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Dairy Management for Livelihood Support of Farmers

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FOREWORD

Uttarakhand state with diverse agro-climatic endowments, the plains and hills present differing scenarios for agriculture. The hill farmers mainly practice subsistence farming. Although, now a days a number of well-educated rural youth are choosing Agriculture as profession and adopt modern agriculture as per their need and situation. Animal Husbandry and Dairying enterprise, along with agriculture, continue to be an integral part of human life since the process of civilization started. These activities have contributed not only to the food basket and draught animal power but also by maintaining ecological balance. They also play a significant role in generating gainful employment in the rural sector, particularly among the landless, small and marginal farmers and women, besides providing cheap and nutritious food to millions of people. India has vast resource of livestock and poultry, which play a vital role in improving the socio-economic conditions of rural masses. There are about 303.76 million bovines (cattle, buffalo, mithun and yak), 74.26 million sheep, 148.88 million goats, 9.06 million pigs and about 851.81 million poultry as per 20th Livestock Census (2019) in the country. India continues to be the largest producer of milk in world. Several measures have been initiated by the Government to increase the productivity of livestock, which has resulted in increasing milk, meat and egg, production significantly. Milk production is growing an annual growth of 5.81 per cent. The per capita availability of milk is around 441grams/day.

The National Livestock Mission (NLM) scheme focuses on entrepreneurship development and breed improvement in rural poultry, sheep, goat and piggery including feed and fodder development, and also in creating better livelihood opportunity for unemployed youth and livestock farmers in the cattle, dairy, poultry, sheep, goat, piggery, feed and fodder sector paving the way towards Atma Nirbhar Bharat by giving 50 per cent subsidy through hub and spoke model. Livestock Health and Disease Control is being implemented to reduce risk to animal health by prophylactic vaccination against diseases of livestock and poultry, capacity building of veterinary services, disease surveillance and strengthening veterinary infrastructure.

I am really delighted that realizing the importance and need, SAMETI Uttarakhand organized an online collaborative training program on “Dairy management for livelihood support of farmers” during February 26-28, 2024 sponsored by the National Institute of Agricultural Extension Management (MANAGE), Hyderabad for the Extension officials, entrepreneurs and faculty of SAUs/KVKs/ICAR institutes, etc. I hope that the participants from different parts of the country would have been immensely benefitted from this online course by interacting with the expert resource persons selected for this training. I have no doubt that the course would have been intellectually rewarding to the participants. The e-book for the above said training programme has been designed to provide first-hand knowledge to the readers. Last but not the least, I am thankful to Dr. Manmohan Singh Chauhan, Hon’ble Vice-Chancellor, G B Pant university of Agriculture and Technology, Pantnagar for encouragement in publishing this e-book. Also, congratulation to Dr B D Singh, Professor (Agronomy) and Km Jyoti Kanwal, Young Professional-II of the Directorate for smoothly organizing the training programme. The financial aid provided by MANAGE, Hyderabad for this training program is duly acknowledged.

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IMPORTANT BREEDS OF CATTLE & BUFFALO AND THEIR CHARACTERISTICS

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India is the highest milk producer and ranks first position in the world contributing about 24.64% of global milk production in the year 2021-22. The milk production of India has registered 58% increase during the last nine years i.e., during the year 2014-15 and 2022-23 and increased to 230.58 MT in the year 2022-23. The evolution of the dairy sector in India and the stellar role played by dairy cooperatives since the launch of Operation Flood form an integral part of the country's remarkable growth story after Independence. During the 1950s and 1960s, the situation was radically different. India was a milk-deficit nation dependent on imports, and the annual production growth was negative for several years. The annual compound growth rate in milk production during the first decade after independence was 1.64%, which declined to 1.15% during the 1960s. In 1950-51, per capita consumption of milk in the country was only 124 grams per day. By 1970, this figure had dropped to 107 grams per day, one of the lowest in the world and well below the minimum recommended nutritional standards. India's dairy industry was struggling to survive. The country produced less than 21 million tonnes of milk per annum despite having the largest cattle population in the world.

Following the visit of late Prime Minister Lal Bahadur Shastri to the Anand district of Gujarat in 1964, the National Dairy Development Board (NDDB) was created in 1965 with a mandate to support the creation of the 'Anand Pattern' of dairy cooperatives across the country through the Operation Flood (OF) programme which was to be implemented in phases. The 'Anand Pattern' was essentially a cooperative structure comprising village-level Dairy Cooperative Societies (DCSs), which promote district-level unions, which in turn promote state-level marketing federation. Starting in 1970, NDDB replicated the Anand Pattern cooperatives through the Operation Flood programme all over India.

Today, milk production is growing at the rate of two per cent in the whole world, whereas in India, its growth rate is more than 5 per cent**.** The per capita availability of milk in India is much higher than the world average. In three decades (the 1980s, 1990s and 2000s), the daily milk consumption in the country rose from a low of 107 grams per person in 1970 to 427 grams per person in 2020-21 as against the world average of 322 grams per day during 2021.

Components of Dairy Farming (5)

- Breeding Mgt/Breeds
- Housing Mgt
- Feeding Mgt
- Health Management
- General Management including marketing etc.

Table.1 Cattle Breeds of India (54)

S.N.	Breed	Home Tract
1	Amritmahal	Karnataka
2	Bachaur	Bihar
3	Bargur	Tamilnadu
4	Dangi	Maharashtra and Madhya Pradesh
5	Deoni	Maharashtra and Karnataka
6	Gaolao	Maharashtra and Madhya Pradesh
7	Gir	Gujrat
8	Hallikar	Karnataka
9	Hariana	Haryana, Uttar Pradesh and Rajasthan
10	Kangayam	Tamil Nadu
11	Kankrej	Gujarat and Rajasthan
12	Kenkatha	Uttar Pradesh and Madhya Pradesh

13	Kherigarh	Uttar Pradesh
14	Khillari	Maharashtra and Karnataka
15	Krishna Valley	Karnataka
16	Malvi	Madhya Pradesh
17	Mewati	Rajasthan, Haryana and Uttar Pradesh
18	Nagori	Rajasthan
19	Nimari	Madhya Pradesh
20	Ongole	Andhra Pradesh
21	Ponwar	Uttar Pradesh
22	Punganur	Andhra Pradesh
23	Rathi	Rajasthan
24	Red Kandhari	Maharashtra
25	Red Sindhi	Sindh province (now found on organized farms only)
26	Sahiwal	Punjab and Rajasthan
27	Siri	Sikkim and West Bengal
28	Tharparkar	Rajasthan
29	Umblechery	Tamilnadu
30	Vechur	Kerala
31	Motu	Orissa,Chhattisgarh and Andhra Pradesh
32	Ghumusari	Orissa
33	Binjharpuri	Orissa
34	Khariar	Orissa

35	Pulikulam	Tamilnadu
36	Kosali	Chhattisgarh
37	Malnad Gidda	Karnataka
38	Belahi	Haryana and Chandigarh
39	Gangatiri	Uttar Pradesh and Bihar
40	Badri	Uttarakhand
41	Lakhimi	Assam
42	Ladakhi	Jammu and Kashmir
43	Konkan Kapila	Maharashtra and Goa
44	Poda Thurpu	Telangana
45	Nari	Rajasthan and Gujarat
46	Dagri	Gujarat
47	Thutho	Nagaland
48	Shweta Kapila	Goa
49	Himachali Pahari	Himachal Pradesh
50	Purnea	Bihar & Jharkhand
51	Kathani (purpose)	Maharastra
52	Sanchoni	Rajasthan
53	Masilum	Meghalaya
54	Frieswal	UP & Uttarakhand

Table.2 Categorization of Important Cattle breeds of India

Milch Breeds	Dual Purpose Breeds	Drought Breeds
1.Sahiwal	1. Rathi	1. Nagpuri
2. Red sindhi	2. Hariana	2. Malvi
3. Gir	3. Mewati	3. Kherigarh
4. Tharparkar	4. Kankej	4. Kankahta
	5. Deoni	5. Nimari
	6. Ongole	6. Panwar
	7. Gaolao	7. Bachur
	8. Krishna valley	8. Khillari
	9. Dangi	9. Amritmahal
		10.Hallikar
		11. Bargur
		12. Kangyam
		13. Siri

Table.3 Characteristics of Important Cattle Breeds of India

Sr No	Breeds	Home tract	Characteristics	Adult weight (kg)		Milk (kg)/lact
Milch Breeds				**M**	**F**	
1	Sahiwal	Montgomery Distt.(Pakistan), Organized farmers In pb Haryana ,Up Bihar, MP,WB	Red /loose skin, horns stumpy short, thick, do not exceed 3 inches	540	400	1800
2	Red Sindhi	Sindh, Organized farms in Haryana,TN and other parts of India	Red/medium size compact animal, well proportioned	460	320	1600
3	Gir	Junagarh , Kathiawar and Baroda	Red/red and white, ears markedly long resembling a tiny curled leaf	550	400	1500
4	Tharaparkar	Ajmer, Jodhpur	White or light grey, medium size	540	350	1700
Dual Purpose Breeds						
1	Rathi	Rajsthan (mixture of Sah, RS and TP)	White or grey or brown patches	380	325	1800

2	Hariana	Rothak, Hisar, Karnal, Guragaon, Western Rajasthan	White or light grey, proportionate body horns short curving inward, stumpy	500	350	900
3	Mewati	Mathura (UP), Alwar And Bharatpur	White with grey patches /similar to Hariana	400	350	4-5kg/day
4	Kankrej	Kutch and Ahmedabad (Gujrat)	Silver or iron grey	550	430	1600
5	Deoni	AP, Karnatak, MS	Black and white Red and white	590	340	900
6	Ongole	Ongole & Nellore (AP)	White or grayish	550	440	700
7	Gaolao	Chhindwada (MP) Wardha and Nagpur, AP	White	490	330	500
8	Krishna Valley	MS, AP, Karnataka	Grey white	500	340	-
9	Dangi	MS, Valsad (Gujrat)	Red and white black and white	365	295	600
Draught Breeds						
1	Nagori	Rajasthan	White or grey	400	340	500
2	Malvi	MP	Grey	430	340	500
3	Kharigarh	Lakhimpur Khiri (UP)	White	475	320	400
4	Kenkatha	Bundelkhand (UP), MP	Grey	340	295	Poor milker
5	Nimari	Nimar and Indore (MP)	Red with white spot	390	320	300
6	Panwar	Pilibhit and Lakhimpur (UP)	Black with white	320	295	-
7	Bachur	Darbhanga , Sitamarhi Muzaffarpur, Champaran (Bihar)	Grey	385	320	500
8	Khillari	MS	White to grey	500	345	300
9	Amritmahal	Karnataka	White to grey	500	320	-
10	Hallikar	Tumkur, Haasan,	Dark or light	450	300	-

		Mysore (Karnataka)				
11	Bargur	Coimbatore	Red and white	340	395	350
12	Kangayam	Coimbatore	White and grey	500	330	600
13	Siri	Sikkim, Darjeeling	Black and white	450	350	900
14	Red Kandhari	Maharashtra	Dark Red	-	-	-
15	Punganur	Andhra Pradesh	White or light Grey	130 to 200		500
16	Umblechery	Tamil Nadu	Grey with white makings on face and legs	-	-	-
17	Vechur	Kerala	Red, black and white	95 to 150		500

Table.4 Cattle Breeds Evolved in India

Sl. No.	Breeds	Characteristics
1	Taylor	Shorthorn and Jersey with local cows around Patna
2	Jersind	Cross of Jersey Red Sindhi at Allahabad
3	Sunandini	Brown Swiss x non descript at Munar (Kerala)
4	Karna Fries	Friesian x Tharparker at NDRI, Karnal
5	Jerthar	Jersey bull x Tharparkar cows at Bangalore
6	Karna Swiss	Brown Swiss x (Sahiwal and Red Sindhi) at NDRI Karnal
7	Frieswal	62.5 % level of exotic inheritance of Friesian and rest Sahiwal at M.D.F.

Table. 5 Exotic Cattle Breeds (Bos Taurus)

Breeds	Jersey	Hololein – Friesian	Ayrshire	Brown Swiss
Country of origin	Island of Jersey in the England channel	Holland	Scotland	Switzerland
Colour	Light yellow colour with or without marking	Black and white	Red/ brown or combination with white	Distinctly brown

Average Body weight in kg	**F**	450	675	550	625
	M	675	1000	850	900
Average milk yield (lt/305 days)		4000	6150	4850	5250
Age at first calving (months)		38	36	40	40
Characteristics	Heads have a double dished, straight top lines, level rumps		Head is long narrow and straight	Most beautiful dairy breed, straight top lines, level rump and good udders	Large head usually dished and thick loose skin, used for ploughing and pulling carts as well as for milk and beef
Fat %	5.5		3.5	4.1	4.0
Protein %	3.9		3.1	3.6	3.6

Table. 6 Buffalo Breeds of India (20)

Sl. No.	**Breed**	**Home Tract**
1	Bhadawari	Uttar Pradesh and Madhya Pradesh
2	Jaffarabadi	Gujrat
3	Marathwadi	Maharashtra
4	Mehsana	Gujarat
5	Murrah	Haryana
6	Nagpuri	Maharashtra
7	Nili Ravi	Punjab
8	Pandharpuri	Maharashtra
9	Surti	Gujarat
10	Toda	Tamil Nadu
11	Banni	Gujarat
12	Chilika	Odisha
13	Kalahandi	Odisha
14	Luit (Swamp)	Assam and Manipur

15	Bargur	Tamil Nadu
16	Chhattisgarhi	Chhattisgarh
17	Gojri	Punjab and Himachal Pradesh
18	Dharwadi	Karnataka
19	Manda	Odisha
20	Purnathadi	Maharastra

Table.7 Characteristics of Important Buffalo Breeds of India

Breeds	Home tract	Characteristics	Weight M/F	Milk lactation
Murrah	Rohtak, Hissar Jind, Nabha , Ludhiana (Haryana, Punjab), distributed in UP, Rajasthan and other places	Black, curled horns, well developed udder and long tail with switch reaching to ground and light neck and head	570/450	1800 kg fat 7%
Nili Ravi	Ferozepur (Panjab)	Black with white markings on forehead, muzzle, legs and tail, horns small with a high coil and the neck is long thin, have coarse and heavy head	600/450	1700 kg fat 7%
Surti	Surat, Baroda (Gujrat)	Brown / black hair, rusty brown to silver grey, horns are sickle shaped and flat which grow in a downward and backward direction and then up wards at the tips forming a hook, medium size, well developed udder	-	1600 kg fat 7.5%
Mehsana (Murrah x Surti)	Mehsana, Sabarkanta, Baroda (Gujrat)	Black to grey with white markings on face and legs, medium sized animals, horns resemble Surti or Murrah breed, as compared to Murrah, the body is longer and tighter, well developed udder carried well behind	600/450	1600 kg
Jaffarabadi	Junagarh Jamnagar, Kutch (Gujrat)	Black with white patches on face and legs, noticeable feature is the very prominent forehead and heavy horns inclined to droop on each side of the back and then turn up at the points but not in such a tight curl as in Murrah buffaloes, body is longer but not so compact, udder well developed	600/450	1800 kg fat 9-10%

Bhadawari	Agra, Etawah (U.P), Gwalior (M.P)	Copper coloured with short hair of black or brown colour, medium body and wedge shaped body, comparatively small head bulging toward horns	475/385	900 kg fat 12%
Nagpuri	Nagpur, Akola, Amaravati (M.S), M.P and A.P	Black with white patched on face legs and tail, lighter type breed, neck also longer with heavy brisket, long, flat & curved horns reaches towards back over the shoulders	-	1000 kg fat 7.0-8.5%
Toda	Niligiri (T. N.)	Grey skin, large sized animals having long barrel and strong build animals furious and dangerous particularly to unknown persons	--	800 kg fat 7%

Chapter-2

CATTLE AND BUFFALO HOUSING MANAGEMENT

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Introduction

Animal housing is required to protect animals from inclement weather, give them a hygienic, comfortable place to live, and enable efficient management. Efficient animal housing aims to increase milk yield, enhance labor efficiency, enhance animal health, lower disease rates, better care and management, and increase milk production. There are several different housing systems. The farmer must select the most efficient housing system while taking into account the number of animals, the neighborhood's surroundings, and their financial situation.

Site Selection Criteria

1. **Soil type:** The optimal soil type is sandy loam, with fertile land designated for fodder cultivation and less fertile land allocated for construction purposes.

2. **Topography and Altitude:** Preferably elevated terrain with proper drainage systems to manage livestock waste effectively.

3. **Sun Exposure:** The site should receive ample sunlight to mitigate dampness, sterilize surfaces, and provide health benefits to animals.

4. **Wind Patterns:** Address high wind velocities with natural windbreaks like tall trees or buildings to shield against extreme temperatures and offer shade during summer.

5. **Water Supply:** Access to fresh, clean, and drinkable water is indispensable for livestock hydration, cleaning, and farm maintenance, avoiding any water contamination from pollutants.

6. **Proximity to Markets:** Ideally located near markets for sourcing quality and cost-effective raw materials, facilitating efficient product distribution, and minimizing storage expenses.

7. **Transportation Accessibility:** Convenient access to well-connected roads or railways to reduce marketing costs, prevent product spoilage, and minimize disturbance from nearby railway tracks.

8. **Electricity Supply:** Availability of electricity for operating farm machinery and providing lighting for livestock comfort.

9. **Labor Force Availability:** Adequate supply of skilled and dependable labor willing to work for fair wages, considering labor costs as a significant expense in livestock farming.

10. **Surrounding Environment:** Avoid proximity to noise, chemical, or sewage-heavy areas, as well as urban and industrial zones, to maintain a tranquil and healthy environment for livestock.

11. **Other Facilities:** Nearby amenities such as banking, postal services, shopping centers, schools, and recreational options for the welfare and convenience of farm workers.

Systems of Housing

There are various kinds of housing systems, such as free-range, traditional barn, and loose housing. In addition to the farmer's preferences, the type of dwelling should take local and geographical conditions into account as well as economic factors. The loose housing system is better suited to Indian conditions.

1. Conventional Barns

Conventional barns are closed houses with complete roof, walls and windows or ventilators at appropriate places, where the cows are kept together on a platform. Neck chain, ropes or stanchions are used to restrain the animals, thereby giving the name stanchion barn. Milking and feeding of concentrate and grain are done inside the barn. Due to their high relative cost, conventional dairy barns are losing favour daily. In traditional barns, cattle are better shielded from unfavourable weather conditions. In the temperate Himalayan regions, where winters are long and harsh, conventional barns are built.

Fig.1 Conventional housing system

Advantages

1. Protection of animals from extreme weather conditions.
2. The animals can be kept cleaner and diseases can be controlled better in barns.
3. Milking can be done in the same shed.
4. Diseases are better controlled.
5. Individual care can be given.

Disadvantages

1. Cost of construction is more.
2. Not suitable in hot and humid climatic regions.
3. Future expansion is difficult.
4. Animals get lesser freedom and exercise.

2. Loose Housing System

This housing system allows the animal to live in an open paddock or pasture during the day and night, except when they are being milked. The animals can stay under the shed along one side of the open pasture when it's hot, cold, or raining. Within the shed there is provision for common watering tank and fodder manger. Concentrates are fed in a separate milking barn at the time of milking. Half walls wooden or basic wire fences surround the open paddock. The majority of the country can use this form of housing, except the temperate Himalayan region and locations with a lot of rain.

Fig.2 Loose Housing system

Advantages

1. The loose housing system is more adaptable in function, less expensive to build, and easier to extend.
2. Feeding and watering is done in common manger, hence managing and feeding stock is simpler.
3. Animals can move freely are more comfortable.
4. 10 to 15 percent extra animals can be kept for shorter period of time.
5. Animal heat detection is simpler.
6. Additionally, animals get enough exercise, which is crucial for better health outcomes.
7. Clean milk production is possible since the animals are milked in a separate milking barn.
8. Suitable for large herds.

Disadvantages:

1. Not suitable for temperate Himalayan region and heavy rainfall areas.
2. More land is required.
3. There is competition for feed and water.
4. A separate milking barn is required for milking animals.
5. Individual feeding and observations are difficult.
6. Not suitable for small holdings.

Facilities of dairy cow building

- The milch animal shed should have the following parts
- Feeding passage, Manger, Standing space, Gutter or drainage channel and Milking passage
- Single row system
- In single row system, 12-16 numbers of animals can be kept.

Double row system

- If it is greater than 16, then double row system is preferable.
- In double row system up to 50 animals can be maintained in a single shed.
- The distance between two sheds should be greater than 30 feet or it should be twice the height of the building.
- In double row system two methods available. They are tail to tail and head to head.
  Tail to tail system: Animals face out. There is less chance of disease transmission. Animals get more fresh air. Milking and supervision of milking is easy.

Head to head system: Animals face in. Feeding of animals is easier. Gutters are more exposed to sunlight. There may be more chances of disease transmission.

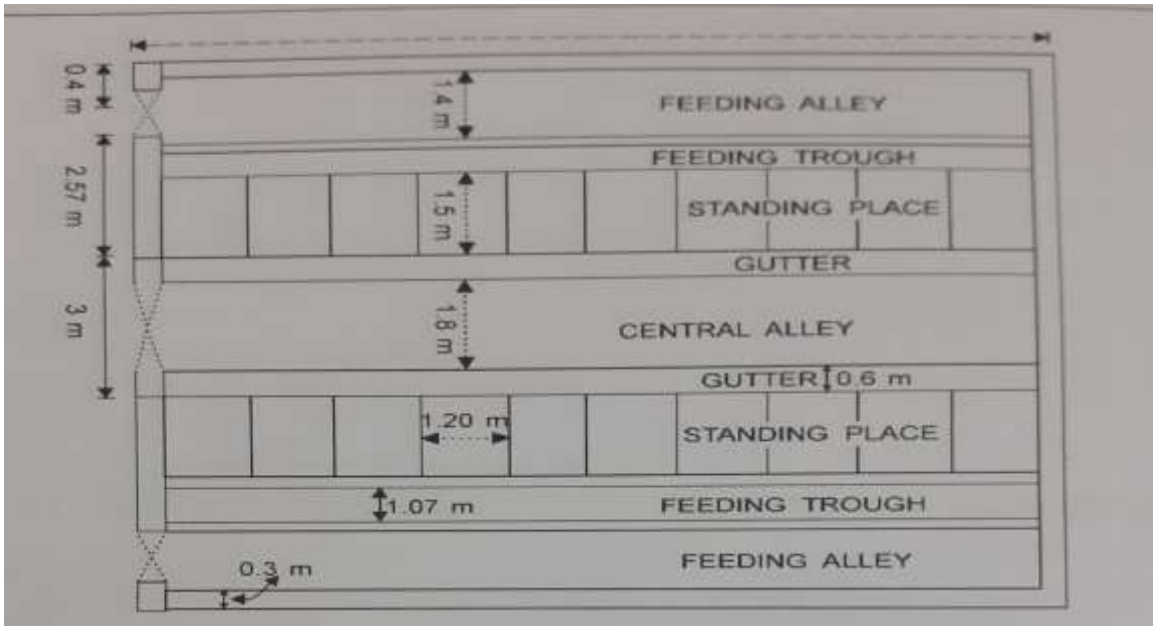

Fig.3 Top view of tail to tail barn

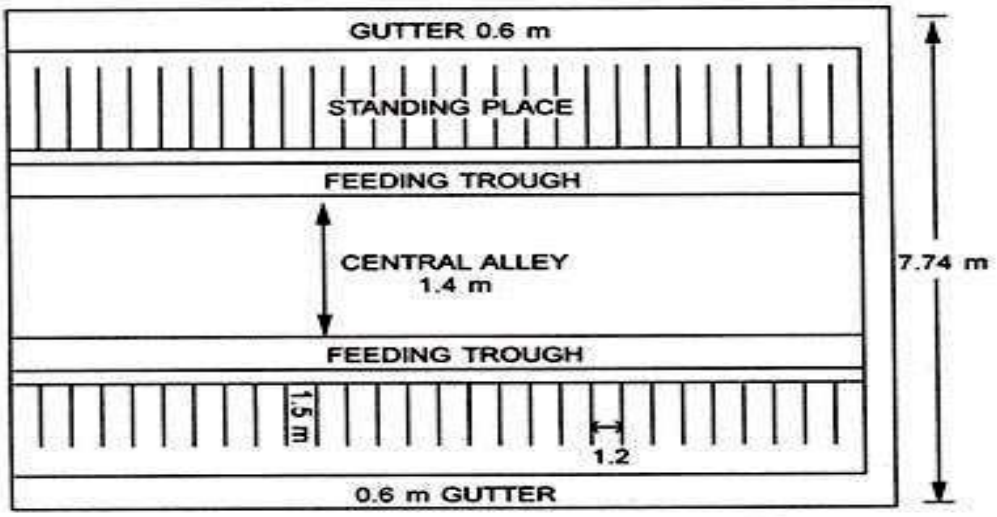

Fig.4 Top view of Head to Head barn

a. Milking barn or parlour

- This is a barn where milch animals are milked and is fully covered.
- It should be located at the centre of the farm with all other farm buildings arranged around it.

- There shall be an individual standing in the milking barns and the number of standings required should be 25% of total number of milch animals in the herd.
- The milking operation should be carried out in batches.

➢ Dimensions of milking barn
➢ Length of standing space: 1.5 – 1.7 m
➢ Width of standing space: 1.05 – 1.2m (80% of length, of standing space)
➢ Width of central passage: 1.5 – 1.8 m
➢ Width of feed alley: 0.75 m
➢ Width of gutter: 0.30 m
➢ Overhang: 0.75 m

b. Down calver shed/ calving pen

- Pregnant animals are transferred to a calving pen 2 to 3 weeks before the expected date of calving.
- Calving pen of 3m x 4m (12 m2) is essential to keep the animals in advanced stage of pregnancy.
- It should be located nearer to the farmer's quarters for better supervision.
- The number of calving pens required is 10% of the number of total breedable female stock in the farm.

c. Calf pen

- This is meant for housing young calves separately. It can be located either at the end or on the side of the milking barn.
- This facilitates taking calves to their dams quickly.
- If there are large numbers of calves, the separate unit of calf shed should be arranged and located nearer to the milking barn.

d. Young stock/ heifer shed

- It is meant for housing young heifers separately.
- Older heifers calves from about six months of age to breeding age are to be housed separately from the suckling calves.
- When a large number of young stocks are there, they should be divided into different age groups and each group housed separately.

e. Dry animal shed

- In large farms, milch and dry cows are housed separately.
- The floor in the covered area should preferably be made of cement concrete.
- Under Indian conditions, in smaller farms, milch and dry animals can be housed together.
- Normally, one third of the animals in a farm will be in dry or in dry cum pregnant stage.

f. Bull shed

- It is meant for housing bulls separately in a farm.
- It should be constructed towards one end of the farm.
- There shall be one shed for each bull.

- The number of bulls required being one for every 50 breedable females on the farm, if natural breeding is practiced.
- When artificial insemination service facilities are available, no necessary to keep the bulls on the farm.
- The bull shed shall have covered 3x4 metre dimensions, leading into a paddock of 120 square metres.

g. Isolation shed

- It is the separation of sick animals from apparently healthy animals to avoid transmission of diseases to healthy stock.
- It should be located at the corner of the shed.

h. Quarantine shed

- It should be located at the entrance of the farm.
- The newly purchased animals entering into the farm should be kept in quarantine shed for a minimum period of 30 to 40 days to watch out for any disease occurrence

Accessory buildings

a. Store room

- All the four walls should be closed and it should be rat proof.
- There should be one concrete store room with feed mixing unit at a distant place and a smaller feed store room behind the milking parlour.

b. Milk room

- It is essential to keep the milk and also to chill the milk in larger dairies having 400 to 700 litres production capacity that requires 3.7 m x 5m size of room and an additional 0.37 m2 for every 40 litres of milk production.
- For a smaller dairy unit below 100 litres a small room with a dimension of 3.75m x 3m can be sufficient for storing milk and concentrate feed.

c. Hay or straw shed

- An adult animal consume about 5 to 10 Kg of hay or straw per day, while young stock consume about 2 to 5 kg of hay or straw per day.
- The annual requirement can be calculated and the space requirement can be arrived.

Housing of calves

The main objective in planning and designing of calf housing is to provide an environment which will minimize the requirement for veterinary aid, minimize calf mortality and encourage the production of healthy calves. The calf housing should provide a suitable environment to both the calf as well as the stockman. Fundamental requirements in a calf shed

- Provide dry bedding.

- Well ventilated environment. It removes the products such as ammonia, hydrogen sulphide, carbon dioxide and methane.
- A specific minimum cubic air capacity per calf.
- A dry bed is important to reduce heat loss to the floor and minimize the use of straw.
- Moisture removal from a calf house is usually accompanied by a combination of drainage and ventilation.
- The cubic air capacity per calf is important in all calf housing designs because it dilutes the intensity of disease producing organism in a building thus reducing the danger of cross infection.
- Height and space provided in the housing allows the air to be introduced into a calf house well above the level of calves thus, minimizing the risk of draught at calf level during winter months.
- If all-in all-out system is practiced proper disinfection and cleaning operation between batches should be ensured.
- A minimum period of 3 weeks between batches should be allowed.
- The age range in a group of calves should be narrow.
- Only calves from the similar background should be grouped together wherever practicable.

Types of housing for calves

Calf housing is basically of three types.

- To house dairy and beef calves reared for replacement or for beef production.
- To house calves reared for veal production.
- To house sucking calves.
- Most of the calves reared come under the first category.
- The type of housing used for calf rearing varies from situation to situation.
- There is great diversity of opinion whether the calves should be reared in individual pen or in groups.
- In India, calves are generally reared in groups in ordinary stall barn or in the same house along with adult cattle.
- Individual pens should be constructed so that they can be easily cleaned and disinfected.
- This prevents naval sucking and prevents the spread of disease through facial or other contact.

- If railed pen divisions are used, contact is not completely prevented so that they can able to see each other.
- But in other types of housing, the contact is completely prevented.
- It is better to keep the calves in individual pens at least 1 month, if possible, up to 3 months.
- After 3 months, 3 to 5 calves are kept in single pen. After 6 months to breedable age, the animals are kept in singles.
- After 6 months of age the male calves are usually disposed for either breeding or slaughter purpose.
- For ease of management, calf shed or calf unit should be placed adjacent to the dairy unit.

Table.1 Recommended floor space requirement for different age group of calves

Age of Calves (months)	Floor space requirement covered area(m2)	Floor space requirement open area(m2)	Number of calves per pen
0-3	1.0	2	24
3-6	1.5	3	16
6-12	2.0	4	12

Housing of bulls

Bull is half of the herd, is literally true in the sense that the dairy bull contributes the off-spring half of the herd's genotype. In hot regions, the bull's semen production is affected if it has not been properly housed. So, adequate, well facilitated bull house is needed to improve the breeding efficiency in a dairy farm. Bulls are housed in pen and yard system. Bulls must be housed individually; it may be housed in singe row or double row system.

Purpose

- To protect from inclement weather and for safety and easy handling.
- Provisions for exercise. To improve the reproductive efficiency in the dairy farm.

Floor space requirement

- In the covered area $12m^2$ per bull can be provided and the open exercise yard $120m^2$ per bull. If open yard is not provided the bull exerciser is needed.

Table.2 Floor space requirements for cattle and buffalo

Type of animal	Floor space per animal (m^2)		Max No of animals/pen	Height of shed at eaves (cm)
	Covered area	Open paddock		
Cows	3.5	7.0	50	175 in medium and heavy rainfall areas and 220 in semi-arid and arid areas.
Buffaloes	4.0	8.0	50	
Down calvers	12.0	12.0	01	
Young calves (<8 weeks)	1.0	2.0	30	
Older calves (>8 weeks)	2.0	4.0	30	
Bulls	12.0	120.0	01	

Table.3 Feeding/ Watering Space requirement

Type of animal	Space per animal (cm)	Total manger length in a pen for 100 animals(cm)	Total water tank length in a pen for 100 animals (cm)	Manger/Water trough dimensions (cm)		
				Width	Depth	Height
Adult cattle & buffaloes	60 – 75	6000 – 7500	600 – 750	60	40	50
Calves	40 – 50	4000 – 5000	400 – 500	40	15	20

Chapter-3

FEEDING MANAGEMENT IN CATTLE AND BUFFALOES

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Introduction

India possesses a huge livestock population. Commercial livestock farming in India is expanding due to income increase, rapid urbanization and changing dietary habits. Cattle and buffaloes have the capacity to convert roughages, by- products from the food industry and other useless waste products, into valuable products like milk and meat. As "waste product utilizers" cattle and buffaloes contribute to the environment. To explore the genetic potential of the cattle and buffaloes, feeding a balanced ration to meet the daily nutrient requirements of the animal in terms of maintenance, weight gain, reproduction and milk production is important. In all commercial livestock farming systems including cattle and buffalo production, the cost of feeding is the most expensive item of the production costs. It is therefore utmost important that feedstuffs are produced and utilized in the most optimal way. To provide balanced feed at low cost is a very important aspect of Cattle and Buffalo Production. There is a deficiency of 23.24 % in dry fodder, 28.9 % in concentrates and 11.24% in green fodder (IGFRI, 2022). So a judicious use of available feed resources is possible only through scientific feeding taking into consideration the different nutrients required by livestock for different physiological functions i.e. maintenance, growth, reproduction and milk production, knowledge of nutrient composition of different feed and fodder resources and their utilization by the animals and by formulating balanced rations using various feed and fodder resources for different physiological functions of the livestock.

Livestock keeper should have excellent knowledge and skills with regard to feeding management. Many of the farmers in India have shortage of land, shortage of high quality feedstuffs and along with these climate change, natural calamities, emergence of new diseases bring different practical problems to them.

Due to the Green Revolution in India, the farmers are now able to produce more and better quality feeds and fodders. However, due to the absence of proper skills in feeding management, the extra feed and fodder resources are not utilized in the best way. An attempt to produce a

properly balanced diet at the least cost to the farmer without affecting the environment can give the farmer the optimum income from Cattle and Buffalo Production. In the last few decades , lot of research has been done for the ways in which livestock use feed to maintain life, to grow, to reproduce and to produce animal products which man uses, especially milk.

Status of cattle and buffalo feeding in India

- Non-descript cows and buffaloes with low milk production ability are allowed for grazing after morning milking till evening milking time. Common grasses are cut and fodders like sorghum fodder,paddy straw are fed as dry fodders.
- Medium and high yielding animals are maintained in house and fed with cultivated grasses like Bajra, Napier grass, Sorghum fodder, Guinea grass and leguminous fodders like Berseem, Lucerne, Cowpea etc. In addition concentrate feeds comprising of grains, oil cakes, brans and mineral supplements are fed.
- In organized farms, the body weight of the animals are measured and the nutrient requirement of the animals for maintenance and production are calculated and accordingly fed a balanced ration containing green fodder, dry fodder and concentrates.

Important Points of Feeding Management:

- The feeding manger should be large enough to allow all animals to eat at the same time. Preferably feed mangers should be 5-10 cm higher than the standing place of the animal. In this position there is more production of saliva during feeding which improves rumen function.
- Feeding of animals should be always at the same time. Animals like routine. It must be ensured that feed is easily accessible. Fodder should be chaffed for its better utilization. Feed enough so that the feeding manger will never be empty. In this situation animals will eat in small portions throughout the day ensuring that the rumen is always full and functioning well. Clean the feeding manger at least once a day (feeding mangers with a smooth easy to clean surface also leads to reduced heating up of feed).
- It should be ensured that animals have access to clean and fresh water 24 hours per day. Animals drink water a no. of times per day usually after milking and after every meal. Preferred temperature should be between 17 – 27 ºC.
- Make sure that there are enough comfortable lying down areas for the animals (they should lie down at least 12 hours per day). They will spend 8 to 10 hours ruminating.

Ration

A ration is the feed allowed for a given animal during a day i.e. 24 hours. The feed may be given at a time or in portions at intervals.

Balanced ration

A balanced ration is a ration which provides the essential nutrients to the animal in such proportion and amounts that are required for the proper nourishment for 24 hours as per physiological status of the animal.

Desirable characteristics of a ration

- The ration should be properly balanced
- The ration must be palatable
- Variety of feed in the ration
- The ration should contain enough of mineral matter
- The ration should be fairly laxative
- The ration should be fairly bulky
- The ration should contain sufficient green fodder
- Avoid sudden changes in the ration
- Maintain regularity in feeding
- The feed must be properly prepared
- A ration should not be too bulky
- Economy in labour and cost

Feedstuffs for cattle and buffaloes feeding

Balanced rations for cattle and buffaloes feeding are made up of five basic types of feedstuffs. When combined in the right amounts, these feeds can supply all the nutrients needed to keep cattle and buffaloes healthy and productive. These five types of feedstuffs are:

a. Bulk forages for energy

These are mostly grass-like plants that have long stems, long narrow leaves and flower spikes and contain a lot of fibre in their structure. They include fresh materials, such as green grass, as well as dry materials, such as straw and hay. They provide most of the energy an animal needs and some minerals and will make up most of the ration – they are

what fills the animal and stops it feeling hungry. Most bulk forages contain only low levels of protein.

b. Supplementary forages for energy and protein

Supplementary forages provide both energy and protein and some minerals. These are fibrous plants, similar to bulk forages, but they are usually especially grown on the farm as feed for cattle and buffaloes and contain higher protein and/or energy levels than bulk forages. Most of them are legumes and include herbaceous plants, shrubs and trees also. They are fed in addition to the bulk forages, usually in smaller amounts. They can be used either to compensate for poor quality bulk forages or they can be used as substitutes for concentrates.

c. Concentrates for energy and protein

These are feeds that supply more highly concentrated nutrients than forages. They contain high levels of protein or energy or both, and also some minerals. They include specially made feeds, such as commercial dairy meals, as well as cereal by-products (wheat bran,rice polish) and other high energy and/or high protein feedstuffs (molasses, fish meal and brewers' dried grains). Cereal grains such as maize, oat and barley if available locally and economically can also be used to feed cattle and buffaloes. Concentrates are expensive and are therefore fed in small amounts in addition to forages, he amount fed depends on the milk produced by the animal.

d. Mineral supplements

Some minerals are naturally present in bulk and supplementary forages and concentrates, cattle and buffaloes also need additional minerals regularly. This is done by regularly offering a commercially manufactured mineral mixture.

e. Vitamin supplements

Not a problem with practical cattle and buffalo rations as some of the vitamins are made by the micro-organisms in the rumen and body while others are naturally present in feeds, such as leafy green forages.

Water

Ideally, cattle and buffaloes should have access to clean drinking water at all times. In addition to the amount required for normal body functions, a milking animal requires about five litres of water to produce one litre of milk.

Conservation of forage crops

To supply greens round the year conservation of forage crops should be done. Seasonal variation creates surplus forages at a particular time, if not conserved properly it would be wasted. Common methods of conserving forages are Hay making which is a simple method to drive off extra moisture in forages, while in Silage making natural fermentation is facilitated to retain moisture in the preserved forage.

Hay making: In hay making, moisture content of the green crop is reduced to a level of 12-14% so as to inhibit the action of plant and microbial enzymes. The harvested crop can be dried either by natural drying or through artificial drying, but natural drying is preferred as it can be done without any expenditure on electricity.

Oat is the best crop for hay making.

Factors to be considered in hay making

- The crop for hay making should have soft pliable stem.
- The crop should be harvested at 2/3rd flowering stage as there are maximum nutrients at this stage.
- Hay should be leafy and green in color.
- Hay should be free from moulds and weeds.
- Hay should have the characteristic aroma of the crop.

Procedure of hay making (Natural drying)

Good quality hay can be produced by harvesting the crop early in the morning and left in the field as such for curing. The harvested crop should be allowed to dry in the field until the moisture content is reduced to about 40%.Frequent turning is necessary to facilitate uniform drying. On sunny days field drying of harvested crop for two days is sufficient to make hay. The air dried crop may be turned and made into small feathery windrows at the end of first day which may be baled at the end of second day and if further drying is required they may be placed over tripods or tetrapods or over

the fence to facilitate aeration during drying. Hay should be stored in well ventilated place. Average quality hay contains 25-30 per cent crude fibre and 45-60 per cent TDN.

Losses during hay making

Nutritive value of hay may be lost due to late cutting of crop, losses of leaves by shattering, fermentation and leaching.

Losses during hay making

Nutritive value of hay may be lost due to late cutting of crop, losses of leaves by shattering, fermentation and leaching.

Artificial drying: Artificial drying is very efficient process of conserving forage crops but it is expensive. In this method drying is done by allowing hot gas (150^{o}C) to pass through herbages for about 20 to 50 minutes depending upon the drier design and the moisture content of the crop. To dry herbages within 0.5 to 2 minutes driers are available in which gases in the range of 500-1000^{o}C are allowed to pass through.

Silage making:

Silage is the preserved material produced by the controlled fermentation of crop under anaerobic conditions in a structure known as silo. Term ensilage is used for the silage making process. The main purpose of silage making is to preserve succulent fodders for usage at the time of scarcity. It involves natural fermentation in anaerobic condition with due care to discourage activities of undesirable bacteria.

Maize is the best crop for silage making.

Factors to be considered in silage making

- Crop with soft and pliable stem is most suitable for silage making.
- Crop should be harvested when 50% of the crop is in ear emergence stage as at this stage crop will be nutritious as well as with high biomass yield.
- Crops with high moisture (85%) will produce more effluents that would go as waste.
- To reduce effluent loss, crops with high moisture content are wilted for few hours, until moisture level is reduced to 60 %.
- The success of silage depends on the ability to provide anaerobic condition in silo.
- Anaerobic condition prevents oxidation of nutrients in crop and promotes conducive environment for desirable organisms to survive and produce lactic acid.
- Thus in order to prevent the development of air pockets in silo, compression of ensiling materials is important.
- Compression can be achieved better by chaffing the crop.
- The silo should be cleaned and re plastered to make the silo walls smooth and strong.
- Molasses at the rate of 2% (Weight of forage) provides readily available carbohydrate necessary for increasing the lactic acid production by lactobacillus.
- Further Molasses increases palatability and nutritive value of silage.
- Molasses is sprayed over the forages to facilitate uniform distribution.

- Salt at the rate of 1% (Weight of forage) is also added to improve palatability of silage.
- Rapid filling of silo is desired for anaerobic condition.
- Silage making should not be undertaken during rainy days.

- Compaction of chaffed material can be brought about by manual trampling or by engaging tractor.
- Compaction is the key step in silage as it removes the air pockets to promote anaerobic fermentation.
- To sustain anaerobic condition and to prevent entry of atmospheric air / rain into silo, the silo should be sealed as soon as the silo is filled.
- It is advisable to fill the silo pit to form a dome shape and cover it with insulators like tarpaulin sheet or plaster it with mud.
- Dome shape filling will facilitate rainwater to run off and prevents seepage.
- Silage will be ready in four weeks time.
- Upon opening the silo, the silage should be taken out daily to feed animals.
- The silo should be cleaned and re-plastered to make the silo walls smooth and strong.

Procedure of silage making

Crop with soft and pliable stem is most suitable for silage making. Crop should be harvested when 50% of the crop is in ear emergence stage. Crops with high moisture (85%) will produce more effluents that would go as waste. To reduce effluent loss, crops with high moisture content are wilted for few hours, until moisture level is reduced to 60 %. In order to prevent the development of air pockets in silo, compression of ensiling materials is important. Compression can be achieved better by chaffing the crop. The success of silage depends on the ability to provide anaerobic condition in silo. Anaerobic condition prevents oxidation of nutrients in crop and promotes conducive environment for desirable organisms to survive and produce lactic acid. When leguminous fodders are used for silage making, molasses at the rate of 2% of weight of forage provides readily available carbohydrate necessary for increasing the lactic acid production by lactobacillus .Further molasses increases palatability and nutritive value of silage. Molasses is sprayed over the forages to facilitate uniform distribution. Salt at the rate of 1% of weight of forage is also added to improve palatability of silage. Rapid filling of silo is desired for anaerobic condition. Compaction of chaffed material can be brought about by manual trampling or by engaging tractor. Compaction is the key step in silage as it removes the air pockets to promote anaerobic fermentation. To sustain anaerobic condition and to prevent entry of atmospheric air / rain into silo, the silo should be sealed as soon as the silo is filled and compressed. It is advisable to fill the silo pit to form a dome shape and cover it with insulators like tarpaulin sheet or plaster it

with mud.Dome shape filling will facilitate rainwater to run off and prevents seepage. Silage will be ready in four weeks time.Upon opening the silo, the silage should be taken out daily to feed animals.

Losses during silage making

Field losses: Harvesting and ensiling on the same day prevents loss of water soluble carbohydrates and protein. Wilting beyond 5 days leads to 6 to 10 % dry matter losses

Oxidation losses: In the presence of oxygen, the action of plant and microbial enzymes on substrates such as sugars, leads to the formation of CO2 and water. Rapid filling of silo and compression eliminates air pockets leaving anaerobic condition suitable for ensiling and thereby preventing oxidation losses.

Fermentation losses: Even though considerable biochemical changes occur during fermentation, the net dry matter loss may not exceed 5% and energy loss may be still lower as high energy compounds like ethanol are formed during ensiling.

Effluent losses: Effluents are highly nutritious as they contain sugars, soluble nitrogenous compounds, minerals and fermentation acids. The amount of drainage effluent produced depends largely upon the initial moisture content of the crop. Crops ensiled with moisture of 85% may result in effluent dry matter losses as high as 10%, whereas crops wilted to about 70% moisture produce little effluent.

Silage Characteristics

Very good silage:

- Clean pleasant fruity odour.
- Uniformly green or brownish in colour with absence of butyric acid, absence of moulds, absence of sliminess and absence of proteolysis.
- The pH is between 3.8 and 4.2.
- The amount of ammonical nitrogen should be less than 10 per cent of the total nitrogen.

Good silage:

- Brownish in colour with traces of butyric acid with pH between 4.2 and 4.5.
- The amount of ammonical nitrogen is 10-15 per cent of the total nitrogen.
- Other points are same as of very good silage.

Fair silage:

- The silage is mixed with a little amount of butyric acid.
- Colour of silage varies between tobacco brown to dark brown
- There may be slight proteolysis along with some mould.
- The pH is between 4.5 and 4.8.
- Ammonical nitrogen is 15-20 per cent of the total nitrogen.

Poor silage:

- Due to high butyric acid and high proteolysis, it has a bad smell.
- Colour tends to be blackish and should not be fed.
- The silage may be infested with moulds.
- Less acidity, pH is above 4.8.
- The amount of ammonia nitrogen is more than 20 per cent.

Haylage:

Haylage is low moisture silage with characteristics between those of hay and silage.It is made from grass and/or legume to a moisture level of about 45-55%.To use up the oxygen and to trap and hold the produced CO_2 within the silo, the silos should be as airtight as possible. This condition will prevent the forage from spoiling by moulding, oxidizing, heating etc.

Advantages:

Haylage has a pleasant aroma, palatable and high quality feed.

Partially dried forage can be made into haylage.

Disadvantages:

Fine chopping, good packing and complete sealing against air entrance inside the silo is more critical than with silage.

There is danger of excessive heating whichreduces protein digestibility.

Physiological phases of cattle and buffaloes

Cattle and buffaloes have different physiological phases. They should be fed in a way that the nutritive requirements as per their physiological phase in which they are is met.

Different physiological phases are

- Maintenance
- Growth
- Pregnancy
- Milk Production
- Work

Maintenance

Maintaining an animal in a state of well-being or good health from day to day,makes no growth, develops no fetus or yields no product. While formulating rations, the maintenance nutrient requirements are satisfied first and the requirements for other purposes are in addition to maintenance. On an average, about one-half of all feed fed to livestock goes for maintenance.

Growth

Growth is increase in muscle, bone, organs, and connective tissue. Growth is essential for an animal to produce meat or to attain mature body weight. The daily growth rate of animals increases up to puberty and then gradually declines. The nutritive requirements for growth are in addition to those for maintenance.

Pregnancy

Nutritive requirements for development of foetus are energy, protein, calcium, phosphorus, and vitamin D in particular and other minerals and vitamins. More than 2/3rd of the foetus growth occurs during the last trimester of pregnancy. Proper feeding during pregnancy is essential to avoid birth of dead foetus or weak foetus, to build up body reserves lost during early lactation and at the same time the animal should not become obese.

Milk Production

Milk is produced and secreted by the mammary glands. Nutrients for milk production are carried by the blood to the mammary glands. The nutrients are removed from the blood by the mammary glands, converted into milk, and secreted into the udder more or less throughout the day.

Nutrients for milk production must come from the feed, either directly or indirectly via body reserves of nutrients, which come originally from the animal's feed. The peak milk production is reached during 4-8 weeks after lactation starts and the animals also lose body weight during early lactation since their appetite is low and they may not take sufficient feed to meet the nutrient requirements. So during peak lactation, milk yield will be high, the feed intake will not be sufficient and the animals lose body weight.

Nutrient requirements for milk production are in proportion to the amount of milk produced and are over and above those for other physiological phases of production such as maintenance, growth, fattening, fetal development, etc.

Work

Energy, protein, minerals and vitamins are required for work.

Feeding of cattle and buffaloes during different phases

Feeding of newborn calves

Calves in village conditions or in unorganized farms are allowed to suck colostrum or milk from the udder of dam for a few minutes to induce letdown of milk and later they are separated to facilitate the milk man to physically milk the cow. At the end of the milking again the calf is allowed to suck the residual milk from the udder, which may not be sufficient to the calf. In organized dairy farms, calves are separated and fed with measured quantities of colostrums/milk in buckets or pails. The calves are trained to drink milk with its mouth turned upwards so that the ingested milk flows directly into abomasum through oesophageal groove.

Colostrum feeding

It should be given fresh as milked from the mother within two hours and minimum for the first three days after birth.

- It provides antibodies which are absorbed intact in the first few days of the calf’s life. It contains immunoglobulins (IgM, IgG, IgA) which are essential for new born calves and can pass through the intestinal membranes freely during the first 12 hours of its life.

- It also contains anti-tryptic enzyme which may help in the protection of whey protein from the proteolysis.
- It is rich in Vitamins (A, D and E) and minerals (Ca, Mg, Fe and P).
- It also has a laxative effect in removing muconium.

The colostrum should be fed at the rate of one tenth of body weight of the calves.If colostrum from dam is not available,colostrum from other cows can be given or artificial colostrum can be prepared and given.

Artificial Colostrum

Components	Quantity
Warm whole milk	525 ml
Warm water	275 ml
Raw egg	One
Castor oil	5 ml
Vitamin A	10,000 IU
Aureomycin	80mg

Mix well and feed at 40^0C, which is sufficient for one meal.

Practical Calf-Feeding Schedule

The calf should be fed three times a day. Whole milk is given from the fourth day onwards till it attains three months of age. Milk replacer is fed to calves as early as at 10 days of age to replace milk from economic point of view**.** Milk replacer should resemble milk more or less on broad chemical composition.

The replacement of milk by milk replacer should be gradual to facilitate its acceptance and to avoid a drop in growth rate. Milk replacers are usually fed in gruel form, which is gradually increased with a simultaneous decrease in the amount of whole milk.

From the 15th day onwards a small quantity of soft green, preferably a legume and a little calf starter may be offered. Early introduction of solid feed helps in the rapid development of rumen. When the calf reaches one and half months of age milk is to be reduced to 1 kg irrespective of weight.

Composition of Milk Replacer

Ingredients	Inclusion level
Wheat	10
Fish meal	12
Linseed meal	40
Milk	13
Cottonseed oil/ coconut oil	07
Citric acid	1.5
Molasses	10
Mineral mixture	03
Linseed oil	03
Butyric acid	0.25
Antibiotic mixture	0.235
Rovimix (A, B2, D3)	0.015

Calf Starter

It is a solid feed consisting of ground grains, oil cakes, animal protein supplements and brans fortified with vitamins, minerals and antibiotic feed supplements. It should contain 23-26 % crude

protein and 75% Total Digestible Nutrients. A calf needs a relatively large proportion of protein in its ration so as to furnish the basic building blocks (aminoacids) for the rapid growth of its tissues. The proportion of protein in the ration should be less as the animal grows older.The quality of protein given to the calf depends on the age of the calf. Since the rumen is not developed, the protein in the calf ration should be of high biological value (till therumen develops calves can be fed with animal proteins also).A standard calfstarter is offered from 15th day of age to supplement the nutrients when they are raised on limited milk intake. About 20-25 % protein should be supplied by an animal protein source for balancing the essential aminoacid requirement of pre ruminant calves which are not able to synthesize them due to their non-functional rumino-reticulum.

Composition of Calf Starter		
Ingredients	**I**	**II**
Crushed Maize	-	50
Crushed Barley	50	-
Ground nut cake/Til cake	20	20
Wheat bran/Rice bran	7.5	7.5
Fish meal/Meat meal/Skim milk powder	20	20
Mineral mixture	02	02
Salt	0.5	0.5

To each 100 kg of above mixture 10 g vitamin supplement and 20 g antibiotic mixture should be mixed thoroughly.

Feeding dairy calves from three months to maturity

From third month onwards cultivated green forages like Napier grass, sorghum fodder, guinea grass etc can be given at the rate of 2 kg per day, and gradually increasing it to 5 to 10 kg at 6 months of age. Green leguminous forages like lucerne or berseem should be wilted in sun for 2 -3 hours before feeding it, to minimize bloat. Similarly concentrate mixture is increased from 0.75kg at 4th month to 1 kg at 5th month and 1.5 kg at 6 months of age.After 6th month male and female calves are kept in separate paddocks and maintained on high quality roughage rations plus minimum concentrate so as to economize the maintenance cost.Assuming a daily weight gain of 500 g from the 6th to 24th month of age, two kg concentrate mixture with 16% Digestible Crude Protein and 70% Total Digestible Nutrients and 15 t0 20 kg of green fodder should be provided to each calf.

The following feeding schedule should be followed for raising calves

From 3-6 months

Category	Concentrate(kg)	Roughage (kg)
Indigenous cattle/ buffaloes	1 - 2	Green grass/maize fodder-10 kg or Legumes 1-2.5 kg + Dry fodder -2 kg or Green fodder – 3 kg + Straw – 2 kg
Crossbred	1.6 – 2.0	Green grass/maize fodder or alike fodders 5 - 10 kg upto 4 months 10- 15 kg from 4-6 months.
From 6-12 months		
Category	**Concentrate (kg)**	**Roughage (kg)**
Indigenous cattle/ buffaloes	1-2	Green grass/maize fodder-15 to 20 kg or 7-10 kg of Legumes+ 5 kg dry fodder or Green fodder 5 kg + Straw 2 to 3 kg
Crossbred	2.0 – 2.5	Green grass/maize fodder or alike fodders - 15 to20 kg

From 1 year to age at conception

Category	Concentrate(kg)	Roughage (kg)

Indigenous cattle/ buffaloes	1 to 2	25 to 30 kg of green maize fodder / or other grasses
Crossbred	1.5 to 2	30 to 35 kg of green maize fodder / or other grasses

Importance of proper feeding of calves from weaning to breeding

The way a heifer is fed is very important as it can greatly affect:

- Age at first service
- Ability to conceive or become pregnant
- Age at first calving
- Lifetime milk production
- Length of productive life

In general, if an animal grows at a faster rate, it will reach sexual maturity earlier. Puberty occurs at a particular live weight rather than at a fixed age. Puberty occurs when heifers weigh between 45 - 50% of mature body weight and under good feeding and management they usually attain 45 - 50% of mature body weight at 13-15 months of age. Breeding should occur when heifers reach 50-60% of mature body weight.Growth rate should be sustained during pregnancy such that heifers weigh 80-85% of mature body weight at first calving and are large enough to calve without difficulty at about 20-24 months of age

Feeding of pregnant heifer

Feeding during this period affect milk production during first lactation. Rapid growth of foetus occurs during the last trimester of pregnancy. Hence, the heifers should move from a steady growth rate after breeding to a rapidly growing phase (1.7 to 2.0 lb/day gain) during the last two to three months of pregnancy. The exact amount of grain to feed before calving depends on forage quality, size and condition of the heifer. During the last trimester of pregnancy heifers are fed 1.5 kg of a concentrate mixture (14 %CP and 70% TDN) to supply about 200 g of CP and 1.0 kg TDN to meet the requirements of rapidly growing fetus.

The mature body weight of elite buffaloes ranges from 450 to 650 kg. Similarly the adult body weight of cows ranges from 300-600 kg or even higher in some breeds. Even after conception, therefore, they continue to grow to achieve mature body weight at about second lactation. Therefore, they should be fed additionally to achieve mature body weight for successive normal reproduction cycle. Delayed growth in first and/or second lactation due to short supply of dietary energy is often attributed to repeat breeding and other reproductive disorders. Therefore, the pregnant heifers are also fed 20 % of maintenance CP and TDN as extra allowance for their body growth.

The pregnant heifers should be provided more amount of good-quality forage and less concentrates to prevent fat deposition. They should receive adequate amount of carotene or vitamin A, as it is essential for maintenance of placental epithelium and foetal growth (deficiency leads to still-birth with hydrocephalus). The vitamin A (alone in buffaloes) or vitamin A and carotene (in cows), stored in the body of cow, are secreted through colostrum in larger quantity. A reserve of this vitamin is thus essential. Since green fodders are very good source of carotenes (precursor of vitamin A), they should be fed in plenty. If green fodder /hay or silage is not available, synthetic vitamin A must be supplied through concentrate mixture. The green fodder has also laxative effect, which is helpful for pregnant animals.

Feeding of concentrate to heifers 2-3 weeks before calving to adapt rumen microbes to the concentrates is the sound nutritional practice. The mineral mixture and common salt should also be supplied adequately. They should get free access to drinking water.

Feeding of milch animals

The nutrient requirement of a lactating cow /buffalo can be conveniently divided into two parts i.e. requirement for maintenance and milk production. If the lactating animal is in first and second lactation, extra allowance is needed to take care of growth and production. Similarly pregnant animals are to be offered extra nutrients during the last two months of gestation. The aim is that by the end of gestation period the cows should not only gain their initial body weight but also put on an extra 25 to 30 kg of body weight. This is necessary to enable the animal to withstand the stress of parturition and to maintain the persistency of milk production during the subsequent lactation period. The provision of extra nutrients should be given in the form of concentrate mixture and not as forage because roughages are not as efficient as concentrate in increasing the body weight. The rest of the ration must contain sufficient green feeds so that the colostrum secreted after parturition should be rich in vitamin A.

During the last 3 days prior to calving, the amount of concentrate mixture should be reduced and a little warm bran is fed to keep the animal in laxative condition before calving.

After parturition, the cow /buffalo should be given fresh warm water and a mash consisting of 1 kg wheat bran, 1-1.5 kg ground/cooked grains, 0.5 kg jaggery and 25 g each of common salt and mineral mixture. This mash may be continued for 3 to 4 days after calving; thereafter, the regular feed is gradually introduced to the cow.

In feeding high-milk yielder, quality feed, i.e. nutrient dense feed need to be given. Ration should contain a minimum 25% DM from forages.Forage should be of superior quality and 30 to 50% of this should be from leguminous crops. Ration may be in the form of complete feed. Frequency of feeding is three to four times a day. To ensure proper nutrient intake, optimum roughage concentrate ratio need to be maintained.

Model rations for cattle and buffaloes with available fodder and concentrates

Two alternatives could be easily considered depending on the availability of green fodder. If green leguminous fodder like berseem, lucerne or subabul is available, a combination of about 6 to 8 kg of leguminous green fodder and 4 to 5 kg of paddy straw can easily meet the maintenance requirement of animals. The other alternative is to feed 1 kg of balanced concentrate mixture**.**

Ration for maintenance of a cow

Option	Feed	Quantity (kg)
1	Green legume Cereal straw	6–8 4 -5
2	Concentrate mixture Cereal straw	1 5-6

Ration for growing crossbred dairy heifers weighing 200 kg

Option	Feed	Quantity (kg)
1	Green legume Cereal straw	8-10 2 -4
2	Concentrate mixture Cereal straw	2.5 4 -5

Thumb rule for feeding concentrates in cattle and buffaloes

- In case of cattle, for every 1 kg of milk production, 0.4 kg of concentrates should be given.
- In case of buffaloes, for every 1 kg of milk production, 0.5 kg of concentrates should be given.

Ration for cow weighing about 400 kg and producing 5 kg of milk

Option	Feed	Quantity (kg)
1	Green legume Green cereals Cereal straw	10 20 4-6
2	Concentrate mixture Cereal straw	3.5 7.0

Feeding high yielding cows/buffaloes

Feeding of milch animals during early lactation

It is difficult to meet the nutrient requirements, particularly the energy requirement of such high yielders (more than 15 kg of milk production per day in cows and 12 kg milk yield per day in buffaloes) through normal concentrate mixture and fodder.High energy diets are to be formulated and challenge feeding has to be adopted.

Feeding Soybean to high yielding cows/buffaloes:

Soybean has to feed as both whole oil seed and solvent extracted soybean meal to cows during lactation, more so during the first 3 to 5 months, to overcome the negative energy balance.

Some examples of concentrate mixtures

Ration 1	
Groundnut cake	35
Wheat bran	20
Maize	15
Oat/Bajra/Sorghum	15
Gram chunnies	12
Mineral Mixture	2
Common Salt	1
Total	**100**

Ration 2	
Mustard cake	20
Wheat bran	45
Green gram chunnies	32
Mineral Mixture	2
Common salt	1
Total	**100**

Ration 3	
Tapioca chips	20
Groundnut cake	30
Gram chuni	22
Rice bran	25
Mineral mixture	2
Common Salt	1
Total	**100**

Ration 4	
Groundnut cake	20
Rice bran	25
Wheat bran	10
Gram husk	27
Cotton seed cake	15
Mineral Mixture	2
Common Salt	1
Total	**100**

Feeding of high yielding cattle and buffaloes

Cows yielding more than 20 kg/day and buffaloes yielding more than 15 kg per day are high yielding animals. Nutrient requirements vary with the stage of lactation and gestation. Five distinct feeding phases can be defined to attain optimum production, reproduction and health of dairy cows:

- Phase 1: Early lactation—1 to 70 days (peak milk production) after calving (postpartum).
- Phase 2: Peak DM intake—70 to 140 days (declining milk production) postpartum.
- Phase 3: Mid- and late lactation—140 to 305 days (declining milk production) postpartum.
- Phase 4: Dry period—60 to 14 days before the next lactation.
- Phase 5: Transition or close-up period—14 days before to parturition.

Phase 1: Early lactation - 0 to 70 days postpartum

The important features of Phase 1 are

Milk production increases rapidly during this period and the peak milk production occurs at 6 to 8 weeks after calving.Feed intake is not adequate because the appetite of the animal during the early lactation (up to 8 weeks) is reduced by 2 to 3 kg per day.

Feeding during Phase 1

Animals should be encouraged to maximize their intake during early lactation. Each additional kg of dry matter consumed can support 2-2.4 kg more milk. A protein level of 13-14 % CP can support 20 kg milk in cows and 15 kg in buffaloes. A guideline is to feed 0.5 kg of a 34 to 50% protein concentrates for every 5 kg of milk produced above 20 kg of milk.

A minimum level of fibre (17 to 18% Crude Fiber in the ration) is necessary because excessive levels of concentrates (over 60 percent of the total DM) fed during early lactation can cause acidosis and low milk fat percentage. To avoid any digestive problems (e.g. acidosis, depressed intake), concentrates should be added gradually at a rate of about 0.5 to 0.7 kg/day for the first two weeks. Do not feed more than 2.5-3.5 kg of concentrates per feeding.

The roughage should not be ground or pelleted but should be chopped to a length of 2 inches or longer.

The energy content of the ration is increased by feeding of full-fat oilseeds like cottonseed, sunflower seed and soybean. They are also rich in TDN; thus their supplementation in the diet is useful for meeting energy requirements of high yielding animals. Cottonseed is the most popular and it also helps in increasing milk fat.The energy content of the ration can also be increased by using fats or oil at 4% in the concentrate mixture or 0.5 kg / day

Challenge Feeding

Feeding of concentrates should be started 2 weeks before calving, if no concentrate is fed during the dry period. This helps in adaptation of the rumen microbes with the grain/concentrate during the ensuing lactation period when nutrient requirement cannot be met, especially in high-yielding (more than 20 kg milk) cows without grain or concentrates.

Generally, the animals are started with 1.5 to 2.0 kg concentrate mixture (@0.3 to 0.5 % of body weight) 2 weeks before calving, followed by an increment of 0.3 to 0.5 kg daily, so that they will be receiving about 1 kg concentrate mixture per 100 kg body weight at calving. This is also called challenge or lead feeding, as it is the practice of feeding higher levels of concentrate to challenge the cow to reach her maximum milk production potential.

Other feeding strategies for high producing dairy cattle during early lactation

- Cows usually eat after milking. So fresh feed should always be available since high producing animals may eat up to 12 times in a day.
- If concentrates are being fed separately from forages, they should be fed several times a day.
- *Feeding frequency:* Increased feeding frequency reduces daily variations in rumen pH and thus helps stabilizing the rumen environment. The proper range and consistency of ruminal pH is critical in fiber digestion.
- *Feeding sequence:* If forage and concentrates are being fed separately, forages should be fed first in the morning followed by a portion of the concentrates.

Phase 2. Peak DM intake - second 10 weeks postpartum

During this phase the feed intake is near maximum and can supply nutrient needs. Animals should not loose body weight, they should either maintain weight or slightly gain weight. Animals are expected to take dry matter at 4 % of body weight. Concentrate intake should not exceed 2.5 percent of the cow's body weight and intake of good quality forage should be minimum 1.5 percent of the cow's body weight (DM basis) to maintain rumen function and normal levels of milk fat. Protein requirements during mid lactation are lower than in early lactation. Therefore rations for dairy cows in mid-lactation should contain 15-17% crude protein.

To maximize nutrient intake feed forages and grain several times a day.

Phase 3. Mid - to late lactation - 140 to 305 days postpartum

This phase will be the easiest to manage. Milk production is declining, the animal is pregnant, and nutrient intake will easily be met or exceed requirements.Concentrate feeding should be at a level to meet milk production requirements and the animals begin to replace body weight lost during early lactation. Young cows should receive additional nutrients for growth (20 percent during 1^{st} lactation and 10 % during 2^{nd} lactation of the maintenance requirement.

Phase 4. Dry period - 60 to 14 days before parturition

The dry period is a critical phase of the lactation cycle to increase milk yield during the following lactation and minimize metabolic problems at or immediately following calving.

The reasons for the dry period

(a) Involution of the udder: The principal reason for the dry period is to allow the secretory tissue of the udder to involute.During this period, the secretory cells of udder actually break

down and are resorbed, and a new set of secretory cells is formed. This cell renewal process takes approximately six weeks and, if a cow is allowed no dry period at all, will result in a loss of milk of at least 30% in the subsequent lactation.

(b) Foetal development: During the last eight weeks before calving the foetus gains almost 60% of its birth weight, an overall rate of gain for the cow of about 0.75 kg/day. At the very least, the cow must be fed for foetal growth.

(c) Replenishment of body reserves: Mineral reserves are an entirely different matter to energy reserves. The high-producing cow will have severely depleted her body reserves of minerals, especially calcium and phosphorus, during her lactation. These reserves can only be completely replenished when the cow is dry. Adequate mineral nutrition during the dry period is very important. If the cow is very weak or underweight, the dry period helps her to replenish body reserves and she may be fed to gain about 20-25 kg body weight during the dry period.

(d) The length of the dry period: Aim for a dry period of eight weeks (56 days).Rations should be formulated to specifically meet the nutrient requirements of dry cows: body maintenance, fetal growth, and for replacing any additional body weight not replaced during phase. Pregnant animals are to be offered extra nutrients during the last two months of gestation.

The aim is that by the end of gestation period the cows should not only gain their initial body weight but also put on an extra 25 to 30 kg of body weight. This is necessary to enable the animal to withstand the stress of parturition and to maintain the persistency of milk production during the subsequent lactation period, The provision of extra nutrients should be given in the form of concentrate mixture and not as forage because roughages are not as efficient as concentrates in increasing the body weight. The rest of the ration must contain sufficient green feeds so that the colostrum secreted after parturition should be rich in vitamin A.

DM intake will be near 2 percent of the cow's body weight. A minimum of 12 percent CP in the DM is recommended. Meet calcium and phosphorus needs, but avoid large excesses. Calcium intakes of 60 to 80 grams and phosphorus intakes of 30 to 40 grams are sufficient for most cows.Avoid excess calcium and phosphorus intakes

Dry cow rations above 0 .6 per cent calcium and 0 .4 per cent phosphorus (DM basis) have substantially increased milk fever problems.Provide adequate amounts of vitamin A, D, and E in rations to improve calf survival and lower retained placenta and milk

fever problems. Trace minerals, including selenium for most producers, should be adequately supplemented in dry cow diets.

Change to a transition ration starting 2 weeks before calving. During the last 3 days prior to calving, the amount of concentrate mixture should be reduced and a little warm bran is fed to keep the animal in laxative condition before calving.

Phase 5. Transition period - 14 days before to parturition

The transition or close-up dry cow feeding program is critical to adjusting dry cows to the lactation ration and preventing metabolic problems. During the last 3 days prior to calving, the amount of concentrate mixture should be reduced and a little warm bran is fed to keep the animal in laxative condition before calving.

After parturition, the cow /buffalo should be given fresh warm water and a mash consisting of 1 kg wheat bran, 1-1.5 kg ground grain, 0.5 kg jaggery and 25 g each of common salt and mineral mixture. This mash may be continued for 3 to 4 days after calving; the regular feed may be gradually introduced to the cow. Some concentrate mixture, if not previously fed, should be fed starting two weeks before freshening.

Introduction of concentrate mixture is necessary to begin changing the rumen bacteria population over from an all-forage digestion population to a mixed population of forage and grain digesters. Also, addition of some ingredients used in the lactation ration during this period minimizes the stress of ration changes after calving. Some suggested management strategies during this period include:

Increase protein in the ration to between 14 and 15 percent of the ration DM. Feeding some of this additional protein in the form of undegradable protein may be beneficial in supplying amino acids for fetal growth.

Feeding of breeding bull calves and bulls

Feeding of bull calves

Animals which are to be raised as future breeding sires, should generally be kept on a liberal amount of milk for the first six months or more of their life. Milk is also supplemented with calf starter from two weeks of age onwards along with good quality hay.

Age of bull calves	**Quantity to be given (kg)**		
	Concentrate	**Green fodder**	**Dry fodder**

6 to 12 months	2.5	5 - 7	*Ad libitum*
1 to 2 years	3.0	7 -10	*Ad libitum*

Young males to be used for draft purpose should only be castrated at 12 to 15 months of age and their feeding schedules should be identical to that of heifers. To economize the cost of feeding more green fodder and hay can be fed (upto 15 -20 kg /day).

Feeding of bulls in service

Breeding bulls are to be fed good quality fodders and concentrates to keep them active. In addition the bulls should be regularly exercised to keep it in prime condition. When berseem/lucerne/cowpea are available they can be fed along with the straw or other good quality roughages like oats without any concentrate. However, when straws form the basal ration, concentrate are to be fed. When non-leguminous green fodders, like oat, maize, sorghum, good grazing etc, form the basal roughage there is no need to feed concentrate mixture.

Feeding of working bullocks

When food supply is adequate, a working animal first draws upon the carbohydrates and fats in the feed. If the supply is inadequate, the body fat is used for the purpose and as a last resort muscles and other protein tissues are used. Thus, as long as there is a sufficient supply of carbohydrates in the feed, an ox at work needs no more protein than required for maintenance except probably when the work done is very hard.

When the animals are not working, they should be fed as per the maintenance requirement. For light work, the animal should be fed with 30 kg green maize and 10 kg cowpea. For heavy work, 10 kg extra cowpea may be fed to take care of extra protein requirement. When cultivated fodders are available 20 kg berseem/lucerne with 20 kg oats may be fed. In addition 30 g of mineral mixture and 30 g of salt should be fed daily.

When wheat/paddy straw form the basal ration, then a concentrate mixture containing 12% DCP and 75% TDN should be fed at the rate of 1, 1.5, 2 and 2.5 kg respectively to 200, 300, 400 and 500 kg animal along with *ad libitum* straw. For heavy work 2, 3, 4 and 5 kg of concentrate mixture should be fed along with wheat straw. 2.5 kg green fodder may be fed to satisfy the vitamin A requirement.

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REPRODUCTIVE MANAGEMENT IN DAIRY CATTLE AND BUFFALOES

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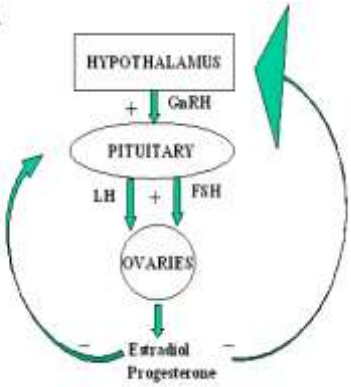
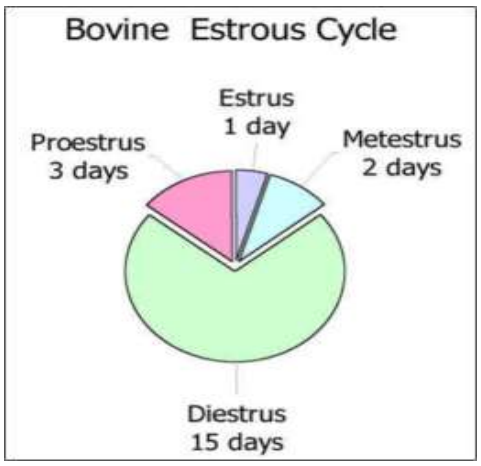
Reproduction is considered as basis of production. Once a female calf is born, she has to pass through different stages of life viz; pre-pubertal stage, pubertal satge, reproduction stage and production stage etc. In the body of all mammals a master controlling axis (hypothalamus-pituitary-gonadal axis) is present that controls all events of reproduction. This axis mature and co-ordinate at a specific age, when female animals achieve about half of their dam's body weight. So pre-pubertal sage of life is the stage during, which this axis remains inactive and once this axis is activated we say that animal has entered in to the stage of puberty and dairy owners have to think about reproductive management of their animals. There are several factors viz; genetics of animal, nutrition, geo-climatic conditions, stress etc. that influence the maturation and activity of this axis.

Once the hypothalamus-pituitary-gonadal axis is activated the female animals start showing sexual desire at a regular interval under the influence of certain specific chemical messengers (hormones) secreted from this axis (Fig 1). This rhythmic pattern of manifestation of sexual desire at a regular interval is called estrous cycle. Estrous cycle length in cattle and buffalo is usually 18-23 days with an average of 21 days.

Figure 1





Estrous cycle in cattle and buffalo

Whole estrous cycle of cattle and buffaloes is divided in to four phases as follows:

1. **Proestrus:** This is building up phase of estrous cycle. In this phase ovarian follicles starts growing under the influence of GnRH and FSH hormone secreted from hypothalamus and pituitary, respectively. Duration of this phase is usually 2 to 3 days.
2. **Estrus:** This is the shortest and only visible phase of estrous cycle in bovines. During this phase of estrous cycle, female animals show signs of heat (estrus) under the influence of estrogen secreted from ovarian follicles. Duration of this phase is highly variable and ranges from few hours (say about 4 hrs) to 24 hours and sometimes up to 48 hours depending upon breed and species of animal.
3. **Metestrus:** This is the ovulatory phase of estrous cycle and usually last for 3 to 5 days. Cattle and buffaloes ovulate during initial part of this phase under the influence of LH surge from pituitary gland. During this phase an ovulatory graffian follicle after ovulation is transformed in to corpus luteum and starts secreting progesterone hormone (hormone of pregnancy)
4. **Diestrus:** This is the longest phase of estrous cycle in bovines that usually last for about 10 to 14 days. During this phase, corpus luteum continues to grow and secrets ample amount of progesterone hormone. If animal has not been bred or fertilization failed to occur, then at around 14 to 16 days of estrous cycle uterus secrets a specific chemical substance (prostaglandin F2 alpha), which lyses corpus luteum so formed and animal again returns in to proestrus phase of estrous cycle. On the other hand if animal has been bred, then developing embryo resist the secretion of prostaglandin F2 alpha from uterus resulting in to maintenance of corpus luteum that support pregnancy.

Signs of estrus (heat) in cattle and buffaloes

Cattle

- Restlessness and aimless wandering
- Reduced feed and water intake
- Reduced milk production
- Bellowing
- Mounting on other animals
- Allow mounting by other animals (standing heat)
- Swelling in vulva with copious mucous discharge

Buffalo

- Restlessness
- Reduced feed and water intake
- Reduced milk production
- Temporary engorgement of teats
- Some but not all animals may show bellowing
- Homosexuality is rarely observed
- Standing to be mounted (surest signs of heat)
- Frequent scanty urination
- Vulva swelling with scanty mucus discharge

Common Reproductive Diseases/Disorders in cattle

There are several reproductive conditions affecting cattle and buffalo reproduction and if not handled timely may put a number of long term or short term economic losses to dairy producers. Anestrus, cystic ovarian degeneration, repeat breeding (RB), abortion, fetal maceration and mummification, dystocia, retention of fetal membrane, endometritis, pyometra, uterine torsion and prolapse of genital organs are some of major clinical reproductive conditions affecting dairy cattle and buffaloes. Some brief description of these problems is given below:

1. Anestrus

Anestrus means "without cyclicity", is a condition when the female does not exhibit regular estrous cycle. Anestrum is a condition, which may also be defined as lack of periodic manifestation of signs of heat. There are various causes of anestrum including hormonal, nutritional and physiological etc. Anoestrum is common cause of infertility in dairy cattle. There are two major categories of anestrum affecting dairy cattle at their different stages of life as physiological anestrus and pathological anestrus.

A. **Physiological anestrus:** This category includes pre pubertal anestrus, postpartum anestrus, lactational anestrus, pregnancy/ gestational anestrus and seasonal anestrus. This type of anestrus can be managed by adopting scientific managemental practices.

B. **Pathological anestrus:** This category includes true anestrus, anestrus due to luteal cyst and anoesrus due to uterine pathology etc. management of this type of anestrus required intervention of veterinarian.

2. Cystic ovarian degeneration (COD)

Traditionally cysts have been defined as anovulatory follicular structures (diameter, >25 mm) that persist for 10 or more days in the absence of a functional corpus luteum and are accompanied by abnormal oestrous behaviour (irregular oestrus intervals, nymphomania or anoestrus). However, recent data using ultrasonography indicate that follicles typically ovulate at 17 mm in diameter, so follicles that persist at 17mm or greater may be considered to be "cystic." Cystic ovarian disease/degeneration in dairy cattle occurs most frequently during the post partum period, 30 to 60 days after calving, when normal ovarian activity usually resumes. This pathological condition arises due to ovulatory defects. Mature follicle of estrus fails to ovulate because of hormonal disturbances and persists. The physiological cause is the absence of an LH surge that normally triggers ovulation.There are three types of cysts as follows:

A. Follicular cyst: This type of cyst is formed, when mature follicle fails to ovulate and act as a continuous source of estrogen. Affected animal shows strong signs of heat for more than normal duration. Estrous cycle of animal is short and there is marked relaxation of sacro-sciatic ligaments in chronic cases resulting in to sterility hump..

B. Luteal cyst: This type of cyst arises due to ovulatory defects. Mature follicle of estrus fails to ovulate because of hormonal disturbances and continues to be letenized without ovulation Affected animal fails to show the signs of heat.

C. Cystic corpus luteum; These are ovulatory types of cysts. In this mature graffian follicle ovulates normally but not gets fully luteinized after ovulation because lack of sufficient concentration of LH hormone. These cysts are non pathogenic in nature.

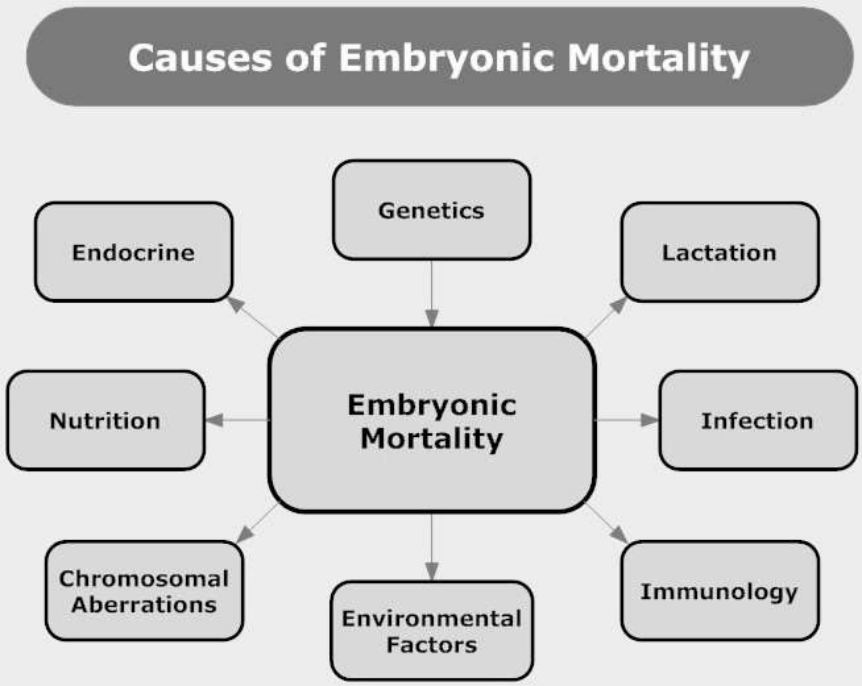
3. Repeat Breeding

A repeat breeder cow has normal or nearly normal estrous cycle and estrus period, bred for 3 or more times to a fertile bull but fails to conceive. On clinical examination there is no any definite lesion to explain the failure of conception. All the major causes of repeat breeding can be grouped into two categories as follows

- Fertilization Failure
- Early Embryonic Death

Fertilization failure may result from death of the egg before sperm entry, structural and functional abnormality in the egg or sperm, physical barriers in the female genital tract preventing gamete

transport to the site of fertilization, or ovulatory failure. On the other hand embryonic mortality denotes the death of fertilized ova and embryos up to the end of implantation. About 25 to 40% of embryos are normally lost in farm species. Most of the embryonic loss in cattle occurs between days 8 and 16 after insemination. Artificial insemination during pregnancy will induce loss, either through mechanical trauma to fetal membranes or the introduction of infection. Nutritional causes such as B-carotene, selenium, phosphorus and copper deficiencies have all been implicated in embryonic loss, but unequivocal data are not available. High intakes of crude protein, in particular rumen – degradable protein have been associated with reduced fertility. This is said to be due to the toxic effects of blood urea or ammonia on the embryo. Stress, e.g. heat stress, has also been shown to result in embryonic loss. A high rate of increase in milk yield in early lactation is negatively correlated with fertility and this could be considered a metabolic stress.



4. Abortion

Abortion is the expulsion from the uterus of a living fetus before it reaches a viable age, or more commonly the expulsion of a dead fetus of recognizable size at any stage of gestation. Economically, abortions are of great concern to the farmer, because

- The fetus is lost
- A prolonged period of uterine disease and sterility may follow

- Unproductive female must be maintained for a long period or sold
- If the cause of abortion is infectious, it threatens the rest of the herd.

There are several causes of abortion including infectious and non infectious causes. Infectious causes include bacteria (Brucella abortus, Leptospira pomona, Listeria monocytogenes, Mycobacterium bovis and Vibryo fetus venerealis), viruses (Infectious bovine rhinotrachitis IBR-IPV, Epizootic bovine abortion, FMD Virus), fungi (Aspergillus spp., Mucorales Spp. including Absidia, Mucor, Rhizopus, and yeasts.) and protozoa (Trichomoniasis, toxoplasmosis, trypanosomiasis, anaplasmosis, babesiasis or piroplasmosis). Non infectious causes include chemical drugs and poisonous plants (Nitrates, chlorinated napthalenes ergot alkaloid etc.), hormonal causes (use of estrogen, glucocorticoids, prostaglandins etc.), nutritional deficiencies especially deficiency of vitamin A, Iodine and other trace minerals etc., physical causes like douching, insemination of pregnant cow, rupture of amniotic vesicle torsion of uterus and umbilical cord etc. and some genetic causes including inbreeding and chromosomal anomalies.

5. Fetal mummification and maceration

Fetal death during the middle or last one third of gestation with failure of regression of the corpus luteum followed by autolytic changes in the fetus, absorption of placental and fetal fluids, and involution of maternal placenta leads to mummification. Condition may persist up to years if not handled without any appreciable change in animals' physiology. Maceration of the fetus is failure of fetus to be expelled due to uterine inertia in a dilated cervix, when invade by bacteria causing autolysis of soft tissues and putrefaction leaving the mass of fetal bones within the uterus. Affecting animal shows systemic signs of illness and discharges foul smelling purulent discharge. Death of animals may occurs if not handled properly.

6. Dystocia

Dystocia refers to difficulty in birth. When the first or usually the second stages of parturition gets markedly extended, it becomes difficult or impossible for the dam to deliver without artificial interference. Factors, related to both dam and fetus are responsible for dystocia. Maternal facors include deficiency of generative forces necessary to expel fetus outside and obstruction in birth canal. Fetal factors include absolute enlarge fetal size (fetal monestry, emphysema etc.) and abnormal fetal disposition of fetus in birth canal. Dystocia cases are true

emergency cases and should be attempted on priority basis to avoid any possible economic loss in terms of either death of dam aor death of fetus or both.

7. Retention of fetal membrane (RFM)

In strict sense, parturition is completed only after expulsion of the fetal membranes, which normally gets detached and expelled within 12 hr following the delivery of the fetus. When the dehiscence is prolonged beyond 12 hr, delay in expulsion occurs and condition is considered as retained fetal membranes. Retention of Fetal Membranes (RFM) is one of the most common post partum disorder encountered in cattle and less common in other domestic species. This condition is considered pathologic and has been associated with an increased incidence of metritis, reduced subsequent fertility, increased mastitis incidence, and increased culling. Lack of uterine contractions after parturition is major etiological factor behind RFM. Hormonal irregularities like abnormal estrogen and progesterone ratio, deficiency of oxytocin etc., deficiency of some nutrients (Calcium, Iodine, Vitamin A and Selenium etc.),stress and some infectious conditions causing palcentitis like Brucellosis, Tuberculosis Vibriosis etc. play important role in RFM.

7. Endometritis, Metritis and Pyometra

Endometritis is inflammation of endometrium of uterus while metritis is inflammation of all three (endometrium, myometrium and perimetrium) layers of uterus. The condition is caused by a variety of ascending or descending infections (bacteria, virus, fungi and protozoa). Dystocia, retention of fetal membranes, unhygienic insemination, prolapsed of genitalia favors these septic conditions. Early postpartum stress, nutritional deficiencies, chronic parasitism, metabolic diseases like ketosis, milk fever, downers cow condition etc. make the animal more prone to setup infection in their genitalia because of impaired immune system. In majorities of the clinical cases animal is cyclic with oozing of purulent discharge at the time of heat. Affected animal shows failure of conception even after repeated inseminations with good quality of semen. Pyometra is accumulation of pus in uterine cavity and persistent of corpus luteum on ovary. Condition is clinically characterized by anestrum with seepage of thick viscous purulent material when animal sits on the ground.

8. Uterine torsion

Uterine torsion is commonly referred to as the twisting or revolving of the gravid uterus on its longitudinal axis. It is most common cause of dystocia in buffalo followed by cattle. Anatomy of genitalia along with the pattern of animal while sitting and getting up on the ground and large belly are some common factors facilitating its occurrence. Uterine torsion may be of right side or left side depending on direction of torsion. Right sided uterine torsion is most common in cattle. Torsion may be of pre cervical or post cervical in nature depending on the location of the twist. Uterine torsion causes difficulty in parturition and thus should be taken seriously and require to be attended on priority basis. It can be corrected by rolling of dam on ground with or without using wooden plank.

9. Prolapse of genital organs

Two types of genital prolapsed are common in animals as Vagino-Cervical prolapse and total uterine prolapse. Vagino-Cervical prolapse usually involves a prolapse of the floor, the lateral walls and a portion of the roof of the vagina through the vulva with the cervix and the uterus moving caudal, not infrequently the entire vagina and cervix are prolapsed through the vulva. This is most severe, highly unmanageable and frustrating condition for veterinarian and dairy owner because of no scientific permanent cure and reoccurrence at subsequent calving. Condition is commonly seen after three months of gestations and proceeds with more severity as the gestation period advances.In the starting period only a small mass of vagina prolapsed out especially when the animal sits on ground and automatically disappears as animal stands. Condition worsens with time if ignored and results in to loss of milk production and termination of pregnancy in complicated cases. Condition may be temporarily controlled by using calcium preparations , anti-inflammatory drugs and rope trusses/ vulvar sutures etc. total uterine prolpase is the another condition which usually occurs after parturition. In maximum of cases prolapse of uterus occurs immediately after parturition but may occurs up to 48 hours after calving. Excessive use of traction forces to take out fetus at calving, general muscular weakness of animal and delay in expulsion of fetal membranes and deficiency of some trace minerals like calcium and phosphorus are some common predisposing factors. This condition can be effectively managed by aseptic replacing of prolapsed uterus back in to its position and using some calcium preparations along with antimicrobials and anti-inflammatory drugs.

Important points to be considered to achieve optimum reproductive rhythm in cattle and buffaloes:

- As calves are real asset for profitable dairy business, so scientific management of calves is very much essential as these calves will transformed in to heifers population.
- Provide required amount (generally 1/10 of calf body weight) colostrums and thereafter milk to the calf. Feeding of soft green grass leaves to calves may be started from 4th week onward.
- Ensure deworming of calf starting at 3rd week of life using suitable anthelmintic in consultation of a veterinarian.
- Provide protein rich diet to growing heifers containing cakes, gram, pulses etc. from 6 month of age to achieve optimum body weight. Strictly ensure feeding of mineral mixture to animals to prevent deficiency diseases.
- Heat detection programme is key success for timed insemination and to achieve maximum conception rate, for this several tools (viz; visual heat detection, use of pedometers, paint marking etc.) may be adopted depending on the resources availabe.
- It is better practice to skip first 1 or 2 heat cycles of the heifers and then bred the animals using good quality of semen if they have attained about 60% of their dam body weight.
- Regular deworming of animals (thrice a year) and feeding of balance ration containing trace mineral mixture have been found very much effective to ensure optimum reproductive rhythm.
- It is better to bred cattle and buffaloes after mid heat with good quality of semen preferably twice at 12 hours interval.
- As signs of estrus in buffaloes last for very few hours so it is very much essential to ensure timed insemination in buffaloes to achieve higher conception.
- Always consult your veterinarian for confirmation of pregnancy 60 days after insemination. If animal found pregnant provide additional ration to animal for optimum fetal growth.
- Always keep yourself on an alert mode during last phase of pregnancy especially during last week of gestation and carefully observed relaxation of sacrosciatic ligaments, loosening of vulva with tenacious whitish discharge, enlargement of udder if any as these indicates that parturition is going to happen during next 24-48 hours.

- In case of prolonged labor pain (more than 6 hours) without any discharge from vulva immediately consults your veterinarian to prevent any mishappening and unwanted economic loss.
- After successful calving, provide energy drink containing gur, ghee/oil, ginger, azwayan etc. to the animal for first 2-3 days as these types of preparations will help in early expulsion of placenta and timed involution of uterus.
- Start milking as soon as possible after calving and feed the milk to newly born calf. Don't wait for expulsion of placenta. If placenta don't expelled after 1 hours of calving then contact your veterinarian.
- Give balance ration to animal after calving as per quantity of milk production to ensure timed occurrence of heat preferably around day 30 after calving.
- Always skip first postpartum heat and target second heat for breeding at round 50-60 days after calving. In case of any delay (more than 70 days) in occurrence of post partum estrus kindly contacts your veterinarian.

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Chapter-5

CARE AND MANAGEMENT OF NEWLY BORN CALF

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Introduction

All dairy operations must be planned with due regard to the comfort the animal. After calving the cow will usually be up and will begin to dry the calf, if for some reason the cow is unable to get up then the calf should be dried with a towel or other suitable material.

1. Make sure that all mucus will be removed from the nose and mouth.
2. If the calf does not start to breathe, artificial respiration should be used by alternately compressing and relaxing the chest wall with the hands after laying the calf on its side.
3. Naval cord should be cut with sterilized scissors leaving “form the body and the entire naval cord be disinfected by Deeping it into a cup containing tincture of iodine.
4. Normally the calf will be on its feet and ready for suckling the dam within an hour. Some assistance in this stage is useful. Clean the udder before the calf starts sucking.
5. Feed the calf with first milk i.e. colostrum at least for 48 hours. The colostrum should be fed within half an hour after birth. Delay in its feeding causes the calf to lose the ability to absorb antibodies across its inertial walls. The antibodies present in colostrum protect the calf against diseases and it has a laxative effect the rate of feeding should be about 10% of the calf s weight per day up to a maximum of 5-6 litters per day.
6. The colostrum is the first secretion of cow after calving. It is thick and yellow in colour. It contains 4 to 5 times more protein and 10 to 15 times more vitamin-A than normal milk. Protein of colostrum contains much higher proportion of globulins. The globulins are to be the source of antibody presumed developing the defence mechanism in the calf for many infections. Colostrum is also rich in minerals like Cu, Fe, Mg and Mn. It also contains several other vitamins like Riboflavin, Cholin, Thiamine, Pantothenic acid etc., which are for growth of calf.
7. The calf is best maintained in an individual pen or stall for the first few weeks. After about eight weeks it may be handled with a group.
8. Take body weight of the calf and identify the calf by tattooing.
9. Dehorn the calf preferably within 15 days after birth.

The future of any herd depends upon how calves are raised. One has to raise one’s own calves to make a good herd. So the calf rearing should be taken upon scientific lines and it should be achieved economically.

Management practice up to six months

1. Provide fresh, clean water all times, particularly when milk feeding is induced discontinued
2. Giving of identification mark which is necessary for keeping proper records, proper, feeding, better ore and management.
3. Dehorning the calves: at the age of 2-3 weeks, bull calves should be castrated suitably.
4. Castration of bull calf: At age of 2-3 months, bull calves should be castrated suitably.
5. Removal of extra teast: In female calves, the following points to be noted
6. Housing: While housing the calves/ the following points to be noted.
7. Calf pen should be close to cow shed.
8. Pen should provide sunlight; good ventilation floor should not be slippery.
9. After 6-8 weeks, calves may be grouped according to age, sex.
10. The feed boxes & watering equipment should be provided in the pen.

Care and management of Heifer

1. Better Care and Management of heifer will give high quality replacement stock to the dairy farm.
2. Feed the heifer sufficiently to produce normal growth. During the early stage relatively more protein than energy is needed.
3. Most heifers grow well if excellent hay is given as much they can eat. The amount of growth depends upon the quality of forage fed.
4. The heifers should be provided with a dry shelter free from drafts. A loose housing system with a shelter open to one side is sufficient.
5. The size rather than the age of a dairy heifer at breeding time is important. Breeding under sized animals is never profitable.
6. Though the heifer that is bred to calve at an older age yields higher milk yield in the first lactation, the total milk produced by such a cow will be less when compared to the heifers that freshens at an early age. Usually, the heifer is bred to freshen at 24-30 months of age.
7. Place the heifer in a separate shed about 6-8 weeks before calving time.
8. Feed 2 - 3 kgs of concentrate daily and adequate forage also.
9. Before calving let the heifer becomes accustomed to handling and to the procedures used in the milking herd.
10. Maintenance of health among heifers is very important for proper growth.
11. The health among the heifers is maintained by hygienic housing, water, balanced feeding and taking necessary preventive steps against common diseases.
12. Periodically the heifers in the herd should be checked for their proper growth and other progress.
13. Animals lagging behind below the required standards should be removed from the herd.

Care and management of Milch Cows

1. To get high milk during any lactation, the milch animal should be properly fed and necessary care and management practices should be followed.
2. Provide green succulent forage together with leguminous hay or straw to the extent of animal can consume, so that all its maintenance requirements are met through forage feeding.
3. Extra concentrate at the rate of 1 kg for every 2 to 2.5 litters of milk should be provided. Salt and mineral supplements should be given to maintain the lactation.
4. Never frighten or excite the animals. Always treat them gently and with kindness.
5. With proper feeding and care, a cow will come to heat within 16 days of calving. Do not withhold insemination unnecessarily after the signs of heat are noticed in a cow.
6. The shorter the interval between calvings, the more efficient the animal is as a milk producer.
7. By maintaining proper records of breeding and calving of the animals will ensure a study flow of milk throughout the year.
8. Individual attention to feed each animal according to its production is a must. For this purpose, maintain individual production records.
9. Keep up regularity of feeding. Concentrate mix is fed before or during milking, when as roughage after milking.
10. Water should be provided to drink at will or at frequent intervals. It is more beneficial, if the animal is maintained on paddy straw as sole roughage.
11. Regularity in milking is essential.
12. Rapid, continuous, dry hand milking should be practiced without undue jerking of teats. Milking should be done with whole hand, but not with thumb and index finger.
13. Cows should be trained to let down milk without calf suckling. This will held to wean the calves early.
14. Loose housing with shelter during hot part of the day should be provided. The animals will get maximum exercise in loose housing system.
15. Grooming of the cows and washing of the buffaloes before milking help in clean milk production.
16. Daily brushing will remove loose hair and dirt from the coat. Grooming will also keep the animal hide pliable.
17. Wallowing of buffaloes or water spraying on their bodies will keep the buffaloes comfortable especially in summer.
18. Common ailments should be properly detected and treated.
19. Common vices should be properly detected and care should be taken. Eg. Kicking, licking, suckling etc.

20. Provide at least 60 - 90 days dry period between calvings. If the dry period is not sufficient, the milk yielding of subsequent lactation will be reduced.
21. Vaccinate the cows- against important diseases and also guard against insects and pests.
22. Every animal should be numbered and particulars pertaining to milk, fat percentage, feed taken, breeding, drying and calving dates should be recorded.
23. Check for mastitis regularly.

Care and management of Pregnant Cows

1. The good care and management practices given to pregnant animal will give good calf and also high milk yield during the successive lactation.
2. Extra concentrate mix of 1.25 to 1.75 kgs should be provided for pregnant animal and also feed good quality of leguminous fodder.
3. The animal should not be not - lean - not fat in condition.
4. Provide clean drinking water and protection from thermal stress.
5. Do not allow them to mix with other animals that have aborted or that are suffering from or carriers of diseases like brucellosis.
6. Allow moderate exercise, which helps in calving normally.
7. Do not allow them to fight with other animals and take care that they are not chased by dogs and other animals.
8. Avoid slippery flooring conditions, which causes the animal to fall which will leads to fractures, dislocation etc.
9. If accurate breeding records are available, calculate the expected date of calving. Separate it one or 2 weeks before and shifted to individual parturition pens.
10. These pens are thoroughly cleaned and fresh bedding may be provided.
11. Feed one kg extra concentrates during last 8 weeks of gestation.
12. Feed laxative about 3 - 5 days before and after calving (Wheat bran 3 kgs + 0.5 gms of Groundnut cake + 100 gms of mineral mixture of salt).
13. Symptoms of delivery may be observed i.e. swelling of external genitalia, swelling of udder, usually majority of animals will deliver without any help.
14. If there is any difficulty, provide veterinary help.
15. After parturition external genitalia, flank should be cleaned with proper care.
16. Placenta will normally leave the cow within 2 - 4 hours after calving. If not, takes the help of a veterinarian.
17. Take care of the animal before calving from milk fever. Give calcium supplement.
18. Sometimes the udder will be swollen just before calving, such cases remove the milk partially.
19. Provide always free access to drinking water.

Chpter-6

HYGIENIC MILK PRODUCTION, MILK PROCESSING, PREPARATION OF MILK PRODUCTS AND MARKETING

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Hygienic milk production

In addition to being a nutritious food for humans, milk provides a favorable environment for the growth of micro-organisms. Yeasts, moulds and a broad spectrum of bacteria can grow in milk, particularly at temperatures between 16 and 35°C. Microbes can enter milk via the cow, air, feeds, milk handling equipment and the milker. Once micro-organisms get into the milk their numbers increase rapidly. It is more effective to exclude micro-organisms than to try to control microbial growth once they have entered the milk. Bacterial types commonly associated with milk are given in Table. Milking equipment should be washed thoroughly before and after use — rinsing is not enough. Microbial growth can be controlled by cooling the milk as most micro-organisms reproduce slowly in colder environments. Cooling milk also slows chemical deterioration. The temperature of freshly drawn milk is about 38°C. Bacteria multiply very rapidly in warm milk and milk sours rapidly if held at these temperatures. If the milk is not cooled and is stored in the shade at an average air temperature of 16°C, the milk temperature will only have fallen to 28°C after three hours. Cooling the milk with cold running water will reduce the temperature to 16°C after one hour. At this temperature bacterial growth will be reduced and enzyme activity retarded. Thus, milk will keep longer if cooled.

Natural souring of milk may be advantageous, e.g. in smallholder butter making the acid developed assists in the extraction of fat during churning. The low pH retards growth of lipolytic and proteolytic bacteria and therefore protects the fat and protein in the milk and it also inhibits the growth of pathogens. The acidity does not, however, retard the growth of moulds. Naturally soured milk is used to make many products, e.g. *irgo,* yoghurt, sour cream, ripened buttermilk and cheese. These products provide ways of preserving milk and are also pleasant to eat.

They are produced by the action of fermentative bacteria on lactose and are more readily digested than fresh milk. The initial microflora of raw milk directly reflects microbial contamination during production.. High counts (more than 105 cells/ml) are evidence of poor production hygiene. Rapid tests are available for estimating the bacterial quality of milk

Milk is one of the most valuable foods for humans and young mammals. It also provides an excellent medium for the growth of bacteria which may spoil the milk or render it unsafe for human consumption or unfit for further processing. There is a constant challenge to those involved in milk production to prevent or minimize the entry and subsequent growth of bacteria in milk. Milk of good hygienic quality is necessary to produce milk products of good quality and adequate shelf-life and to provide a safe, wholesome food for the consumer.

Sources of contamination for milk

1. The interior of the udder

At one time it was generally accepted that milk as it was removed from the udder contained no bacteria. It has subsequently been shown that the normal udder contains bacteria which enter the milk as soon as it is secreted. The number of bacteria in aseptically drawn milk varies from animal to animal and even from different quarters of the same animal. On average, aseptically drawn milk from healthy udders contains between 500 and 1000 bacteria/ml. Infected udders usually yield milk with very high counts. The fore milk contains many bacteria but numbers decrease during milking. This decrease is due to mechanical dislodgement of the bacteria particularly in the teat canal. The species of bacteria found in milk as it comes from the udder are limited to a few genera. The micrococci are generally present in the greatest proportion followed by streptococci and rods. Micrococci are comparatively slow growing but if allowed to grow in milk they cause proteolysis (protein breakdown) and acid formation resulting in a very distasteful product. The streptococci in uninfected udders occur less frequently than the micrococci but they are more important owing to their action in milk. *Streptococcus agalactiae* is the organism commonly present even when there is no clinical evidence of mastitis. The number of *S. agalactiae* increases before the time the udder

shows inflammation and persists after the recovery of the animal from active mastitis. This organism is not pathogenic to humans and is killed by pasteurisation (72°C for 15 seconds).

2. Animal

There are various pathogens that may be present in the milk of infected cows many of which can cause illness to humans. Fortunately, the incidence of disease transmitted by milk has been greatly reduced by better husbandry, disease prevention and eradication programmes and better sanitation methods of milk production. Mastitis infections may result in large numbers of bacteria in milk. Mastitis is caused by *Streptococcus pyogenes* or *Staphylococcus aureus* which constitute a health hazard to consumers. *Brucella abortus* is found in the milk of cows suffering from the disease brucellosis. This disease is very infectious and is the cause of contagious abortion in cattle and undulant fever in humans. Tuberculosis, caused by *Mycobacterium tuberculosis*, is another disease that may occur in cattle and which may be transmitted to humans who drink raw milk. The exterior of the udder can be a major source of bacterial contamination to milk. Cleaning and removal of soil, bedding material and manure from the udder and flanks of the cow before milking is necessary to prevent the entry of many types of bacteria into the milk. Special care must be given to the cloths used for cleaning the udder. The re-use of cloths for cleaning and sanitising may result in re-contamination of the udder. It is therefore recommended that separate cloths be used for cleaning and sanitising and, if possible, each cloth should be used for one cow only. Clipping and grooming the udder and flanks makes cleaning and sanitising more effective. In addition to the exterior of the udder, the cow's coat may also serve as a vehicle of contamination by adding bacteria directly to the milk during milking. The coat may carry bacteria from stagnant pools of water and muddy grazing areas. Coliform bacteria and members of the genus *Bacillus* may enter the milk from soil and manure adhering to the coat of the cow. The presence of such organisms in milk is undesirable as they may cause off flavours and a reduction in the quality and shelf-life of milk and milk products. Periodic clipping in addition to daily washing and brushing the coat are recommended practices in the production of milk of good hygienic quality.

3. Milking utensils

Utensils used for milking and handling milk can be a most important cause of milk contamination. Increased mechanization of milking, handling and storage has contributed significantly to the production of clean milk. However, it has been shown that where milking equipment, milk pipelines and storage tanks are improperly cleaned and maintained the hygienic quality of the milk is worse than that obtained through manual milking and handling. It is important, therefore, that milking and milk handling utensils are properly cleaned and maintained.

4. Miscellaneous sources

Micro-organisms occur in the air and in dust particles originating from manure, soil and feed. Conditions that increase the dust content in the air around the milking area will increase the microbial population and lead to increased bacterial contamination of the milk particularly where hand milking is practiced. To reduce the dust content of the air the following practices should be avoided:

· sweeping the milking area before milking

· handling hay and feeds before and during milking

· brushing the cow immediately before milking

· dusty bedding

· accumulation of dirt and dust on the walls and ceiling.

The milking barn or area must be kept clean and, to facilitate cleaning, the floors and walls should be constructed of smooth-surfaced concrete or other impervious material. Adequate lighting is needed to carry out milking and cleaning operations satisfactorily and proper ventilation is required in the milk house to avoid condensation on the walls and ceiling. Flies, insects and rodents must be kept out of the milking house since their presence on milking equipment contributes not only to the total bacteria entering milk but also to the possibility that pathogens may be introduced. The milk house should have screened doors and windows. The health of milkers and personnel handling milk is of considerable importance. These people should be in good health and their hands free from any infections. Hands with infected wounds can add pathogenic streptococci or micrococci to milk and cause subsequent human infections. Wet-hand milking is also discouraged. Milk may serve as a carrier of human pathogens from one person to another. Typhoid and paratyphoid fever, dysentery, scarlet fever, septic sore throat, diptheria and cholera have been found to be milk-borne and to enter the milk from infected workers.

Significance of cooling milk

To prevent or retard growth of bacteria in milk and to maintain its quality for domestic consumption or during transport to the processing plant, it is essential to cool the fresh milk as quickly as possible. The temperature to which milk can be cooled on the farm will depend on the facilities available. If mechanical refrigeration is available then the milk can be cooled to 3–4°C and the frequency of delivery to the processing plant need be no more than three times a week. However, refrigeration does not reduce bacteria numbers it only slows down their growth. Some bacteria (psychrotrophs) are capable of growing at low temperatures so the importance of limiting contamination of milk by unclean utensils, poor water supplies, unhealthy cows and general unhygienic milking practices and conditions is further emphasised. In the absence of mechanical cooling facilities other means of cooling milk to the lowest possible temperature must be employed. In some situations water supplies may be inadequate so the milk container should be placed in a cool, shaded area. The milk can may be placed in a trough of cool water or in a stream It may also be placed in a box or cabinet surrounded with sacking material and a layer of sand or charcoal. At high ambient temperatures the temperature of the cooling box and therefore of the milk can and its contents can be reduced to about 20°C by spraying the outside of the box with water. The evaporation of the water (evaporative cooling) reduces the temperature within the cooling box. Other methods of cooling milk which require large quantities of water include in-can coolers and surface coolers. In both cases cold water passes through metal tubes giving indirect contact with the milk outside the metal tubes. Whatever method of milk cooling is employed the fresh milk should be cooled quickly to the lowest possible temperature.

Important consideration in the production of clean milk from healthy cows:

1. Udder washing. Before milking, the udder should be washed with clean water. A clean cloth or, if possible, disposable towels should be used.

2. Use of strip cup. A strip cup should be used to check for mastitis in each quarter before milking starts. This will prevent mixing mastitic milk with good milk.

3. Milking. The body of the cow should be free of soil, dirt and manure and contamination of milk from external sources such as animal hairs, dust, flies and dirty water dripping from the

cow's body should be minimised. Avoid using dusty bedding and avoid feeding animals during milking. Milking equipment should be clean and well maintained.

4. Milkers. Milkers and milk handlers should be in good health and their hands should be clean and free from cuts and sores.

5. Milk house. The milking barn should have a good floor that is easy to clean and drain. There should be good ventilation and lighting and facilities for manure disposal and washing cows. A good supply of clean water is required.

6. Cooling milk. Cooling milk is essential to prevent an increase in bacterial numbers and spoilage of the milk.

Processing of milk

Processing of milk includes Cream separation, pasteurization, homogenization and value added milk products manufacturing

Pasteurization

Pasteurization term has been coined after the name of Louis Pasteur of France, who in 1860 – 64 demonstrated that heating wine at a temperature between 122 to 1400F (50 to 600C) killed the spoilage organisms and helped in preservation. The application of this term "Pasteurization", although Louis Pasteur pioneered studies on heat treatment for preservation, pasteurization of milk was first attributed to Dr. Soxhlet of Germany in 1886.

Definition : The term pasteurization as applied to market milk today refers to the process of heating every particle of milk to at least 63 0C (1450F) for 30 Mts. or 720C (1610F) for 15 seconds or to any temperature – time combination which is equally efficient in approved and properly operated equipment and finally cooling to 40C. As per international Dairy federation (IDF) pasteurization is defined as a process applied to a product with an object of minimizing possible health hazards arising from pathogenic micro organism associated with milk by heat treatment, which is consistent with minimal chemical, physical and organoleptic changes in the products.

Objectives:

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

Need: As it is difficult to exercise strict supervision over all milk supplies, it becomes necessary to pasteurize milk so as to make it safe for human consumption. Any impairment of nutritive value is of the slightest extent.

Objections :

1. Pasteurization encourages slackening of efforts for sanitary 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.
6. Pasteurization may be carelessly done; it gives false sense of security.
7. It fails to destroy bacterial toxins in milk.
8. In India, pasteurization is not necessary; as milk is invariably boiled on receipt by the consumer.

Note: Pasteurization carried out with reasonable care has no effect on vit A, carotene, riboflavin and no. of remaining vit B, and vit D, of the reminder, a 10% loss of thiamine and loss of 20% ascorbic acid may be expected. Sterilization increases the losses of thiamine and ascorbic acid to 30-40% and 50% resp.

Formulation of Standards:

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

Bacterial Destruction: Cent percent for pathogens. Mycobacterium tuberculosis, being considered the most heat resistant among pathogens, was chosen as the index of organisms for pasteurization earlier. Now it is considered that "Q" fever organism "Coxiella bernette" was considered the heat resistant organism among pathogens. Any heat treatment (i.e. temperature – time combination), which kills T.B. / Q fever organism, also destroys all other pathogens in milk.

Cream Line reduction: The cream line or cream volume is reduced progressively with increase in temperature – time of heating. The consumer judges the quality of milk on the basis of the cream line).

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

Thus the standards of pasteurization were such as to ensure

1. Complete destruction of pathogens
2. Negative phosphates test and

3. Least damage to the cream line. As T.B. germs are destroyed by a heat treatment slightly lower than that for phosphatase inactivation, pasteurization is carried out at a heat treatment temperature above that for phosphatase inactivation and yet below that for cream – line reduction **Types of Pasteurization**:

1. Batch Pasteurization
2. High temperature short time pasteurization (HTST)
3. Ultra – high Temperature pasteurization (UHT)
4. Vacuums Pasteurization
5. Stassanization.

TYPES OF PASTEURIZATION.

This is also called low temperature – Long time (LTLT) method. The milk is heated to 630C / 145 0F for 30 mts and promptly cooled to 5 0C or below. In this method heating and cooling of the product is done through a metal wall. When the product is heated or cooled gentle agitation is done for rapid heat transfer. Agitation must not be so rapid that whipping or churning occurs. For continuous processing 3 to 5 tanks may be connected in series. Depending upon the method of heating the batch process may be classified into four types.

1. **Water Jacketed Vat or Flooded tank system**: This is double walled around the sides and bottom in which hot water or steam under partial vacuum circulates for heating and cold water for cooling. The outer wall (lining) is usually insulated to reduce heat loss. The heat exchange takes place through the wall of the inner lining. The difference between the temperature of the heating water and the milk is kept to a minimum. The milk is agitated by slow moving (revolving) paddles / propellers. When heating, the vat cover is left open for escape of off flavours and when holding, the cover is closed. During the holding period, an air space / foam heater (steam or electrically heated) prevents surface cooling of milk.

Advantages:

a) Flexibility is use (It is also known as a multipurpose or multi process vat).

2. **Water Spray type**: It consists of an inner tank for product surrounded by an outer tank to form space between the two. A film of hot water is sprayed from a perforated pipe over the outer surface of the tank holding the product. The product is agitated. A rapidly moving continuous film of hot water provides rapid heat transfer. The temperature of hot water is kept about 72 0C to heat the

product to 620C. The speed of the agitation is 45 to 50 rpm. The overall heat transfer coefficient of a water spray heat exchanges is approximately 1000 k cal / hm2oC.

Advantage: a) Flexibility in use b) It provides quicker control.

3. **Coil-Vat type**: In this method the heating or cooling medium is pumped through a coil placed in either horizontal / or vertical position, while the coil is turned through the products. The turning coil at a speed of about 130 rpm agitates the product. The coil and walls of the tank is constructed of stainless steel. The side and bottom of the tank in insulated. Stream or hot water may be used for heating medium. The overall coefficient about 1000 k cal / hm2oC.

Disadvantage: Coils are difficult to clean, which accounts for decline in their use.

4. **High Velocity liquid type**: A heating or cooling medium is pumped at a high velocity over the outside surface of the tank through pipes surrounding the tank. Vat pasteurization are well suited for small plants and for low volume products. It can handle a variety of products with a wide range of physical characteristics. But vat pasteurization is a batch operation and is slow. It requires manual controls and constant attention must be given to prevent overheating and over holding. Regenerate heating is not possible so heating and cooling of products is relatively expensive.

Agitation of Liquids.

In food industry the purpose of agitation may be promoting heat transfer, uniform heating or cooling, preventing separation of various elements of the product being processed; through mixing of products or maintenance of homogeneous distribution and equalization of concentration and temperatures.

HTST PASTEURIZATION

The HTST system usually employs plate heat exchangers for heating, regeneration and cooling. In this method milk is heated to 720C for 15 seconds. An HTST unit consists of a balance tank, a timing pump, a regeneration tank, a heating section, a holding section, a cooling section, a flow diversion value (FDV) and controls. HTST pasteurizer was first developed by A.P.V.Co. in the U.K. in 1922.

Milk Flow: The following steps or stages are involved as milk passes through the HTST pasteurization system balance tank, pumps, regenerative heating, heating- holding, regenerative cooling and cooling by chill water or brine. An arrangement for incorporation of the filter / clarifier, homogenizer etc., in the circuit is also made when desired.

Raw milk from storage tank will enter in to float control balance tank (FCBT) which controls the flow rate by sinking or floating in milk. Centrifugal milk pump with a flow control device to ensure constant output is and after FCBT or a rotary positive pump between regeneration and heater.

Plates: The heat exchanger plates about 1.25 to 3 mm thick. The plates are used for heating of milk to temperatures which are below the point of boiling. The plate heat exchanger is a compact, simple, easily cleaned and inspected unit. It's plates may be used for heating, cooling, regeneration and holding. These plates will have ports or openings to permit transfer of fluid through the plates, which are gasketed in such a manner that during operation, milk and medium cannot mix and no leakage can occur. The gap between the plate is about 3-5 mm. These plates are supported in a press between a terminal block in each heating and cooling section. The heat moves from a warm to a cold medium through stainless steel plates. These plates are numbered and must be properly assembled. They are tightened in to place and are so designed as to provide a uniform but not excessively turbulent flow of products with rapid heat transfer. Raised sections (corrugations) on the plates in the form of knobs, diamonds and channels, help to provide the turbulent action required. Usually the ports are provided in appropriate places, both at the top and bottom of the plates, to permit the products and heating cooling medium to flow in alternative passages without mixing.

Regenerative Heating: The raw cold incoming milk is partially and indirectly heated by the hot outgoing ilk (milk to milk regeneration). This adds to the economy of the HTST process, as the incoming milk requires less heating by hot water to raise its temperature for holding.

Filters: Various shaped filter units to connect directly to the HTST system are placed after the preheater or regenerative heating section at 43 0C for warm filteration. Usually 40 – 90 mesh cloth, usually in cylindrical shapes are used. Usually two filters are attached but they are used one at a time. This permits continuous operation, the flow being switched from one to the other while replacing a filter. The warm raw milk is forced by a pump through the final heating section, which raises the temperature of milk by using hot water or vacuum stream to 720C and then through holding section it takes at least 15 sec to traverse.

Flow Diversion Value (FDV): It routes the milk after heat treatment. If the milk has been properly pasteurized, it flows forward through the unit; that which is unpasteurized (i.e in which the

temperature does not reach the legal limit) is automatically diverted back to the FCBT for reprocessing.

It is usually operated by air pressure working against, a strong spring. Should the temperature fall, air pressure is released and the valve snaps shuts immediately. When the temperature is regained, air pressure builds up and the valve opens to forward flow. The system is so arranged that any failure of air or electricity moves the valve in the diverted position. The flow of unpasteurized milk can also be stopped with a 'pump stop' which automatically stops the milk pump motion if the product temperature drops below the desired level. When the proper temperature is reached the pump stop restarts the operation and allows the flow of milk to continue.

Regenerative Cooling: The pasteurized hot outgoing milk is partially and indirectly cooled by incoming cold milk (milk to milk regeneration). This again adds to economy of HTST process. In fact when precooled (raw) milk is received the high degree of regeneration (72 to 85%) allows water cooling to be dispensed with entirely. From regenerator down the milk goes to the final cooling section. When chilled water cools the milk usually to 40C. Flow rates of hot water and cooling water are about 4-8 and 2.5 to 4 times that of milk respectively. As mentioned above, the final heating may be achieved by hot water or vacuum steam. In the hot water system, the water is circulated through the pasteurizer is heated by stream injection in a compact unit usually mounted on the pasteurizer. Steam injection is controlled by a diaphragm valve operated via a pneumatic relay, which is actuated by a thermosensitive bulb placed in the hot water pipe or in the milk line. Variations in the water temperature produce an immediate response in the diaphragm valve and consequently in the amount of stream injected. The water temperature is then maintained within very narrow limits. In the vacuum steam heating system, the heating section of the pasteurizer is put under vacuum by a vacuum outfit, which consists of centrifugal pump, section pipe, water tank, cooling coil and three water injectors. This also evacuates condensate. Steam is fed to the pasteurizer through steam valve and expands in under pressure prevailing in the heating section. A damping device supplies condensate to the steam, preventing over heating of the latter.

Control Panel: Contains instruments, controls, FDV – mechanism and holding system, all centralized in one moisture proof panel. The lower half of the panel forms an air-insulated chamber which carries the holding tube.

i. Automatic control Device: This include I) Steam pressure controller: Maintains a constant hot water temperature for heating of milk accurately to the required pasteurization temperature. (Acts as a reducing valve in the stream supply line, so as to give a constant steam pressure).

ii. Water Temperature Controller: Regulates the amount of stream entering the hot water circulating system.

iii. Milk Temperature Recorder: Records the temperature of milk leaving the holding tube / plate. This is an electric contact instrument that operate either a FDV or a milk supply pump, automatically preventing milk from leaving the holding section at sublegal temperature. Both the frequency and duration of the flow diversion and the temperature of milk leaving the holder are recorded on the thermograph (recording chart) by means of two separate pens. The check thermometer is placed near the milk temperature recorder.

Pressure in the System: The normal pressure maintained in the HTST system are

Pasteurized milk - 15 PSI

Raw Milk - 14 PSI

Heating / Cooling medium - 12 to 13 PSI

Holding time test: The holding time of a HTST pasteurizer is the flow time of the fastest particle of milk at a prescribed temperature through the holding section. The holding time is calculated between the points at which the heated milk leaves the heating section and reaches the FDV. The efficiency of pasteurization in the HTST system depends as much on the correct maintenance of temperature as on the holding time. Hence the later should be checked periodically.

UHT PASTEURIZATION

Ultra High Temperature pasteurization (UHT) was developed in 1950's. In this method milk is heated to 135 - 1500C for no hold (a fraction of a second).

UHT process is carried out by two main ways.

1. Indirect heating system
2. Direct heating system

Indirect Heating System: These are selfcontained continuous sterilizing plants, and are to some extent like the conventional HTST pasteurizing plants, although the operating pressure are higher. The heat is transmitted to the milk through a stainless steel wall. The heat exchanger may be of plate type, tabular coil type or sometimes scraped surface type. The heating medium in steam under pressure. Most of the plants employ either plate or double or triple concentric tube heat exchanger.

The operating principle is same for all plants. The operating temperature is achieved by regeneration and indirect steam heating.

Milk is pumped from the balance tank (1) through the first regeneration section of the heat exchanger (2) and is filtered. It then passes to a section (3) heated by low pressure steam (0.35 – 0.45 atm) controlled by hand operated valve. In this section the milk is heated to 85 0C and then the milk is homogenized (4). The milk is held to 5-7 mts in a holder tank (5) to reduce the amount of deposit formed on the heating surfaces from the milk at later stages. The homogenizer provides the pressure to pass the milk through the unit. A spring loaded relief valve (6) Set at about 5 atm is connected between the homogenizer outlet and the balance tank to prevent excessive pressure developing in the plate assembly. Then the milk passes through a second regenerator section (7) and through a section (8) heated by steam at a pressure of 5-6 atm. Milk leaves this section at about 135 – 1450C and after a short period of 2-4 sec. holding period, it passes through a flow diversion value (9) operated by the control system and the two regenerator sections (7,2) to the milk outlet. The second regenerator is by passed by a line with a hand-operated valve in order to give manual control of the outlet temperature. This will be 700C for hot filling before an in – bottle sterilizing process. If the milk has to be cooled further more regeneration will be used. Milk diverted by the flow diversion valve must be cooled to below boiling point before it can be returned to the balance tank. This is done in water cooling section of the heat exchanger (10) preset valves (11) are connected as restrictions. A temperature sensitive element (x) measures the temperature of milk as it leaves the heater and the controller provides air pressure to a diaphragm valve in the steam line to the final heating section.

Advantages:

1. Produces the milk of high bacteriological quality.
2. Little effect on colour and flavour of milk.
3. Control system are simple compared to direct system.
4. Water and electricity requirements are less than direct system.
5. Stream consumption is same as in the direct system.

Disadvantages:

It forms deposits on the heating surfaces, which is difficult to clean.

Uperization: this is itself a short form of ultra-pasteurization, which have been developed in Switzerland. In this process milk is heated with direct steam upto 1500C (3020F) for a fraction of second. This process is continuous.

Vacuum pasteurization (Vacreation): this refers to pasteurization of milk/cream under reduced pressure by direct steam. The equipment used is known as vacreator and the process is vacreation. It is designed to remove feed and other volatile flavors from cream and to pasteurize it for butter manufacture.

Stassanization: This type of pasteurization is carried out in tabular heat exchanger consisting of three concentric tubes. The principle of its operation is that heating of milk to the desired temperature by passing it between two water heated pipes through the narrow space of 0.6 – 0.8 mm. The milk is heated to 740C (1650F) for seven sec. The rest of the process is just like HTST system.

Bactofugation: is the process of removing 99% of the bacteria by centrifugal force. It is claimed that the method triples the selflife of market milk. Generally it removes the bacteria from milk with two centrifugal clarifires in a series, the first operating at a high velocity (20,000 rpm). The process considered supplementary to pasteurization, for it is still necessary to destroy the bacteria not removed.

STERILIZATION OF MILK

Sterilized milk may be defined as milk which has been heated to a temperature of 1000C or above or such lengths of time that it remains fit for human consumption for at least 7 days at room temperature. Commercially sterilized milk must

a) Keep without deterioration for a sufficient period to satisfy commercial requirement.

b) Be free of microorganisms and toxins harmful to health of consumer.

c) Be free of any microorganisms capable to proliferate, it should not show any signs of bacterial growth.

Sterilization Systems and Plants:

There are three methods of milk sterilization as indicated bellow

a) Incontainer sterilization, in which milk is bottled and heated for 20 to 40 mts at temperature between 110 and 1200C.

b) Ultra high temperature process discussed under UHT pasteurization

c) Two-stage process, where the milk is first sterilized according to UHT process, then bottled and finally subjected to further heat treatment to destroy any spores which may have entered during bottling.

In container Sterilization

In this process the milk is heated in container at a temperature of 100 – 1200C, usually by steam. The temperature of milk rises slowly on account of the slow heat penetration especially when the container is not agitated in the sterilizer, because of this, and for the fact that the bottles do not withstand sudden and extreme temperature changes, the milk must be sterilized by a time. temperature combination where by the temperature is low and the time correspondingly is long. This tends to give the milk a rather strong flavour and a brownish colour, especially when the bottles are not agitated in the sterilizer. In container sterilizers are grouped in two categories i.e Batch Sterilizer, Continuous sterilizer

Batch Sterilizer: These sterilizers use steam as heating medium. Batch sterilizers may be either stationary type or rotary type. The simplest type is the stationary autoclave or Sterilizer. This is a pressure vessel, either cylindrical or rectangular in cross-section, designed to hold steam under a Pressure sufficient to give required sterilizing temperature. The Sterilizer is fitted with doors at one or both ends which are provided with gaskets to make them air tight when closed. The autoclaves are equipped with indicating pressure gauge, indicating thermometers and temperature and pressure controller to maintain the inside steam pressure of required level.

Batch process is relatively wasteful of steam, and large heat losses are unavoidable. The steam consumption will be 0.2 – 0.5 kg per litre of milk.

Continuous Sterilizer

In this system the contains of milk are loaded mechanically in to a conveyor which carries them in continuous sequence through the plant, so that the milk is automatically subjected to the required sterilizing process. These sterilizers can be divided into two kinds – namely those operating with steam as the sterilizing medium and those using hot air. Those operating with steam are either hydrostatic or hydrolock system. Hydrostatic Sterilizer: Consists of a number of towers which together form a number of ‘U’ shaped passages. One of the towers filled with steam, is maintained at high temperature.

The milk is promptly cooled to 5 0C for bulk storage and to check bacterial growth. Then milk is preheated to 35 - 40 0C for efficient filtration / clarification, so as to remove visible dirt etc., and

to increase the aesthetic quality. Then milk is again cooled to 50C so as to preserve its quality. Then milk is preheated to 600C for efficient homogenization to prevent any visible cream layer formation. Then milk is homogenized at 600C with 2500-PSI pressure. The homogenized milk should be clarified to remove the sediment formed during homogenization process. Then milk is filled in bottles and then sealed with special caps (of crown seal type). Then bottles are sterilized by any method discussed in this chapter. Usually the temp applied is 108 – 1110C (225 – 2300F) for 25 – 30 mts.

The sterilized milk bottles are gradually cooled to room temperature (sudden cooling cause's breakages of bottles) and stored at room temperature. The official checking test for efficiency of sterilized milk is turbidity test.

HOMOGENIZATION DEFINITION - ADVANTAGES AND DISADVANTAGES

Homogenization refers to the processing of forcing the milk through a homogenizer with the object of sub-dividing the fat globules. According to the United States, public health service, homogenized milk is milk, which has been treated in such a manner as to insure breakup of the fat globules to such an extent that after 48 hours of quiescent storage no visible cream separation occurs on the milk, and the fat percentage of the milk in the top 100 ml of milk is a quart of bottle, or of proportionate volumes in containers of other sizes, does not differ by more than 10 percent of itself from the fat percentage of the remaining milk, as determined after thorough mixing (In efficiently homogenized milk, the fat globules are sub divided to 2 microns or less in diameter).

If heating is not done it leads to the development of hydrolytic rancidity with the liberation of lower chain fatty acids. Heating destroys lipase and thus prevents lypolysis. Non heating and homogenization will result in fast lypolysis by lipase resulting in rancid flavour by liberation of lower chain fatty acids from the glycerides. It is desirable to heat the milk before homogenization. Other due to heating and homogenization there are other physico-chemical changes which occur in milk. These include easy digestibility of milk, soft curd formation and tasteful products. However, homogenization results in difficulty in cream separation. Homogenization is primarily employed in the preparation of flavored milk, ice cream mix and evaporated milk.

Advantages

Homogenization of milk also serves the following purposes.

1. Prevents cream formation.
2. Increases milk viscosity, it gives richer appearance to tea or coffee.

3. Fat globules do not rise readily and there is no necessity for agitating the milk before serving.

4. Prevents churning of fat during rough handling or excessive agitation.

5. Reduces curd tension, i.e. forms a soft curd when homogenized milk is coagulated, i.e. milk becomes more palatable due to brighter appearance, heavier body and richer flavor.

6. Milk becomes more digestible partly because of the smaller fat globules and partly because of the lower curd tension. The homogenized milk can be recommended for infants.

7. Reduces the chances of separation of fat during the manufacture of evaporated milk and ice-cream, it gives a smoother texture of the product.

8. Homogenizer can be used to prepare reconstituted milk by mixing butter oil or butter with skim milk.

9. The milk becomes less susceptible to oxidized flavor development.

However, if we are interested in recovery of fat, then homogenized milk should not be taken. Fat recovery from homogenized milk is difficult

Disadvantages

Increased cost of production.

2. Returned homogenized milk difficult to salvage, fat recovery is a problem.

3. Sediment appearance to a greater degree.

4. Curdling is cookery.

5. More susceptible to production of activated or sunshine flavor defect.

Factors influencing homogenization

1. Temperature: the milk should**,** at the time of homogenization be at a temperature above the melting point of fat, viz. above 33 0C. This is because milk should be in the liquid state for proper sub division. The enzyme lipase should be inactivated, preferably prior to homogenization or immediately afterwards. This can be achieved by heating the milk to a temperature of 550C or above. In routine practice, the milk is heated to 65-700C for homogenization. The danger zone of lipase activity, viz., temperature 38-490C should be avoided during or after homogenization.

2. Pressure: in single stage, upto 6%fat milk, usually 2000-2500psi pressure is sufficient. Higher pressure may increase th tendency for the milk to curdle when cooked, due to the increased destabilizing effect on milk proteins. With liquid products with more than 6% fat, two stage homogenization is needed to prevent fat clumping: 2000psi at the first stage and 500psi at the second.

Preparation of milk products and their marketing

PANEER AND CHHANA

Paneer and Chhana are two heat and acid coagulated traditional product made from milk in our country since score of centuries. These products contains fat and proteins in concentrated form.

Paneer refers to the milk product obtained by the acid coagulation of hot milk and subsequent drainage of whey. The acids commonly used are citric, lactic, acetic, etc. and sour whey or cultured whey can also be used for coagulation of milk. The phenomenon of coagulation involves the formation of large structural aggregates of proteins in which milk fat and other colloidal and soluble solids are entrained with whey. Paneer is a popular indigenous variety of soft cheese.

CHEMICAL COMPOSITION

Paneer is a highly nutritious and wholesome food. It is a rich source of milk protein and milk fat and is one of the best methods of conserving milk solids in highly concentrated form. Paneer is used as a base material for the preparation of large number of culinary dishes. Paneer contains on an average approximately 54.0 per cent moisture 27%milk fat, 17.5 per cent protiens, 1.5 per cent minerals and lactose. The chemical composition of paneer depends mainly on the type of milk, composition of milk, the conditions of coagulation, the technique of straining/ pressing and the losses of milk solids in the whey.

Typical chemical composition of paneer

Chhana	Moisture(%)	Protein(%)	Fat(%)	Lactose(%)	Ash(%)
Buffalo milk	52.3	15.8	27.0	2.3	1.9
Cow milk	52.5	25.0	17.3	2.2	2.0

FACTORS AFFECTING QUALITY OF PANEER

The quality of paneer depends mainly on the initial composition of milk, type of milk, the conditions of coagulation, the technique of straining/pressing and the losses of milk solids in the whey. A minimum of 5.5 per cent fat in buffalo milk and 4.5 per cent fat in cow milk is necessary for producing a desirable good quality paneer whereas a lower fat level than the above
in milk results in a hard body and coarse texture with increased chewiness. The higher fat content in milk is also not desirable since it produces

greasiness, softness and weak body and texture in paneer. The higher fat in milk results in more loss of fat in whey. For manufacture of good quality paneer sweet milk (fresh milk) is the best suitable raw material, developed acidity or sour milk tends to produce sour flavour and bitter taste, which makes it unsuitable for preparation of culinary dishes. Acceptable quality paneer could be produced from slightly acidic and neutralized milk.

CHHANA

Chhana is an Indian traditional milk product formed by heat and acid coagulation of milk followed by draining of whey. It is used as a base and filler for the preparation of a large number of Bengali Sweets such as rasogulla, sandesh, rasmalai, chamcham, chhana-murki, rajbhog, etc. Its preparation ismainly confined to the cottage sector, largely in the eastern parts of India, notably West Bengal, Bihar and Orissa, and more recently, in Bikaner district of Rajasthan. However, chhana based sweets are gaining popularity in other parts of country.

chhana as a product obtained from cow or buffalo milk or a combination thereof by precipitation with sour milk, lactic acid or citric acid. It should contain not more than 70 per cent moisture and itsmilk fat content should not be less than 50 per cent on the dry matter basis (Total solids).Milk solids may also be used in preparation of this product.

CHEMICAL COMPOSITION

The chemical composition of chhana is influenced by the type of milk, fat level in milk, temperature of heating, condition employed for coagulation of milk, draining of whey and moisture content in the finished product. The amount of whey removed and the fat loss in the whey indirectly affect the composition of chhana.

Chhana	pH	Moisture(%)	Protein(%)	Fat(%)	Lactose(%)	Ash(%)
Cow milk Chhana	5.7	53.4	17.4	24.8	2.2	2.1
Buffalo milk Chhana	5.4	51.7	14.4	29.7	2.3	1.9

Chhana contains fairly high level of fat and proteins as well as some minerals. It is also a good source of fat-soluble vitamins A, D, E and K. So, its nutritive value is fairly high. Its nutritive value is further enhanced due to the entrapment of whey proteins that are rich sources of essential amino acids.

FACTORS AFFECTING QUALITY OF CHHANA

i. Type of Milk

Cow milk produces chhana with moist surface, light yellow colour, soft body, smooth texture and mildly acidic flavour. Cow milk chhana is more suitable for Bengali sweets preparation than buffalo milk chhana;. Goat milk can also be converted into acceptable quality chhana, which is suitable for sweet preparation.

ii. Quality of Milk

Minimum fat level of 4 per cent in cow milk and 5 percent in buffalo milk is necessary for producing good quality chhana. The low fat milk results in a hard body and coarse texture in chhana, whereas higher fat level is also not desirable as it produces greasiness and stickiness in the chhana sweets.

iii. Type and Strength of Coagulant

The body and texture of chhana is influenced by the conditions of coagulation such as pH of coagulation, strength of coagulating solution, type of acid, speed with which the milk is stirred during coagulation and temperature and time of coagulation. Low acid strength (0.5 percent) results in very soft body and smooth texture suitable for rasogulla but unsuitable for sandesh making, while high acid strength (8 per cent) results in hard body and less smooth texture, suitable for sandesh making but not for rasogulla. The optimum strength of coagulant solution should be between 1 to 2 per cent citric acid or lactic acid to produce good quality chhana suitable for making both kinds of sweets.

iv. Coagulation Temperature

Chhana of satisfactory quality from cow milk can be obtained at a coagulation Temperature of about 82 oC. The optimum coagulation temperature for making chhana from buffalo milk is around 50o C.

v. pH of Coagulation

The optimum pH for chhana making from cow and buffalo milk is 5.4 and 5.7 respectively.. An optimum pH of 5.35 has been reported when making chhana from cow milk using calcium lactate as coagulant. Higher speed of stirring during coagulation reduces the moisture content in chhana and increases its hardness, whereas with lower speed the reverse holds true. Slow stirring (40-50 rpm) is preferred to avoid foam formation.

vi. Method of Straining

The method of straining of coagulated mass effect the body and texture of paneer, moisture retention and solids recovery in chhana. The coagulated mass should be collected in fine cloth and hung to remove moisture. In case of chhana external pressure is not applied for removal of moisture from the coagulated mass. Method of straining is an important factor which affects the body and texture of chhana by influencing the moisture retained in it. In general two types of straining is employed viz. immediate or delayed. Immediate straining is carried out by promptly gathering the coagulated mass and tying it up in a piece of fine cloth and then hung up for draining out the whey and cooling the chhana. In case of delayed straining process, the coagulated mass is left in the whey either as such or loosely enclosed in a piece of cloth, so as to cool it to ambient temperature and thereafter it is hung for removal of whey. Delayed straining produces a comparatively soft and smooth texture chhana than immediate straining. Higher moisture, increased yield, improved recovery of milk solids..

METHODS OF MANUFACTURE OF CHHANA

Chhana making is essentially a process involving destabilization of casein particle by acidification of milk with dilute acid at relatively higher temperature. Acidification affects the stability of casein directly by disturbing the charges carried by the particles and indirectly by releasing the calcium ion from colloidal calcium phospho caseinate. The destabilization results in formation of large aggregates from the normal colloidal dispersion of casein micelles in which milk fat, serum proteins and other constituents get entrained together. Thus, the large structural aggregates formed is known as coagulum.

i. Traditional Method

Milk for chhana making is brought to boil by heating it directly in a large iron *karahi* over an open fire with continuous stirring to prevent burning. This hot milk is ladled out in batches of about 1-1.5 litre in a separate coagulation vessel and adequate amount of coagulant solution normally cleansed sour chhana-whey is added to it while gentle stirring the contents. After complete coagulation, the contents is poured over a piece of clean muslin cloth stretched over another vessel. The process is repeated till all the milk is used up. The cloth containing the
coagulated mass is then removed, tied into a bundle and hung up to drain out the whey completely without applying any external pressure.

ii. Bulk Method

In this method, the same steps are followed as mentioned above except instead of small lots of 1-1.5 litres, all the milk (normally5-20 litres) is coagulated in one bulk. Coagulant solution is added slowly with uniform constant stirring till clear whey separate out. The coagulated solid mass is collected by straining it through a muslin cloth.

iii. Improved Method

The method of production of chhana remains the same as mentioned above with some improvements. These involve consideration of equipment, quality of milk, conditions of coagulation and method of straining etc. In this process boiling, cooling, coagulation of milk are accomplished in the same steam jacketed stainless steel kettle by employing steam or tap water as and when required, coagulation of milk is carried out at 80oC by adding 1-2 per cent citric acid solution (pH of coagulation 5.4). The coagulant solution is added with in 30-60 seconds and while addition of coagulant a slow stirring is referred so as to avoid foam formation and also breakage of curd into fines. After attaining complete coagulation of milk the coagulated mass is strained as mentioned above.

iv. Continuous Method

In order to overcome problems of small scale, attempts have been made to mechanize chhana production. A prototype machine with a capacity of 40 kg chhana per hour has been developed at NDRI, Karnal. The major components of the equipment are a balance tank, injection chamber, tubular heat exchanger, cooling chamber, mechanized strainer, whey tank etc. In this mechanized process, standardized cow milk is pumped from a balance tank at the rate of 250-litres/ hour to an injection chamber where culinary live steam is directly injected into the milk. Steam gets completely condensed in milk and raises its temperature to 90-95oC.Thereafter, milk is brought in contact with coagulant solution, the quantity of which is regulated manually in proportion to the rate of flow of milk. The mixture of milk and coagulant is circulated through a holding coil to facilitate complete coagulation of milk. The coagulated product, along with the whey is then pumped to a double-jacketed cooling tank, where it is cooled down to room temperature. Finally, the coagulated mass is directed to a mechanical strainer, a double jacketed inclined sieve, where it is drained thoroughly. Chhana with 55-65 per cent moisture is discharged through the outlet

and collected in the basket. Drained whey is transferred to a separate tank for subsequent use. Finally the chhana is packaged in suitable packaging material and stored in cold room.

METHOD OF MANUFACTURE OF PANEER

The manufacture of paneer involves standardization of milk, heat treatment, coagulation, draining of whey, pressing, dipping in chilled water and packaging.

i. Buffalo Milk Paneer

Buffalo milk is an ideal raw material for manufacture of good quality paneer. Buffalo milk is standardized to a fat level of 5.8 to 6.0 per cent using fresh buffalo skim milk. The standardized milk is heated to MORE THAN 90oC without holding. Citric acid solution is added at around 85 oC with continuous stirring till clear whey separate out. After complete coagulation, the stirring is stopped and the coagulated mass (curd) is allowed to settle down for about 5 minutes. The whey is then drained through stainless steel strainer. The hoops containing curd is pressed for about 10-20minutes. Thereafter, the pressed block of curd is removed, cut into pieces and immersed in chilled water of 5-6oCfor about 2 hours. Dipping of paneer pieces facilitates cooling of product and also it absorbs moisture and improves the body and texture of paneer. The paneer is cut into desirable size and packaged in suitable packaging material. Finally it is stored under refrigeration till marketing and consumption. The flow chart for manufacture of buffalo milk paneer is given in

ii. Cow Milk Paneer

Cow milk is standardized to a fat level of 4.5 to 5.0 per cent using fresh cow cream. To this milk calcium chloride is added at the rate of 0.05 to 0.10 per cent. The milk is heated to more than 90oCwithout holding. Thereafter, the temperature ofmilk is brought down to 80oC coagulated at this temperature using 2 per cent citric acid solution. The citric acid solution is heated to 80-85oC prior to its addition to milk. Rest of the manufacturing process is same as in case of buffalo milk Paneer.

YIELD OF PANEER AND CHHANA

The yield of paneer and chhana is largely depend upon the total solids content of milk, type of milk, manufacturing conditions and moisture retained in the paneer and chhana. Normally, the average yield of chhana is about 20 per cent from cow milk and about 25 per cent from buffalo milk. The yield of paneer depends on the fat and solids-not-fat content of milk, manufacturing

conditions and moisture, fat retained in the paneer. An average yield of about 19-20 percent for buffalo milk and about 16- 17 per cent for cow milk is generally obtained.

PACKAGING OF PANEER AND CHHANA

Packaging, of paneer should protect it against microbiological and chemical spoilage, maintain quality and provide consumer convenience. In general, various packaging materials used for preserving paneer at refrigeration temperature include wax coated parchment paper, polyethylene pouches, flexible films, heat induced shrink films, and saran films. Flexible packaging films like polypropylene, retort pouches and co-extruded laminates hold a great promise for packaging paneer for longer period.

The packaging material should protect chhana from heat, light, oxygen, microbial contamination, moisture loss, foreign odour, etc.The package should also be nontoxic. At best, vegetable parchment paper has been used for chhana packaging, but with limited success. Chhana packaged in tin cans and cellulose films/ LDPE and stored at 37oC has a shelf life of only three days. When poster-paper/ Al. foil/ LDPE is used, refrigerated storage for chhana at 4-5oCis required. Chhana stored in tin cans showed the least chemical changes during storage at 37oC.Tin cans and poster-paper/Al. foil/LDPE also provided maximum protection against chemical deterioration as compared to other packaging material.

Chhana Based Sweets

The shelf life of chhana based sweets is largely depend on the processing and packaging conditions, method of handling, season and moisture content in the product. Normally sandesh has a very limited shelf life of two to three days. Hard grade has better shelf life than soft grade ones. In summer, the shelf life of hard grade Sandesh is between three to four days while in winter it kept well four to six days. The relatively longer shelf life of this product maybe due to low moisture and high sugar contents. Serpak Sandes his having maximum shelf life of two to three months under refrigeration storage. Serpak is prepared by heating chhana and sugar for a longer duration. Babupak Sandesh deteriorates rapidly and in summer its shelf life is one day. Whereas, Batupak sandesh is having shelf life of two of three days. Inwinter, the shelf life of Babupak and Batupak sandesh maybe extended upto two and five days, respectively. The shelf life of rasogulla is quite longer as compared to sandesh. Rasogulla is packaged in lacquered tin cans with hot syrup. Sodium metabisulphite is added to maintain white colour to tinned rasogulla. The shelf life of rasogulla with permissible preservatives in tin containers is above three months.

Paneer	Chhana	
Type of milk	Buffalo	Cow
Quality of milk (fat%)	B=5.5, C=4.5	C=4, B=5
Type and Strength of Coagulant	Citric acid (1-2%)	Sour whey (0.9%)
Coagulation temprature	700C	820C
Method of straining	Pressed by pressing mould	To external force

Fermented milk products			
Types of fermented milks			
Name	**Country of origin**	**Milk types,**	**conditions** **Microflora**
Dahi (Dadhi)	India, Persia	Cow's or buffalo's milk	*L. lactis* subsp. *lactis, S. salivarius* subsp. *thermophilus, L. delbrueckii* subsp. *bulgaricus, plantarum,* lactose fermenting yeasts, Mixed culture (not defined)
Shrikhand (chakka)	India	Cow's or buffalo's milk	*S. salivarius* subsp. *thermophilus, L. delbrueckii* subsp. *bulgaricus*
Lassi	India	Cow's or buffalo's milk	*S. salivarius subsp. thermophilus, L. delbrueckii* subsp. bulgaricus
Cultured butter milk	Scandinavian and European	Cow's or buffalo's milk	*L. lactis* subsp. *lactis, L. lactic subsp. diacetilactis, Leuconostoc dextranicum* subsp. citrovorum
Acidophilus milk	Australia	Cow's milk	*Lactobacillus acidophilus*

Yoghurt (bio yoghurt)	Middle Asia, Balkans	Cow's milk, goat's or mixed milk	*S. salivarius* subsp. *thermophilus, L. delbrueckii* subsp. *bulgaricus,* Micrococcus and other lactic acid cocci, yeasts, molds
Kefir	Caucasian mountains of the former USSR	Sheep's, cow's, goat' mixed milk,	fermentation in skin bag or in wooden barrels *L. lactis* subsp. *lactis, Leuconostoc spp. L. delbrueckii* subsp. *caucasiucu, Saccharomyces kefir, Torula kefir,* micrococci, spore forming bacilli and kefir grains
Kumiss	Asiatic steppes	Mare's, camel's or asse's milk	fermentation in skin bag *L. delbrueckii* subsp. *bulgaricus, L. acidophilus, Torula kumiss, Saccharomyces lactis,* micrococci, spore forming bacilli lactis, micrococci, spore forming bacilli
Leben Labneh	Lebanon and Arab	Goat's or sheep's milk	fermentation in skin bag/ earthenware *L. lactis* subsp. *lactis, S. salivarius* subsp. *thermophilus, L. delbrueckii* subsp. *bulgaricus, lactose fermenting yeasts*

DAHI

Dahi, Indian curd, is a well known fermented milk product consumed by large sections of the population through out the country, either as a part of the daily diet or as a refreshing beverage. In India, dahi also known as dadhi is largely made at home using traditional kitchen recipes, involving milk of buffaloes, cows and goats. Generally a mixture of cow and buffalo milk is used. Milk is boiled and cooled, inoculated with dahi starter, usually the left over from the previous day's stock, and incubated undisturbed at ambient temperature for four to six hours until it acquires a thick consistency. Dahi is generally consumed in its original form as an accompaniment to the meal or it may be converted into raita. Dahi may be consumed as such or as sweet or savoury drink as a dessert containing sugar, spices, fruits, nuts, etc. An extensive all-India survey project on dahi revealed that there are, broadly speaking, two types of dahi prevalent in the country for direct

consumption, viz. a sweet/mildly acidic variety with a pleasant flavour, and a sour variety with a sharp, acidic flavour.

The PFA Act deifines dahi or curd as a semi-solid product, obtained from pasteurized or boiled milk by souring (natural or otherwise), using a harmless lactic acid or other bacterial cultures. Dahi may contain additional cane sugar. It should have the same minimum percentage of fat and solids-not-fat (SNF) as the milk from which it is prepared. Where dahi or curd, other than skimmed milk dahi, is sold or offered for sale without any indication of the class of milk, the standards prescribed for dahi prepared from buffalo milk shall apply. The Bureau of Indian Standards (BIS) specifications for fermented milk products are based on the type of culture used in their preparation. Mild dahi is made from mesophillic lactococci. Leuconostocs maybe adjunct organisms for added buttery odour and flavour. Sou rdahi contains additional cultures belonging to the thermophillic group, which are generally employed in the manufacture of yoghurt. These thermophillic organisms grow rapidly at 37-45oC, producing dahi in less than 4 hours.

Dahi made from buffalo milk produces a thick bodied product because of its high SNF content. It is recommended to make dahi/ yoghurt from a mix containing 11- 13 percent SNF. The increased protein content in the mix results in a custard like thick consistency following the required fermentation. Higher milk solids also keep the product from wheying off. Dahi prepared from whole milk contains about fat 5- 8, protein 3.2 – 3.4 lactose 4.6 – 5.2,Ash 0.70 – 0.72, and titratable acidity 0.60 –0.80 percent.

iii. Method of Manufacture

i) Traditional method: In this method dahi is prepared at small scale, either in the consumer's household or in the confectionary (Halwais) shop. In the household, the milk is boiled, cooled to room temperature, inoculated with 0.5 to1.0 percent starter (previous day's dahi or buttermilk) and then incubated undisturbed for setting for about overnight. In cold weather, the dahi setting vessel is usually wrapped up with woolen cloth to maintain appropriate temperature. In the confectionary shops, the method employed for preparation of dahi is more or less same except that the milk is concentrated in a open pan before inoculation and usually dahi is set in a earthenware.

ii) Standardized method: Process on the basis of scientific lines has been developed for dahi making in the organized sector. Fresh, sweet, good quality milk is received, pre-heated and subjected to filtration and clarification. The milk is standardized to 2.5 to 3.0 percent fat and 10 percent solids not fat, pre-heated to 60oC and homogenized single-stage at a pressure of 176-kg/sq

cm. The milk is heated to 85 – 90oC for 15-30minutes, cooled to 22-25oC and inoculated with 1-2 percent of specific dahi starter culture. It is then filled in suitable packaging containers of the appropriate size and incubated at 22-25oCfor 16-18 hours. After proper setting of the dahi, the acidity of dahi reaches 0.6 to 0.7 percent and a firm curd is formed. The curd is cooled by circulating chilled water or air around the containers and then transferred to cold room maintained at about4-5oC.

YOGHURT

Yoghurt is a coagulum obtained by lactic acid fermentation of prescribedmilk or milk products by the action of *Lactobacillus delbrueckii subsp. bulgaricus* and *Streptococcus thermophilus,* the addition of additives is optional. The final product should contain large quantities of the above microorganisms. Yoghurt is characterized by a pungent, fruity small and acid taste. It has a firm body like dahi. Commercial yoghurts are divided into three main categories, i.e.. plain/natural, fruit and flavoured, and these different types of yoghurt are manufactured in many forms such as set, stirred, liquid/drinking, frozen and dried/instant types. The international standards

The basic ingredients of yoghurt are milk and microflora. The milk is converted into yoghurt by growing within it specific lactic acid bacteria and souring it under defined conditions. According to FAO/WHO(1977) "Yoghurt is a coagulated milk product obtained by lactic acid fermentation through the action of *Lactobacillus bulgaricus* and *Streptococcus delbrueckii subsp. thermophilus,* from milk and milk products (Pasteurized milk or concentrated milk),with or without optional additions (milk powder, skimmilk powder,whey powder, etc.).The microorganisms in the final product must be viable and abundant". The origin of yoghurt is not clear. According to some sources yoghurt originated in Asia, where the ancient Turks lived as nomads. The first Turkish name appeared in the 8th century as "Yogurut" and was subsequently changed in the 11th century to its present form. A dried type of yoghurt was called "Kurut: and a beverage type "Suvuk yoghurt". According to still some authors, yoghurt originates from the Blakans.

i) Batch Method: This method was originally used in small-scale production. The manufacture of set yoghurt is carried out as follows:

The clarified milk, adjusted to a specific solids content, is heated in a jacketed vat to 90-95oCfor 15-25min, cooled to 43-45oC, inoculated with 1-3 percent yoghurt culture and thoroughly mixed with the milk and then filled into retail containers, incubated in an incubator at 41-43oC for 2-3 hours and cooling within the same incubation chamber or in the cold store. Alternatively,

incubation and cooling can be done in water trays. In the manufacture of stirred yoghurt, heat treatment of the milk, cooling, inoculation and incubation are carried out in a jacketed vat, followed by cooling either in the samevator in a cooler, with subsequent filling in to retail containers. With larger plants it will be desirable to include homogenization of the milk. This can be done using a plate heater or heating the milk to the homogenizing temperature (55-65oC) and then to pasteurize homogenized milk in a jacketed vat.

Both types of yoghurt can be produced as natural or plain or flavoured and fruit. Flavouring or fruit are added before incubation when making set yoghurt and after incubation and cooling when making stirred yoghurt.

ii) Modern Process: Modern process lines for yoghurt are used in medium or large scale production. The following factors contributed to the introduction of modern process lines:

1. Standardization of the fat content in milk by using specially designed equipment.
2. Increasing the solids content in milk, by concentration of the milk using specially designed evaporating units concentration of the milk by10-15% (raising of dry matter for about 2-3%) normally gives an optimum solids content. This method is usually used in large scale production. Alternatively, 1-3%skimmilk powder may be added for increasing the solids content in milk.
3. Homogenization at 55-65oC under a pressure of 2000-2500 psi in a homogenizer, usually before heat treatment of the milk.
4. Heat treatment of the milk in pasteurizers at 90oC for 5min and in UHT sterilizers (direct and indirect heating) at 135-145oC for few seconds, with subsequent cooling to the fermentation temperature.
5. Culturing of milk by the addition of bulk starter (1.5 – 2.0%) with subsequent stirring for few minutes.
6. In manufacturing stirred yoghurt, incubation is carried out in a series of insulated tanks working in rotation. After the completed incubation (41- 43oC for 2-3 hrs) the yoghurt is discharged by a positive pump to the plate or tube cooler. Cooled yoghurt is transferred to a pair of buffer tanks which continuously supply it to packaging machines. On the packaging line, previously pasteurized flavouring ingredients are continuously added in-line by a positive metering pump and mixed with the yoghurt.
7. In the manufacturing of set yoghurt, the inoculated milk in a pair of mixing tanks is fed to packaging machines for filling into retail containers. On this route, previously pasteurized

flavouring or fruit concentrate maybe added in line by a metering pump and mixed with the yoghurt milk. The filled containers are transferred to incubation chambers for incubation until a pH4.7 is reached. Cooling can be done either within the same chambers or in the cold store.

8. Processing equipment of the plant such as tanks, pumps, heat exchangers, piping and others, being designed for cleaning in-place and sterilization.

Difference in yoghurt and dahi

Yoghurt	**Dahi**	
Total solids (%)	21-22	12-14
Acidity (%)	0.9-1.2	0.5-0.6
Starter culture	*S. salivarius* subsp. *thermophilus, L. delbrueckii* subsp. *bulgaricus,* Micrococcus and other lactic acid cocci, yeasts, molds	*L. lactis* subsp. *lactis, S. salivarius* subsp. *thermophilus, L. delbrueckii* subsp. *bulgaricus, plantarum,* lactose fermenting yeasts, Mixed

culture (not defined)		
Incubation temperature	41-42 0C	24-30 0C
Incubation period	3-4 Hrs	16-18 Hrs
Flavoring compound	acetaldehyde	diacetyl

LASSI

Lassi (stirred dahi) is a ready-to-serve fermented milk beverage popular in India Particularly in summer months. In many parts of the country products, like buttermilk, chhach, mattha obtained after churning of sweet cream, or whole milk dahi and removal of butter are termed as lassi and usually consumed in salted or spiced form. Also a product prepared from cultured skim milk, commonly known as cultured buttermilk is classified as lassi.

i. Chemical Composition

Lassi is a white to creamy-white viscous liquid with a sweetish, rich aroma and pleasant mild acidic taste. The chemical composition of lassi depends on the type of milk, initial composition of milk, level of concentration of milk solids and the sugar level.

Proximate composition of lassi

Milk fat - 1.5 – 3.8%

Milk TS - 9.00%

Sugar - 13 – 20%

Sodium dihydrogen phosphate optional - 0.5%

Low methoxy Pectin optional - 0.5%

Acidity (minimum) - 0.7% LA

ii. Manufacture of Lassi

Production of lassi has been confined, to a large extent, to the households and local halwa is mainly because of non-availability of a standardized technique for the manufacture of uniform quality lassi and its limited shelf life.

The method of manufacture of lassi involves standardization, heating and cooling of milk to inoculation temperature, addition of starter culture and setting of milk. Sugar@ 12-15%ofmilk dissolved in equal quantity of water is added in the form of a syrup which has been pasteurized and cooled separately. Smooth consistency of lassi is obtained by homogenization of

the mix. Flavour is added before packaging. In general, the quality of milk, starter culture and the method of manufacture influence the quality of lassi. Pooled milk is considered to be the most suitable for the manufacture of fermented milk products, like, yoghurt, dahi, shrikhand etc. A suitable heat treatment is applied to milk to make it free form most of the vegetative cell of microorganisms associated with raw milk. The culture must be pure, active and free from gas producing microorganisms. Presence of more than one type of lactose fermenting microorganisms in the starter culture is required for the production of diacetyl flavour in dahi. A lactic culture comprising of *Lactococcus lactis subsp. lactis, Lactococcus lactis subsp. cremoris* and *Lactococcus lactis subsp. diacetilactis* is used for dahi for lassi making. Setting of milk is terminated at an acidity of 0.70 – 0.80 per centLA.

In a typical method of manufacture of lassi, standardized milk (4%fat) is heated to 90oCfor 10min and cooled to 25oCbefore addition of starter culture (1%).Cultured milk is incubated for 12-16 hr at 25-28oC, the set curd is broken by stirring and sugar syrup is mixed. The mixture is homogenized and packaged after the addition of flavour. On an average the product contains 3 per cent fat., 6-7 per cent SNF and 10-11 per cent sugar. The acidity ranges from0.6 to 0.7%LA. Flowchart for mechanized production of lass is depicted in Fig. 2.4.

Lassi Powder:. The method involves concentration of skim milk by reverse osmosis process, standardization of the concentration with cream to contain 10 per cent fat and 30 per cent total milk solids, inoculation with starter culture and setting of curd. The curd is broken by agitation to obtain a smooth slurry which is subsequently spray dried under predetermined conditions. Sugar is dry Continuous pre fermentation in tanks and main fermentation in packs. (Upto pH 5.2 milk remains Liquid) Aseptic packaging in the sales pack blended. The powder on reconstitution with water yields lassi-like beverage. Acceptability of the beverage could be enhanced by fortification with fruit juices. The lassi powder was found to contain moisture 5 per cent, fat 29-31 per cent and protein 23-34 per cent.

MARKETING OF MILK AND MILK PRODUCTS

Marketing is a flow of goods and services from producer to consumer and users. In this process the activities include moving the goods from the point of production to the point of consumption. The activities like creation of time, place, form and utility are involved. According to Philip Kotler, marketing as a human activity directed at satisfying the needs and wants through exchange process. The performance of the trade activities involved in the flow of goods and services affect the marketing efficiency and producer's share in the consumer

rupee. A marketing system consists of different milk marketing channels. That marketing channel is considered good in which producer get the highest share in consumer rupee and consumer share is highest in producer's rupee. The interest of the Producer is to get the highest possible returns from their milk. Between them, there are marketing intermediaries or middlemen who perform various marketing functions like transporting and retailing. All the intermediaries/middlemen are also interested to make highest profit from the milk business.

Dairy marketing truly came into the public's consciousness with the introduction of the "Got Milk" campaign in 1993. The basic dairy product became associated with a memorable and catchy slogan that helped drive sales. There are many other strategies, though, to market all types of dairy products. These include promotion of nutritional value, appeal to the organic market, and use of social media networks and development of new dairy products. According to American Marketing Association marketing as "the process of planning and executing the conception, pricing, promotion, and distribution of ideas, goods, and services to create exchanges that satisfy individual and organizational objectives." Marketers use an assortment of strategies to guide how, when, and where product information is presented to consumers.

Milk Marketing Channels in India

Sr. No.	**Milk Marketing Channels**	**Number of intermediaries**
1	Producer ⇨ Consumer	0
2	Producer ⇨ Halwai/tea shops ⇨ Consumer	1
3	Producer ⇨ Milk Vendor ⇨ Consumer	1
4	Producer ⇨ Milk Vendor ⇨ Contractor - Consumer	2
5	Producer ⇨ Dairy Co-operative ⇨ Milk Plant ⇨ Consumer	2
6	Producer- Milk trader-Processor-Retailer -Consumer	3
7	Producer-Dairy Cooperatives-Milk transporter-Processor-Retailer-Consumer	4

Costs Involved in Marketing of Milk and Milk Products

Cost components

The marketing agencies made capital investment on building, transportation vehicles, and dairy equipments and incurred various variable costs time to time with respect to human labour, purchase of milk, fuel, repairs, electricity etc. Therefore, the expenditure on various items was classified according to their fixed and variable nature.

Fixed costs

Fixed costs are those costs, which are incurred whether or not the production is carried out or do not change with the level of production. These costs include interest on fixed capital and depreciation on buildings and equipments. In addition to this actual expenditure incurred in obtaining the driving license and road tax was taken into account while calculating the fixed costs.

Variable costs

Variable costs include cost of raw milk actually purchased, fuel cost as expenses incurred on petrol for the vehicle, electricity was used for running electric equipments.

Chapter- 7

IMPORTANT DISEASES OF DAIRY ANIMALS

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1. FOOT AND MOUTH DISEASE

This is a highly infectious viral disease of farm animals.This disease mostly manifests the lesions in the mouth, feet and mammary gland. Milk yield drops dramatically in milking animals, suckling calf usually die and pregnant animals may abort and infertility may ensure following abortion.

Symptoms

- High fever up to 104-106˚F (41˚C) and anorexia.
- Profuse salivation (saliva hanging in long ropy strings up to the ground).
- Animal stamps its feet and wounds in the interdigital space of legs followed by lameness.
- Oral ulcers and lesions.
- Smacking of lips.
- Vesicles in the mammary gland.

Treatment Control and prevention

- Mouth and feet of the affected animals should be washed with 1% potassium permanganate (KMnO4) antiseptic mouth wash3-4 times a day.
- Glycerin may be applied over the lesions.
- Regular vaccination of farm animals, first dose at 3 months of age, followed by second dose at 30 days after first vaccination. Then repeated once in 6 months interval preferably during April- May.
- Ring vaccination may be followed for control of disease outbreak and border vaccinations to protect disease free zones.
- No purchase of animals from disease prevailing areas.
- Unvaccinated animals should not be allowed to cattle fairs.
- Strict quarantine measures for newly purchased animals.
- Always prefer to purchase / procure fodder from a place where FMD has not been recorded for a period of six months or so.
- Affected animals should not be allowed to drink water from ponds/streams/ rivers etc.

- Diseased animals should not be allowed to roam about with other animals of the village.

2. LUMPY SKIN DISEASE

Lumpy skin disease is one of the highly infectious disease of cattle and buffaloes. It is a viral disease which affects all the age groups of animals. The causative virus resembles to the sheep pox virus. Cattle and water buffaloes are the worst affected. Biting flies such as certain species of flies, mosquitoes and ticks are the mechanical vector of this disease. The disease can also spread by contaminated equipment, fodder, water, saliva, nasal discharge, milk, semen of affected animals and directly from animal to animal contact. The disease is not fatal but the greatest economic loss of the farmers is due to reduced milk yield, temporary or permanent sterility in bulls, loss of condition and reduced value of hide of the animals.

Clinical Signs

- The disease is characterized by high fever, ocular discharge, nasal discharge, profuse
  salivation and pale mucous membrane
- The regional lymph nodes of the animal become swollen . Characteristic skin eruptions which are round, firm, painful, slightly raised and well circumscribed nodules spread all over the body, i.e., body, face, muzzle and udder .There is edema on the brisket region, legs and udder.
- There may also be marked reduction in milk yield of the lactating animals, abortion in pregnant animals and loss of condition.

Treatment

Administration of antibiotics, anti-inflammatory and multivitamin injections are directed to control secondary bacterial infection, inflammation, fever and for improving the appetite of the animal. Along with this, good nursing care are also recommended.

Preventive Measures

- Mass vaccination is the only method for prophylaxis of the disease. The vaccine for this disease is originally registered as goat pox vaccine and the recommended dose in cattle and buffalo is 3ml.
- Along with vaccination, strict hygiene and good nursing care should be practiced for the prevention of this disease. Insecticidal sprays should be used twice a week for keeping the environment free from biting flies.

- If animal found infected, then should be quarantined and treatment should be provided immediately by a veterinarian.
- Quarantined animal should be restricted for grazing in fields as saliva act as a source of infection for the healthy ones.

3. HAEMORRHAGIC SEPTECEMIA

- This is an acute bacterial disease of cattle and buffaloes which usually occurs during monsoon.
- Mortality rate may be as high as 80 %.

Symptoms

- High temperature, sudden decrease in milk yield.
- Salivation and serous nasal discharge.
- Severe oedema of the throat region.
- Difficultly in breathing, animal produces a grunting sound.
- Animal usually dies within 1-2 days of showing symptoms.
- In endemic areas, most deaths seen in older calves and young adults.

Treatment Control and prevention

- Pasteurella is amenable to Penicillin-G, streptomycin, chloramphenicol, chlortetracycline, sulpha and tripmethoprim, enrofloxacin and oxytetracycline.
- Segregate the sick animal from healthy ones and avoid contamination of feed, fodder and water.
- Avoid crowding especially during wet seasons.
- Vaccinate all animals which are 6 months and above of age annually before the onset of monsoon in endemic areas.

4. ANTHRAX

B.anthracis causes Anthrax in animals. *Bacillus anthracis* spores remain viable for many years in soil, water and animal hides and products. The main routes of entry of endospores are by ingestion, from soil when grazing or in contaminated food and by infection of wounds.

Symptoms

- In peracute sepeticemia death occurs within 2 hours after animal collapsing with convulsions, sudden death in animals that appeared normal is common.

- In acute septicemia death occurs within 48 to 96 hours clinical signs include fever, anorexia, ruminal stasis, hematuria and blood tinged diarrhea.
- Pregnant animals may abort and milk production often abruptly decreases.
- Terminal signs include severe depression, respiratory distress and convulsions.

Prevention and Control

Prevention of anthrax in animals is aided by active immunization. The organism is susceptible to penicillin-G, tetracyclines, erythromycin and chloramphenicol.

5. BRUCELLOSIS

Brucella abortus cause abortion in last trimester of pegnancy

Symptoms

- The incubation period is usually from 30 to 60 days.
- After bacteraemia the infection localizes in the placentae, if the animal is not pregnant, the infection localizes in udder (interstitial mastitis).
- In the bull, orchitis and epididymitis.
- Abortion at 6 months and retained placentae are the cardinal signs.

Prevention and control

- The attenuated live vaccine is used in female calves 4 to 12 months of age.
- The adjuvant bacterins is used as booster vaccine.

6. MASTITIS

Mastitis is an inflammation of the mammary gland. In which the milk undergo physical, chemical and microbiological changes whereas mammary glandular tissue undergo physical and pathological changes. In which infected milk colour, consistency change and contains more amount of leucocytes.

Clinical signs

- Acute form: Swollen udder, changes in quality of milk. Milk become curd like, yellow, brown fluid with flakes and clots.
- Subacute form: No changes in the udder tissue.
- Chronic form: Udder is haemorrhagic, and fibrotic. Udder is thick, firm, nodular and atrophic, yellowish or white fluid with clots and flakes.

Treatment

- Stripping out the milk from the infected quarters.
- Cleaning of infected quarters with normal saline and distilled water. Infusion of antibiotic therapies immediately after the infection.
- Continuous use antibiotics as per the antibiogram.

Control:

- Hygenic measures are important.
- Animals diagnosed positive should be milked at last.
- Milkers should wash their hands before milking
- A separate clean cloth for each cow is used for washing the udder with a disinfectant.
- The first stream of milk from each quarter should not be allowed to drop on floor but collected in a separate container.
- The first stream of milk from each quarter should not be allowed to drop on floor but collected in a separate container. Milkers should not wet their hands with first stream of milk.
- A separate clean cloth for each cow is used for washing the udder with a disinfectant

7. MILK FEVER

Milk fever is a metabolic disease in cows soon after calving. Due to fall in serum calcium level in cows after calving as a result of failure to mobilize calcium reserves and of the development of negative calcium balance in late pregnancy.

Symptoms

- Disease flares up within 72 hours of calving
- Iinitially the cows show excitement, incoordination of movement muscular tremors in limbs and head, lying in recumbent position with her head directed towards flank.
- In final stages subnormal temperature, dilatation of the pupil, impalpable pulse, coma and death.

Treatment & Control

Recovery by intravenous administration of 300-400 ml calcium borogluconate with Vitamin D3 injected intramuscularly. Continued mixing of ½ liter of supernatant lime water for cow may reduce the incidence.

VACCINATION SCHEDULE IN DAIRY ANIMALS

Disease	Age	Interval	Month
FMD	3rd month	Every six month	Jan-Feb, June-July
BQ	6th Month	Every year	Aug-Sep
HS	6th Month	Every Year	Sep-Oct
Anthrax	6th Month	Every Year (Affected area only)	April - May
Brucellosis	4-8th month of Heifer	--	Mar - April

Chapter-8

PRODUCTION TECHNOLOGY OF MILLETS

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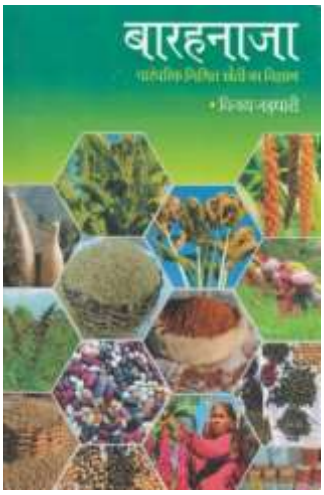
Millets are a group of cereal food grain crops constituting variety of small grains that are often termed nutri-cereals and super foods etc. Millets are comprisingof sorghum, pearl millet, finger millet (Major millets) foxtail millet, little millet, kodomillet, proso millet and barnyard millet (minor millets). Traditionally, India has a history of high millet consumption and cultivation. They are resilient to climate change having low carbon and water footprint requirements, can withstand high temperature and grow on poor soils with little or no external input, which makes them ideal for a populated country like India. They are usually grown with limited water resources and without any fertilizers or other inputs. They are regarded as harder crops and can sustain and flourish even the most adverse climatic conditions.However, millets did not get its importance at the time of green revolution in India. In the era of climate change, revisiting the forgotten millets has become inevitable apart from its gaining importance due to its health benefits partially because of the increased awareness in health.



The Himalayan region of Uttarakhand had been a major niche region for millet crops as acomponent of the ethnic culture and livelihood. Hillyarea is characterized by gravel and light textured soil which do not retain water for long time, hence favours millets cultivation. The traditional millets ofkharif season includes, finger millet barnyard millet,foxtail millet etc. Here, kharif season mixed cropping (usually called as **Barahnaja)** as complete mixtures of millets, legumes, amaranth, buckwheat, sesame, etc. is a common practice in many areas of Uttarakhand hills. Minor millets such as finger millet, barnyard millet, foxtail millet, proso millet and pulses have a great potential to withstand stress condition as compared to other crops. This is the

reason that these crops are being grown since ancient time in hills of Uttarakhand. Millets are known for their resilience, which is helpful in adjusting to diverse ecological situations.

Table 1: Common and botanical name of major and minor millets with picture

Common Name	Botanical name	Picture
MAJOR MILLET		
Sorghum (Jowar)	*Sorghum bicolor*	
Pearl millet (Bajra)	*Pennisetum glaucum*	
Finger millet (Ragi/Mandua)	*Eleusine coracana*	
MINOR MILLET		
Foxtail millet (Kangani/Kakun/Kauni)	*Setaria italica*	
Proso millet (Cheena)	*Panicum miliaceum*	

		
Kodo millet (Kodo)	*Paspalum scrobiculatum*	
Barnyard millet (Sanwa/Jhangora/Madira)	*Echinochlo aesculenta*	

Little millet (Kutki)	*Panicum sumatrense*	
PSEUDO MILLET		
Buckwheat (Kuttu/ Oogal)	*Fagopyrum esculentum*	
Amaranth (Chuva/ Chaulai)	*Amaranthus viridis*	

Millets are incredibly water-efficient crops. Sorghum, Pearl millet, and Finger millet require less rainfall than sugarcane and bananas, and 30% less rainfall than rice. One kg of rice requires 4,000 litres of water to thrive, whereas all millets require no irrigation. Particularly in the decades to come during the climate crisis, this couldwind up being a huge national benefit. Millets could emerge as the food of security in a future where a water and food tragedy confronts us.

Amongst different millets, adoption pattern varied depending upon the climate, soil conditions, uses and integration in cultural and rituals. Major millets viz. sorghum and pearl millets cultivated in wider area covering many states of the country, although small millets are grown on selected niches of country but they have uniquecapability of adaptation. Small millets grown in the country from sea level south to to 8000 ft altitude north particularly in Himalayas and North Eastern region. Sorghum is cultivated on largest area followed by pearl millet and thendifferent small millets. All the millets necessarily grown under water scarcity prone areas their cultivation areas, uses and importance are follows:

Sorghum (*Sorghum bicolor*), or great millet is the world's fifth major cereal in terms of production and acreage. Sorghum is among the most efficient crops of the worldin use of solar energy and water to produce food and biomass, is a drought tolerant crop that is environmentally friendly. In the semi-arid regions sorghum is a dual- purpose crop, as both grain and stover are highly valued for human and animal consumption, respectively. It is grown extensively in north-western, western and central India and southern peninsula, with maximum acreage in Maharashtra and Karnataka.

Finger millet (*Eleusine coracana*) is an important crop under cultivation serving as the primary food for rural populations of Southern India, parts of eastern India and Uttarakhand. Finger millet or ragi has a relatively wide range of adaptation within moderate temperatures and moisture ranges. It is most widely cultivated on hills andplains, lateritic soils in the 50-100 cm rainfall belt of the tropics and sub-tropical regions. It has high-yielding potential producing highest mean yield among the millets in India, and is frequently grown both dry and irrigated on lands where moisture is insufficient for rice. More than 60% of finger millet is produced by the state of Karnataka followed by Uttarakhand in India, which is about 34% of global production.

Foxtail millet (*Setaria italica*), grown in semi-arid regions, has a low water requirement and successful almost entirely to its short growing season. It matures in 65-70 days. Foxtail millet can be planted when it is too late to plant most other crops. It is drought - resistant, grows at higher elevations (up to 8000 feet) and is frequently sown as an alternate crop with sorghum on black cotton soils when rainfall is deficient. It also grows well on loamy or alluvial and clayey soils.

Proso millet or common millet (*Panicum miliaceum*), is a relatively short-duration emergency or quick-season irrigated crop with low moisture requirements. Proso millet is well suited for

many soil types and climate conditions. Compared to all millets proso is a short season crop, reaching maturity 60 to 75 days after planting. It is most frequently grown as a late seeded summer crop. This millet was grown in Russia, China, the Balkan countries and Northern India in historical times, being laterreplaced in most areas by rice and other cereals.

Kodo millet (*Paspalum scrobiculatum*) is extensively grown on the poorest of soils and reputed to be extremely hardy, drought resistant and grows on stony or gravelly soils which would not support other crops. It is relatively long in duration requiring five or six months to mature compared with two to four months for the other miIlets.

Little millet (*Panicum miliare*) is similar to proso millet, and is grown on a limited scale with minimum care on poor lands. Little millet matures quickly and withstandsboth drought and water logging. Both kodo and little millet are grown in parts of Madhya Pradesh, Chhattisgarh and Tamil Nadu. Little millet is also grown in many other states, but on a limited scale. . In many tribal areas, little millet is considered as a cash crop as it fetches much higher prices than rice.

Barnyard millet (*Echinochloa frumentacea*) is predominantly cultivated in India, China, Japan, and Korea for food as well as fodder. Japanese and Indian species of his millet are vigorous and have a wide adaptation in terms of soil and moisture requirements. In India maximum area under this crop is in Uttarakhand where this crop is grown upto altitude of 1600 feet. Besides the crop is alsogrown in Tamilnadu, Jharkhand, Chhattisgarh and some parts of Bihar and Uttar Pradesh.

Millet crops area, production and yield during 2009-13, 2014-19 & 2019-20

	Area (000 ha)			**Production (000 ton)**			**Yield (kg/ha)**		
	2009-2013	**2014-2019**	**2019-20**	**2009-2013**	**2014-2019**	**2019-20**	**2009-2014**	**2015-2019**	**2019-20**
Sorghum	6684	4910	4480	6101	4404	4380	913	897	1051
Pearl millet	8480	7142	6770	9029	8738	8900	1065	1223	1265
Finger millet	1211	1104	970	1914	1710	1680	1580	1549	1662
Small millets	773	570	460	428	403	340	554	707	804
Total millets	**17149**	**13726**	**12680**	**17472**	**15255**	**15300**	**1019**	**1111**	**1236**

(Based on estimations of Dept. of Economics & Statistics, DAC&FW, GoI, New Delhi)

Table. 1. Production scenario of small millet crops in N-W Himalayan states and AllIndia

States	Crop	Area ('000 ha)	Production ('000 t)	Yield (Kg/ha)
Uttarakhand	Finger millet (Ragi)	89	129.85	1459
	Other small millets	49	71.00	1449
Himachal Pradesh	Finger millet (Ragi)	0.58	0.490	842
	Other small millets	2.41	2.34	972
Jammu and Kashmir	Finger millet (Ragi)	0	00	00
	Other small millets	8.11	2.14	264
North-Western Himalayas	Finger millet (Ragi)	**89.58**	**130.34**	**1455.05**
	Other small millets	**59.52**	**75.48**	**1268.25**
All India	Finger millet (Ragi)	**1159.40**	**1998.36**	**1724.00**
	Other small millets	**444.05**	**346.95**	**781.00**

(Source: Directorate of Economics and Statistics, Ministry of Agri. and Farmers Welfare, GOI, 2020-21)

In the light if wide publicity of millets, production technology, value added products etc., Government of India announces the center of excellence for millets as below

Sl No	Name of Institute/organization	Responsible for
1	Indian Institute of Millets Research, Hyderabad	Global Centre of Excellence
2	CCS-Haryana. Agriculture University, Hissar	Promotion of Pearl Millet/ Bajra
3	Indian Institute of Millets Research, Hyderabad	Promotion of Sorghum/Jowar.
4	University of Agricultural Sciences, Banguluru	Promotion of Small Millets

Nutritional Importance of Millets

Gluten-free: Patients with celiac disease and gluten intolerance can opt for a pearl millet-based diet as it is gluten-free. Wheat, the widely consumed cereal in world along with rice and corn, contains a protein gluten that causes gastrointestinal problems like bloating, flatulence and irritable bowel syndrome.

Enriched with Vital Nutrients: It contains most of the Vitamin-B and rich in other minerals such as iron, magnesium, calcium, phosphorus, manganese, potassium, copper, zinc, and chromium. It also contain higher potassium, calcium, and iron content amongst other cereal crops. It has the highest folic acid amongst the cereals,which makes it the diet of choice for pregnant women.

Plant-Based Protein Source: It contains approximately 14% protein, thereby becomes the best source of protein among common millet varieties. However, it is does not contain adequate amounts of the amino acid lysine. Hence, consuming pearl millet flour combined with lysine-rich foods such as beans, moong dal, chana dal, etc. make meal into a complete source of protein.

Rich in Antioxidants: It is a rich source of antioxidants, their consumption offers protection against free radical mediated diseases such as cancer, arthritis, cardiovascular disease, diabetes and Alzheimer's disease.

Controls Iron Deficiency: A healthy choice of food for pregnant women and nursingmothers

due to iron and folic acid contents. The new pearl millet varieties provide higher level of dietary iron to women. Besides iron, it also contains significant amount of zinc, essential for normal growth and development of strong immunity. Iron deficiency anaemia is very common in children as they often consume rice andwheat, which is a very poor source of iron.

Reducing Blood Sugar Levels: Pearl millet, very effective in maintaining the normal blood sugar levels, contains high fibre and carbohydrate content that are digested slowly and maintain a stable glucose level for a long period. This makes them a healthy food option for diabetics.

Reduces Cholesterol: Rich in dietary fibres and cholesterol-lowering properties of these grains are good for heart patients. Phytic acid in pearl millet increases the cholesterol metabolism, thereby stabilizing the cholesterol level in the body. It also contains the vitamin niacin, which reduces the cholesterol.

Omega-3 Fats: It is a better source of healthy omega-3 fats compared to other cereals. Omega-3 oils have been associated with lowering blood pressure, triglycerides, slowing the development of plaque in the arteries, maintaining a regular heart rate, and are known to be cardio protective. Bajra is also rich in potassium that is needed for those with high blood pressure. Consuming more foodsrich in potassium helps in flushing out sodium from the body, which in turn will reduce blood pressure.

Relieves Constipation: The rich fibre content of pearl millet eases the process of digestion and provides a relief from constipation. Small amount of pearl millet may be fed regularly to children suffering from chronic constipation.

Other Benefits: Pearl millet is good for lactating mothers. Lactating mothers must include pearl millet in their diet to increase milk production. Additionally, pearl milletcontains three times the amount of calcium that is present in milk. Thus, theconsumption of pearl millet is beneficial for both mother and the babies. Foxtail millet exhibits anti-hyper glycaemic and anti-lipidemic activities.

High yielding varieties of millets

One of the most important reason of declining of the area and production of millet cultivation in the country was non-availability of improved varieties/ hybrids in these group of crop. However, due to continuous efforts and systematic breeding progammes and partnership of public and private organizations resulted in the development of varieties and hybrids in major millets viz. sorghum and pearl millet but such efforts are limited to public sector in case of small millets. The important varieties/ hybrids available for the cultivation in all millets given below.

Pearl millet (bajra)

S. No.	Cultivation season/ uses	Hybrids	Varieties
1	Kharif (grain type)	AHB 1200, HHB 299, 86M01, Kaveri Super Boss,Bio 448, 86M86, GHB 558, PB 106, Pusa 444, MBH 160, Pusa 322 (MH 322), ICMH 356, HHB 67, MLBH 104, Pusa 23	Dhanshankti, Pusa Composite 383, Raj 171, Raj Bajra Chari-2, ICTP 8203, ICMV 221
2	Summer (grain type)	Nandi-75 (NMH 82), 86M13, Nandi-72 (NMH 75), Nandi-70, 86M64, Nandi 64, PB 727 (Pro Agro 9555), PB 180 (Pro Agro 9444), GHB 526, PB 172, GHB 183, Pro Agro 1 (FMH 3)	Raj 171
3	Forage type	FMH 3, GHB 15, GHB 235, ProAgro 1, FBC 16	Giant Bajra, PCB 15, PCB 141, Raj Bajra Chari 2, AFB 2, CO 8

(Source : Sathyavati *et al*; 2018)

Sorghum (Jowar)

S.No.	Cultivation season/ uses	Hybrids	Varieties
1	Kharif sorghum	CSH 30, CSH 33, CSH 33, CSH 34, CSH 34, CSH 35, CSH 37 CSH 38, CSH 41, CSH 42	CSV 11, CO 26, CSV, 13, CSV 15, CSV 17, CSV 20, CSV 23, CSV 27, CSV 28, CSV 31, CSV 34, CSV 36, CSV 43
2	Rabi Sorghum	CSH 7R, CSH 8R, CSH 12R, CSH 13R, CSH 15R, CSH 19R, CSH 31R CSH 39R	CSV 26, R, CSV 29R
3	Sweet Sorghum	CSH 22SS	CSV 19SS, CSV 24SS
4	Forage Type	PCH 106, CSH 20MF, CSH 24MF, CSH 13, CSH 36F, CSH 40F, CSH 43F	Pusa Chari 23, CSV 21 F, csv30 F, SSG 59-3, CSV 33-MF, CSV 35F, CSV 38F, CSV 40 F, CSV 44F,
	Dual-purpose	CSH 13, CSH 18	CSV 15, CSV 18, CSV 23, CSV 27

(Source : Aruna *et al;* 2020)

Small Millets

Sl. No.	Name of variety	Year of release	Maturity (days)	Avg.Yield (q/ha)	Area of adaptation

Finger Millet					
1	GPU 48	2005	95-100	28-30	Karnataka
2	PRM 1	2006	110-115	20-25	Hills of Uttarakhand
3	Bharathi	2006	110-115	26-30	Andhra Pradesh
4	GPU 66	2009	112-115	35-40	Karnataka
5	GPU 67	2009	114-118	30-35	National
6	VR 847	2009	110-115	26-28	Andhra Pradesh
7	KMR 301	2009	120-125	35-40	Southern Karnataka
8	KOPN 235	2011	115-120	25-26	Sub mountain and ghat zone of Maharashtra
9	OEB 526	2011	110-115	25-26	Odisha, Bihar, Chhattisgarh, Karnataka, Tamilnadu
10	OEB 532	2012	110-115	22-25	Odisha, Bihar, Chhattisgarh, Karnataka, Tamilnadu
11	KMR 204	2012	95-100	30-35	Karnataka
12	VR 936	2012	115-120	28-30	Andhra Pradesh
13	PPR 2700 (Vakula)	2012	105-110	25-30	Andhra Pradesh
14	Indira Ragi 1	2012	120-125	25-26	Chattisgarh
15	VL 352	2012	95-100	33-35	All Ragi growing areas of country
16	Chattisgarh Ragi -2	2012	115-118	32-35	Chhattisgarh
17	VL 376	2016	103-109	29-31	All Ragi growing areas of country
18	GNN-6	2016	120-130	28-30	Gujarat
19	GN-5	2016	120-130	25-27	Gujarat
20	VL Mandua -348	2016	104-112	18-20	Uttarakhand
21	KMR 340	2016	90-95	35-40	Karnataka
22	Dapoli-2 (SCN-6)	2017	118-120	25-27	Konkan region of Maharashtra.
23	CO 15	2017	115-120	29.0	Tamilnadu
24	GNN-7	2017	123-128	25.0 q/ha.	Gujarat
25	VL-379	2017	105-107	30-32	Uttarakhand, Bihar, Jharkhand, Madhya Pradesh and NEH region
26	Chhattisgarh Ragi-2 (BR-36)	2018	115-118	34-36	Chhattisgarh

27	DHFM-78-3	2018	114-116		Recommended for cultivation in
Foxtail Millet					
1	Co 7 (TNAU 196)	2005	85-90	18-19	Tamil Nadu
2	HMT 100-1	2008	90-95	20-25	Karnataka
3	SiA 3085	2011	80-85	20-30	All foxtail millet growingareas ofthe country
4	Suryanandi (SiA 3088)	2012	70-75	20-25	All foxtail millet growing areas ofthe country
5	SiA 3156	2012	85-90	20-25	Andhra Pradesh, Bihar, Gujarat, Karnataka, Madhya Pradesh, Tamilnadu and Uttarakhand
6	Rajendra Kauni 1-2	2017	80-83	23-25	Irrigated and Rainfed upland of Bihar
7	DHFt-109-3	2018	86-88	28-30	Karnataka state
Kodo Millet					
1	JK 13	2007	95-100	22-23	National
2	JK 106	2009	100-105	19-20	M.P. State
3	JK 65	2009	105-110	23-25	National
4	JK 98	2010	100-105	25-30	National
5	DPS 9-1	2011	105-110	27-30	National
6	Indira Kodo 1	2012	100-105	22-25	Chhattisgarh
7	Chhattisgarh kodo 2	2014	95-100	25-26	Chhattisgarh
8	TNAU-86	2012	95-110	27-30	National
9	RK 390-25	2012	100-105	25-28	National
10	Jawahar Kodo 137	2016	100-105	26-29	Madhya Pradesh
Barnyard Millet					
1	CO(KV) 2	2008	95-100	21-22	Tamil Nadu
2	PRJ 1	2009	115-120	20-22	Uttarakhand hills
3	DHBM 93-3	2016	90-95	22-24	National
4	DHB-93-2	2018	86-88	27.6	Karnataka state
5	MDU-1	2018	95-100	15-17 q/ha	Tamil Nadu
6	VL 207	2008	90-95	20 – 22	Uttarakhand
Little Millet					
1	OLM 208	2009	100-105	12-15	National
2	OLM 217	2009	105-110	15-16	National

3	Co 4	2005	75-80	16-20	Tamilnadu
4	JK 36	2009	75-80	10-12	M.P. state
5	BL 6	2016	90-95	12-14	National
6	DHLM 36-3	2018	95-100	14-16	Karnataka
7	Chhattisgarh Kutki-2	2016	90-95	10-12	Chhattisgarh
8	GV-2	2016	115-125	26-28	Gujarat
9	Phule Ekadashi	2016	120-130	12-14	Maharashtra
10	Jawahar Kutki 4 (JK 4)	2016	75-80	13-15	Madhya Pradesh
11	DHLM-14-1	2017	97-99	16.0	Tamilnadu, Karnataka, Gujarat, Maharashtra and Orissa
12	GNV-3	2018	110-115	28-29	Gujarat
Proso Millet					
1	TNAU 145	2007	70-72	18-20	Tamil Nadu
2	CO(PV) 5 (TNAU 143)	2007	70-75	23-25	National
3	TNAU 151	2008	72-75	18-20	National
4	TNAU 164	2009	70-75	18-20	National
5	Pratap Cheena-1 (PR-18)	2006	65-70	15-17	National
6	PRC 1	2008	70-75	10-12	Uttarakhand hills
7	TNAU 202	2011	70-75	18-20	National
8	TNPm-230	2017	70-75	21-23	National
9	DHP-2769	2018	70-72	24-26	Karnataka state

(Source: IIMR, Hyderabad)

Millets- Seed Rate and Method of Sowing

S.N.	Crop	Line Sowing	Broadcasting	Spacing	Depth of Planting	Thinning
1.	Pearl Millet (Bajra)	3-4 Kg/ha	4.5-5 Kg/ha	45x10-15 cm	2.5-3 cm	Removal of excess plant at 20-25 DAS and maintain line spacing of 15 cm
2.	Sorghum (Jowar)	7-8 Kg/ha	9-10 Kg/ha	45x12-15 cm	3-4 cm	Removal of excess plant at 20-25 DAS and maintain line spacing of 15 cm
3.	Finger Millet	Direct seeding 8-10 Kg/ha	11-12 Kg/ha	22x10 cm	3-4 cm	Removal of excess plant at 20-25 DAS and maintain line spacing of 10 cm

		Transplanting 5 Kg/ha (20-25 days old plants are ideal)				
4.	Barnyard Millet	8-10 Kg/ha	12-15 Kg/ha	25-30 cm x 8-10 cm	3-4 cm	Removal of excess plant at 20-25 DAS and maintain line spacing of 10 cm
5.	Foxtail Millet	8-10 Kg/ha	15 Kg/ha	25-30 cm x 8-10 cm	2-3 cm	Removal of excess plant at 20-25 DAS and maintain line spacing of 10 cm
6.	Proso Millet	10 Kg/ha	15 Kg/ha	25x10 cm	3-4 cm	Removal of excess plant at 20-25 DAS and maintain line spacing of 10 cm
7.	Kodo Millet	8-10 Kg/ha	15 Kg/ha	22.5 cm x 10 cm	3-4 cm	Removal of excess plant at 20-25 DAS and maintain line spacing of 10 cm
8.	Little Millet	8-10 Kg/ha	12-15 Kg/ha	25-30 cm x 8-10 cm	2-3 cm	Removal of excess plant at 20-25 DAS and maintain line spacing of 10 cm
9.	Buck wheat	25-30 Kg/ha	32-35 Kg/ha	30x10 cm	4-5 cm	Removal of excess plant at 20-25 DAS and maintain line spacing of 10 cm
10.	Amaranth	1.5-2 Kg/ha	2-2.5 Kg/ha	50x15 cm	3-4 cm	Removal of excess plant at 20-25 DAS and maintain line spacing of 15 cm

Sowing time of Millets

S.N.	Crop	Sowing Time		
		Kharif	**Rabi**	**Summer**
1.	Pearl Millet	First fortnight of July with the onset of monsoon.	October (Tamil Nadu)	-
2.	Sorghum	Third week of June- First week of July with the onset of monsoon.	2nd fortnight of September-1st fortnight of October	-
3.	Finger Millet	Plain- June-July with the onset of monsoon. Lower Hills (upto 1000m)- First fortnight of June	September-October	-

		Mid Hills (1000-1500m)- Second fortnight of May High Hills (more than 1500m)- First fortnight of May		
4.	Barnyard Millet	Plain- June-July with the onset of monsoon. Lower Hills (upto 1000m)- Second fortnight of May-June first week Mid Hills (1000-1500m)- Mid April-Mid May High Hills (Above 1500m)- First fortnight of April	September-October	January-March
5.	Foxtail Millet	Plain- June-July with the onset of monsoon. Lower Hills- May End-First week of June Mid Hills- Mid April-First fortnight of May High Hills- First fortnight of April	August-September (Tamil Nadu)	-
6.	Proso Millet	First fortnight of July	August-September (Tamil Nadu & Andhra Pradesh)	Mid March-Mid May (Bihar & UP as irrigated catch crop)
7.	Kodo Millet	Mid June-Mid July	September-October	
8.	Little Millet	First fortnight of July with the onset of monsoon	August-September (Tamil Nadu & Andhra Pradesh)	Mid March-Mid May (Bihar & UP as irrigated catch crop)
9.	Buck wheat	Mid Hills- First fortnight of June High Hills- Second fortnight of May	-	-
10.	Amaranth	Mid Hills- First fortnight of June High Hills- Second fortnight of May	-	-

Nutrient management: Traditionally, these crops are grown as rain fed crop on negligible and least fertile soil with poor adoption of improved package of practices, resulting into poor yield. However, productivity may be enhanced many folds by the judicious fertilizer use along with adoption of improved practices. Standard fertilizer doses are given here under for various millets

Sorghum (Kharif)

For light soils and low rainfall areas: 30 kg Nitrogen per ha, 30 kg P_2O_5 per ha and 20 kg K_2O per ha at sowing. Apply 30 kg Nitrogen at 30-35 days after sowing (DAS). However, for medium-deep soils and moderate to high rainfall areas: 80 kg Nitrogen per ha, 40 kg P_2O_5 per ha and 40 kg K_2O per ha. Apply half Nitrogen + full P_2O_5 and full K_2O at sowing

and remaining Nitrogen at 30 DAS. Depending upon availability, application of well decomposed FYM @ 5-10Tone/ ha is beneficial for the crop.

Sorghum (Rabi)

For rainfed (shallow to medium soil), apply 40:20:00 Kg NPK/ ha as basal dressing. Similarly, for rainfed (deep soil) use 60:30:00 Kg NPK/ ha as basal dressing. In irrigated areas, the dose should be 80:40:40 Kg NPK/ ha (N in two equal splits 50 per cent as basal and 50 per cent at 30-35 days after sowing. Though, full P and K should be broadcasted at time of sowing). Depending upon availability, application of well decomposed FYM @ 5-10Tone/ ha is beneficial for the crop.

Pearl millet (Bajra)

Application of 40 kg N + 20 kg P_2O_5/ha for arid regions and 60 kg N/ha +30 kg P_2O_5/ha for semi-arid regions is recommended for sole pearl millet as well as intercropping system. In light soils (sandy loams) the applied nitrogen may be lost due to leaching with heavy rains. So, only about half of the recommended nitrogen dose should be applied at seedbed preparation. The remaining half of nitrogen dose is side-dressed when the crop is 25 days old. On soils which do not leach easily like black soils, all of the nitrogen may be applied during seedbed preparation. Pearl millet seeds are sensitive to fertilizer burn. Do not apply fertilizer in the furrow with the seed or very near the seed in the row after sowing. It should be applied as side dressing Use of biofertilizer (*Azospirillum* and PSB) can economize the N and P fertilizer application. In zinc deficient soils of the pearl millet growing area of the country, application of 10 kg $ZnSO_4$/ ha is recommended. To correct the zinc deficiency in standing crop, spray of 0.2% $ZnSO_4$ at tillering to pre-flowering stage is recommended. Under prolonged dry spell, skip top dressing of N and spray 2% urea. Under excessive rain situation during vegetative phase, additional dose of nitrogen @ 20 kg/ha should be given.

Finger millet (Ragi/mandua)

Application of addition quantities of organic matter in soil for finger millet is considered beneficial, since it helps to improve physical condition of soil which helps soil to retain moisture for a longer period of time. Manures are applied @5-10 t/ha about a month before sowing. The crop responds well to fertilizer application. The general recommendation for finger millet is 60 kg nitrogen, 30 kg P_2O_5 and 30 kg K_2O per hectare under irrigation and 40 kg nitrogen, 20 kg P_2O_5 and 20 kg K_2O per hectare under rainfed

conditions.

Entire P_2O_5 and K_2O are to be applied at sowing, whereas nitrogen is to beapplied in two or three split doses depending upon moisture availability. Treating seeds with bio fertiluzer *Azospirillum brasilense* (N fixing bacterium) and *Aspergillus awamori* (P. Solubilizing fungus) @ 25 g/kg seed is beneficial. In case seeds are to be treated with seed dressing chemicals, treat the seeds first withseed dressing chemicals and then with bio-fertilizers at the time of sowing

Barnyard millet (Jhangora/ Madira)

Manures- 5-10 t/ha FYM could be applied about a month before sowing. Fertilizers- 40 kg nitrogen, 20 kg P_2O_5 and 20 kg K_2O per hectare.

Foxtail millet (Kauni/kangani)

The crop is usually manured with 5 to 10 t/ha farm yard mannure abouta month before sowing. Generally fertilizer recommendations to get a good cropare 40 kg nitrogen, 20 kg P_2O_5 and 20 kg K_2O per hectare. All the fertilizers should be applied as a basal dose at a time of sowing. Fertilizer required for different states is as follows. Soil test - based fertilizers applications is recommended. Apply entire quantity of phosphorus and half of nitrogen at sowing andremaining half of nitrogen at 30 days after sowing.

Little millet (Kutki)

Well decomposed FYM @5-10 t/ha should be applied about a month before sowing. In addition, application of 40 kg nitrogen, 20 kg P_2O_5 and 20kg K_2O per hectare should be applied.

Proso millet (Cheena)

Proso millet being a short duration crop, requires relatively less amount of nutrients compared to other cereals. To get a good crop, general fertilizer recommendations under irrigated condition are 40-60 kg nitrogen, 30 kg P_2O_5 and 20 kg K_2O per hectare. Apply half of the nitrogen and whole amount of phosphorus and potash as a basal dose at the time of sowing. The remaining half of nitrogen should be applied at the time of the first irrigation.

Under rainfed condition, fertilizer dose is reduced to half of the irrigated crop. If organic manure is available, it may be added to the soil about a month before sowing at the rate of 4 to 10 tonnes per hectare.

Kodo millet (Kodo)

Addition of organic manures is always beneficial since it helps to improve the water retention capacity of soil in addition to providing essential nutrients to the crop plants. The crop should be manure with 5-10 t/ha FYM about a month before sowing. Apply 40 kg nitrogen, 20 kg P_2O_5 and 20 kg K_2O per hectare. All the fertilizers may be applied at the time of sowing in furrows. However, in high rainfall areas of Madhya Pradesh and Chattisgarh, nitrogen should be applied in 2 splits: half at sowing and remaining half at 35-40 days after sowing.

Weed Management

The weed inhibits the crop yield by suppressing the growth of crop and if they are not controlled timely and effectively, they cause yield reduction from 10-60 per cent. The severity of damage depends upon crop nature, moisture availability, aeration, temperature etc. The major Grassy weeds in the millets are: *Echinochloa colonum*, *Enhinochloa crusgulli* (sawan), *Dactyloctenium aegypticum* (makra), *Elusine indica* (kodo), *Setaria glauca* (banra), *Cynodon dactylon* (doob), *Phragmites karka* (narkul), *Cyperus rotundus* (motha), *Sorghum halepanse* (banchari) while Broad-leaved weeds are *Celosia argentia* (chilimil), *Commelina benghalensis* (kankoua), *Phylanthus niruri* (hulhul), *Solanum nigrum* (makoi) and *Amaranthus viridis* (chaulai). These weeds should be controlled timely. The control measures for each millet is mentioned below.

Sorghum (Kharif)

For effective weed control, keep the crop free from weeds for about 35 days at initial growth stage. One hand weeding at 20 DAS and inter cultivation 2 times at 21 and 40 DAS has been found enough to minimize weed population. For chemical control, Spray of atrazine @ 0.5 kg a.i./ha should be done immediately after sowing. Striga can be controlled by hand pulling when population is less, otherwise spray sodium salt, 2,4-D@ 1.0 kg a.i./ha

Sorghum (Rabi)

Application of Atrazine @ 0.5 kg a.i/ha is recommended for spraying as pre-emergence application immediately after sowing.

Pearl millet (Bajra)

Two hoeings and weedings at 15 and 30 DAS are sufficient for controlling weeds effectively which is comparable with the herbicidal weed control through pre-emergence application of Atrazine @ 0.5 kg/ha superimposed with one hand weeding. Second weeding helps to conserve soil moisture.

Finger millet (Ragi/mandua)

Two manual weeding at 15-20 and 30-35 DAS . For Chemical control, herbicide Isoproturon @ 0.75kg/h should be applied immediately after sowing. If some weeds remain in the field they may be uprooted manually.

Barnyard millet (Jhangora/ Madira)

Two hand weeding at 20 and 35-40 DAS in broadcasted crop. For chemical weed control, post-emergence application of 2, 4-D sodium salt (80 per cent) @ 1.0 kg a.i./ha at 20-25 DAS or Isoproturon @ 1.0 kg a.i. /ha as pre-emergence also give good result.

Foxtail millet (Kauni/kangani)

Two hand weeding at 20 and 35-40 DAS in broadcasted crop. For chemical weed control, post-emergence application of 2, 4-D sodium salt (80 per cent) @ 1.0 kg a.i./ha at 20-25 DAS. Isoproturon @ 1.0 kg a.i. /ha as pre-emergence spray is also effective in weed control.

Little millet (Kutki)

Two inter- cultivation and one hand weeding in line sown crop and two hand weeding in broadcast crop at 20 and 35 DAS are necessary for effective weed control. For chemical weed control, post-emergence application of 2, 4-D sodium salt (80 per cent) @ 1.0 kg a.i./ha at 20-25 DAS. Isoproturon @ 1.0 kg a.i. /ha as pre-emergence spray is also effective in weed control.

Proso millet (Cheena)

For getting high yield and minimizing loss of soil moisture and nutrients, the field should be kept weed-free up to 35 DAS. Two inter- cultivation and one hand weeding in line sown crop and two hand weeding in broadcast crop at 20 and 35 DAS are effective for weed control. For chemical weed control, post-emergence application of 2, 4-D sodium salt (80 per cent) @ 1.0 kg a.i./ha at 20-25 DAS. Isoproturon @ 1.0 kg a.i. /ha as pre-emergence spray is also effective in weed control.

Kodo millet (Kodo)

It is essential to control weeds at the initial stages of plant growth. Generally, two weeding at an interval of 15 days are sufficient. Weeding may be done with hand hoe or wheel hoe in line sown crop. In assured rain fall areas application of Isoproturon @ 0.5 kg a.i./ha pre-emergence has been found effective to control weeds. Similarly, application of post-

emergence herbicide 2, 4-D sodium salt (80%) @ 1.0 kga.i./ha at 20-25 DAS is equally effective.