forms an important constituent of fat globule membrane.

Contributes to the richness of flavour of milk. Sensitive to oxidative changes. Phospholipids stabilize the milk fat in emulsion.

b) **Cholesterol** : Present in true solution in the fat; as a part of the fat globule membrane complex

c) **Pigments** : Fat soluble: Carotene, Xanthophyll

Water soluble: Riboflavin.

Carotene Colouring matter of green leaves gives yellow colour to milk. It acts as anti-oxidant and precursor of Vitamin - 'A'.

Cow has capacity to transfer carotene from feed to milk fat than buffalo. Hence buffalo milk is white in colour.

Riboflavin : Besides being a vitamin is greenish yellow pigment gives characteristics colour to whey - -

d) **Enzymes** : These are biological catalysts i.e. retard / hasten chemical changes without participate in reactions. They are inactivated by heat.

Amylase - Starch splitting.

Lipase - Fat splitting leading to rancid flavour.

Phosphatase - Basis of pasteurization. Splitting certain in phosphoric ester

Protease - Protein splitting.

e) **Vitamins** :

Present in food in very minor quantity, vital for health and growth. As to day over 25 vitamins have been reported.

Vitamins are of two types :

1) Fat soluble : A, D, E, K

2) Water soluble : Vitamin B complex group.

Thiamine (B₁)

Riboflavin B₂

Pantothenic acid

Niacin, Biotin (B₁₂)

present in food in very minor quantity, vital for health
i.e. growth is called is vitamins

Lecture No. 7, 8 and 9

Reception and processing (Plat form test, Chilling, Standardization, Homogenization, Pasteurization, Storage and Marketing) of milk

I) Collection :

The milk production is mainly in rural areas whereas demand for milk is in urban areas. Hence, it is collected and transported from production point i.e. rural areas to processing and distribution or consumption points i.e. cities.

A) Common systems of collection of milk :

i) **Cooperative organization** : the milk cooperative societies formed by milk producer or other persons suited to producers as no middlemen involved. ii) **Contractors** ; The milk is collected by an individual contractors from producers and supplied to market.

iii) **Individual producers** : It is suitable for producers located near cities or processing plants.

B) **Milk collection-cum-chilling centers** : These centers are for the collection of the milk and keeping of low temperatures till it is transported to processing dairy.

II) Transportation of milk :

Since the milk is produced at rural areas and consumed at cities, it requires to be transported from production to demand point. In Indian conditions, milk is regularly collected and transported twice a day (morning and evening). The modes of transport adopted depend upon load, distance of collection and local conditions. The following modes of transport are adopted.

Sr. No.	Mode	Optimum load (kg)	Optimum distance km	Remarks
1.	Head load	15-25	3-8	Important in hilly areas
2.	Shoulder Sling	Up to 40	3-5	Opted for short distance
3.	Pack animal	Up to 80	6-10	Ponies, horses, donkeys used
4.	Bullock cart	300-400	10-12	Slow mode of transport
5.	Tonga	250-300	12-25	Larger quantities and faster mode
6.	Bicycle	40-50	15-25	Quick and handy
7.	Boat	40-200	2-10	For crossing of river or water
8.	Auto rickshaw	250-500	15-40	Greater capacity and faster
9.	Motor truck	1-4 tonnes	15-100	Increasingly used where good road facilities
10.	Railway wagon	11 tonnes or more	80 or more	Great scope in future
11.	Tankers (Road / Rail)	5 tonnes	80 or more	Great scope in future.

Problems : The problems under Indian conditions in relation to collection and transportation of milk are :

- i) Small and scattered production of milk.
- ii) Milk is liquid, perishable and bulky – requires fast and specialized transportation than general goods.
- iii) Tropical climate – helps to microbial growth.
- iv) Lack of road and transport facilities.
- v) Lack of countrywide organizations for collection and transport.
- vi) Vested interest among local merchant makes hurdle for development.

III) Receiving of Milk :

The operations carried out at processing plant are as below :

1. Unloading : If motor truck is mode of transport, it is positioned to level of platform, the unloading of milk cans is done manually by pulling. The cans are assembled in definite order for grading. If tander is positional properly that connection for unloading can be made conveniently.

2. Grading : means classification of milk on the basis of quality, for price fixing purposes. This is done by the skilled person known as milk grader. Grading is based as organoleptic (sensory) tests, i.e. smell, taste, appearance and touch, acidity, sediments etc. These tests are to check the quality of incoming milk on the receiving platform to make quick decision regarding primary acceptance or rejection. The inferior or doubtful quality milk is rejected to prevent it being mixed with high grade milk.

Platform Tests :

a) Smell : To test, the cover of each can is removed, inverted and raised to nose. The odour or smell is representative of that can. The milk should be free from any off-flavours.

b) appearance : By observing milk in each can, it can be ascertained that milk should be normal in colour, free from churned fat globules and free from extraneous material.

c) Temperature : The temperature at which milk is delivered is indication of its quality. It can be ascertained with a high degree accuracy whether or not milk is sufficiently cold. A temperature at 5 °C or below is satisfactory.

d) Sediments : It shows the visible foreign matter contained in the milk. A low sediment is desirable.

e) Acidity : Natural or apparent acidity of milk does not harm the quality but the developed or real acidity does adversely affect the quality of milk.

f) Lactometer Reading : The addition of water to milk results in lowering its lactometer reading. This test applied to detect the adulteration of milk with water.

3. Sampling : The correct representative sample of milk for subsequent chemical and bacteriological analysis is required to be taken. Before taking

sample, the milk in the can is thoroughly mixed with plunger or stirrer. The samples taken are preserved till the test with addition of preservatives like mercuric chloride, formalin, potassium dichromate.

4. Weighing : This is important for accounting for milk receipts and disposal, making payments. This is done by weigh tank, weigh bridge or by flow meters for tankers.

5. Testing : Testing is done to take final decision regarding to take final decision of acceptance or rejections about the doubtful quality lot of milk.

STANDARDIZATION

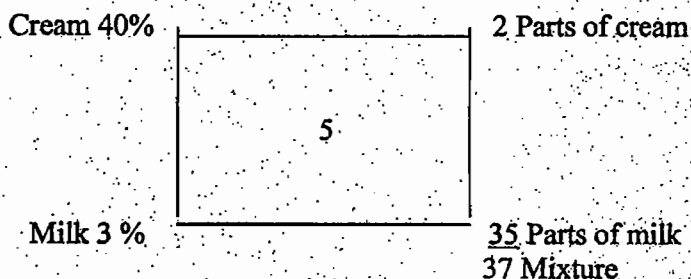
Standardization of milk refers to the adjustment of fat and solids - not - fat i.e. rise or lowering the fat and / or solids-not-fat of milk to a desired level so as to conform the legal standards as prescribed.

Procedure:

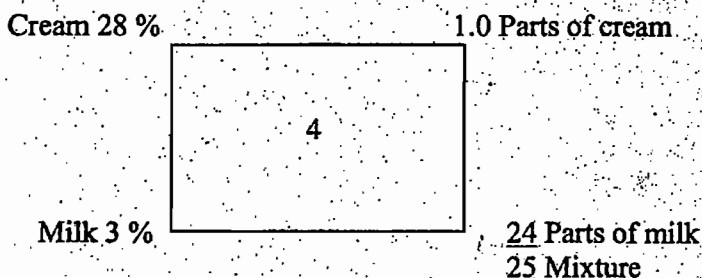
1. By addition of milk cream with a higher or lower fat % than that of the material to be standardized.
2. By addition of skim milk to cream.
This is done by use of Pearson's square formula.

PROBLEM :

1. How many parts by weight of 40% cream and 3% milk must be mixed to make milk testing 5% fat.



- 2) How many kgs of each of 28% cream and 3% milk will be required to make 500 kg of a mixture testing 4% fat.



In a mixture of 25 there is 1 part of cream
 In a mixture of 500 how many parts of cream ?

$$\frac{500 \times 1}{25} = 20 \text{ kg of cream}$$

Answer : 20 kg of cream

HOMOGENIZATION

(प्रसिद्धता करी)

Homogenization refers to the process of forcing the milk through a homogenizer with the object of sub-dividing the fat globules (10 times less).

Homogenizer is a machine which causes sub-division of fat globules. It consist of high pressure piston pump which forces the milk at higher pressure and velocity through a narrow opening between the homogenizing valve and its seat. The fat globules in the milk are thereby sub-divided in to smaller particles of more uniform size.

Homogenizers are either :

1. Single stage – High pressure
2. Two stage – High and low pressure

Merits :

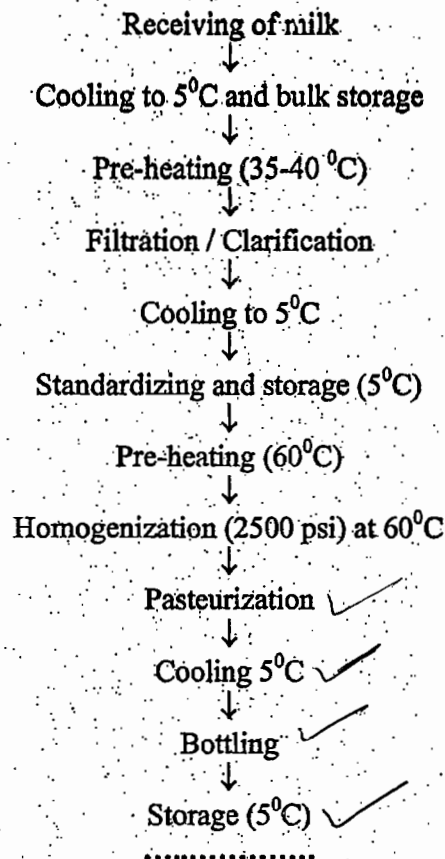
- i) No formation of cream layer.
- ii) Fat in milk does not churn due to excessive agitation.
- iii) More palatable, brighter appearance.
- iv) Produces soft curd and is better digested, recommended for infant feeding.
- v) Less susceptible to oxidized flavour.

Demerits :

- i) Increased cost of production.
- ii) From returned milk fat recovery is difficult (i.e. separation).
- iii) Sediments appears to a greater degree.

Factors influencing Homogenization :

- ✓ 1) Temperature of homogenization : Temperature should be above 91°F i.e. melting point of fat, so that proper sub-division occurs. The enzyme lipase enzyme is inactivated.
- ✓ 2) Pressure of homogenization :
 - a) In single stage : Up to 6% fat 2000-2500 psi pressure is sufficient.
 - b) In two stage : For liquid products having more than 6 % fat in Ist stage 2000 psi pressure and in IInd stage 500 psi pressure.

Stages of Homogenization : Method of manufacture :**Flow diagram of manufacture :****PASTEURIZATION**

The term Pasteurization has been coined after the name of **Louis Pasteur** (France) who in 1860-64 demonstrated the wine heating at 122 to 140 °F (50-60 °C) for killing spoilage organisms. Pasteurization of milk was first attributed to **Dr. Soxhlet of Germany in 1886.**

Definition: Refers to the process of heating every particles of milk to at least 63 °C (145 °F) for 30 minutes or 72 °C (161 °F) for 15 seconds (or any time temp. combination equally efficient) in approved and properly operated equipments. After pasteurization milk is immediately cooled to 5 °C.

Objects:

1. To render milk safe for human consumption by destructing cent per cent pathogenic micro organisms.
2. To improve keeping quality of milk by destruction of almost all spoilage organisms (85-99%).

Objections:

1. It diminishes unsanitary milk production.
2. It may be used to mask low quality milk.
3. It diminishes significantly the nutritive value of milk.
4. It reduces the 'cream line' or 'cream volume'.
5. Pasteurized milk will not clot with rennet.

Formulation of standards : The following considerations were involved in the formulation of the standards of pasteurization.

a) **Bacterial destruction :** Cent per cent for pathogens. Mycobacterium tuberculosis, being considered the most heat-resistant among pathogens, was chosen as the index organism for pasteurization. Any heat treatment (i.e. temperature-time combination), which killed T.B. germs, also destroyed all other pathogens in milk.

b) **Cream line reduction :** The creamline or cream volume is reduced progressively with increase in the temperature-time of heating.

c) **Phosphatase inactivation :** The complete destruction of phosphatase by pasteurization. (The phosphatase test is used to detect inadequate pasteurization).

1) **Mycobacterium tuberculosis : T.B. Bacteria**

Most heat resistant also destroyed and this is the index of pasteurization.

2) **Phosphates inactivation : (-) ve test.**

METHODS :

a) **In the bottle pasteurization :**

Bottles filled with milk, tightly sealed with special clips, held at 63-66 °C for 30 minutes- cooled in water sprays.

b) **Batch/holding pasteurization : Low Temperature long time (L.T.L.T.) :**

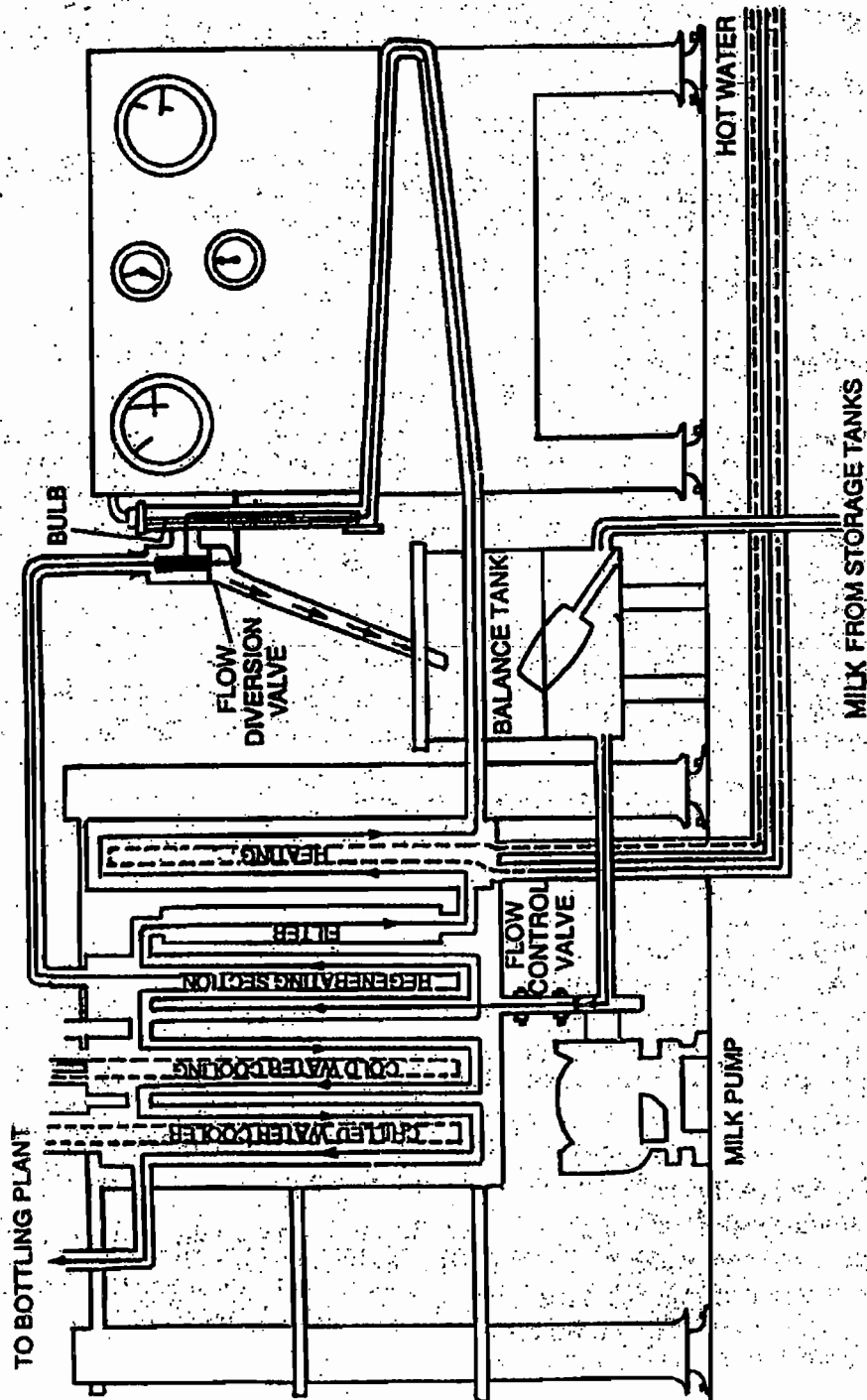
Milk is heated to 63 °C / 145 °F for 30 minutes and promptly cooled to 5 °C.

In this indirect heating of milk is done. Heat moves through a metal wall to milk. 1) Water-jacketed vat. 2) Water-spray type 3) Coil-vat type.

1) **Water-jacketed vat:**

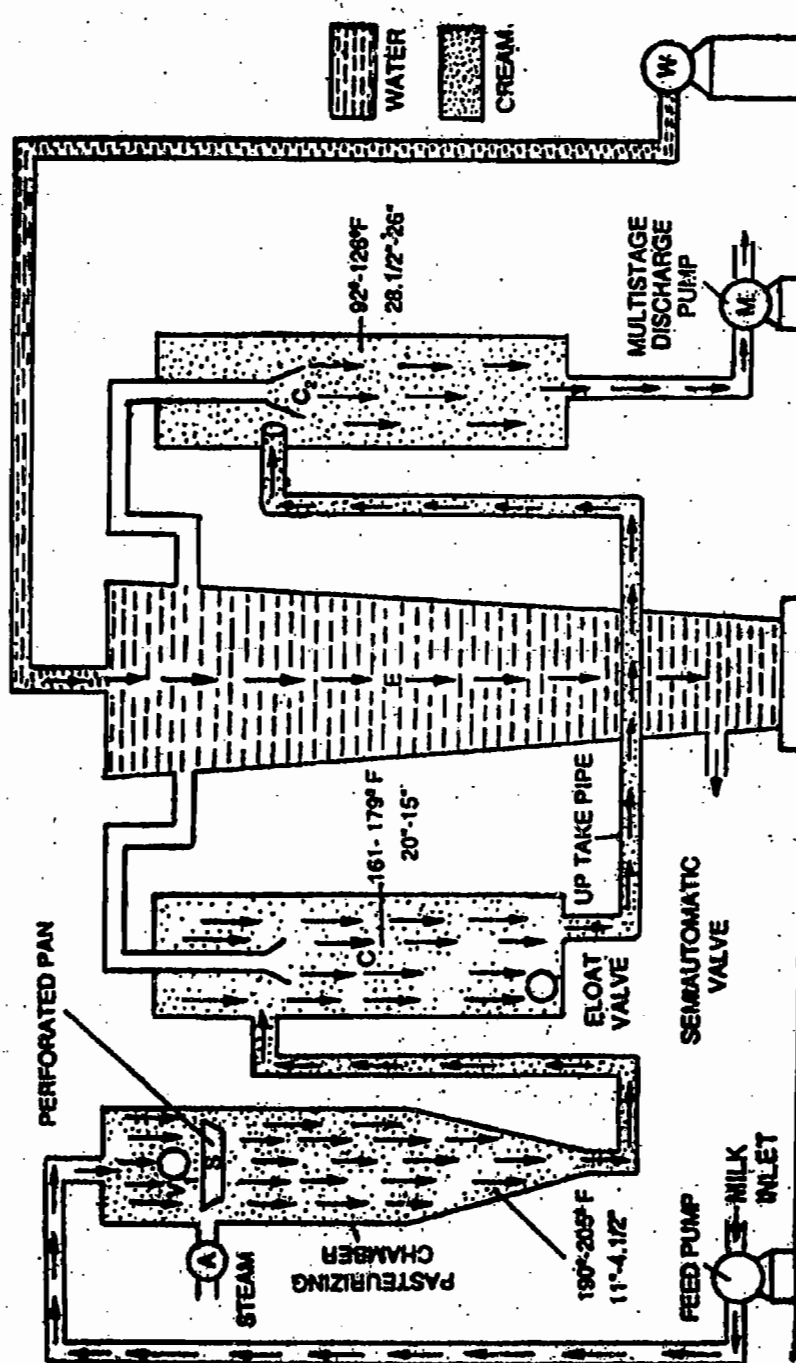
Double walled, in which hot water / steam under partial vacuum circulated for heating and cold water for cooling. The outer well is insulated to reduce heat loss. The heat exchange takes place through the wells if inner lining.

Advantage: It is a multipurpose vat.



Method of Pasteurization





Vacreator or Vacuum Pasteurizer

2) Water-spray vat :

A film of hot water is sprayed from a perforated pipe over the surface of tank holding the product.

3) Coil-vat type :

Heating / cooling medium is pumped through a coil placed in horizontal / vertical position while the coil is turned through the product.

Disadvantage : Coils are difficult to clean.

c) High temperature short time (HTST) Pasteurization :

First developed in U.K. in 1922 by A.D.V.O. It is the modern method. Large volume of milk can be handled. It gives continuous flow of milk, heated to 72 °C (161 °F) for 15 seconds and cooled below 5 °C.

Advantages:

- i) Capacity to heat treat milk quickly and adequately, rigid quality control over raw and pasteurized milk.
- ii) Less floor space requirement.
- iii) Lower initial cost.
- iv) Milk packaging can start as soon as pasteurization is over, so efficient use of labour for packaging and distribution.
- v) Easily cleaned and sanitized (system adopts itself well to CIP-cleaning).
- vi) Lowest initial cost due to fullest use of regeneration.
- vii) Pasteurizing capacity can be increased at nominal cost.
- viii) Reduced milk losses.
- ix) The process can be interrupted and quickly re-started.
- x) Automatic precision controls ensures positive pasteurization due to flow diversion valves.

Disadvantages:

- i) Not adaptable for handling small quantities.
- ii) Gaskets require constant attention.
- iii) Complete drainage is not possible (but less losses than holder system).
- iv) Product sanitary control is so narrow that automatic control precision instruments are required in its operation.
- v) High thermophilic count is not fully diminished.
- vi) Greater accumulation of milk stone in heating section.

HTST system has got following parts:

- i) Float controlled Balance Tank (FCBT).
- ii) Pump
- iii) Regenerative heating section
- iv) Holding section
- v) Flow diversion valve.
- vi) Regeneration cooling section

vii) Automatic control devices.

- a) Steam pressure controller
- b) Milk temp. recorder.

i) Balance tank with float control :

Fed raw milk pump, also receives un-pasteurized milk diverted by F.D.V.

ii) Pump :

Rotary positive pump between regeneration and heater or centrifugal pump with flow control device.

iii) Plates :

The plate heat exchangers — heat the milk below boiling point of milk. The plates are supported a press between a terminal block in each heating and cooling section. Space between two plates is 3 mm. They are so assembled to form turbulent flow.

iv) Regeneration of heating :

The raw cold incoming milk is partially heated by the hot outgoing milk. So less heat is required to raise the milk temp.

v) Holding :

The holding tubes or plates ensures that the milk is held for specified time not less than 15 seconds at 72 °C. Temperature.

vi) Flow diversion valve (F.D.V.) :

This routes the milk after proper pasteurization and the milk, which is not properly pasteurized, is automatically diverted back in FCBT. It is operated by air pressure against strong spring.

vii) Regeneration (cooling) :

The pasteurized hot outgoing milk partially cooled by incoming raw milk.

viii) Automatic control devices :

(a) Steam pressure controller :

Maintains a constant hot water temp. for heating milk to required temperature.

b) Milk Temperature Recorder :

It is electric contact Instrument operates at FDV.

c) Holding time set :

It is the flow time of milk at prescribed temp. through the holding section.

OTHER METHODS:

1) Vacuum pasteurization (Vacreation) : Pasteurization of milk at reduced pressure by direct steam.

This refers to pasteurization of milk / cream under reduced pressure by direct steam. The equipment used for this is called "Vacreator" developed in New Zealand by M/s Murry Deodorisers Ltd to remove volatile flavours from cream and pasteurize it for butter making in 1932.

The vacreator has three stainless steel chambers connected to one another (a) pasteurizing chamber (b) volatilizing and (c) cooling chamber. The product (in the form of fine droplets) enters the first chamber of the vacreator where pasteurization occurs. This chamber is operated under a vacuum of 11 to 6 inches per kg at a temperature of 90 – 95 °C. The steam is fed from the top and the product falls by gravity to the bottom of the chamber. Then the product with some free steam are moved from the bottom of the first chamber to the top of second chamber. The temperature of the second chamber is maintained at 72 to 82 °C under a vacuum of 20 to 15 inches per kg. A portion of the steam previously added is removed and the product moves down through the chamber. Some of the volatile off-flavours are removed by heat and vacuum treatment in this chamber. The product then moves to third chamber at 43 °C under vacuum of 26 to 27 inches per kg and here more water and off-flavours are removed. A multistage centrifugal pump removes the product from the third chamber (Figure given on next page).

2) **Stassanization** : Milk is heated to about 74 °C (165 °F) for 7 seconds.

3) **U.H.T. Pasteurization** : Developed in the 1950s. Milk is heated to 135 to 150 °C (276 to 302 °F) for no hold.

4) **Uprization** : This is itself a shortened form of the word 'Ultra-pasteurization', which has been developed in Switzerland. In this process milk is heated with direct steam up to 150 °C (302 °F) for a fraction of second. The process is continuous.

Advantages :

- i) Long keeping quality.
- ii) Removal of feed and other volatile off-flavours
- iii) Appreciable homogenization effect
- iv) Reduction in acidity
- v) Efficient destruction of microorganisms.
- vi) Effect of uperization on nutritive value and flavour no greater than that of pasteurization.

Storage

Introduction :

Modern milk plants hold both raw and pasteurized milks for a much longer period than before. Normally the milk storage capacity is equal to one day's intake. This allows a more nearly uniform work day for processing and bottling operations with less dependence on the time for receiving raw milk.

Storage tanks are used in Milk Plants for the storage of raw, pasteurized or processed products, often in very large volumes. Because of the longer periods of holding, storage tanks are among the most important items of equipment. They must be designed for ease in sanitization, preferably by the circulation cleaning method.

Objects :

1. To maintain milk at a low temperature so as to prevent any deterioration in quality prior to processing / product manufacture
2. To facilitate bulking of the raw milk supply, which will ensure uniform composition;
3. To allow for uninterrupted operation during processing and bottling.
4. To facilitate standardization of the milk.

Types :

i) Insulated or Refrigerated :

In the former, there are 5 to 7.5 cm of insulating material between the inner and outer linings; in the latter, the space between the two linings is used for circulation of the cooling medium.

ii) Horizontal or Vertical :

While the former requires more floor space and less head space, the latter requires less floor space and more head space. Modern circulation cleaning methods have made very large vertical storage tanks practical.

iii) Rectangular, Cylindrical or Oval :

Of these, the first suffers from the disadvantages of having dead corners during agitation while the other two do not.

iv) Built for gravity flow, air pressure or vacuum operation :

The first is the most common. However, air pressure is sometimes used to evacuate the product. This requires special construction of the storage tank for greater strength than necessary for normal operations under gravity flow. Yhr gitdy id

v) Location :

In one system, the storage tanks are located on an upper floor. The milk is pumped from the receiving room to the floor above. It then flows by gravity to the pre-heater, filter or clarifier, pasteurizer, cooler and bottling machine.

Distribution

Distribution of milk is the last or final stage of the market milk industry. Others are preparatory to placing the product into the hands of the consumer. The quality of the product alone will not assure its wide distribution, which should be planned and executed intelligently.

Distribution facilities consist of (i) the physical equipment and personnel required for transporting the products from the milk storage rooms to the consumer / retailer (ii) sales promotion personnel and (iii) advertising.

A successful distribution programme require :

- i) A product of high quality.
- ii) an attractive package.
- iii) neat and courteous route salesmen
- iv) delivery equipment of pleasing appearance
- v) efficient use of men and equipment.
- vi) effective advertising.

Route organization :

This varies with the size and the type of business. In a small plant, the same drivers and trucks may deliver both wholesale and retail goods. In larger organization wholesale and retail distribution are usually handled by separate personnel and equipment. Wholesale routes handle larger volumes and have fewer stops than do retail routes.

Payment of route sales men : Three different methods are in use :

- (i) **Flat salary.** Gives no incentive to sell more products, secure new customers etc.
- (ii) **Salary plus commission :** Most satisfactory.
- (iii) **Straight commission :** Used when the driver owns the route and equipment.

Checking out the routes :

Different systems may be used for loading the trucks in checking out the routes. The trucks must be loaded rapidly so that the drivers are not delayed at loading stations. the principle systems are : (i) loading directly from the storage rooms through one or more doors (ii) using a long loading platform with conveyors from the milk storage rooms (iii) loading platform trolleys in the storage room with orders for the different routes.

Checking in the routes :

This consists of verifying the driver's count of empty bottles and unsold goods and conveying the bottles to the washers or to storage. The driver usually places the bottles on the platform, conveyor or platform trolley.

Sales outlets : These include the following :

- i) home delivery
- ii) milk booths
- iii) stores
- iv) soda fountains
- v) coin vending machines
- vi) automatic dispensers
- vii) factories, hospitals, jails, restaurants, schools etc.
- viii) lunch counters.

Anticipating daily demand :

This is usually based on past experience, taking into consideration holidays, fairs and festivals, special events etc.

Frequency of distribution :

Due to highly changeable temperatures during most seasons and the lack of refrigeration facilities at the average customer's home in India the milk has to be distributed twice daily viz. morning and evening.

Utilization of returned milk :

Unsold milk presents a problem of economic disposal. Under tropical conditions as in India, the returned milk should not be sent again for sale as liquid milk since exposure to high temperatures during its inward and outward journeys subject it to quality deterioration and hence may cause consumer complaints. The unsold milk can be given for separation or utilized for preparation of *dahi* etc.

Systems of collection for the payment of milk :

These are credit, cash or advance payment.

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Lecture No. 10, 11 and 12

Classification and composition of milk products (heat coagulated, Heat and acid coagulated, evaporated, fermented, frozen and fat riched products).

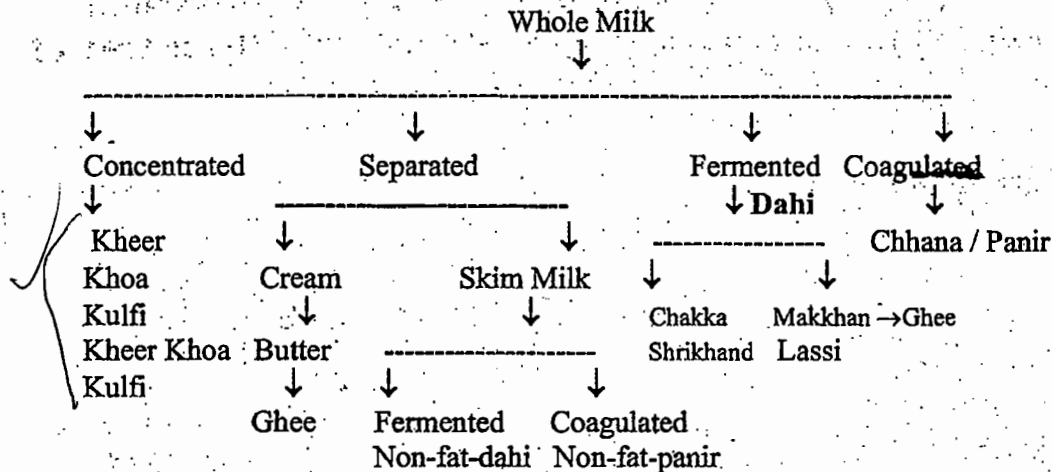
Classification and uses of traditional milk products of India

S.No.	Principles of manufacture	Products	Uses
1.	<u>Heat desiccation</u>	Khoa	Khoa based sweets (Burfi, Peda, Gulabjamun, Kalakand, Milk cake, Kunda etc.)
2.	<u>Heat and acid coagulation</u>	Chhana	Chhana based sweets (Rasogolla, Sandesh, Rasamalai, Chhana murki, cham-cham etc.)
		Paneer	Culinary dishes, Direct consumption
3.	<u>Fermentation</u>	Dahi	Culinary dishes, Direct consumption
		Chakka	Shrikhand, Shrikhand vadi
		Misti dahi	Direct consumption
4.	<u>Fat concentration (Fat rich products)</u>	i) Ghee	Culinary purpose, Direct consumption
		ii) Makkhan	Direct consumption, used for Ghee making
5.	<u>Frozen</u>	Kulfi / Kulfa	Direct consumption
7.	<u>Addition of cereals and desiccation</u>	Kheer Payasam	Direct consumption

INDIAN DAIRY PRODUCTS — 0.1

No.	Indian Dairy Products	Corresponding Western product
I.	Concentrated whole milk products	
a)	Kheer / basundi	Condensed milk
b)	Khoa/Mawa	Evaporated milk
c)	Rabri	Clotted cream
d)	Kulfi - Indian desert	Ice-cream
II.	Coagulated milk products :	
a)	Dahi	Curd / yoghurt
b)	Srikhand	Curd (Sweetened)
c)	Paneer	Soft cheese
d)	Chhana	Lactic coagulated green cheese.
III	Products of the clarified butter fat	
a.	Makkhan	Butter
b.	Ghee	Butter oil
c.	Lassi	Butter milk
d.	Ghee residue	

Flow Diagram of Manufacture of different milk products from whole milk



Availability of Indian dairy products depend upon :

- quantity of milk available
- traditional practices
- dietary habit of people
- market demand
- purchase power of consumer
- local conditions, like seasonal, regional etc.

Ginger ↑

{A} Khoa OR Mawa

It is used as base for indigenous sweets. Produce more in northern and eastern region. U.P. produce 36% of the country's total khoa production.

Definition :

Khoa refers to the partially dehydrated whole milk product prepared by continuous heating of milk in karahi over a direct fire, with continuous stirring-cum-scrapping using khunti till it reaches a semi-solid (doughy) consistency. There after, the pan contents are removed from the fire and worked up into a solid mass or khoa fat.

As per Indian Standard Khoa should contain not less than 20% milk fat.

Composition :

The chemical composition of khoa depends mainly on the initial composition of milk, the degree of concentration composition of cow and buffalo

milk khoa is given below. The fat, total solids and ratio of concentration of cow milk used was 4.8%, 13.8 % and 5.4 while that of buffalo milk 8.4%, 18.2% and 4.5.

Chemical composition of khoa (Percentage)

Type of milk	Moisture	Fat	Protein	Lactose	Ash	Iron ppm
Cow	25.6	25.7	19.2	25.5	3.8	103
Buffalo	19.2	37.1	17.8	22.1	3.6	101

Iron concentration is from the surface of karahi while scrapping.

Procedure:

Normally 2-3 kg of milk is taken per batch in a karahi and boil it over a non smoky fire. Stirred the milk vigorously and constantly with a circular motion by a khunti. It should be stirred 90 to 100 circular stirring per minute.

During hating all parts of the pan with which the milks comes in to contact are lightly scraped to prevent the milk from scorching. Constant evaporation of moisture take place and the milk thickens progressively. At certain stage, thicken mass shows abrupt change in colour due to heat coagulation of milk proteins. This stage occurs when concentration of milk reaches 2.8:1 in case of cow milk and 2.5:1 for buffalo milk. The heating is continues with greater control here after and the speed of stirring-cum-scrapping increase the viscous mass reaches a pasty consistency and begins to dry up. Very close attention is given to the last stages. The final product is ready when it shows signs of living the bottom and sides of karahi and sticking together. At this stage pan is removed from the fire and work the content up and down by khunti to form pad.

Physical quality of Khoa :

It includes colour, appearance, body and texture, flavour and a suitability for sweets.

Good quality khoa should be compact mass, light yellow colour (cow milk) and dull white colour (buffalo milk), slightly heated flavour. Free from oiliness or acidity. Smooth texture and firm body. it should not have visible water droplet or shows signs of oozing fat. If khoa is made from buffalo milk it should have a uniform whitish colour with a tinge of borwn, slightly oily or greasy appearance, soft body, smooth granular texture, rich nutty flavour, mild cooked and sweet taste and highly suitable for sweet making. If khoa is made from cow milk, it should be straw or pale yellow colour with a tinge of brown, moist surface appearance, slightly hard body and slightly sandy or coarse texture, rich nutty flavour, slightly salty taste and suitable for sweet making.

Yield of Khoa :

The yield of khoa is variable. It is influenced by type of khoa, type of milk, quality of milk, the extent of dehydration and losses during handling. Normally the yield of khoa with 28 per cent moisture ranges from 17-19 % from cow milk and 21 to 23 per cent from buffalo milk.

Keeping quality of Khoa :

The higher the storage temperature the lower the keeping quality. At 37 °C for 7 days, 24 °C for 10 days and 5-10 °C for 25 days. At room temperature 24-30 °C is characterized by a rancid flavour, while at low temperature (5-10 °C), it has a stale / sour flavour.

Overrun :

The overrun in khoa refer to the excess weight of khoa over the total amount of total milk solids in the milk used for its production.

Overrun is influenced by the moisture retained in khoa and losses of milk solids. It is usually expressed in percentage :

$$\text{Percentage overrun \% (OR)} = \frac{K - TS}{TS} \times 100,$$

Where,

OR = Over run

K = Weight of khoa (in kg)

TS = Weight of total solids in milk (in kg)

Packaging :

Vegetable parchment paper wrapper, butter paper, plastic (polythene) film bags / pauches, laminated pauches, tin plate can are used for packing khoa. The pack size varies from 0.5 to 1 kg.

Type of khoa : There are 3 types as per quality and use for specific type of sweet making.

S.N	Type of Khoa	Uses	Fat %	TS %
1	Pindi type khoa	used for making <u>Burfi</u> or <u>peda</u>	21-26	67-69
2	Dhar type khoa	<u>Gulabjamun</u> and <u>Pantooa</u>	20-23	56-63
3	Danedar type Khoa	<u>Kalakand</u> , <u>Goud Burfi</u>	20-25	60-65%

Milk of high acidity produce granular khoa.

Defects of khoa ::

- i) Flavour : Smoky, Rancid, Sour / Acidic and Stale
- ii) Body texture : Hard, coarse and gritty
- iii) Colour and appearance : Dry surface, visible dirt, Browning, mouldy surface, and fat and / or water leakage.

Score card of khoa (tentative)

Sr.No.	Particulars	Score
1.	Flavour	45
2.	Body texture	35
3.	Colour and appearance	15
4.	Packaging	05

(B) Chhana ✓

It is also called Paneer in some parts of country. In West Bengal and Eastern part it is used for sweet meat like Rossogolla and Sandesh.

Principle :

Chhana refers to the milk solids obtained by the acid coagulation of boiled not whole milk and subsequent drainage of whey. The acids commonly used are lactic or citric, in both natural or chemical form.

Definition :

As per PFA Rules 1976, Chhana is the product obtained from cow or buffalo milk or combination thereof by precipitation with sour milk, lactic acid or citric acid. It should not contain more than 70% moisture and the milk fat content should not be less than 50% of the dry matter.

Chemical composition:

It is influenced by composition of milk, coagulant used, moisture retained and loss of milk solids in whey. Average composition of chhana made from whole milk is as under :

Chemical composition of Chhana

Sr. No.	Type of milk	Moisture	Fat	Protein	Lactose	Ash
1	Cow	53.4	24.8	18.4	2.1	2.1
2	Buffalo	51.6	29.6	14.4	2.3	2.0



24.8g/100g
2.1g/100g

4.8

Procedure :

Milk 2-5 kg is boiled in karahi or aluminium vessel over open fire with stirring by khunti. Then keep it simmering hot in karahi. The hot milk is taken in coagulating vessel in batches 0.5 to 1 kg. The coagulant is then added 2 to 2.5 g/hg milk in to milk and stirred with ladle so that it mixes properly and clear coagulation take place. The chhana is collected by straining it through muslin cloth. Then it is cooled and stored for preparation of sweets.

Quality of Chhana :

The body and texture of chhana is influenced by several factors i.e. pH/acidity of coagulant, temperature at time of coagulation, strength of the coagulant, type of coagulant, speed of stirring while mixing coagulant.

Requirement to good quality of Chhana :

- i) Cow milk is suitable.
- ii) pH of coagulant should be 5.4
- iii) Temperature of coagulation should be 82 °C and coagulation should be effected about 0.5 to 1 minutes.
- iv) Strength of coagulating acid should be 1-2%. The lactic acid produce granular texture which is suitable for rossogolla making while citric acid produce pasty chhana which is suitable for sandesh.

Physical quality of Chhana :

Cow milk produce soft body and smooth texture and suitable for sweets i.e. Rossogolla and sandesh while buffalo milk produce slightly hard body, greasy and coarse texture and not suitable for making sweets.

S N.	Characters	Cow milk chhana	Buffalo milk chhana
1.	Colour	Light yellow	Whitish
2	Appearance	Moist surface	Greasy surface
3	Body	Soft	Slightly hard
4	Texture	Smooth	Slightly coarse
5	Flavour	Mildly acid	Mildly acid
6	Suitability for sweets	Highly suitable	Not suitable

Yield :

Normally the yield of chhana containing 49-54% moisture ranges from 16-18% for cow milk and 22-24% for buffalo milk. It is affected by fat and casein or TS in milk, moisture in chhana, method of stirring and losses.

Keeping quality :

The keeping quality of chhana under ordinary packing is at 7 °C for 12 days, at 24 °C for 3 days and at 37 °C for 2 days.

Defects in chhana :

- Flavour : Sour, rancid, smoky, stale.
- Body texture : Hard body, coarse texture
- Colour and appearance : Dry surface, visible dirt and mouldy surface

Uses :

- Rasogolla, sandesh, pantota and chhana kheer (kheer-paneer) etc.
- for direct consumption with an addition of sugar or salt.
- for the preparation of cooked vegetable dishes e.g. matar paneer, sag paneer etc.

(C) Paneer

Definition : Panir refers to the indigenous variety of rennet coagulated, small sized, soft cheese. Examples are surti panir, bandal cheese, etc.

Composition of Panir (percentage)

Sr No.	Type of milk used	Moisture	Total solids	Fat
1	Cow	71.2	28.8	13.5
2	Buffalo	71.1	28.9	13.1

Method of preparation :

Fresh buffalo milk, standardized to 6% fat, is pasteurized by heating it to 78 °C for 20 minutes and promptly cooled to 35 °C. The milk is coagulated in a batch of 0.5 to 2 kg milk in coagulated vat by adding good quality lactic starter @ 0.5 % of milk and thoroughly mixed. This is followed by addition of rennet @ 6-7 ml / 100-litre of milk. The rennet solution is prepared by diluting it in 20 times of its volume of water. The renneted milk is allowed to set till a firm coagulum fit for basketing is obtained. During coagulation and setting the temperature is maintained at 35 °C by circulating warm water around vat. The curd is then ladled out with a vertical stand in thin slices and filled by cleaning them with deeping in 10% lukewarm salt solution for 10 minutes and then thinly dressed with salt. Then curd is placed in basket layer by layer. Salt @ 2% of milk is sprinkled on every layer till filling of basket. Filled baskets are placed on draining rack for drainage of whey for 50-60 minutes and whey is collected in a tray. At this stage curd is turned in respective basket. After 30-40 minutes again second turning is given. So that panir will attain desired firmness and consistency. Whey collected previously is strained. The pieces of panir removed

पनीर
↓ 10%
Coagulate
↓
वसुधा
↓
पनीर
↓
पनीर

from baskets carefully and submerged in the whey for 12-36 hours till disposed of or used.

Yield:

The yield of panir is approximately 28.5% for cow milk and 34.0 % for buffalo milk.

Keeping quality:

This is normally 1-2 days at room temperature and 6 days at 5-10 °C storage.

Use : For direct consumption.

Market quality :

When kept in whey, panir should have firm body and smooth texture with no internal cracks, striations or loose moisture droplets. It has a salted, mild acid-curd flavour.

↑ 2nd / 12th (D) Dahi / Yoghurt

Dahi is well known fermented milk product consumed by large section of the population throughout India, either as a part of the daily diet or as refreshing beverage. The fermented milks constituent 9 per cent of the total milk production and 16.6 per cent of the milk converted in to milk product. The conversion of milk into *Dahi* is an important intermediary step in the manufacture of indigenous product such as butter and ghee.

Food and Nutritive value of *Dahi* :

It has been established that fermented milk products including dahi increase in food and nutritive value as compared to the original milk.

- i) *Dahi* is more palatable.
- ii) It will be consumed by those people who do not like to drink milk.
- iii) *Dahi* is more easily digested and assimilated than milk.
- iv) *Dahi* content antibiotic produced by starter culture.

Hence it has therapeutic value in stomach and intestinal disorder.

Definition : *Dahi* is the product obtained from pasteurized or boiled milk by souring, natural or by harmless lactic acid or other bacterial culture. It should have same percentage of fat and solids-not fat of the milk from which it is prepared. *Dahi* may contain addition cane sugar (in case of sweet *dahi*).

According to the Indian standard, *Dahi* should have following requirement

Requirements for *Dahi* :

Sr. No.	Characteristics	Requirement	
		sweet <i>dahi</i>	sour <i>dahi</i>
1	Acidity, lactic acid (% wt) (maximum)	0.7	1.0
2	Yeast and mold count per g (maximum)	100	100
3	Coliform count per g (maximum)	10	10
4.	Phosphatase test	-ve	-ve

Classification of *Dahi* :

Dahi for direct consumption is classified into

- i) Whole milk *dahi*
- ii) Skim milk *dahi*
- iii) Sweet (or mildly sour) *dahi*
- iv) Sour *dahi*
- v) Sweetened *dahi*.

Traditional method for preparation of *dahi* :

It is prepared on small scale by consumer's house hold or sweet maker's. In household milk is boiled, cooled to body temperature, inoculated with 0.5 to 1 per cent starter culture i.e. previous day *dahi* or butter milk and then allowed to set undisturbed over night. In winter *dahi* setting vessel is usually wrapped up with woollen cloth to maintain warm condition. Earthen pots are used for making *dahi*.

Dahi thus prepared is sub-standard due to low quality milk, use of undesirable starter culture, improper temperature of incubation, badly cleaned utensils.

Standard method for preparation of *dahi* :

Procedure:

Fresh, sweet, clean milk is used for preparation of *dahi*. It is pre-heated to 30-40 °C and filter or strain through muslin cloth. It is then standardized to 2.5-3.0 % fat and 10.0 per cent solids not fats to improve the body. Then milk is preheated to 60 °C and homogenized it at a pressure of 176 kg/sq. cm. followed by pasteurization of milk at 80-90 °C for 15-30 minutes and cooled to 22-25 °C. It is then inoculated with 1-3 per cent of specific starter culture such as *Streptococcus lactis*, *Streptococcus cremoris* and *Streptococcus diacetylactis* single or in combination with or without *Leuconastock citrovorum* or *Leuconostoc dextranicum*. It is then filled in wide mouth glass bottles or plastic cup and incubated at 22-25 °C for 16-18 hours during which period the acidity

reaches 0.6 to 0.7 % and firm curd is formed. The curd is then cooled to less than 12 °C in about 1 hour by circulating chilled water and then stored at 5 °C if a cold room.

Keeping quality:

Dahi prepared by traditional method has a short keeping quality at room temperature, under refrigerated storage it keeps well for one week.

Uses of dahi :

(a) Whole milk dahi :

- (i) used for direct consumption,
- (ii) preparation of chakka, shrikhand and makkhan and Lassi.

(b) Skim milk dahi :

- (i) used for heart patients.
- (ii) It is low in fat and cheap but nutritious hence suitable for low income group of people.

Quality of dahi : Good quality dahi should have following requirements :

(i) Colour:

Yellowish creamy white for cow milk and creamy white for buffalo milk and free from browning.

(ii) Appearance :

Smooth and glossy surface, cream layer on top and free from extraneous matter.

(iii) Flavour :

Mild, pleasant smell, clean acid taste, free from off flavours.

(iv) Body :

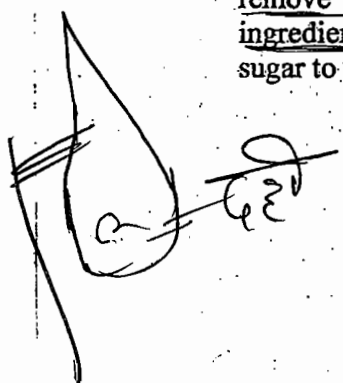
Soft and firm, free from gas holes and whey pocket.

(v) Acidity : Per cent lactic acid : 0.75 – 0.85.

Carbon di oxide gas is bubbled through the milk at the rate 1 psi for 1 minute and bottles are crown corked. The milk is then incubated at 25 – 30 °C for 16 to 18 hours until a firm curd is obtained. Such dahi has storage life of 15-30 days at room temperature.

(E) Chakka and Srikhand

Srikhand is semi-soft, sweetish-sour, whole milk product prepared from lactic fermented curd. The curd/dahi is partially strained through a cloth to remove the whey and thus produce a solid mass called Chakka (The basic ingredient for shrikhand). This chakka is mixed with the required quantity of sugar to yield srikhand.



→ ram

2 pistu, fa fall,
claw

Signature

Composition of Srikhand :

The composition of chakka will depend on the initial composition of milk, the degree of fermentation (i.e. acidity developed) and the extent of whey removed. These three factors along with the amount of sugar added, influenced the composition of srikhand.

Composition of chakka (Percentage)

Product	Moisture	Fat	Protein	Lactose	Ash	Sugar	Lactic Acid
Chakka	59.6	22.4	10.3	4.4	1.0	-	2.3

Method of preparation:

- 1) Take fresh, sweet, standardized buffalo milk to 6.0%
- 2) Pasturized it at 71 °C for 10 minutes and cooled to 28-30 °C.
- 3) It is then inoculated @ 2.0 per cent with lactic culture and mixed well.
- 4) Incubate the mixture at 28-30 °C for 15-16 hours (over night).
- 5) When the curd is set firmly and developed acidity 0.7 to 0.8 per cent, broken the curd.
- 6) Place the broken curd in a muslin cloth bag and hung it on pag for removal of the whey for 8-10 hours. During this period the position of curd may altered or squeezed it to facilitate whey drainage.
- 7) The solid mass so obtained is called as chakka.
- 8) The clean, good quality crystal or ground sugar in required quantity i.e. 35 to 45 % of weight of chakka is added and mix it uniformly by kneading chakka.
- 9) Add colour and flavour and mix it properly and uniformly.
- 10) The product obtained is known as Srikhand.

F) Ghee

Definition : It is clarified butter fat prepared chiefly from cow or buffalo milk.

According to PFA rules, 1976, ghee is the pure clarified fat derived solely from milk or from desi butter or from cream to which no colouring matter is added.

Chemical composition of Ghee :

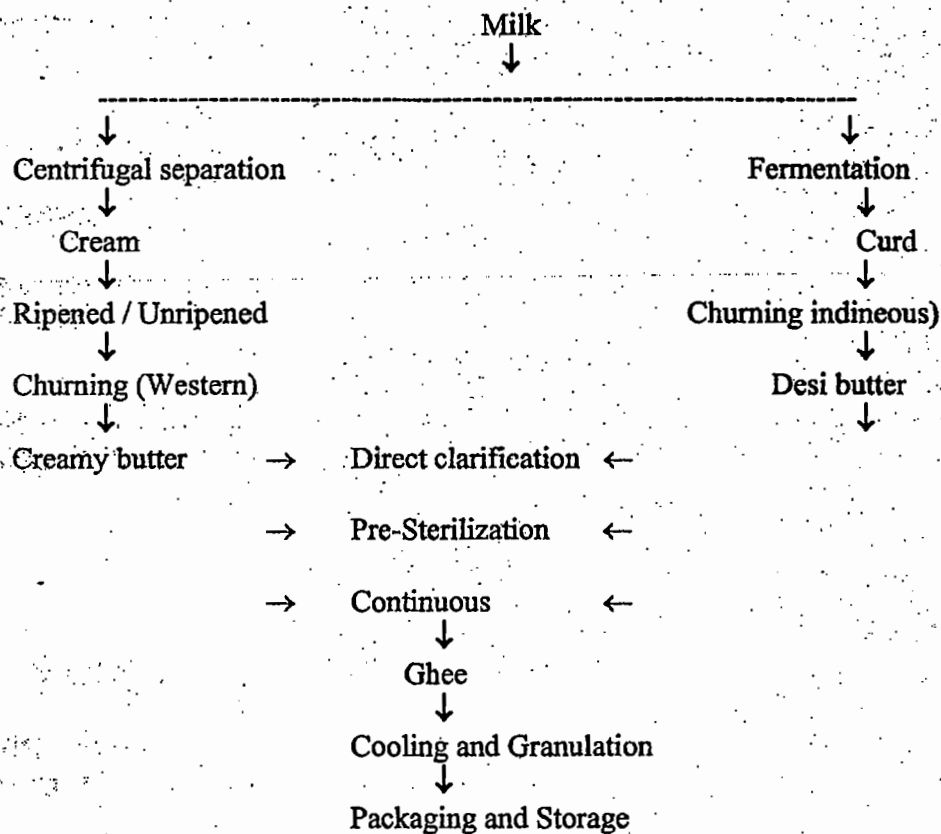
Characteristics	Cow	Buffalo
Milk fat (%)	99.0 - 99.5	99.0 - 99.5
Moisture (%)	0.2 - 0.5	0.2 - 0.5
Unsaponifiable matter		
a) Carotene (ug/g)	3.2 - 7.4	-

b) Vitamin A (IV/g)	19 – 34	17 – 38
c) Tocopherol (ug/g)	26 – 48	18 – 37
Free fatty acid (% oleic)	1 – 3	1 – 3

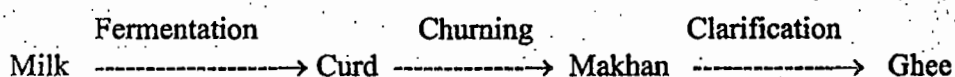
Methods of production :

- Country / Desi method
- Creamery butter method
- Pre-stratification method
- Direct – cream method
- Continuous method

Flow diagram of manufacture



A) Country / Desi method : the indigenous route -



Butter milk

This is the traditional method in which milk taken with or without boiling in to vessel and allowed to sour by itself or seeded with curd of uncertain quality. Curd (soured milk) stored for long periods before churning. Churning performed in earthen or mud pots. The buttermilk is consumed and makhan (butter) stored for long periods in pots. Clarification done in mud / metallic pot either too high or too low temperatures. Ghee is ready stored in mud pots or metallic vessels. Melted frequently for use.

B) Creamery Butter Method :

Standard method adopted in organized dairies. Raw material used is unsalted creamery butter (white ghee).

The butter is heated in an improved ghee boiler, which is of stainless steel jacketed pan (vessel) provided with manual stirrer. A steam control valve, pressure and temperature indicators are also provided.

The solid mass of butter is heated over a low fire and carefully stirred so that it melts. Mass starts boiling and water vapours from contents over 90°C get off. The temperature is kept constant till all moisture is driven out. The scum gathers on the top of boiling mass removed from time to time by perforated ladle.

When practically all moisture is driven out, the temperature of liquid mass suddenly shoots up and heating is carefully controlled. At this stage characteristic of ghee flavour emanates, which is the indication that it has been heated sufficiently. The final temperature of heating or clarification ranges from 110 to 120°C .

When final stage reaches the cooling is done, the ghee is filtered through muslin cloth so as to separate it from sediments known as ghee residue.

Ghee goes on for granulation and packaging.

C) Pre-Stratification method :

It is based on the principle of clarification and separation into layers has been called pre-stratification.

When butter is left undisturbed at a temperature of $80-85^{\circ}\text{C}$ for 15 – 30 minutes, it stratifies into 3 distinct layers i.e. Top layer – heating denatured particles of curd. Middle layer – fat and Bottom layer - of butter milk.

The bottom layer of butter milk is mechanically removed without disturbing the top and middle layers.

Afterwards, the temperature of remaining two upper layers is raised to usual clarifying temperature of $110-120^{\circ}\text{C}$.

D) Continuous method :

This is under development. It is to manufacture ghee or industrial scale as continuous process, to ensure uniform quality, greater economy.

To reduce human labour, utilization of machine to get fat recovery and clean production.

(G) Lassi

Definition : Lassi is also called Chhas or Matha. Lassi refers to Desi butter milk, which is the by-product obtained when churning curdled whole milk with indigenous device for the production of desi butter.

Composition : The composition of lassi varies according to the composition of dahi, the extent to which curd is diluted when churning and the efficiency of fat removed.

Composition of Lassi (Percentage)

Water	Total Solids	Fat	SNF	Protein	Lactose	Ash	Lactic acid
96.2	3.8	0.8	3.0	1.3	1.2	0.4	0.44

Food and Nutritive value :

Lassi contained appreciable amount of milk proteins and phosphitids. It is an excellent beverage for quenching thirst due to its acidity by lactic acid.

Yield :

It depend on the dilution of curd when churning. On an average 55 kgs of lassi is produced for every kg of ghee.

Uses :

- As a beverage in summer by addition of ice, salt, sugar
- As a starter culture
- As a coagulant.

H) Basundi / Kheer

Definition : Kheer or basundi is an Indian milk product prepared by the partial dehydration of whole milk in a karahi over direct fire together with sugar and usually rice or occasionally somolina.

Chemical composition of Basundi (percentage) :

Sr.No.	Particulars	Percentage
1	Moisture	67.02
2	Fat	7.83
3	Protein	6.34
4	Lactose	8.45
5	Ash	1.41
6	Sugar (added)	8.95

It depends on composition of milk, dehydration or extent of concentration, added sugar and rice.

Standardized method of Basundi preparation :

Fresh clean cow or buffalo milk is standardized to 4 per cent fat, is vigorously boiled in a jacketed stainless steel pan or kettle for 3 to 5 minutes with constant stirring cum scrapping with khunti. High grade (basmati) rice is cleaned and washed with cold water is added in the milk @ 2.5 per cent of milk. The mixture is gently boiled with periodical stirring cum scraping. When milk is concentrated about 1.8 : 1 clean good quality ground sugar is added @ 5% of milk. Gentle heating is continued for another 3 to 5 minutes till a final concentration of about 2:1 is obtained. Heating should be stopped, some what before this stage. Then Basundi should be packed and stored under refrigeration.

Yield :

Yield of Basundi / kheer vary according to total solids in milk, amount of rice and sugar added and the ratio of concentration. If the ratio of concentration is about 2:1 then yield of finished product is about the 50 per cent of the milk used.

Keeping quality : The average shelf life of Basundi is 2 to 3 days at $37 \pm 1^\circ\text{C}$ and 10 to 15 days at $4 \pm 1^\circ\text{C}$.

Uses : For direct consumption as a dessert

(I) Rabri

Definition : Rabri is essentially clotted cream, skimmed off from slowly evaporating whole milk with sugar.

Principle :

This is an especially prepared concentrated and sweetened whole milk product, containing several layers of clotted cream while the milk is slowly evaporated (without stirring) at simmering temperature in a karahi over an open fire, pieces of skin form on the surface of the milk are continuously broken up and moved to the cooler parts karahi till volume of milk is reduced to one fifth of its original volume. Sugar is added to it. Then layers of clotted cream are immersed in the mixture and finished product obtained by heating the whole mass for another short period.

Procedure:

Take 3-4 kg whole milk in a clean karahi, keep it over open fire to semmering temperature $85-90^\circ\text{C}$ and maintain the temperature by controlled heating. The milk is neither stirred nor allow to boil. The skin is formed on the surface due to evaporation of water. This skin is broken in to pieces about 3-4

cm squire by wooden stick or khunti and moved to the cooler part of the karahi. When volume of the milk is the pan reduced to about 1/5 of its original volume, Good quality sugar @ 5-6 per cent by weight of the original milk is added in the concentrated milk and dissolve it. The layer of the cream skin spread previously over the cooler part or surface of the karahi are scrapped and immersed in the mixture. Then heat the mixture gently for brief period to obtain Rabri. The product is then packed in suitable container.

Composition of Rabri :

It depends on the milk composition, degree of concentration of milk solids and sugar added. Average composition in percentage is as follows :

Sr.No.	Particulars	Percentage
1	Moisture	30%
2	Fat	20%
3	Protein	10%
4	Lactose	17%
5	Ash	3%
6	Sugar	20%

Lecture No. 13

ISI, PFA and AGMARK standards for milk products.

Comparative study of PFA and Agmark standards

Sr. No.	Particulars	BIS	PFA	Agmark
1	Expansion of standards	Formerly Indian Standards Institution, Now Bureau of Indian Stand	Prevention of Food Adulteration	'Ag' for Agricultural and 'mark' for marking.
2	Committee members	<p>Members from chemical, civil engineering, consumer product, electro technical, engineering, structural, textile and agril. Food products. Each representative is nominated by Government of each state.</p> <p>Two representatives are nominated by Central Government to represent two union territories.</p> <p>One representative each nominated by Central Govt. to represent the Agr. Commercial and industrial interest.</p> <p>Five representatives are nominated by the Central govt. to represent the consumer interest one of whom shall be noted interested.</p> <p>One representative is nominated by ISI.</p> <p>One representative of the medical proportion nominated by the Indian Council of</p>	<p>Director General for health service.</p> <p>Director of the food laboratory. Two experts are nominated by the Central Government. One representative for each Department of food and agriculture.</p>	<p>Members from Ghee testing laboratory.</p> <p>Members from Agril. Marketing department.</p>

		Medical Research.		
3	Presiding authority the ex-officio	Union Minister of Industry is the ex-officio President of BIS.	Director General of health services is the presiding authority	State marketing Officer of the Agril Marketing is President of DFA, 1938.
4	Commencement	1947	PFA act attracted in 1954 Pfa rule started in 1955	1938
5	Functions	In the international field ISI represents India in the International Organisation (ISO), International electro Technical Commission (IEC) respectively link 54-40 countries and function through 18 and 58 technical committees	The Central Government, shall by notification in the official gazette establish one or more central food laboratories to carry out the functions entrusted to the central food laboratories, by this act, on any rules made under this act.	Ghee testing laboratories should have precise apparatus glassware and glass ware and chemical for the complete examination ghee for its physico chemical constants free fatty acid and performance of boundonic test and other test.
6	Object	To prepare standard on national and International basis and promote their general adaptation	To prevent food adulteration if any	To ensure the consumer a product of pre-tested quality and purity
7	Labeling	BIS	Contains permitted Food colour conforms to Indian Prevention of food Adulteration rules	To enable manufacture of high quality products 'Agmark'

AGMARK : (AG for "Agricultural" and MARK for "Marketing") : With a view to developing the orderly marketing of agricultural produce on an all India Basis. The Indian Legislature had passed the **Agricultural Produce (Grading and Marketing), Act, 1937**, and **The General Grading and marketing Rules, 1937**, and **Ghee Grading and marketing Rules, 1938**. This provides for the grading of Ghee on a voluntary basis.

ISI Standards (Indian Standards) : According to the Prevention of Food Adulteration (PFA) Rules, 1976, the standards for different classes and designations of milk and milk products.

Legal standards : a) Milk : As per PFA Rules, it is recommended as below :

Standards of different milks in India

Sr. No.	Class of milk	Designation	Minimum	
			% MF	% MSNF
1	Buffalo milk	Raw, pasteurized, boiled, flavoured and sterilized.	6.00	9.0
2	Cow milk	-do-	3.5 - 4.0	8.5
3	Goat or sheep milk	-do-	3.0-3.5	9.0
4	Standardized milk	-	4.5	8.5
5	Recombined milk	-	3.0	6.5
6	Toned milk	-	3.0	8.5
7	Double Toned milk	-	1.5	9.0
8	Skim milk	-	Not > 0.1	8.7

Note : i) When milk offered for sale without any indication of the class, the standards prescribed for buffalo milk shall apply.

ii) The heat treatment for the various designated milk shall be as follows :

Designation	Heat treatment
Raw	Nil
Pasteurized	Pasteurization
Boiled	Boiling
Flavoured	Pasteurization or Sterilization
Sterilized	Sterilization

Quality test : Plat form test) :

Market requires milk of higher (standard) quality from the stand point of good health, flavour, sanitary quality, keeping quality, aesthetic quality and legal requirements. The quality of milk influences the quality of milk products manufactured from it.

The various plat form tests used to check quality for the receiving milk in the dairy industry as :

- | | |
|------------------|------------------------|
| i) Smell (odour) | ii) Appearance |
| iii) Temperature | iv) Sediment |
| v) Acidity | vi) Lactometer reading |

AGMARK Standards for Ghee

Objectives :

- i) to assure the consumer a produce of pre-tested quality and purity.
- ii) To enable manufacturers of high grade products to obtain better returns and
- iii) To develop an orderly marketing by eliminating malpractices when transferring commodity from producer to consumer.

Pre-requisites for using the AGMARK label :

- i) The grading under the Act is voluntary.
- ii) Application should be submitted through State marketing Officer to the Agricultural Marketing Adviser to the Government of India.
- iii) Eligibility is assessed to the person who have full facilities of modern dairy factory for ghee making and storing, should have modern refinery and spacious godown, well equipped laboratory, a wualified ghee chemist,
- iv) there should be enough space for receiving butter or kachacha aghee and the testing the same.
- v) The ghee testing laboratory should have precise equipments, apparatuses, glassware and chemicals to examine free fatty acids, performance of baudouin test and phytosterol acetate test.

Procedure for using AGMARK label :

Agmark ghee is packed under two grades i.e. special and general which is represented by two different coloured labels i.e. Red label and Green label, respectively. The difference in grades is decided on the extent content of free fatty acids (oleic) i.e. special grade is limited to 1.4 % & general grade to 2.5 %.

The samples of each lot of freshly made ghree at both places, factory and refinery are drawn, divided in 3 parts. One analysed by chemist himself, other sent to control laboratories maintained at Kanpur (UP) at Rajkot (Gujrath). Third is sealed kept with packet for future reference.

Sample drawn ghee is filled in new tins which are marked with particulars i.e. melt number, date of packing, name of authorized packer. If the analysis of sample satisfies specifications, the chemist arranges for fixation of AGMARK labels of appropriate grade. Agmark labels printed under security conditions on water mark paper bearing word "Government of India" in macro tint to avoid counter feiting.

Quality control checks :

- i) A check on the quality and purity of ghee is exercised by frequent inspection of the grading stations by State and Central Marketing staff. Samples of graded ghee collected from market (both retail and wholesale). If on analysis, it is found below specifications, the entire melt declared mis-graded and packet has to arrange for the removal of Agmark labels.

- ii) to ensure that graded ghee is not stored for an indefinite period so as to impair its quality, chemist require to draw representative check samples from stored tins and sent them to Control Laboratories. If the acidity there is developed in excess of limit prescribed on label, it is down graded from Special to General or rejected and Agmark label removed from tins.

Agmark Ghee specifications : The standard specifications for all India and for all seasons are as below :

Agmark Standards for Ghee

Sr.No.	Tests	All India	Regional *	
			Winter	Summer
i)	Baudovin		Negative	Negative
ii)	Phytosterol acetate		Negative	Negative
iii)	B.R. reading (400C)	40.0 - 43.0	41.5-44.0	42.5 - 45.0
iv)	R.M. value	Not < 28.0	Not < 23.0	Not < 21.0
v)	P. Value	1.0 - 2.0	0.5 - 1.2	0.5 - 1.0
vi)	Moisture (%)		Not > 0.3	Not > 0.3
vii)	Free fatty acid (% oleic)			
a.	Agmark Red label		Not > 1.4	Not > 1.4
b.	General grade Agmark Green label		Not > 2.5	Not > 2.5

(* Note ; where cotton seed is extensively fed to milch animals)

prevention & food adulteration (

58

14) INTERNATIONAL STANDARDS

Codex Alimentarius Commission is international group of food standards to which many countries have given their approval to ease movement of food commodities across foreign boundaries. The basic purpose of Codex is to ensure safety and uniform quality of the foods traded internationally and to provide equitable contract treatment to purchaser & seller. The Codex Alimentarius Commission was created in 1962 by a joint effort of FAO & WHO of the United Nations.

Table 1. Standards of Whole Milk Powder (WMP) and Skim Milk Powder (SMP)

Characteristics	Name of the Product						
	W.M.P			S.M.P			
	PFA	BIS*	Codex**	PFA	BIS*	Codex**	
					Standard grade	Extra grade	
Fat %	26.0 Min.	26.0 Min.	26.0-42.0	1.5 Max.	1.5 Max.	1.25 Max.	1.5 Max.
Moisture %, Max.	5.0	4.0	5.0	5.0	4.0	3.5	5.0
Total Ash %, Max.	-	7.3	-	-	8.2	7.3	-
Acidity %, Max.	1.2	1.2	-	1.5	1.5	1.5mg/g (lactate)	-
Solubility %, Min.							
Spray	98.5	98.0	-	98.5	98.0	-	-
Roller	85.0	85.0	-	85.0	85.0	-	-
Insolubility index ml., Max. Spray	-	2.0	-	-	2.0	0.5	-
Roller	-	15.0	-	-	15.0	-	-
Total count/g, Max.	50,000	40,000	Absent	50,000	50,000	40,000	Absent
Coliform count/g, Max.	90	Absent in 0.1 g	Absent	90	Nil in 0.1 g	Nil	Absent
Stabilizers %, Max.	0.3		0.5	-	-	-	0.5
Milk proteins in milk SNF %, Min.	-	-	34.0	-	-	-	34.0
Scorched particles	-	-	-	-	-	Disc. B	-
BHA %, Max.	0.01	-	0.01	-	Nil		0.01
Staph. aureus	-	-	-	-	-	Nil	-
Salmonella	-	-	-	-	-	Nil	-

* on dry matter basis

** the proposed standards. The product shall be free from micro-organisms and parasites and not contain any substance originating from micro-organisms in amount which may represent a hazard to health.

- Not prescribed

Table 2. Standards of Whole Milk Powder (WMP) and Skim Milk Powder (SMP)

Characteristics	Name of the Product					
	W.M.P.			S.M.P		
	FAO	IDF	ADMI *	FAO	IDF	ADMI*
Fat %	26.0 min.	24.0 min.	26.0 min.	1.5 max.	1.5 max.	1.25 max.
Moisture % Max.	5.0	5.0	2.5	5.0	5.0	4.0
Titrate Acidity % of the reconstituted milk, Max.	-	-	0.15	-	-	0.15
Bacterial count/g. Max.	-	50,000	30,000	-	50,000	30,000
Coliform count/g. Max.	-	100		-	100	-
Solubility index ml. Max.	-	-	0.5	-	-	0.5
Salmonella/g Max.	-	Absent		-	Absent	-
<i>S. Aureus</i> /g, Max.	-	10	A	-	10	A

* For extra grade powder

- Not prescribed

Table 3. Standards of Cream Powder & Partly Skimmed Milk Powder

Constituents	Cream powder		Partly skimmed milk powder	
	PFA	Codex*	PFA	Codex*
Fat %, Min.	-	42.0	1.5-26.0	1.5-26.0
Moisture %, Max.	-	5.0	5.0	5.0
Proteins in milk SNF %, Min.	-	34.0	-	34.0
Acidity Regulators %, Max.	-	0.5	0.3	0.5
Anticaking agents %, Max.	-	0.1	-	0.1
BHA %, Max.	-	0.01	0.1	0.01

* Proposed standards, the product shall be free from micro-organisms and parasites and not contain any substance originating from micro-organism in amounts which may represent a hazard to health.

- Not prescribed

Table 4. Standards for Condensed Milk products

Name of the product \$	Constituents (%)											
	Fat(%)				Milk Solids(%), min.				Sugar(%), min.			
	PFA	BIS***	FAO	Codex*	PFA	BIS**	FAO	Codex*	PFA	BIS*	FAO	Codex*
S.C.M	9.0 min	9.0 min.	8.0 min	8.0 min	31.0	31.0	28.0	28.0	40	40	-	-
S.C.S.M	0.5	0.5 max.	-	1.0	26.0	26.0	24.0	24.0	40	40	-	-
Evaporated Milk	8.0	-	7.5	7.5	26.0	-	25.0	25.0	-	-	-	-
Evaporated S. Milk	0.5	-	-	1.0	20.0	-	20.0	20.0	-	-	-	-
Evaporated partly S.Milk	-	-	-	1.0-7.5	-	-	-	20.0	-	-	-	-
S.C.H.F.M	-	-	-	16.0	-	-	-	14.0**	-	-	-	-
S.C.P.S.M	3.0- 9.0	-	-	1.0-8.0	28.0	-	-	24.0 20.0**	40	-	-	-
Evaporated high fat milk	-	-	-	15.0	-	-	-	11.5**	-	-	-	-

- S.C.M - Sweetened Condensed Milk
 S.C.S.M - Sweetened Condensed Skim Milk
 Evaporated Milk - Unsweetened Condensed Milk
 Evaporated S. Milk - Unsweetened Condensed Skim Milk
 S.C.H.F.M - Sweetened Condensed High Fat Milk
 S.C.P.S.M - Sweetened Condensed Partly Skimmed Milk

* Proposed standards, The product shall contain min. 34% proteins in M.S.N.F. free from micro-organisms and parasites

** Milk Solids-not-fat

*** Shall not contain more than 0.35% acidity, 500/g total count, 10/g yeasts and mould count. The *coliforms* and *S. aureus* should be absent

\$ Shall contain not more than 0.3% each of acidity regulators and stabilizer under codex and 0.3 % when used in combination under PFA and BIS.

- Not prescribed

Table 5. Standards for Table Butter

Constituents	Name of the standard				
	PFA	Agmark	Codex**	FAO	IDF
Fat %, Min.	80.0	80.0	80.0	80.0	80.0
Moisture %, Max.	-	16.0	-	18.0	18.0
S.N.F.(Curd) % Max.	1.5	1.0	2.0	2.0	2.0
Salt %, Max.	3.0	-	-	-	-
Diacetyl, Max. ppm.	4.0	4.0	-	-	-
Acidity Regulators %, Max.	0.2	-	0.2	-	-
Annato extract Max., %	*	-	0.002	-	-
Lead, Max. ppm.	0.5	-	0.05	-	-
BHA %, Max.	-	0.02	-	-	-

* Allowed but not specified

** Proposed standards, The product shall be free from micro-organisms and parasites and not contain any substance originating from micro-organisms in amounts which may represent a hazard to health

- Not prescribed

Table 6. Standards for Butter Oil and Ghee

Constituents	Butter Oil				Ghee			
	PFA	BIS	Codex*	FAO & IDF	PFA	Codex*	Agmark***	
							Sp. quality	General quality
Milk fat %,Min.	-	99.5	99.6	99.3	-	99.6	-	-
Moisture %, Max.	0.5	0.5	0.1	0.5	0.5	0.1	0.3	0.3
R.M.Value**, Min.	28.0	28.0	-	-	28.0	-	28.0	28.0
BR at 40°C**	40-44	40-44	-	-	40-43	-	40-43	40-43
Peroxide value+	-	0.8	0.6	-	-	0.6	-	-
FFA % Max.	3.0	0.3	0.4	-	3.0	0.4	1.4	2.5
BHA: mg/kg(i).	200	200	100	-	200	100	-	-
BHT,mg/kg(ii)	-	-	75	-	-	75	-	-
Propyl gallate, mg/kg(iii)	-	-	175	-	-	175	-	-
Combination of i,ii & iii,mg/kg	-	-	200	-	-	200	-	-
Tocopherols, mg/kg	-	-	500	-	-	500	-	-
Boudouin Test	-Ve.	-	-	-	-Ve	-	-Ve	-Ve

* Proposed standards. The product shall be free from micro-organisms and parasites and any other substance, originating from micro-organisms in amount which may represent hazard to health.

** For Northern region, different for different regions in the country

*** For non-cotton tract Area.

+ Milli equivalent of oxygen/kg fat.

- Not prescribed

Table 7. Standards for different types of Ice-creams and Frozen Confections

S.No.	Constituent	Ice cream			Reduced-fat Ice cream		Low-fat Ice cream		Frozen confection		Reduced-fat frozen confection		Low-fat frozen confection	
		PFA	Codex	BIS**	PFA*	Codex	PFA*	Codex	PFA*	Codex	PFA*	Codex	PFA*	Codex
1.	Total solids, % (min.)	36	30	36	28	28	26	26	36 (30)	30	30	30	20	20
2.	Milk fat, %	10	8	10	2.5-6	2.5	<2.5	<2.5	-	-	-	-	-	-
3.	Fat including, if present, milk fat, %	-	-	-	-	-	-	-	10 (8)	8	2.5-6	5	<2.5	<5
4.	Milk protein [@] , %	3.5	2.5	-	2.5	2.5	2.5	2.5	-	-	-	-	-	-
5.	Protein including, if present, milk protein [#]	-	-	-	-	-	-	-	3.5 (2.5)	2.5	2.5	2.5	2.5	<2.5
6.	Emulsifier & Stabilizer(%)	0.5	1.0	0.5	0.5	1.0	0.5	1.0	0.5	1	0.5	1.0	0.5	1.0
7.	Weight per litre, g, min.	525/540*	475	525/540	525	475	525	475	525	475	525	475	525	475
8.	SPC/g* Max.	2,50,000 [†]	(-)	250,000	50,000	(-)	50,000	(-)	50,000	(-)	50,000	(-)	50,000	(-)
9.	Coliform count/g, max.	100*	(-)	90	100	(-)	100	(-)	100	(-)	100	(-)	100	(-)

* Proposed

** Acidity (max.) 0.25% l.a.; sucrose (max.) 15%

@ Whole milk equivalent

PER 2.7 corrected at 2.5 for casein

(-) The product shall not contain any pathogenic organisms; it shall not contain any substances originating from micro-organisms in amounts which may represent a hazard to health; it shall not contain any other poisonous or deleterious substances in amounts which may represent a health hazard.
Not prescribed

Table 8. Proposed standards for PFA for different type of cheeses

S.No.	Name of the Product	FDM % Min.	Moisture % Max.
1.	Permesen, Romano cheeses	32	35
2.	Brick, Swiss, Gouda cheeses	45	52
3.	Low fat permesen, Romano-cheeses	19.5	35
4.	Low fat Brick, Swiss, Gouda Cheeses	27.0	52
5.	Cottage, Cream Ricotta cheeses	20	80
6.	Low fat Cottage Cheese	0.5-2.0	82.5
7.	Process cheese food	23 % of the finished product	44
8.	Mozzeralla cheese	35	60
9.	Pizza cheese	35	54
10.	Cheese powder	40	5

Table 9. Standards for different types of cheeses

Characteristics	Name of the product (Cheese)							
	Hard (cheddar)		Processed			Spread		
	PFA	BIS	PFA	BIS	Codex *	PFA	BIS	Codex*
F.D.M % ,Min.	42.0	42.0	40.0	40.0	40.0	40	40	40.0
Moisture %, Max.	43.0	43.0	47.0	45.0	48.0	60	60	60.0
Emulsifier/Stabi lizer %, Max.	-	-	4.0	-	-	-	-	-
Sorbic acid %, Max.	0.1	-	0.1	-	-	-	-	-
Salt %, Max.	-	3.0	-	3.0	-	-	-	3.0

* Proposed standards, The products shall be free from micro-organism and parasites and not contain any substance originating from micro-organisms in amounts which may represent a hazard to health.

- Not prescribed

Lecture No. 15

Preservation of milk and milk products by Bio, Herbal, Chemical and Physical preservatives in use.

PRESERVATION OF MILK AT COLLECTION CENTRES :

Operational procedure:

Essentially this is the same as in small dairy on arrival, the milk is graded for the acceptance/rejection, weighed, sampled for testing, cooled and stored at low temperature, until dispatch to processing dairy.

Cooling of Milk : (On farm cooling or at the chilling centers)

Importance :

Milk contains some micro-organisms when drawn from the udder, their number increases during subsequent handling. The common milk micro-organisms grow best between 20 to 40 °C. Bacterial growth is invariably accompanied by deterioration in market quality due to development of off flavours, acidity etc. One method of preserving milk is by prompt cooling to a low temperature.

Effect of storage temperature of bacterial growth in milk

Milk held for 18 hours at 0 °C temp	Bacterial growth factors *
0 °C	1.00
5 °C	1.05
10 °C	1.80
15 °C	10.00
20 °C	200.00
25 °C	1,20,000.00

*Multiply initial count with this factor to get final count.

It will be seen that 10 °C is a critical temp. for milk. Freshly drawn raw milk should therefore, be promptly cooled to 5 °C or below and also held at that temp, till processed.

METHOD :

1) In can or can immersion method :

From carrying pails, the milk is poured directly into cans through a strainer, then cans gently lowered into a tank having cooled water. See that water is not to be entered in milk (so put water level less than can level).

II) Surface cooler:

This may be plain, conical, spiral or horizontal, tubular in shape, although the last named is commonly used.

Milk is distributed over the outer surfaces of the cooling tubes from the top by means of a distributor pipe or a flow. The cooling medium is chilled water which is circulated in the opposite direction through the inside of the tube. The cooled milk is collected in trough by a gravity or a pump.

Advantages :

1. Heat transfer is rapid.
2. Relatively in expensive.
3. Aerates the milk, thus improving its flavour.

Disadvantages :

1. Require constant attention on flow.
2. Chances of air borne diseases.
3. Cleaning and sanitation is not efficient.
4. Slight evaporation losses.

III) In tank or bulk tank cooler :

This method is used in USA, properly designed, run by mechanical refrigeration cools the milk to 5 °C or below and automatically the temp. is maintained during storage period.

Advantage : Permits alternate day milk collection.

Disadvantage: Relatively expensive.

IV. Plate coolers :

For continuous cooling, commonly used in dairy industry, especially for large scale handling. It consists of number of thin flat, grooved, stainless, steel plates, sealed at the edges with a gaskets and clamped tightly within a press. The space between the plates are occupied alternately by the milk and the cooling medium (Chill/brine water). The plates can be added to increase capacity.

Advantages :

1. Heat exchange
2. Not exposed to air borne contamination
3. Cleaning and sanitization is easy by dismantling.

V) Other methods :

Others are tubular cooler, jacketed tanks (for batch cooling) consist tank within a tank with a spacing meant for cooling medium.

PRESERVATIVES**1) BORIC ACID :**

Boric acid and its salts gives red colour with turmeric paper.

Take 5 ml milk in test tube. Add 1 ml conc. HCl and mix well. Dip a strip of turmeric paper in the acidified milk. Dry paper immediately and note the change in colour.

Turmeric paper turns red if boric acid and its salts are added in milk. Development of red colour turning to dark green with Ammonium hydroxide show their presence conformity.

2) CARBONATES AND BICARBONATES:

Rosalic acid develops a rose red colour with milk containing carbonates and bicarbonates, whereas it gives only brownish colour with pure milk.

Take 10 ml milk in a test tube. Add 10 ml of 95 per cent Ethyl alcohol and shake well. Add 3 drops of 1 % aqueous rosolic acid solution. Mix well and observe any change in colour. Rose red colour indicates presence of Carbonate and bicarbonates.

3) FORMALIN :

Formaldehyde gives characteristics violet colour with ferric salts and other oxidizing agents.

Take 10 ml milk in a test tube. Add 0.5 ml FeCl_3 solution. Add carefully 5 ml of conc. H_2SO_4 down sides of the test tube in such a way that it forms a separate layers at the bottom without mixing with milk. Observe the colour of the ring formed at the junction. Development of violet colour indicates presence of formaldehyde.

4) HYDROGEN PEROXIDE:

Para-phenylene diamine hydrochloride gives intense blue colour with H_2O_2 .

Take 10 ml of milk sample in a test tube. Add 2 drops of para-phenylene diamine hydrochloride. Mix thoroughly and observe the colour. Development of intense blue colour shows that H_2O_2 has been added as preservatives.

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Lecture No. 16

Utilization of dairy by products whey and high acid milk.

Dairy by-product may be defined as a product of commercial value produced during the manufacture of a main product.

1. Significance / purpose of judicious utilization :

- i) Increases availability of nutritional milk foods.
- ii) Minimizes problem environmental pollution.
- iii) Makes dairying a profitable industry.
- iv) General welfare in the form of food products.
- v) Justifiable in countries where milk is in short supply.
- vi) Increases return.

2. Kinds of dairy by products and their composition (Table)

Composition of some important dairy by-products

Name of by-product (from cow milk)	Composition				
	Water	Fat	Protein	Lactose	Ash
Skim milk	90.6	0.1	3.6	5.0	0.7
Butter milk	91.0	0.4	3.4	4.5	0.7
Lassi	96.2	0.8	1.4	1.2	0.4
Ghee residue	9.7	61.4	24.8	--	4.1
Channa whey	93.6	0.5	0.4	5.1	0.4
Cheese whey	93.1	0.3	0.9	4.9	0.6
Acid casein-whey	93.1	0.1	1.0	5.1	0.7

3. Methods of Utilization : Utilization of the various indigenous as well as foreign dairy by-products with the names of commonly made food products are given in below table.

By-products	Principle of utilization	Food products is made
Skim milk	Pasteurization	flavoured milk
	Sterilization	Sterilised flavoured milk
	Fermentation	Cultured butter milk
		Acidophilus milk
		Bulgarian butter milk

By-products	Principle of utilization	Food products is made
	Permentation and Concentration	Concentrated sour skim milk Plain condensed skim Milk Low-lactose Condensed skim milk Sweetened Condensed skim milk
	Drying Coagulation	Dried skim milk, Cottage cheese, Bakers Cheese, Quarg Crameloss Sap, sago, casein (edible)
Butter milk	Fermentation and Concentration Drying Coagulation	Condensed butter milk Dried butter milk Soft cheese
Whey	Fermentation Concentration	Whey beverage Yeast whey Plain condensed whey Sweetened condensed Whey, Whey protein Concentrate, Whey paste Lactose Drying Dried whey
	Coagulation	Ricotta cheese Mysot, Gjetort Cheese, primost
Lassi	Icing and seasoning	Beverage
Ghee residue	processing	Toffee or paste or Indigenous sweet meat

Whey :

Whey is obtained as a by-product in preparation of chhena, paneer, cheese and casein. In India major amount of whey about 80 % is obtained as by product from chhena and paneer manufacture.

Whey production is estimated at 3 lakh tons per annum. It is a fluid obtained after separating coagulum from coagulated milk or skim milk. Composition of different types of whey and uses are given below :

Product	Water %	Protein %	Fat %	Lactose %	Sugar%	Ash %
Whey	93.1	0.9	0.3	5.1	-	0.6
Whey milk	90.5	3.6	0.1	5.1	-	0.7
Butter milk (sweet cream)	91.0	3.4	0.4	4.5	-	0.7

Use of whey in different food products

Beverages products	Bakery foods	Cheese	Stimulated milk
Chocolate milk	Confectioneries	Baker's cheese	Meal substitute
Acidophilus milk	Candy	Cottage cheese	Egg substitute
Fresh beverages	Dressing	Process cheese	Margarine
Lactic beverages	Ice cream		
Yoghurt	Soups Sausages		

Preparations made out of whey :

1. **Whey Beverages :** Whey is utilized in the production of fermented beverages, both alcoholic and non-alcoholic (acidic).

a) **Whevit :** it is a name given to soft drink made out of whey. Fresh whey from chena/paneer making is passed through cream separator to remove fat. Then whey is pasteurized at 67 °C for 30 minutes and cooled to room temperature. It is kept overnight to allow whey proteins to precipitated settle down and then filtered through muslin cloth. Now 50 % sugar syrup and 40 % whey, 10 % citric acid and selected colour and flavour in required amounts are added. This mixture is inoculated with yeast culture of *Sacchromyces cerevisiae*.

After mixing the inoculum in whey, it is incubated at 22 °C for 16 hours. It is then bottled and sealed. These sealed bottles of whevit are pasteurized at 72 °C for 15 minutes in hot water, cooled and stored at 5 to 8 °C.

b) **Yeast whey :** Following is the procedure for it :

i) **Types of whey to be used :** Whey obtained in making cottage cheese, cheddar, cheese, casein etc.

ii) **Supplementation of whey :** This is done to increase yield by adding nutrients like ammonium sulphate / phosphate etc.

iii) **Type of yeast culture :** *Saccharomyces fragillis*.

iv) **pH :** 5.0 to 5.7

v) **Temperature :** Optimum temperature 32 °C.

vi) **Size of inoculum :** It is determined by the time required to obtain maximum yield. The yeast suspension is concentrated with a centrifuge so that a slurry of 15-18 % solids is produced. It may be washed at this stage so that the final product is more blend in flavour.

c) Carbonated whevit :

carbonated whevit may be prepared, by using the same method as described for the whevit. The process consists of receiving the whey, separating and steaming it, cooling and precipitating proteins, filtering, adding sugar syrup, citric acid, colour and flavour. The mixture is then filled at 5-10 °C into the carbonation-cum-bottling plant for carbonation and crown-corking. The bottles and their contents are subjected to pasteurization at 75 °C for 10 minutes in hot water, then slowly cooled and stored at a low temperature (5-10 °C) till marketed. Whevit bottles should be gently inverted 2 to 3 times, if required, to make the product homogenous.

2. Whey Paste :

This is manufactured in Russia by pre-concentrating a mixture of whey and skim milk in a vacuum evaporator, and adding sufficient sugar syrup, butter and cream so as to obtain 15 % sugar, 15 % fat and 65 % total solids in the finished product. After slow cooling it to 48 °C, vanilla is added and the product cooled rapidly to 18-20 °C before packaging.

3) Plain Condensed Whey :

This is made by pasteurizing the separated whey and draining the hot liquid into the vacuum pan. The whey may be condensed to any degree upto 70 % total solids. Condensed whey is highly supersaturated with lactose, which may crystallize in the pan itself and prevent the viscous product from flavouring. If crystallization in the pan can be avoided, a smooth bodied paste will flow from the pan as a clear syrup. This must then be rapidly cooled to about 32 °C (90 °F), seeded with lactose and run into containers. It may be used in human and animal food products, it is also valuable in confectionery, baked foods, cheese foods and to make excellent chicken food.

4) Sweetened Condensed Whey :

Separated, pasteurized, sweet, cheese whey with a quantity of sugar equal to the weight of the solids in the whey, is drawn into a vacuum pan and condensed to atleast 75 % total solids. The concentrate is cooled to 35 oC, seeded and stirred slowly for 1 – 3 hours to crystallize the lactose. It may be packed in barrels or cans. It has a salty taste and a characteristic whey flavour. It has good whipping properties, the whipped, sweetened and condensed whey may be used in fruit whips, certain candies and frozen dessert preparations.

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Lecture No. 17

Packaging of milk and milk products with modern techniques.

PACKAGING OF MILK

Introduction :

Package is the technique of using the most appropriate containers and components to protect, carry identify and merchandise any product. It constitutes a vital link between the manufacturer and eventual consumer for the safe delivery of the product through the various stages of manufacture, storage, transport, distribution and marketing.

In spite of all the efforts taken to produce high grade processed milks or manufactured dairy products, unless they are delivered in a fresh, sound and convenient form to the consumer, they are likely to be rejected, thus causing enormous wastage. This loss can be minimized to a great extent by adequate protective packaging to withstand the hazards of climatic changes, transportation, handling, etc.

As a result of socio-economic changes, packaging has become increasingly important in the scheme of distribution. The criteria by which a package is judged are usually the following :

- i) it must protect and preserve the commodity from the time it is packed to the point of consumption,
- ii) it must be suitable for the chosen selling and distribution system;
- iii) it must be attractive to the consumer,
- iv) easy to open,
- v) store and dispose and
- vi) it must cost no more than the market can bear.

Definition :

Packaging means placing a commodity in to a protective wrapper or container for transport or storage.

Functions :

A package must perform the three-fold functions of containing, protecting and merchandizing :

- a) To contain the product : the package / container should be adequately large to hold the product. It should have proper constructional features so as not to allow leakage and spillage. It should have enough strength to withstand handling, transportation and storage hazards. Finally, it should also be as compatible as possible with the product.
- b) To protect the product : The package should safeguard the product against contamination or loss and damage or degradation due to microbial action,

exposure to heat, light moisture and oxygen, accidental spillage, evaporation, pilferage, etc.

c) **To help in selling the product :** The shape of the package should be favourable to dispensation and reclosure, and to its disposal or re-use.

Present status of the packaging industry :

(a) In developed countries :

The packaging industry in developed countries has made tremendous advances. The consumer is extremely package conscious. With newer marketing systems like super markets, self-service stores, etc. packaging technology in these countries has risen to great heights. Newer and better packaging materials, development of packaging machinery and appliances, improved system of packing etc have all advanced in an integrated manner. In fact, Western packaging technology is undergoing a revolution.

(b) In developing countries :

In contrast, the packaging industry in many developing countries is still in its infancy. The benefits of adequate and functional packaging seem to have touched only the fringe of the population.

✓ Packaging Materials and forms :

A) MATERIALS :

These include : Paper and paper-based products, glass, tin plate, aluminium foil, timber (wood), plastics and laminates.

✓ i) Paper and paper-based products :

These may be kraft paper (bleached or unbleached); grease-proof paper; vegetable-parchment paper; glassine paper; wax coated paper; plastic coated paper; paper boards; solid fibre boards; box boards etc. The papers are used commonly in the form of wrappers, cartons, boxes, bags, cups, etc; while boards are used as cartons, boxes, etc. The merits of paper are : its relative weightlessness, its printability, low cost and easy disposal. On the other hand, it has the demerits of low tear and wet strength.

✓ ii) Glass :

It may be transparent or opaque (coloured). Transparency may be an advantage or disadvantage. Used in the form of bottles, jars, jugs, tumblers, etc. Glass has the merits of strength, rigidity, chemical inertness, an excellent gas and water vapour barrier, and the demerits of heavy weight and fragility.

✓ iii) Tinplate :

This consists of a thin sheet (0.025 mm thick) of mild steel coated on both sides with a layer of pure tin. For packing certain products, it is desirable to use an internally, lacquered can which provides greater resistance to corrosion.

Tinplate has the merits of good strength, excellent barrier properties, etc. and the demerits of high cost, heavy weight, difficult reclosure and disposal etc. Used mostly in the form of cans.

iv) Aluminium foil :

The common thickness of this medium for use in food products is 0.012 – 0.015 mm. The increase corrosion resistance, it may be coated with lacquer or plastic. It has good barrier properties, is grease proof, non sorptive, shrink proof, odourless and tasteless, hygienic, non-toxic, opaque to light, bright in appearance etc.

v) Timber :

It should be free from odour, have an attractive appearance and necessary mechanical strength. May be treated with casein-formalin, or sprayed with paraffin-wax or plastics, to make it more water resistant and prevent the passage of the timber-taint to butter. Used in the form of a box, tub, cask or barrel.

vi) Plastics :

the use of plastics in packaging has made tremendous advances in recent years throughout the world. A wide variety of rigid plastics can be used as thermoformed, injection-moulded or blow-moulded containers such as bottles, cartons, cups, boxes etc. The merits of rigid plastic containers are its low cost and ease of fabrication; and its demerits are lack of product compatibility, low barrier properties, plastic deterioration, lack of resistance to high heat and fragility at low temperature.

vii) Laminates :

These are formed by combining the complete surfaces of 2 or more webs of different films, with the primary object of overcoming the defects of single films. Laminations are made for the following reasons :

- to further strengthen the film material i.e. toughness, tear resistance etc.
- to improve barrier properties
- to improve grease-resistance
- to provide a surface that will heat seal

viii) Others :

These include textiles (such as cloth, jute, hessian) or use in the form of bags, sacks etc.

B) FORMS :

These consist mainly of bottles, cartons, sachets / bags / pouches, boxes/tubs ; casks / barrels; cups and collapsible tubes etc.

i) Bottles :

The glass bottle still continues to be the most fragently used package for milk in the world. However, a several developed countries, it has already lost ground to single service containers.

ii) Carton :

This is a common package for milk; also used for liquid, frozen and coagulated milk products. Cartons are commonly made of 'food' grade paper coated on the inside with wax or plastic or lined with paper, plastic film or aluminium foil, or made of laminates. Its merits are maximum space utilization in vehicles and storage; ability to carry attractive printing and convenience.

iii) Sachet / bag / pouch :

Flexible water proof plastic bags are commonly used for packaging milk and liquid milk products. Since it is difficult to pour from these, a jug is usually also provided.

iv) Can :

This is commonly used for all types of solid, semi solid and powdered products. Cans are traditionally made of soldered tinplate steel, generally lacquered on the inner surface to prevent corrosion.

v) Box / tub

It may be made of wood or paper board. While wooden boxes / tubs are used for the bulk packing of butter and butter oil with butter paper / plastic liners, paper board boxes are generally used as over-wraps.

vi) Barrel / cask :

Commonly made of wood and coated with wax on the inner surface. Used for bulk packaging of sweetened condensed milk, semi-solid butter milk / whey, butter-oil etc.

vii) Cup :

It is made of paper wax or plastic coating on the inside. Used for frozen and coagulated products.

viii) Collapsible tube :

Generally made of aluminium and lacquered on the inside. Its merits are; low cost; light weightness; ease handling and dispensing; product protection etc. used for semi-fluid products such as sweetened condensed milk, processed cheese spread, etc.

Packaging Machinery :

In developed countries all types of packing machinery are available, including those for the production of basic packing materials and for converting these into finished packages, for filling and sealing, handling and storage, printing, testing etc. Developing countries, on the other hand, are largely dependent upon imported machinery. It is in this field that there is an urgent need of improvement, as lack of suitable packaging machinery is impeding the productivity of industrial and consumer goods.

Standardization in packaging :

The adoption of standard packaging materials and techniques, both with regard to testing and usage, would go a long way to improving productivity, as well as national and international trade. The Indian Standards Institution is already engaged in the development of standards both for packaging materials and filled packages for use in this country.

Package disposal :

After product use, the empty packages have necessarily to be discarded. These constitute a fair proportion of the solid waste proposed by the community, especially in big cities. The collection and proper disposal of these empty packages should be a concern of the Municipal / Public Health authorities. The common disposal methods include land-in-fill, incineration and bio-deterioration, and care should be taken, when selecting them, to avoid subsequent atmospheric or land pollution.

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SYLLABUS

Course Title : Technology of Milk and Milk Products

Course No. ASDS-353 Semester : V Credits : 1 + 1 = 2

Theory :

Present status of Dairy Industry in Maharashtra and India. Definition and composition of milk, physico chemical properties of milk. Microbial quality of raw milk. Factors affecting composition of milk. Physico-chemical and microbial standards for different types of milk. Nutritional importance of milk and its constituents. Reception and processing (plat form test, chilling, standardization, homogenization, pasteurization, storage, marketing) of milk. Classification and composition of milk products (Heat coagulated, heat and acid coagulated, Evaporated, fermented, frozen and fat riched products). ISI, PFA and Agmark standards for milk products. International requirement for export of Dairy products. Preservation of milk and milk products by Bio, Herbal, Chemical and Physical preservatives in use. Utilization of dairy by products whey and high acid milk. Packaging of milk and milk products with modern techniques.

Practical :

Platform tests, sampling of milk and milk products for various tests. Determination of fat, SNF, TS, Acidity, Sp. Gravity. Standardization of milk. Cream separation. Cleaning and santization of dairy equipments. Manufacture of Khoa, Basundi and Rabri, paneer, Chhana, Dahi ice cream and kulfi, butter and ghee. Manufacture of milk sweets Pedha, Gulabjamun, Rosogolla, Shrikhand.

Text Books recommended :

1. Milk and its properties – Shrivastava, S.M. (1993). Kalyani Publishers, 1/1 Rajinder nagar, Ludhiana.
2. Milk and milk products – Winton and Winton (1993). Agrobios (India), Agro, House, behind Nasrani cinema, Chopsani road, Jodhapur.
3. Milk testing – Davis, J.G. Agrobios (India), Agro, house, behind Nasrani cinema, Chopsani road, Jodhapur.
4. Chemistry of milk and milk products – Singh V.B. (1965) Asian publishers, New mandi, Muzaffarnagar.
5. Dairy in India – Gupta, H.A. (1997), Kalyani publisher, 1/1 Rajinder nagar Ludhiana.

6. Outlines of Dairy Technology – Sukumar De (2000), Oxford University Press, New Delhi.

Theory (Teaching schedule)

Lecture No.	Topic to be covered	Weightage per cent
1	Present status of dairy industry in Maharashtra and India	6
2.	Definition and composition of milk	7
3	Physico chemical properties of milk	9
4	Microbial quality of raw milk. Factors affecting composition of milk	6
5	Physico chemical and microbial standards for different types of milk	7
6	Nutritional importance of milk and its constituents	9
7,8 and 9	Reception and processing (platform test, chilling, standardization, homogenization, pasteurization, storage and marketing) of milk	10
10,11 and 12	Classification and composition of milk products (heat coagulated, heat and acid coagulated, evaporated, fermented frozen and fat riched products)	10
13	ISI, PFA and AGMARK standards for milk products	7
14	International requirement for export of dairy products	6
15	Preservation of milk and milk products by bio, herbal, chemical and physical preservatives in use	7
16	Utilization of dairy by products whey and high acid milk	8
17	Packaging of milk and milk products with modern techniques.	8

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Maharashtra Agril. Universities Exam. Board, Dapoli
SEMESTER-END EXAMINATION

B.Sc.(Agri.) Course

Semester : VIII

Academic year: 2005-2006

Course No.: AHDS-484

Title: Technology of Milk and
Milk Products

Credits: 2=1+1

Total marks : 40

Day and Date: Tuesday, 18.04.2006

Time: 14.00 to 16.00 Hrs.

- Note : 1. Solve ANY FIVE questions from Section 'A'.
 2. All questions from section 'B' are compulsory.
 3. All questions carry equal marks.
 4. Draw neat diagrams wherever necessary.

SECTION "A"

- Q.1 Write the present scenario and weaknesses of Indian dairy industry.
 Q.2 Define milk and explain in brief the physico-chemical properties.
 Q.3 Describe Operation Flood Programme and its impact on dairy development in India.
 Q.4 Write the procedure of preparation of following products (any two) :
 a) Khoa. b. Paneer c. Lassi
 Q.5 Define pasteurization of milk and explain different methods of pasteurization.
 Q.6 Write short notes on (Any two)
 1. Clean and hygienic milk production 2. Standardization of milk
 3. Classification of indigenous milk products on the basis of methods of production.
 Q.7 Differentiate between (any two) :
 a. Chakka and Channa b. Ice-cream and Kulfi
 c. Sweetened condensed milk and khoa

SECTION "B"

- Q.8 Define the following terms :
 a. Paneer b. Standardized milk c. Double toned milk
 d. Recombined milk e. Homogenization of milk
 Q.9 Fill in the blanks :
 a. Milk protein is present in state in milk.
 b. Crossbred cow milk contains 3.5 % fat and % S.N.F.
 c. Specific gravity of buffalo milk ranges from To
 d. Table butter contains 80 % fat and 3 % salt.
 e. Ice-cream should contain minimum 10 % fat and 13-15 % total sugar.
 Q.10 Match the pairs

- | | |
|-------------------------|------------------------------------|
| a. Evaporated milk (2) | 1. Cheese |
| b. Rennet (1) | 2. 9 % fat |
| c. Homogenized milk (5) | 3. To check spore forming bacteria |
| d. UHT Milk (3) | 4. More than 99 % fat |
| e. Ghee (4) | 5. No cream line |

Maharashtra Agril. Universities Exam. Board, Pune
SEMESTER-END EXAMINATION

B.Sc.(Agri.) Course.

Semester : VIII

Academic year: 2006-2007

Course No.: AHDS-484

Title: Technology of Milk and
Milk Products

Credits: 2=1+1

Total marks : 40

Day and Date: Tuesday, 24.04.2007

Time: 14.00 to 16.00 Hrs.

Note : 1. Solve ANY FIVE questions from Section 'A'.

2. All questions from section 'B' are compulsory.

3. All questions carry equal marks.

4. Draw neat diagrams wherever necessary.

SECTION "A"

- Q.1 Enlist the factors affecting composition of milk and explain any two of them.
 Q.2 Describe different phases of operation flood programme.
 Q.3 Enlist the methods of pasteurization and explain in short HTST method of pasteurization.
 Q.4 Write short notes (any two) :
 1. Nutritive value of milk 2. Homogenization
 3. Over run in ice-cream 4. Chakka and shrikhand
 Q.5 Give the detailed classification of milk constituents and describe milk fat.
 Q.6 Enlist the physico-chemical properties of milk and describe any two properties.
 Q.7 Write the procedure of preparation of following products. (Any two)
 1. Yoghurt 2. Kulfi 3. Chhana

SECTION "B"

Q. 8 Fill in the blanks :

1. Energy value of milk protein is Cal /g., (9.3 / 4.1 / 1.4)
 2. Emulsifiers are used in the manufacture of Product (khoa / ice-cream / channa)
 3. Colostrum is practically normal after days (5 / 10 / 15).
 4. Milk is rich source of (iron / copper / calcium).
 5. milk contains higher percentage of lactose (Cow / Goat / Human).

Q.9 Define the following terms :

1. Milk 2. Pasteurization
 3. Khoa 4. Dahi
 5. Standardization.

Q. 10 State whether true or false.

1. The yellow colour of cow milk is due to carotene. T
 2. Standardized milk should contain 5.4 % fat and 8.5 % SNF. F
 3. Proteins are among the most complex of organic substance. T
 4. Chhana is a desiccated product. F
 5. Average titratable acidity of fresh cow milk varies from 1.032 to 1.035. F

- ① Homogenization
- ② Pasteurization
- ③ milk
- ④ Standardization
- ⑤ Lactation
- ⑥ Colostrum
- ⑦ Skim milk
- ⑧ Total milk

13-09- 87
 88
 05-07- 1989 93 94 2001 2007
 90 94 98 2002 2008
 91 95 98 2003 2009
 92 96 2006 2004 2010
 2005 2011

1.2. SOURCES OF FARM POWER

There are different sources of farm power in India which are classified as:

1. Human power
2. Animal power
3. Mechanical power
 - (a) Tractors
 - (b) Power tillers
 - (c) Self propelled combines
 - (d) Oil engines
- (i) Diesel engine
- (ii) Petrol/Kerosene engine
4. Electric power, and
5. Renewable energy (Bio Gas + Solar + Wind). With passage of time there is gradual increase of all power units except draft animals.

Human Power

Human power is an important source for operating small implements and tools. Stationary work like chaff cutting, lifting, water, threshing, winnowing and many other such works are done by manual labour. An average man can develop maximum power of about 75 watts (about 0.1 hp for doing farm work).

Animal Power

Power developed by an average pair of bullocks is about 750 watts (about 1 hp) for usual farm work. Bullocks are employed for all types of farm work in all seasons. Besides bullocks, other animals like camels, buffaloes, horses, donkeys, mules and elephants are also used at different places.

A draft animal can exert about one-tenth (1/10) of its body weight for doing farm work.

Mechanical Power

Mechanical Power includes:

- (a) Tractors
- (b) Power tillers
- (c) Oil engines
- (d) Diesel engines & Petrol or Kerosene engine
- (e) Self propelled combines
- (f) Oil engine (Internal combustion engine) is a good device for converting fuel into useful work. These engine are of two types:
 - (a) Diesel engines, and
 - (b) Petrol or Kerosene engine.

FARM POWER AND FARM MECHANISATION

Thermal efficiency of diesel engine varies from 32 to 38 percent, where as that of petrol engine varies from 25 to 32 percent.

In modern days, almost all tractors and power tillers are operated by diesel engines. Stationary oil engines are used for:

- (a) Pumping water
- (b) Flour mills
- (c) Oil ghanis
- (d) Cotton gins
- (e) Chaff cutter
- (f) Sugarcane crusher
- (g) Thresher
- (h) Winnower
- (i) And many such equipments.

Tractor

Tractors are available in following classes, depending upon hp:

- (i) 20 hp
- (ii) 21 - 30 hp
- (iii) 31 - 40 hp
- (iv) 50 hp and over.

The most popular tractor is found in 31-40 hp segment, which accounts for about 60% of the total sales in the country.

Tractor manufacturing was started in India in the year 1961 by first manufacturer M/s Eicher Good earth.

The number of tractors increased from about 2 lakh in 1971 to about 3 millions at present.

Electrical Power

Electrical power is used mostly in the form of electrical motors on the farms. Motor is a very useful machine for farmers. It is clean, quiet and smooth running. Its maintenance and operation needs less attention and care. The operating cost remains almost constant throughout its life. Electrical power is used for water pumping, dairy industry, cold storage, farm product processing, fruit industry, poultry industry and many similar things for farmers.

Renewable Energy

It is the energy mainly obtained from biomass, sun and wind. Biomass energy, wind energy and solar energy are used in agriculture and domestic purposes with suitable devices. It can be used for lighting, cooking, water heating, water distillation, food processing, water pumping, diesel engine operation and electric generation. Renewable energy is inexhaustible in nature.

1.3. MERITS AND DEMERITS OF DIFFERENT FORMS OF POWER

Human Power:	
Merit	Demerit
1. Easily available	1. Costliest power compared to all other forms of power.

medium, medium and large farm holders. India is yearly producing more than 2.5 lakh tractors, 10,000 power tillers, 10 lakh pumping sets, 2000 combine harvester.

Yet Indian agriculture lacks farm power which needs to be increased from 1.25 kW/ha to at least 2.00 kW/ha.

Draft animals and farm workers are important sources of farm power. Mechanisation possibility is strongly influenced by:

(a) Farm size

(b) Cost of farm labour

(c) Availability of suitable machines

(d) Pressing need of farmers and socio economic compulsions of local people to have custom hiring services.

The farming system continues to utilize manual labour, animal power and tractor based technology in almost all operations. Agriculture machinery and implements are capable of doing field operations of better quality and in lesser time.

The economic progress of a nation depends directly upon availability of energy and its consumption for fruitful utilization. Increased energy input in agriculture directly or indirectly increases the production of crops. It is an established fact that inadequacy of power and machinery results in poor yield in general. In order to bring more land under cultivation and to improve productivity, it is necessary to introduce other sources of power like tractors, power tillers, oil engines, self propelled combine harvester, electric motors and renewable energy (specially wind mills for water pumping). More and more application of these devices call for more and more machinery to carry out the required agricultural operations in a short period. The availability of power from different sources has been given in Table 1.1 and Table 1.2.

Table 1.1. Farm Power Sources in India

Year	Draft Animals millions	Tractors millions	Diesel engines millions	Power Tillers, 000 Nos.	Self propelled combines 000 Nos.
1950	65	0.008	0.07	0.0	0.0
1960	80.4	0.037	0.23	0.0	0.0
1970	82.6	0.168	1.70	9.6	0.2
1980	73.4	0.531	2.88	16.2	0.3
1990	70.9	1.192	4.80	31.2	3.2
1997	62.6	2.032	5.55	65.9	4.4

Source. Agricultural Engineering To-day, Vol. 24 (2): 35-50, 2000.

Merit	Demerit
2. Used for all types of work	2. Very low efficiency
	3. Requires full maintenance when not in use
	4. Affected by weather condition and seasons.

Animal Power:

Merit	Demerit
1. Easily available	1. Not very efficient
2. Used for all types of work	2. Season and weather affect the efficiency
3. Low initial investment	3. Can not work at a stretch
4. Supplies manures to the field and fuels to the farmers	4. Requires full maintenance when not in use
5. Lives on farm products	5. Creates unhealthy and dirty atmosphere near the residence
	6. Very slow in doing work.

Mechanical Power:

Merit	Demerit
1. Efficiency is high	1. Initial capital investment is high
2. Not affected by weather	2. Fuel is costly
3. Cannot work at a stretch	3. Repairs and maintenance needs technical knowledge.
4. Requires less space	
5. Cheaper form of power	

Electrical Power:

Merit	Demerit
1. Very cheap form of power	1. Initial capital investment is high
2. High efficiency	2. Requires good technical knowledge
3. Can work at a stretch	3. If handled carelessly, it causes great danger
4. Maintenance and operating cost is very low	
5. Not affected by season	

1.4. STATUS OF FARM POWER IN INDIA

Agriculture is the most important sector of Indian economy. Most of the farming is done on small holdings. About 78% farm holdings belong to small and marginal farmers, about 22% belong to semi-

Table 1.2. Availability of Farm Power in India

Year	Total power, kW/ha	Source wise %	
		Animate power (Human + animal)	Mechanical
1961	0.25	97.4	2.1
1961	0.31	94.9	3.7
1971	0.36	79.2	16.3
1981	0.63	48.2	32.3
1991	0.92	34.5	34.7
1999 (Estimated)	1.25	21.0	44.2
			Electrical
			0.50
			1.40
			4.50
			19.5
			30.8
			34.8

Source: Agricultural statistics at a glance 1999.

Desirable Farm Power under Present Circumstances.

- (i) Tractors 66/1000 ha @ 15 ha/tractor, or
 - (ii) Power tiller 200/1000 ha @ 5 ha/power tiller
 - (iii) Draught animal 1000/1000 ha or
- a mix of all the sources of power in different proportions.

1.5. FARM MECHANIZATION

Concept of Farm Mechanization

Farm mechanization is the application of engineering and technology in agricultural operations to do a job in a better way to improve productivity. This includes development, application and management of all mechanical aids for field production, water control, material handling, storing and processing. Mechanical aids include hand tools, animal drawn equipments, power tiller, tractor, oil engines, electric motors, processing and hauling equipments.

Farm mechanization does not mean the use of only big machines and tractors for farm work. Mechanization is a need based process which provide sufficient time gap for self adjustment of various inputs without causing sudden impact of changes.

Scope of farm Mechanization

There is a good scope of farm mechanization in India, Gulf countries, South East Asia and African countries due to the following reasons:

- (i) Improved irrigation facility in the area.
- (ii) Introduction of high yielding varieties of seeds.
- (iii) Introduction of high dose of fertilizers and pesticides for different crops.
- (iv) Introduction of new crops in different parts of the country.

FARM POWER AND FARM MECHANISATION

- (v) Multi cropping system and intensive cultivation, followed in different parts of the country.

The above factors are responsible to encourage farm mechanization, which can be viewed with the following points in mind:

- (a) Population of the country is increasing day by day. Steps have to be taken to arrange food and fibres for such large population by adopting intensive farming in the country. Intensive farming required machines on the farm.
 - (b) In multiple cropping system, generally high yielding variety of seeds are sown, so farm operations are required to be completed in limited time with economy and efficiency. This is possible only with help of mechanization.
 - (c) Farm mechanization reduces drudgery (boredom, monotony) of labour to a great extent. A ploughman has to walk about 66 km on foot while ploughing one hectare of land once by bullocks having 15 cm. furrow width.
 - (d) A large number of female worker and children work on farms unwillingly due to shortage of power. From the human stand point, it is not desirable to engage females and children for arduous farm work.
- A child must go to school and woman must devote time for managing home affairs to make life pleasant. If machines are used, the following relief may be expected:
- (i) A farmer and his animals can be relieved of hard work.
 - (ii) He will do his job with machine better and quicker.
 - (iii) He will get more leisure and devote more time to other work.
 - (iv) He will earn better living and enjoy life in nice manner.
 - (v) The proper utilization of basic inputs like water, seed and fertilizer will be possible only when proper equipments are used.
 - (a) The seeds and fertilizer should be placed at a certain depth with respect to each other for the optimum interactions of the two, which is possible by a seed drill.
 - (b) Seed bed should be prepared to required tilth for better crops.
 - (c) The field should have uniform slope for better irrigation and drainage.
 - (d) There are certain operations which are rather difficult to be performed by animal power and human labour such as:
 - (i) Deep ploughing in case of deep rooted crops.
 - (ii) Killing the pernicious weeds by deep tillage operation.
 - (iii) Levelling of uneven land.
 - (iv) Land reclamation.
 - (v) Application of insecticides during epidemic seasons.

These operations need heavy mechanical equipment for satisfactory completion.

Benefits of Farm Mechanization

The following are the benefits of farm mechanization:

1. Timeliness of operation
2. Precision of operation
3. Improvement of work environment
4. Enhancement of safety
5. Reduction of drudgery of labour
6. Reduction of loss of crops and food products
7. Increased productivity of land
8. Increased economic return to farmer
9. Improved dignity of farmer
10. Progress and prosperity in rural areas.

Limiting Factors in Farm Mechanization

The following are the limiting factors in farm mechanization in India:

1. Small land holdings
2. Less investing capacity of farmers
3. Agricultural labour is easily available
4. Adequate draft animals are available in the country
5. Lack of suitable farm machine for different operation
6. Lack of repair and servicing facilities for machines
7. Lack of trained man power
8. Lack of coordination between research organization and manufacturer
9. High cost of machines
10. Inadequate quality control of machine.

Suggestion for Farm Mechanization

1. To develop a national policy on farm mechanisation.
2. To establish an apex body to implement the national policy on farm mechanisation. This may provide basis for industries to plan their capacities, sale and servicing of equipment.
3. To open adequate training centres for imparting training to engineers, mechanics, technicians, operators, and users on the farm power and machinery regarding proper selection, operation, maintenance and repair of machines.
4. To start testing and evaluating centres for farm power and machinery on regional basis.

FARM POWER AND FARM MECHANISATION

5. To establish adequate centres for repairs and spare parts of machines.
6. To reinforce tractor testing station on the lines of international testing stations.
7. To improve the industrial policy for maintaining better quality of implement and machines.
8. Agricultural Engineering Extension Education is required to be established on sound footing to keep the farmers upto-date on various aspects of application of engineering to agriculture.
9. The landless workers need financial assistance to own hand tools to improve their earnings.
10. Post harvest technology deserves special attention.
11. Custom hiring system is required to be encouraged in rural areas.

1.6. STATUS OF FARM MECHANISATION IN INDIA

Present status of farm mechanization in India can be viewed under the following general categories:

1. Improved manual tools
2. Improved animal drawn implements
3. Tractor operated implements
4. Custom hiring units on the farm
5. Other stationary equipments like threshers, irrigation pumps, sprayer, duster etc.

1. Improved Manual Tools

Improved manual tool plays important role in minimizing the physical strain on the worker. It increases the output of work, per unit time. This category includes sickles, Khurpi, pruning knives, wheel hand hoe, long handle hoes, manually operated seed drills and many such items. The manual tools vary in their size and design to some extent according to local condition.

2. Animal Drawn Improved Implements

More than 80% farmers depend upon animal drawn implements. Improved implement increases the output and quality of work. This includes improved steel ploughs, cultivators, harrows, seed drill, seed-cum fertilizer drills, multi purpose toolbar, bakhar, puddlers, levellers, improved carts, scrapers and many other implements. At present a large number of animal drawn implements are manufactured by local firms.

Traditionally, soil stirring and mould board ploughs are used by farmers having animals as power source. The field capacity of traditional implements is about 0.3-0.4 ha/day and thus work output is low.

Internal Combustion Engine

3

3.1. INTRODUCTION

Heat engine is a machine for converting heat, developed by burning fuel into useful work. It can be said that heat engine is an equipment which generates thermal energy and transforms it into mechanical energy. Heat engine is of two types:

1. External combustion engine
2. Internal combustion engine

✓ **1. External combustion engine.** Here the combustion uses heat in form of steam, which is generated in a boiler, placed entirely separate from the working cylinder. In *Internal combustion engine*, the combustion of fuel takes place inside the engine cylinder and heat is generated within the cylinder of the engine.

✓ **2. Internal combustion engine.** It is the engine designed to derive its power from the fuel, burnt within the engine cylinder. It uses the expansive force of gases, produced by burning the fuel within the cylinder. The generated heat is converted into useful power by a piston, constrained within the cylinder. The motion of the piston rotates a crankshaft with the help of a connecting rod. The heat that supplies the energy for working substance is generated within the cylinder. Hence the name is given as *Internal combustion engine*. There are two ways in which combustion takes place in the cylinder:

- (a) By rapid explosion of air-fuel mixture within the cylinder, when it is ignited by a spark, is called *constant volume combustion (C.V.C.)*.
- (b) Combustion takes place by slow burning when the fuel is injected into highly compressed heated air contained in the cylinder. This is called *constant pressure combustion (C.P.C.)*, because when the combustion takes place, the pressure in the cylinder is almost constant.

3.2. THERMODYNAMIC CYCLE

It is a series of events that repeat themselves in a regular sequence. The cycle consists of events taking place between two successive explosions in a cylinder of the engine. There are several types of cycles but thermo-dynamic cycle, used for internal combustion

engine is of two types:

1. Otto cycle and
2. Diesel cycle

✓ 1. OTTO CYCLE

In this cycle, the heat is taken in at one constant volume and rejected at another constant volume of the cylinder. In the pressure volume diagram (Fig. 3.1) of the Otto cycle.

V_1 = total cylinder

volume.

V_2 = clearance volume.

$V_1 - V_2$ = piston displacement.

The line MN represents atmospheric pressure level and AB represents the admission of the charge at a pressure slightly below the atmospheric pressure. BGC represents the compression of the charge in the cylinder, where the ignition occurs at the point C. The line CD represents the pressure rise in the cylinder, which occurs at constant volume V_2 . DE represents power stroke of the engine. Exhaust takes place at the point E and the pressure reduces nearly to atmospheric pressure during the exhaust stroke FA.

Analysing the heat and the energy evolved in the cylinder, the thermal efficiency (η) of the engine is given by:

$$\eta = 1 - \left(\frac{1}{r} \right)^{\gamma-1}$$

where

$$r = \text{compression ratio} = \frac{\text{total cylinder volume}}{\text{clearance volume}} = \frac{V_1}{V_2}$$

$$m = \text{air constant} = \frac{C_p}{C_v} = 1.4$$

C_p = specific heat at constant pressure

C_v = specific heat at constant volume

Engines based upon this principle of *otto cycle* is called *Otto engines* or *Spark ignition engines*.

✓ 2. DIESEL CYCLE

In diesel cycle, the heat is taken in at constant pressure and rejected at constant volume. In the pressure-volume diagram (Fig. 3.2)

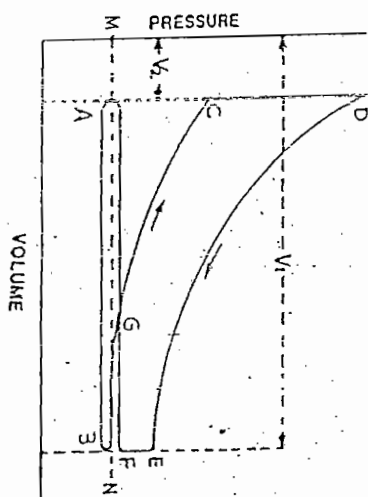


Fig. 3.1. Pressure-Volume diagram of spark ignition engine

of gases from sides of the piston. Usually a cylinder is bored in a cylinder block and a gasket, made of copper sheet or asbestos is inserted between the cylinder and the cylinder head. The combustion space is provided at the top of the cylinder head where combustion takes place. There is a rod called *connecting rod* for connecting the piston and the crankshaft. A pin called *gudgeon pin* or *wrist pin* is provided for connecting the piston and the connecting rod of the engine. The end of the connecting rod which fits over the gudgeon pin is called *small end* of the connecting rod. The other end which fits over the crank pin is called *big end* of the connecting rod. The crankshaft rotates in main bearings which are fitted in the crankcase. A flywheel is provided at one end of the crankshaft for smoothening the uneven torque, produced by the engine. There is an oilsump at the bottom of the engine which contains lubricating oil for lubricating different parts of the engine. Mechanical cycle of internal combustion engine can be completed in two ways:

1. When the cycle is completed in two revolutions of the crankshaft, it is called *four stroke cycle engine*.
2. When the cycle is completed in one revolution of the crankshaft, it is called *two stroke cycle engine*.

3.4. FOUR STROKE CYCLE ENGINE

In four stroke cycle engine, all the events taking place inside the engine cylinder are completed in four strokes of the piston. This engine has got valves for controlling the inlet of charge and outlet of exhaust gases. The opening and closing of the valve is controlled by cams, fitted on camshaft. The camshaft is driven by crankshaft with the help of suitable gears or chains. The camshaft runs at half the speed of the crankshaft. The events taking place in I.C. engine are as follows:

1. Air or air-fuel mixture (charge) is taken in the cylinder.
2. The charge is compressed in the cylinder by the piston.
3. If charge is only air, the fuel is injected at the end of compression.
4. The charge is ignited at a predetermined time under specified pressure inside the engine cylinder.
5. The power developed due to expansive forces of gases inside the cylinder is transferred to the crank-shaft through the connecting rod.
6. Exhaust gases go out of the cylinder at regular interval of time.

The complete cycle covers all these events in systematic manner. Four stroke cycle engine completes all these events in four strokes of the piston, whereas the two stroke cycle engine covers all these events in two strokes of the piston. The four strokes of the piston are:

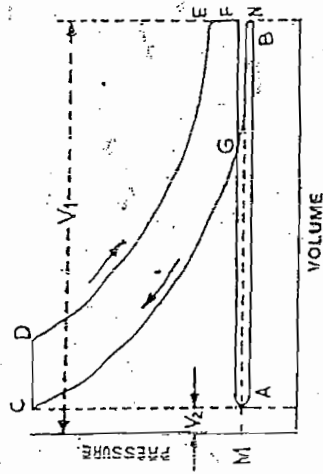


Fig. 3.2. Pressure-Volume diagram of diesel engine

At D with exhaust valve opening at E and exhaust stroke FA. Analysing the heat and energy evolved in the cylinder, the thermal efficiency of the engine is given as:

$$\eta = 1 - \left[\frac{1}{r} \right]^{m-1} \left[\frac{\rho^m - 1}{m(\rho - 1)} \right]$$

where ρ is cut off ratio.

The engine based upon the principle of diesel cycle is called *Diesel engine*.

3.3. PRINCIPLES AND WORKING OF I.C. ENGINE

PRINCIPLE

A mixture of fuel with correct amount of air is exploded in an engine cylinder which is closed at one end. As a result of the explosion, heat is released and this causes the pressure of the burning gases to increase. This pressure increase, forces a close fitting piston to move down the cylinder. This movement of piston is transmitted to a crankshaft by a connecting rod so that the crankshaft turns a flywheel. To obtain continuous rotation of the crankshaft this explosion has to be repeated. Before this can happen, the used gases have to be expelled from the cylinder, the fresh charges of fuel and air must be admitted and the piston must be moved back to its starting position. This sequence of events is known as *working cycle*.

WORKING

I.C. engine converts the reciprocating motion of piston into rotary motion of the crankshaft by means of connecting rod. The piston which reciprocates in the cylinder is very close fit in the cylinder. Rings are inserted in the circumferential grooves of the piston to prevent leakage

1. Suction stroke
2. Compression stroke
3. Power stroke
4. Exhaust stroke

1. **Suction stroke.** During suction stroke, only air or mixture of air and fuel are drawn inside the cylinder. The charge enters the engine through the inlet valve which remains open during admission of the charge. The exhaust valve remains closed during this stroke. The pressure in the engine cylinder is less than atmospheric pressure during this stroke [Fig. 3.3 (a) and 3.4 (a)].

Compression stroke.

The charge taken in the cylinder is compressed by the piston during this stroke. The entire charge of the cylinder is compressed to a small volume contained in the clearance volume of the cylinder. If only air is compressed in the cylinder (as in case of diesel engine), the fuel is injected at the end of the compression stroke. The ignition takes place due to high pressure and temperature. If the mixture of air and fuel is compressed in the cylinder (as in case of spark ignition engine) the mixture is ignited by spark plug. After ignition, tremendous amount of heat is generated, causing very high pressure in the cylinder which pushes the piston backward for useful work. Both valves are

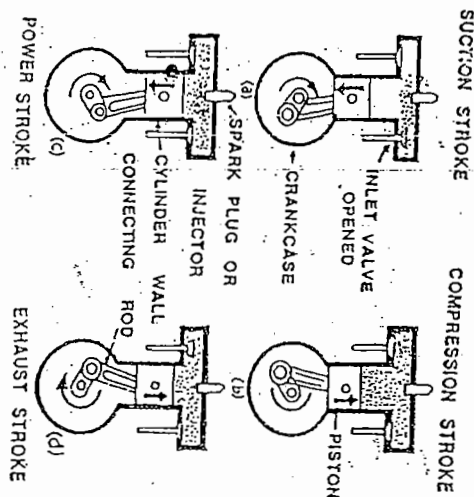


Fig. 3.3. Four stroke cycle engine

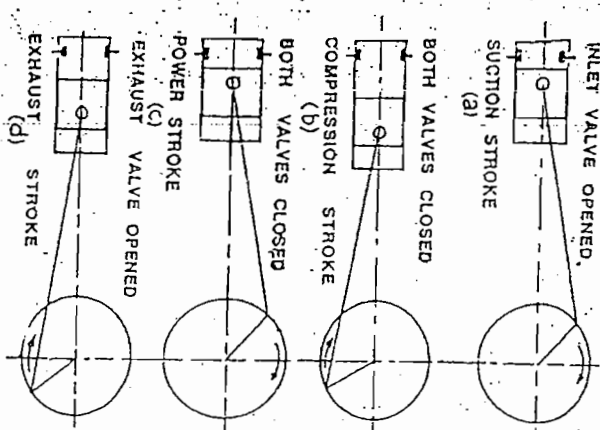


Fig. 3.4. Position of pistons with respect to crank shaft rotation in four stroke cycle engine

INTERNAL COMBUSTION ENGINE

closed during this stroke [Fig. 3.3 (b) and 3.4 (b)].

Power stroke. During power stroke, the high pressure developed due to combustion of fuel causes the piston to be forced forward or backward at regular intervals. The connecting rod with the help of crank shaft transmits the power to the transmission system for useful work. Both valves are closed during this stroke [Fig. 3.3 (c) and 3.4 (c)].

Exhaust stroke. Exhaust gases go out through exhaust valves during this stroke. All the burnt gases go out of the engine and the cylinder becomes ready to receive the fresh charge. The inlet valve is closed and exhaust valve remains open during this stroke [Fig. 3.3 (d) and 3.4 (d)].

Thus it is found that out of four strokes, there is only one power stroke and three idle strokes. The power stroke supplies necessary momentum for useful work.

3.5. TWO STROKE CYCLE ENGINE

In such engines, the whole sequence of events i.e. suction, compression, power and exhaust are completed in two strokes of the piston and one complete revolution of the crankshaft. There is no valve in this type of engine. Gas movement takes place through holes called *ports* in the cylinder [Fig. 3.5 (a)]. The crankcase of the engine is gas tight in which the crankshaft rotates.

First stroke (Suction + compression). When the piston moves up the cylinder it covers two of the ports, the *exhaust port* and the *transfer port*, which are normally almost opposite to each other. This traps a charge of fresh mixture in the cylinder and further upward movement of the piston compresses this charge. Further movement of the piston also uncovers a third port in the cylinder *suction port*. More fresh mixture is drawn through this port into the crankcase. Just before the end of this stroke, the mixture in the cylinder is ignited as in the four stroke cycle. [Fig. 3.5 (c) and (d)].

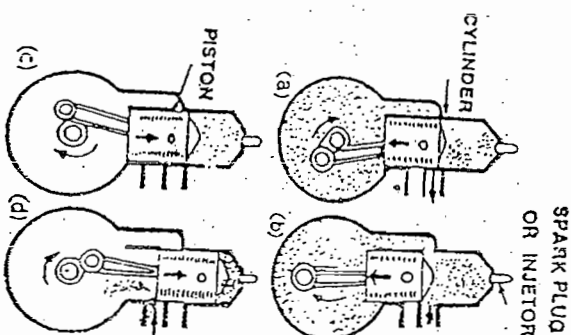


Fig. 3.5. Two stroke cycle engine

Second stroke (Power + Exhaust). The rise in pressure in the

Second stroke (Power + Exhaust). The rise in pressure in the

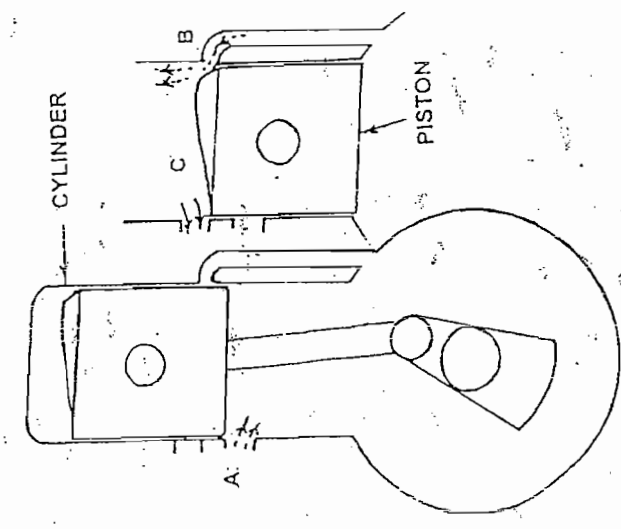


Fig. 3.6. Two stroke engine, (A) Suction port, (B) Transfer port, (C) Exhaust port

cylinder caused by the burning gases forces the piston to move down the cylinder. When the piston goes down, it covers and closes the suction port, trapping the mixture drawn into the crankcase during the previous stroke then compressing it. Further downward movement of the piston uncovers first the exhaust port and then the transfer port. This allows the burnt gases to flow out through exhaust port. Also the fresh mixture under pressure in the crankcase is transferred into the cylinder through transfer port during this stroke. Special shaped piston crown deflect the incoming mixture up around the cylinder so that it can help in driving out the exhaust gases [Fig. 3.5 (a) and (b) and 3.6].

When the piston is at the top of its stroke, it is said to be at the top dead centre (TDC). When the piston is at the bottom of its stroke, it is said to be at its bottom dead centre (BDC). In two stroke cycle engine, both the sides of the piston are effective which is not the case in four stroke cycle engine.

Scavenging. The process of removal of burnt or exhaust gases from the engine cylinder is known as scavenging. Entire burnt gases do not go out in normal stroke, hence some type of blower or compressor is used to remove the exhaust gases in two stroke cycle engine.

COMPARISON BETWEEN 4 STROKE AND 2 STROKE ENGINE

S. No.	Particulars	4 stroke engine	2 stroke engine
1.	No of power stroke	One stroke for every two revolutions of crankshaft	One stroke for every one revolution of crankshaft
2.	Power for the same cylinder volume	Small	Large (about 1.5 times of 4 stroke)

INTERNAL COMBUSTION ENGINE

S. No.	Particulars	4 stroke engine	2 stroke engine
3.	Valve mechanism	Present	Ports are there instead of valves
4.	Construction & cost	Complicated, expensive	Simple, cheap
5.	Fuel consumption	Little	High (about 15% more)
6.	Removal of exhaust gases	Easy	Difficult
7.	Durability	Good	Poor
8.	Stability of operation	High	Low
9.	Changeability of rpm	High (with large flywheel)	Low (with small flywheel)
10.	Lubrication	Equipped with an independent lubricating oil circuit	Using fuel, mixed with lubricating oil
11.	Oil consumption	Little	Much
12.	Carbon deposit inside cylinder	Not so much	Much because of mixed fuel
13.	Noise	Suction & exhaust is noiseless but other working is noisy	Suction & exhaust is noisy but other working is noise less
14.	Air tightness of crankcase	Unnecessary	Must be sealed
15.	Cooling	Normal	Chances of over-heating
16.	Self weight and size	Heavy & large	Light & small

3.6. DIESEL ENGINE

I.C. engines are of two types:

1. Petrol Engine (Carburetor type, Spark Ignition Engine)
2. Diesel Engine (Compression Ignition Engine)

1. Petrol engine (Carburetor type). It is the engine in which liquid fuel is atomised vapourised and mixed with air in correct proportion before entering into the engine cylinder. The fuel is ignited in the cylinder by an electric spark.

2. Diesel engine (Compression ignition engine). It is an engine designed to convert chemical energy of heavier fuel oil into mechanical energy. The injected fuel is ignited by the heat of the air which is compressed by the piston within the cylinder head. In this engine, only air is sucked during suction stroke.

Principle of diesel engine

In such engines, only air is drawn into the cylinder instead of mixture of air and fuel as in carburetor type engine. Compression of the air during the compression stroke makes the charge very hot. Towards the end of the stroke, diesel fuel is injected into the cylinder in atomised form which ignites in the cylinder, causing rise in pressure which forces the piston down. No electrical ignition system is provided for sparking.

The basic elements of diesel engine are same as spark ignition engine but the method of fuel introduction and ignition are different to a great extent. The engine has high compression ratio hence the air in the cylinder attains very high temperature and pressure at the end of the compression stroke. At the end of the compression stroke, the fuel is sprayed into the cylinder through atomisers (injectors). The cylinder contains air at high pressure and temperature, hence the fuel begins to burn as soon as the fuel reaches the cylinder in atomised form. Such engines are called *compression ignition engines* because the ignition of fuel takes place due to heat of compression. Diesel engine is equipped with fuel injection pump and injectors. The injectors protrude into the combustion space of the engine.

Special features of diesel engine

1. Engine has high compression ratio ranging from 14:1 to 22:1.
2. During compression stroke, the engine attains high pressure ranging from 30 to 45 kg/cm² and high temperature of about 500°C.
3. At the end of the compression stroke, fuel is injected into the cylinder through injectors (atomisers) at a very high pressure ranging from 120 to 200 kg/cm².
4. Ignition takes place due to heat of compression only.
5. There is no external spark in diesel engine.
6. Diesel engine has better slogging or lugging ability i.e. it maintains higher torque for a longer duration of time at a lower speed.

Operation of diesel engine

For operation of diesel engine, the piston is placed inside the cylinder and it is attached to the crankshaft through the connecting rod. The piston is moved up and down in the cylinder. This up and down motion of the piston is changed into rotary motion of the crankshaft by the connecting rod. Fly wheel is attached to the rear end of the crankshaft. This makes the shaft revolve uniformly when the engine is running. The cylinder is tightly closed at the top by cylinder head which houses inlet and exhaust valves. Inlet valve admits air into

INTERNAL COMBUSTION ENGINE

the cylinder and exhaust valve allows the burnt gases to go out of the engine. The valves are held closed by valve spring and are made to open by means of rocker arms, which are operated by camshaft through valve lifters and push rods. The camshaft and fuel injection pump shaft are driven by the crankshaft through gears. The fuel supplied by fuel injection pump is injected into the cylinder through fuel injector. Fuel is ignited by heat of compression and piston is forced back by the expanding gases. Thus cycle is repeated.

Combustion Process in Diesel engine

In Diesel engine, only air is compressed in the cylinder by the piston. Then fuel is injected into the cylinder approximately 15° before top dead centre (TDC) and continues to approximately 10° after TDC

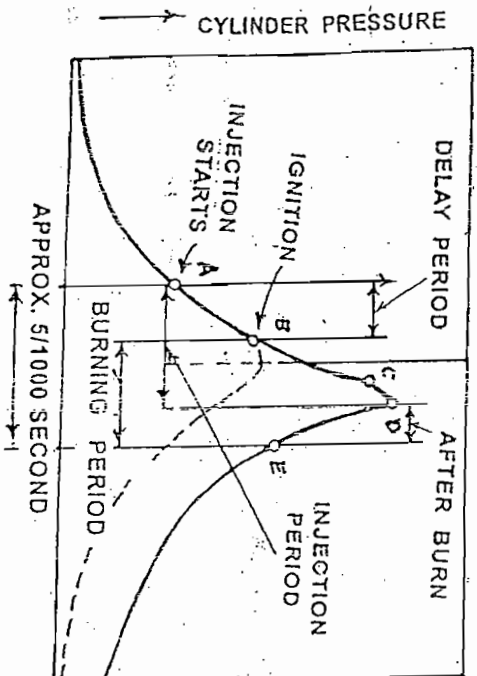


Fig. 3.7. Combustion process in Diesel engine

(Fig. 3.7). Due to fuel being in highly atomised form, it is self ignited by heat of the compressed air. That's why compression ratio of diesel engine is required to be high (14 to 22), and the compressed air temperature to be over 500°C.

The combustion takes place in the following four stages:

- (a) **Delay period before ignition** (Fig. 3.7). During this period, some fuel has been admitted but has not yet been ignited. At the completion of Delay period i.e. at the point B, ignition starts with rapid pressure rise.
- (b) **Period of rapid pressure rise and heat transmission** (Fig. 3.7 during B-C). Once ignition has been started and a flame established, the heat is transmitted to the piston and the

particles, resulting in rapid combustion and pressure rise in the combustion chamber.

(c) **Period of direct burning of later injected fuel (Fig. 3.7 during C-D).** At this stage, the temperature and pressure in the combustion chamber are so high that later injected fuel burn as soon as they enter.

(d) **Period of after burn (Fig. 3.7 during D-E):** At point D, fuel injection stops and fuel which has failed to burn till this period, burn during the period D-E.

If during the "Delay period", excessive fuel has been injected into the combustion chamber, the fuel will burn explosively, during the period B-C. Thus excessive pressure is created in the combustion chamber, which results in engine "Knocking".

Fuel injection pump

The fuel injection pump is the most important unit of diesel engine. It consists of barrel and a plunger. A cam is there to raise the plunger and the plunger returns back by the tension of a spring. The plunger fits so tightly that it seals off without a gasket at very high pressure. On the downward stroke of the plunger, the fuel enters from the suction chamber and fills the barrel. When the plunger goes upward, the fuel is compressed until the top edge of the cylindrical part of the plunger covers the portion, leading to the suction chamber. From there the fuel is forced out through the delivery valve and delivered to the pipe going to injector nozzle. The amount of fuel is adjusted to suit the requirement by means of a *governor* which changes the angular position of the plunger in the barrel.

Injector or atomiser

The atomiser or the injector receives the fuel from the fuel injection pump and sprays the fuel into the combustion chamber. The needle spindle of the atomiser is spring loaded at the top with a certain pressure. When the pressure exerted by the fuel overcomes the spring load, the needle valve is lifted from its seat and the oil is injected through the orifices.

3.7. COMPARISON OF DIESEL ENGINE WITH PETROL ENGINE

S. No.	Particulars	Diesel engine (Compression ignition engine)	Petrol engine / Kerosine engine (Spark ignition engine)
1. Cycle		Diesel cycle	Otto cycle
2. Fuel		Diesel fuel	Petrol/Kerosine

S. No.	Particulars	Diesel engine (Compression ignition engine)	Petrol engine / Kerosine engine (Spark ignition engine)
3. Charge		Only air is compressed in cylinder.	Air fuel mixture is compressed in the cylinder
4. Fuel supply		Fuel is injected into the combustion chamber through fuel injection pump & injector.	Air fuel mixture is prepared in the carburetor & supplied to engine
5. Ignition		By heat of compression	By electric sparks
6. Thermal efficiency		32 to 33%	25 to 32%
7. Compression ratio		14:1 to 22:1	5:1 to 8:1
8. Fuel consumption		160 to 200 g/hp-hr.	200 to 280g/hp-hr
9. Compression pressure		35 to 45 kg/cm ²	6 to 10 kg/cm ²
10. Temperature		About 500°C	About 260°C
11. Engine weight per hp		High	Comparatively low
12. Operating cost		Low	Comparatively high

3.8. ENGINE COMPONENTS

Internal combustion engine consists of a number of parts, which are given below:

1. **Cylinder.** It is a part of the engine which confines the expanding gases and forms the combustion space. It is the basic part of the engine. It provides space in which piston operates to suck the air or air-fuel mixture. The piston compresses the charge and the gas is allowed to expand in the cylinder, transmitting power for useful work. Cylinders are usually made of high grade cast iron (Fig. 3.8).

2. **Cylinder block.** It is the solid casting which includes the cylinder and water jackets (cooling fins in the air cooled engines).

3. **Cylinder head.** It is a detachable portion of an engine which covers the cylinder and includes the combustion chamber, spark plugs and valves.

4. **Cylinder liner or sleeve.** It is a cylindrical lining either wet or dry which is inserted in the cylinder block in which the piston slides. Cylinder liners are fitted in the cylinder bore and they are easily replaceable. The overhauling and repairing of the engines, fitted with liners is easy and economical. Liners are classified as:

(a) Dry Liner, and

(b) Wet Liner (Fig. 3.9).

8. *Flash test.* The flash point of an oil is the temperature at which inflammable vapours are given off. The oil sample is heated and the temperature at which distinct flash is obtained when flame is passed over the container is called *flash point*. The results are important for safety and fire protection measures.

Qualities of diesel fuel

The diesel fuel is of two types:

1. High speed diesel oil (HSD)
2. Light diesel oil (LDO)

High speed diesel oil is used for high speed diesel engines. It is lighter than LDO. Light diesel oil is the main source of fuel for slow speed engines.

- (i) Diesel fuel should be free from acid or any foreign matter, dirt and moisture.
- (ii) It must be able to lubricate the fuel pumps and fuel injection nozzles. Light fuels lack sufficient lubricating qualities.
- (iii) Diesel fuels are rated according to the cetane number, which is the indication of ignition quality of the fuel. The higher the cetane number, the better the ignition quality of the fuel.

Fuel combustion

The process of fuel combustion converts the chemical energy of the fuel into heat energy. Fuel combustion of I.C. engine takes place in two ways:

- (i) A mixture of air and fuel is compressed and ignited by a spark. This is called *spark ignition engine* or *carburetor type engine*.
- (ii) Air alone is compressed and fuel is injected near the end of the compression stroke. Fuel is ignited by the heat of compression. This is called *diesel engine* or *compression ignition engine*.

For getting maximum power from the carburetor engine, it is essential:

- (i) To maintain proper proportion of fuel and air.
- (ii) To ignite the mixture at the proper time.

Best result is obtained when carburetor is so adjusted that air-fuel ratio is about 15:1. Such mixture is called chemically correct mixture. This relation is explained in the following example:

Example 5.1. Find air-fuel ratio for complete combustion of fuel in a carburetor engine, using petrol which approximates to hexane C_6H_{14} .

Solution. Air contains 23% oxygen by weight.
Petrol when mixed with oxygen forms carbon dioxide (CO_2) and water.



... (i)

FUEL SYSTEM

After balancing the above equation, it is obtained as:

$$2(C_6H_{14}) + 19(O_2) = 12(CO_2) + 14(H_2O)$$

$$\text{or } (2 \times 86) + (19 \times 32) = (12 \times 44) + (14 \times 18) \text{ or } 780 = 780$$

$$\text{Oxygen per kg of fuel} = \frac{608}{172} = 3.54 \text{ kg.}$$

$$\text{Correct air supply per kg of fuel} = 3.54 \times \frac{100}{23}$$

$$= 15.36 \text{ kg.}$$

$$\text{Correct air-fuel ratio} = 15.37:1.$$

5.2. FUEL SUPPLY SYSTEM IN SPARK IGNITION ENGINE

The fuel supply system of spark ignition engine consists of:

1. Fuel tank
2. Sediment bowl
3. Fuel lift pump
4. Carburetor and
5. Fuel pipes.

In some spark ignition engine, the fuel tank is placed above the level of the carburetor (Fig. 5.2). The fuel flows from the fuel tank to

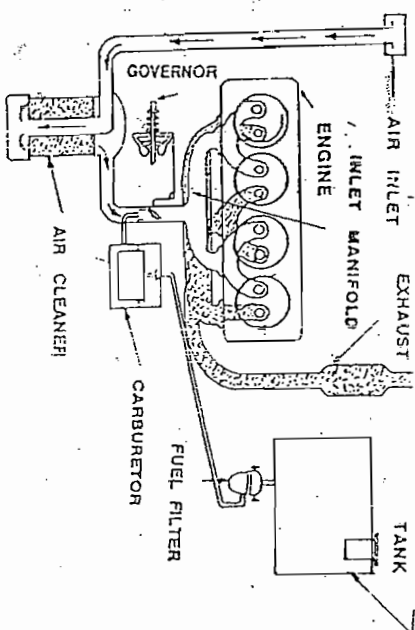


Fig. 5.2. Fuel system of spark ignition engine

the carburetor under the action of gravity. There are one or two filters between the fuel tank and the carburetor. A transparent sediment bowl is also provided to hold the dust and dirt of the fuel. If the tank is below the level of the carburetor, a lift pump is provided in between the tank and the carburetor for forcing fuel from the tank to the carburetor of the engine. The fuel comes from the fuel tank to the sediment bowl and then to the lift pump. From there the fuel goes to the carburetor through suitable pipe. From the carburetor, the fuel goes to the engine

the fuel. The secondary filter removes fine sediments from the fuel. Usually the primary filter is placed between the tank and the transfer pump.

5.8. AIR CLEANER

It is a device which filters and removes dust, moisture and other foreign matter from the air before it reaches the engine cylinder. Air cleaner is usually of two types:

1. Dry type air cleaner and
2. Oil bath type air cleaner

1. Dry type air cleaner. The filtering element in this case is a type of felt. The air passes through the element. The element has got larger surface area so the air speed becomes relatively low and consequently particle or dirt in the air is deposited on or stopped by its surface.

2. Oil bath type air cleaner. In this type of air cleaner, the incoming air impinges upon the surface of the oil, kept in a container in the lower part of the casing. The foreign particles of the air are trapped in the oil and then the air passes through a wire element before reaching the inlet manifold of the engine. The wire element also arrests the remaining dirt particles of the air.

Process to remove airlock in the diesel engine

Very frequently there is airlock in diesel engines. It is very important to remove airlock from the fuel system for satisfactory running of the engine. The following sequence should be followed for this purpose.

1. Open the fuel cock and fill the precleaner bowl with fuel.
2. Loosen the bleeding screws of the fuel filters and pump manually till diesel oil flows out without bubbles from both filters. Tighten the screw of the filters one by one.
3. Loosen the bleeding screws of the fuel injection pump and pump manually until bubble free diesel oil flows around these screws. Tighten the screws.
4. Loosen the capnuts on the injectors one by one and bleed the fuel till the bubble free fuel comes out from the capnuts. Tighten the capnuts one by one.

Precautions in handling diesel fuels in diesel engine

1. Fuel injection pump and injectors are very precise components of diesel engine. Dust is very harmful for fuel injection equipments. Hence extreme care should be taken to use perfectly

clean fuel. 90% of the troubles of diesel engines can be removed if absolutely clean fuel is used in the engine.

2. It is very dangerous to touch the spray of the diesel oil. The atomised fuel may enter the flesh of the body and poison the blood.
3. Disassembly and assembly of nozzles should be done in fresh fuel with extreme care.
4. Fuel filters should be cleaned at regular interval and they should be changed at specified time.
5. Fuel injection pump, injectors and governors should be opened and repaired by authorised technicians only and not by others.
6. While filling the diesel tank, a strainer should always be used.

Example 5.2. An I.C. engine consumes high speed diesel oil at the rate of 0.5 kg/h . Calculate the power of the engine.

Solution.

Heat value = quantity (kg) \times calorific value (kcal/kg)

$$= 0.5 \times 10550$$

$$= 5275 \text{ kcal/h.}$$

[Take calorific value of HSD = 10550 kcal/kg]

$$1 \text{ calorie} = 4.2 \text{ joules}$$

$$1 \text{ joule/sec} = 1 \text{ watt}$$

$$5275 \text{ kcal/h.} = 5275 \times 4.2 \text{ k joules/h.}$$

$$= \frac{5275 \times 4.2 \times 1000}{60 \times 60} \text{ joules/sec.}$$

$$= \frac{5275 \times 4.2 \times 1000}{60 \times 60} \text{ watts}$$

$$= \frac{5275 \times 4.2 \times 1000}{60 \times 60 \times 1000} \text{ kW}$$

$$\text{Power of engine} = 6.15 \text{ kW}$$

Example 5.3. A four stroke diesel engine operating at 800 rev/min uses 0.11 kg of fuel in 4 minutes. While developing a torque of 75 Nm . Calculate brake specific fuel consumption.

Solution.

$$\text{Power (kW)} = \frac{2 \pi n T}{60 \times 1000}$$

$$= \frac{2 \pi 800 \times 75}{60 \times 1000}$$

$$= 6.28 \text{ kW}$$

$$[T \text{ in N.m, } n = \text{rev/min}]$$