

Problems of Storage of Milk and Milk Products*

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■ The demand for milk and milk products in urban centres has increased enormously with rapid concentration of population consequent to growing employment in industrial townships. As the towns and cities become larger, the milk supplies become inadequate to meet the demand, and more milk has to be drawn from distantly located villages. Unlike many agricultural commodities, milk is produced in small consignments. It is a highly perishable and bulky product and for this reason alone, it is necessary to make elaborate arrangements for its transportation in such a manner that when it reaches the dairy plant it is still clean, wholesome, nutritious, good to taste and fit for further processing. The quality of raw milk influences the final quality of the resultant products and their storageability.

Problems in the storage of milk

Quality of Raw Milk: The initial quality of raw milk in India is generally unsatisfactory because of the lack of awareness of hygienic principles of clean milk production and economic backwardness of the milk producers. The high ambient temperature of the subtropics, absence of cooling facilities for milk immediately after milking, inefficient transportation systems and admixing of milk with numerous adulterants either singly or in combination lead to fast

deterioration of milk quality. Village milk supplies carry very heavy bacterial load and resulting poor keeping quality. The milk plants in India usually receive about 2 to 5% of their total milk as of substandard quality with total lactic acidity ranging from 0.25% to 0.62%. In a study of the quality of milk at collection centres conducted under the All India Coordinated Research Project (ICAR), it was observed that the temperature of milk at the collection point ranged between 70 to 90°F. As many as 8.2% to 65% of the field samples of milk were found to clot on boiling (C.O.B. test). Seasonal effects greatly influenced the extent of souring and positive C.O.B. test. Reception of milk in early hours of the day was desirable since the sourage went on increasing with the rise of temperature during the day. Most of the milk samples showed a viable plate count of higher than 5 million per ml. indicating the need for improvements at all stages of handling. It is not known how much quantity of milk gets spoiled in unorganized sector which commands a major share of the total milk produced in India. One can, however, imagine that the spoilage figures under subtropical conditions would certainly be alarming. In India, there is an acute shortage of milk and any loss of this costly but essential food should be considered unethical.

Off Flavours in Raw Milk: Milk is an ideal medium for growth of bacteria. Many types of organisms may contaminate the milk and adversely affect its shelf life as well as the quality and stability of milk products. Off flavours caused by metabolism of milk proteins and carbohydrates as a result of bacterial growth

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in raw milk are not effectively removed by pasteurization or vacuum heat treatment. Fruity flavours develop in milk as a result of the growth of psychrotrophic gram negative rods producing ester like off flavours. Pasteurization will effectively control these organisms. Their presence is generally attributed to post pasteurization contamination from spoiled equipment, condensates or plant water. Unclean, bitter and putrid flavours due to protein breakdown are developed subsequent to pasteurization by psychrotrophic organisms gaining entry into milk through contact or moisture drips from improperly sanitized surfaces. Table 1 shows the causes of various off flavours in milk.

Table 1. Off flavours in milk.

Causes	Description of off flavours
Microbial	Acid, bitter, fruity, malty, putrid, unclean.
Light induced	Sunlight, activated.
Lipolyzed	Rancid, butric, bitter, goaty,
Oxidized	papery, cardboard, metallic, oily, fishy.
Transmitted	Feed, weedy, cowy, barny,
Absorbed	dusty, astringent, flat, salty, lacking freshness.
Heated	Cooked, carmelized, scorched.

Light induced off flavours are caused due to sun rays, fluorescent and diffused day light. Homogenization increases the incidence of light induced flavours due to hydrolysis of milk fat. Lipolyzed flavours are developed by the activity of lipases producing fatty acids. It appears that light triggers the conversion of methionine into methionol in the presence of riboflavin causing development of sun flavour. Degradation of vitamin B₂ and oxidation of vitamins C and A will also lower the nutritive value of milk. Over agitation, foaming, cooling then

re-warming, and mixing raw milk with homogenized pasteurized milk would also accelerate this defect.

Though cooling has been recommended to arrest the growth of micro-organisms, the practices of bulk handling and prolonged storage have given rise to the problems of psychrotrophic bacteria (32-45°F). Water and dust may contaminate the surface of bulk tanks and other milk holding vessels. Organisms of this type can grow on stainless steel surfaces with as little as 0.1 mg. per cm.² of food soil well below the detectable limits with naked eyes. It is for this reason that equipment must be kept extremely clean, mineral and protein film must not be allowed to develop on S.S. surfaces and more importantly, cracks and pits must be eliminated from equipment.

Storage Quality of Pasteurized Milk: The shelf life of pasteurized fluid milk is affected by a number of factors from assembling of raw milk through distribution and storage to consumers mode of handling. Acceptable shelf life of processed milk having fresh flavour and aroma will depend upon the temperature of storage. Consumers have no concern about bacterial counts so long as the flavour of milk is fresh and as long as there is no public health hazard. Well processed milk in U.S.A. keeps for 21 days at suitable refrigerator temperatures, whereas in India pasteurized milk at 4.5°C must keep well for atleast 72 hours.

Usually bottle fillers account for 60 to 70% of the contamination problems in pasteurized milk. Almost all water used in processing plants is contaminated with spoilage organisms unless it is sanitized with approximately 50 ppm. chlorine or 12.5 ppm iodophor. Low level chlorination of water (0.5 to 1 ppm) is sufficient to reduce the potential of food borne disease outbreaks, but it is not sufficient to inactivate spoilage organisms.

Proper storage temperature is important in

extending the shelf life of pasteurized milk. For each five degree Fahrenheit increase in temperature the shelf life is reduced by one half.

Most psychrotrophs grow rapidly at temp. above 50°F; the optimum temperature being between 70-90°F.

Prediction of shelf life of milk is done by incubating it at elevated temperatures, and the growth of the bacteria is then detected by the reduction of a dye. In addition to being rapid these tests are relatively efficient for detecting post pasteurization contamination.

Market Quality of Pasteurized Milk: A number of studies confirm that the quality of fluid milk products sold in the market fluctuate to a great extent. The state of the product when subjected to sensoric and bacteriological quality at the time of consumption is influenced by such factors as the quality of raw material, processing conditions, storage temperature, transportation and distribution circumstances and conditions of handling by the consumers themselves. A report from Pennsylvania, U.S.A. shows that from 22 to 29% of milk collected from various shops was rated as poor. There is a need for studying market quality of milk supplied to the consumers in all the towns and cities of India, so that based on extensive work, standards for quality could be prescribed under Indian conditions.

Storage Quality of Sterilized Milk: The sterilized milk has excellent keeping quality and the average commercial product will remain fit for human consumption for atleast 70 days. Observations have been made that sterilized milk kept at temperature will above germination point of spores was found sound and drinkable even at the end of one year period. Kamal (1956) showed that the milk samples sterilized at 105°C for 30 min. remained good upto 72 months, while samples of milk sterilized at 120°C for 30 min. were good upto 12 months. Thakar (1977) observed that the temperature time combinations of 120°C for 10 min. and 115°C for 15, 20 and 25 min. failed to produce sterilized recombined milk with a keeping quality of 7 days at 55°C as required under the Indian Standards specifications for sterilized milk. The sterilization temperature of 115°C for 30 min. was found satisfactory. However, this product was more brown than normal sterilized milk. Apparently more exhaustive studies would be necessary to suggest modifications in the technology for the manufacture of sterilized milk from raw milk with heavy bacterial population.

Problems of storage of milk products

Milk products can be classified on the basis of the length of time to which they remain acceptable for consumption under specified temperature conditions (Table 2). This dura-

Table 2. Classification of dairy products based on shelf life.

Class of life	Duration of storage at room temperature	Examples
Very short	Upto 7 days	Khoa, Chhana, Cream and Cream-cakes, multigrain products, cottage cheese, dahi, Srikhand.
Short	More than 7 days but less than 14 days.	Dairy desserts, Khoa and chhana sweets.
Medium	Greater than 2 weeks but less than 6 months.	UHT milk, whole milk powder, cheese.
Long	Greater than 6 months.	Skim milk powder, ghee, sweetened condensed milk.

tion of storage can be prolonged by modifying processing parameters, low temperature storage, effective packaging and by incorporating permitted chemical additives.

The successful marketing of short life products is dependent upon storage conditions from production until consumption by the consumer. Products which would become unsaleable after 48 hr. at ambient temperatures can be kept for for 1, 2 or 3 weeks, if stored at less than 4°C. Low temperatures not only restrict the growth of spoilage organisms but also effectively retard the physical breakdown (such as serum separation) and enzymatic changes. The conditions for low temperature storage must be defined and standards fixed.

A good cold storage chain after processing of milk and milk products, should involve the following operations.

1. Cold store at the production factory.
2. Trunking operation via large refrigerated vehicle.
3. Cold store at local distribution depots.
4. Delivery to retail outlets via smaller refrigerated vehicles.
5. Product holding in cold cabinet until purchased by the customer.

It is strange that planners in India have not paid much attention to refrigerated distribution of perishable dairy products. Reference made for refrigerated transport of khoa with the Railway Board in the past was not welcomed. Most short life dairy products are distributed locally and quality is dependent on a rapid turnover of stocks. With the growth of national dairy marketing grids, it is all the more important to provide refrigerated transport for milk products. A beginning has already been made for transport of milk in insulated rail tankers in India, which is acclaimed as a satisfactory system for milk transport of milk from the place of plenty to place of scarcity.

Processed Cream: The word 'Cream' is syno-

nymous with excellence in quality. Its sale in India is negligible except for table purposes because of its short shelf life. In order to boost the sales of cream the following conditions must be complied with :

1. Legal requirements must be fully met.
2. Subjective quality (appearance, taste, colour and flavour) must be adequate.
3. Physical properties including viscosity, stability, whipping properties and freedom from serum separation, oiling, feathering and other defects must be according to specifications. These need to be defined in India, specially from buffalo milk. The legislation for cream is not adequate.

4. Bacterial content must be so low as to ensure a safe product and adequate shelf life.

Cream must be classified under appropriate designations such as untreated, pasteurized, UHT, sterilized, whipped, single or half cream depending upon the fat content. A mention is to be made about additions permitted such as sugar, stabilizer, nisin and nitrous oxide. Whipped cream sold to bakers may contain upto 13% sugar and a maximum of 0.3% stabilizer such as sodium alginate CMC, carrageenin and gelatin. Sterilized and UHT cream may contain calcium chloride, sodium or potassium salts of carbonic acid, and orthophosphoric acid upto a maximum of 0.2%.

Time is now ripe to lay down and publish advices on processing, storage and distribution under the 'code of hygienic practices' for all the dairy products, including the minimum heat treatment, precautions relating to cleaning and sterilizing and requirements for chilled storage.

Yoghurt: Yoghurt, usually having pH of 3.9 to 4.4, is bacteriologically safe, except that yeast and mould contamination limit its shelf life. Fruit yoghurts may get contaminated from preprocessed fruit. With this in mind dairy industry wants permission for sorbic acid preservative to be added in fruit yoghurt.

Sorbic acid at a level of 200 ppm more than doubles the life of yoghurt at 5°C. Potassium sorbate at 300 ppm was found to prevent yeast growth in Yoghurt stored at 10°C. At these levels, the sorbates do not inhibit the viability of the yoghurt cultures. In sweetened yoghurt, the total solids and sugar content can inhibit the growth at 22% and 8% levels respectively.

Table butter: Both salted and unsalted butter are subjected to rises in microbial counts if kept for long time at chilling temperature, and in a correspondingly shorter time at high temperatures. Butter held in cold storage and transported in unrefrigerated condition will exert considerable influence on the final viable count. It is, therefore, suggested that the count be made at the time of grading itself before transportation from factory to consuming centres. The quality specifications formulated by ISI for yeast and mould count per g. of butter are given in Table 3.

Table 3. ISI specifications for microbiological quality of butter

Yeast & Mould count/g.	Sanitary Index.
Below 20	Good
21 to 50	Fair
51 to 100	Poor
Over 100	Very poor

There is a general feeling that these standards of sanitation are difficult to achieve under Indian situation unless stringent sanitary controls are exercised at all stages of manufacture. The New Zealand grading system provides separately 50-100 yeasts and 10-40 mould/g. for satisfactory quality of butter. The butter improvement service of the Queensland Department of Agriculture suggests an arbitrary

standard for butter of sound microbiological quality if the yeast and mould count is less than 100 per g. The mould mycelia count in butter in U.S.A. is used as an index of the amount of mould in cream before pasteurizing, but is not an index of contamination of the butter itself with viable mould since much of the mycelia observed are rendered innocuous by the pasteurization of cream.

Sweetened condensed milk: SCM undergoes marked colour change during storage. As it is not subjected to high processing temperature, browning is not marked during manufacture. Formation of melanoidin is promoted by the invert sugar formed due to irregular manufacturing procedure. Low viscosity causes separation of fat in SCM. Fat agglomeration results from low quality milk, heavy bacterial load, high acidity and low viscosity of the product. An effective remedy will be to homogenize the cream used for standardizing the milk before condensing. The development of cooked flavour is attributed to the formation of sulphhydryl compounds which parallels the browning. Within 4 months storage at 30°C SCM acquires a caramel taste. Addition of 50 mg. of *L. ascorbic acid* per litre of concentrated milk improves the flavour. Rancid flavour in SCM is caused by lipases of native or bacterial origin, which can be controlled by proper pasteurization and viscosity adjustment.

Common microbial defects in SCM appearing during storage are (1) Mould buttons (2) Thickening and (3) Bloats. These may develop due to the growth of *Aspergillus repens/glaucus*. Mould growth in SCM can be prevented if the product is stored below 16°C, by vacuum sealing and maintaining strict sanitation during all operations. Addition of 0.05% sorbic acid prevents the growth of moulds upto six months at 30°C and that a concentration of 0.1% is effective for 8 months. Budding yeasts cause bloating by fermenting sugar into alcohol

and carbondioxide. Bacterial thickening is usually accompanied by high germ-count, disagreeable and cheesy flavour and increased acidity. Staphylococci and bacilli often cause this defect. The sucrose in water concentration be kept at 64.5%. Age thickening is also associated with the formation of protein agglomerates, increased casein micellar size. Addition of stabilizing agent prevents this defect. The rate of thickening is maximum at 37°C, less at 22-25°C and least at 5-7°C.

Sugar sediment at the bottom of the cans of SCM appears predominantly due to lactose crystals. This defect is the result of gravity difference between crystallized lactose and the remainder of the condensed milk, large crystal size and low viscosity of the SCM. This defect could be reduced if cans are turned at specific intervals during prolonged storage, provided the crystal size is not big and viscosity sub-normal.

Problems of Storage of Dried Milks: Drying of milk is one of the common methods of preservation. Although, the life of roller dried whole milk powder from cow's milk is reported to be about 10 months, the spray dried product cannot be stored for more than six months at 17°C and half of this time at 27°C. The keeping quality of dried milk is affected by the quality of raw milk, fat content of dried milk, factors influencing fat oxidation, air inclusion, moisture, protein, and lactose content, packaging materials and microbiological factors. The major changes are in respect of flavour, colour, free fat content, fat acidity, carbonyl values and physical properties such as solubility, dispersibility, bulk density etc.

The structural changes in spray dried skim milk powder take place with increase in moisture content and relative humidity. Lactose gets crystallized at moisture levels ranging from 7-9.5% (42-52% R.H.) at 25°C causing lumpiness and caking. A number of dairy

plants in India have observed such difficulties in the storage of SMP especially at temp. above 30°C. It is suggested that the moisture content of spray dried skim milk should be kept below 6% and relative humidity 40% in the storage room at 25°C. The ferricyanide value of proteins increases only slowly in samples with 2-3% moisture stored at 20-23°C, but the increase gets accelerated with increasing storage temperature and particularly increasing moisture content. In sample with normal moisture content stored at room temperature the carbonyl content was very low and did not change appreciably even during prolonged storage. During 6 months storage, the bulk density of dried milks increases from 0.519 to 619 g/cm.³ indicating increased proportion of large particles in the product. Powder solubility drops by about 7% after 5 months storage at room temperature and changes in the fat fraction take place as indicated by increases in Lea value, TBA test and carbonyl content. Changes in the free fat content depend on the absorption of moisture. Positive correlations were observed in moisture and free fat. TBA and benzidine values were strongly correlated with free fat contents and duration and temperature of storage. Exposure of dried whole milk to light leads to the development of tallowy flavour after one week, lysine content decreases during 6 months storage by 12, 23, 49% respectively at 4, 20 and 37°C at 75% R.H. and by 73% at 37°C at 95% R.H.

Browning, oxidation and staleness are common defects that develop during storage of dried mixes of milk-shake, srikhand and ice-cream. High moisture content and high storage temperature accelerate these reactions. All precautions i.e. low moisture content, high preheat treatment, prompt cooling of powder, gas packaging and low temperature storage are recommended for improving the storage quality of these products.