Fat Rich Dairy Products

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Definition Of Laziness:
It's a talent of taking rest before you get tired...
B'coz prevention is better than cure...
Be lazy think crazy...

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Lesson 1

Status of lipids in milk

1.1 INTRODUCTION:

The total milk production of India during the year 2010-11 is 116 million tones out of which 33 percent was converted into ghee. As per FAO statistics, about 3.08 million tones of butter and ghee is being marketed in India during the year 2007. The amount of table butter produced in organized sector is 0.055 million tons during the year-2005 both in cooperative and private dairies and the value is 7,700 million rupees, which will be increased to 0.1 million tons and 22,500 million rupees respectively during the year 2011.

1.2 STATUS OF MILK LIPIDS:

Milk contains approximately 3.4% fat. Of all edible fats, milk fat has the most complex fatty acid composition. Over 400 individual fatty acids have been identified in milk fat. However, approximately 15 to 20 fatty acids make up 90% of the milk fat. The major fatty acids in milk fat are straight chain fatty acids that are saturated and have 4 to 18 carbons (C4:0, 6:0, 8:0, 10:0, 12:0, 14:0, 16:0, 18:0), monounsaturated fatty acids (C16:1, 18:1), and polyunsaturated fatty acids (C18:2, 18:3). Some of the fatty acids are found in very small amounts but contribute to the unique and desirable flavor of milk fat. For example, the C14:0 and C16:0 ß-hydroxy fatty acids spontaneously form lactones upon heating which enhance the flavor of butter.

The fatty acid composition of milk fat is not constant throughout the cow's lactation cycle. The fatty acids that are 4 to 14 carbons in length are synthesized in the udder. Some of the C16 fatty acids are made by the animal and some come from the animal's diet. All of the C18 fatty acids come from the animal's diet. There are systematic changes in milk fat composition due to the stage of lactation and the energy needs of the animal. In early lactation, the animal's energy comes largely from body stores and there are limited fatty acids available for fat synthesis, so the fatty acids used for milk fat production are obtained from the diet and tend to be the long chain C16:0, 18:0, 16:1 and 18:2 fatty acids. In late lactation, more of the fatty acids in milk are formed in the mammary gland so that the concentration of the short chain fatty acids such as C4:0 and 6:0 are higher than in early lactation. These changes in fatty acid composition do not have a great impact on nutritional properties of milk, but may have some effect on processing characteristics for products such as butter.

The fatty acids are arranged on the triglyceride molecule in a specific manner. Most of the short chain fatty acids are at the bottom carbon position of the triglyceride molecule, and the longer fatty acids tend to be in the middle and top positions. The distribution of the fatty acids on the triglyceride backbone affects the flavor, physical, and nutritional properties of milk fat.

Milk fat melts over a wide temperature range, from approximately - 40°C to 40°C. This is best illustrated by the firmness of butter at refrigerator temperature versus room temperature. At refrigerator temperature butter is approximately 50% solid, but is only about 20% solid at room temperature, which is why it spreads more easily as the temperature increases. The melting properties of milk fat are a result of the melting points of the individual fatty acids that make up milk fat and their arrangement on the triglyceride molecule.

The triglycerides of milk fat are in the form of globules. The globules are surrounded by a protein and phospholipid membrane that stabilizes the globules in the serum (water) phase of milk. The native globules range in size from less than 1 μm to over 10 μm. The uneven size distribution allows the larger globules to float in a process called creaming, thus resulting in a "cream line" at the top of the container. Milk is homogenized to reduce the size of the large globules to less than 1 μm, create a uniform distribution of globules throughout the serum phase, and minimize creaming.

Milk fat can be degraded by enzyme action, exposure to light, and oxidation. Each of these processes proceeds through different mechanisms. Enzymes that degrade fat are called lipases, and the process is called lipolysis. Lipases split fatty acids from the glycerol backbone of the triglyceride. Usually the action of lipase causes undesirable rancid flavors in milk. Pasteurization inactivates native lipase and increases the shelf life of milk. However, in some cheeses, such as Blue cheese and Provolone, a small amount of lipolysis is needed to achieve the characteristic flavor. Light induced degradation can happen fairly rapidly in milk and produces a characteristic off-flavor. The majority of this off-flavor is caused by protein degradation. Storing milk in opaque containers minimizes this process. Milk fat can also be degraded by a classical chemical oxidation mechanism i.e., the attack on double bonds in the fatty acids by oxygen. Oxidation of the unsaturated phospholipids in milk produces off-flavors that are described as painty, fishy, or metallic. Milk fat though quite bland in taste, imparts richness and smoothness to fat containing dairy products.

The colour of fat depends upon its carotene content and varies with the species, breed and feed of the animal. The yellow colour of cow milk is because of carotene. Buffalo milk does not contain carotene. Milk fat also contains cholesterol (0.23 to 0.1 %) and phospholipids (lecithin, phosphatidyl serine, sphingomyelin, inositol and cerebrosides) some of which serve as antioxidants in prolonging the shelf life of ghee.

Milk fat is the highly expensive item among all the constituents of milk. The shelf life of fat rich products is longer than that of milk. Fat rich products are important milk products from which the dairy gets more profits. At last, the fat rich products are utilized since years as wound healing agent, lighting the wicks of cotton and used in performing homa's, further even now the house wives are using milk fat (ghee) as cooking medium.

1.3 GENERAL COMPOSITION OF MILK FAT:

Milk fat, though quite bland in taste, imparts richness/smoothness to fat-containing dairy products. In freshly secreted milk, it occurs as a microscopic globular emulsion of liquid fat in an aqueous phase of milk plasma. Fat is the most variable component of milk. The average size of fat globules in buffalo milk is larger (4.15 to 4.60 µm) than in cow milk (3.36 to 4.15 µm). Milk fat globules fall in to three overlapping size distributions (Table 1.1).

Table 1.1: Size distribution of milk fat globules

Class	Diameter(µm)	Proportion of the total globule population (%)	Fraction of total milk lipid (%)
Small	Below 2	70-90	<5
Intermediate	3-5	10-30	90
Large	8-10	0.01	1-4

The fat globules are stabilized by a very thin membrane of 5-10 µm thickness, closely resembling plasma membrane. The membrane consists of proteins, lipids, lipoproteins, phospholipids, cerebrosides, nucleic acids, enzymes, trace elements and bound water (Table 1.2). The membrane is important in keeping fat from separating as free oil when it is subjected to physical abrasion during handling/ processing of milk. It also protects milk lipids against the action of enzymes, notably lipase, in development of rancidity. Certain enzymes such as alkaline phosphatase and xanthine oxidase, as well as certain important minerals like iron and copper, are preferentially attached to the fat globule membrane.

Table 1.2 Average compositions of milk fat globules membranes

Component	Buffalo	Western cow
Lipid content	38.5	35.7
Neutral lipids	74.4	65.7
Phospholipids	19.7	18.6
Triglycerides	52.7	45.5
Diglycerides	7.4	5.5
Sphingomyelin	4.3	3.2
Phosphatadyl serine	3.1	2.4
$C_{18:0}$ Stearic acid	34.4	24.1
$C_{16:0}$	22.4	23.8
$C_{18:1}$	14.5	14.5
$C_{14:0}$	12.6	14.4
Protein (g/100 g fat globule)	1.36	1.8

1.3.1 Fatty Acid Profile of milk fat: Both buffalo and cow-milk fats consist chiefly of the triglycerides of fatty acids, which make up 95-99 per cent of milk fat. The remaining portion of milk fat is composed of diglycerides (about 4.1% in buffalo milk and 1.26-1.59% in cow milk), monoglycerides (about 0.7% in buffalo milk and 0.016-0.038% in cow milk). High, medium and low molecular weight triglycerides in buffalo milk occur in the proportion of 42.5, 17.1 and 40.5 per cent, respectively and corresponding values for cow milk fat are 52.9, 18.9 and 28.2 per cent, respectively. Free fatty acid content of buffalo milk fat is lower (0.22%) as compared to that in cow milk fat (0.33%).

The functional properties of milk fat are attributed to its fatty acid make-up. Milk fat contains approximately 65% saturated, 30% monounsaturated, and 5% polyunsaturated fatty acids. From a nutritional perspective, not all fatty acids are considered equal. Saturated fatty acids are associated with high blood cholesterol and heart disease. However, short chain fatty acids (C4 to 8) are metabolized differently than long chain fatty acids (C16 to 18) and are not considered to be a factor in heart disease. Conjugated linoleic acid is a *trans* fatty acid in milk fat that is beneficial to humans in many ways. Milk also contains 7 per cent short-chain fatty acids (C_4-C_8), 15-20 per cent medium-chain fatty acids (C_{10}-C_{14}) and 73-78 per cent long-chain fatty acids (C_{16} or higher). In all, milk fat contains 19 or more fatty acids (Table 1.3).

Table 1.3: Fatty acid profile of buffalo and cow milk fat

Fatty acids	Common name	Composition (wt/wt %)	
		Buffalo milk	Cow milk
$C_{4:0}$	Butryic	4.36	3.20
$C_{6:0}$	Caproic	1.51	2.11
$C_{8:0}$	Caprylic	0.78	1.16
$C_{10:0}$	Capric	1.28	2.57
$C_{10:1}$	-	-	0.31
$C_{12:0}$	Lauric	1.78	-
$C_{14:0}$	Myristic	10.81	11.93
$C_{14:1}$	Myristoleic	1.27	2.12
$C_{15:0}$	-	1.29	1.23
$C_{16:0\ (branched)}$	-	0.18	0.30
$C_{16:0}$	Palmitic	33.08	29.95
$C_{16:1}$	Palmitoleic	1.99	2.16
$C_{17:0}$	-	0.58	0.34
$C_{18:0\ (branched)}$	-	0.24	0.35
$C_{18:0}$	Stearic	11.97	10.07
$C_{18:1}$	Oleic	27.15	27.42
$C_{18:2}$	Linoleic	1.51	1.49
$C_{18:3}$	Linolenic	0.47	0.59

Buffalo milk fat contains appreciably higher butyric acid in its triglycerides in comparison to cow milk fat. However, other short-chain fatty acids (caproic, caprylic, capric and myristic) are lower in buffalo milk fat. The content of long-chain fatty acids (palmitic and stearic) is relatively higher in buffalo milk. The unsaturated fatty acid level of buffalo and cow milk is comparable. Milk fat also consists of varying quantities of other lipids such as phospholipids, sterols, carotenoids, vitamins A, D, E and K and some traces of free fatty acids.

There are characteristic physico-chemical differences between fats of buffalo and cow milk. (Table 1.4) summarizes some of these differences.

1.3.2 Cholesterol: The cholesterol content of milk is significantly affected by the species, breed, feed, stage of lactation and season of the year. Generally, the cholesterol content is higher in the western breeds of cattle (317-413 mg/100 g fat), followed by zebu (desi) cow (303-385 mg/100 g fat). It is lowest for buffalo (235-248 mg/100 g fat). Generally lowest at the beginning of the lactation period, the cholesterol content progressively rises to reach its highest level towards the end. It is quite high in colostrum, being 570 to 1950 mg per 100 g fat in the first milking after parturition, progressively declining to normal levels during subsequent milkings.

Table1.4: Some physico-chemical properties of buffalo and cow milk fat

Physico-chemical Properties	Buffalo milk fat	Cow milk fat
Softening point range	34.3 - 36.3°C	33.5 - 35.9°C
Melting point range	33.4 - 46.4°C	31.5 - 35.2°C
Acid value	0.17 - 0.352	0.26
Refractive index	1.4515 -1.4533	1.4498 -1 .4530
BR reading	41.00 - 43.50	41.05 - 42.40
Saponification number	218.23 - 236.10	221.0 - 238.0
Iodine value	27.00 - 33.90	27.70 - 37.32
Reichert-Meissel value	27.83 - 35.50	24.60 - 29.70
Polenske value	0.70 - 1.60	1.30 -1.80
Density	0.905 - 0.917 g/ml	0.888 - 0.911 g/ml
Grain size	0.20 - 0.41 mm	0.098 - 0.190 mm
Fat globule size	4.15 - 4.60 µm	3.36 - 4.15 µm
Unsaponifiable matter	392 - 398 mg/100ml	414 - 450 mg/100ml

1.3.3 Phospholipids: The total phospholipid content of buffalo milk fat averages 21.04 mg/100 ml of milk, whereas for cow milk the corresponding value is 33.71mg/100 ml. (Table 1.5) shows the concentration of various fractions of phospholipids present in buffalo and cow milk.

Table 1.5: Concentration of phospholipid fractions in buffalo and cow milk

Phospholipid fraction	Concentration(mg/100ml)	
	Buffalo milk	Zebu cow milk
Lecithin	7.29	10.01
Cephalin	9.12	15.57
Sphingomyelin	4.63	8.13

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Lesson-2

Types of Fat Rich Dairy Products

2.1 INTRODUCTION:

Being largest entity in milk, fat globules can relatively be easily separated from the rest of the milk, thereby yielding products of varying fat concentrations. Also processes leading to change in status of fat globules with respect to type of emulsion can result in different products. Thus, milk fraction concentrated in fat gives cream, which in turn can be converted in products such as butter, ghee, butter oil etc.,

2.2 TYPES OF FAT RICH DAIRY PRODUCTS:

2.2.1 Cream

Cream is a yellowish component of milk, rich in fat globules, that rises to the surface naturally if milk is allowed to stand. In the dairy industry cream is separated mechanically. Homogenization of cream reduces the size of the fat globules, and the resulting product is less suitable for whipping.

Cream can be defined as

1. That portion of milk, which is rich in milk fat
2. That portion of milk into which has been gathered and which contains large portion of milk fat
3. When milk fat is concentrated into a fraction of the original milk that portion is called cream.

It may be of following three categories:

1. Low fat cream--containing milk fat not less than 25.0 percent by weight.

2. Medium fat cream--containing milk fat not less than 40.0 percent by weight.

3. High fat cream--containing milk fat not less than 60.0 percent by weight.

It may contain permitted food additives.

2.2.2 Butter

Butter may be defined as fat concentrate, which is obtain by churning cream, gathering the fat into a compact mass and then working it. Butter consists of 80-90% fat with maximum of 16% water and other daring ingredients. Permitted additives are water, salt and butter colours. The fat free dry matter contains should not exceed 2%

2.2.3 Fat Spreads

Fat spreads are solid plasticized foods of water in fat type of emulsion which by principle contain an aqueous phase as well as fats and oils. These fats and oils are foods on the basis of fatty acids have a vegetable, animal; marine origin or it may be milk origin.

2.2.4 Cream and Butter Powder

Cream Powder means the product obtained by partial removal of water from cream obtained from milk of cow and / or buffalo. The fat and / or protein content of the cream may be adjusted by addition and/ or withdrawal of milk constituents in such a way as not to alter the whey protein to casein ratio of the milk being adjusted. It shall be of uniform

colour and shall have pleasant taste and flavour free from off flavour and rancidity. It shall also be free from vegetable oil/ fat, mineral oil, added flavour and any substance foreign to milk.

2.2.5 Ghee

Ghee means the pure heat clarified fat derived solely from milk or curd or from desi (cooking) butter or from cream to which no colouring matter or preservative has been added.

2.2.6 Butter oil

Butter oil and Anhydrous Milk fat / Anhydrous Butter oil means the fatty products derived exclusively from milk and/ or products obtained from milk by means of process which result in almost total removal of water and milk solids not fat. It shall have pleasant taste and flavour free from off odour and rancidity. It shall be free from vegetable oil/ fat, animal body fat, mineral oil, added flavour and any other substance foreign to milk. It may contain permitted food additives such as antioxidant ascorbyl stearate(500mg/kg maximum), Propyl gallate, Octyl gallate, Ethyl gallate(1000mg/kg maximum for each)and Butylated hydroxy anisole(BHA, 175mg/kg maximum). It shall conform to the following requirements.

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Lesson-3

Classification, Standards and Composition of cream

3.1 INTRODUCTION:

Cream is the fatty portion of milk which rises to the top of milk on quiescent storage and is rich in fat. It is produced by separation of un-homogenized whole milk. The concentration of non-fat components (SNF) in cream is in the proportion to the amount of non-fat components transferred from the original milk from which cream is obtained. The indigenous product similar to cream is *malai.*

3.2 LEGAL DEFINITION:

According to Food Safety and Standards Regulations (FSSR) 2011, Cream including sterilized cream means the product of cow or buffalo milk or a combination thereof. It shall be free from starch and other ingredients foreign to milk. It may be of following three categories, namely:—

1. Low fat cream—containing milk fat not less than 25.0 percent by weight.

2. Medium fat cream—containing milk fat not less than 40.0 percent by weight.

3. High fat cream—containing milk fat not less than 60.0 percent by weight.

Note:- Cream sold without any indication about milk fat content shall be treated as high fat cream.

2.3 CLASSIFICATION:

The fat in cream varies from 18-85%. As the fat percentage in cream increase the components of milk in cream gradually decreases. The SNF content constitutes lower proportions than present in milk. Broadly, cream may be classified into two groups:

1. **Market Cream :** The cream used for direct consumption

2. **Manufacturing or Industrial Cream:** It is used in production of various milk products.

Different types of cream following under these groups are:

Table cream Light cream	}	20-25% milk fat
Coffee cream Whipping cream	}	30-45% milk fat
Heavy cream Plastic cream	}	65-85% milk fat

2.4 DESCRIPTION OF CREAM AS PER CODES ALIMENTARIUS COMMISSION:

2.4.1 Cream is the fluid milk product comparatively rich in fat, in the form of an emulsion of fat-in-skimmed milk, obtained by physical separation from milk.

2.4.2 Reconstituted cream is cream obtained by reconstituting milk products with or without the addition of potable water and with the same end product characteristics as those of cream.

2.4.3. Recombined cream is cream obtained by recombining milk products with or without the addition of potable water and with the same end product characteristics as those of cream.

2.4.4 Prepared creams are the milk products obtained by subjecting cream, reconstituted cream and/or recombined cream to suitable treatments and processes to obtain the characteristic properties as specified below.

2.4.5 Prepackaged liquid cream is the fluid milk product obtained by preparing and packaging cream, reconstituted cream and/or recombined cream for direct consumption and/or for direct use as such.

2.4.6 Whipping cream is the fluid cream, reconstituted cream and/or recombined cream that is intended for whipping. When cream is intended for use by the final consumer the cream should have been prepared in a way that facilitates the whipping process.

2.4.7 Cream packed under pressure is the fluid cream, reconstituted cream and/or recombined cream that is packed with a propellant gas in a pressure-propulsion container and which becomes Whipped Cream when removed from that container.

2.4.8 Whipped cream is the fluid cream, reconstituted cream and/or recombined cream into which air or inert gas has been incorporated without reversing the fat-in-skimmed milk emulsion.

2.4.9 Fermented cream is the milk product obtained by fermentation of cream, reconstituted cream or recombined cream, by the action of suitable micro-organisms, that results in reduction of pH with or without coagulation. Where the content of (a) specific micro-organism(s) is(are) indicated, directly or indirectly, in the labelling or otherwise indicated by content claims in connection with sale, these shall be present, viable, active and abundant in the product to the date of minimum durability. If the product is heat-treated after fermentation the requirement for viable micro-organisms does not apply.

2.4.10 Acidified cream is the milk product obtained by acidifying cream, reconstituted cream and/or recombined cream by the action of acids and/or acidity regulators to achieve a reduction of pH with or without coagulation

In general, the following types of cream are relevant to market and industrial purposes:

* **Table Cream:** This type of cream contained 18 to 22% fat and used for eating directly. Various food preparations are made from this cream as fruit cream etc.
* **Light Cream or Thin Cream:** Fat percentage in this type of cream is about 20 to 25 and used for table purpose and for manufacturing of cream cottage cheese etc.
* **Coffee Cream:** This is light or thin type fresh cream containing 18 to 25 percent fat. It is used mostly in coffee making. If this cream has any lactic acid, it becomes coagulated after adding to coffee. These cream coagulates are known as "Cream feathers". This feathering may be prevented by addition of sodium citrate to this slight acidic cream. If the water which used in coffee making has more calcium, accelerate the cream feathering. The addition of 0.05% sodium citrate also reduces the hardness and thickness of cream plug in cream bottles.
* **Heavy Cream:** This type of cream contains 30 to 40% fat and used in production of butter and ice cream. Sometimes it can be used in panner production.
* **Plastic Cream:** The cream of 30-40% fat re-separated to obtain the cream of 80 per cent and this rich cream is known as plastic cream. Mostly this type of cream is used for ghee production. This cream can be produced directly from milk which is separated in an especially designed plastic cream separator.
* **Whipped Cream:** When the normal cream (30-40% fat) is incorporated with air, the air bubbles are stabilized by protein adsorption. The fat globules are assemble around these air bubbles. As whipping continues, these air cells subdivided into smaller one each with adsorbed layer and in numerable fat globules. At the maximum stiffness, these smaller air cells (nuclei) are surrounded by films of adsorbed protein which is so thin that drainage is at a minimum and the structure of dry foam is set up. The favorable temperature for whipping is 10 ºC. Over whipping may produces a buttery product. The cream pasteurization and sugar addition declines the whipping rate in cream. Some of the dairy plants used Nitrous oxide gas for cream whipping. Whipped cream is used in cakes and ice cream etc. for decorative purpose.

* **Sour Cream:** This type of cream are produced by inoculating sweet, pasteurized and homogenized cream with a starter culture containing lactic acid producing and aroma producing microorganism and incubated to proceed fermentation. This cream has 0.6% lactic acid, clean flavour and smooth texture. Sometimes rennet can be added @ 0.03 ml/gal cream to get more firm product. Sour cream should be stored at 40 ºF or less temperature to check the further increase in acidity.

* **Clotted cream:** To obtain the clotted cream, milk is scalded for fifteen minutes at about 85-90 ºC in shallow pan and allowed to form a cream layer. Considerable evaporation occurs from the cream layer and on cooling over a period of twenty four hours, the clotted cream may be removed. The main difference between ordinary cream and clotted cream are the decreased ratio of SNF/water and relatively higher proportion of protein in the clotted cream.

* **Frozen Cream:** Cream is frozen to improve its keeping quality. Pasteurize the ordinary cream (40-50% fat) at 77 ºC for 15 minutes and packing in paper, plastic or tin containers after cooling at 4 ºC or below. Freeze quickly this packaged cream and store at –12 ºC or below. This stored cream is used during shortage in preparation of ice-cream etc. During storage the fat globule membrane may ruptured by ice crystals. Therefore, this cream tends to 'Oil-off 'on thawing. This 'Oiling-off impairs the whipping characteristics of the ice cream.

* **Sterilized or Canned Cream:** Homogenize the 20% cream at 80 ºC using pressure 175 kg/cm^2 in the first stage and 35 kg/cm^2 in the second stage and cooled to 16^{0}C immediately. Tri-sodium phosphate is added @ 0.2% as a stabilizer to the cream. This cream is packaged in tin cans or bottles and sterilized in following manner:

- Coming up time 15 Minutes to 114± 1 ºC
- Holding time 15 Minutes to 114± 1ºC
- Cooling time 15 Minutes to room temperature

* **Reconstituted Cream:** By vigorous emulsification of unsalted plain butter in milk or separated milk or reconstituted milk or condensed milk, the fat globules are dispersed and coated with a layer of adsorbed protein, the resulted product is closely resembles with cream and known are reconstituted cream.

* **Synthetic Cream:** In the artificial cream, butter fat is substituted with margarine fat and resulted product is known as synthetic cream. Margarine is an imitation and substitute of butter. In production of synthetic cream, the refined oils are carefully blended to have some physical cream, the refined oils are carefully blended to have some physical properties resemble to butter fat. Synthetic cream may have some emulsifying agents such as egg yolk, vegetable lecithin and glycerol- Mono or di-stearated etc.

*** Whey Cream:** Separation is sometimes used to remove fat from cheese whey and resulted cream is known as whey cream. It is slightly differs in composition from regular fresh cream obtained from milk.

3.3 COMPOSITION OF CREAM:

Cream generally contains all the constituents of milk but non-fat constituents are inversely proportional to the fat content as show in table 3.1

Table 3.1 Composition of cream

	Cream with 30% fat	Cream with 50% fat
Water	64.0%	44.43%
Fat	30.0%	50.00%
Protein	2.4%	1.69%
Lactose	3.5%	2.47%
Minerals	0.4%	0.37%
SNF	6.3%	4.53%

SNF of cream can be calculated by taking the ratio of water to SNF of milk

If ratio of water to SNF of milk is 10:1, then the approximate SNF in cream = (100-F/11) where F is fat content of cream. SNF in cream can be estimated as:

3.4 PHYSICO-CHEMICAL PROPERTIES:

Some of the important physico-chemical properties relevant to cream processing and consumption are discussed below:

3.4.1 Viscosity: It is the resistance offered by the liquid to flow. Consumer judges the richness of cream by its viscosity. The factors affecting the viscosity of cream are given below:

- **Fat percentage:** Higher the fat % greater is the viscosity.
- **Temperature:** Higher the temperature lower is the viscosity.
- **Separation conditions:** Higher temperature of separation lowers the viscosity.
- **Homogenization:** Homogenization increases the viscosity of cream. Single stage homogenization increases viscosity more than the double stage homogenization.

· **Cooling:** Cooling of cream increases the viscosity.

· **Ageing:** The viscosity of cream increases with storage period.

· **Clumping:** It refers to the tendency of fat globules to adhere loosely to one another and form clumps. Clumping depends on fat globule size, temperature (maximum at 7 ºC), agitation and method of separation. The greater is the clumping, greater will be the viscosity.

3.4.2. Whipping Quality: Whipping means emulsion of gas or foam production by beating of cream. Whipped cream has remarkable stability. This is used in cakes, ice creams and for decorative purposes. The most satisfactory fat content for production of whipping cream is 30-35%. The optimum aging period is 24 hours at 4°C. Homogenization, acidity and stabilizers in cream reduces the whip-ability of cream.

3.4.3. Titratable Acidity (TA): There is an inverse relationship between the percent fat and percent titratable acidity. Fresh cream has lower acidity percentage than milk.

Formula for Acidity:

$$\text{Cream TA \%} = \frac{\text{\% of serum in cream}}{\text{\% of serum in milk}} \times \text{\% of titratable acidity of milk}$$

or

$$\text{Cream TA \%} = \frac{100 \quad \text{\%of fat in cream}}{100 - \text{\% of fat in milk}} \times \text{\% of titratable acidity of milk}$$

3.4.4 Specific Gravity: Specific gravity of cream is inversely proportional to the fat percentage as shown below:

Fat percentage in milk / cream	Specific gravity
0.025	1.037
4.0	1.032
6.0	1.030
10.0	1.025
20.0	1.013
30.0	1.003
40.0	0.995

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Lesson-4

Principles and methods of Cream Separation

4.1. INTRODUCTION:

When milk is allowed to stand un-disturbed for some time, an upward motion of the fat globules takes place, leading to the formation of a surface layer on milk in which the percentage of fat is considerably increased. This upward motion of fat based on the fact that milk fat is lighter than the skim milk portion. At 16^0C, the average density of milk fat is 0.93 and of skim milk is 1.0404. Therefore when milk (a mixture of fat and skim milk) is subjected to either gravity or centrifugal force, the two components, cream (fat-rich portion of milk) and skim milk (reduced-fat portion of milk), by virtue of their differing densities, separate from each other.

PURPOSE OF CREAM SEPARATION

1 . To obtain a fat-reduced or fat-free milk

2 . To concentrate milk fat for the production of high-fat products

3 . To standardize the fat content of milk

4 To recover fat from milk

The cream separation process has significant economic importance, as it controls the efficiency of the fat separation. The key objective is to manufacture skim milk with the lowest possible fat content, which corresponds to good separation efficiency. Knowledge of the basics of the fat separation is important for an optimal de-creaming process. Cream separation is based on the facts that fat exists in poly-disperse system in an emulsified state and that the specific density difference between milk fat (p = 0.93 g/cm^3) and skim milk (p = 1.035 g/cm^3) is fairly large. Basically two processes for fat separation are possible, natural de-creaming and separation with machines. Natural creaming has no industrial significance.

4.2. SEPARATION PROCESSES:

There are two methods of cream separation viz.,

- Gravity Method
- Centrifugal Method

4.2.1. Cream Separation by Gravity Method

When milk is allowed to stand undisturbed for some time, there is a tendency of fat to rise. The velocity or rate at which the fat globules rise is given by the following equation, which is known as Stoke's Law:

$$V = (2/9) * Gr^2 * (d_s - d_f) / N$$

Where, V = rate of rise of fat globule in centimeter per seconds

r = radius of fat globule

G = Force of gravity (981 dynes)

η= Viscosity of skim milk

d_s = density of skim milk

d_f = density of fat globule

From, Stoke's Law it is observed that theoretically velocity increases with:

a. Increasing radius of fat globule ,

b. Increasing difference in densities of skim milk and fat

c. Decreasing viscosity of skim milk

However, in practice the factors affecting the rate of rise of fat in gravity method of separation are:

* **Size of fat globules:** As the size of fat globules increases, the rate at which fat rises also increases. Larger fat globules rise faster than smaller ones. Thus, in buffalo milk gravity creaming occurs faster due to the larger fat globules than those in cow milk.
* **Temperature**: As temperature increases, viscosity decreases.
* **Clumping:** A clump or cluster acts like a single globule in so far as movement through skim milk is concerned. Thereby the effective 'r' is increased, which in turn increases velocity, as shown below

Effect of size of fat globules on its rate of rise	
Diameter of fat globule or cluster (μm)	Rate of rise (mm/h)
3.2	1.26
41.0	242

There are five various methods for separating the cream using gravity method:

i. Shallow Pan Method: Milk is allowed to stand in a pan of 10 cm depth and 45-60 cm diameter at 7°C for 24 h. During this time, cream rises to the surface.

ii. Deep Pan Method: Milk is allowed to stand in pan of 20" depth and 8 to 12" diameter at 10°C for 24 h. These tall cans have glass on one side of can and a faucet placed near the bottom. Skim milk is drawn through the faucet.

iii. Water Dilution Method: Milk is diluted with water and allows standing for 12 h at 37.7°C temperature. Water would make the milk less viscous, thus facilitating the rising of the fat globules.

iv. Scalding Method: Heating and cooling of milk slowly causes the formation of cream layer at surface of milk

v. Jersey Creamery Method: Milk is heated to 40°C using hot water in the jacketed vat and then cool to 10°C using chilled water in place of hot water in the jacket of Vat. The cream will be separated rapidly on cooling, immediately after heating the milk, by increasing the difference in densities of milk fat and serum.

Gravity method being very slow, it is no longer used commercially for cream separation.

4.2.2 Cream Separation by Centrifugal Method

Milk is fed to machine through flow regulator. Milk comes to regulating chamber from milk basin by milk faucet. When milk enters the revolving bowl through milk regulator of machine, it is subjected to a gravity and centrifugal force. Centrifugal force is about 3000 to 6000 times more than gravitational force. Fat (0.9) and skim milk (1.037) are varying in their specific gravity. When fat and skim milk are subjected to centrifugal force, the difference in density affect the fat and skim milk *i.e.* (heavier Portion) affected more intensely than the fat (lighter portion). So skim milk is forced to the periphery and fat portion (cream) moves towards the centre. Cream and skim milk forms separated vertical walls within the bowl and goes out through separate outlets near the axis of rotation. The cream outlet is at higher level than skim milk outlet. The rate or movement of a fat globule in machine is estimated by following Stoke's equation.

$$V = r^2 * ((a_s - d_f) / n) * N^2 * R * K$$

Where:

V = rate of movement of a single fat globule

r = radius of fat globule

ds = density of skim milk

df = density of fat

N = Revolution per minute of bowl

R = Distance of fat globule from axis of rotation.

K = Constant

N = Viscosity of skim milk

It will be seen from the above that the speed (rate) of cream separation is increased by:

- greater radius of the fat globule
- greater difference in density between skim milk and fat
- greater speed of the bowl
- greater size of the bowl
- lower viscosity of skim milk

4.3 CHARACTERISTICS OF GRAVITY AND CENTRIFUGAL METHODS:

Gravity and centrifugal cream separation compare as shown below:

Particulars	Gravity Method	Centrifugal Method
Nature of force causing Separation	Gravitational force	Centrifugal force
Speed of separation	Extremely slow	Practically instantaneous
Direction of movement of fat and skim milk particles	Vertical	Horizontal
Bacteriological quality of cream or skim milk	Low	High
Fat % of cream	10-25% only	18-85 %
Skim milk	0.2 % above	0.1 or below

Scale of operation	Small	Large
Fat % recovered in cream	not more than 90	99-99.5

When the centrifuge bowl, filled with liquid, is put into rotation, the liquid surface level is lowered at first, and a rotation paraboloid is created. With an additional increase in revolutions, the surface level is lowered to the rotation axis and then rises in parallel. At corresponding high revolutions in the bowl a liquid ring is created. Imagine particles of skim milk and fat with the same particle diameter in a rotating liquid, the resulting force acts toward the inside. It corresponds to the force, according to motion theory, which is required to accelerate a body moving in a circle and maintain it in an orbit. This force is called the centripetal force (F_{ep}); it is opposite to the centrifugal force F_{ef}. In this example, the skim milk particles enter a phase in which the forces are in balance, as $F_{ep} = F_{ef}$. Because of their lower specific density, less centrifugal force is exerted on fat particles of equal size, resulting in $F_{ep} > F_{ef}$. The difference in force here is very small, so the fat particles migrate slowly toward the inside.

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Lesson-5

Construction of Cream separators

5.1 INTRODUCTION:

Cream separation is the mechanical separation of milk into cream and skim milk by means of centrifugal force. Cream separator is a device used to separate cream from milk. There are different types of cream separators available in dairy industry. Performance of cream separators will largely be influenced by its design and operating conditions.

5.2 CREAM SEPARATORS IN DAIRY INDUSTRAY:

There are two basics types of separators depending on their mode of operation

1. Hand operated and
2. Power driven

The power driven cream separators are further classified as:

1. Open-bowl separator
2. Semi-closed or semi-hermatic separator
3. Closed bowl or Hermatic separator
4. Self-desludging separator

5.2.1 Open bowl separators: These are characterized by an open top milk inlet and pressure less, skim milk and cream outlets open to atmosphere. The main parts of a cream separator are: Supply can/milk basin, milk faucet, regulating chamber with float, cream screw and skim milk screw, cream spout and skim milk spout, Separator bowl (consisting of bowl shell, milk distributor, discs and rubber ring), spindle, gears, crank handle and bowl nut. The base consists of horizontal, vertical drive prime consisting of electrical motor, centrifugal pump, drive shaft with a worm wheel. The v ertical drive prime consists of a shaft known as bowl spindle. At the top of the bowl spindle a separator bowl is mounted. Power is transmitted from worm to a worm gear connecting to the spindle. Discs, shaped as cones, are stacked in into disc assembly and placed in the bowl shell.

Milk is introduced on to vertically aligned distribution holds in discs at a certain distance from edge of discs from start. Under influence of centrifugal force the particles and droplets of milk will begin to settle either outward or inward in separation channels radially according to their densities related to continuous medium. There are up to 120 discs are arranged one over other and, angle of inclination is 45-60° to the horizontal. Outward diameters of discs are between 200-300 mm. Disc are generally made up of stainless steel and wall thickness will be around 0.4 mm. The space between discs varies the flow through narrow gaps in laminar flow ensuring the separation. Larger gaps between discs are necessary if there is a danger of clogging. Disc bowls used have an rpm of 5500-6000 and at mass rate flow of 20,000 liters per hour. The space between the discs must be increased if the cream of high fat % content is to be obtained. In a normal cream separator, clogging can expected if fat in cream is above 55%-60%. The required high fat content can be obtained only after subjecting the cream again to fat separation. Suppose milk is to separate below 25°C then the distance between the discs must be increased due to higher viscosity. The number of discs in cream separator relates to its capacity.

In gravity fed type cream separator, a supply tank is mounted on bowl unit. It consists of two separate outlets one for cream and another for skim milk. To handle small capacity units, a screw arrangement is provided on cream line just at the outlet point. This cream screw helps manipulate the flow rate of cream.

Precautions for Efficient Working of open bowl separator

1. Proper assembling and fitting of different parts
2. Proper lubrication in machine
3. Quality of milk to be separated:
4. Temperature of milk (30-40 °C)
5. Speed of the bowl
6. Uniformity in speed of bowl
7. Uniform supply of milk
8. Sanitary condition of machine

The disadvantage with this separator is that lot of excess foaming in skim milk.

5.2.2 Semi-closed separators: These are the separators with milk feed at atmospheric pressure and paring discs located in the cream and skim milk outlets which discharge into closed pipes at elevated pressure. The milk inlet is so designed as to prevent any air getting into the milk stream. This helps to prevent foaming in cream and skim milk.

This paring disc converts rotational energy of milk and cream to a linear kinetic energy. They are constructed like the impeller of centrifugal pump and dipped in rotating ring of liquid. The liquid is made to flow with a high peripheral speed into channel openings of the paring discs. These discs are fixed to the feed pipe. The liquid enters horizontally along spiral channels, which are divided, and flows vertically through the discharge channel in the shaft of the paring disc. Here the kinetic energy is converted into peripheral energy and 2.5-5 bar pressures can be generated depending on the rotational speed and diameter of paring disc. The generated pressure can be used to push the exiting cream and skim milk through variable flow. Restrictive devices and outlets can be used to generate back pressures which can control flow so that a fairly accurate control of fat content is feasible.

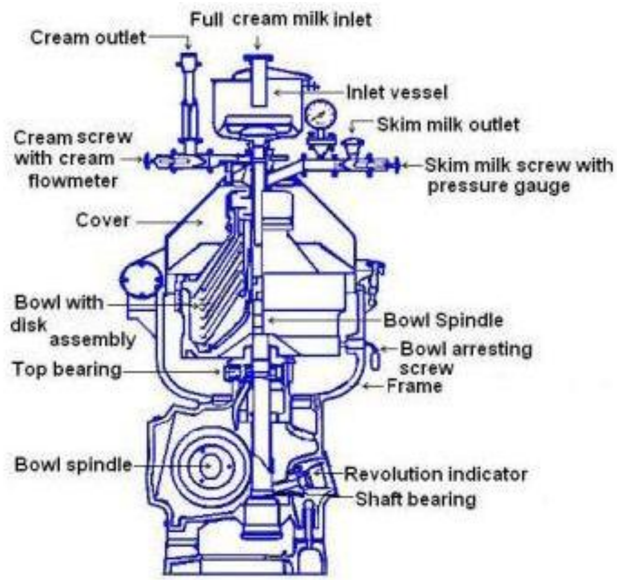

Fig.5.1 Semi Closed

(To edit figures 3.2 semi closed)

5.2.3 Closed bowl or hermetic separators: In these separators, milk inlet and the cream and skim milk outlets are all connected to closed pipe lines. The milk is transferred in a closed pipeline under pressure, which is mostly flow controlled. This design is normally used for self-cleaning (self-desludging) separator; i.e., the dirt is discharged periodically without interruption of the process.

With closed separators incorporation of air is nearly totally excluded, which results in the following advantages:

(a) Gentle treatment of the milk in the bowl, as its entire volume is occupied by the liquid

(b) High skimming efficiency (up to 0.005% of fat in skim milk)

Closed bowl separators are usually provided with self desludging mechanisms

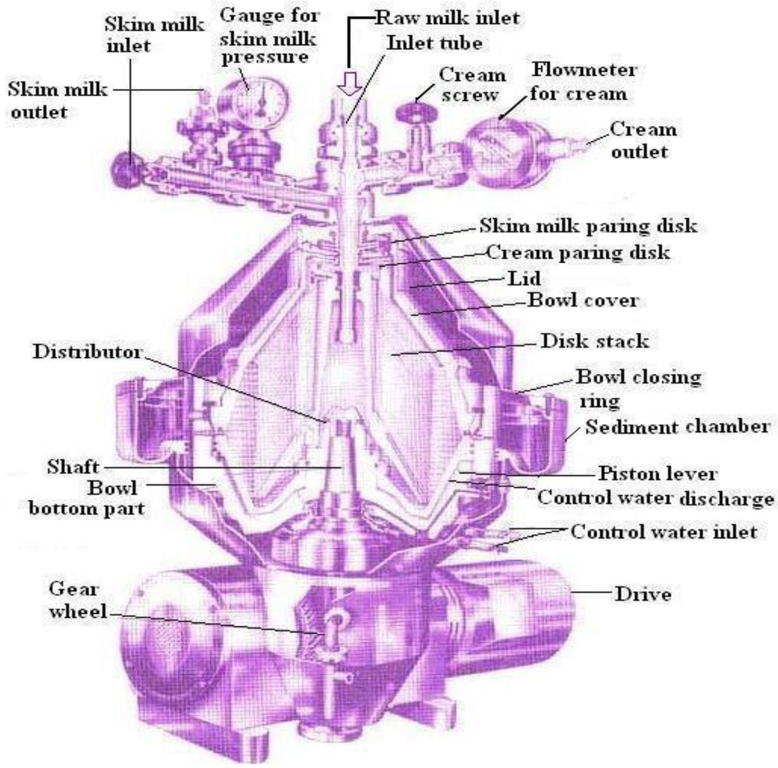

Fig.5.2 Hermatic closed Separator

The separator shown in Figure 5.1 is also equipped with a self-cleaning bowl. The dirt (which is separated from the milk) is collected in a bowl (which is conical to the outside) and is ejected periodically through ports. This permits the separator to be included in a CIP circuit without requiring time for disassembly. The operating time is independent of the sludge container capacity which permits a multi shift continuous operation.

5.3 CONSTRUCTION AND WORKING PRINICIPLE OF CREAM SEPARATOR BOWL:

(Edit figure for clarity)

Whole milk is fed via the central pipe to the distributor at the bottom of disc stack and is subjected to rotation. The distributor serves as the base for the assembly of 110-130 discs. The coarse dirt particles settle down in the conical bottom part, i.e the sludge space. The milk flows upwards through the openings in the discs which are inclined towards the rotational axis. Thus, in the disc assembly, milk rises in channels, which are parallel to the rotational axis. The channels are formed by the rising holes of the disks and the milk is distributed in thin layers in the space between the disks, (distance of 0.5-1.0 mm). It is here that separation of milk into cream and skim milk takes place and at the same time the dirt is deposited as slime in the sludge space.

The heavier part of the liquid (skim milk) moves toward the outside, and the cream (which is lighter) moves in the opposite direction toward the center. In a slit between the bowl base and the disc inner rim, the cream rises to the cream retention chamber and goes into the cream outlet. After passing the disk space, the skim milk goes into the bottom part of the bowl and flows as a liquid ring into the slit between the bowl cover and the separation disks into the skim milk chamber. The separator discs serve to keep the skim milk separate from the cream. The skim milk is then directed via the paring disc of the skim milk chamber into the skim milk outlet. As explained above, the fixed separator discs have the effect of a rotating centrifugal pump, so that in each chamber the required pressure (for transporting the liquid) is generated.

5.4 SELF-DESLUDGING SEPARATOR:

Working principle of the self desludging separator bowl:

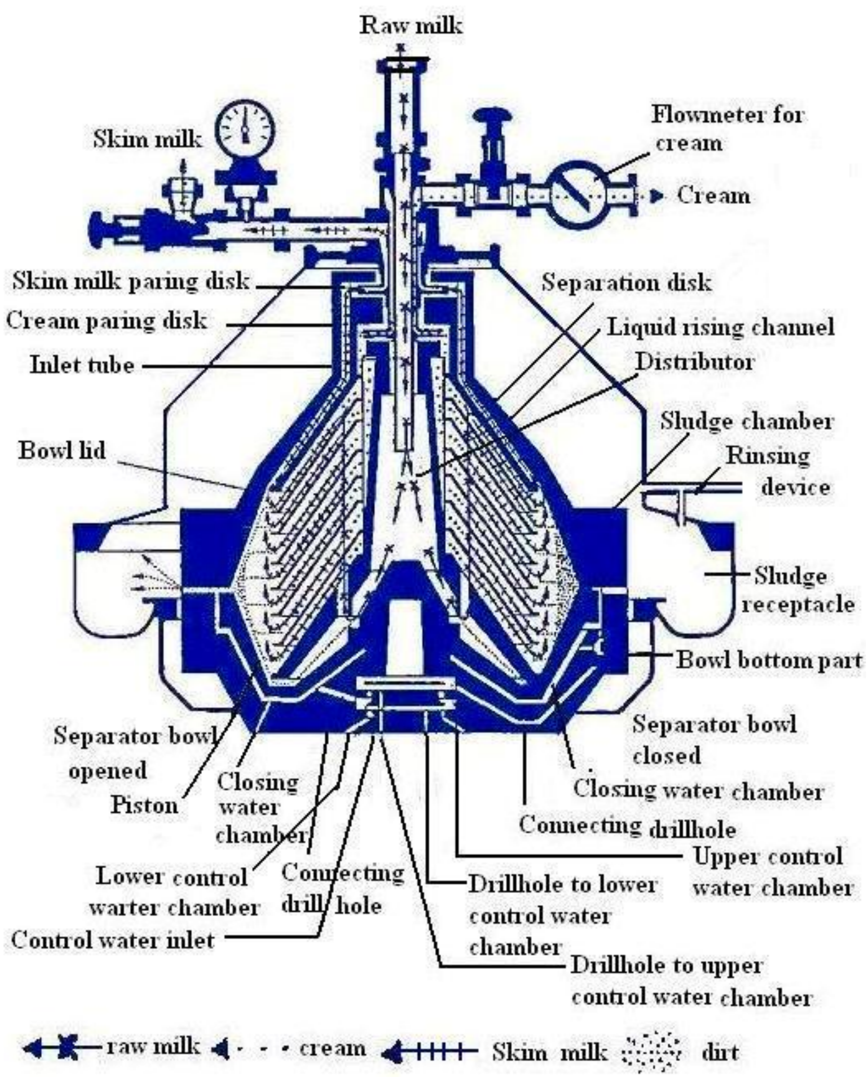

Fig.5.3 self desludging separator bowl

The particulate impurities such as dust and cellular material from blood are dense solid material and hence collects on the outside of the rotating bowl. If left like that, it fill up the sludge space and inhibit the flux of skim milk there by hindering the separation process. Self desludging separator does not permit the accumulation of sludge in the bowl. Self Desludging ia a mechanism for automatically removing solid material without having to interrupt the operation of the separator. Slots are cut in the outside of the bowl and are normally kept close by a sliding bowl bottom which is elevated by hydraulic pressure of running water in a reservoir underneath. Intermittently hydraulically operated valve opens up and the reservoir drains to allow the bowl bottom to fall and this causes opening of these slots. The outward pressure on the sediment forces it into the outer bowl. The valve then closes to allow the reservoir to refill and the slots to close. The action is very rapid and it discharges at regular intervals, which depends upon the volume of sediment, space in the separation bowl and condition of the milk.

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Lesson-6

Factors affecting skimming efficiency and richness of cream

6.1 INTRODUCTION:

Normally the objective of separation is to attempt to recover all the fat in the whole milk within the cream fraction, with the minimum amount of fat being retained in the skim milk. Skimming efficiency is assessed as the fat content of the skim milk. If the skim milk is to be converted into skim powder or casein then it is important that the fat content be low, to meet various specifications and functional requirements of these products.

6.2 FACTORS INFLUENCING THE FAT PERCENTAGE OF CREAM:

The important factors influencing the fat percentage of cream by centrifugal separation are discussed below:

6.2.1 Position of the cream screw: The cream screw/outlet consists of a small, threaded, hollow screw pierced by a circular orifice through which the cream emerges. This screw can be driven IN or OUT, thus bringing it nearer to, or away from, the centre of rotation. Similarly, the skim milk screw/outlet is for the removal of skim milk. Once the cream screw or skim milk screw has been adjusted, the cream separator delivers, under normal conditions, a definite ratio of skim milk and cream, which is usually 90:10 (or 85:15) by volume. Basically, any change in the separation procedures which alters the relative quantities of skim milk and cream will influence the fat test of the cream. By altering the position of the cream screw (or skim milk screw), the ratio of skim milk to cream changes. Thus, when the cream screw is moved IN towards the axis of rotation, a higher fat percentage in cream is obtained, and vice versa; this is because the force tending to discharge cream through the orifice is decreased ('R' in the formula $F = KWRN^2$ is decreased),. A smaller proportion of cream is therefore discharged, which, contains the same quantity of fat, resulting in a higher fat percentage. Screwing OUT the cream screw produces thinner cream. Similarly, the skim milk screw OUT results in richer cream, and vice versa.

6.2.2 Fat percentage in milk: The higher the fat percentage in milk, the higher the per cent fat in cream, and vice versa. Since practically all the fat in milk is contained in the cream, the cream from the separation of high-fat milk has a higher fat content than that from low-fat milk; a greater fat content in cream, the amount of which remains unaltered in the two cases, will obviously show a higher fat percentage in it, and vice versa.

6.2.3 Speed of the bowl: The velocity of a fat globule is proportional to the square of the rotational speed so an increase in bowl speed will have a very major effect on separation efficiency. An increase in bowl speed however requires an increase in energy input and a more robust design to withstand the large forces at the bowl periphery. The separator also generates more noise. For this reason bowl speeds have not increased significantly as skimming efficiency is quite adequate at moderate speeds of 4000-6000 rpm. The higher the speed of the bowl, the higher will be the fat % in cream. The higher the speed of the bowl, the greater will be the centrifugal force and more rapidly the skim milk leaves the bowl with higher fat % in cream.

6.2.4 Rate of the milk flow: The higher the rate of milk inflow, the lower the fat percentage in cream, and vice versa. When the rate of inflow increases, the discharge from the cream outlet increases. As the skim milk discharge remains constant (with constant centrifugal force); more cream containing the same amount of fat results in a lower fat test, and vice versa.

6.2.5 Temperature of milk: An increase in temperature of milk leads to both an increase in density difference between milk fat and skim milk. So increase in temperature will lead to lower separation efficiency. Higher temperature will lead to disruption of fat globule which will result in heavy fat losses in skim milk. The fat losses are higher at 70°C than at 54.5°C. The optimum separation temperature is 40°C. Higher temperature leads to protein denaturation and phospholipids.

Cold milk separators that will operate at temperatures less than 10°C are available. These allow separation of milk as it is received at the factory, and although fat losses to skim milk are somewhat higher they do sometimes allow substantial savings in energy and capital costs. In some cheese making operations heat treatment of the milk is undesirable and cold milk separators offer some advantages. In addition cold milk separators produce cream with greater phospholipids content which gives better whipping properties. The major modification in a cold milk separator is wider disc spacing than in a conventional model to allow adequate flow of the more viscous cold cream.

6.2.6 Amount of water or skim milk added to flush the bowl: The greater the quantity of water or skim milk added to flush the bowl, the lower the fat percentage in cream, and vice versa. The addition of more water or skim milk will cause an increase in the amount of cream produced, which, with the same fat content, will show a lower fat test.

6.3 FACTORS AFFECTING THE FAT LOSSES IN SKIM MILK DURING SEPARATION:

6.3.1 Skimming efficiency: It refers to the % of total fat from milk recovered in the cream. The higher the fat % in milk, the greater the fat losses in the skim milk, the lower will be the skimming efficiency

(SE) and vice versa. The best indication of higher SE is lower fat percentage in skim milk. SE of machine may be calculated using the following equation:

$$SE = ((C . (F / 100) / M . (F_1 / 100))) X 100$$

Where,

C - Amount to cream (Kg)

F - Fat percentage in cream

F_1 - Fat percentage in milk

M -Amount of milk (Kg)

Examples:

1. **Given:** 100 kg milk testing 7.5% fat; cream produced 14.1 kg cream testing 52.5% fat. Calculating skimming efficiency (SE).

$$SE = \frac{14.1 X (52.5/100)}{100 X (7.5/100)} = 98.7$$

2. 100 kg milk testing 4.8% fat produced 10.3 kg cream testing 45.5% fat. Caluculate(SE)

$$SE = \frac{10.3 X (45.5/100)}{100 X (4.8/100)} = 97.6$$

Note. In the above examples, high fat-test milk shows a higher SE than low-fat-test milk.

6.3.2 Factors affecting fat losses in skim milk

The important factors influencing the fat losses in skim milk obtained through centrifugal separation are discussed below:

6.3.2.1 Temperature of milk: The lower the temperature of milk, the higher the fat losses in skim milk and vice versa. For efficient separation, the temperature of milk should be above the melting point of fat, so that the milk fat in the fat globules is entirely in liquid form. A satisfactory temperature for separation is around 40°C. The higher the temperature, the more efficient is the separation. There is no marked increase in efficiency after 43-49°C. On the other hand, separation at low temperatures (in warm-milk separators) may lead to partial clogging of the bowl due to high viscosity of cream at these temperatures, resulting in a greater fat loss in skim milk.

6.3.2.2 Speed of the separator bowl: The lower the speed of the bowl, the higher the fat loss in skim milk, and vice-versa. At below-rated speed there will be more fat loss in skim milk because insufficient centrifugal force is generated for efficient cream separation. However, at above rated speeds, the skimming efficiency will not increase greatly.

6.3.2.3. Rate of milk in-flow: The higher the rate of inflow of milk, the higher will be the fat losses in skim milk, and vice versa. If the rate of inflow is increased above the designed capacity of the separator, the milk passes through the bowl too rapidly and do not to allow for complete separation, thereby resulting in a higher fat loss in skim milk. On the other hand, underfeeding the separator does not greatly increase the efficiency of the separation.

6.3.2.4. Position of cream screw: A good separator is designed to give efficient skimming within a fairly wide range of positions of the cream screw, so that the fat test of the cream can be varied without influencing the efficiency of skimming. With most separators, the position of the cream screw has little effect on the fat test of skim milk until the cream test is above 45 to 50 per cent. From this point up to a 60 per cent fat test in cream, the fat content of the skim milk increases. Separation of very thick cream at low temperatures may lead to higher losses due to clogging of the bowl with viscous cream.

6.3.2.5 Mechanical condition of the machine: Unsatisfactory mechanical condition of cream separator causes greater loss in skim milk.

* **Vibration of separator:** This reduces the efficiency of separation by disturbing the currents of cream and skim milk. Vibration is caused by installation on an insufficiently firm foundation, the bowl being out of balance, bearings being worn out, the axis of rotation not exactly vertical, etc.

* **Condition of the discs:** Discs in an unsatisfactory condition suffer a loss of skimming efficiency due to the uneven flow of the counter-current streams of cream and skim milk between them. An unsatisfactory disc is one which is out of shape, dirty, scratched or rough.

6.3.2.6 Amount of separator slime in the bowl: If too much slime accumulates, the fat loss in skim milk increases; this is caused not only by a disturbance in the even flow of the counter-currents of cream and skim milk, but by reduction in the centrifugal force (because of decrease in the 'effective' diameter of the bowl).

Separator slime (which is usually considered identical with clarifier slime) consists of the slimy mass which accumulates inside the bowl shell of the cream separator. It is made up of foreign matter, milk proteins, leucocytes, fragments of the secreting cells from the udder, fat calcium-phosphate and other minerals, bacteria and, occasionally, red blood corpuscles.

The average composition of separator slime is given in Table 6.1.

Table 6.1 Composition of separator slime

Constituent	Moist Slime %	Dry Slime %
Water	68.2	-
Fat	1.4	4.4
Protein	25.3	79.6
Lactose	1.8	5.6
Minerals	3.3	10.4

Source: Hunziker (1940)

6.3.2.7 Size of the fat globules: The greater the number of fat globules of less than 2 µm size, the higher the fat loss in skim milk and vice versa. Fat globules of less than 2 µm size usually enter the skim milk, as they are not subject to sufficient centrifugal force to be recovered in the cream.

6.3.2.8 Degree and temperature of separation: The higher the degree and temperature of agitation, the greater will be the loss of fat in skim milk and vice versa. Agitation of hot milk causes the disintegration of normal fat globules in to smaller ones which escape the effect of centrifugal force there by leading to more fat loss in skim milk.

6.3.2.9 Presence of air in milk: The greater the amount of air in milk the higher the fat losses in skim milk. If the milk delivered to the separator contains entrapped air bubbles, centrifugal force will disturb the counter-current streams of cream and skim milk between the discs, and lower the efficiency of separation. The effect of air in the milk is greater with hermetic than with non-hermetic cream separators.

6.3.2.10 Acidity of Milk: The higher the acidity of milk, the lower the efficiency of separation, the lower the stability of casein particles which in turn get precipitated and clog the bowl there by lowering the efficiency of separation.

6.4 YIELD OF CREAM AND SKIM MILK:

6.4.1 Yield of cream: This can be calculated by the formula:

$C = M * (f_m - f_s) / (f_c - f_s)$

Where,

C = weight of cream (kg);

M = weight of milk (kg);

f_m = fat percentage of milk;

f_s = fat percentage of skim milk;

f_c = fat percentage of cream.

Fat recovery in cream: This can be calculated by the formula:

$$\text{Per cent fat recovered in cream} = \frac{\text{Kg fat in cream}}{\text{Kg fat in milk}} \text{X } 100.$$

6.4.2 Yield of skim milk: This can be calculated by the following formula:

$S = M * (f_c - f_m) / (f_c - f_s)$

Where,

S = weight of skim milk (kg);

M = weight of milk (kg);

f_m = fat percentage of milk;

f_s = fat percentage of skim milk;

f_c = fat percentage of cream

Fat lost in skim milk: This can be calculated by the formula:

$$\text{Per cent fat lost in skim milk} = \frac{\text{Kg fat in skim milk}}{\text{Kg fat in milk}} X\ 100 \ldots \mathbf{I}$$

$$= \frac{fc-fm}{fc-fs} X \frac{fs}{fm} X\ 100 \ \ldots \mathbf{II}$$

Where f_c, f_m and f_s are as above.

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Lesson-7

Standardization of cream

7.1 INTRODUCTION:

The important factor in standardisation of cream is the fat content. Standardization means adjusting the fat content in cream to a desired level so as to meet legal requirements of the cream products and to have ease in churning in butter manufacture and minimize fat losses in buttermilk. In market cream, if the fat content is higher than the specified requirement, then financial returns will suffer. If the fat content is low, then the cream may not meet regulatory requirements and also lack desired functional properties, such as viscosity or whipping. Too low a fat content will result in a high buttermilk volume; this will not give returns as much as the skim-milk. Standardisation is also an important facet of market milk production, and much of the technology is applicable to cream and milk.

7.2 PURPOSE OF STANDARDIZATION:

Standardization of cream refers to the adjustment, i.e. raising or lowering, of the fat of cream to a desired value, so as to conform to the legal or other requirements of the process.

1. To prepare consumer cream products with fat content to meet legal/quality standards

2. To avoid economic losses accompanying excess fat content in preparaed product

3. To minimize fat losses in buttermilk

7.3 METHODS OF FAT ESTIMATION IN CREAM:

To achieve accurate standardisation, the fat content should ideally be controlled as it leaves the separator. For small-scale operations, however, standardising in bulk is the norm. The separator is adjusted to give a slightly higher fat content than required and a suitable diluent such as skim-milk is added to obtain the required fat content. Such dilutions can be calculated conveniently by using Pearson's square. A very important consideration in this operation is the measurement of fat content.

Normally a reasonably quick measurement method such as Babcock or Gerber methods is required. Accurate methods such as Werner-Schmidt or Rose-Gottlieb method are time consuming. The Babcock and Gerber methods, which rely on volumetric measurement of extracted fat, are quicker, but are a little less accurate. Most dairy factories, however, possess Milko-testers, Milko-scans or instruments that will give rapid measurements of good accuracy provided they are set in the correct mode with a properly prescribed diluent in the cream. Once the fat content of the cream has been determined, it is necessary to add the correct proportion of diluent (e.g. skim-milk or whole milk) to get the required fat content.

Cream storage tanks may be fitted with load cells, but are normally fitted with volumetric measures of contents, and as such the density of the cream should be taken into account as higher fat contents give lower densities.

7.4 CALCULATIONS FOR STANDARDIZATION OF CREAM:

Example 1. 5,300 litre quantity of cream with a fat content of 42·3 per cent is available. Cream with a fat content of 40 per cent is required. How much skim-milk should be added assuming that skim-milk contains 0 per cent fat.

Quantity of fat in cream = 5300 x 0.423 x p kg =2241.9 p kg

where p is the density of the cream.

The total amount of cream that would have this quantity of fat as 40 per cent of its content would be

2241.9p x 100/40= 5605p kg = 5605p/p' l

where p' is the new density of the cream.

305 (=5605-5300) litres of Skim milk shall be added to 5300 litres of cream to obtain 5605 litres of standardized cream.

Alternatively, the Pearson square method can be used with more convenience as shown below: (to be calculated)

Example 2. If in the above example whole milk with 4·2 per cent fat content were to be used as a diluent, the calculations will be as shown below:

The essentials of the method are shown in Fig.8.2. The fat content of the cream used is set in the top left-hand corner of a square (42.3 per cent) with the fat content of the diluent at the bottom left-hand corner (4.2 per cent). The required fat content is then placed at the intersection of the square's diagonals (40 per cent) and the proportions of the cream and the whole milk are simply obtained by subtraction along the diagonals.

Cream required =40-4.2 = 35·8 parts Whole milk required =42.3-40= 2·3 parts

Thus the amount of whole milk added to 5300 I of cream should be

5300 × 2.3/35.81=3411

i.e. the cream should be made up to 56411 with whole milk.

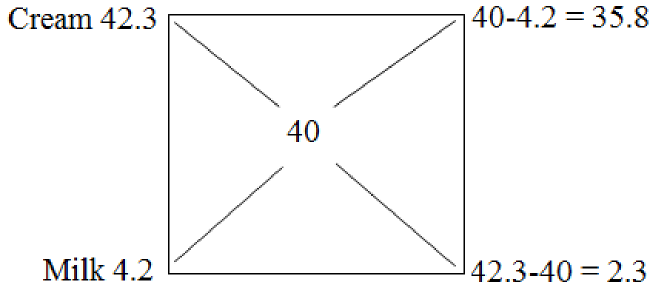

Fig.7.1 Pearson's square as a means of calculating proportions of components for standardising.

These are only approximations, as strictly speaking the calculation should be based on weight rather than volume. However, if the change in fat content between the original and the standardised cream is not too great, then the approximation of equal density can be made. The relative inaccuracy of the tank volume measurements and any air entrained in the cream will also give a false volume measurement. Because of these inaccuracies, final analytical checking of fat content is advisable.

In high volume factories, it is more convenient to produce cream of a required fat content directly from the separator. This can be done purely by adjusting the flow of skim-milk and cream via back pressures for a fixed flow of incoming milk. Provided the fat content of the milk is known, the back pressures on the cream and skim-milk lines can be adjusted with special valves to provide the required proportional flow of skim-milk and cream. The important factors in such an operation are that standard conditions prevail during separation and that flow regulators are accurately calibrated. Flow measuring devices that assist these operations are available.

More sophisticated operations require an accurate measurement of milk fat content as the cream leaves the separator. A convenient method of ascertaining the fat content of cream is to measure its density, which is a function of the fat content. For example, in the temperature range 40-80°C density (kg/m^3) can be computed using an equation

$$D = 1038.2 - 0.17T - 0.003T^2 - Ø (133.7 - 475.5/T)$$

Where T= Temperature in ^{0}C

Ø = Fractional fat Content

or

$$\text{Density of cream} = \frac{\text{Fat \% x Density of fat + Skim milk \% x Density of Skim Milk}}{100}$$

As cream density is largely influenced by fat content and the use of an in-line densitometer can provide a constant monitor on fat content. For standardization, a constant density is required, and in this regard the unsophisticated principle of maintaining a constant volume at a constant weight can be used. A U –shaped tube of liquid is counterbalanced by weights, and any movement of the tube through losing balance can provide a signal to a controller to restore the balance. A diagram of such an instrument is given fig 7.3 and 7.4. It also contains density measurement as a means of direct standardization.

The densitometer is sensitive to vibration, and air incorporation in the cream will greatly affect its accuracy. Other mass flow meters that relate density and total flow of liquid are available. Less sophisticated systems that incorporate a Milkotest are available and are less sensitive to environmental changes, although not as accurate as a densitometer. There have been very significant advances in control systems, which incorporate microprocessors to receive signals from measuring devices and transmit them to operate controls. Figure 7.3 illustrates a typical arrangement for producing standardized cream. Figure 7.4 shows an extended system for producing standardized milk and cream. The major perturbations for such systems are changes of milk feed silos, which may change milk composition as well as feed pressure to the separator, and de-sludgings of the separator. The efficiency of a system depends very much on the rapidity of response to such changes and the re-establishment of the required conditions through design and tuning of the feedback control loops.

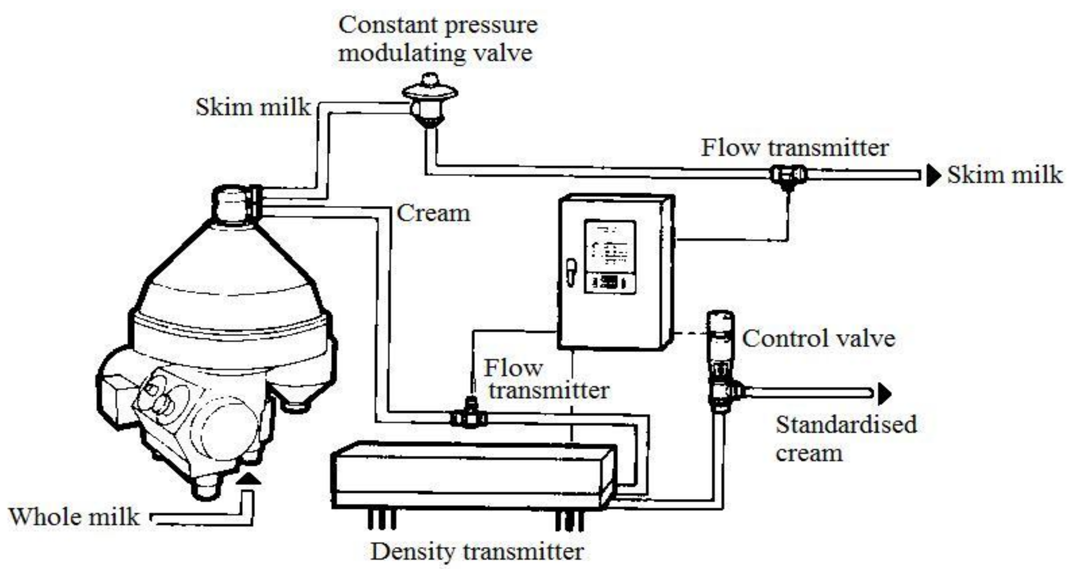

Fig.7.2 System for automatic production of standardised cream

(ALFAST, courtesy of Alfa-Level)

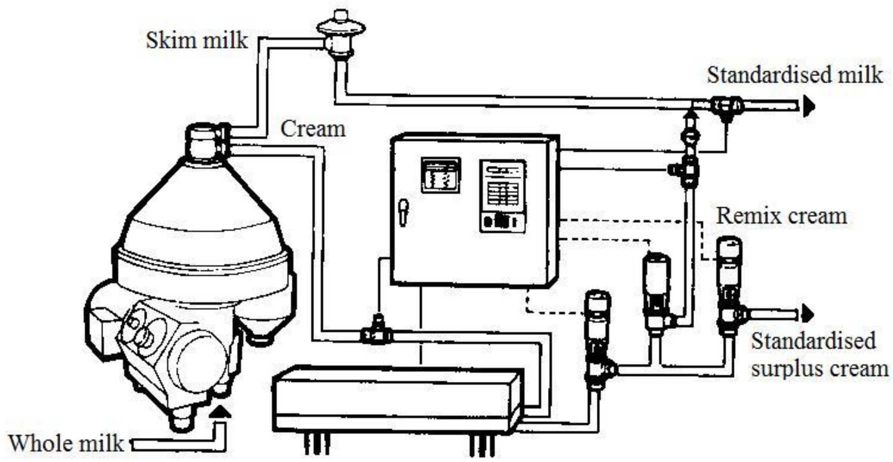

Fig.7.3 System for automatic production of standardised cream and milk

(ALFAST, courtesy of Alfa-Level)

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Lesson -8

Pasteurization of Cream

8.1 INTRODUCTION:

Heat treatment of cream is necessary to destroy organisms that may be pathogenic or cause spoilage and inactivate enzymes. Lactic acid produced by bacteria, causes souring and coagulation of cream. Protelytic enzymes may produce bitter peptides and also cause coagulation. Lipolytic enzymes will break down the lipids to produce free fatty acids which give a rancid flavor. Cream can be pasteurized by conventional means and the principles of heat treatment of milk can be applied to cream. Cream is more viscous and somewhat more susceptible to mechanical break down, and this should be borne in mind when choosing equipment for cream pasteurization. For example positive pumps would be preferred to centrifugal pumps. Whereas 72°C for 15 s might be a typical regime for pasteurizing milk, a higher temperature about 80°C would generally be used for pasteurizing cream. A higher temperature than 80°C may impair cream quality, possibly through activation of bacterial spores.

Pasteurization of cream refers to the process of heating every particle of cream to not less than 70°C for 20 min or 80°C/25 s.

8.2 OBJECTIVE:

The objectives of pasteurization of cream are:

* To destroy the pathogenic organisms in cream

* To destroy the undesirable micro organisms and inactivate the enzymes

* To complete the neutralization process in the manufacture of butter

* To eliminate some of the gaseous tainting substances

* To make possible the removal of some volatile off flavors by vacreation

8.3 METHODS OF PASTEURIZATION:

8.3.1 Batch Pasteurization: It is a satisfactory and economical method for small scale operations, but is not practicable for larger scale operation. The cream is heated to 70°C for 20 minutes and then promptly cooled. An increase in temperature may reduce the time say, 25 s at 80 °C. The vat pasteurizers in commercial use are of two general types, namely, jacketed vats with mechanical agitators and vats without jacket that are equipped with revolving or oscillating coil. In the jacketed vat the jacket contains the heating and cooling element. The hot water, cold water, or brine, respectively, is sprayed against the jacket side of the heating surface. The cream is agitated by a series of blades moving to and fro length wise or in the case of round tanks by a vertical rotating wing agitator, or by one or more impellers.

8.3.2 High Temperature Short Time Pasteurization: The HTST is done with the help of plate heat exchangers. The plate heat exchanger is made up of a series of thin metal plates that are held tightly together in a press. The plates are grooved (corrugated) either on one side or on both sides; in the latter case the grooved plates alternate with flat plates. The grooves serve as canals through which the cream flows. This pasteurizer is built for high temperature flash heating, or limited retarding or holding pasteurization, with regenerative and cooling units. The heating medium and the cold water and brine travel in counter current to the flow of cream. The depth of the grooves in the plates determines the thickness of the layer of cream between the plates. The grooves are shallow and even deep. They therefore, ensure a uniformly thin layer of cream. This fact together with the thinness of the metal plates and the high velocity of the heating medium ensures rapid and uniform heat exchange and makes possible the use of hot water at a temperature only a few degrees higher than the desired pasteurizing temperature of the cream. It also practically eliminates the tendency of scorching and of cooked flavor. The plate heat exchanger is flexible to alter the capacity. For increasing its capacity more sections of plates are added. Generally plate type pasteurizers are used with regenerative system. This is a continuous process and most suitable for large scale operation. The plate type pasteurizers may have some problem with some acidic/neutralized cream as this forms burnt-on-films more easily on the plate while it is most suitable for freshly separated sweet cream. In this system, the maximum heating temperature may be 95-100 °C for 15 seconds. A temperature of 82.2 to 85°C / xxxxxx time is most common.

8.3.4 Vacuum Pasteurization: The pasteurization of cream by this system, using the principle of reduced atmospheric pressure has advanced rapidly in recent years. In some countries it is replaces all other machines. Vacuum pasteurizers are available as vacreator or volatilizer.

8.3.4.1 Vacreator: Pasture feeding of animals can produce flavour taints through herbage derived substances dissolved in the fat. As most of the tainting substances are relatively volatile, a process was devised in New Zealand both to pasteurise the cream and to remove the volatiles through what is essentially a steam distillation process. The piece of equipment is known as a Vacreator, which was the trade name adopted for the Murray Vacuum Pasteuriser (present manufacturers and agents NDA Engineering Group, Auckland, New Zealand). The process is known as vacreation. Vacreation has been used in a number of countries, and not only it improves the flavour of creamery butter, but also extends the shelf-life significantly when compared with butter derived from plate-pasteurised cream. In the Vacreator, steam is intimately mixed with cream and the condensed vapour plus volatiles are removed by flash evaporation under vacuum. Figure 8.1 shows a diagram of a Vacreator consisting of five vessels. The typical pressure and temperature conditions pertaining to each vessel are shown on the diagram. Raw cream is preheated in a tubular heat exchanger by vapours exiting from vacuum vessels 3 and 4. The cream is mixed with steam and vapours. It exits from vessel 1 and passes into vessel 3, where the pressure is reduced slightly and the cream and vapours are separated. The cream is then mixed with steam and vapour, exits from vessel 2 and the mix is passed into vessel 4 for separation. The vapours from vessels 3 and 4 are combined and passed through the preheater, before passing to a water jet condenser which provides vacuum and condenses the remaining condensable vapours. A spring-loaded baffle valve applies a back pressure to vapours from vessel 3, so that the pressure difference required to transfer cream between vessels is maintained.

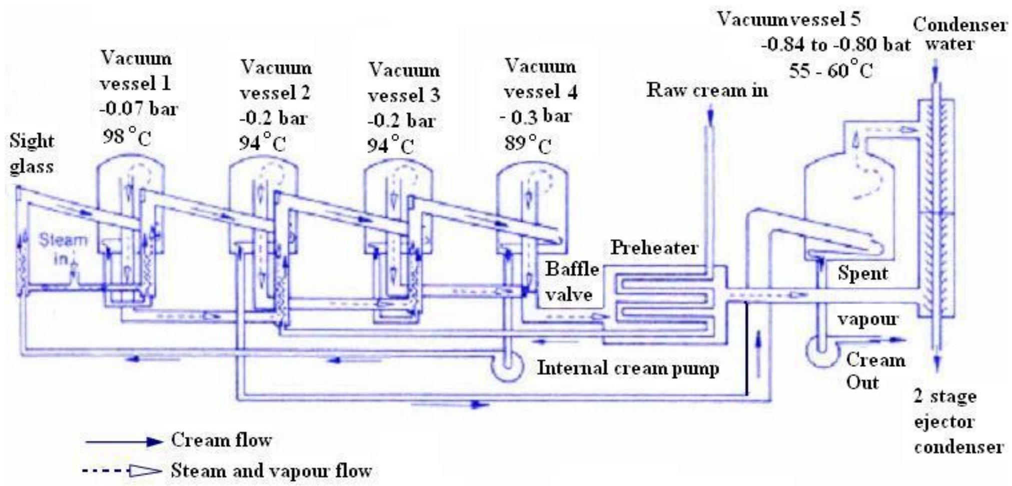

Fig.8.1 Schematic diagram of a Vacreator ®

The cream from vacuum vessel 4 passes into an internal cream pump and is pumped to vessel 1, where it meets fresh incoming steam. The cream separated in vessel 1 is mixed with fresh steam again before passing into vessel 2. The cream exiting from vessel 2 passes into vessel 5 which acts purely as a flash cooler, with the vacuum removing water vapour and the associated latent heat. The cream exits at approximately 55-60 °C, and the vapours are removed in the condenser. The somewhat complicated system is called 'weaving flow', and is essentially counter-current with the cleanest cream meeting the cleanest steam.

The somewhat complex nature of flows has been found to be necessary because of the tendency of cream to foam under vacuum, so that the separation of the liquid and vapours becomes difficult. The liquid and 'vapours are separated via a cyclonic centrifugal action with the cream being fed tangentially into each vacuum vessel at a slight down-wards angle. The vapours are removed through a centrally mounted pipe. If foaming is severe, liquid gets carried over with the vapour stream resulting in product loss. The flow of steam assists in providing the cream with sufficient kinetic energy to flow through the system, but loss of energy occurs in the separation process which necessitates the use of the internal cream pump to push the cream to the final two stages. The flow from vessel to vessel is also controlled through the pressure differential between the vessels, but the high operating temperatures (and thus low vacuums) mean that transfer of cream by pressure differences is limited to two vessels in series. The vacuum levels, temperatures and flows of cream and steam thus require very careful control to ensure that excessive product loss through foaming or flooding does not occur. The modern Vacreator is now equipped with microprocessor control to assist in achieving optimum temperature conditions during operation.

The amount of taint removed is proportional to the quantity of steam used. In the spring or during prolonged periods of wet weather, feed growth and the proportion of green feed in the diet results in increased levels of taints, and consequently high steam flows during vacreation are required, typically 0.25-0.3 kg steam/kg cream. During drier parts of the season, less green feeds are consumed so that less steam is required, typically 0.18 kg steam/kg cream, to remove the lower levels of taint. Taints resulting from poor quality cream may also be removed by vacreation, but high steam flows are required.

The major disadvantage of vacreation is its energy usage through the relatively large quantities of steam required, as the design of the Vacreator is such that vessel flooding will prevent operation at steam flows less than 0.15 kg steam/kg cream. Some heat is recovered through the preheater. Also available are thermo re-compressors, which will generate low pressure steam from waste heat recovered from the vapours. The low pressure steam can be fed to the raw steam entering the Vacreator, but the cost of thermo re-compressors warrants their use only with large, high-throughput units. The high energy usage of the Vacreator has led to some companies investigating flash-pasteurisation which incorporates a limited vacuum treatment. Such a process is acceptable for treating cream with a low taint level, but is generally unsuitable for cream with a high taint level if the cream is to be used for producing butter. Further experimental work in New Zealand has indicated that steam: cream ratios can be reduced if the proportion of steam entering vessels 1 and 2 is more carefully controlled. Control is by a valve that limits the quantity of steam passing to vessel 2, which is at lower pressure. With such control, the differential pressure between the two vessels can be maintained, and flooding of vessel 1 is eliminated even at steam flows as low as 0.09 kg steam/ kg cream

Steam quality is of utmost importance in Vacreator treatment. It must be of culinary standard and filtered because of the intimate contact with the cream. This limits the use of certain chemicals for the treatment of boiler feed water.

Steam is injected into cream during vacreation at a velocity of approximately 140 m s^{-1}(500 km h^{-1}), and this violent treatment causes disruption of fat globules with an increase in the proportion of fat present as small globules (<2 μm). Vacreation will also increase the number of large fat globules (> 10 μm) due to agglomeration resulting from foaming or flash-boiling. The increase in the number of small fat globules can lead to higher losses of fat in buttermilk. The introduction of low velocity steam diffusers alleviates this, and is possible when the steam split into vessels 1 and 2 is carefully controlled.

Certain models of Vacreator have the water ejector condenser replaced by a plate heat exchanger surface condenser and liquid-ring mechanical vacuum pump. Cream throughput of these models has been increased from maximum of 10,000 kg h^{-1} to 18,000 kg h^{-1}. The four primary vacuum vessels lie in a line with the pre-heater lying horizontally just underneath and to the rear of these. The flash vacuum vessel and condenser are situated behind the pre-heater.

8.3.4.2 Volatilizer: It consists of a steam injection flash pasteurizer and high vacuum retort (vacuum pan). Steam enters the pasteurizer (Stainless steel) at the top through direct steam jets. Cream is uniformly heated here to 85°C by direct steam. This heated cream is discharged from the pasteurizer through float controlled valve to a high vacuum chamber (which is made of glass-coated steel) at the top by vacuum discharge tubes. Its release into high vacuum pan causes it to form a fine mist which impinges against the sides of the pan and flows down over the glass coated surface in a thin film. The escaping water vapours and volatilized products are voided through the condenser, and the high vacuum (27-20 inches) lowers the temperature of the cream to about 38°C. The treated cream discharges from the vacuum pan at the bottom.

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Lesson-9

Cooling of Cream

9.1 INTRODUCTION:

The primary purpose of cooling of cream is to minimize the growth of microorganisms and bring about the desired fat crystallization required in butter making. With the advent of more efficient heat exchangers, plate cooling of cream is common. Relatively higher viscosity of cream as compared to milk necessitates particular attention in the design of plate heat exchanger.

9.2 METHODS OF COOLING PASTEURIZED CREAM:

9.2.1 Farm-scale Cooling: Cooling of cream can be accomplished by using tank type batch cooler or surface cooler, when the scale of operation is small as in case of farm cream production. For industrial purposes, surface coolers can be used but plate coolers and tubular coolers are commonly used. For small quantities of cream, use of ice water makes it possible to achieve rapid cooling to a sufficiently low temperature.

It is economical to provide a simple cream cooling tank, preferably insulated, in which the cream can is immersed in cool water. The ideal cream cooling tank is large enough to hold, sufficient body of water to avoid rapid warming up. It is sufficiently insulated to hold the temperature within a few degrees for eight to twelve hours. It is deep enough to allow the water to cover the cans at least as far up as the cream will reach when the cans are full.

9.2.2 Regenerative Heater Coolers:

Under commercial conditions, cream is cooled as part of HTST pasteurization process, where regenerative cooling is followed by final cooling by means of chilled water or other cooling media. The regenerative heater coolers operating on the plate-based or tube-plate based principles of reciprocating heat exchanges between the hot outgoing and the cold incoming cream. They are in reality preheaters and pre-coolers, since they neither heat nor cool to the desired final temperature.

When using a combination of intra-tube heater and surface cooler, the hot cream flows up through the inside of the pipe unit and the cold cream flows down over the outside of the pipe unit. The incoming cold cream is thus heated by the hot cream coming from the pasteurizer, and the out flowing hot cream is cooled by the cold, raw cream flowing to the pasteurizer. Under average conditions the temperature of the cold cream is thus raised by about 12-15^{0}C by the hot cream, and the temperature of the hot cream is lowered approximately 12-15^{0}C by the cold cream, thus accomplishing a considerable saving of heat energy.

9.3.2 Surface Cooler: Under average plant operating conditions, the surface cooler appears highly suitable for the cooling of flash-pasteurized cream. Surface cooler comprises two corrugated/undulated SS plates providing horizontal passages for cooling water or liquid refrigerant between the plates. The cream allowed to flow from top reservoir over the outside of the plates gets cooled. In order to avoid inconvenient height for operation and cleaning, the surface cooler is usually confined to two sections, each arranged with independent in-take and out-flow for the refrigerant. The upper section is cooled with water and lower section with brine or direct expansion ammonia.

The surface cooler has the added advantages of aerating the cream. This is especially desirable where steam jet pasteurization is practiced for the purpose of volatilizing objectionable flavors, thus facilitating escape of the volatilized products from the cream that is flowing in a thin film over the outside of the surface cooler. The surface cooler also permits some evaporation of moisture, which is desirable in the case of cream that has suffered dilution with steam condensate, as the result of steam injection pasteurization.

One of the drawbacks of the surface cooler is that, it "breaks" the closed system of the cream flow. Unless the cooler can be installed at an elevation high enough to permit the cooled cream to flow into the cream vat by gravity, an additional pump is necessary. In addition, the higher its elevation, the less accessible are its upper portions for proper cleaning. The cabinet surface cooler eliminates the drawbacks of excessive height. This type of surface cooler consists of multiples of cooling tube section, arranged on the same level, instead of one on top of the other as represented by the old line surface cooler. The cabinet cooler has distinct advantages over the open surface cooler.

9.3.3 Internal Tube Cooler: The internal tube cooler consists of the two-tube principles, one inside of the other. The cream flows through the inner tube, while the refrigerant flows in counter current between the inner and outer tubes. The usual unit consists of one or two sections for water and one section for brine or direct expansion ammonia.

This type of cooler has the advantage of preserving the "unbroken," closed system of cream flow, discharging the cream into the vats and up to any reasonable elevation without the need of a pump at the discharge end of the cooler. The internal tube cooler does not subject the cream to aeration. If aeration is desired it should be provided before the cream reaches this cooler.

In the case of sour, neutralized cream, the internal tube cooler usually does not permit of cooling to a temperature much below 15.5^0 C without danger of the formation of a cream plug and of clogging. This tendency is especially prevalent when such cream has received severe prior treatment, such as, for instance, in connection with prolonged vacuum for removal of obnoxious flavors and odors. It is to refrain from attempting to cool such cream to churning temperature (below 15.5^0 C) in this cooler, and to finish the cooling to the final low temperature in the coil vat.

Forcing the cream through several standard sections of internal tube cooler, subjects it to considerable pressure, which further aggravates the tendency of cream in which the emulsion coefficient has already been lowered to near the” breaking” point, to churn either in the cooler or in the vat, causing delay and extra labor, and often costly loss of fat.

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Lesson -10

Coffee Cream, Sterilized Cream and Whipped Cream

10.1 INTRODUCTION:

Cream is added as an ingredient to a large number of commercial food products including canned soup, dried bakery mixes, etc. In this context the cream serves as a source of dairy fat and its structural properties are of little importance. There are, however, two major product groups viz., alcoholic cream liqueurs and cream cakes, desserts etc., where cream is both a major ingredient and a major determinant of the properties of the complete product. The major consumer cream products include coffee/table cream, whipped & whipping cream and sterilized cream.

10.2 COFFEE CREAM:

Coffee cream is a low-priced cream with a fat content of 16 to 25 per cent, which is used in coffee and on fruits and cereals. Coffee cream is a long-shelf-life product, similar to UHT milk. It is a special type of low-fat cream processed to minimize 'feathering', the coagulation and release of free fat, which occurs when cream is added to hot coffee. Further, coffee cream is providing an attractive appearance to the coffee with an appropriate modification of flavor.

Production of coffee cream by UHT process: The fat content for coffee cream has to be standardized as per the legal requirements. The standardized coffee cream must be homogenized to prevent fat layer or fat plug formation in the container, thus improving taste, whitening power and stability. Homogenization has a direct influence on the flocculation stability of coffee cream in hot coffee. A double-stage homogenization is optimal for UHT cream. The first homogenization is done before the UHT treatment; the second aseptic one is done after the UHT treatment. For both processes the pressure in the first stage should be about 200 bar and in the second stage about 50 bar. Standardized coffee cream is processed as per the UHT process and is filled aseptically into one-way containers of standard net volumes.

Production of coffee cream by sterilization process: When preserving coffee cream by the sterilization process is carried out, first fat content is stanfderdized, then pasteurized at 90°C, homogenized, filled into bottles, closed by crown corks and finally sterilized in retorts. In the process of sterilizing cream in the pack, homogenization has to take place before the sterilization, which again is a double-stage process using the same pressures (200/50 bar) as per UHT process.

10.3 STERILIZED CREAM:

Sterilized cream is packed in cans and sterilized using similar plant to that used for sterilized milk. In the production of sterilized cream the fat content is standardized, then the cream is preheated to 140°C for 2 s to reduce bacterial spores. The cream is homogenized at 50-75°C using either single or two-stage processes. The stabilizing salts are then added to prevent the 'grainy' texture which is a defect that occurs following sterilization. The cream is filled into cans which are seam closed. The cans are coated on the inside with a lacquer, e.g. an epoxy-phenolic compound suitable for both acid and non-acid foods, which prevents reactions between the cream and the tinned steel of the can. Sterilization may take place in static batch retorts, agitated batch retorts or continuous retorts. If the product is agitated during processing, it increases the rate at which the required can-centre temperature is reached, thereby reducing the overall processing time. Generally for a 170 g can, the time required for a static retort is 40 min to reach 118°C, followed by a further 30 min at this temperature to effect sterilization . In contrast, for an agitating retort only 23 min is required to reach 118°C followed by a further 18 min at this temperature to effect sterilization. A continuous retort requires 26 min at 119.5°C for sterilization. After sterilization the cans are cooled with chlorinated water, dried, labeled, packed in paperboard boxes and stored at ambient temperatures prior to distribution.

10.4 UHT CREAM:

Indirect process: The Process for the preparation UHT cream is similar to the production process of UHT milk. For the production of UHT cream the heat exchangers used are mainly of plate or tubular design. Homogenizers are placed between the regeneration and UHT sections. The plant with up-stream of the UHT section and holding tube can be regarded as non-sterile, while those downstream are sterile and the plant must be maintained to a high standard of hygiene before use to reduce the risk of bacterial spores contaminating the product. The pre-sterilization of all plant with steam is most effective.

Direct Process: Cream may be UHT processed using methods of direct heat exchange. Apart from diluting the cream by as much as 10-15%, the instantaneous heating of cream and the shear effects occurring, as cream and steam are mixed, can destabilize the milk fat globules. Homogenization is therefore necessary to restore the emulsion, and when direct methods of heat exchange are used the homogenizer is placed downstream of the heat-treatment section. Clearly, a vacuum cooling section is required to remove the water added through the direct contact of cream with steam and this is placed before the homogenizer. Whether cream is homogenized prior to UHT treatment or after, the product temperature should be between 50-75°C. Low-fat UHT creams require high pressure homogenization, whereas other creams may be homogenized at lower pressures.

Aseptic packaging: UHT cream must be aseptically packed. The following are the various packages are commonly used:

* The form-fill-seal laminated carton is used as it contains aluminum layer in the laminate which is essential if the product is to be preserved from the auto-oxidative influences of light during storage.

* Thermoformed containers made from the coextrusion of polystyrene and polyvinylidene chloride (PVDC) are also used and these containers are closed with heat sealed polyethylene/ aluminium laminate foil.

* Blow-moulded polyethylene or polypropylene containers formed at the point of filling may be used and for bulk UHT cream, bag-in-box packages made from metallized plastic laminates may be aseptically filled.

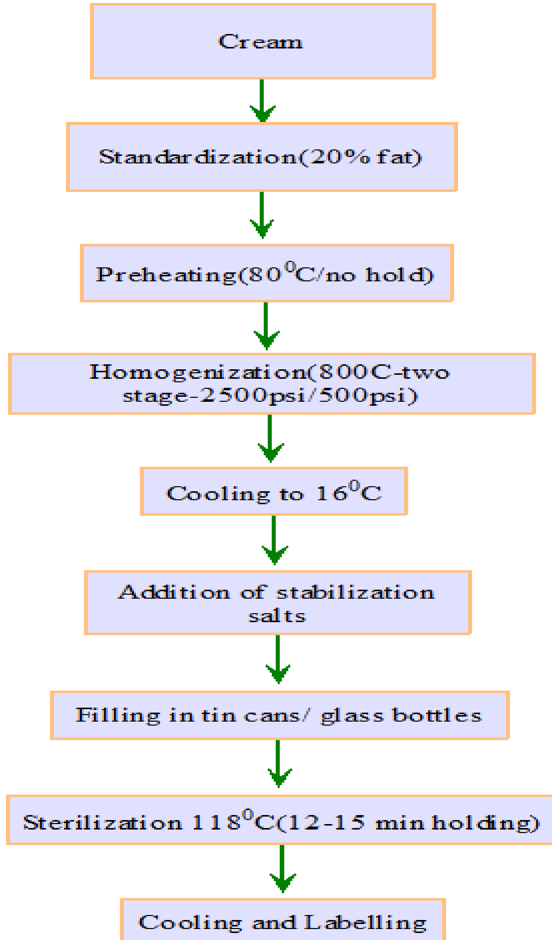
10.5 WHIPPING CREAM:

Whipping cream is one of the food foams. It is widely accepted due to its taste and multiple applications in decorating and refining of food. Whipping cream can be differentiated into the fresh whipped product as manufactured in the dairy for distribution and the whipped cream. The cream is usually whipped immediately prior consumption, either by the consumer or in the catering outlets. The basic requirements for this product are:

a. Good whippability i.e., short beating time and a volume increase of at least 80%, mostly 100-150%.

b. Good foam stability and firmness of the foam i.e a defined weight of 100 g with defined dimensions should not penetrate more than 3 cm within 10 seconds.

c. Low serum formation i.e., a cube of whipped cream with 6 cm length/width/depth should not exude serum after 1 hour at 18^0C and should exude a maximum of 1 ml after 2 hour of storage.



10.1 Flow diagram for manufacture of sterilized cream

Process:

Cream preparation and fat standardization: Standard quality requirements for raw milk must be applied when manufacturing whipping cream. A special point is the fatty acid composition, which depends on the feed situation. Milk fat with a majority of saturated fatty acids i.e., high melting point and a low iodine number (so-called winter cream), results in firmer foam than a softer fat. Fat standardization is done in the separator in the same way as for market milk. Minor modifications can be made by adding whole milk or cream with a higher fat content. Fat corrections with skim milk result in reduced whippability and foam stability. These decisive quality criteria are improving with increasing fat content (> 30%), with 35% being the optimum.

Acidification/ripening: Whippability depends on both the characteristics of fat globular membrane and the state of hydration ofthe serum protein. Favorable conditions for foaming of the proteins exist at a pH of 6.4-6.2. To set the pH of the cream, butter cultures can be added (0.5-2%), followed by ripening at 10-15 °C, until the preset pH has been reached. The objective of the ripening is to achieve good fat crystallization or fat hardening. Total ripening time (before and after filling/packing) should be a minimum of 1-2 days at temperatures < 10°C.

Homogenization: In general, homogenization improves foam stability and avoids the creaming of the fat, which is an absolute requirement for UHT and sterilized cream with their longer shelf life. Experience has shown that a single-stage homogenization leads to earlier gelation of the product, due to the inherent and additional viscosity caused by the agglomeration of fat globules. A two-stage homogenization is preferable with the following criteria for a 30% fat cream:

* I-Stage at 70°C and a pressure of 60-70 bar

* II- Stage at 70 °C and a pressure of 15-20 bar

For pasteurized cream having the same shelf life as fresh milk, homogenization is not necessary.

Heating and cooling: Whipping cream must be heat treated with an approved process. For fresh whipping cream, pasteurization is done mainly with a high-heat process, where temperatures > 95°C are chosen. Whipping cream with an extended shelf life is manufactured by the UHT process and filled aseptically. Sterilized whipping cream is sterilized after the filling operation. After heating, a shock cooling should be applied for fresh cream, using temperatures of < 10°C (optimum 2-4°C) in order to achieve good fat crystallization and foam stability.

Filling is done into glass bottles or into one-way containers (for shelf-stable whipping cream) such as cups or bricks with user-friendly volumes of 150 g, 200 g, 250 g, and 500 g. For large-scale users containers with a net volume of 2 liters up to 15 liters or churns of 20 liters content are used.

Two methods are used in the application of aerosols:

a. Aseptic filling of homogenized, UHT or sterilized cream into spray cans (used as one-way containers)

b. Non-aseptic filling into so called siphon bottles, in which after filling of cream and closing of the bottle, a cartridge with a compressed air is used.

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Lesson-11

Clotted Cream, Frozen Cream, Cultured Cream

11.1 INTRODUCTION:

Clotted cream and cultured creams are essentially used for direct consumption or as topping in salads etc., while frozen cream is generally used for reconstitution purposes as source of fat.

11.2 CLOTTED CREAM (>55 per cent fat):

The traditional process involves batch heating of gravitationally separated cream. The heating process induces rapid fat rise. The fat agglomerates on the surface and protein denaturation also takes place. It is characterized by a thick and spreadable texture, nutty flavor and slightly granular texture. The color varies from a pale to a deep yellow depending on local preference. Clotted cream was, for many years, a farmhouse product and significant quantities are still made on a small scale by traditional process.

Traditional Process: The process in which cows' milk is strained into shallow pans which are left for 6-14 h to allow the cream to rise to the surface of the milk. The milk with cream layer is then heated in the pans over a water bath, and the product is held at a temperature of 82-91°C for 40-50 min. During cooling over a period of 24 h the cream layer forms a solid crust which can be lifted clear of the skimmed milk beneath to yield a product with > 55% fat content and often around 67% fat.

Commercial Process: Two methods of larger-scale manufacture are used for producing two types of clotted cream;

* Float cream method and
* Scald cream method

Float cream method: The float cream is made in large, open top vessels often arranged in tiers. This method involves scalding a layer of double cream poured over skimmed milk or whole milk held in shallow trays. The trays have jacketed bottoms which are heated with either steam or very hot water. Over a period of 45-60 min the clotted cream crust develops and the product can then be cooled for 12-18h. The cream hardens and it can then be scooped clear of the milk layer and packaged.

Scaled cream method: In this process mechanically separated cream with >54% milk fat content is used. The cream is poured into aluminum or stainless steel shallow trays to form a layer about 20mm deep and the trays are heated either in a water bath or over a low pressure steam chest. During

scalding the cream reaches 77-85^{0}C for 45-70min, following which the trays are transferred on trolleys to a chilled store to cool the product.
Before packing the temperature of both float cream and Scald Cream should be 4-7^{0}C. Clotted cream may be packed in polystyrene flat-topped round containers, closed with a polyethylene/aluminum laminated foil. Alternatively, it is often packed in square or rectangular, shallow HDPE containers closed with a clear plastic film and inserted into a paperboard sleeve carrying the product information.

11.3 FROZEN CREAM:

Cream which is intended purely for ingredient use where structure is unimportant may be frozen without any special precautions. The objectives of frozen cream are as follows:

* To improve the keeping quality of cream during transportation over long distances
* To store surplus cream for use during shortage. Mainly used by ice-cream manufactures who add sucrose (10 to 15 percent by weight) to cream before freezing to prevent oiling off after thawing

Method:

* Separate and standardize cream to 40-50 percent fat.
* Cream should be pasteurized at 75-88^{0}C for 15s
* Cooled to 1^{0}C as quickly as possible before freezing
* Freezing may be carried out within containers, on a band to give a sheet or pellets, or by direct contact with liquid nitrogen
* Bulk storage of frozen blocks of cream in polyethylene bags may be used for surplus cream that is to be later converted into butter or anhydrous milk fat.
* Cream should be frozen as quickly as possible and stored at -18 to -26^{0}C, the lower the temperature better will be keeping quality.

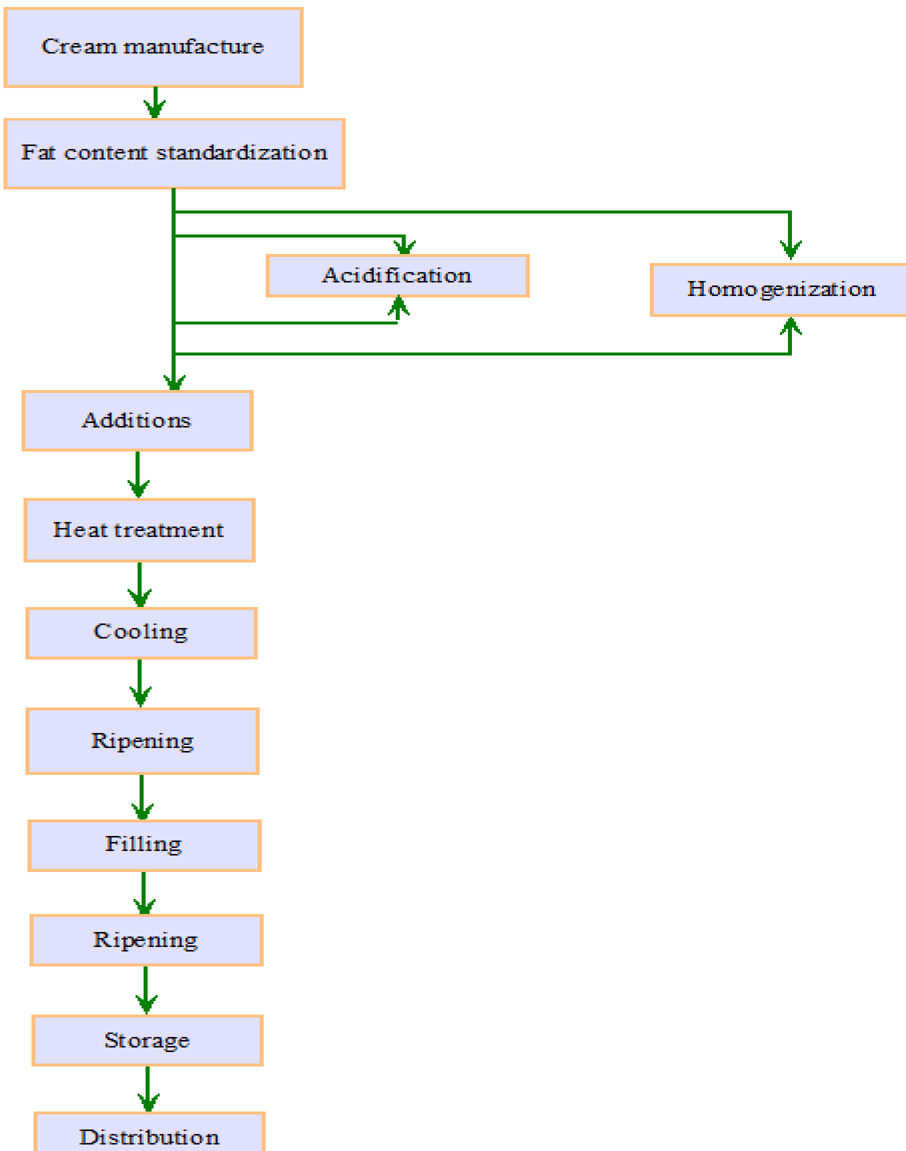
A keeping quality of 2-18 months with an average of about six months can be expected. The shelf-life of the cream will be limited by physical and chemical constrains for that product.

11.4 CULTURED (SOUR) CREAM:

Sour cream is mainly used in prepared foods, less often in drinks or beverages. Sour cream is an extremely viscous product with the flavor and aroma of butter milk, but with a fat content of 12-30%, its method of consumption is more similar to that of normal cream. Sour cream is used in a number of meat dishes, vegetable dishes and confectioneries.

Production: A typical schedule for production would involve fortifying/standardization whole milk with cream to give the desired fat content, and then heating the mix to around 80°C for 30 min. Homogenization at 13-14 MPa (minimum) and 60-80°C follows, and then in general increases in pressure or temperature above the minimum tend to improve the consistency of the retail material. After cooling to the inoculation temperature of around 21°C, the cream is mixed with 1-2% of mesophilic butter culture, and incubated at 21°C until an acidity of 0.6% lactic acid has been reached (18-20 h).

On cooling, the sour cream is then ready for packing in cartons prior to dispatch, but care must be taken at this stage to avoid any serious deterioration in viscosity. It is for this reason that some manufacturers incubate the cream in the retail cartons, and certainly this process can give rise to a markedly thicker material.



11.1 Flow diagram for manufacture of sour cream

Lesson -12

Other Consumer Cream Products

12.1 INTRODUCTION:

Cream products are classified according to their method of production and their fat content. Cream is defined as that part of milk rich in fat which has been separated by skimming or otherwise and compulsory descriptions exist for clotted cream, double cream, whipping cream, whipped cream, sterilized cream, cream or single cream, sterilized half cream and half cream. Pasteurized cream accounts for most of the cream produced for retail consumption and industrial use. Other pasteurized creams include extra thick creams, the texture of which is modified by homogenization and sequential cooling, and frozen versions of single, whipping and double creams. UHT creams conforming to the standards for half, single, whipping and double creams are made for the convenience of extended life storage at ambient temperatures. UHT cream packed in aerosol containers with a nitrous oxide propellant and containing, for example, sugar, carrageenan and mono- and di-glycerides of fatty acids to enhance foam stability, are available for dessert and beverage applications example for topping hot chocolate.

12.2 HALF AND SINGLE CREAMS (10-18 PERCENT FAT):

These creams would normally be used as pouring creams for use in desserts and beverages. Homogenization is essential for half and single creams both to produce an acceptable viscosity and to prevent separation of the fat and serum phases. Single cream is commonly subject to single-stage homogenization at pressures up to 25 MPa, but higher pressures of up to 30 MPa, are required to produce an acceptable viscosity in half cream. In each case a homogenization temperature of 55°C is used. In the US a product described as 'half and half is retailed and consists of a mixture of milk and cream with a fat content between 10.5 and 18%. 'Light' cream has a fat content of 18-30%.

12.3 DOUBLE CREAM (> 48 PERCENT FAT):

Double cream is marketed predominantly in Europe and represents an extra rich product for addition to desserts. Homogenization is not usually necessary for double cream with the exception of UHT sterilized product. Homogenization, controlled cooling, or a combination of these processes may, however, be used to produce 'extra-thick' pasteurized creams of much higher viscosity than is normal. Single-stage homogenization is used at a pressure of 3.5 MPa, or less, at. 55°C.

12.3.1 High-fat spreadable creams: These are produced in other countries including Yugoslavia and Iran. Manufacture of some types involve passage of cream through a second, specially designed separator, but in other cases a heating process similar to that of scald cream is used.

12.3.2 High fat creams: Several high fat spredable creams are found as indigenous products around the world. Examples are Gammer cream (Iraq) and Kajmac (Yugoslavia). High fat creams can be simply produced by passing normal cream through a second separation. Such a separator should have relatively wide disc spacing, and the distribution channels should be approximately half way down the disc faces. As the fat content in the cream rises and the globules pack together more tightly, the stability of the emulsion is reduced and phase inversion takes place very easily. A very high fat cream (70-80 percent fat) is known as plastic cream.

12.3.3 Confectionary, butter or mock creams: Such products are low moisture products containing high concentrations of sugar or other sweeteners and are used as cake and bun fillings. They are in fact, phase inverted creams with the aqueous phase emulsified in the fat. The fat base is aerated by mechanical beating. Sweetener is usually added later.

12.4.4 Dried cream: Dried cream may be considered to be a dried milk product with a higher fat content than dry whole milk. Depending on the initial cream the fat content is 40-70% and the moisture content is less than 2% (cf. anhydrous milk fat). Spray drying is used, problems arising not from the drying stage, but from handling the warm powder. The fat is in the liquid state on leaving the drying chamber and prone to membrane rupture and subsequent caking. Non-fat solids, usually sodium caseinate, and a carbohydrate carrier (lactose, sucrose or glucose) must be present to encapsulate and protect the fat globules and cyclone separation is not suitable due to caking on the cyclone walls and blocking of filters. A satisfactory solution is to remove the powder from the dryer on a moving belt and cool to solidify the fat in a fluidized bed. Alternatively, the Filtermat dryer may be used.

Dried cream powder is susceptible to oxidation and manufacture requires a high heat treatment, prior to drying, to inactivate lipases and the addition of an anti-oxidant before storage. A 'free-flow' agent such as calcium silicate should also be added and the storage temperature should be sufficiently low to maintain the fat in solid form and prevent caking. Dried cream has only limited functionality and does not reform as the natural product unless special emulsification and homogenization procedures are used. The product does, however, have an ingredient role as a free-flowing milk fat concentrate.

12.4 CREAM SUBSTITUTES:

The demand for substitutes arises primarily for economic reasons rather than the dietary concern which has stimulated the development of other dairy product substitutes. Indeed the high sugar content of many substitute creams precludes their acceptance as truly 'healthful' foods, although low calorie and reduced-fat substitutes are now increasingly popular.

Imitation cream: It is available in a number of consistencies corresponding to different types of natural cream. The product resembles natural cream in being a fat-in-water emulsion. A fat content of 15% is common and such a formulation also containing 7% sugar, 3% milk solids-non-fat and 0.4% emulsifier. When vegetable fats are used, the selection of fats depends on the properties required in the end product. Fat modification permits close matching with desirable organoleptic properties, but in all cases homogenization, usually two-stage, is an essential part of processing. The physical properties of imitation creams closely resemble those of their natural counterparts, but the physico-chemical relations of the fat globules are entirely different.

12.4.1 Imitation soured cream: It is made using acidulants such as glucono-δ- lactone and has recently found popularity as a 'party-dip'. Some types of imitation creams are suitable for whipping, but various types of 'whipped topping' are produced. These include aerosolized products containing 24-35% fat, 6-15% sugar and 1-6% vegetable protein which, in combination with stabilizers and emulsifiers, produce a very stable whip. Frozen, ready whipped toppings and powders, formulated for easy reconstitution, are also widely available and utilize the same basic ingredients. Flavouring and colouring may be added to produce a mousse.

12.4.2 Coffee whitener is prepared either as a liquid product, frozen for retail distribution or as a powder blend. The fats in such products are usually of non-dairy origin.

12.4.3. Low calorie cream substitutes are made in which a sweetener, usually aspartame, replaces sugar and there is an increasing demand for products in which the fat is partly or wholly replaced. Bulking agents such as carboxy methyl cellulose, pectin or poly dextrins may be used as the base or the fat may be replaced directly by fat-replacers such as Stellar, prepared from modified corn starch, or Simplesse, prepared from whey protein concentrate. Dried cream extract may be added to improve flavour. A product with many of the properties of cream, 'cell cream', has also been developed which consists of ultrafine cellulose particles dispersed in water.

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Lesson -13

Packaging and Storage of Cream

13.1 INTRODUCTION:

Cream is a high moisture product, and hence is easily perishable. It needs special care to preserve and improve the shelf life. Pasteurization of cream extends the shelf-life to greater extent, but packaging of cream also play in extending the shelf life of cream. Type and characteristics of packaging material used for cream will vary depending on the manufacturing process of cream and also intended use of finished end product i.e. for retail or wholesale marketing.

13.2 GENERAL REQUIREMENTS FOR PACKAGING OF CREAM:

Various formats exist for the packaging of pasteurized or fresh cream. The following are the important factors to be considered in packaging of all creams, whether pasteurized, UHT treated or sterilized:

* The exclusion of light is important as light can initiate auto-oxidation of milk fat resulting in the production of rancid flavors. Homogenized cream is particularly susceptible to the action of light.
* Cream may be tainted by the absorption of odors from various sources and packaging material must, therefore, be impermeable to gases.
* The absorption of moisture or fat can cause the quality of cream to deteriorate and packaging must, therefore, be impermeable to both.
* The packaging materials themselves may contain compounds which can migrate into the cream causing a gradual deterioration in quality, e.g. monomers from plastic packaging and printers' inks and dyes used for labels and decoration. Packaging materials should be carefully selected to avoid such problems.
* The design of the container can also influence product quality. With some creams serum separation may occur during storage and the ability to shake the contents to ensure mixing can be important to consumer acceptability.

Table cream : Table cream is packaged for retail sale in units similar to those for milk such as glass bottle, paper carton, low density polyethylene sachet, plastic bottles etc. When table cream is produced for the purpose of coffee whitening, UHT processing is combined with aseptic packaging employing 'multi-cup tray' package format, each cup quantity serving as a single dose sufficient for one cup of coffee.

13.3 PACKAGING FOR PASTEURIZED CREAM:

Retail packaging: Pasteurized cream is packaged in cartons and bottles for retail sale with package size usually being in the range of approximately 100-1000 ml. Pasteurized cream for retail sale was earlier packaged in glass bottles, waxed cartons and polyethylene-coated cartons, but now the most common form of packaging used is the injection moulded polystyrene pot, or flat topped round container. Polypropylene containers are used an alternative as these less likely to cause taint and, when used as a copolymer with polyethylene, it is more robust under chilled condition. However, due to technical difficulties these have limited use.

To improve the barrier properties of plastics packaging for fresh cream, multilayer materials may incorporate an ethylene vinyl alcohol (EVOH) layer. Once filled, the containers are closed with a heat-sealed polyethylene/ aluminum foil laminate and often a clear plastic lid is provided for consumers to reseal the container once opened.

Bulk packaging: It may be used for catering or institutional use. Normally plastic (e.g. polythene) bags contained in plastic crates or cardboard cartons are used for bulk packaging. In this case package size ranges from 5 to 25 liters.

13.4 STERILIZED CREAM:

In case of retort sterilized cream, tin cans and glass bottles are commonly used packaging formats. The simplest method of sterilization is to package the material, then heat the complete package and material to confer sterility. The can and glass bottle have been the traditional containers for such operations, but other retortable plastic materials are now available for packaging. It is normal to give the cream a preheat treatment before packaging to destroy bacterial spores. Sterilization takes place in a retort or hydrostatic sterilizer using temperature-time regimes of 110--120°C for 10-20 min. This severe heating induces gross changes in the cream with protein denaturation, Maillard browning and fat agglomeration may take place to modify texture and flavor. A calcium sequestering agent, such as sodium citrate or a sodium phosphate, may be added to make more casein available for stabilizing the emulsion. The unit packaging volumes have to be relatively small (400 ml) because of the restriction on heat transfer with larger volumes. Normally cream of approximately 23 per cent fat content is the base cream for in-can sterilized cream manufacture. It enjoys a substantial market as a dessert adjunct or ingredient in a number of food items, such as dressings and sauces. It is well known to be a good base for party dips.

13.5 UHT CREAM:

A number of different packaging options are available for packaging the UHT cream to pack and the following are some of the packaging options:

* Aseptic canning was probably the first to be utilized with cream
* Plastic (polythene), paper and foil laminate cartons and
* Plastic (polystyrene or polypropylene) form-fill-seal packages are most widely used
* Lacquered aluminum or tin-plate cans are used for Aerosol cream
* Preformed pots or with laminates
* Plastic (polythene) bag contained within a cardboard carton (bag-in-box) is used for bulk packaging of UHT cream with unit volumes are in the range 5-1000 liters.

For aseptic packaging the packaging material is first treated with hydrogen peroxide solution, later removed by squeezing or natural drainage. Residual solution is removed by heat; while the evaporating and decomposing peroxide sterilizes the material. The sterilized product must then be filled in a sterile environment. In Tetra Pak system, the laminate is in the form of a continuous tube and the evaporating peroxide above the filler forms a natural aseptic barrier. Individual packages are formed by heat sealers and cutters at the base of the filler. Most other systems incorporate laminar air flow cabinets for filling operations. Unit sizes range from 7·5 ml (coffee cream) to 1000 ml.

13.5.1 Storage and distribution

· Fresh cream can be stored at 5ºC and the shelf-life is 14 days. Cream is distributed as early as possible but preferably within 3 hours of removing it from cold storage.

· Frozen cream can be stored for 18 months.
· Sterilized cream can be stored for 6 months.
· Sterilized UHT creams have a shelf-life of several months at 5°C.

In addition to pasteurization, sterilization and UHT treatment of cream, the cream can also be preserved and stored for several months by freezing and drying of cream.

13.5.2 Freezing: Bacterial spoilage of cream can be inhibited by freezing of cream however this process leads to destabilization and gross separation of fat and serum resulting on thawing. Freezing of cream is done by two process:

Plate freezing: The plates contain circulating refrigerant are arranged vertically, in parallel, with bottom and end seals to form a series of moulds with hydraulic pressure maintaining the plates in place. The cream is poured into gaps between plates, and surface freezing is instantaneous at the pre-cooled plate surface; this is essential to prevent adhesion of the cream to the plate. The cream freezes progressively towards the centre with refrigerant in the plates absorbing the heat, so that finally slabs of frozen creams are formed. The slabs are removed for packaging and subsequent storing by separating the plates.

Drum freezing: A rotating drum containing recirculating refrigerant is immersed in a vat of cream to form a frozen film. The frozen cream is then removed from the drum with a knife, and a flaked product is obtained. Such a process gives somewhat more rapid freezing than plate freezing and is less damaging to the cream and is continuous. The cream flakes are packaged in heat-sealed plastic bags as used for frozen vegetables.

A temperature less than -18°C is recommended for long-term storage of frozen cream.

Uses: Frozen cream may be used as

* An additive for 'cream soups

* In recombined milk and ice cream

13.5.3 Drying (spray dried cream): Removal of water from cream gives a product with an extended shelf-life. The most common method of producing dry products from liquids is through spray drying. The particular problem in the production of spray dried cream is the high fat: SNF ratio in the finished product. The fat is in a liquid state at the temperature at which it would exit a spray drying chamber, so it is essential that the fat globules are encapsulated and protected by the non-fat solids. For cream, this normally requires the addition of extra protein, usually sodium caseinate, and the addition of a suitable carbohydrate (e.g. lactose, dextrose, maltodextrin or sucrose) to act as a carrier. Cooling of the powder is necessary to solidify the fat and prevent caking, which will occur if the thin protective membranes are ruptured. Cyclone collection of the powder results in mass caking of powder on the cyclone walls, and bag filters soon become impervious if fat is deposited. A Filtermat drier has a continuous woven belt for collecting powder from the primary chamber and cool air can then be directed on to the powder in subsequent (fluid bed) stages of the drier. This drier is used extensively to dry powders with high fat contents; these powders are usually based on vegetable fats.

The high fat content of cream powder renders it susceptible to deteriorations which impair the flavour. It is essential that the cream is given sufficient heat treatment to destroy lipases. Oxidation of the fat is also a potential problem, and addition of antioxidant extends shelf life. Storage of cream powders should be at low ambient temperatures, as an elevated temperature gives high proportions of liquid fat, resulting in caking problems, as well as more rapid flavour deterioration. The addition of free-flowing agent is recommended to help prevent caking.

Dried cream can be used as an ingredient for dried soup, dessert, ice cream or packet cake mixes.

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Lesson -14

Quality of Cream

14.1 INTRODUCTION:

The keeping quality of retail cream is more critical than that of milk for although cream usually receives a more severe heat treatment than milk but the distribution system is different. Thus, milk is usually pasteurized one day, delivered the next, and consumed a day or two later, while cream has to be separated, standardized, cartoned and distributed, often through a retail dairy organization, and then sold through super markets or shops. There may be no temperature control during this procedure, and as cream sales tend to be concentrated at weekends and on special occasions, and the carton may be opened and used more than once, the keeping quality requirements are severe. Some dairies now achieve, or at least aim at a keeping quality of 14 days with the cream held at temperature not exceeding 5°C

14.2 FACTORS EFFECTING THE PRODUCTION OF GOOD QUALITY CREAM:

1. Production of clean milk from the animals will have better keeping quality; as well the procurement of good quality milk is also most important. Poor quality raw milk, particularly with high spore and thermoduric counts leads to cream of short shelf life.
2. The milk procured from the farmers needs immediate cooling to prevent the growth of psychotropic bacteria that are responsible for the production of various taints in cream during storage.
3. Separation and processing the milk under hygienic conditions is another factor that affects the quality of cream. Cream separators are the important source of bacteria if not properly cleaned.
4. Wrong choice of temperature for heat treatment.
5. Prompt cooling of cream and its storage at lower temperature
6. Transport of cream to the dairy under lower temperature.

Of these factors the quality of the raw milk and storage temperature of the end product are perhaps the most important.

14.3 MICROBIOLOGICAL QUALITY OF CREAM:

The micro environment of cream and milk are the same except the difference in the proportion of various constituents like fat, protein, lactose etc. as a result the initial microbiological quality of cream is almost parallel to that of milk, but later stages cream presents more problems than milk because of longer storage and erratic distribution pattern.

The micro flora of cream processed in an unclean plant may include a very high number of psychrotrophs. If cream is not cooled rapidly to less than 5°C the organisms like *STAPHYLOCOCCI, LACTOBACILLI AND BACILLUS* cereus have generally been found to predominate. On the other hand, the prolonged storage of cream at low temperature leads to the predominance of psychrotrophs and psychrophilies usually of Protelytic and Lipolytic , mainly 'pseudomonads' a gram negative, non spore forming , oxidase positive, catalase positive rods which enter the product as contaminants from dirty water. Holding cream at 5°C results in the predominance of microflora like Pseudomonas, Alcaligenes, Acinetobacter, Aeromonas and Achromobacter where as at 30°C *CORNYBACTERIUM, BACILLUS, MICROCOCCUS, LACTOBACILLUS AND STAPHYLOCOCCUS* predominate. The coliforms in refrigerated cream multiply slowly at 3 to 5°C and may increase 100 to 1000 folds in few days.

14.4 RELATIONSHIP BETWEEN MICROBIOLOGICAL QUALITY AND CONDITION OF CREAM:

The quality of cream can be interpreted on the basis of microbiological counts like total count, coliform count, yeast count, mould count and spore count as follows:

Results	Interpretation
High count and high Coliforms	Inadequate heat treatment and or Unhygienic manufacture and or storage at high temperature.
High count but low Coliforms	Good hygiene but storage at high temperature
Low count but high Coliforms	Poor hygiene in manufacture but storage at low temperature less than 5°C
Low count and low Coliforms but high Moulds	Good hygiene except aerial contamination in dairy
Low count and low Coliforms but high yeasts	Good hygiene except contamination from fruits, directly or indirectly
Low count and low coliforms but high aerobic spores	Cream made from milk having a high spore count

14.4.1 Microbial defects: The following are some of the common causes that are responsible for the entry and for proliferation of spoilage causing microorganisms in cream.

1. Unhealthy udder of the milch animal which gives rise to infected milk and ultimately an unsafe cream.
2. Unhygienic production of milk leading to high microbial population in milk or cream.

3. Separation of cream in improperly clean cream-separator
4. Storage of milk or cream in unhygienic containers.
5. High temperature storage or in other words, lack of proper cooling of milk or cream, at various stage especially before heat processing.
6. Inadequate heat treatment during the pasteurization or sterilization.
7. Unhygienic personnel handling the cream after heat processing.
8. Faulty filling/packing/ canning of the product.
9. Delayed distribution of market cream coupled with storage under ambient conditions.

The commonly occurring microbial taints in cream include: sour or high/coarse acid cream, bitterness, rancidity, fruity taint, cheesy or putrid flavor, yeasty flavor and discolouration. The organisms responsible for one or more of such defects belong to different categories, namely pseudomonads, aerobic sporeformers, Gram-negative rods, lactic acid producers, yeasts and molds,. etc. Cold storage of pasteurized cream at 7.2°C to 10°C results in rapid multiplication of psychrotrophs like pseudomonas, other Gram-negative bacteria including coliforms and certain yeasts and molds, unlike that at 3.3 °C. Some mesophilic lactic streptococci, micrococci and aerogenes-cloacae strains of coliforms, which are derived from post-pasteurization contamination, can multiply relatively rapidly in cream held at 10°-12°C or above.

14.5 DEFECTS IN CREAM, THEIR CAUSES AND PREVENTION:

Defects in cream may arise from low grade milk and faulty methods of production, processing and storage. The common defects in both table and manufacturing creams, their causes and prevention, are given in the following Table.

(A). Table cream

FLAVOUR DEFECTS:

Name of Defect	Causes	Prevention
(a) Flavour Cooked	Excessive heating of cream during pasteurization.	Proper heating of cream during pasteurization
Highly acid/sour	i. Using sour milk for separation ii. Acid development in cream	(i). Using fresh, sweet milk for preparation. (ii). Neutralization of cream.
Oxidized/oily/ Metallic/Tallowy	Fat oxidation due to direct contact of milk with copper or iron, exposure of milk or cream to sunlight, etc.	i. Proper tinning of milk or cream holding vessels, or using aluminium alloy or stainless steel as contact surface ii. Vacuum pasteurization of cream
Rancid	Fat hydrolysis due to lipase action in milk or cream	Inactivating lipase by proper pasteurization of milk and cream

(b). Miscellaneous

Name of defect	Causes	Prevention
Feathering in hot coffee	i. Excessive homogenization pressure ii. Using sour cream iii. Addition of salts	(i). Proper homogenization pressure (ii). Using sweet cream (iii). Avoiding addition of salts

(B). Manufacturing cream

(a). Flavour Defects

Name of defect	Causes	Prevention
Barny	(i). Poor ventilation of milking byre/barn (ii). Not keeping milk properly covered during production	(i). Proper ventilation of milking byre/barn (ii). Keeping milk properly covered during production
Bitter	(i). Intake of bitter weeds by milch animals (ii). Lipase activity during (raw) cream separation (iii). Growth of Proteolytic bacteria in cream	(i). Eradication of off ending weeds. (ii). Checking lipase activity by avoiding the 'danger zone(38-49^{0}C) in cream separation. (iii). Storage of cream at 5^{0}C(40^{0}F) or below to check bacterial growth.
Cheesy	Growth of Proteolytic bacteria leading to casein break down.	Storage of cream at 5^{0}C(40^{0}F) or below to check bacterial growth.
Coarse-acid/sour	Uncontrolled acid development in cream	Storage of cream at 5^{0}C(40^{0}F) or below to check acid development
Cooked , Feed and weed Rancid Oxidized etc.	Feeding of milk tainting feeds and weeds within 3 hours before milking.	(i). Avoid Feeding of milk tainting feeds and weeds soon milking (ii). Eradication of milk tainting weeds. (iii). Vacuum pasteurization of cream
Fruity	Development of by-products of growth of certain un-desirable micro-organisms	Storage of cream at 5^{0}C(40^{0}F) or below to check microbial growth.
Utensil	Using dirty utensils	Using well cleaned utensils
Yeasty	Growth of lactose fermenting yeasts	Storage of cream at 5^{0}C(40^{0}F) or below to check yeast growth

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Lesson -15

Grading of Cream

15.1 INTRODUCTION:

The purchase of inferior cream at top prices, arising from very keen competition and bitter antagonism amongst buyers, One creamery would rigidly enforce measures towards keeping up the standards of quality of their product, by paying for cream according to purity and the fat content, while other creameries, regardless of reputations, added to their patrons by buying at the highest price irrespective of its quality.

Purpose.-The grading of the daily receipts of cream at the factory has a two-fold purpose, namely:

1. Each can of raw material is or should be graded for purpose of enabling the creamery to pay for it on the basis its quality, and to reject deliveries that are unfit for butter manufacture.
2. Grading is essential also in order to enable the operator to group the cream according to quality into such grades manufacture, as will best suit the market requirements of different grades of butter.

The manufacture of butter of superior quality depends, primarily, on good milk or cream. The quality of the raw material is the foundation of the quality of the finished product. The only permanently successful monitor for the creamery to insure a supply of milk and cream of quality is that of grading every can of raw material received and paying for it according to its quality. This will make the market for a product of good quality attractive and profitable to the producer, and it will make his market for a product of inferior quality unattractive and unprofitable.

Practice of Grading Cream: With hand-separated cream the first duty of the grader is to get the cans methodically, and to test each one for aroma and smell, which can be done most effectively immediately after the lids are removed. It should, therefore, be an understood order in creamery management that no person but the grader should take the lids off the vessels. With a taint in cream, and if volatile, as most are particularly in warm weather, the air space over the cream will be charged with gases, and these will be instantly liberated on the opening of the cans. The next duty of the grader is to examine for flavor and taste.

15.2 JUDGING OF CREAM:

Flavor: In testing samples the use of the finger is permissible, and as soon as the examination is over, the finger should be cleansed. As the work entails considerable strain on the palate, it is unwise to swallow even small quantities of choice cream. To facilitate accurate results of different samples it is suggested that the grader should wash the mouth at intervals with warm water. The use of the finger may be queried. To detect the smell of the cream, the sample should be properly stirred. The cans which give evidence of staleness may be classed as unfit to mix with a first-rate product. After grading, the cream passes through the straining process and is then pasteurized separately.

Body and Texture: The cream should show an even consistency, firm in body with a velvety surface. When poured from one vessel to another, faint granular appearance should be noticed. There should be no clots or lumps in the cream. Condition frequently arising from the mixing of warm and cold supplies, which vary in density, and the presence of churned or half-churned granules of butter show a faulty condition. The cream should also be free from ropiness or sliminess arising from contamination with bacteria of diseased udders, or from cows long in milk, inferior herbage, or it may be from cleaning separators in strong alkaline solutions, and not washing away all traces of the soap.

Colour : The cream should be free of whiteness caused by poor food, and breed of cows; freedom from red streaks or a yellow colour indicative of diseased udders, colostrum or injurious bacterial changes.

15.3 TABLE CREAM:

A. Score card for judging cream is same as for Market Milk
B. Procedure of examination
  a) Sampling
  b) Sequence of observations. Carefully transfer bottle/container from refrigerator/cold room (5-10°C/40-50°F) to the laboratory in a vertical position, avoiding undue agitation. Then examine in the following order:

i. take note of serum separation;
ii. take note of sediment at the bottom of the bottle;
iii. observe container and closure for fullness, cleanliness and general appearance;
iv. take note of cream plug, if any;
v. secure representative sample for bacterial count (aseptically by standard procedures), to be used later for other tests;
vi. temper cream to 10°C (50°F) and determine viscosity;
vii. Take about 20 ml cream in a 100 ml beaker. Warm it to 15-21°C (60-70°F) and note the smell. Then put some cream in the mouth and note the taste;
viii. determine percentage of titratable acidity and fat;

ix. Test for defects such as oiling-off, feathering in coffee, etc.

Requirements of high-grade table cream: High quality table cream should have a clean, sweet, pleasant, nutty flavor. The body should be smooth, uniform and reasonably viscous for the percentage of fat present. The physical appearance should be good.

15.4 CLASSIFICATION OF CREAM GRADES:

- **A. Special or Sweet Cream Grade.**-cream that is clean, fresh, sweet and free from any off- flavor ,free from any visible or objectionable extraneous matter; and the acidity of which has at no time exceeded 0.2% , calculated as lactic acid.
- **B. First Grade Cream**- Cream that is clean in flavor, free from off-flavors and from objectionable extraneous matter; and the acidity of which has at no time exceeded0.6%, calculated as lactic acid.
- **C. Second Grade Cream:** Cream may have acidity in excess of 0.6%. It may contain objectionable flavors and odors to a moderate degree, such as slightly cheesy, slightly rancid, slightly tallowy, slightly metallic, slightly bitter, slightly yeasty, etc. It must be free from the flavor and odor of obnoxious weeds, such as onion, garlic, leek, French weed, peppergrass, etc.; from the flavor or odor of gasoline, kerosene, machine oil, or other foreign oil; from contamination with dirt, filth and other objectionable extraneous matter; and from mold and products of putrefaction.
- **D. Weed Flavored Cream Grade:** To this grade belongs all cream suitable to be classed with any of the previous grades, but that is infested with the flavor of obnoxious weeds, such as onion, garlic, and leek. French weed, certain weeds associated with peppergrass, etc.
- **E. Illegal Cream:** This includes all cream that fails to meet the requirements of any of the previous grades. It is cream that contains the flavor of gasoline, kerosene, machine oil, or other foreign oil; or that is so deteriorated as to have a pronounced cheesy, rancid or metallic flavor; or that is contaminated with products of putrefaction, or dirt, or filth or other objectionable foreign matter that renders it unfit for human consumption.

15.4.1 Uses of Cream

i. For direct consumption as table/coffee/whipping creams;
ii. In the preparation of special dishes;
iii. In the production of plastic, frozen and cultured (sour) creams;
iv. In the manufacture of butter, cream, cheese, ice cream, butter oil and ghee(India)
v. For creaming cottage cheese.
vi. Dried cream is used for dried fruits, dried soups, cake mixes desert makings, Ice cream mixes etc

Lesson-16

FSSAI Definition, BIS specifications and Codex Requirements

16.1 INTRODUCTION:

Butter is a dairy product made by churning fresh or fermented cream. It is generally used as a spread and a condiment, as well as in cooking applications, such as baking, sauce making, and pan frying. Butter is a water-in-oil emulsion resulting from an inversion of the cream, an oil-in-water emulsion; the milk proteins are the emulsifiers. Butter remains a solid when refrigerated, but softens to a spreadable consistency at room temperature, and melts to a thin liquid consistency at 32–35 °C.

It generally has a pale yellow color, but varies from deep yellow to nearly white. Its unmodified color is dependent on the animals' feed and is commonly manipulated with food colorings in the commercial manufacturing process, most commonly annatto or carotene.

16.2 DEFINITION:

Butter may be defined as a fat concentrate, obtained by churning cream, gathering the fat into compact mass and then working it.

As per FSSAI (2011), Butter means the fatty product derived exclusively from milk of cow and/or buffalo or its products principally in the form of water-in-oil type of an emulsion. The product may be with or without added common salt and starter cultures of harmless lactic acid and/or flavour producing bacteria. Table butter shall be obtained from pasteurised milk and/or other milk products which have undergone adequate heat treatment to ensure microbial safety. It shall be free from animal body fat, vegetable oil and fat, mineral oil and added flavour. It shall have pleasant taste and flavour free from off flavour and rancidity. It may contain food additives permitted in these Regulations (Table 2). It shall conform to the microbiological requirements of the regulation (Table 3).

It shall conform to the requirements presented in Table 1.

Table 16.1: FSSAI standards for butter

Product	Moisture	Milk Fat	Milk solids not fat	Common salt
Table Butter	16.0% (w/w, max.)	80.0% (w/w, min.)	1.5% (w/w, max.)	3.0% (w/w, max.)
Desi/cooking butter	---	76.0% (w/w, min.)	---	----

Note: Where butter is sold or offered for sale without any indication as to whether it is table or desi butter, the standards of table butter shall apply.

Table 16.2: Permitted food additives in butter as per FSSR

Additive	Quantity
Colors (natural: singly or in combination)	
Curcumin	100 ppm max.
Beta carotene	100 ppm max.
Carotene (Natural extract)	100 ppm max.
Annatto extract on Bixin/ Nor bixin basis (50:50 ratio)	20 ppm max.
Beta apo-8 carotenal	35 ppm max.
Methyl ester of Beta apo-8 Carotenoic acid	35 ppm max.
Acidity regulaotrs	
Sodium and Calcium hydroxide	2000 ppm max.

Table 16.3: Microbiological requirements of pasteurized butter (FSSAI, 2011)

Microbiological parameter	Sampling Plan	Count
Total Plate Count	m	10,000/g
	M	50, 000/g
Coliform Count	m	10/g
	M	50/g
E.Coli	M	Absent/g
Salmonella	M	Absent/25g
Staphylococcus aureus	m	10/g
	M	50/g
Yeast and mold count	m	20/g
	M	50/g
Listeria monocytogenes	M	Absent/g

Note: m, M denotes standard sampling procedure as given by FSSAI, 2011

Table 16.4 BIS standards for pasteurized butter

Characteristic	Table Butter	White Butter
Milk fat, percent by mass, *Min*	80.0	82.0
Moisture, percent by mass, *Max*	16.0	16.0
Acidity (as lactic acid), percent by mass,*max.*	0.15	0.06
Curd, percent by mass, *Max.*	1.0	1.5
Common salt, percent by mass, *Max.*	2.5	----
Coliform count, per ml, *Max*	5	5
Total yeast and mould count, per ml, *Max*	20	20

16.3 CODEX STANDARDS OF BUTTER:

Definition: As per Codex, Butter is a fatty product derived exclusively from milk and/or products obtained from milk, principally in the form of an emulsion of the type water-in-oil.

Essential Composition and Quality Factors

Raw materials: Butter should be made from milk and/or products obtained from milk.

Permitted ingredients

- Sodium chloride and food grade salt
- Starter cultures of harmless lactic acid and/or flavour producing bacteria
- Potable water.

Composition

Minimum milk fat content 80% m/m

Maximum water content 16% m/m

Maximum milk solids-not-fat content 2% m/m

The products should comply with any microbiological criteria established in accordance with the *Principles for the Establishment and Application of Microbiological Criteria for Foods* (CAC/GL 21-1997).

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Lesson-17

Composition and Classification of Butter

17.1 INTRODUCTION:

By the nature of its production principle, butter is a product containing predominately fat (~80%) and a little quantity of SNF besides added ingredients such as salt. However, compositional variations can occur depending on the type of butter, which may be covered under various classification schemes.

17.2 COMPOSITION OF BUTTER:

Butter is principally composed of milk fat, moisture, salt and curd. It also contains small amount of fat, lactose, acids, phospholipids, air, microorganisms, enzymes and vitamins. The proportion of principal constituents in butter is largely controlled by the method of manufacture and this is turn is chiefly regulated to conform to the standards of butter prescribed by regulatory authorities such as codex and FSSAI. General composition of butter is given in table 17.1

Table 17.1: Composition of butter

Constituents	Quantity (% w/w)
Fat	80-83
Moisture	15.5-16.0
Salt	*0-3
Curd	1-1.5

* 0 percent salt indicates that butter is unsalted and it is not intended for direct consumption

Butter is considered as high calorie food as 100 g of butter provides almost 700 Kcal. Butter is extremely rich in minerals like Calcium, Phosphorus and Potassium. It has good amount of sodium and small amounts of fluoride, selenium, zinc and magnesium. It is also rich in Vitamin A, Vitamin E, Riboflavin, Niacin and Pantothenic acid. It also has Vitamin K, Folate and Vitamin B_{12} in small amounts.

Nutritional composition of butter is given in Table 17.1

Table 17.2 Nutritional composition of butter

Constituents	Per 100g
Energy (Kcal)	744
Fat (g)	82
Saturates	52.1
Monounsaturates	20.9
Polyunsaturates	2.8
Trans fatty acids	2.9
Protein (g)	0.6
Carbohydrate (g)	0.6
Thaimin (mg)	Trace
Riboflavin (mg)	0.07
Niacin (mg)	Trace
Vitamin B6 (mg)	Trace
Vitamin B12 (µg)	0.3
Folate (µg)	Trace
Pantothenate(mg)	0.05
Biotin (µg)	0.2
Vitamin C (mg)	Trace
Retinol (µg)	958
Carotene (µg)	608
Vitamin D (µg)	0.9
Vitamin E (mg)	1.85
Sodium (mg)	606*
Potassium (mg)	27
Calcium (mg)	18
Magnesium (mg)	2.0
Phosphorus (mg)	23
Iron (mg)	Trace
Copper (mg)	0.01
Zinc (mg)	0.1
Chloride (mg)	994
Selenium (Ig)	Trace
Manganese (mg)	Trace
Iodine (µg)	38

*Unsalted butter contains 9 mg Sodium per 100g

Butter's fatty acid composition is also important for several reasons. The proportion of low melting triglycerides and high melting triglyceride largely determines the body and texture of butter. The significant amount of short-chain fatty acids contributes to butter's quality as a softer fat with a lower melting point. This, in turn, ensures a quick flavor release when melting, which is desirable in numerous foods. Fatty acid composition of butter is given in Table 17.2

Table 17.2 Fatty acid composition of butter

Fatty Acids	**Average (g/100g)**
Unsaturated	
Monounsaturated Fatty Acids	21.021
16:1 Palmitoleic Acid	0.961
18:1 Oleic Acid	19.961
Polyunsaturated Fatty Acids	3.043
18:2 Linoleic Acid	2.728
18:3 Linolenic Acid	0.315
Saturated Fatty Acids	
4:0 Butyric Acid	3.226
6:0 Caproic Acid	2.007
8:0 Caprylic Acid	1.19
10:0 Capric Acid	2.529
12:0 Lauric Acid	2.587
14:0 Myristic Acid	7.436
16:0 Palmitic Acid	21.697
18:0 Stearic Acid	9.999

17.3 CLASSIFICATION OF BUTTER:

Butter may be classified based on treatment given to cream, salt content, method of manufacturing and end use.

I. Classification based on acidity of cream used for butter making:

1. Sweet cream butter: Sweet cream butter (made from non-acidified cream; this includes butter in which no bacterial culture have been added to enhance diacetyl content) having pH of ≥6.4 (acidity of the churned cream does not exceed 0.2%).
2. Mildly acidified butter (made from partially acidified sweet cream) having pH in the range of 5.2 to 6.3 and

3. Sour cream butter (made from ripened cream which has more than 0.2% acidity) having pH ≤ 5.1from cream.

II. Classification based on salt content

1. Salted butter: Butter to which salt has been added. It is added to improve flavour and keeping quality of butter.

2. Unsalted butter: This type of butter contains no salt. It is usually prepared for manufacturing other products such as ghee and butter oil.

III. Classification based on end use (as followed by BIS):

1. Table Butter: the product made from pasteurized cream obtained from cow or buffalo milk or a combination thereof with or without ripening with the use of standard lactic culture, addition of common salt, annatto or carotene as colouring matter and diacetyl as flavouring agent.

2. White Butter**:** the product made from pasteurized cream obtained from cow or buffalo milk or a combination thereof without ripening and without addition of any preservati ve including common salt, any added colouring matter or any added flavouring agent.

IV. Classification based on the manufacturing practice (as followed by FSSAI):

1. Pasteurized cream butter/ Pasteurized Table butter: This is made usually from pasteurized sweet cream. Such butter usually has a milder flavour than that made from similar cream not pasteurized.

2. *Desi* butter: The butter obtained by traditional process of churning *dahi* or *malai* as practiced at domestic levels.

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Lesson-18

Process Outlines of Butter Making

18.1 INTRODUCTION:

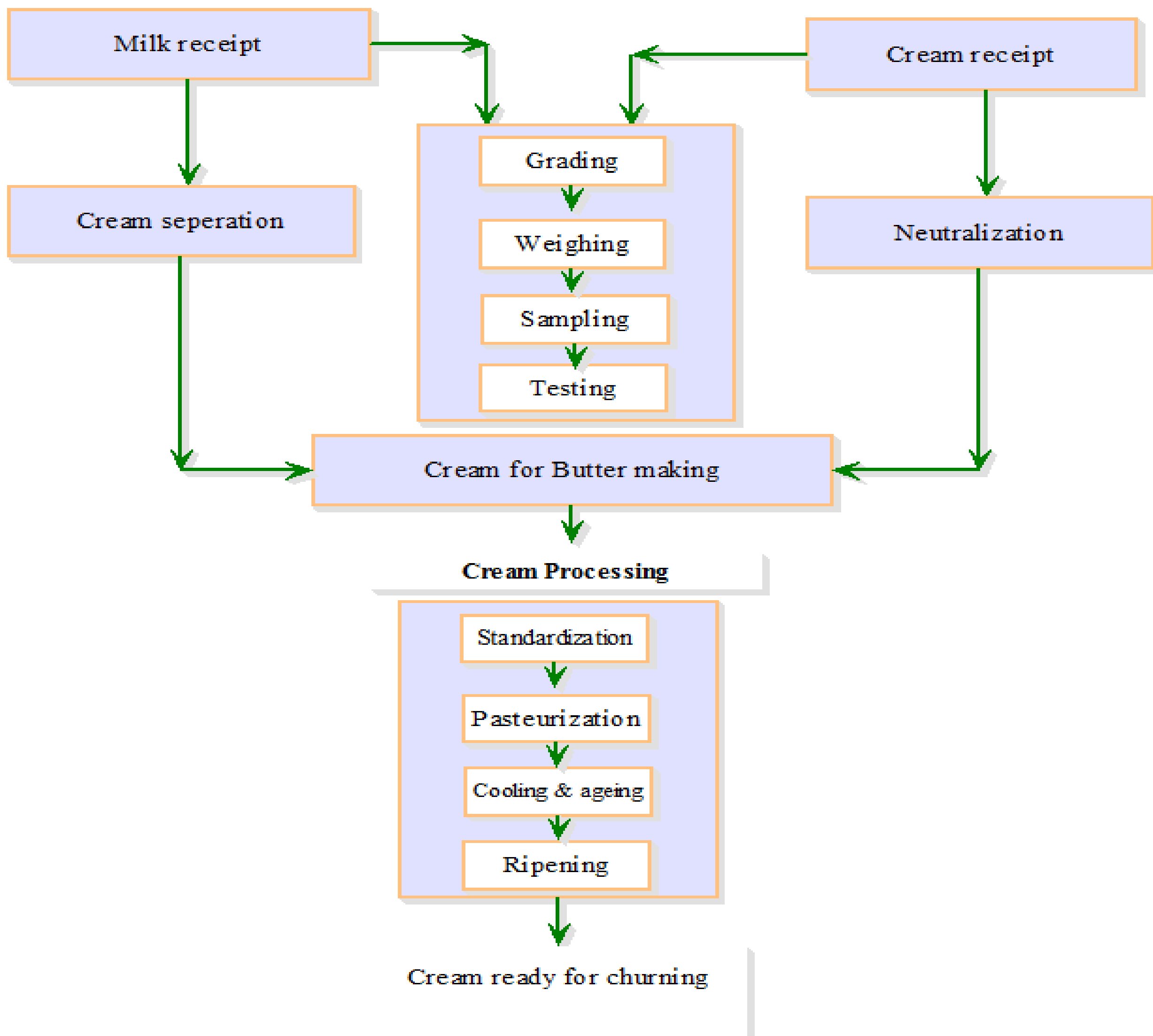
Butter, a fat rich dairy product obtained by churning cream and working the granules thus obtained into a compact mass, has been a staple item of diet in many countries of the world. Up to the middle of the nineteenth century, manufacture of this product was mainly confined to the farm on cottage scales. It was only after the development of centrifugal cream separator in 1879, fat testing methods by Babcock (1890) and Gerber (1892) together with introduction of artificial refrigeration and pasteurization around 1980, the industrial production of butter developed rapidly. Prior to 1970 most of the world's butter was manufactured by batch-process. However, since World War-II, continuous processes have been introduced to achieve increased manufacturing efficiencies. Regardless of manufacturing method employed, the essential feature of churning evolves destabilization of cream emulsion by means of mechanical agitation.

Butter and other fat spreads can be characterized by the type of emulsion. In milk or cream, fat is dispersed in the continuous phase of serum while in butter, there is a reversal of phase i.e. fat becomes the continuous phase with serum dispersed in it. This phase reversal is carried out by churning cream in butter churns.

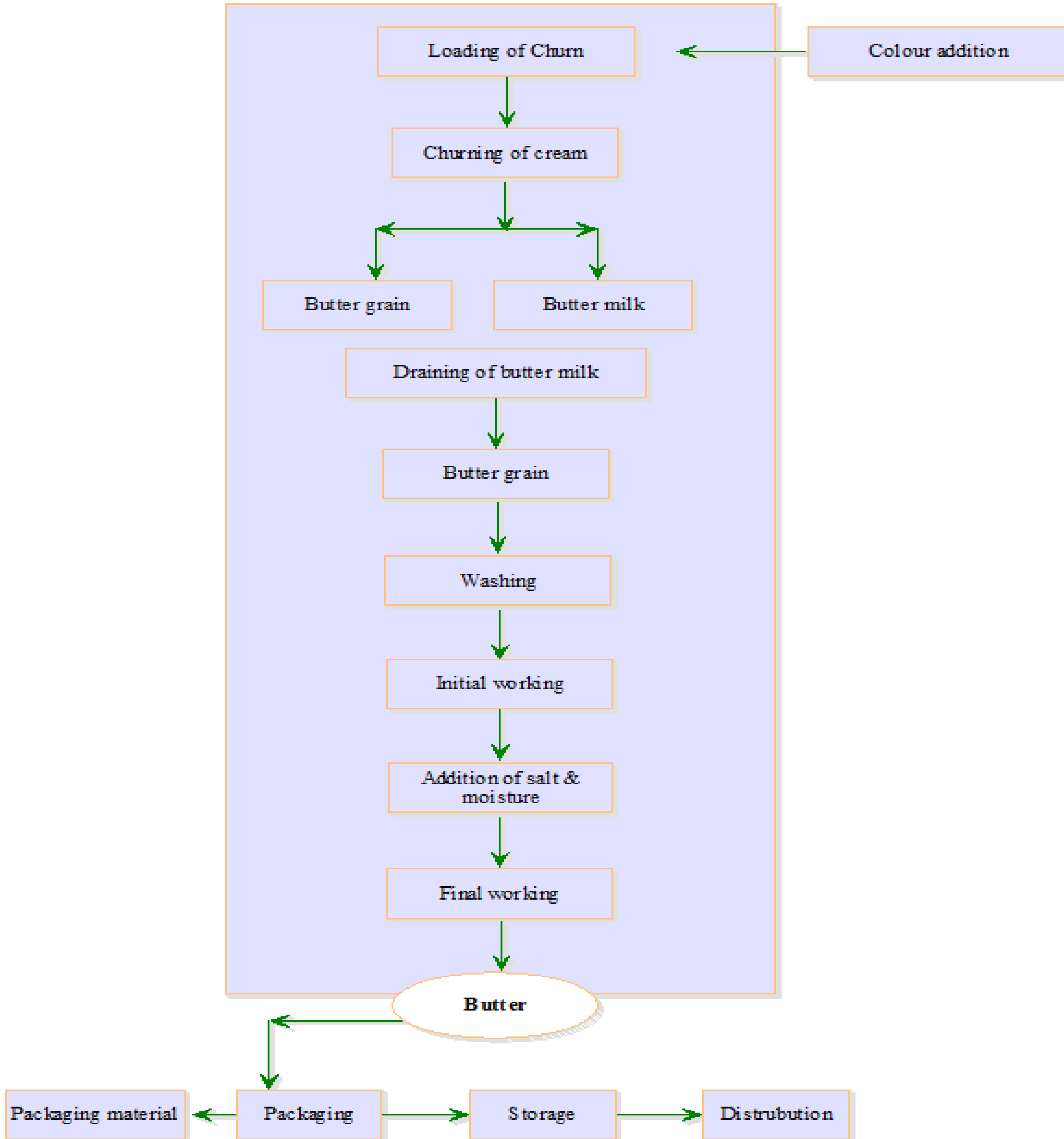
Steps involved in the conventional process of butter making which comprises preparation of cream and churning and working are given in Figs. 18.1 and 18.2 and described below.

18.2 PREPARATION OF CREAM:

Commercial butter can be produced from both sweets as well as cultured cream. Very little cultured butter is produced in India and U.S.A., although in Europe and Canada, cultured butter is an important product. However, most creamery prefer to produce butter from sweet cream as it result in sweet butter milk which has better economic value than sour butter-milk that results when sour/cultured cream is churned.



Flow Diagram of Cream preparation for Butter Manufacturing



Flow Diagram of Butter Manufacturing

18.2.1. Neutralization of Cream

Sour cream must be neutralized to make butter of good keeping quality. It is under stood that by neutralization of cream acidity of cream is reduced. Churning of High acid cream may cause high fat loss which can be prevented by neutralization. In pasteurization of sour cream, the casein curdles, by entrapping fat globules, as the bulk of curd goes in butter milk, causing high fat loss.

18.2.1.1 Objectives of Neutralization

1. The objectives of neutralization are to reduce the acidity in cream to a point (0.14 -0.16%) which permits pasteurization without risk of curdling, to produce butter which keeps well in cold storage
2. To avoid excess loss of fat which result from the churning cream i.e excessively sour.

3. To guard against undesirable flavors which may result when a cream of high acid which is subjected for pasteurization at higher temperatures.

4. To improve the keeping quality of butter from high acid cream. Salted-acid-butter develops a fish flavor during commercial storage at -23 to -29°C.

18.2.1.2 Theoretical Basis of Cream Neutralization

Soda neutralizer:

$NaHCO_3 + CH_3CHOHCOOH$----- $CH_3CHOHCOONa + H_2O + CO_2$

84 90

NF=84/90=0.933

$Na_2CO_3 + CH_3CHOHCOOH$----- $CH_3CHOHCOONa + H_2O + CO_2$

106 90

NF= 106/180=0.58

$NaOH + CH_3CHOHCOOH$----- $CH_3CHOHCOONa + H_2O$

40 90

NF=40/90=0.444

Lime neutralizers:

$Ca(OH)_2 + 2\ CH_3CHOHCOOH$----- $(CH_3CHOHCOO)_2Ca + 2H_2O$

74 90×2=180

NF= 74/180=0.411

$Mg(OH)_2 + 2\ CH_3CHOHCOOH$----- $(CH_3CHOHCOO)_2Mg + 2H_2O$

58 180

NF= 58/180=0.322

NF = Neutralization factor

The quantitative relationship between amount of lactic acid present in solution and amount of pure neutralizer required to give exact neutralization is fixed and definite amount of CO_2 is driven off by air.

Ex: 90g of lactic acid requires 84g $NAHCO_3$ (or) 106g Na_2CO_3 (or) 40g of NaOH for neutralization.

18.2.1.3 Expression of Acidity in Cream

Acidity in cream is present chiefly in the serum portion and not in fat. The acidity in cream as a whole known as cream acidity (C.A.) while the acidity per cent found in serum is known as cream serum acidity (C.S.A). Cream serum acidity is more reliable than cream acidity.

There is a relationship between CA & C.SA as below:

CA % = Serum % in cream

CSA % 100

18.2.1.4 Factors affecting neutralization

Accurate neutralization of sour cream is important to get a desired quality product. Neutralization is influenced by several factors such as:

i. Accuracy in sampling.

ii. Accuracy in testing.

iii. Accuracy in estimation of amounts of cream and neutralizer.

iv. Careful weighing the quantity of neutralizer.

v. Thorough mixing of neutralizer in cream prior to pasteurization.

18.2.1.5 Method of neutralization of cream

There are five essential steps to follow for cream neutralization. These are:

1. Adoption of definite standard of churning acidity
2. Correct estimation of acidity
3. Calculating the amount of neutralizer to be added
4. Adding neutralizer in the correct manner
5. Checking results by re-testing acidity

Adoption of a definite standard of churning acidity.

Acidity of cream at churning time controls the flavour and keeping quality of the butter. Therefore, it is important to decide that at what acidity the cream shall be churned.

Churning acidity should be kept upto that maximum acidity where freedom from chemical deterioration of butter (fishy flavour) with age can be ensured. For cream of average richness (about 30%), fishy flavor can be prevented by keeping the churning acidity to 0.3% maximum.

The safe maximum limit of churning acidity varies with the richness of the cream. Since the acidity of cream is chiefly contained in the cream serum, cream serum acidity adjustment would give better results.

e.g. 30% fat cream, cream acidity 0.25%

= 0.357%

Usually serum acidity is kept at 0.35% to achieve best keeping quality of butter.

Ex.1 cream test 20% fat, serum acidity 0.35% is desired what should be the acid test of the cream?

% cream serum: 100-20 = 80

% serum acidity = 0.35

% acid in cream = % cream serum × % serum acidity

= 0.80 × 0.35

= 0.28%

Correct Estimation of Acidity

Representative sample should be taken. Weight of cream should be accurately measured as the final amount of neutralizer will be dependent on the weight of cream.

Effect of CO_2 on acidity should be taken care especially in high acid cream (acidly > 0.65%)

Calculating the amount of neutralizer to be added

Quantity of Neutralizer (g) =

N. F. for Sodium bicarbonate $NaHCO_3$ 1.1

Sodium bicarbonate Na_2CO_3 1.7

Calcium hydroxide $Ca(OH)_2$ 2.43

Magnesium hydroxide $Mg(OH)_2$ 3.1

Sodium hydroxide NaOH 2.25

Adding neutralizer in the correct manner

Neutralizer should be dissolved or emulsified in clean water, diluted to approx. 20 times its weight with water; the solution must be distributed quickly & uniformly throughout the entire batch of cream and mixed thoroughly with cream. For efficient mixing, neutralizer is usually sprayed onto the surface of well agitated cream. While the neutralizer is added, the cream should be agitated vigorously and continuously. Agitation of cream is preferable for 5-10 min after neutralization. Temperature at the time of neutralization should be 30°C. (High enough for smooth consistency & low enough to prevent abnormal heat curdling of the sour cream).

The above precautions are essential, if efficiency of neutralization, protection of butter against neutralizer flavour, oily metallic flavour and mealy body, avoidance of pasteurizing difficulties and prevention of excessive fat losses in the buttermilk are to be assured.

Checking Results of Neutralization by Re-testing for Acidity

Acidity should not be checked immediately after neutralization because of the following reasons:

- In case of lime and Magnesia neutralizers, the neutralizing action is slow. It completes after pasteurization & cooling.

- In case of soda neutralizers, CO_2 is liberated and this reacts acid toward the phenolphthalein indicator. After pasteurization, expulsion of CO_2 is largely accomplished. Therefore, testing acidity after pasteurization would give correct results.

18.2.1.6 Role of carbon dioxide in neutralization of cream with sodium bicarbonate: Fresh cream always contains some dissolved carbon dioxide (as carbonic acid) which reacts with sodium hydroxide during titration and shows a higher acidity test. But the carbon dioxide does not react with sodium bicarbonate neutralizer and consequently over neutralization results.

18.2.1.7 Double neutralization with lime and soda: The objectives of double neutralization are:

1. To avoid the intense effect on flavor of a large amount of any one neutralizer with high-acid cream.

2. To avoid production of excessive carbon dioxide by the use of sodium bicarbonate with high-acid cream

For this purpose the cream is first neutralized with lime neutralizer and bring the cream acidity down to 0.3-0.4 percent. Next use soda neutralizer to bring the cream acidity down to the desired level.

18.2.1.8 Neutralizing Precautions

In order to secure the desired results, i.e., accurate acid reduction, absence of objectionable neutralizer flavor and of excessive fat losses, make sure of the correctness of weight of cream and acid test. Do not heat the sour cream above 85 to 90°F, before neutralization, use the correct amount of neutralizer in properly diluted form, distribute it evenly over the cream, and continue agitation of the neutralized cream for 5 to 10 minutes before starting to pasteurize.

18.2.1.9 Type of Neutralizers

Neutralizers in order to accomplish the purpose, for which they are used in the creamery, must have alkaline properties. They must be alkalis, alkaline earths or their substances. An alkali is a substance that has the property of neutralizing acids, forming salts with them. The neutralizers used for reducing acidity in cream belong to either one or the other of two groups namely.

- Lime Neutralizers
- Soda Neutralizers

Lime neutralizers: The principal constituent of the majority of lime neutralizers is calcium. Many of the lime neutralizer's available for cream neutralization also contain some magnesium. The various commercial lime neutralizers differ from one another chiefly with respect to the proportion of calcium and magnesium they contain. They are conveniently placed in three groups, as follows:

a. Low magnesium limes: Containing 5% or less of magnesium. A well Known brand of creamery lime belonging to this group is peerless lime.

b. Medium magnesium limes: Containing about 30-35% magnesium. To this group belong such brands ad Kelly Island lime, Neutra-Lac and Neutra-Lime.

c. High magnesium limes: Containing about 45 to 55% magnesium. All wood lime is an outstanding representative of this group. All magnesium limes in the form of magnesium oxide and magnesium carbonate are also available. They are artificially prepared limes and demand a higher price than the natural limes. Their effect on the flavor of cream and butter however is outstandingly favorable.

Calcium carbonate-low solubility, low alkalinity unsuitable for cream neutralization and action is very slow.

In general the medium and high magnesium limes react somewhat more satisfactorily in the cream than the low magnesium limes. The higher the magnesium oxide content of lime the greater is its alkalinity and its neutralizing strength.

Soda neutralizers: Soda neutralizers commonly used in the creamery are

1. Bicarbonate of soda or baking soda
2. Sodium carbonate or soda ash
3. Mixtures off baking soda and soda ash, such as Sodium sesquicarbonate, Neutralene and Wyandotte.

18.2.1.10 Comparison between lime and soda neutralizers

1. **Purity:** Soda Neutralizers will have less than 0.1 impurities whereas lime neutralizers will have sand and clay.
2. **Solubility:** Sodium Neutralizers are completely soluble whereas lime neutralizers are slightly soluble in waste.
3. **Action:** Sodium Neutralizers act quickly. Lime Neutralizers react slowly.
4. **Action on casein:** Soda neutralizers will have solvent and softening action and assist in minimizing clogging during processing. Lime neutralizers tend to granulate (or) precipitate casein which results in bitter lime flavor on pasteurization.
5. **Acid reaction:** Soda Neutralizers act on serum acidity first. In lime neutralizers the calcium has natural affinity towards casein, lime particles attach themselves mechanically to casein and it is not completely available for neutralizing the lactic acid. The neutralizing capacity of lime neutralizer is 80-85%.
6. **Foaming effect:** Soda neutralizers will produce violent foam when there is high acidity $NaHCO_3$ has more effect than Na_2CO_3. Lime neutralizers do not create foam.
7. **Neutralizing strength:** Soda neutralizers are weaker alkalis than lime neutralizers about twice as many kilograms of soda neutralizers are required to neutralize given amount of acid as compared to lime neutralizers.
8. **Material cost:** Lime neutralizers are cheaper than soda neutralizers.

9. **Effect on texture of butter:** In case of high acid cream especially neutralizes to a low point there is a tendency to butter from lime neutralizer cream will give less smooth texture than soda neutralizers.

10. **Effect on flavor of butter:** Soda neutralizers produce soapy type of flavor. Lime neutralizers' produces course lime flavor. In over all the butter will give neutralizer flavors.

18.2.2 Standardization of Cream

It refers to adjustment of fat to desired level. It is done by adding calculated quantity of skim milk or butter milk. Desired level of fat in cream for butter making is 33 to 40 per cent. Standardization to both higher and lower level leads to higher fat loss in butter milk. Reduction of fat by adding water should be avoided as it interferes ripening of cream and also results in butter with 'flat' or 'washed off' flavour.

18.2.3 Pasteurization of Cream

It refers to adjustment every particle of cream to a temperature not less that 71°C and holding it at that temperature for at least 20 min or any suitable temperature-time combination using properly operated equipments. The main objectives of pasteurization are: (i) it destroys pathogenic microorganisms in cream so as to make it, and the resultant butter, safe for human consumption. (ii) It also destroys bacteria, yeast, mould, enzymes and other biochemical agents that may lower keeping quality. (iii) It also eliminates some of the gaseous and training substances. A number of equipment viz. LTLT (law temperature long time, 74°C for 30 min); HTST (high temperature short time, 85^{o}C for 15 s.) and Vacreator, a direct steam injection method, can be employed for this purpose. More severe heat treatment of cream should be avoided as higher, the temperature the greater the migration of copper from the milk serum into milk fat globules. This increases the level of copper associated with the milk fat making it more prone to the development of oxidative rancidity and reduce the shelf-life of butter.

Pasteurization of cream for making ripened cream butter is commonly carried out at higher temperature than for sweet cream butter e.g. 90-95^{o}C for 15 or 105-110^{o}C with no holding. Severe heat treatment denatures whey proteins, particularly lactoglobulins, exposing-SH groups which act as antioxidants and can enhance starter growth.

18.2.4 Ripening of Cream

Ripening refers to the process of fermentation of cream with the help of suitable starter culture. This step can be eliminated if sweet-cream butter is desired. The main object of cream ripening is to produce butter with higher diacetyl content. Ripening improves the keeping quality of salted butter but it reduces the keeping quality of a salted butter. Starter culture consisting of a mixture of both acid producing (*Streptococcus lactis, S.cremories*) and flavour producing (*S.diacetylactis, Leuconostoc citrovorum* and/or *Leuc. dextranicum*) organisms is added. Amount of starter added depends on several factors and usually ranges between 0.5-2.0 percent of the weight of the cream. After being thoroughly mixed, the cream is incubated at about 21^oC till desired an acidity is reached. Cream is subsequently cooled to 5-10^0C to arrest further acid development.

Biosynthesis of diacetyl is not sufficient above pH 5.2. Stopping fermentation of cream by cooling at pH 5.1-5.3, results in a milder flavour; whereas continuing fermentation upto pH 4.5-4.7 results in higher levels of both diacetyl and lactic acid, giving more pronounced flavour.

18.2.4.1 Purpose

The fundamental objects of cream ripening are to produce butter with a pleasing, pronounced flavor and aroma, and to produce this flavor and aroma uniformly from day to day. Ripening also influences somewhat the exhaustiveness of churning and it affects the keeping quality of the butter variously, according to quality of original cream, churning acidity, and whether made into salted or unsalted butter.

18.2.4.2 Starter Culture

Mixture of both acid producing organisms (*Lactococcus lactis*, *L. cremoris*) and flavour producing organisms (*S. lactis* subsp.*diacetylactis*, *Leuconostoc citrovorum* and/or *Leuconostoc dextranicum*). Starter culture is added at the rate of 0.5 to 2.0% of the weight of cream and incubated at about 21 ^oC till desired acidity is reached. Usually it takes 15-16 hrs.

18.2.4.3 Effect of Cream Ripening on Butter

Effect on Flavor and Aroma: The mildly acid and pronounced "nutty" flavor that is characteristic of the pleasing flavor of good butter is usually accompanied by a high, attractive aroma. The typical butter flavor is due to the presence of diacetyl in combination with lactic acid, carbon dioxide, acetoin and intermediary products such as acetaldehyde, and probably other aromatic products as yet not definitely determined. These substances are the products of fermentation, brought about by the associative action of lactic acid-producing bacteria and citric acid-fermenting bacteria.

These bacteria are propagated and their flavor and aroma substances produced in the starter. During cream ripening the starter that is added to the cream, therefore, functions in two ways. It seeds the cream with species of bacteria that are capable of producing the desired aroma and flavor substances in the cream, and it adds to the cream the aroma and flavor substances produced and already contained in the starter.

Factors which Influence the Diacetyl + Acetoin Content of Butter: Cream ripened with a normal starter shows a varying ratio of diacetyl to acetoin. In the case of 20% cream, a ripening temperature of 17˚C. (62.6˚F) yields the largest amount of diacetyl. With increasing fat content the amount of diacetyl + acetoin increases. Cream testing 40% fat yields higher diacetyl content in the butter than 20% cream, or whole milk. The diacetyl content of butter to affect its flavor as follows:

Amount of Diacetyl	Flavour
Absence of diacetyl	Flavorless
0.2 to 0.6 ppm diacetyl	Mild flavor
0.7 to 1.5 ppm diacetyl	Full flavor

Distribution of Diacetyl + Acetoin by the Churning Process: - Butter contains a relatively small proportion of the diacetyl and acetoin content of the cream from which it is made. Fresh buttermilk contains larger amounts of diacetyl and acetoin than the corresponding butter and than the original cream, at churning time. The serum of butter contains larger amounts of diacetyl + acetoin than the fat of the same butter. The wash water contains appreciable amounts of diacetyl + acetoin. Churning 2 liters of cream yields the following amounts of diacetyl in the buttermilk, wash water and butter:

Butter milk	6.14 mg Diacetyl
First wash water	3.16 mg Diacetyl
Second wash water	0.00 mg Diacetyl
Third wash water	0.00 mg Diacetyl
Butter	0.30 mg Diacetyl

The following amounts of diacetyl + acetoin are present in washed and unwashed butter:

	Diacetyl (mg/kg)	Diacetyl + Acetoin (mg/kg)
Unwashed Butter	1.69	9.30
Washed Butter	0.86	3.78

These findings indicate that in commercial manufacture of butter, particularly in the case of unsalted butter, excessive washing gives the finished butter, even when made from properly ripened cream, a disappointing "washed-out" flavor.

Effect of Cream Ripening on Keeping Quality of Butter

The development of flavor and aroma in butter by cream ripening, or by any other process of manufacture, can be of value only, provided that it does not impair or destroy the keeping quality of the resulting butter. The ripening of cream affects the keeping quality of butter in two fundamental ways, namely, by its control of age deterioration due to bacterial causes, and by its influence on age deterioration due to chemical causes.

Bacteriological effect: The ripening of cream improves the keeping quality of butter as far as keeping quality is dependent on freedom from age deterioration due to biological causes. Cream ripening assists in controlling bacterial deterioration in butter. In butter made from ripened cream there is a great prevalence of lactic acid bacteria and a relatively high acidity and probably an abundance of lactate salts. These agencies are antagonistic to the great majority of flavor-damaging organisms that may be present in the butter, thus retarding their action, preserving the fresh or desired flavor, and prolonging the keeping quality of the butter.

***Chemical Effect*:** Cream ripening does not improve the chemical stability of butter. On the contrary, under average commercial conditions of manufacture, the ripening of cream to a full aroma and flavor shortens the life of salted butter. The usual flavor defects that develop with age in butter made from fully ripened cream are oily-metallic, fishy and sometimes tallowy flavor. There is a tendency also to intensify the well-known cold storage flavor. This is especially true of salted butter made from cream that arrives at the factory in sour fermented condition, is neutralized, pasteurized and re-ripened to a high acidity. It applies also, through to a somewhat lesser extent, to salted butter made from ripened sweet cream. It does not apply to unsalted butter.

Salted butter made from sweet, unripened cream, or from sour cream, neutralized and pasteurized, keeps better from the standpoint of absence of flavor deterioration due to chemical causes, than salted butter made from the same cream ripened to a full flavor and aroma.

18.2.4.4 Percent Acid to which the Cream should be Ripened

For fresh consumption salted butter, cream of moderate richness (30% fat) may safely be ripened to about 0.25 to 0.30% acid. For salted butter of commercial cold storage, it has been found preferable not to ripen the cream and to churn it at an acidity of about 0.21% acid or lower. In case of unsalted butter, the cream may be ripened to any acidity without jeopardizing keeping quality.

18.2.5 Cooling and Ageing

Cooling and ageing are processes which prepare the cream for subsequent operation of churning. When cream leaves the pasteurizer, the fat in the globule is in liquid form. When cream is cooled, fat crystallization starts, cream will not churn unless the butter fat is at least partially crystallized. If solidification of fat is not sufficient, the fat losses in butter are high. Rate of cooling has an important influence on the body and texture of butter. The temperature to which cream is cooled is chosen is such a way that the butter produced is of optimum consistency and cream churns to butter in a responsible time of about 35-45 minutes. Churning at too high temperature may give butter with 'greasy' body which may work up too quickly and become sticky. Generally cooling temperature in summer should be 7-9°C and that if in winter (10°-13°C).

Crystallizing of the milk fat during aging

Before churning, cream is subjected to a program of cooling designed to control the crystallization of the fat so that the resultant butter has the right consistency.

Butter fat contains varying amounts of soft and hard fats. The relative amounts of fatty acids with high melting point determine whether the fat will be hard or soft. Soft fat has a high content of low-melting fatty acids and at room temperature this fat has a large continuous fat phase with a low solid phase, i.e. crystallized, high-melting fat. On the other hand, in a hard fat, the solid phase of high-melting fat is much larger than the continuous fat phase of low-melting fatty acids.

In butter making, if the cream is always subjected to the same treatment it will be the chemical composition of the milk fat that determines the butter's consistency. A soft milk fat will make a soft and greasy butter, whereas butter from hard milk fat will be hard and stiff.

Pasteurization causes the fat in the fat globules to liquefy. And when the cream is subsequently cooled a proportion of the fat will crystallize. If cooling is rapid, the crystals will be many and small; if gradual the yield will be fewer but larger crystals. The more violent the cooling process, the more will be the fat that will crystallize to form the solid phase, and the less the liquid fat that can be squeezed out of the fat globules during churning and working.

The crystals bind the liquid fat to their surface by adsorption. Since the total surface area is much greater if the crystals are many and small, more liquid fat will be adsorbed than if the crystals were larger and fewer. In the former case, churning and working will press only a small proportion of the liquid fat from the fat globules. The continuous fat phase will consequently be small and the butter firm. In the latter case, the opposite applies. A larger amount of liquid fat will be pressed out; the continuous phase will be large and the butter soft.

So by modifying the cooling program for the cream, it is possible to regulate the size of the crystals in the fat globules and in this way influence both the magnitude and the nature of the important continuous fat phase.

Treatment of hard fat

For optimum consistency where the iodine value is low, i.e. the butterfat is hard, as much as possible of the hardest fat must be converted to as few crystals as possible, so that little of the liquid fat is bound to the crystals. The liquid fat phase in the fat globules will thereby be maximized and much of it can be pressed out during churning and working, resulting in butter with a relatively large continuous phase of liquid fat and with the hard fat concentrated to the solid phase.

The program of treatment necessary to achieve this result comprises the following stages:

- rapid cooling to about 8ºC and storage for about 2 hours at this temperature; heating gently to 20 - 21ºC and storage at this temperature for at least 2 hours (water at 27 - 29ºC is used for heating);
- cooling to about 16ºC.
- Cooling to about 8ºC causes the formation of a large number of small crystals that bind fat from the liquid continuous phase to their surface.

Treatment of medium-hard fat

With an increase in the iodine value, the heating temperature is accordingly reduced from 20-21ºC. Consequently a larger number of fat crystals will form and more liquid fat will be adsorbed than is the case with the hard fat program. For iodine values up to 39, the heating temperature can be as low as 15ºC.

Treatment of very soft fat

Where the iodine value is greater than 39-40 the "summer method" of treatment is used. After pasteurization the cream is cooled to 20°C. If the iodine value is around 39 - 40 the cream is cooled to about 8°C, and if 41 or greater to 6°C. It is generally held that aging temperatures below the 20° level will give a soft butter.

18.3 CHURNING OF CREAM:

It is during the churning process that cream is converted into butter. Here the fat gloubles are disrupted under controlled conditions to destabilize o/w emulsion and bring about agglomeration of milk fat. What happens during churning has been explained by various theories of churning as discussed in lesson 8.3. The sequence of events that occur during churning is as follows:

i) Churning is initiated by agitation of cream causing incorporation of numerous air bubbles into the cream.

ii) With incorporation of air there is increase in the volume of cream and air plasma interface.

iii) Surface active (such as frictional, impact, concussion etc.) causes partial disruption of fat globule membrane

iv) The fat film, thus formed, serve as a foam depressant causing the air bubble to burst.

v) The liquid fat also serves as cementing material causing fat globules to clump together and eventually butter grains are formed which floats in plasma i.e. butter milk.

18.3.1 Initial Working: Working of butter is essentially a kneading process in which butter granules are formed into a compact mass. During this operation, any excess moisture or buttermilk is removed. However, the emulsion (w/o) at this stage is not fully stable.

18.3.2 Salting of Butter: In conventional process, butter may be salted by adding salt to butter churn after initial working of butter. Salt to be added must be high quality e.g. IS 1845:1961, with low level of lead, iron and copper. The grain should be fine, all passing through IS: sieve-85 (aperture 8424). It should be 99.5 to 99.8% sodium chloride and microbial count should be less than 10/g. Salt sets up osmotic gradient which draws water from the butter grains. This can lead butter to be leaky. Salted butter should therefore, must be thoroughly worked. Salt may be added either in dry form or as saturated brine solution.

18.3.3 Adjustment of Moisture: After the addition of salt, the moisture content in butter is adjusted by adding calculated amount of additional water. In most countries, maximum limits of 16% is placed on the level of moisture. Amount of water is to be added in a batch of butter is calculated as follows:

Starter distillates, if required, may also be added at this stage to enhance the flavour of resultant butter, if cream has not been cultured.

18.3.4 Final Working of Butter: The objective of working butter is to incorporate moisture and uniformly distribute added moisture and salt in butter. During this process remaining fat globules also break up and form a continuous phase, and moisture is finally distributed to retard bacterial growth in butter. It is safer to slightly over-work butter than to under-work. Under-worked butter may be leaky in body with large visible water droplets and may develop 'mottles' on standing. Moisture droplet size normally ranges from 1 to 15 micron and there are approximately 10 billion droplets per gram of butter. Working affects the colour of butter (making is slightly light). Working also increase air content (this favors growth of microorganisms, oxidative effects and therefore poor keeping quality). Vacuum working of butter may be carried out with advantage to reduce the air content of butter. Vacuum range from 15-40 cm of Hg may be used. Air content of conventional butter range from 3-7% by volume with an average of 4 ml/100 while that of vacuum worked butter it is about 1 ml/100g.

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Lesson-19

Churning of Cream

19.1 INTRODUCTION

Churning is the process of converting cream into butter through appropriate mechanical manipulations leading to the conversion of oil-in-water (O/W) emulsion of cream into water-in-oil (W/O) emulsion desired in butter. The emulsion change accompanied by removal of buttermilk and working of butter yields the desired structure and texture in the product.

19.2 THEORIES OF CHURNING

The conversion of oil-in-water (O/W) emulsion of cream into water-in-oil (W/O) emulsion to form butter has been explained by various theories of churning. These are discussed below:

19.2.1 The Phase Reversal Theory

This theory was proposed by Fischer and Hooker in 1927, the theory is therefore also referred as Fischer and Hooker's theory. According to this theory churning is a process of phase reversal i.e. changing of oil in water emulsion (O/W) to water in oil emulsion (W/O). The stability of emulsion is related to the relative volumes of the two constituents present. When oil and water are mixed together, the resulting suspension may be a suspension of (o/w) or suspension of w/o. The type of emulsion obtained depends on the proportion of the two main constituents present, the order in which they are added and the type of emulsifier used.

In churning cream, initially the ratio of surface area to volume (S/V) of the fat globules is large. When the churning proceeds, surface area decreases and with progressive churning, surface area keeps on decreasing. The reduced surface area can no longer hold all the butter milk so it breaks i.e. separates out.

Agitation of cream during the churning process causes coalescence and clumping of fat globules until eventually the ratio of surface area to volume of the fat units becomes so small that the reduced surface area can no longer contain the butter milk in stable form. The O/W emulsion then suddenly breaks; giving butter grains consisting of an emulsion of W/O and free butter milk.

The supportive evidence of this theory is established by the fact that in normal butter, water is not in continuous phase. It has been demonstrated that plastic cream, containing 80-82% fat, conducts electricity and it responds to the pH determination showing water is in continuous phase but butter is a very poor conductor of electricity and pH determination cannot be done on butter but only on serum separated from it.

Microscopic structural studies conducted by Rahn (1928) revealed that butter is not a true W/O emulsion. A proportion of globular fat are still intact in worked butter. He explained that since butter fat is cooled and largely crystallized before the start of churning, true W/O type emulsion is rarely possible.

19.2.2 The Foam Theory

This theory was put forward by Rahn (1928). According to Rahn, cream (and also milk) contains a foam producing substance which gets solidified gradually when cream (or milk) is agitated.

During churning first foam is produced. The fat globules then, due to surface tension, tend to concentrate on the foam bubble and thus are bought into such close contact that clumping of fat globules take place. Subsequently the foam producing substance assumes a solid character and the foam collapse. The fat globules then coalesce and butter is formed.

According to Rahn's theory, fat in cream at churning time is completely crystallized and the pass in to butter with their membrane intact and thus butter is a compact mass of fat globules in which butter milk, water and air are distributed as small globules.

Rahn's theory was based on his findings that air was necessary for normal churning of butter. Application of normal amount of mechanical agitation, in the absence of air did not result in churning of cream. The effect of overloading of churn resulting in increased churning time supported this theory (in case of overloading the churn, there was no sufficient space in the churn for the formation of required amount of foam hence more time).

This theory was, however, subsequently criticized because of the fact that foam formation i.e. presence of air, is not required in some of the continuous butter making processes developed subsequently.

19.5 King's Theory

King's theory was proposed in 1930 and 1953 and it is regarded as the modern theory. According to this theory, what happens during churning is mid-way between the 'Phase Reversal theory' and Foam theory. The modern concept has been summarized by Mc Dowall as follows:

i) The fat in the cooled cream, at churning temperature, is present as clusters of fat globules. And within each globule it is present partly in solid and partly in liquid form.

ii) Agitation (churning) breaks up the clusters and causes foam formation. The globules become concentrated to some extent in the film around the air babble in the foam and thus are brought into close contact of each other.

iii) The movement of the globules over one another in the foam film and the direct concussion between them causes a gradual wearing away of the emulsion protecting surface layer (of phospholipid protein complex). The globules then adhere together to form larger and larger particles. Eventually these particles become visible as butter grains. The grains enclose some of the air from the foam. The fat still mainly remains in globular form.

iv) The working of the butter grains causes the globules to move over one another. Some of them, under the effect of friction and pressure cause some yields out a portion of the liquid fat, others are broken during working. Finally there is enough free liquid fat present to enclose the water droplets, air bubbles and intact fat globules.

19.3 FACTORS INFLUENCING CHURNABILITY OF CREAM:

The factors which influence the churnability of cream can be classified into two groups as

i. The factors related to the initial character of the cream

ii. The conditions in the process of manufacturing

Factors related to the initial character of the cream includes chemical composition of the butter fat, size of fat globules, richness of cream and viscosity of cream while factors related to processing conditions are churning temperature, fullness of churn, speed of churn, design of churn etc. All these factors are discusses in the following sections.

19.3.1 Chemical composition of butter fat

Churnability of cream is greatly influenced by the proportion of soft fats (low melting point fat) and hard fats (high melting points). This proportion determines the degree of fat solidification in the cooled cream. If the proportion of soft fats is more than the churning period will be shortened, butter made will have less firmness and there will be more fat losses in butter milk. If the proportion of soft fats is low, it will prolong the churning period.

19.6.2 Richness of Cream

The amount of fat in cream affects its churnability considerably. The richer the cream the sooner will be the completion of the churning provided the cream is not rich enough to be so thick as to cause the cream to adhere to the inside of the churn and thus escape agitation.

If rich cream is churned at a high temperature the butter will form in a remarkable short time, providing all other conditions are favourable. Thin cream churns much more slowly, and can be churned at high temperature than thick cream, without injuring the quality of butter when rich cream is churned at a high temperature and the butter forms in a short time (about 10 min), the butter will usually be greasy in body and will not contain a much of butter milk, which will be more or less difficult to remove on washing. When thick cream is churned, the butter does not break in the form of small round granules, as it does when thin cream is churned.

When thick cream is (36 to 38% fat) is churned at as high a temperature as is consistent with getting a good texture, the best result are obtained. This type of cream produces less butter milk and consequently less part loss in the butter milk and this will give increase over run and the breaking of the butter at the end of the churning will be such as to cause the granules to appear large and flaky, rather than small round granules. The more flaky granules of butter will retain more moisture than the small, harder granules under the same treatment.

When thick cream is churned and the temperature is moderately high, it is almost impossible to churn the butter into granules. This condition causes butter from thick cream to contain more moisture than butter from thin cream.

19.6.3 Viscosity of Cream

The more viscous the cream, more time is required to complete the churning process. More viscosity diminishes the freedom of movement of the fat globules, lessens their opportunity of being brought together and retard coalescence, thereby increases churning time.

19.6.4 Size of Fat Globule

Cream containing large fat-globules (avg. diameter 4.6μ) churn more quickly than cream containing small globules. Cream containing small fat globules (avg. diameter 3.4 μ) churn with difficulty and require twice as much time to break as the large globule cream. The butter made from such cream has short grains and crumbly character.

19.6.5 Churning Temperature

The temperature is one of the most influential factors in determining the churnability of cream. The higher the temperature of cream, the sooner the churning process will be completed. Too high a churning temperature is however not desirable. It causes the butter to contain soft lumps instead of in a flaky granular form. This is deleterious to the quality of the butter. It causes first a greasy texture of butter, and secondly, it causes the incorporation of too much butter milk in the butter. This butter milk contains lactose, curd, and water, which when present together in butter, are likely to sour and in other ways deteriorate the butter. Curd and lactose should be excluded from butter as much as possible, in order to eliminate food for bacteria which may be present. Too low temperature is also undesirable although it is better to have the temperature a little low rather than too high. Cream at low temperature becomes more viscous. On agitation in the churn such cream if it is very thick will adhere to the sides of the churn and rotate with it without agitating; consequently no churning will take place. Too low a temperature brings the butter in such a firm condition that it takes up salt with difficulty, and when this hard butter is being worked, a large portion of the water in the butter is expressed, and the overrun will be lessened to a great extent without increasing the commercial value of the butter.

The degree of hardness of the fat in cream is the governing factor in deciding the temperature during churning. The hardness of the fat depends upon:

(1) The season of the year.

(2) The individuality of the cow.

(3) The stage of lactation period.

(4) The kind of food fed for the cows.

All these factors influence the melting point of butter fat- The higher the melting point of butter fat, higher is the churning temperature and the lower the melting point of the fat; the lower is the churning temperature.

During spring, the cows yield milk containing a longer proportion of soft fats; consequently the churning temperature is always lower in the spring than in the winter. During the winter, when the cows are fed on dry food chiefly the harder fat increases in quantity, therefore, a higher churning temperature is necessary during that time.

The nature of food fed affects the melting point of butter to a considerable extent. Cotton seed will cause butter to become hard. When larger amount of cotton seed is fed, the butter assumes a crumby, hard condition.

It can be concluded that the churning temperature may vary between wide limits, but the average desirable churning temperature according to the season is

Winter --- 10-13°C; Summer--- 7-9°C

19.6.6 Amount of Cream in Churn

For maximum agitation to take place during churning, the cream must dash from side to side or from top to bottom. Optimum load for maximum agitation should be one third to one half full.

Overloading of the churn diminishes free space in the churn, diminishes concussions and leads to increase in churning time. The overloaded cream may be churned at higher temperature so that churning time is not prolonged but this is not recommended as higher temperature increases fat loss in butter milk and produces soft and leaky butter.

Under loading the churn is not economical for the manufacturer and at the same time the cream will adhere to the inner side of the churn and delay churning,

19.6.7 Nature of Agitation

Proper agitation is necessary for churning cream into butter. The speed of the churn provides agitation to cream. So, the maximum speed of the churn is the speed that yields the maximum amount of agitation. It is dependent on the ratio of centrifugal force and gravity force. Centrifugal force should be less than gravitational force.

Calculating the speed of the churn

$$\text{Centrifugal force} < \text{gravity force}$$

$$m\omega^2 R < m.g$$

$$(2\pi n)^2 .R < g$$

$$n < \sqrt{\frac{g}{R}} \frac{1}{2\pi}$$

$$\approx \frac{1}{2\sqrt{R}}$$

Where, m= mass of the cream

N= speed of the churn

g= gravitational acceleration

R= distance from centre of churn to the periphery

19.4 CHURNING DIFFICULTIES:

The causes of churning difficulties are usually associated with the peculiar character of the cream and particularly where the source of cream is confined to a single herd. Usual causes of prolonged churning time and difficulty in formation of butter are excessive hardness of fat, small fat globules, use of thin cream for butter making and high protein content in cream.

i) Excessive hardness of fat: Winter cream usually contains more hard fats. Use of such cream for butter making prolongs churning time because it diminishes the ability of fat globules to coalesce during churning.

ii) Small fat globules: cream that contains small fat globules takes more time for churning as the ratio of membrane material to fat increases and thus provides increased protection to fat globules.

iii) High protein content: such cream delays butter formation because of increased viscosity that minimizes the force of concussion between the globules.

iv) Use of thin cream: Such cream also have increased protection due to higher membrane protein to fat ratio and also due to intervening serum that keeps globules apart during churning.

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Lesson-20

Use of Break Water and Other Factors Influencing Fat Losses In Butter Milk

20.1 INTRODUCTION

Economy of butter manufacture greatly depends on the recovery of milk fat into butter, which in turn is decided by the amount of fat lost into buttermilk. There are several factors which determine the extent of fat losses in buttermilk. Use of break water is an important one among them. The primary purpose of adding break water and washing the butter is to reduce the amount of residual buttermilk in butter. When butter grains are formed, break water is added before draining the buttermilk. Break water helps in controlling the temperature of the butter churns and thereby the product's consistency.

20.2 ADDITION OF BREAK WATER

Breaking refers to the stage where cream (oil-in-water emulsion) is converted to butter (water-in-oil emulsion). The butter grains formed are of pin head size and they tend to stick together to form large butter clumps. This may result in incorporation of buttermilk in these clumps which may not be washed later in the washing stage. To prevent this clumping of butter grains, break water is added just after phase reversal and draining of butter milk. The temperature of break water is slightly below the temperature of buttermilk drained.

20.3 WASHING OF BUTTER

Washing of butter means removal of remnants of curd adhered to surface of butter grains. After draining the butter milk, drain plug is closed and churn is filled with water (1-2^{o}C below churning temperature) to same level as when filled with cream. The churn is then run at slow speed for 12-15 revolution and wash water drained.

The purpose of washing butter grains is:

i) To wash away free butter milk from the butter granules so as to reduce the curd content of butter and thus to improve keeping quality.

ii) To control the temperature of granules so as to facilitate the subsequent working operation and to control the firmness of resultant butter.

iii) To wash off undesirable flavouring compound, thus it has dual effect:

- a) If cream is of poor quality, washing may improve flavour and even double washing may be practiced.
- b) If cream is of good quality, washing may flatten the flavour and therefore washing may be eliminated.

The curd content of unwashed butter varies from 1.1 to 1.5% and that of washed butter from 0.6 to 1.0%. If butter is made from good quality, well pasteurized sweet cream washing may be eliminated otherwise washing is important for production of sound butter of good keeping quality.

20.3.1 Temperature of wash water: The temperature of wash water has a noticeable effect on the firmness and texture of butter. Under normal conditions and with butter granules of desired firmness, it is general practice to keep the temperature of wash water few degrees below the temperature of buttermilk (or equal to the temperature of cream in the churn). Since lower temperature harden and higher temperature soften the butter, it has been the general practice to keep lower wash water temperatures in summer (when the butter tends to be excessively soft) and to use higher wash water in winter where the natural tendency is for the butter to be excessively hard and crumbly.

20.3.2 Thoroughness of washing: The proportion of the buttermilk constituents contained in butter such as curd, acid and ash that can be removed by washing is limited to the buttermilk that adheres to the surface of the butter granules and that is entrained between the granules. But the buttermilk contained in the interior of the granules is so finely dispersed within the granules that it is not removed by wash water. It is for this reason that the washing of butter does not remove curd completely from butter. It is suggested that approximately 25% of the curd contained in unwashed butter is removed after washing.

20.3.3 Relevance of Washing in unsalted butter: Washing is done to maximize keeping quality of butter but excessive washing may not always do so. Under certain conditions, it may tend toward accelerating deterioration. This is particularly noticed in unsalted butter made from properly ripened cream. When such butter is excessively washed, much of the pronounced flavour character passes into the wash water and is lost to the butter. The preservative characteristics developed in ripening (lactic acid, lactates etc.) are washed away by wash water and resistance to bacterial deterioration is diminished. Such butter usually have washed out or flat flavour defects and soon develop a stale flavour followed by cheesy flavour. On the other hand, unsalted butter when optimally washed resists bacterial deterioration better and fresh flavour is retained longer.

20.3.4 Quality of wash water: Wash water should be free from taints or smell and dissolved Fe and Cu ions. It should be bacteriologically sterile. Satisfactory chilled water may be sterilized by addition of chlorine sanitizer to give 2 ppm available chlorine content.

20.3.5 Initial working: After draining of wash-water there is just sufficient water left in the churn to give (when worked into butter) initial moisture content of about 13-15%. It is an important stage judged by the operator by observing the flow of wash water.

If moisture content is likely to become more after draining of wash water, the churn should be closed and revolved for several minute until granules join together to form large lump. The churn is then stopped and free water drained.

20.4 FACTORS INFLUENCING THE FAT LOSSES IN BUTTER MILK

20.4.1 Season: fat losses in buttermilk are higher in summer than in winter. Lowering the cooling temperature of the cream sufficiently to compensate for the softer summer fat assists in preventing fat loss in buttermilk.

20.4.2 Fat content of cream at churning: Higher the percentage fat of cream, higher will be the percent fat in buttermilk but the percentage loss of fat will be lesser. The percentage of fat in butter milk will be high if the percent fat in cream is high. Cream of medium richness gives low fat loss.

20.4.3 Size of fat globules: The greater the proportion of small sized fat globules (2 microns or less), the greater will be the fat loss and vice versa. Small fat globules have more surface area and thus there are more protective substances on small fat globules. Due to these protective substances, small fat globules escape churning action and pass on to the butter milk and thus results in more fat loss.

20.4.4 Acidity of cream at churning: Higher the acidity of cream, more will be the fat loss in buttermilk if the high acidic cream is pasteurized. Heat treatment of high acidic cream results in precipitation of protein which also entraps some fat globules. This precipitate is lost in butter milk along with the entrapped fat globules.

20.4.4 Neutralization: Cream should be neutralized properly before pasteurization to prevent excessive fat loss in buttermilk. Excess acidity should be neutralized before pasteurization otherwise protein may get precipitated incorporating fat with it and thus lead to more fat loss in buttermilk.

20.4.5 Cooling temperature of cream: The temperature to which cream is cooled and churned and the time for which cream is held before churning are important fundamental factors that control the fat loss in buttermilk. When butter comes abnormally fast and is soft, fat in buttermilk is invariable high. This is usually due to insufficient cooling of the cream and/or not holding it long enough at the cooling temperature.

20.4.7 Physical properties of butter fat: Physical properties of butter fat particularly the ratio of high and low melting point triglycerides are affected by a number of factors like season, stage of lactation, feed and many more. Higher the proportion of low melting point triglycerides more will be the fat loss in butter milk.

20.4.8 Load of churn: Overloading of churn affects the exhaustiveness of churning and thus incomplete churning leads to higher fat loss in buttermilk. It also prolongs the churning time. Churning time can be controlled by increasing temperature but then, the increased temperature result in more fat loss.

20.4.9 Common causes of loss of an excessive amount of the fat in the butter milk

1. Low testing or excessively high testing cream.
2. Diluting the cream with water or with an excessive amount of starter.
3. Improper neutralization and pasteurization.

4. Slow cooling and excessive agitation during cooling or forgetting to stop the coil when cooling is finished.

5. Partial churning during pumping.

6. Churning too soon after pasteurization and cooling especially during spring and summer.

7. Not holding cooled cream at low enough temperature after pasteurization

8. Churning at too high temperature.

9. Washing the cream excessively during churning.

10. Excessive speed of the churn.

11. Over loading the churn.

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Lesson-21

Addition of Color and Salting of Butter

21.1 INTRODUCTION

Butter colours are required to manufacture uniform quality butter all the year round as the natural components (like carotene) responsible for colour in butter, varies according to many factors like season, breed, stage of lactation, feed among others. Therefore, a calculated amount of colour is added in butter so that it does not have influence of varying natural colouring components present in milk or cream.

21.2 DESIRABLE PROPERTIES OF BUTTER COLOURS

– It should be free from ingredients injurious to health

– It should be free from undesirable odors and flavors

– Strength should be such that only a small quantity is required

– It should have such permanency of emulsion as to prevent settling out upon standing

– It must be oil soluble

21.3 TYPES OF BUTTER COLOURS

Butter colours are classified on the basis of their source as vegetable butter colours and mineral butter colours.

21.3.1 Vegetable Butter Colours: This class of butter colours is derived from plants. The most common is the colour obtained and extracted from the seed of the annatto plant (Bixa orellana). The extract of vegetable butter color is made by boiling the annatto seed in oil for several hours. During the latter period of the process the heat is raised to a high temperature, about 115°C for extraction of annatto principle in permanent emulsion with oil. The mixture is then filtered through heavy canvas, either by gravity or under pressure.

21.3.2 Mineral Butter Colours: The colouring principle of this class of butter colours is derived from harmless oil soluble coal tar dyes. This coal tar dyes are mixed with the neutral oil, boiled and filtered. The coal tar dyes certified by USDA are

- Yellow A B (Benzeneazo- β- naphthlyamine)
- Yellow O B (Ortho- Tolueneazo- β- naphthylamine)

Mineral colors have greater concentration of coloring principle and therefore less of the butter color is needed to produce desirable color in butter than is the case with vegetable colors. The emulsion of mineral butter color in oil is more permanent as compared to vegetable butter colors.

FSSR 2011 has permitted some food colors to be incorporated in butter. These are shown in Table 21.1

Table 21.1 FSSR 2011 permitted colors in butter

Colors (natural: singly or in combination)	Quantity
Curcumin	100 ppm max.
β-carotene	100 ppm max.
Carotene (Natural extract)	100 ppm max.
Annatto extract on Bixin/ Nor bixin basis (50:50 ratio)	20 ppm max.
β-apo-8 carotenal	35 ppm max.
Methyl ester of β-apo-8 Carotenoic acid	35 ppm max.

21.3.4 Quantity of Butter color to be added: The amount of color that must be added varies greatly under diverse conditions and may vary from none to about 250 g for every 100 Kg of butter.

21.3.5 Manner of adding butter color: The butter color should be preferably added to the cream while loading the churn. Alternatively, it may be added to and mixed with salt just before final working of the butter. It is then worked into the butter and distributed uniformly.

21. 4 SALTING OF BUTTER

Butter manufactured for direct consumption is added with salt to improve keeping quality and flavour. It also increases overrun in butter.

21.4.1. Purpose of Salting:

i) It enhances flavour and offers consumer satisfaction.

ii) It improves the keeping quality by preventing the growth of bacteria, yeast and molds particularly when made from sweet cream. Butter, if made from acid cream, salt accelerate chemical defect.

iii) Salt increases over-run.

The finely dispersed moisture droplets in butter give it light creamy colour due to scattering of light. When salt is added, due to osmosis effect, diffusion of water take place towards strong brine solution and thereby bigger moisture droplets are formed which is liable to make the butter leaky hence proper working of salted butter is even more important. In addition, the high salt content has the tendency to precipitate the curd contained in the butter and reduce the water holding capacity of butter. This also favors the water droplets to become large.

Complete working of salted butter is essential to ensure adequate subdivision of the brine and to provide butter with even colour and free form leakiness.

Effect of salt on keeping quality of Butter

Salt added to butter influence keeping quality in two ways, namely, bacteriologically and chemically. The salt in butter is present in water portion. Concentration of salt in butter serum has inhibiting effect on microorganisms responsible for deterioration of butter. Thus, it can be said that salting improves bacteriological quality of butter. On the other hand, salting hastens chemical deterioration of butter. This deterioration is most pronounced in the presence of acid. This deterioration is slow but it takes place at any temperature even at low temperatures of commercial cold storage. Thus, it is more apparent in cold storage butter than in short held butter. High salt content causes more intense and more rapid chemical flavor deterioration in storage butter than low salt content.

Effect of salt on moisture distribution and texture of butter

Moisture is present in butter in the form of myriads of small droplets, finely and evenly dispersed throughout the butter granules. This gives butter an opaque appearance and a relatively light creamy color. This butter also contains some loosely held unevenly dispersed moisture droplets. The addition of salt draws the less firmly held water droplets together, forming larger aggregates. In addition, salting out reaction on protein colloidal material further enhances the destabilization of moisture dispersion. This results in precipitation, contraction, dehydration, loss of viscosity and diminished moisture holding ability. The compact waxy texture of butter changes to a coarse, more open and leaky structure.

21.4.2 Quantity of salt to be added

The amount of salt added to butter largely depends on the market requirements. Addition of salt increases overrun in butter. So to avoid addition of excessive salt to butter for economic benefits, standards are laid for maximum limit of salt that can be added. In India, as per FSSR, 2011, maximum permissible limit of salt in butter is 3.0 %.

Salt is added to churn before working. Amount of salt to be added to get desired salt in finished butter can be calculated as per the equation mentioned below.

The amount of salt to be added to butter is calculated by the following equation:

In the above equation, constant 1.25 denotes 80% fat in butter. Therefore, 1.25 x Kg of fat in churn is actually amount of finished butter. Thus the value 1.25 may vary as per the final fat percent desired in finished butter.

21.4.3 Quality of salt to be added: Salt to be used for butter should be of good quality. It should be white, free from foreign insoluble matter and chemically pure. According to BIS specification (IS: 1845: 1961), butter salt should be coarse grained and free from lumps. It should pass through IS: sieve-85(aperture 842 micron). It should have 99.5 to 99.8% sodium chloride and bacterial count should be less than 10/g. Presence of traces of Ca and Mg chloride in salt causes it to moisten and cake. Salt should, therefore, be stored in air tight container and in dry atmosphere away from foreign odours such as kerosene, petrol etc.

21.4.4 Method of adding salt: There are three methods of adding salt to butter namely dry salting, wet salting and brine salting.

a) **Dry salting**: It is the most common method and is suitable for butter of normal softness. In this method, dry salt is sprinkled evenly over the butter granules before working. If butter is abnormally soft it takes more time to dissolve it and dry salt crystals may get coated with soft fat. Thus, dry salt crystals do not get sufficient moisture to dissolve and make the butter 'gritty'.

b) **Wet salting**: In this method, the salt is wetted down before the working begins. First dry salt is distributed over butter granules as is done in dry salting method. It is then followed by pouring enough water to completely wet it. Then the butter is worked. This method assists in rapid solution of salt and avoids presence of undissolved crystals.

c) **Brine salting**: Here salt is added in the form of saturated solution of brine hence can be used only where 'lightly' salted butter is to be made. It requires additional equipment and maintenance hence it is not preferred in commercial butter manufacturing.

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Lesson-22

Butter Moisture Control and Working of Butter

22.1 INTRODUCTION

Moisture control and working of butter are essential steps in butter manufacturing which determines the final body and texture of butter. When the butter granules are formed, its moisture is checked and the amount of makeup water is calculated to get desired moisture content in the finished butter. As water and salt are added after granules formation, it is not easy to incorporate these into mass of butter fat. Working of butter assists in proper incorporation of these into butter.

22.2 ADJUSTMENT OF MOISTURE CONTENT

The adjustment of moisture after churning is necessary so as to meet the legal requirements and also to control body and texture characteristics of the final butter. As per FSSR-2011, butter should not contain more than 16% moisture. The butter, after initial working is tested for its moisture content and then the required quantity of makeup water in calculated.

After initial working, a sample of butter is taken and analyzed for its initial moisture content (i.e. first moisture test). The factors that affect estimation of the correct amount of water to be added are:

a) Accuracy of sampling: Sample of butter should be taken from various places. If moisture content does not appear to be uniform, the sample should be taken from the places in the churn where butter with highest moisture content is present. Take a large sample and mix well to divide up the large droplets, before commencing the weighing.

b) Estimation of the load of butter in the churn: Accurate estimation of the quantity of water to be added is possible only if the load of the butter in the churn is accurately known. The method commonly recommended is to measure the weight or volume of cream in the churn, estimate the fat content of the cream and calculate the expected yield of butter from the churn on an assumed over-run.

22.2.1 Calculation of makeup water

Let first moisture be 15%, desired moisture content be 15.8%, weight of cream be 1000 Kg, fat calculate of cream be 40% and desired over run is 23%. Then expected yield of butter = Kg of fat ´ 1.23

= 400 x 1.23 = 492 Kg.

By straight method water to be added = ((15.8 - 15) / 100) x 492

= 3.94 kg

This basis of calculation, however, is erroneous. The first moisture is taken on unfinished butter and the second on the finished butter. So, before straight % method could be used, it would be necessary to correct the first moisture to the basis of finished butter. It would be simple to use the formula:

= ((desired moisture - first moisture) / water free solid in) x kg of butter in churn

= 100 part of unfinished butter

Then from example given above,
wt. of water to be added = ((15.8 - 15) x 492 / 100 - 15) = 4.63kg

i.e. the difference with respect to straight method is by 4.63/3.94 = 1.2 times. Therefore the correct formula may be given as:

Amount of water to be added

= ((desired moisture - first moisture) x kg of fat in churn x 1.25 x 1.2) / 100

*where over-run is 25%

22.3 WORKING OF BUTTER

Working of butter is essentially a kneading process in which butter granules are formed into a compact mass. The primary purpose of working the butter is to completely dissolve, uniformly distribute and properly incorporate the salt, to accomplish complete fusion of brine and water in butter and to bring the butter granules together into a compact mass for convenient handling and packing.

Working of butter granules is carried out in two stages namely,

1. Initial working and
2. Final working.

During initial working, excess moisture and buttermilk is removed. This is followed by salt and make-up water addition and the butter granules are worked again. This is called as final working and the purpose of this is to properly incorporate salt and moisture in butter to form a compact mass.

After calculated amount of water and salt has been added, churn door is closed and is set in motion at slow speed. Working in this way is continued until the free moisture has been taken up by butter and churn is dry. At this stage there should be no moisture on the trier plug or a cross section cut from the block of butter and colour should be uniform.

It is safer to slightly over work butter than do under work. Under worked butter may be leaky in body with large visible water droplets and may develop mottles on standing. This favours mould growth. Moisture droplet size normally ranges from 1 to 15 micron and there are approximately 10 billion droplets/g of butter.

If grains are firm and hard, over working can cause stickiness. Over working of soft butter on the other hand, tend to produce butter with greasy texture. With softer butter over working may be necessary to prevent 'mottled' colour. Working affects the colour of butter (making it slightly light).

22.3.1 Effect of working on distribution of moisture in butter

The moisture is associated in washed butter in two forms. A portion of this water is present in form of a myriad of minute droplets enmeshed and permanently held within the butter granules. This portion constitutes approximately 8-9% of the weight of butter. The remaining moisture is present in loosely bound form between the butter granules.

At the beginning of the working process, much of the loosely held water is expelled and the moisture content of butter decreases to about 12 to 13%. As the working progresses, the butter loses its granular state and becomes less friable and more plastic. Free butter fat forms the continuous phase in which free water droplets starts to be assimilated. At this stage, moisture content of butter increases again. This increase continues and the amount of water that the butter is capable of assimilating in the working process depends on the firmness of butter, the speed of the worker rolls and the amount of free water in the churn.

22.3.2 Vacuum working

Besides increasing the degree of dispersion of water droplets, working also increases the air content (which favours growth of microorganisms, oxidative defects and therefore poor keeping quality of butter). Conventional butter contains 3-7% air by volume, with an average of 4ml/100g. To avoid air incorporation in butter, vacuum working is carried out. In vacuum working a partial vacuum is maintained during working. In winter the vaccum range from 30-40 cm. of Hg during the first part and from 15-20 cm. Hg during the last part. A lower vacuum is used during summer. This ranges from 20-25 cm during first part and 10-12 cm during the last stage of working.

If too high a vacuum is used, there is a possibility of drawing liquid fat out of the butter resulting in greasy butter. To prevent this, it may be necessary sometimes to omit using vacuum during final stages especially during summer.

22.3.3 Test for dispersion of moisture droplet in worked butter: Indicator papers may be used to check proper dispersion of moisture.

i) Bromo phenol blue indicator paper is used for butter in the pH range of 3-4.6 (ripened cream butter). The indicator paper is brought in contact with the surface of worked butter. Development of blue spots on indicator paper indicates improper working. No spot of blue colour will develop if moisture droplets are small and well distributed.

ii) Bromo thymol blue is used in the pH range of 6 to 7.6 and

iii) Bromo phenol red is used for the pH range 5.4 to 7.

22.3.4 Removal of worked butter from the churn: Worked butter is removed from the churn either manually (this is done with the help of a metal or wooden scoop) or by gravity (where a large metal tray, on wheel, is placed below the churn and churn rotated at slow speed with its gate open. The butter thus falls in the tray). In another method, a large metal tray is wheeled to and inserted into the churn. The churn is then rotated to lift the mass of butter and let into the tray. Besides this, quite often, butter is removed from the churn by means of compressed air (compress air at 3 to 5 psi is used to push out the butter – the butter in this case should, however, be soft.

22.4 BUTTER OVER-RUN

Over-run in butter may be defined as the difference between the weight of fat churned and the weight of butter made from that. In addition to fat, butter contains non-fatty constituents such as moisture, salt, curd and small amounts of lactose, acid and ash. These non-fatty constituents make over-run of butter.

22.4.1 Calculating Over-run in Butter;

Over-run in butter can be calculated if fat content of final butter and the weight of the total fat present in cream is known. Suppose, the butter has 80% fat and the weight of butter in cream is 100 Kg, then the quantity of butter made will be:

Hence, butter made from 100 kg fat in cream is 125 Kg. Thus, the difference between butter made and the weight of butter fat in cream is 125 -100 = 25.

Thus, the percent over-run is 25%.

According to FSSR-2011, butter should contain a minimum of 80% fat, so maximum over-run possible in butter is 25%.

Other factors that influence over-run are accuracy of testing weight and fat content of cream, fat losses in butter milk, mechanical losses of fat etc.

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Lesson-23

Continuous Butter Making

23.1 INTRODUCTION:

Continuous butter making, introduced after World War II, increased the efficiency and output of butter manufacture. To overcome the disadvantage of batch method of production continuous method is evolved and it has the following advantages.

i. **Highly economical:** Due to reduced labour cost, reduced power consumption.

ii. **More hygienic:** Because it is processed under closed system, no manual handling is necessary and no chance for air borne contamination.

iii. **Quicker:** Butter can be produced in a span of few minutes from cream.

iv. Large volume can be easily produced.

v. Can be connected directly to packaging lines.

23.2 CONTINUOUS BUTTER MAKING PROCESS DEPENDS ON THREE PRINCIPLES:

i. **Churning or frothing:** In this method butter grain is formed by aggregation of the fat globules under the action of air present in the cream. During churning, air is beaten into the cream and is dispersed into small bubbles. The fat globules touch these bubbles, often spread part of their membrane substances and some of their liquid fat over the air–water interface, and become attached to the bubbles. one bubble can catches several globules. This resembles flotation, although in true flotation the foam is collected. In the churning process, however, the air bubbles keep moving through the liquid and collide with each other due to the rotation of beater. They thus coalesce and adhering together In this way small fat clumps are formed. Mechanism is shown in fig 23.1. This involves the use of high-speed beaters to destabilize the fat emulsion in chilled cream, and cause the formation of grains of butter in few seconds. The buttermilk is then drained out and butter granules are worked in kneading section consists of screw type kneader.

The proportion of solid fat is crucial, if the globules contain very little solid fat, then the cream does not churn. Higher the proportion of solid fat, the slower the churning, and the lower the fat content in the buttermilk. The temperature will therefore have a considerable effect on the churning.

Eg. ***Fritz. Fritz Eisenrich process. Contimob (Simon Frever) Westfalia and Silkborg are based on this principle.***

ii. Concentration and phase Reversal: In this method the concentrated cream will be subjected to combined effects of cooling and working and bring about a direct conversion of cream to butter. Thus it by-passes the butter grain stage.

Eg. ***Alfa Process and maleshin (Russian) Process.***

iii. Emulsification: In this process, liquid butter fat and serum are emulsified and emulsion is cooled and worked to form butter.

Eg. ***Creamery Package and Gold's flow process.***

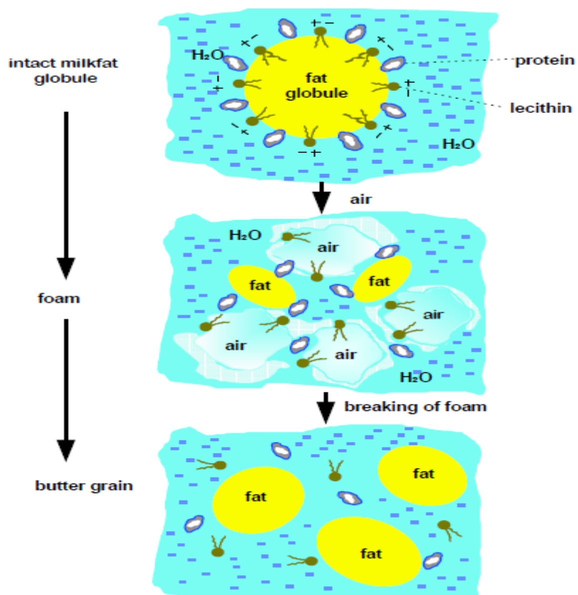

Fig23.1: Formation of butter granules according frothing principle

23.3 FRITZ-EISENRICH PROCESS:

- Fritz butter making machine; it contains only one churning cylinder and twin screw working device. This was only suitable for sweet cream of 40-50% fat.
- The second churning cylinder was developed by Eisenrich which basically have second churning section, buttermilk discharge section and wash compartment. This allow, churning of ripened cream as well.

23.3.1 First Churning Section: It is cylindrical in shape with cooling jacket. It contains beater whose battens are at a distance of 2-3 mm from the wall(Fig. 23.2)

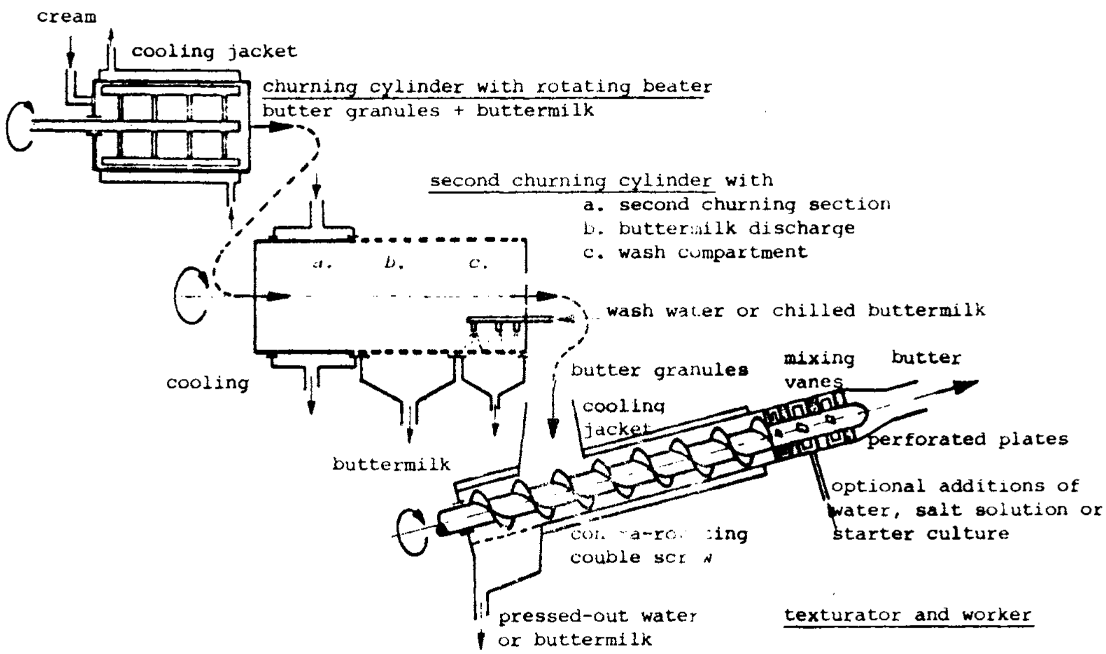

Fig: 23.2: Fritz process of continuous butter manufacturing

(Source: Ing and Kessler, 1981)

Beater rotates at a high speed (600-2800 rpm) which can be adjusted according to the requirement. Cream containing 40-50% fat is passed to this section at a temperature of 7-10°C. Butter granules are formed here within 3-5 seconds. Cream is set into the rapid motion in the form of a thin film. Fine cream froth is produced. Through the breaking of these froth bubbles and through the action of the very vigorous mechanical action the cream is churned to butter granules and buttermilk.

30% fat cream can also be churned by increasing the unevenness of the inner surface (by inserting perforated cylinder). Mixture of butter granules and buttermilk is displaced from the cylinder by the incoming cream. The beater speed is adjusted accurately to yield butter grains of correct size. If the size is too small it causes difficulty in drainage of buttermilk. Thus, fat loss in buttermilk increases. On the other hand, if the size is too big it will entrap more buttermilk resulting in unsatisfactory drainage of buttermilk.

23.3.2 Second Churning Section: This is also in cylinder shape and rotates at 10-25 rpm. In this section cylinder is cooled and butter granules are able to form loose agglomerates. Metal rods are attached to this cylinder so they rotate at the same speed loosen the mass and prevent the formation of lumps. In the buttermilk discharge section major part of the buttermilk is drawn off through a wire mesh which covers the perforated cylinder. Removal of buttermilk is almost complete and water is in very fine state of dispersion. Washing of butter granules can be done in wash compartment but it is hardly necessary.

23.3.3 Twin Screw Working Device

Butter granules are collected by two rotating screws and worked intensively. Buttermilk is pressed out here, to reduce the moisture content of butter. Screws force the butter through a number of perforated plates arranged in series. This treatment serves to produce a fine dispersion of water in the butter. Process is assisted by mixing vanes which are assisted between the plates and attached to the shaft.

In this working section water or salt solution may be added through an opening immediately in front of the perforated plates to adjust moisture or salt.

Modern butter making machine have vacuum compartments to reduce the air content of the butter and improve the spreadability to some extent.

23.4 CONTIMAB PROCESS:

In this method, cream churns into butter granules in 1-2 seconds, churning cylinder rotates at 600 – 800rpm. Two major working sections are provided, one is wet and another one is dry(Fig. 23.3). In wet working section washing and cooling of butter granules and removal of buttermilk takes place. In dry working section, butter is further worked and reduces the moisture content to 13 to 14%. Further butter travels to dosing section, where adjustment of salt and moisture will be happen. At the end vacuum chamber is provided to reduce the air content of the butter.

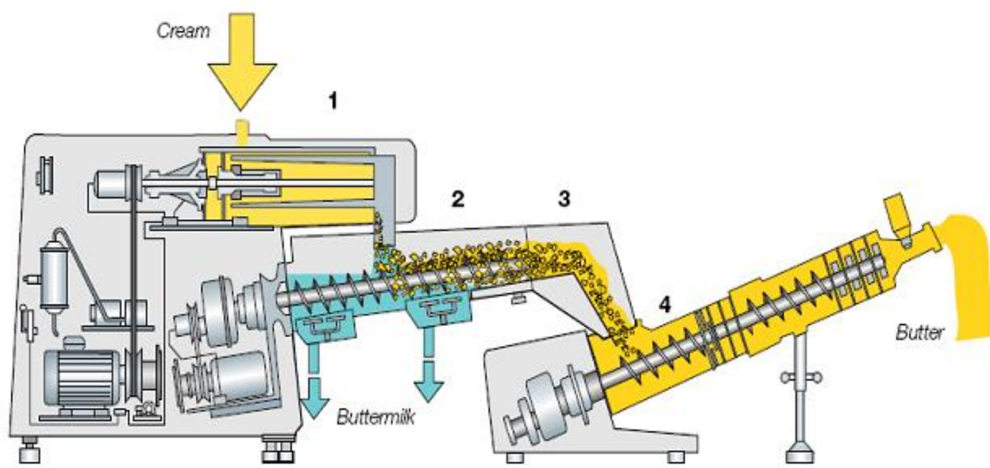

Fig: 23.3 Schematic diagram of contimob process of continuous butter manufacturing

(Source: Tetrapak Processing System, AB, Lund, Sweedan)

1. Churning cylinder

2. Separation section

3. Squeeze-drying section

4. Second working section

23.5 ALFA PROCESS:

Cream of 30% fat is pasteurized at 90⁰C, degassed, cooled to 45 – 50⁰C and separated at this temperature in a cream separator to 82% fat. The cream, which is still in the form of oil in water emulsion, but it is almost the composition of butter. In this cream fat globules are so closely packed that their fat globule membranes are in contact with each other. As fat crystallizes and fat crystals perforate the fat globule membrane and free fat is released out. Rubbing together of the fat globules helps this process as they move in the cooler. Thus phase inversion takes place and water-in-oil emulsion (butter) is formed. It contains all the fat globule membrane material, thus it has high phospholipids content and no buttermilk is produced in this process. Process flow diagram for Alfa process is given below.

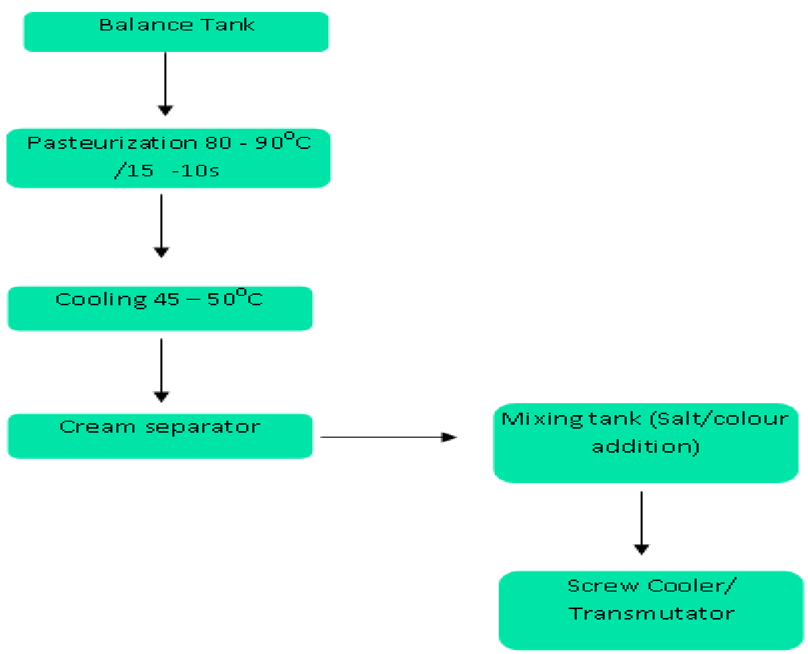

Fig.23.4: Alfa Process flow diagram of continuous butter making

Salting in Continuous Butter making: Salt is added only after removal of buttermilk and preferably entry is in between 1st & 2nd perforated plates. Salt is commonly injected in the form of 50:50water salt slurry. Only 26% salt is soluble, so half the salt remain undissolved in slurry.

23.6 CHERRY-BURRELL GOLD'N FLOW PROCESS:

This process essentially includes following steps;

1. Destabilizing cream and separating it to 88-90% fat

2. Pasteurizing the high fat concentrate

3. Standardizing to the composition of butter

4. Chilling and working into butter

The process starts with 18^0C cream that is pumped through a high-speed destabilizing unit and then to a cream separator, from which a 90% fat plastic cream is discharged. Destabilization is a process of packing small fat globules together to form large ones. Destabilizing unit consists of a perforated blade travelling at high speed, beating chamber, an adjustable hold back valve and an air inlet valve. The blade travelling at high speed packs the fat globules together by mechanical force. The adjustable hold-back valve insures that the cream is held in beating chamber long enough.

It is then vacuum pasteurized and held in agitated tanks, wherein color and salt are added. Now, product is in the form of 80% fat-water emulsion, which is maintained at 49^0C, is cooled to 4^0C by use of scraped surface-heat exchangers. It then passes through a crystallizing tube and then a perforated plate that works the butter. Before chilling, 5% nitrogen gas is injected into the emulsion. It is possible to manufacture butter from high-fat cream (>82% milk fat) on a continuous basis.

23.7 SALT QUALITY & SLURRY PREPARATION:

If the butter is to be salted, salt is spread over the surface in batch production, or added in slurry form during the working stage in continuous butter making. Very finely grounded salt to be used and which is of high quality (TBC <10/g) and Purity (99.5 – 99.8% Sod. Chloride). Salt grain should be fine, all pass through IS: Sieve-85(aperture 8424). Salt slurry should be made before 30min and vigorously agitated. Need a proper working after salting otherwise "loose moisture" or mottling defect may happen.

Determination of salt in butter

There are several ways of determining the salt content of butter. The analysis can most conveniently be carried out with a 10-gram sample that has already been used for determination of the moisture content of the butter. The butter is melted and poured into a 150 ml beaker. The butter residue is washed into the beaker by means of 50- 100 ml of water at 70°C. After addition of 10 drops of saturated potassium chromate solution, titration takes place with the use of a 0.17 n silver nitrate solution (AgNO3), added gradually until the colour changes from yellow to brownish. The salt content is then determined in accordance with the following equation:

Salt % = ml of silver nitrate solution used x 0.1

Lesson-24

Packaging, Storage and Distribution of Butter

24.1 INTRODUCTION:

The primary purpose of packaging is to offer butter to the trade and to the consumer in packages of such size, material, form and appearance, as will best meet the requirements and satisfy the preferences of the buyer. In addition, packaging also prevents butter from contamination, weight loss and flavor deterioration. Butter may be packed for wholesale or for consumer packages. Type of packaging, form and material differ for wholesale and retail packaging.

24.2 PACKAGING OF BUTTER:

Objectives of packaging are:

i) To protect butter against contamination.

ii) To prevent loss of weight during storage. (due to evaporation)

iii) To prevent degradation of butter (resulting in off-flavour development)

iv) To increase sales appeal and identification of the content.

The ideal system is to pack the butter as soon as possible after churning otherwise a colour defect known as 'Primrose' appear on the surface of butter due to evaporation of moisture. If butter is to be held before packaging, it should be kept covered with a wet muslin cloth and transferred to a tempering room at 5^{o}C.

24.2.1 Packaging material: Packaging material for butter should have excellent barrier properties such as

· It should be moisture proof

· It should be grease proof

· It should be impervious to light

· It should have good strength (to prevent tempering during transportation etc.).

Some of the packaging materials used for butter packaging are

i) Parchment paper – also known as butter paper.

ii) wax coated paper

iii) cellophane

iv) cardboard boxes and teak wood drums lined with food grade plastic

v) Aluminium foil laminates

vi) Lacquered tin cans (it is costly but is advantageous in tropical countries and prevents de-shaping during storage and transportation.)

24.2.2 Techniques of packaging:

1. Manual moulding and wrapping
2. Mechanical moulding and hand wrapping
3. Fully automatic units which mechanically moulds, patts and wraps. It reduces labour cost, handling losses and is suitable for large scale operation. The machine can be reset for different size viz. 10, 15, 100, 250 and 500g. Some of the well-known brands of fully automatic butter packaging machines are Kustner, Benhill (both are German) and SIG (Swiss). In these machines, after wrapping, the pat go to carton machine for packing in card boxes and transferred to cold storages (5°C) for 24-48 h and then shifted to low temperature storage (-23 to -29°C).

24.3 STORAGE OF BUTTER:

For the sake of consistency and appearance, butter should be placed in cold store as soon as possible after wrapping and should be chilled to 4°C for 24 to 48 h. Unless this is done, fat crystallization is very gradual and the butter retains its freshly churned consistency and appearance for several days. However, once it has been sufficiently chilled, a subsequent rise in temperature will not make it as soft as it would have been at the same temperature prior to its chilling. The initial freshly churned, somewhat ointment like consistency is transformed to that typical for butter. This change is known as setting of butter. The butter cannot be considered finished until it has been chilled or set. A low storage temperature also improves its keeping quality and reduces the risk of the package being deformed.

As butter is essentially a perishable product it should not be stored longer than necessary. However, when production exceeds demand and also quite often to level out the fluctuation between high flush season production and low summer production, storage of butter becomes unavoidable. For short period butter can be stored at about 4°C but if longer storage is involved it must be deep frozen at -23°C and only best quality butter should be selected for deep freezing. Since solubility of salt is low (35.7% at 0°C), some salt crystallization may occur during storage but the crystals re-dissolve on thawing.

24.3.1 Shrinkage of stored butter

This refers to the loss in weight of butter packs mainly due to evaporation of moisture during storage. The causes of moisture evaporation are:

i. Condition of moisture in butter: incomplete incorporation of moisture in butter due to incomplete working

ii. Size of pat: the smaller the butter pat, greater the surface area/unit volume, which results in greater shrinkage and vice-versa.

iii. Temperature of storage: the higher the temperature, greater the shrinkage and vice-versa.

iv. Relative humidity of storage room: the higher the humidity, lower the shrinkage and vice-versa. However, high humidity favors mold growth and hence it is avoided.

24.4 TRANSPORTATION OF BUTTER:

Quality of butter is largely dependent on temperature. It affects mainly firmness and standing up properties of butter. For transportation of butter from factory to distributors and from distributors to retailers, cold chain is essential to maintain.

Butter may be transported either frozen or chilled. For frozen transportation of butter, temperature range is -16 to -18°C while for chilled transport; temperature range is 1-4°C. Temperatures may deviate from these values, depending on the particular transport conditions. Butter must be flash-frozen to protect it from losses in quality. The rapid cooling results in the formation of small ice crystals which has no negative effect. If, however, the temperature is reduced very slowly, relatively large ice crystals are formed which can result in losses of quality (crumbly texture).

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Lesson- 25

Judging and Grading of Butter

25.1 INTRODUCTION:

Butter may be judged from a commercial and from an individual standpoint. It is important that the judge should become familiar with the quality of the butter as required by the standard markets, and then judge the butter according to the demands of the mass of the consumes, rather than according to the personal likes and dislikes. In order to become a good butter judge it is essential that the senses of taste and smell be acute even if one's taste and smell are keen and sensitive, considerable practice or experience is necessary. Almost anyone can tell good sample of butter from a very poor one, but when it comes to differentiate between two samples, which are nearly alike in quality, skill and experience are required. Most important in scoring butter is to become thoroughly familiar with the ideal flavour of butter; then by repeated comparisons of different samples of butter to this one ideal flavour, one will soon become efficient in grading the butter. Various scorecards are formulated for sensory evaluation of butter wherein maximum scores are allotted for various sensory attributes of butter as shown in Table 25.1.

Table 25.1 Score Card for Butter

ADSA Score Card	
Attribute	**Perfect Score**
Flavour	45
Body & Texture	30
Colour	10
Salt	10
Package	5
Total	100
BIS Score Card	
Attribute	**Perfect Score**
Flavour	50
Body & Texture	30

Colour	15
Salt	Not Prescribed
Package	5
Total	100

25.1.1 Desirable attributes of Butter

- Package: should be attractive, neat, clean & tidy in appearance and have good "finish" (smooth, attractive surface). All packages should be fastened firmly & neatly.
- Salt: it must be uniformly distributed & properly dissolved. If undissolved salt is present, gritty effect is usually noticed in butter.
- Colour & appearance: a uniform light, pale yellow colour is liked most by the consumers.
- Body & texture: the body of butter should be firm & exhibit a distinct waxy, close-knit texture. When broken, the appearance of good quality butter should present somewhat jagged, irregular, wrought-iron like surface. Butter should have smooth "spreadability".
- Flavour: It should have a mild, sweet, clean & pleasant flavour & delicate aroma. A characteristic feature of high-quality butter is that instigate appetite to crave more of the product.

25.2 MANNER OF JUDGING:

(i) Body: After the trierful of butter has been drawn out, the first thing to notice is the aroma, and the body or texture of the butter. The butter on the outside should be examined at once before it is affected by the temperature of the room. Notice its colour, whether it is even or uneven, low or high. Determine to the appearance of the butter whether it is greasy, fallow, spongy or sticky. Whether salty or salted uniformly. Squeeze the butter with the thumb to ascertain the character of the body. The aroma of the butter should also be noticed in connection with scoring the butter on body and texture, as it is more pronounced immediately after the trierful of butter has been drawn.

(ii) Flavour: It is impossible to describe flavours found in butter. However, there are a few flavours which stand out more prominent and are more commonly met with than any of the others. Good butter should possess a clean, mild, rich, creamy flavour, and should have delicate milk, pleasant aroma.

Flat flavour is noticeable in butter made from unripened cream. Such butter is otherwise clean, little objection is made to this kind of butter for ordinary commercial purposes. The remedy is to ripen the cream a little higher with a proper ferment.

Rancid flavour is applied to butter which has an undesirable strong flavour. Rancid flavour is the most common defect developing in butter on standing other flavours developing in butter are, fishy stable flavour. Cheesy flavour is another characteristic which is very common in butter. This condition develops chiefly in butter containing little or no salt. It is claimed that it is due to the decomposition of the curd matter in the butter.

Weedy flavor is quite common in butter. They are due to moisty to the condition of milk previous to the manufacture of the butter. The remedy is to take the cows away from the pasture in which weeks of the different kinds are growing, such as gartic, milk onion etc.

Acid flavour is another common defect found in butter. It is usually due to the improper ripening.

(iii) Colour: Colour of butter should be bright and even. The color preferred in Indian markets is chiefly a high straw colour.

(iv) Salt: The amount of salt likewise depends upon the market and unless the salt content is extremely high or extremely low, butter should not be criticized on account of the amount of salt.

The chief thing to consider in judging butter on its salt content is the condition of the salt. Notice whether it has been thoroughly dissolved and evenly distributed.

(v) Style: Style is the appearance of the butter and package whatever the shape of the package, the chief thing to consider is that it is clean and neatly finished.

25.3 GRADING OF BUTTER:

BIS has given an evaluation card of butter, which is shown in fig 25.1. The score obtained after sensory evaluation of butter as per the card suggested by BIS, is used to grade butter. As per BIS, grading of butter is as follows:

Quality	**Score**	**Grade**
Excellent	90 or above	A
Good	80-89	B
Fair	60-79	C
Poor	59 and below	D

EVALUATION CARD FOR BUTTER

Name: Date:

Batch or Code No.: Time:

A. Assign score for each sample for different characteristics. First go through section B.

Characteristics	Maximum Score	Sample score
Flavour	50	
Body and texture	30	
Colour and appearance	15	
Package finish	5	

B. Indicate, if any, the degree of defects such as the following. Encircle the one applicable and deduct from the appropriate attribute.

Characteristics	Defect	Degree of Defects		
		Suspicion	Slight	Pronounced
Flavour	Rancid	5	7	15
	Tallow	5	7	15
	Neutralizer	1	3	5
	others	1	3	5
Body and texture	Leaky	3	5	10
	Greasy	1	3	10
	Oily	1	3	10

Fig 25.1 Evaluation card for Butter

Uses of Butter: Butter can be used for direct consumption (table butter), in the preparation of sauces, as a cooking medium, in the baking and confectionery industries and in the manufacture of ice cream. Butter is also used in the manufacture of butter oil and ghee and in the production of recombined milk.

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Lesson-26

Rheology of Butter

26.1 INTRODUCTION:

Rheology is defined as the science of the deformation and flow of matter. The most important aspect of rheology deals with the relationship between force and time on one hand and deformation and flow of the material on the other.

Butter is an example of plastic materials that is upon application of force, the product tends to yield or undergo permanent deformation. Butter texture is a critical factor in determining functionality and consumer acceptance. It influences spreadability, taste, mouth feel, appearance, and its suitability for various uses. Spreadability is by far is the most significant in relation to the table use of butter. Several methods have been developed to determine the spreadability of butter in particular and texture in general.

Most of the tests used to characterize butter rheology are empirical in nature and designed to imitate sensory perceptions for quality control operations. These are based mainly on the principles of penetrometry, extrusion, and sectility and involve large deformations which break down the material's structure. The response of the material to an applied stress provides an index for some consistency parameter which is generally used to regulate a step in the butter making process.

Butter is a multiphase emulsion, consisting of fat globules, crystalline fat, and an aqueous phase dispersed in a continuous oil phase. The textural properties of butter are closely linked to their fundamental structures.

26.2 BUTTER STRUCTURE:

Fat exists in butter in form of liquid fat and also in the form of intact globules. Liquid fat makes the continuous phase in butter. Water droplets and air cells are dispersed in this continuous phase. Some amount of fat is present as crystals. The number and size of the fat crystals greatly depend on the temperature and the temperature history. A considerable part of crystalline fat may be inside the fat globules because during churning, liquid fat is extruded from the globules, mainly by spreading over the air bubbles. But there are also crystals outside the globules and these aggregate to a continuous network and may grow together to form a solid structure, which is mainly responsible for the butter firmness. The microstructure of butter is shown in figure 26.1.

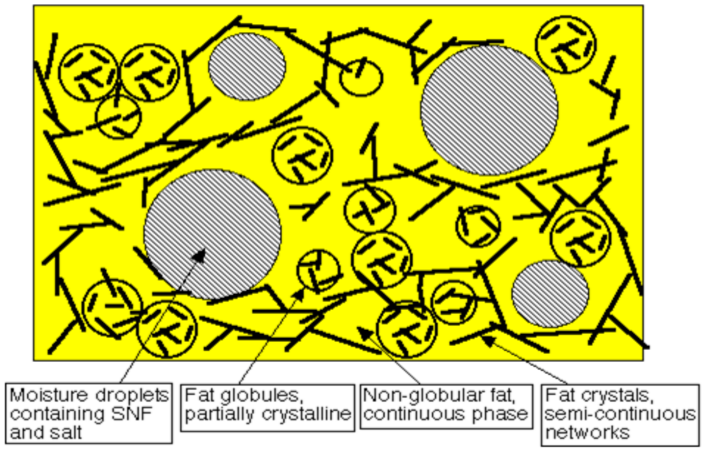

Figure 26.1: Butter Structure

26.2.1 Rheological properties of butter

The rheological properties of butter, to a large extent, are determined by the physical state of milk fat. Hence, the consistency of fat can be modified in several ways like by changing the temperature of cooling and working, and by changing the mechanical treatment. Butter being an emulsion, ratio of solid to liquid fat, crystal dimensions and polymorphic transformations play a major role.

26.2.1.2 Hardness and spreadability of butter

Butter hardness and spreadability are inversely related parameters and are two of the most important aspects of texture. They have been the two most commonly measured sensory properties as they greatly influence consumer acceptability. Butter possesses poor spreadability at refrigeration temperatures, and poor structural stability at room temperatures. At room temperature, butter also demonstrates oiling off and moisture migration. The change in butter's solid fat content between 10 and 20°C is very pronounced, resulting in a very limited temperature range within which there is desirable spreadability. At lower temperatures, more triacylglycerols crystallize into the solid fat network. The degree of milk fat crystallinity is the largest determinant of the rheological properties of butter. For easy spreading, butter should contain between 20 and 40% fat in solid form and, in general, butters with "yield stresses" below roughly 125 kPa have satisfactory spreadability.

Butter texture depends on many interrelated parameters, and no single factor appears capable of explaining its consistency. Milk fat's fatty acid composition and positional distribution influence the melting point, and therefore are of major importance. The iodine value and average fatty acid chain length account for much of the variation in butter firmness. A change in iodine value of 3% can effect a 50% change in firmness. Winter butter is harder than summer butter because of seasonal variations in cow feed which result in a more saturated fat overall during the winter.

26.2.3 Setting

Fat crystals, which are suspended in liquid fat, aggregate into 3-dimensional networks because of Brownian motion and Van der Walls forces. This aggregation continues in freshly made butter for months, resulting in increased firmness. The extent of this setting depends on a number of variables, including composition, storage temperature, storage time, the butter's initial hardness, and the conditions during manufacturing.

26.2.4 Work softening

Butter may get softened by working. When the butter is subjected to extensive working, its firmness is considerably reduced. The effect of working varies according to the type and origin of butter. The greatest amount of breakdown occurs when the temperature is around 10-15°C. If the butter is allowed to stand after working, firmness gradually returns as discussed in setting of butter.

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Lesson-27

Microbiological aspects of butter

27.1 INTRODUCTION

Microbiology of Butter reflects the micro flora present in pasteurization cream from which it is made, water added at the time of salting of butter, Sanitary Condition of process of equipment, manufacturing environment and conditions under which the product is stored. Intrinsic properties of butter for e.g., pH salt content, uniformity of moisture distribution and droplet size, all impact microbiological stability.

27.2 MICRO-ENVIRONMENT OF BUTTER

Micro-environment of Butter is unfavorable for growth of Microorganisms compared because of the following compositional and structural differences.

27.2.1. Compositional differences

a) Fat content in butter is relatively resistant to microbial decomposition is greater butter in butter (about 80%) compared to cream (except for high fat plastic cream)

b) Lactose which is readily utilizable by many of the microorganisms is present in lower quantities.

c) Moisture content which is essential for microbial growth is present lower quantities (<16%) in butter.

d) Salt in butter make its micro environment unfavorable for microbial growth.

27.2.2. Structural differences

The nature of distribution of water and fat in cream and butter makes their microenvironment different. In cream water is in continuous phase and fat is in discontinuous phase, where are the reverse in case of butter where water is discontinuous phase present as drops dispersed in fat. A large number of water droplets are more than the number of Microorganisms in butter. Moreover, unlike that in cream, Microorganisms cannot proliferate easily and spread in butter because of the following reasons.

a) Water phase is separated by relatively resistant fat phase in butter. Molds and Psuedomycelia forming yeast are able to grow and penetrate through the fat phase of butter.

b) Limited supply of nutrients in the H_2O droplet in butter while in cream microorganisms can grow in the continuous H_2O phase having dissolved nutrients and migrate one portion to the other.

27.3 MICROFLORA OF BUTTER

In spite of unfavorable conditions in butter for microbiological growth; since cream utilized for butter making is pasteurized, the bulk of Microbial population in the final packet is contributed by post pasteurization contamination during butter making. Microorganisms of the post pasteurization contamination from utensils, H_2O, air etc and belong to different groups of bacteria such as psychrophilic/psychrotropic (proteolytic/Lipolytic), Mesophilic (Lactic and non lactic acid) and spore forming bacteria. In case of yeast and molds, they may enter through aerial route. The microflora of butter which belongs to above groups are summarized in the Table 1.

27.3.1. Sources of Microorganisms in Butter

Microorganisms which are present in Butter are derived from a variety of sources are explained below.

27.3.1.1 Raw Material (Milk or Cream)

The quality of milk/cream utilized for production of Butter has a direct impact on microbiological quality of the final product. Butter made from cream separated from EOD (Every other day) collected farm bulk tank milk or bulk collected milk (refrigerated) was slightly inferior quality with respect to flavor to butter made from daily collected can milk (cooled at 12° C). This is due to higher microbial number and activity in the EOD or bulk collected milk. Highly heat resistant extracellular lipases which one secreted by Psychrotropic bacteria in such milk may resettled in high free fatty acid content and also affect final composition and flavor of cream and butter manufactured from it. This type of cream exhibited slow acid developed during ripening due to possible adverse effects of liberated free fatty acids.

Both sour and sweet creams are generally used for manufacture of butter. Sweet cream contains fewer nor organisms predominantly bacteria compared to yeast and molds. On the other side sour cream contains larger nor of microorganisms sometimes up to a humdrum million per ml. Sometimes the cream may be accumulated before churning into butter. During this period microbial growth may occur. In some cases, because of the high initial population, a large number of bacteria may survive in the pasteurized cream. Since the quality of cream has a direct bearing on the microbiological quality of butter, these are a need for adopting the following measures to maintain the quality standards of butter.

1) Hygiene production of milk and cream.
2) Proper quality control of cream before butter making.
3) Avoiding accumulation and high temperature (75˚ C)

Storage of cream before butter making.

The following test may be carried out for quality control of cream for butter making:-

- **a)** Organoleptic test
- **b)** Acidity
- **c)** Sediment test
- **d)** MBR test
- **e)** Total bacterial count (TBC)
- **f)** Yeast & Mould count

As per the procedure laid down by APHA (American Public Health Association) for milk and cream. The Following standards as given in Table 2 have been suggested for grading of cream on the basis of various microbiological tests.

In India, no separate standard have been suggested for recommended for cream for butter making, though the prescribed ISI standards are available market cream.

27.3.1.2 Equipments

The sanitary condition of various equipments used during butter manufacture determines to a great extent the degree of contamination. Among these equipments, butter churn is microorganisms' important source of contamination particularly in regard to psychrotrophic organisms and yeast & molds, metals churns are advantageous from sanitary point of view but still in many places, the wooden churns continue to be in use. These wooden churns are difficult clean and sanitize since the wood surface is irregular which takes up water and subsequently cracks, thereby, making the removal of solid particle difficult molds penetrates deep inside pores and crevices of the wood and serve as a potential entry for contamination. The parts of pasteurizers and allied units like pipelines, pumps, valves and coolers may be the other sources of contamination.

27.3.1.3 Water Supplies

During manufacturing of butter, water may be used for different purposes like to flush residual cream form holding values into churns, for dilution of cream as break water, as chilled wash water, for wet salting and for adjusting the moisture content of butter. In case of continuous butter making process, water is used for washing of butter granules. The contaminated water used one or more of those points lead to important sources for the entry of microorganisms. The psychrotrophic bacteria known to cause spoilage in butter may gain entry into butter through such water supplies. The bacteria which are causing spoilage into the final product through such water supplies are shown in Table 3.

Psychrotropic bacteria can grow extensively H_2O in dairy tanks, when particularly when water contains some organic matter and has not been efficiently chlorinated Coliforms and some heat resistant Psychrotropic strains of bacilli and clostridia have been found to occur in natural water.

Psychrotropic counts of >100/ml & lipolytic counts of >10/ml are indicator of faulty chlorination of H_2O supplies. Total colony counts of >250/ml (determined at 21 or 25°C) & Most probable number (MPN) of > 10/ml (at 30°C) for Coliforms are indicator of unsatisfactorily quality of H_2O supplies. The effective measures to check contamination through water is chlorination of H_2O supply by adding suitable concentration of chlorine (1-5 ppm).

27.3.1.4 Air

Air is comparatively important source of contamination a butter plant than any other during product plant. All plants don't have a separate packing room or don't maintain a high standard of hygiene in butter packing room or don't maintain a high standard of hygiene in butter packing and printing room. Thus butter often gets exposed to air for long periods prior to or during packing and get contaminated bacteria are the most predominant sources of aerial contamination followed by yeast and molds. Suggested standard reported Bacterial counts of air ranging from 11-132/ft^3 & yeast & mold count of 4-26/ft^3 during butter packing and printing operations. Psychrotrophs are also encountered in the air of dairy plants. Molds spores remain suspended in air and contaminant walls or wooden structures in the packing room, which can serve as growth centres for molds. The main sources of aerial contamination in dairy plant appear to be announcement of workers, fans, drains and dust from the surrounding areas.

27.3.1.5 Personnel

The persons involved in the manufacture and handling butter may introduce Microorganisms to butter through contaminated hands, clothing, mouth, nasal discharge, sneezing etc particularly doing packaging stage unhealthy persons, particularly those suffering from respiratory disorders should not be allowed to handle butter. The personnel engaged in the packaging room should follow the hygiene measures.

27.3.1.6 Butter Color

The color used for incorporation into butter is particularly free from micro organisms. However, if it is kept in open containers or is mixed with water in a unclean measuring containers, there are chances of contamination of butter through butter color.

27.3.1.7 Packaging material

Normally, parchment paper is used for packing butter. This paper is usually received in a satisfactory condition from the manufacturer but it may get contaminated especially with molds. Subsequently during transportation or storage use of dry parchment and or air treatment of parchment with hot brine or antifungal chemicals like sorbic acid/ potassium sorbate, Propionic acid/ calcium or sodium propionate or benzoic acid/ Sodium benzoate may reduce the mold contamination. Normally, a combined treatment of hot brine and sorbic acid (0.5%) for 24 hrs is recommended.

27.3.2 Effect of Processing on the Microflora of butter

A number of factors like processing of cream, method of manufacture, working and salting and conditions of storage affect the Microflora of final product.

27.3.2.1 Effect of cream processing

The processing of sweet or sour cream like neutralization, pasteurization and cooling have a pronounced effect on the microbiological quality of butter.
a) **Neutralization of cream**: The sour cream is neutralized before heat processing. The neutralization step may affect the microbiological quality in the following manner.
The contaminated neutralization solution as a result of poor quality water used for dissolving neutralizers may add microorganisms in cream. However, the contaminants entering at this step may get killed during subsequent pasteurization of the neutralized cream.
(ii) Pasteurization: - Cream is pasteurized at 71.1°C for 30 min (LTLT) or 90°C for 16 sec (HTST), which is more severe treatment than that required for fluid milk. This leads to nearly 99% destruction of microorganisms in cream. However, some of the cream borne Microorganisms are still carried over to the butter due to the following reasons:

- **a)** Resistance of certain microorganisms to survive pasteurization enables some of these organisms like psychotropic heat resistant bacteria to cause spoilage in butter.
- **b)** Improper pasteurization may results the survival of some spoilage causing Microorganisms. Hence, a proper time-temperature combinatory for pasteurization should be meticulously followed.
- **c)** The practice of mixing raw cream with the pasteurized cream into the vat may also be responsible for the subsequent transfer of microorganisms to the butter.

(iii) Ripening of cream: This step is applicable for making ripened cream butter. Ripening of cream affects the microbiological quality of butter in the following ways.

- **a)** There is considerable increase in the total bacterial count in butter involves direct addition and multiplication of the added organism.
- **b)** If the cultures used are contaminated, the considerable organism can also enter the product.
- **c)** In general, the acid production by butter cultures during ripening suppresses the growth of spoilage causing organisms. (Eg. proteolytic and lipolytic pseudomonades)

(iv) Cooling /ageing of cream: After pasteurization, the cream is cooled to low temperature and it is help at this temp for ageing (which helps in getting butter fat recovery in during churning). The temperature of cooling and ageing generally followed under Indian conditions varies from 5-10°C for 2-4 hrs or overnight. However, minimum holding is desirable in modern processing practices. If the cream properly cooling/ageing conditions from satisfactory, there is little significance of such cooling/ageing conditions from microbiological point of view. Bacterial numbers in pasteurized cream is relatively lower and mainly thermophilic organisms are present which by and large appears to be harmless in butter.

27.3.2.2 Effect of butter making

(i) Churning:-

Churning during conventional batch method of butter making involves vigorous agitation of cream at 10°C. This step affects the microbiological quality butter in the following ways.

- **a)** This process causes quantitative changes in microflora by breaking the bacterial clumps and consequently increasing the total bacterial count.
- **b)** Contamination of butter churn from extraneous sources may further add to the microbial load in butter.
- **c)** Major part of bacterial population goes to butter milk instead of butter during churning, whereas rivers are true for molts due to this bigger size.

27.3.2.3 Effect of process for Moisture distribution (working, printing and reworking)

The distribution of moisture droplet in butter is directly affected by working; printing and reworking process the working of butter breaks the bigger droplets and brings about a uniform distribution of tiny droplets, printing of butter, however, leads to aggregators of water into bigger droplets and loss of free water from butter. Reworking of butter needed where moisture content of lot of more and needs removal or when two or more lots of butter are to be mined. This is preserved to have the same effect as the 'Working' process on moisture distribution.

The nature of moisture distribution in turn affects the microflora of butter. The microbial growth is restricted only infected droplets and a large number of tiny droplets in properly worked butter remain sterile since migrations of bacteria through the resistant fat mass is difficult the proliferation of organism in the infected droplet is restricted due to limited availability of nutrients. On the other hand, in under worked or unworked butter, the bigger water droplets support greater proliferation of microorganisms, thereby leading to butter spoilage. Based on this mechanism, working of butter discourages microbial growth due to fines and uniform moisture distribution whereas printing encourages microbial multiplication by creating bigger droplets. Reworking has been observed to cause rapid deterioration of butter samples stores for long time probably by renewed microbial activity.

27.3.2.4 Effect of Salting

Salt, generally added to butter, is inhibitory to the growth of microorganisms. However, its action is influenced by its concentration and its uniform distribution in water droplet which in turn in dependent if butter is worked efficiently. The salted tiny droplets will contain high concentration (>15% salt and hence prevent bacterial growth). If salt is not is uniformly distributed, the bacteria will grow in regions where the salt concentration in moisture is low or absent. Therefore, microbial growth is checked in the infected droplet in droplets in salted butter and as a result microorganisms are more active in can worked or under worked salted butter than in properly salted butter.

However some salt tolerant organisms for example particularly fluorescent pseudomonades can grow in 3% salt concentration very few can grow in 5% salt and none can grow in 6% salt concentration certain molds can also tolerate high slat concentration and grow on the butter surface.

27.3.2.5 Effect of Packaging

The addition of contaminating microorganisms in butter at packaging stage mainly through air and packaging materials, although the role of unhygienic packaging equipment surfaces of personnel cannot be excluded.

27.3.2.6 Effect of storage

The temperature and time of storage have a definite effect on the microbiological quality of butter. There is a wide range of temperature over and Microorganisms grow in butter. In tropical countries like India, butter is stored at room temperature and conditions are congenial for the microbial multiplication.

At low temperature storage, particularly in cold stores, the rate of growth of Microorganisms decreases and only Psychrotropic organisms can multiply at such temperature. Coliform bacteria die out during cold storage. Slight growth will occur in butter held at temperature below 0°C and none is expected at -15°C. At this, temperature the total bacterial would be expected to decrease slightly especially unsalted butter. Hence the ideal temperature for storage of butter for keeping quality (12-18 months) is -12 to 18°C. Since the cooling rate of butter is slow due to its high fat content, bacterial counts will often increase especially in unsalted butter during the initial stage of storage.

27.3.3 Microbial deterioration/spoilage of Butter

Growth of micro organisms in butter causes a variety of color and flavor defects. Most of the microorgansims in cream gets killed during pasteurization, the spoilage organisms mainly come through post pasteurization steps and butter making. The defects in butter mainly attributed to the presence of psychotropic bacteria (lipolytic & proteolytic), yeast and molds. The psychotropic bacteria which are entering the product through unhygienic equipment grow during low temperature storage. However, molds create problems and relatively high temperature as prevalent India.

A. Color defects (Discoloration)

Discoloration of butter may be caused by bacteria, yeasts and molds. However major color defect in butter are caused by yeast and molds.

Bacterial Discoloration

a) ***Black discoloration (like grease smudge) causative organisms: Pseudomonas nigrificans.*** Due to butter stored at low temperature (optimum for pigmentation is 4^0C i.e. 15-20% salt concentration in the moisture droplets.

b) ***Fungal Discoloration:*** Butter gets discolored due to surface growth of molds and the defect is also described as 'moldy butter'. This is a major defect commonly occurred in India since the ambient temperature storage condition encourages the growth of Fungi in butter. Fungi growth also favored by higher moisture content and acidity. Some psychotropic molds like Alternaria, Harmodendrum, phoma and stamphylium have been appear to grow in butter (unsalted) at low temperature (5^0C) slightly growth @ -4 to -6^0C but not @ -7 to -9^0C. Some common fungal discoloration frequently occurred in butter areas follows

Discoloration Causative agent

a. **Mold discoloration**

i. **Black** Cladosporium Eg. C. harbarum, Aspergillus, Hasmodendrum,Alternaria, Mucor, Rhizopus, and Stamphylium

ii. **Brown** *Aspergillus spp, and Phoma spp* (muddy brown)

iii. **Green & blue green** *Penicillium spp and Aspergillus app*

iv. **Orange & yellow** *Geotrichum candidum*

v. **Reddish pink** Fusarium

b. **Yeast**

i. **Black** *Torula spp*

ii. **Pink** *Rhodotorula spp*

B. Flavor defects: - Rancid & putrid or cheesy odor is the most common flavor defects in butter. The other defects like malty, Shunk-like flavor yeasty may also occur in butter.

a. **Rancid flavor: -** Butter gets rancid due to microbial, enzymatic or chemical degradation of fat constituents. The fat hydrolysis in butter mainly due to the activity of microbial lipases. Many of the lipolytic microorganisms are psychotropic and are able to grow @ temperature slightly under 0^0C and survive cold storage @ -10^0C. Some of the lipase producing organisms which can grow on butter is as follows.

Bacteria	Mold	Yeast
Ps. fragi	*Geotrichism Candidum*	*Candida lypolitica*
P. fluorescence	*Cladosporium butyri*	*Torulopsis spp*
P. putida	*Penicillium spp*	*Rhodotorula spp*

Achromobacter lipolyticum *Aspergillus spp* *Saccharomyces fragilis*

b. **Putrefactive taint: -** Defect is due to breakdown of proteins by various Putrifactor organisms like *Pseudomonas putrefacien*, coliform, *Flavobacterium maloloris*. The chemical compound which produced during the breakdown of protein is closely related to isovaleric acid responsible for off-flavor. The causative organism enter butter through unchlorinated water supplies and equipments (butter churns, Creat vats)

c. **Cheese taints: -** Cheese like flavors in butter is due to association action of different gram negative rods shaped bacteria due to butter stored above 10^{0}C.

d. **Other flavor taints: -**

i. **Malty flavor: -** is due to presence and growth of streptococcus Lactsis variable maltigenes in cream. The formation of 3-methyl butanol in butter mainly responsible for malty flavor.

ii. **Shunk-like flavor: -** Pseudomonas mephitica

iii. **Fishy taint:** *Pseudomonas ichthyosmia, Geotrichum candidum* and Yeasts due to decomposition of lecithin to Trimethyl amine by microbes.

27.4 PUBLIC HEALTH IMPORTANCE

Butter is not an ideal medium for the growth of pathogenic or food poisoning organisms due to high fat content, yet it may carry certain pathogen if contaminated during production, handling and packaging. Certain pathogens have been found to remain viable for long periods in butter the possible sources of pathogens in butter may be the cream itself (improperly pasteurized) or the post-pasteurization contamination. Handler in the butter plant is usually the major sources of such organisms in butter. Very few outbreaks of diseases or food poisoning have been reported so far from butter. *Staphylococcus aureus* and salmonella have been encountered in butter. Butter may, however, serves as a good medium for the growth molds including aflatoxins and other Mycotoxins producers. Such toxins may cause serious health hazards in consumers. The necessity of checking mold contamination and growth in butter.

27.5. Legal Microbiological Specifications for Cream and Butter

Consumer safety is paramount criteria for any food manufacturer or producer. To ensure the safety to the consumer Food Safety and Standards Authority of India (FSSAI) introduce the Act to monitor the food safety. It assigns the responsibility of food safety to the producer and provides the necessary guideline, some chemical and microbial standards for the products like butter are compulsory and every food manufacturing or dairy product manufacturing organization need to follow these mandatory standards.

27.5.1 BIS Standards for Cream & Butter

Beuro of Indian standards (BIS) has given the following standards for raw and pasteurized cream

i. **Raw cream**

Plate count/mL (or g)	Grade
< 4 x 10^5	Very good
4 x 10^5 – 20x 10^5	good
20x 10^5 – 1x 10^6	fair

>1x 10^6	poor

Coliform count /mL (or g):

Not more than 100 Satisfactory

ii. Pasteurized cream

The plate count/mL (or g) should not be exceeding 60,000 and coliform count/mL (or g) should not be more than 10.

iii. BIS Standard for Butter

Standards and recommendations of Indian standards Institution for butter as follows

i) SPC. No standards have been suggested

ii) Coliform. The presence of more than 10cfu/mL butter is an index of insufficient pasteurization or contamination of butter from external source like wash water, equipment and other sources during manufacturing and packaging.

iii) Yeast & Molds (Y&M)

Y&M counts/mL	Quality
Less than 20	Good
21-50	Fair
51-100	poor
More than 100	Very poor

USDA Specifications for Light Butter

Microbial determinations shall be made in accordance with the methods described in the latest edition of Standards Methods for the Examination of Dairy Products, published by the American Public Health Association. Samples shall be taken as often as necessary to insure microbial control.

- Coliform -- Not more than 10 per gram.
- *E. coli.* -- Negative.
- Yeast and Mold -- Not more than 10 per gram.
- Standard Plate Count -- Not more than 1,000 per gram.

27.4.1 Sampling Plans for Cream and Butter

The FSS regulations for microbiological criteria for the acceptance or rejection of sample lots. It sets out (FSSR, 2011):

- the food which must comply with the microbiological limits set in relation to that food;
- the micro-organism or group of micro-organisms of concern;
- the number of sample units to be taken and tested;
- the level of micro-organisms considered acceptable, marginally acceptable or critical(depending on the sampling plan specified); and
- The number of samples that should conform to these limits.

The following terms, as used by the International Commission on Microbiological Specifications for Foods (ICMSF), are defined and used in Standard 1.6.1.

n = the number of sample units which must be examined from a lot* of food. Most sampling plans specify taking five sample units. However, when the risk has been assessed as relatively high, a greater number of sample units is specified.

c = the maximum allowable number of defective sample units. This is the number of sample units, which may exceed the microbiological limit specified by 'm'. These are considered marginal results, but are acceptable providing they do not exceed the limit specified by 'M'.

m = the acceptable microbiological level in a sample unit. Sampling plans in which m=0 and c=0 are equivalent to 'absent' or 'not detected' reporting for the stated analytical unit size. In most cases this is 25 g (e.g. not detected in 25 g).

M = the level which, when exceeded in one or more samples, would cause the lot to be rejected.

*A lot means a quantity of food, which is prepared or packed under essentially the same conditions, usually:

- From a particular preparation or packing unit; and
- During a particular time ordinarily not exceeding 24 hours.

A lot of food does not comply with the standard if the number of defective sampled units is greater than c, or the level of a micro-organism in a food in any one of the sample units Exceeds M.

SI. No.	Requirements	Sampling Plan	Pasteurized cream	Pasteurized Butter
1	Total plate count	m	30,000/g	10,000/g
		M	50,000/g	50,000/g
2	Coliform Count[2]	m	< 10 /g	10/g
		M		50/g
3	*E.coli*3	M	Absent/ g	Absent/g
4	*Salmonella*4	M	Absent/ 25g	Absent /25g
5	*Staphylococcus aureus*5 (coagulase positive)	m	< 10/ g	10/g
		M		50/g
6	Yeast and mould count6	m	-	20/g
		M	-	50/g
7	Spore Count:		-	-
	(a) Aerobic7a (*B. cereus*)	m		-
		M	-	-
	(b) Anaerobic7b (*Clostridium Perfringens*)	m	-	-
		M	-	Absent/g
8	*Listeria monocytogenes*8	M	Absent/g	Absent/g
Sampling Guidelines9		n[1-8]	5	5
		c	2[1-2, 5]	2[1-2, 5-6]
			0[3,4, 8]	0[3,4, 8]
		Storage & transport	0 to 4°C	-18°C
		Sample size	100ml or g	100ml or g

Lesson-28

Butter Defects

28.1 INTRODUCTION

Defects in butter can be classified as defects related to flavour, body and texture and colour. These defects may also be classified as defects related to cream and defects related to faulty methods of manufacturing. All these defects are discussed in detail in this lesson.

28.2 FLAVOUR DEFECTS

28.2.1 Cream-related off flavours

28.2.1.1 Feed and Weed flavours and odours

The feed and weed flavours that appeals in freshly drawn milk are more or less readily soluble or absorbed by the milk fat. They, therefore, are often more intense in the cream than in the original milk and they appear in the butter churned from such cream.

28.2.1.2 Cowy and Barny flavour

This type of defect is due to contamination of milk with manure or stable air or both. The Cowy flavour may be due to cows with unclean udders and to milking with wet hands, to the handling and prolonged exposure of the milk and cream in poorly ventilated stables.

Prevention:

- Sanitation and cleanliness in the production of cream/milk such that there is no
- Contamination with manure, stable, dust and impure stable air.
- Milking with clean dry hands.
- Prompt removal of milk from the farm.
- Handling and storing milk/cream in a place free from stable air.

28.2.1.3 Unclean or utensil flavor

The task suggests contact of cream with utensils incompletely washed such as unclean strainers, cream cans or separator bowls or faulty sanitary conditions of factory equipments such as vats, pumps, conveyors, pipes, churns or packing equipments.

Unclean flavour may be the direct result of contamination of the cream with milk remnants from unclean utensils or of absorption of their odours; it may also be the indirect result of the activity of m. o. contained in the milk remnants of unclean utensils.

28.2.1.5 Musty, Smothered flavour

Causes:

· When warm cream from the separator is held in a tightly sealed can, it often acquires a peculiar smothered musky flavour and odour which may follow it into the butter.

· Storing of cream in a damp, musky smelling cellar, or other poorly ventilated room.

· Empty, sealed cans that have been out of service for a considerable period.

Prevention:

· Prompt and proper cooling of the freshly separated cream.

· Storage in a properly ventilated place.

· Rinsing and clean cans before use.

28.2.1.5 Bitter flavour

Causes:

· Abnormal physical condition of certain cows.

· Feeds and weeds.

· Protein and clean cans before use.

Some cows in late lactation regularly yield milk that has a bitter flavour.

Such feeds and weeds as lupines, ragweed, bitter weed, beet tops, raw posture, raw potatoes, diverse decayed if feed stuffs, moldy oat and barley straws have been found to be the cause of bitter flavour.

Bitter flavour also occurs due to the action of yeasts on proteins resulting in formation of peptones and amino acids.

28.2.1.6 Yeasty flavour and odour

It is caused by the fermentation of the cream by certain species of yeasts (*Torula Cremoris and Torula sphaerica*). In early stages of yeast fermentation of cream, the odour usually is not unpleasant, aromatic and nutty character. Prolonged yeasty form generally gives the butter a disagreeable bitter yeasty taste. In many cases, the yeasty flavour and odour are accompanied by profuse foaming of the cream.

Prevention:

i) Wash utensil after each use.

ii) Cool the cream to as low a temperature as possible as soon as it leaves the separator.

iii) Do not allow the cans to stand on the station platform exposed to the sun in hot weather.

29.2.1.6 Cheesy flavour

It denotes a very low grade of raw material. The cheesy flavour in such case is usually of the cheddar cheese character. It is the result of very old cream that has been produced and held under conditions that cause high acidity, curdiness and curd decomposition.

29.2.1.7 Metallic flavour

The causes for this defect cab be classified as (i) contamination of cream with metallic taste and (ii) action of certain species of bacteria.

The absorption of metallic salts by the cream is probably the most common cause of metallic flavour in butter made from sour farm skimmed cream. This is attributable chiefly to the condition of the utensils in which the cream is held on the farm and of the cream shipping cans. Exposed surfaces of copper such as in copper vats, fore warmers, pasteurizers, cream pipes etc with defective in coating also surface of alloys containing considerable copper such as white metals are potential sources metallic flavour in butter.

Metallic flavour is also caused by bacterial activity. The starters at certain advanced stages of fermentation may and often do become metallic and may cause metallic flavour in the cream inoculated with them. High acidity is practically always a factor in the combination of conditions that produces this flavour defect. Cream rich in butter fat, likewise, is more susceptible to the tendency to develop metallic flavour than cream low in butter fat.

Preventions:

i) Keep fat % less than 35.

ii) Encourage use of cans that are clean and not rusted.

iii) Keep all copper surfaces in plant equipment properly, tinned.

iv) Efficient CIP/Cleaning of equipments.

v) Do not over ripen the cream as don't hold it excessively long.

28.2.2 Process-related off-flavours

a) Flat flavour

Butter termed flat in flavour lacks the pronounced pleasing flavour and aroma that is characteristic of butter of superior quality.

Causes:

i) Low content of volatile acidity, Diacetyl and other products that make up the desired complex of desirable butter flavour.'

ii) Churning the cream sweet and without the use of starter.

iii) Profuse dilution of the cream with water.

iv) Excessive washing of butter.

Prevention:

i) Proper ripening of cream.

ii) Avoiding dilution with water.

b) High Acid and Sour flavour:

High acid flavour in butter is characteristics of butter made from cream received in sour condition and that is not neutralized.

High acid flavour and aroma may also be caused by churning over-ripened cream or by the use of over-ripe starter or by the use of high cream ripening temperature in the presence of starter that lacks flavour organization and process acid only.

Prevention:

i) Use of starter containing the proper balance of acid and flavour organisms.

ii) Ripening at optional temperature/time combination.

Butter with a typical sour flavour is usually the result of the presence of excessive buttermilk. Such butter may also develop a curdy, cheesy flavour. This defect is obviously due to insufficient washing and is avoided by washing the better sufficiently to avoid in the butter.

c) Cooked or Scorched flavour:

This flavour is characteristic of butter made from pasteurized cream. It is caused by exposure of cream to high temperature.

- v Cream properly pasteurized – cooked flavour in fresh butter which disappears before the butter reaches market.
- v If the temperature difference between heating medium – Scorched flavour and cream is too high.
- v More chances of scorched flavour when high acid cream is neutralized with lime neutralizers.
- v Heating the cream by means of direct steam pasteurization under pressure (with live steam) and without metallic heating surface minimizes the danger of cooked or scorched flavour, even when pasteurizing at high temperature.

d) Neutralizer Flavour

The tendency for this defect to appear and its intensity, depend largely on the amount of neutralizer used. This amount of neutralizer depends on the initial acidity of cream and the point to which it is neutralized.

The sourer the cream and the lower the point to which it is neutralized the greater is the tendency for butter to show neutralizer flavour.

Lime and Magnesia neutralizer – Limy, bitter flavour

Soda - Soapy flavour

Causes:

i) Reducing acidity of high acid cream to a very low level.

ii) Adding the neutralizer in too concentrated form, not distributing it quickly and uniformly throughout the body of the cream or not giving the neutralizer sufficient time to complete the reaction in the cream.

Prevention:

i) Double neutralization

ii) Proper addition of neutralizer.

e) Oily or Oily Metallic Flavour

This defect is usually present in the fresh butter at the churn. The exact reactions responsible for this defect are not a yet fully understood. However some factors are identified modifying or controlling these factors can possibly prevent this defeat. These factors are:

1. High acid cream

2. High fat content cream (more than 33% fat)

3. High temperature of pasteurization.

High temperature treatment of sour neutralized cream provides a combination of conditions that is highly favourable to the production of oily metallic flavour in the butter.

4. Prolonged holding after Pasteurization

5. Contamination of the cream with metallic salts.

There is no evidence that the presence of metallic salts like oxide cause this defect. These oxides and salts are active oxidizers and catalizers so they intensify the defect.

Prevention:

1. Vat pasteurization at temperature not exceeding 160^0 F/30min.

2. If higher temperature must be used, churn as soon as possible.

3. Avoid cream contact with surfaces of copper/other metals.

28.2.3 Storage-related off-flavours

a) Surface Taint, Limburger or Putrid Flavour

The defect is called surface taint because it first develops at the surface taint because it first develops at the surface. However the putrid flavour is not confined to the surface, it rapidly involves the whole mass or package of butter.

The putrid flavour defect is also called as Limburger flavour suggesting the flavour and odour of Limburger cheese.

The putrid flavour defect is mostly found in butter made from unripened or sweet cream and light salt butter.

Causes:

1. Protein decomposition by putrefactive bacteria Achromobacter putrafaceins, pseudomonas and B. flourescens liquefaciens.

2. Contamination of butter cream after pasteurization. (Efficient pasteurization destroys all putrefactive bacteria.)

Prevention:

1. Efficient pasteurization.

2. Sanitation between pasteurizer and churn.

3. There should be no contamination from churn.

4. At the time of draining buttermilk it should be kept in mind that no buttermilk should flow back to the churn as the bottom line is seldom clean and it usually contains milk remnants with putrefactive bacteria.

5. Water supply.

6. Precaution in packing water.

b) Cheddar and Roquefort Flavours

§ Found mostly in light salted and unsalted butter.

§ Absent in butter held in commercial cold storage.

Cheddar cheese type flavour is caused by Proteolysis and lipolysis by several species of bacteria.

Roquefort cheese flavour is usually associated with mold growth which involves both proteolysis and fat hydrolysis.

Prevention:

1. Good sanitation practices throughout the process.

2. Cream ripening with good starters.

Trends of flavour change

Rancid Flavour

It is a common flavour defect of butter made from raw cream. Rancid flavour in butter resembles the pungent respecting taste and odour of such volatile fatty acids a butyric, caproic and caprylic acids. It is caused by hydrolysis of fat which splits the butter fat into FFA and glycerol.

Hydrolysis of fat is brought about by the action of m. o. or enzymes or both.

Prevention:

1. Proper pasteurization

2. Efficient sanitation in plant

3. Clean water supply.

c) Tallowy flavours

The tallow flavour of butter resembles the flavour and odour of mutton tallow. In severe cases of tallowiness, the butter usually also bleaches in colour. It is caused by oxidation of the fat, involving the unsaturated fatty acids in butter such as the oleic acid. Some investigations suggested that oleic acid combined with free glycerol (produced by fat hydrolysis) forms glycolic acid ester of oleic acid. This product is responsible for tallow flavour.

Causes:

1. Air, light and heat

Exposures to air cause oxidation of fat. This is accelerated in the presence of light and heat.

2. Metals

The presence in butter of certain metals, their salts or oxides, greatly hastens reactions that lead to tallowy flavour. (Cu, iron)

3. Neutralization

Over neutralization aggravates the tendency of tallowy flavour as an alkaline condition promotes fat hydrolysis and oxidation.

4. Diacetyl

Diacetyl is capable of causing tallowy flavour and bleaching of butter fat in the presence of air. Excessive fortification with diacetyl thus causes tallowiness. Diacetyl in butter should not be more than 4 ppm.

5. Absence of bacteria

Bacteria utilize oxygen in their metabolism and thus retard tallowiness.

Prevention:

1. Uses if air and light proof liners and wrappers, treatment of wrappers with harmless antioxidants such as Oat flour solution.

2. Surfaces should be properly tinned SS should be used.

d) Fishy flavour

Butter has a flavour and odour characteristic of fish. It is very serious defect of butter.

Causes:

i) Certain feeds and feeding areas cause fishy flavour fish. It is very serious defect of butter.

ii) Activity of microorganisms.

28.3 DEFECTS IN BODY AND TEXTURE

i) Crumbly, Brittle body

The proposition of high and low melting fats present is controlled by the composition of the butter fat and this is turn is primarily affected by the season of the year i. e. the feed.

Winter – decreased amount of low melting point fats.

Summer – increased amount of low melting point fats.

Thus the winter butter fat is often accompanied by excessive hardness, crumbliness and stickiness of butter. Winter butter fat contains large coarse fat crystals that will continue to grow in size after manufacture, has a hard, friable, crumby texture.

Prevention:

i) Avoid low cream cooling temperature and prolonged holding of cream at low temperature.

ii) Chilling granular butter with cold wash water.

ii) Sticky Butter

This defect refers to butter that doesn't cut clean. It sticks to knife or trier.

Prevention:

i) Same as for crumbly.

ii) Churning immediately after cooling.

iii) Wash the butter with wash water at a temperature of 3 to 4^0 F below that of the bottom.

iii) Weak Body

It lacks the desired firmness and standing up property.

Causes:

i) Incomplete fat crystallization.

ii) Faulty adjustment of cooling temperature of cream or holding time.

iii) Low proportion of high m. p. glycerides.

iv) Greasy Texture

This defect occurs when butter is worked excessively while in soft condition. The danger of greasiness is usually greatest in the case of abnormally rich cream insufficiently cooled, and churned and worked while too warm.

Prevention:

i) Proper cooling of cream.

ii) Chilling the butter granules thoroughly with very cold water (ice water) before working.

v) Leaky butter

Usually appears wet to the eye. When bored, it shows small droplet of moisture on the plug and the back of the trier looks wet.

Butter suffers excessive shrinkage and loss of weight in storage.

Causes:

i) Incomplete or improper working.

ii) Lack of fine dispersion of moisture in butter.

vi) Gummy butter

Butter when placed in mouth does not melt readily. It sticks to the roof of the mouth and gives the impression of gumminess.

Cause:

i) Presence of an excess of high melting triglycerides.

vii) Mealy butter

Mealiness is most likely to occur in butter made from sour cream that is improperly neutralized with lime. Lime particles combine with the sour casein, forming minute particles of insoluble calcium caseinate. In subsequent pasteurization these casein lime particles contract and harden giving both the cream and butter, a disagreeable rough graining as mealy character.

28.4. COLOR DEFECTS IN BUTTER

The ideal color of butter ranges between a straw color and a golden yellow color. It must be uniform churning to churning and the colour must be solid that is it must be of the same shade or intensity throughout the body of the butter.

i) Bleached Butter due to oxidation of fat.
ii) Mottled – Unevenness of colour in the body of butter is shown in the form of streaks, waves and mottles.

Causes:

i) The whitish opaque dapples in mottled butter are due to localized sections of innumerable, very minute droplets.
ii) Salting out action of the salt.
iii) Uneven working of different portions of butter of one and the same churning.

Prevention:

i) Keep working rolls in good mechanical condition.
ii) Do not overload the workers/churn.
iii) Dissolve the salt completely.

Other defects:

Yellow specks, white specks, green discoloration, Pink color and Moldy butter.

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Lesson-29

History of butter churn development, Construction, Operation and Sanitary Care

29.1 INTRODUCTION:

Two major types of churns are classified mainly as a batch churns and continuous butter making churns. In batch churns there are wooden and metallic churns. Presently wooden churns are obsolete and metallic batch and continuous butter making equipments are popular.

29.2 HISTORY OF BUTTER CHURN DEVELOPMENT:

Role of churn is to agitate the cream, today's churn design is the modification of several earlier designs, and following are the types of churn design evolved over the time. During the ancient time wooden churns were popular and in recent time metallic churn are widely adapted.

1. **Swinging Churns**: In this, cream moves backward and forward in horizontal plane, they were first used by the Arabs, a wooden made vessel is suspended and swung from a tripod
2. **Rotating Churns:** A barrel rotating on its axis at the centre of the axis or at the centre of the ends. Shelves are provided to increase the agitation effect and barrel suspended from one side slightly eccentrically to provide movement to the cream inside the barrel.
3. **Dash Churns:** Have agitator or dash which rotates to convert cream into butter while the containing vessel remains stationary. Ther are two major types of dash churns, they are;
    a. **Plunger type:** in which plunger usually made of wood, is moved up and down in a tall open vessel containing the cream.
    b. **Rotating-agitator type:** in which an agitator is immersed in the cream itself. The dash may be rotated on either a horizontal or a vertical axis. Simplest type of vertical dash churn is **Indian paddle churn** consisting of earthenware vessel in which a wooden paddle is operated by means of double rope around the long handle.

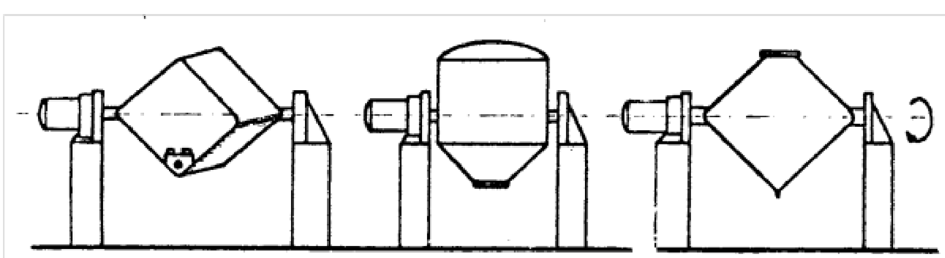

Fig.29.1 operation of Batch type butter churns

1. Cubical 2. Cylindrical-Conical 3. Double Cone

(Source: Ing and Kessler, 1981)

There are three major designs in batch type churns; 1. Cubical, 2. Cylindrical-Conical and 3. Double Cone, all these will not have any interior fittings and they rotate at the speed of 20 to 30 rpm and this varies with capacity of the churn. The interior corners, edges and other irregularities on inner surface of the churn support whipping. Interior surface of the churn is roughened to prevent the sticking of butter granules to the walls of the churn.

Degree of mixing predominantly depends upon the amount of cream in the churn and rate of revolution of the churn. Too low a rate of revolution results in insufficient turbulent for whipping and yield more loss of fat in skim milk. Too high rate of revolution causes centrifugal force to exceed the gravitational force, thus cream will stick to the periphery and rotate there with the drum and cream may not churn or delay churning of cream. Therefore, best condition for churning is when force of gravity is just exceeds the centrifugal force that causes maximum turbulence. Following equation provide the detailed information on how to adjust centrifugal force slightly less than the gravitational force for ideal churning.

Centrifugal force < force of gravity

$\mathbf{m\omega^2R < m.g}$ Where; m – mass, ω- angular velocity,
R –radius of the path and g – gravitational force.

$\rightarrow (2\pi n)^2 . R. < g$, because $\boldsymbol{\omega} = 2\pi n$,

$\rightarrow n < (\sqrt{(g/R)}). 1/(2\pi)$, since g and π are constant

So, $n < 1/\ 2\sqrt{R}$ assume if the furthest point of the interior of the churn from axis of rotation is 1m, then $n < 0.5$ per second or 30 per minute.

29.4 HISTORY OF CONTINUOUS BUTTER CHURNS:

Between 1930 and 1960 a number of continuous processes were developed. In the Alfa, Alfa-Laval, New Way, and Meleshin processes phase inversion takes place by cooling and mechanical treatment of the concentrated cream. In the Cherry-Burrel Gold'n Flow and Creamery Package processes, phase inversion takes place during or immediately after concentration, producing a liquid identical to melted butter, prior to cooling and working. The Alfa, Alfa-Laval, and New Way processes were unsuccessful commercially. The Meleshin process, however, was adopted successfully in the Republic of Russia. The Cherry-Burrel Gold'n Flow process appears to have been the more successful of the two American processes.

The Fritz continuous butter-making process, which is based on the same principles as traditional batch churn, is now the predominant process for butter manufacture in most butter-producing countries. In the churning process crystallization of milk fat is carried out in the cream, with phase inversion and milk fat concentration taking place during the churning and draining steps. However, because of the discovery that cream could be concentrated to a fat content equal to or greater than that of butter, methods have been sought for converting the concentrated or plastic cream directly into butter. Such methods would carry out the principal butter-making steps essentially in reverse order, with concentration of cream in a centrifugal separator, followed by a phase inversion, cooling, and crystallizing of the milk fat.

Increased demands on the keeping qualities of butter require that, in addition to careful construction, operation, and cleaning of the milk and cream processing equipment, research to develop machines that will ensure butter production and packing under conditions eliminating contamination and air admixture must be carried out. It has been demonstrated that butter produced under closed conditions has a better keeping quality than butter produced in open systems.

There are two classes of continuous processes in use: one using 40% cream, such as the Fritz process, and the other using 80% cream, such as the Cherry-Burrell Gold'n Flow. As much as 85% of the butter in France is made by the Fritz process. In this process 40% fat cream is churned as it passes through a cylindrical beater in a matter of seconds. The butter granules are fed through an auger where the buttermilk is drained and the product is squeeze dried to a low moisture content. It then passes through a second working stage where brine and water are injected to standardize the moisture and salt contents.

The Cherry-Burrell Gold'n Flow process is similar to margarine manufacture. The process starts with 18.3°C cream that is pumped through a high-speed destabilizing unit and then to a cream separator from which a 90% fat plastic cream is discharged. It is then vacuum pasteurized and held in agitated tanks to which color, flavor, salt, and milk are added. Then this 80% fat-water emulsion, which is maintained at 48.9°C, is cooled by use of scraped surface heat exchangers to 4.4°C. It then passes through a crystallizing tube, followed by a perforated plate that works the butter. Prior to chilling, 5% nitrogen gas is injected into the emulsion.

Although the Meleshin process continues to be in widespread use in the former USSR, the use of alternative continuous butter-making processes based on high-fat cream has declined in Western countries during the past 20 years. The principal reasons for this decline appear to be the economics and butter quality, particularly when compared with the Fritz process. A Fritz manufacturing process can be installed in existing batch churn factories with almost no modification to cream-handling or butter-packing equipment. The churns could be retained in case the Fritz breaks down. However, very little batch plant equipment could be reused in the alternative systems (ie, Gold'n Flow). Butter from the Fritz process is nearly identical in its physical and flavor characteristics to batch-churned butter, whereas butter produced by the alternative processes tends to be different. These differences may be perceived as defects by the consumer, and manufacturers have been reluctant to alter a traditional product.

29.5 CONSTRUCTION OF CONTINUOUS BUTTER CHURNS:

Continuous butter churns essentially consists of double jacketed cylinder and extruder (Fig29.1). Product contacting surfaces should made of stainless steel AISI 304. Double jacketed cylinder has been used to make butter granules from cream of 35 – 45% fat, wherein baffles are provided inside to break the fat globule membrane and thus release the free fat by rotating the cylindrical at higher rpm. In this type of equipment provision has made to wash the butter granules and to take out buttermilk out of the process by introducing another perforated cylindrical rotating drum after formation of butter granules. Perforated cylinder is positioned at inclined angle to drain out buttermilk. Working of butter takes place in extruder. Common type of extruder is rotating screw type, few manufacturer also adopts contra-rotating double screw worker wherein two screws contra rotates thus assist in proper working of butter. Moisture and salt adjustment can also be done in extruder.

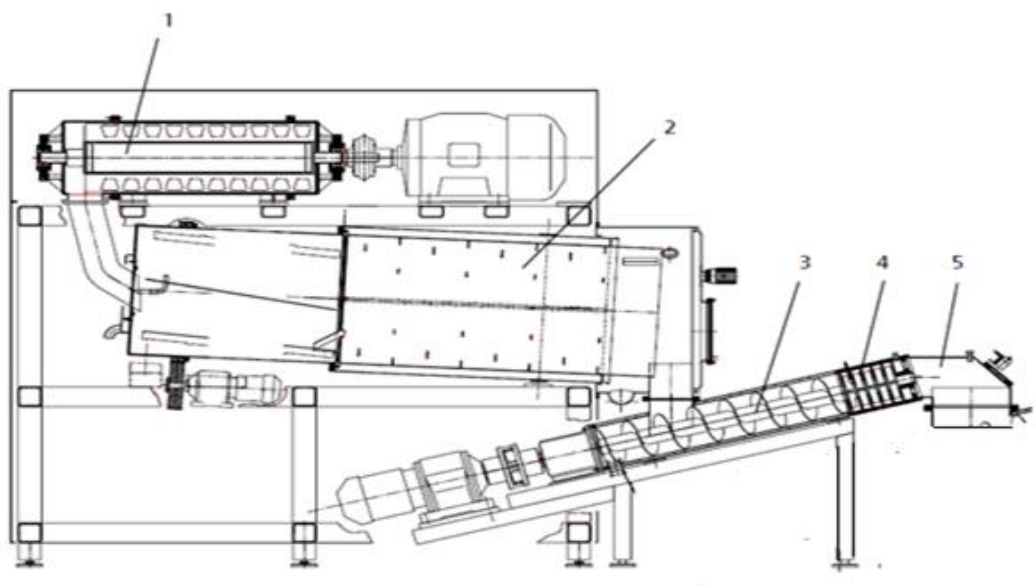

Fig. 29.2: Line diagram of continuous butter making machine (CBMM)

1. Churning cylinder first stage
2. Churning cylinder second stage
3. Working screw
4. Mixing vanes
5. Butter outlet

29.6 OPERATION OF BATCH TYPE CHURNS:

1. Cool the cream after pasteurization to 10^0C and maintain temperature of cream in between 10 to 13^0C for overnight. During storage cream should not be agitated at higher speed that may cause partial churning of the cream resulting in short grained butter.

2. Cream having fat percentage of 35 to 40 percent fat is ideal for churning. Churning temperature should adjust in such a way that small peas size granules should form in 40 to 50 minutes. Churning temperature should be in between 13 to 15^0C .

3. Churn should not be overload, slightly under loading is preferable.

4. Spray the granules with a small amount of pasteurized chilled water and allow the rinsed water to drain from the churn.

5. For washing and chilling add enough pasteurized chilled water at a temperature of 7^0C.

6. Revolve the churn in high speed gear (i.e. 12 to 15 revolutions per minute).

7. Drain the wash water and work the granules until they have formed into mass. This allows the removal of considerable amount of water.

8. Drain the water from the churn and then add calculated quantity of salt and some minimum quantity of chilled water of 7^0C.

9. Work the butter until it is fairly dry and test the moisture in the product. If the level of moisture is less then calculate the required amount of water and add into the churn. Te temperature of water should be same as temperature of butter.

10. Work the butter thoroughly and compete the working.

11. When there is clear visible sight glass without any butter sticking to the surface that is time to stop the churn and unload the butter.

12. Store the butter in a refrigerator at 4 – 7^0C.

29.7 OPERATION OF CONTINUOUS BUTTER MAKING MACHINE (CBMM) USING FRITZ PROCESS IS EXPLAINED BELOW:

1. After overnight storage of standardized cream, then pump the cream to small supply tank for steady flow of cream.

2. Then cream flows into water jacketed horizontal cylinder wherein cold water (at 4 – 5^{0}C) is circulated through the jacket. Cream strikes the baffles as cylinder rotates at higher rpm (~600 to 3000rpm). Butter granules are formed in 2-3seconds. Ideal churning temperature is 7 to 10^{0}C.

3. Then butter granules are conveyed to buttermilk separating section, where butter milk got separated through perforated drum.

4. Then butter granules are passed through the Butter granules are collected by two contra rotating screws and worked intensively to press out buttermilk.

5. Screws force the butter through a number of perforated plates arranged in series. This treatment serves to produce a fine dispersion of water in the butter.

6. Process is assisted by mixing vanes which are assisted between the plates and attached to the shaft.

13. Water or salt solution(usually 50% solution) may be added through an opening immediately in front of the perforated plates to adjust moisture or salt

14. Modern butter making machine have vacuum compartments to reduce the air content of the butter and improve the spreadibility to some extent.

15. The evacuation is done in the last stage of working screw, this also extends the working time which helps to improve the spreadibility.

Operation of Contimob CBMM is also similar to Fritz process, It has one churning cylinder and two working sections, in first working section it removes buttermilk and in second working section it reduces the moisture content to 13 to 14 % level.

Operations in other CBMM methods such as Alfa and New Way processes of follow this

1. Cream of 30% fat is pasteurized at 90^{0}C, degassed, cooled to 45 – 50^{0}C and separated at this temperature in a cream separator to 82% fat.

2. The cream, which is still in the form of oil in water emulsion, but it has almost the composition of butter.

3. In this cream fat globules are so closely packed that their fat globule membranes are in contact with each other

4. This cream is then passed through a two or three stage screw cooler where it is cooled to 8 – 13^{0}C

5. There the fat crystallizes and fat crystals perforate the fat globule membrane so that free fat escape

6. This process is helped by rubbing together of the fat globules as they move in the cooler

7. Thus phase inversion takes place and water-in-oil emulsion (butter) is formed. It contains all the fat globule membrane material, thus it has high phospholipids content and no buttermilk is produced in this process.

29.8 CLEANING AND SANITARY CARE OF THE BATCH CHURN:

1. Routine Cleaning of metallic churn:

 · Add hot water 80 to 90^{0}C, equivalent to 10 to 12% of the churn capacity.

 · Add 0.2 to 0.3% of the fat emulsifying cleaner such as trisodium phosphate.

 · Revolve the churn at high speed for 5 minutes.

 · Stop the churn and drain the water.

 · Rinse the interior and then add water at near boiling temperature and revolve the churn for few minutes followed by draining.

 · Rinse air escape valve

2. To remove milk stone following schedule to be practiced at certain intervals.

 · Revolve the churn at working speed with a 2% solution of caustic soda (at a temperature of 60^{0}C) for about 15minutes. Volume of caustic soda should be 5% of its capacity.

 · Drain the solution and rinse with hot water several times.

 · Add 0.5% nitric acid solution (approximately 5% of the churn capacity) at 60^{0}C and revolve the churn at working speed for 15min.

 · Drain the acid solution from the churn and rinse with hot water several times.

3. Cleaning of pumps and fittings associated with butter churn:

- Before use, the pumps, pipes and filters should be rinsed with hot water of 90 – 95^{0}C or steamed or rinsed with chlorine solution containing 100ppm available chlorine.

- These pumps and fittings should be cooled before running the product using portable water.

29.9 CLEANING AND SANITARY CARE OF CONTINUOUS BUTTER CHURNS:

Hot water rinsing is the first step to melt the fat in the churn, pump the hot water of 70 – 80^{0}C through the churning cylinder, washing unit and through extruder for 20 to 30min.

- Caustic soda of 0.5% strength can be circulated after hot water rinse, intermittently to remove the adhered milk soil.

- Then wash with hot water to flush out the residues of alkali.

- Sanitization using chlorine solution can be achieved by circulating hypochlorites or chloride of lime with 200 - 250ppm of available chlorine.

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Lesson-30

Whipped Butter, Whey Butter Flavoured Butter,

30.1 INTRODUCTION

High price component of milk is milk fat, no dairy entrepreneur would like to drain or waste the fat neither directly nor indirectly from the plant. All the necessary steps would be taken to extract and / or preserve the milk fat. This accumulated or extracted fat may be used to make special kind of products like whey butter (prepared exclusively from the fat of whey). Special butter are the another class of products wherein novelty would be incorporated like whipped butter and flavoured butter.

30.2 WHIPPED BUTTER:

It is regular butter whipped for easier spreading. Whipping increases the amount of air in butter and increases the volume of butter per pound. For whipping normal air or nitrogen are used. According to United States legal requirement whipped butter has to contain at least 25% butterfat. For the production of whipped butter, the butter is softening to 20 – 24^{0}C, so that it is soft enough to work easily. At this stage colour and salt are added, then product is whipped to get the desired over-run (50 to 100%), packed and stored at refrigerated temperature. It may contain butter fat around 45 to 50%, so its caloric value is less than that of butter.

It isn't recommended to use whipped butter in cooking, however, as it melts quite a bit faster than normal butter and often creates a foam. Additionally, whipped butter isn't a good substitute in baking recipes, because these recipes usually give measurements in terms of volume.

Uses: Many restaurants create their own whipped butter to serve with bread or before-dinner items. In addition to easy spreadability, many people consider it supportive of healthier eating, as most people wind up eating less butterfat when they use whipped butter.

30.3 WHEY BUTTER:

This is made from whey separated from curd during the making of cheese. It is a strong tasting with a bit of a cheesy flavour in it. It can be salty tasting, if salt was added to the cheese-making process before the whey was drained off. It will be less shiny than regular butter and a deeper yellow. It may have added salt and annatto colouring, just as regular butter would. It may contain residual starter cultures from the cheese batch, and added casein.

Process:

Whey cream will be prepared from three sources of whey, particularly cheese, paneer and chhana. The fat content of the whey cream should range from 40 to 45 percent. The cream should be smooth and free from lumps. After separation of cream, it should be cooled to 4 – 7^0C. Then cream should be heat treated / pasteurized at 60^0C for 20 minutes or at 85^0C for 25 seconds. Vacreation method / plate heat exchanger can be used for pasteurization and cool quickly to 4^0C. The butterfat content will end up being between 80 and 90%. In Canada, the legal definition is that it must be a minimum of 80% butterfat by weight. In Ireland, it will be 82% butterfat, 16% water, and 2% milk solids. It is popular in Sweden, where it is sold in most stores as an everyday butter called " mess-smor". In other parts of the world, whey Butter is used commercially in baked goods and in making candies. Whey butter had the softest texture, more porous compare to regular butter.

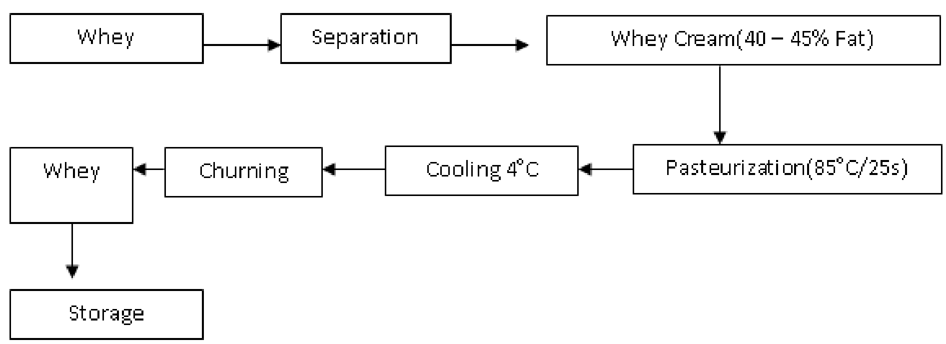

Fig. 30.1 Schematic flow diagram for production of whey butter

Shelf life: Approximately 12 months from date of production when stored under appropriate conditions at <-18°C and approximately 3 months at 0-5°C.

Composition of whey butter

Whey cream is higher than sweet cream in unsaturated fat and biologically active compounds that originate from the milk fat globule membrane, such as sphingomyelin and mucins. Sphingomyelin may help prevent the onset of cancer and control the growth of cancerous cells. Following table shows the composition butter made from whey cream, sweet cream and cultured cream.

Table: 30.1: Chemical composition of whey butter, sweet cream butter and cultured cream butter

	Whey cream butter	Sweet cream butter	Cultured cream
Fat	95.80	96.03	93.03
Protein	0.75	0.92	0.89
Solid	87.66	86.02	88.20
Ash	0.09	0.12	0.15
Lactose	3.36	2.93	5.93

pH	6.36	6.12	4.87

Whey butter has minimum ash content compare to others. Whey butter was less hard and more spreadable than other regular butter.

30.4 FLAVOURED BUTTER:

Flavoured Butter is popular in western world to use in sandwiches and spreads. Flavourings are added to enhance the taste of the product. Natural flavourings such as dry onion powder, red chilly powder, pepper powder and ginger powder are used to flavor the product. These were mixed after butter prepared and care should be taken to minimize the contamination as these ingredients are added directly to butter after butter has been made.

Addition of Starter distillates to enhance the flavor:: A mixed strain starter of Streptococcus diacetilactis and Lactococcus lactis or / Lactococcus cremoris, that accumulates high concentration of alpha -acetolactate, was grown in a skim milk or whey medium, adjusted to pH 3.5 and steam distilled. About 85% of available diacetyl was obtained when 10% of the original culture volume had been evaporated. These flavour concentrates are encapsulated through spray drying technology using maltodextrin and other carriesr and made it into granules to use as flavour enhancer. Butter made by adding 0.07-0.14% distillate (containing approx. 2000 mg diacetyl/kg) during working is comparable with cultured butter in terms of flavour.

30.5 Natural Butter Flavors: Technology has been developed for the production of flavor systems via controlled enzyme modification of milk fats. Lipases and esterases from various sources are used. Methods for producing a variety of fairly pure enzymes, economically and in large quantities has been established. These enzymes are used to enhance the butter favour substance using butter as substrate. These lipases (glycerol ester hydrolases) from microbial sources have made it possible for researchers to employ the catalytic properties of these enzymes in innovative ways. One application in which the use of lipases has become well established is the production of lipolyzed flavors from feedstocks of natural origin. Immobilization of lipases on hydrophobic supports has the potential to (1) preserve, and in some cases enhance, the activity of lipases over their free counterparts; (2) increase their thermal stability; (3) avoid contamination of the lipase modified product with residual activity; (4) increase system productivity per unit of lipase employed; and (5) permit the development of continuous processes. As the affinity of lipases for hydrophobic interfaces constitutes an essential element of the mechanism by which these enzymes act, a promising reactor configuration for the use of immobilized lipases consists of a bundle of hollow fibers made from a microporous hydrophobic polymer.

These enzymes (lipases, lactases and proteinases) are used in optimum combination to act on substrate under controlled conditions. This treatment increases the flavour components or volatile substance which is highly desirable. Along with volatile flavour components, fatty acids such as butyric, caproic, caprylic and capric acids in much greater molar concentration. Later on, this reaction is arrested using proper treatment thereby avoiding off-flavour development and oxidized flavour development.

These products are used as flavouring ingredient to enrich the non-dairy products like biscuit, non dairy topping, sauses and savoury products. After arresting enzymatic action product is spray dried to extend the shelf life of the product.

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Lesson – 31
Fractionation of Milk Fat

31.1 INTRODUCTION:

The physical properties such as melting point and consistency of butter are depending on chemical composition of the milk fat. The different triglycerides have different melting points and can therefore easily divided into different fractions consists of different fatty acids. When molten milk fat is slowly cooled, a crystalline solid and an uncrystallized liquid phase are formed. Separation of these phases yields fractions with high and low softening points respectively. Due to the fact that fat is composed of triglycerides of various molecular weights with different physical properties, fractionation of milk fat into fractions markedly different from one another in composition and physical properties is the most logical basis of modification. Economic fractionation of milk fat into oil and hard fat fractions will facilitate an increased utilization of milk fat in many food applications, such as chocolate, confectionary and bakery products and in developing new convenient (e.g. freeze spreadable) and dietetic (e.g. cholesterol reduced and short and medium chain enriched triglycerides) butter types. Differences in molecular weight, melting temperatures (molecular weight and entropy of fusion), volatility and intermolecular interaction energy of constitutive triglycerides, can provide the physical basis for fractionation of milk fat triglycerides. Fractional crystallization is most promising process to separate milk fat, a laboratory method of fractional crystallization is explained in detail in following paragraph.

31.2 MELTING CHARACTERISTICS OF MILK FAT:

More than 400 fatty acids have been identified in milk fat and their melting point varies from - 40^{o}C to 40^{o}C. This is due to variation in the composition of milk fat with season, region, breed of cows and type of feed.

Table 31.1: Classification of milk fat fraction based on melting temperature

Milk Fat Fraction	Melting Temperature Range (^{o}C)
Very High Melting Fraction	>50^{o}C
High Melting Fraction	32 - 50^{o}C
Middle Melting Fraction	25 - 32^{o}C
Low Melting Fraction	10 - 25^{o}C
Very Low Melting Fraction	<10^{o}C

Following table gives the melting point of major fatty acids of milk fat

Table 31.2: Melting point characteristics of common fatty acids of milk fat

Carbon Number	Common Name	Melting point (Deg C)	Type	Typical Composition (%w/w)
4:0	Butyric	-8	Short chain, Saturated	3.9
6:0	Caproic	-4	Short chain, Saturated	2.5
8:0	Caprylic	17	Short chain, Saturated	1.5
10:0	Capric	32	Medium chain, saturated	3.2
12:0	Lauric	44	Medium chain, saturated	3.6
14:0	Myristic	54	long chain, saturated	11.1
16:0	Palmitic	63	long chain, saturated	27.9
18:0	Stearic	70	long chain, saturated	12.2
18:1	Oleic	16	long chain, unsaturated	21.1
18:2	Linoleic	-5	long chain, saturated	1.4
18:3	Linolenic	-10	long chain, saturated	1.0
Others			long chain, saturated	10.6

31.3 FRACTIONATION TECHNOLOGIES:

Following are the various methods for fractionation of milk fat

1. Crystallization from Melted Milk Fat(Dry method)
2. Crystallization using Solvents(Wet method)
3. Supercritical Fluid Extraction

31.3.1 Crystallization from Melted Milk Fat

It is basically temperature controlled process. Dry fractionation consists of two steps, a partial crystallization of triacylglycerols from a melt and a subsequent separation. More than 400 fatty acids have been identified in milk fat and their melting point varies from - 40°C to 40°C. This is due to variation in the composition of milk fat with season, region, breed of cows and type of feed.The driving force for melt crystallization is the difference between the melting point of a substance and the crystallizationtemperature. The efficiency of separation of the liquid (olein) from the crystalline phase (stearin) influences the quality of the solid fraction to a great extent. The crystallization step has a greater influence on the chemical composition of the pure fractions.Crystallization in general can be divided into two characteristic process steps: nucleation and growth. To crystallize a fat compound, super saturation or super cooling is necessary. This is the driving force for both crystallization steps. For fat systems, crystallization is complex because natural fats are a mixture of various triacylglycerols. Consequently, the concentration of each triacylglycerol is low and, for example, increased super cooling is needed to achieve nucleation of this low concentrated species. Furthermore, triacylglycerols are characterized by a complex melting behavior. They can solidify in three different crystal structures (α, β′, β) (polymorphism). Different crystal grid structures result depending on the magnitude of the driving force of crystallization. Less stable modifications require a lower driving force. The different polymorphic modifications have different thermodynamic stability, and the metastable polymorphic modifications (α, β′) are transformed with time to the stable β form.

The triglycerides are separated according to their melting points by filtration or centrifugation. After the process of crystal formation and growth, a filtration step is used to separate the solid product from the remaining melt. Filtration efficiency is determined by the size, shape, and mechanical stability of the milk fat crystals and depends on the amount of the mother liquor adhering to the crystals.

Another method which is widely used for crystallization is Solid layer melt crystallization. This process has only recently been applied to fractionation of milk fat (4–6) although it is widely used in the chemical processing industry. In layer crystallization processes, crystals generally grow on the cooled surface of a specially designed multi-tube or plate heat exchanger. The crystalline product is removed by re-melting crystals after draining the residual melt.

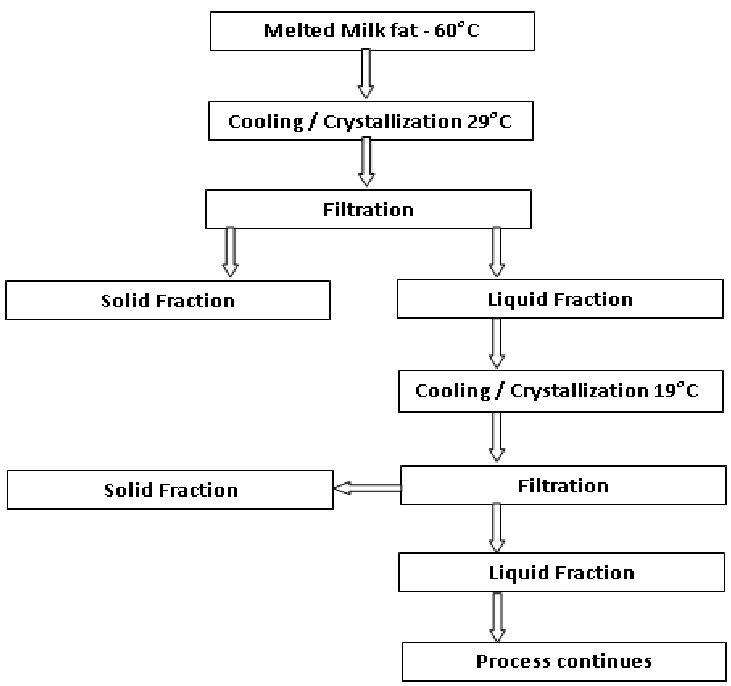

Fig: 31.1 Flow diagram of crystallization from melted milk fat

On laboratory method is explained below, wherein milk fat was melted completely and washed several times with warm water, dried under vacuum and filtered at 50-60^{0}C.

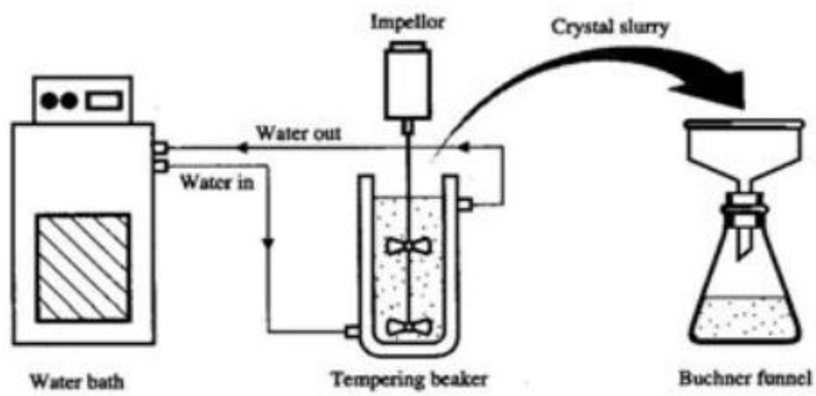

Fig: 31.2 Fractionation by crystallization of molten milk fat in laboratory

500g sample was melted in a beaker which is kept in thermostat controlled water bath at 60^{0}C. Fat was stirred at about 100rpm. Then crystallization temperature was adjusted from 25^{0}C to 32^{0}C at an interval of 1^{0}C for six hours. After crystallization at one of these temperatures fat was filtered on a Buchner funnel resulting in a liquid and a solid fraction at each of the selected temperatures. Fatty acid composition was determined using gas-liquid chromatographic determination.

The solid fraction (stearin) and the liquid fraction (olein) displayed a different triacylglycerol (TG) composition. Stearin fraction was enriched in long-chain fatty acids, whereas olein fraction was enriched in short-chain and unsaturated fatty acids.Determinations of fatty acid composition by GLC showed that unsaturated and short chain fatty acids were present in increased concentration in the liquid fraction (average 37·8 and 12·4% as compared with 32·1 and 10·8% in the original milk fat) and long chain saturated acids in the solid fraction (average 57·8 as compared with 53·8%). There was some concentration of carotene and vitamin A, and to a lesser extent of cholesterol, in the liquid fraction

31.3.2 Crystallization using Solvents

This process involves dissolving melted milk fat in a solvent prior to crystallization. Solvents employed are generally acetone, ethanol, pentane or hexane. Melting temperature used is similar to dry fractionation. Crystals separation is done by filtration. Fractions are heated to remove the solvent. However, the costs incurred by solvent recovery, the hazardous nature of the operation, and the process losses make this process less frequently used than crystallization and filtration.

Isopropanol is used as solvent for fraction of milk fat. It should be added (4 mL/g butter oil), to butter oil. Mixture should keep at different temperature viz., 15, 20, 25 and 30 °C and stirred by a low-speed mechanical stirrer for 1 h. Then, solid part and liquid part were separated by filtration under vacuum. The fractions were desolventized at 80°C for 1 h at 10 mm Hg pressure, weighed, and stored in a refrigerator.

Both the stearin fractions and the olein fractions show differences in the fatty acid compositions as reported by **Bhattacharyya et al., 2000** The stearin shows higher content of short-chain acids and other saturated acids than the oleins.

The melting point of the stearin fraction at 15°C has increased from original butter oil by 4.1°C due to the increase in both palmitic acid (from 31.7 to 39.1%) and stearic acid (from 14.0 to 21.3%). On the other hand, in the olein fraction, palmitic acid and stearic acid have both decreased from 31.7 to 24.7% and 14.0 to 12.6%, respectively, while oleic acid has increased. The fatty acid compositions of the stearin and olein fractions obtained at 30°C and also at 25°C from isopropanol closely matches with the pattern composition of fatty acids of the corresponding fractions isolated by dry fractionation technique.

The SFC of the stearin fractions indicated significant values, *viz.* 62–67 at 10°C, 39–51 at 20°C, and 21–34 at 30°C. The stearin fractions obtained at 30, 25, and 20°C are all fairly similar in properties. This suggests that the temperature of fractionation, between 30, 25, and 20°C, does not lead to significant differences in physical characteristics.

31.3.3 Supercritical Fluid Extraction (SFE)

Supercritical CO2 extraction may be used in batch or continuous systems to fractionate anhydrous milk fat into fractions with specific properties to enhance its use. A gas above its critical pressure and temperature exhibits unique solvent properties. SFE of milk fat is generally performed with carbon dioxide. Milk fat fractions are selectively dissolved in SFE CO_2 and separated when pressure and temperature return to atmospheric conditions. Supercritical carbon dioxide (SC-CO_2) fractionation holds promise as a means to turn milk fat into a value-added ingredient.

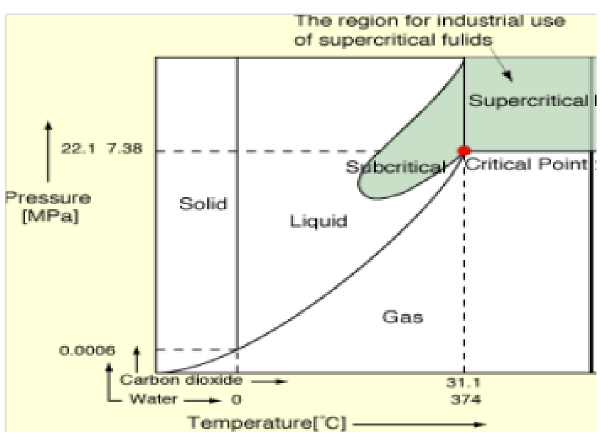

Fig. 31.3: Supercritical state of fluids

The removal of cholesterol and fractionation of butter oil with supercritical fluids have been reported. The use of co-solvents to improve the removal efficiency in the extraction of cholesterol with supercritical CO_2 have been evaluated. It has been reported that only 5% of the cholesterol in the initial butter using supercritical extraction followed by adsorption on silica gel.

In one study conducted by Torres *et al.*,(2009), wherein butter oil is fractionated based on the individual fatty acid types via countercurrent CO2 extraction at pressures ranging from 8.9 to 18.6 MPa and at 2 different temperatures (48 and 60°C). Using this methodology, fractions as high as 70% of SCFA and MCFA ethyl esters were obtained. Figure 13.3 shows a flow diagram of the countercurrent supercritical fluid extraction system employed in this study.

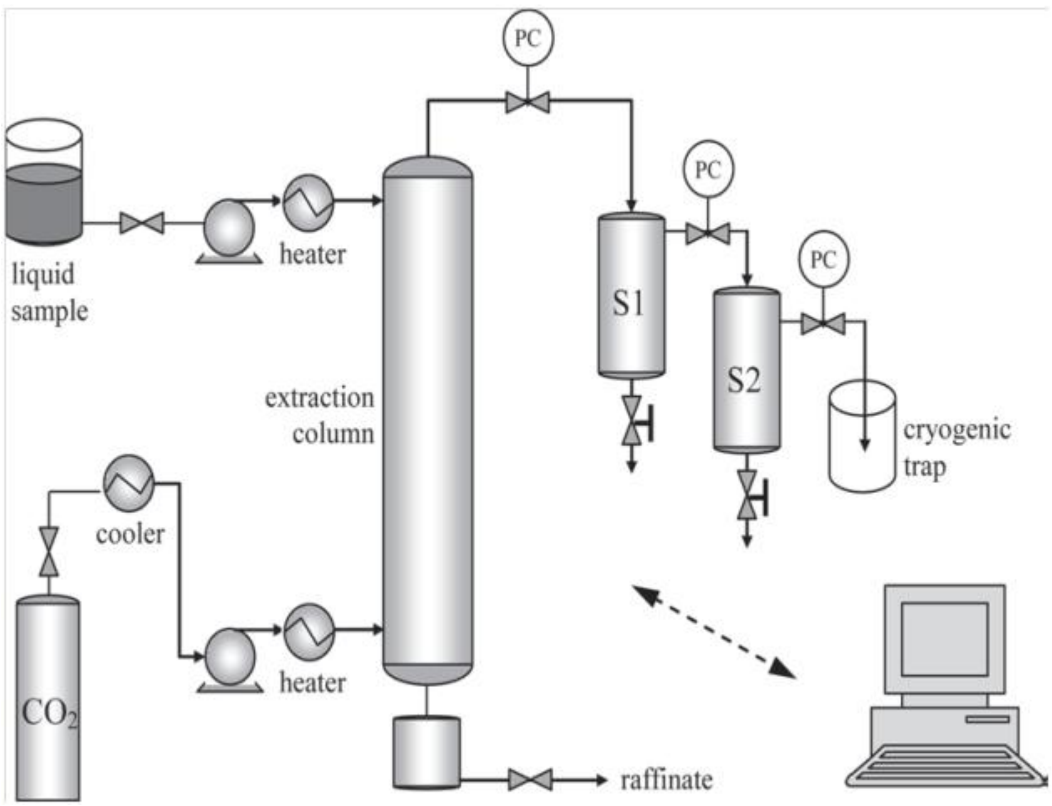

Fig 31.4 Countercurrent supercritical fluid extraction equipment

The countercurrent extraction column (316 stainless steel) is 100 cm × 12 mm i.d. and is packed with Fenske rings (3 × 0.5 mm). The countercurrent supercritical fluid extraction device also includes 2 separator cells (S1 and S2) of 270 mL capacity each (where a cascade decompression takes place) and a cryogenic trap at atmospheric pressure. Both CO2 and liquid feed sample were preheated at the exit of their respective pumps before introduction into the extraction column. All units were equipped with electrical thermostats. The device has computerized programmable logic controller-based instrumentation and a control system with several safety devices including valves and alarms. During the extraction, a continuous flow of CO2 was introduced into the column through the bottom. When the operating pressure and temperature were reached, the liquid sample was pumped (100 mL/h) from the top during the entire extraction time (60 min). The first separator was maintained at 6 MPa and 20°C and the second separator cell was maintained at low pressure and temperature (2

MPa and 10°C). The raffinate and liquid fractions collected in the separators were weighted and analyzed. The material balance closed in all experiments with an inaccuracy <7.4%.

Table31.2: Advantages and disadvantages of different fractionation methods

	Crystallization form melted fat	**Crystallization from solvents**	**Supercritical CO_2extraction**
Advantages	• No additives • Simple process • Successfully commercialized	• More discrete fractions produced • Can use low temperatures • Reduced time for crystal formation	• No additives • CO2 is nontoxic • More discrete fractions produced
Disadvantages	• Less pure fractions • Limited temperature range • Long residence time for crystal formation	• Potential toxicity of solvent • Flavour changes in milk fat • High cost of operation and solvent recovery	• High capital investment

31.4 USES OF MILK FAT FRACTIONS:

1. Low Melting Fraction <15°C

i. Has strong butter flavour

ii. Can be incorporated into milk powder to improve functionality

iii. Has applications in confectionery products

iv. Can be used to make normal butter spreadable at refrigerator temperatures

2. Medium -Melting Fraction 15 - 30°C

i. Can be used as shortening to provide crusty, flaky texture to croissants and pastries
ii. Can be used in making cakes and biscuits such as shortbread

3. High-Melting Fraction > 30°C

i. Hard fraction can be used in chocolate manufacturing instead of cocoa butter

ii. Has been reported to act as bloom inhibitor in dark chocolate

iii. Can be used as a flavour and texture agent in milk chocolate

iv. Hard fraction can improve the whipping properties of cream which is desirable in ice cream manufacturing

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Lesson-32

Fat Spreads

32.1 INTRODUCTION:

Spreads have a similar composition to margarine but are usually lower in fat. Low fat spreads have a fat content of 40g/100g. Spreads may be fortified with vitamins A and D. The production of margarine and spreads is very different to that of butter. Butter is pure and natural and has undergone minimal processing, whereas margarines and spreads are heavily processed and contain a number of additives, preservatives and colour compounds.

32.2 CLASSIFICATION OF SPREADS:

Fat Spreads are classified as,

1. Dairy Spreads: Wherein only milk fat is used as a source of fat
2. Non-Dairy Spreads: Wherein Vegetable fat with or without milk fat used as a source of fat

In Indian contest fat spreads can further classified as follows.

1. Low fat spreads: Fat percent will be between 40 to 60%
2. Reduced fat spread: Fat percent will be between 60 – 70%fat

   Eg: Amul lite: 10% Milk fat and 49% vegetable fat.

Based on fat content spread and margarine products are as classified as follows.

Fat Content %	Milk fat products	Mixed Fat Products	Margarine Products
80 – 95	Butter	Blend	Margarine
>62 - <80	Dairy spread	Blended spread	Fat spread
60 – 62	¾ fat or reduced fat buter	Reduced fat blend	Reduced fat margarine
>41 - <60	Reduced fat dairy spread	Reduced fat blended spread	Reduced fat spread
39 – 41	½ or low fat butter	½ or low fat blend	½ or low fat margarine
<39	Low fat dairy spread	Low fat blended spread	Low fat spread

FSSR-2011 classification of Fat Spreads:

(a) Milk fat spread............made of exclusively milk fat.

(b) Mixed fat spread.....made of a mixture of milk fat with any one or more of hydrogentated, un-hydrogenated, refined edible vegetable oils or interesterified fat.

(c) Vegetable fat spread……made of a mixture of any two or more of hydrogenated, unhydrogenated, refined vegetable oils or interesterified fat.

32.3 FSSR-2011 DEFINITION FOR FAT SPREAD:

According to FSSR-2011, fat spread is a product in the form of water in oil emulsion,

· Product may contain not more than 80%Fat and not less than 40%Fat by weight,

· Moisture should not be more than 56% and not less than 16% by weight,

· It may contain edible salt not exceeding 2% by weight in aqueous phase,

· Starch not less than 100ppm and not more than 150ppm,

· Diacetyl may be used as flavouring agent not exceeding 4.0ppm

· Permitted class II preservatives namely sorbic acid, and its sodium, potassium and calcium salts (calculated as sorbic acid), benzoic acid and its sodium its sodium and potassium salts (calculated as benzoic acid) singly or in combination not exceeding 1000 parts per million by weight,

· It may contain sequestering agent,

· Permitted emulsifier and stabilizer, permitted antioxidants (BHA or TBHQ) not exceeding 0.02% of the fat content of the spread,

· It may contain annatto and/or carotene as colouring agents,

· It shall be free from animal body fat, mineral oil and wax,

· Vegetable fat spread shall contain raw or refined Sesame oil (Til oil) in sufficient quantity, (so that when separated fat is mixed with refined groundnut oil in the proportion of 20:80 the red colour produced by Baudouin test shall not be lighter than 2.5 red units in 1 cm cell on a Lovibond scale.)

· The vegetable fat spread shall contain not less than 25 IU synthetic vitamin 'A' per gram at the time of packing

· Acid value of extracted fat should not be more than 0.5.

- Melting point of Extracted fat shuld not be more than 37^{0}C, in case of vegetable fat spread using capillary method.

- Unsaponifiable matter of extracted fat

  (a) In case of milk fat and mixed fat spread Not more than 1 per cent by weight

  (b) In case of vegetable fat spread Not more than 1.5 per cent

  (c) Acid value of extracted fat Not more than 0.5

32.4 LABELING OF FAT SPREAD:

The word 'butter' will not be associated while labeling the product. The fat content shall be declared on the label. In mixed fat spread, the milk fat content shall also be declared on the label along with the total fat content.It shall be compulsorily sold in sealed packages weighing not more than 500gram under Agmark certification mark.

32.5 MANUFACTURING PROCESS OF FAT SPREAD:

In general, production of spreads can be divided into the following parts**:**

- Preparation of the water phase and fat phase
- Emulsion preparation
- Pasteurisation
- Crystallisation
- Filling

The emulsion consists of a fat phase and a water phase. Minor ingredients such as emulsifiers, salt, preservatives or additives, colour, flavour and vitamins are dispersed in the respective phases according to their solubility. Consequently, the raw materials used in the emulsion preparation prior to processing of spreads can be divided into a fat phase and a water phase. The major ingredients in the fat phase are:

- Fat blend, normally consist of a blend of different fats and oils in order to achieve a defined solid fat content. In regard to reduced fat products, the fat phase constitutes less than 60% of the total emulsion.

- Minor ingredients such as emulsifier, lecithin, flavour and colour are dissolved in the fat phase before emulsification. Fat-soluble flavour and colour, butter flavour and β-carotene are added to achieve products which taste and look like butter. In addition, β-carotene has pro-vitamin A activity.

The major ingredients in the water phase are:

·Water in which the minor ingredients are dissolved.

Salt and preservative, whey powder, skimmed milk powder or other types of milk can be added.

· Since high water content is available n spreads, stabiliser(s) system is needed in order to have the necessary stability in the final crystallised product. Water-soluble flavour and colour can also be added, but are primarily used in low fat spreads. Alginates, pectin and carrageenans have a good water binding effect and gives stable emulsions.

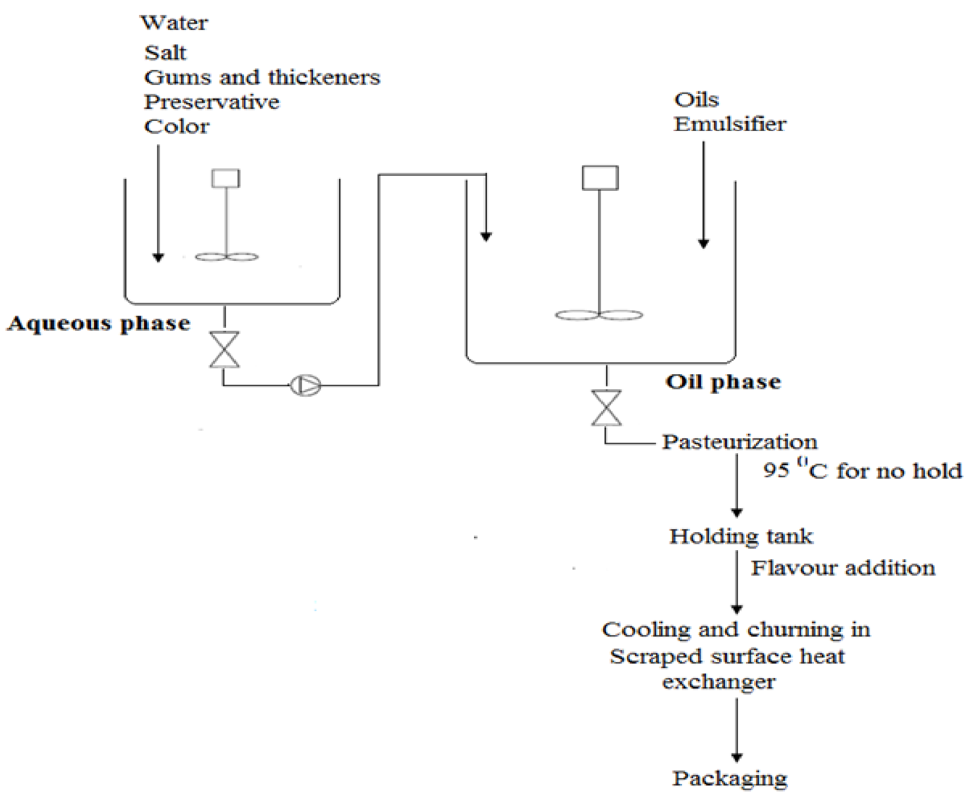


Fig.32.1 Schematic diagram of manufacture of vegetable fat spread.

In the case of low fat spreads, the water phase and the oil should have similar temperature and should be combined slowly when forming the emulsion. Additionally, it is very important that the emulsion is properly agitated to ensure homogeneity. However, care should be taken not to incorporate air during emulsification.

Prior to entering the crystallisation equipment, the emulsion is pasteurised, preferably in a scraped surface heat exchanger. A typical pasteurization process include a heating and holding sequence of the emulsion at 75-85°C for 16 sec. and subsequently a cooling process to a temperature of 45-55°C. The end temperature depends on the melting point of the fat phase: the higher the melting point, the higher the temperature.

The emulsion is pumped to the crystallisation line by means of a high pressure plunger pump (HPP). The crystallisation line for the production of margarine and related products typically consists of a high pressure SSHE which is cooled by ammonia or Freon type cooling media. The heart of the crystallisation line is the high pressure SSHE, in which the warm emulsion is super-cooled and crystallised on the inner surface of the chilling tube. The emulsion is efficiently scraped off by the rotating scrapers, thus the emulsion is chilled and kneaded simultaneously. When the fat in the emulsion crystallises, the fat crystals form a three-dimensional network entrapping the water droplets and the liquid oil, resulting in products with properties of plastic semi-solid nature. The crystallisation process, the processing conditions and the processing parameters have a great influence on the characteristics of the final spread product.

Limitations of conventional process: Using conventional mixers and agitators several difficulties can arise:

i. Additives designed to thicken the product tend to form agglomerates which agitators cannot easily break down

ii. Long processing times are often required to complete hydration.

iii. Poor hydration may lead to unsatisfactory "mouthfeel", and an unstable product

iv. Leading to storage problems once the product has been opened.

So, to overcome these limitations venturi assembly is introduced which is shown below schematically.

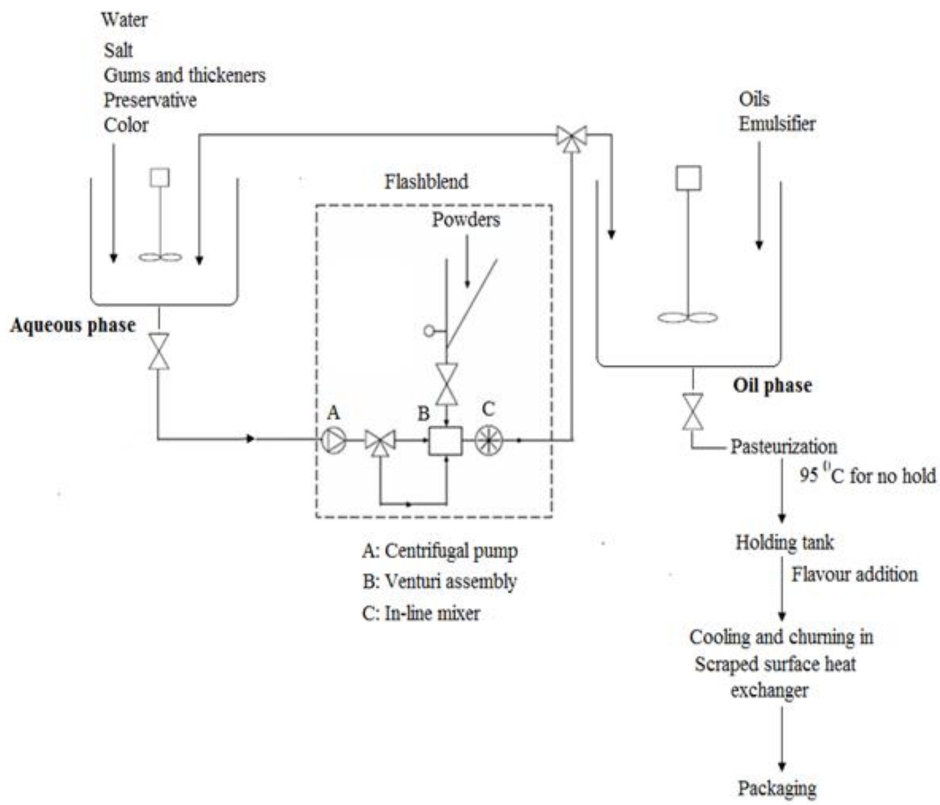


Fig.32.2 Schematic diagram of manufacture of vegetable fat spread with venturi system

Selection of ingredients for Fat Spread: Major ingredients are commonly used in preparation of spreads are milk fat, milk proteins, vegetable fat, emulsifiers, stabilizers, acidulants, salt, colouring & flavouring agents, vitamins, and antioxidants.

Source and role of fat: Milk fat - cream, butter, butter oil, vegetable fat - sunflower, corn, soyabean & groundnut oil are preferred, milk fat fractions / vegetable oil fractions can also be used. Fat provides structure, energy, and taste including creaminess. It is acarrier of flavour and vitamins. It is good source of essential fatty acids. It improves spreadibility, firmness, plasticity depending on amount of fat used in the spread**.**

Source and role of Protein: Milk Protein - SMP, Whey Powder, WPC; Vegetable protein - Soy protein isolate Improve organoleptic, functional and nutritional properties Proteins play a role in viscosity, water holding capacity as well. Protein helps in enhancing emulsion stability of the spreads.

Emulsifiers: Fat soluble emulsifiers are preferred because of fat is the major portion in the product also fat present in continuous phase. Monoglycerides of saturated fatty acids, unsaturated fatty acids, lecithin, egg yolk solids are used at a level of 0.1 to 0.6%. These emulsifiers help in reducing the size of aqueous droplets and create stabilizing films at the water/oil interface, so product will be more softer and spreadable.

Stabilizers: Especially important in reduced/low fat spreads wherein high water holding ability of stabilizer improves body & texture of the spread. They help in increasing the viscosity and also to inhibit the coalescence of aqueous phase droplets during processing. Carboxy methy cellulose(CMC), Modified starch, Sodium alginate, starch can be used as stabilizers at a level of 0.1 to 0.5%.

Following are the two typical recipes of mixed fat spreads

	Ingredients	**Formulation A, % of the Emulsion**	**Formulation B, % of the Emulsion**
Fat phase	Emulsifi er(s)	0.5-1.5	0.5-1.5
	β-carotene	4 ppm	4 ppm
	Flavour	0.15	0.15
	Fat Blend (30 parts interestified blend or hydrogenated oil having melting point 41°/42°C + 70 parts liquid vegetable oil)	Upto 40%	Upto 40%
Water phase	Water	up to 60%	up to 60%
	Salt	0.5-2	0.5-2
	Flavour	0.02	0.02
	Whey powder		0.5-1.5
	Stabiliser		0.5-2

32.6 PACKAGING:

Moisture and air proof containers are required to pack this fat rich product. Suitable packaging materials for this purpose are polystyrene based / polypropylene based cups or tubs, polyethylene coated paper packs along with parchment paper.

32.7 SHELF LIFE AND STORAGE:

Various factors influences the shelf life of the fat spreads, they are

i. Moisture content

ii. Process treatment

iii. Type of ingredients

iv. Salt content

v. pH of the product

vi. Temperature of storage

vii. Preservative level

Refrigerated Storage is preferred for long life at 5^0C, shelf life varies from 90days to 180days. Processing conditions & formulations also have influence on the shelf life of the product.

32.8 USES:

· Direct consumption along with sandwiches, salads etc.,

· Confectionery industry

· Bakery Industry

****** ☺ ******

Lesson-33

Margarine Production

33.1 INTRODUCTION:

Margarine is an emulsion of edible oils and fats with water. Physical properties of margarine are similar to butter. It shall be free from mineral oil and animal body fats. It may contain common salt not exceeding 2.0 per cent, permitted emulsifying and stabilizing agents, BHA or TBHQ upto a maximum limit of 0.02 per cent.

33.2 DEFINITION OF MARGARINE:

According to FSSR-2011, margarine is classified as Table margarine and Industrial margarine. **Table margarine** means an emulsion of edible oils and fats with water. It shall be free from rancidity, mineral oil and animal body fats. It may contain common salt not exceeding 2.5%, skimmed milk powder not exceeding 2%. It shall conform to the following specifications, give below in table.

Table.33.1 FSSR-2011 Requirement for table margarine

Constituent	Limit
Fat	Not less than 80% mass by mass(m/m)
Moisture	Not less than 12% and not more than 16% (m/m)
Vitamin A	Not less than 30 IU per gram at the time of sale
Melting point of extract	31^0C - **34^0**C (by Capillary slip method)
Unsaponifiable matter	Not more than 1.5% by weight extracted fat
Free fatty acids	Not more than 0.25% (as oleic acid) of extracted fat
OR	
Acid value	Not more than 0.5

Another class of margarine according to FSSR-2011 Act – 2011 is bakery or **industrial margarine**. It shall be free from added colour and flavour, rancidity, mineral oil and animal body fats. It may contain common salt not exceeding 2.5%, further its standards are listed below.

Table 33.2 FSSR-2011 Requirement for industrial margarine

Constituent	Limit
Fat	Not less than 80% mass by mass(m/m)
Moisture	Not less than 12% and not more than 16% (m/m)

Vitamin A	Not less than 30 IU per gram at the time of sale
Melting point of extract	31^0C - 41^0C (by Capillary slip method)
Unsaponifiable matter	Not more than 2.0% by weight extracted fat
Free fatty acids	Not more than 0.25% (as oleic acid) of extracted fat
OR	
Acid value	Not more than 0.5

Table 33.3 Common permitted food additives for Margarine/Table Spread according to FSSR-2011

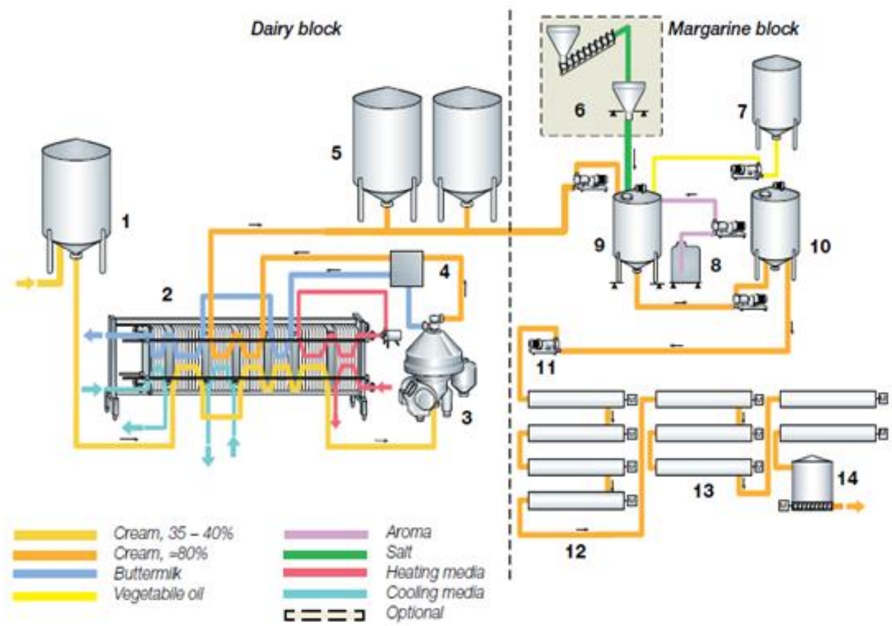
Natural food colours	
Beta carotene	25 mg/kg (maximum)
Annatto extracts (as bixin/norbixin)	20 mg/kg(maximum)
Curcumin	05 mg/kg (maximum)
Antioxidant (Singly or in combination)	
Lecithin	GMP
Ascorbic acid	GMP
Propyl gallate, ethyl gallate, Octyl gallate, Dodecyl gallate or a mixture thereof	200ppm (maximum)
Butylated Hydroxy Anisole (BHA)	200ppm (maximum)
Natural and synthetic tocopherols	
Citric acid, Tartaric acid, Gallic acid	GMP
TBHQ	200ppm (maximum)
Antioxidant Synergist	
Sodium citrate	GMP
Emulsifying agents	
Mono and di glycerides of fatty acids	GMP
Mono and di glycerides of fatty acids esterified with acetic, acetyl tartric, citric, lactic, tartaric acids and their sodium and calcium salts	10g/kg (maximum)
Lecithin	GMP
Polyglycerol esters of fatty acids	5g/kg(maximum)
Preservatives	
Sorbic acid	1000 mg/kg(maximum)
Sodium/ Potassium/ Calcium sorbate expressed as Sorbic acid	1000 mg/kg(maximum)
Benzoic acid	1000 mg/kg(maximum)
Sodium/ Potassium/ benzoate expressed as Benzoic acid	1000 mg/kg(maximum)
Acidity regulators	
Citric acid	GMP
Lactic acid	GMP
Flavours	

Natural flavours and natural flavouring substances/ Nature identical flavouring substances/ Artificial flavouring substances	GMP
Diacetyl	4 mg/kg (maximum)

It is also provided further that such coloured and flavoured margarine shall only be sold in sealed packages weighing not more than 500grams. Test for Argememe oil shall be negative. It shall also contain starch not less than 100 p.p.m. and not more than 150 ppm.

33.3 MARGARINE PROCESS LINE:

It consists of two blocks one is "dairy block" wherein the cream concentration, pasteurization and cooling of cream takes place and other is "margarine block" wherein preparation of the mix and phase inversion accompanied by working and cooling takes place.



Dairy Black

1. Salt dosage, optional
2. Vegetable oil tanks
3. Flavour Dosage
4. Mixing
5. Buffer tank
6. High pressure pump
7. Scrapped surface cooler
8. Pin rotars
9. Silo with screw conveyor in the bottom

Dairy Black

10. Cream Tank
11. Plate Heat Exchanger
12. Centrifugal Cream Concentrators
13. Cream Standardization
14. Pre-crystallization tanks

Fig 33.1 Process line for the production of Spreads

(Source: Tetrapak Processing System, AB, Lund, Sweedan)

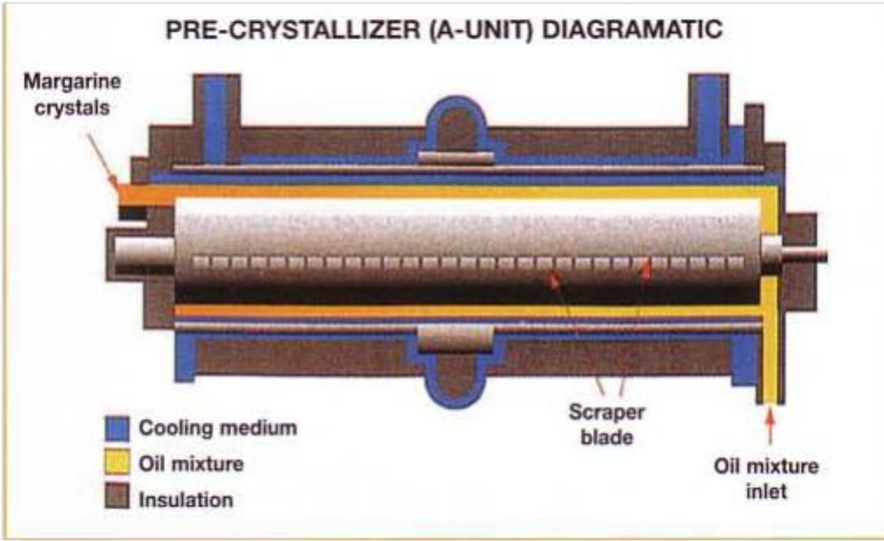


Fig. 33.2: Scrapped surface crystallizer

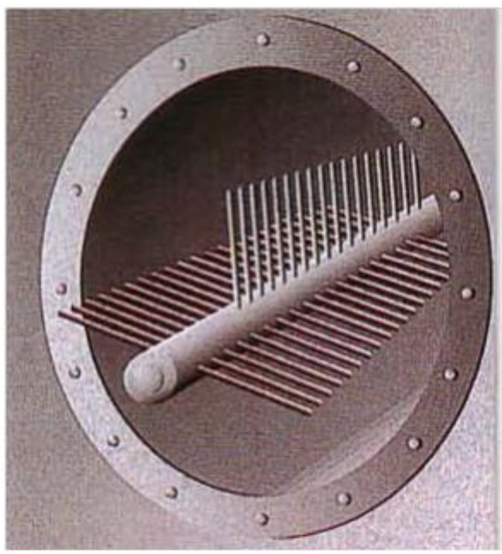


Fig. 33.3: Pin-rotor

Dairy block: Starts with pasteurized cream of 35 to 40 % fat content. Temperature is adjusted to 60 – 70°C before it enters the cream concentrator. Cream fat content is automatically controlled by the continuous standardization device and 82 – 84% fat level is reached in concentrator. Cream is then cooled to 18 – 20°C, before being routed to a holding/pre-crystallization tank (Fig 33.1).

Margarine block: In margarine black product mix is prepared and various ingredients are mixed together, according to the recipe. Concentrated cream is mixed with appropriate volumes of vegetable oil, salt and water phase. After thorough mixing, the mixture is pumped into a buffer tank. The process is continuous from the buffer tank, from which the product mix is taken to the high pressure pump.

It is then fed into the scraped surface coolers, where phase inversion takes place. Before final cooling, the spread is held and worked by pin rotors. The pin-rotors, besides further crystallizing the emulsion, also physically breaks up and works the crystals to improve the texture of the final product. Product enters final cooling stage and then to storage silo. From silo, it is pumped into the filling machine, often a tub-filling machine.

33.3 FACTORS WHICH AFFECTS RHEOLOGICAL QUALITY OF MARGARINE:

Solid fat content (SFC): The solid attributes of a margarine fat through a temperature range is characterized by its SFC or solid fat index (SFI) profile. SFC is an important property of an oil or fat, and is the ratio of the solid to the total phase at a particular temperature. SFC is measured by nuclear magnetic resonance (NMR) spectroscopy as the number of protons in the solid state over the total number of protons in the fat, i.e. in both solid and liquid states. The consistency of margarine at any temperature can be predicted from its SFC1 or SFI at that temperature. The SFC and crystal components are responsible for the consistency of the margarine.

Polymorphic form: polymorphic forms are the solid phases of the same chemical composition with different crystalline structures, but which yields identical liquid phases on melting. Polymorphs are the different forms of the solid state, this is due to existence of TAG molecules in a number of crystal forms. TAGs can crystallize in different polymorphs with the four major forms being sub-α, α, β′ and β. However, the fat crystals in margarine and shortening are only in β′ and β forms. A pure TAG would be most stable in the β form, but a mixture of TAGs will be most stable in the β′ form. Transformation from one polymorph to another can occur in the solid state without melting. The change is from the lowest to the highest melting point, that is, α to β′, β′ to β. Several factors that influence polymorphism, for example, purity of the fatty acids, temperature, rate of cooling, presence of crystal nuclei and the type of solvent used. The β′-crystal polymorph occurs as single needle-shaped crystals about 5–7 mm long, while the β-crystal polymorph is 20-30mm long. The smaller the crystal, the smoother is the product, while bigger crystals will impart a coarse, grainy and brittle texture.

33.4 MERITS AND DEMERITS OF MARGARINE:

Margarine has the following merits compare to butter:

- Spreadability: It is one of the most highly regarded attributes and margarine shows good spreadability at refrigeration temperature as compare to butter. Products with a solid fat index (SFI) of 10–20 at serving temperature were found to be optimal on a consumer panel. SFI at 10^{o}C have been recorded and that is in the range of 19-21.

- Consistency and Texture: Consistency is the measure of smoothness, evenness and plastic state in margarine. It can range from *very soft*, like petroleum jelly, to soft, medium, firm, tough, hard and brittle. Texture is a measure of the structure. It varies from smooth to mealy or floury, grassy, granular or sandy and, finally, coarse and lumpy. This attribute can be altered to the desired level by using different vegetable oil in the formulation where as butter has less scope to alter consistency and texture.

· Contains minimum or no cholesterol in the product

· Product is cheaper than butter

Following are the demerits of Margarine:

· Bland in flavor and taste: Flavour and mouthfeel of margarine is weak as compare to butter.

· Oil Separation: There is possibilities of oil separation when the crystal matrix is inadequate to entrap the liquid oil. This occurs because of transformation of the crystals to the β-form. The β -crystals continuously grow bigger (causing sandiness) until the network can no longer retain its lattice structure to entrap the liquid oil. The liquid oil then exudes from the product and the aqueous phase coalesces.

· Sandiness: β' polymorph is the desired form in margarine. β' has very small crystals so that it can incorporate a large volume of liquid oil in the crystal network giving a smooth, continuous and homogeneous product. However, the β -crystals have the tendency to grow bigger and bigger into needle-like agglomerates. The large crystals impart a sensation of sandiness in the mouth.

33.5 PACKAGING OF MARGARINE:

The wrapping material must be

· Greaseproof

· Impervious to light,flavouring and aromatic substances.

· Impermeable to moisture

· Parchment paper

· Aluminum foil

· Outer paper cartons with PE layer inside

· Plastic tubs of PP / PS.

· Can withstand storage temperature of 50C.

Margarine is first wrapped in parchment paper, after wrapping the pat or bar packets continue to a cartoning machine for packing in cardboard boxes, which are subsequently loaded on pallets and transported to the cold store. Tubs are also used for margarine packing.

33.6 USES:

· Table margarine is used for direct consumption in place of table butter

· Industrial margarine is used in confectionery and bakery industry as shortner.

Lesson-34

Ghee Definition, Standards and Composition

34.1 INTRODUCTION:

At present, about 28% of the total milk production is utilized for the manufacture of about one million ton of ghee per annum.Ghee is a product of tradition with an established market prepared at household level, also at organized dairy plants. Ghee manufacture has great significance and relevance to Indian masses and the dairy industry there is sufficient recorded evidence to prove that the manufacture of ghee originated in India and it has been used extensively for dietary and religious purposes since Vedic times (3000-2000 B.C).

34.2 NECESSITY FOR PRODUCTION OF GHEE:

India is a tropical country with wider variations in ambient temperature from region to region and from season to season. It is very difficult provide a cold chain to protect perishable products like milk and butter for longer time, also this exercise involves additional investment and expenditure. Thus simple, convenient and affordable process to preserve milk fat would favor the milk producers and processors to a greater extent.

Whenever milk left with producer, they experience great difficulty to preserve it, with available resources with them conversion of ghee to malai and then from malai to ghee was found to be the only affordable and convenient way to preserve milk fat at ambient temperature at household level.

- Ghee is a very popular product since from ancient time and have greater demand during festival and other ceremonial functions where use of ghee in food has been considered to delicacy due to its pleasing flavour and aroma.
- Best ways to salvage substandard and returned market milk at commercial dairy level is separation of fat from these and convert this fat to ghee.
- Ghee has a market demand of around one million ton per annum in India, to meet this huge demand and also involvement of simple technology to produce ghee attracts the milk processor to have ghee making plant of variable capacity.

34.3 DEFINITION:

According to FSSR-2011, ghee means the pure heat clarified fat derived solely from milk or curd or from desi (cooking) butter or from cream to which no colouring matter or preservative has been added.

Table: 34.1: FSSR-2011 Standards for ghee state wise in India.

Sl. No.	Name of the State / Union Territory	Butyro Refractometer reading at 40^0C	Min. Reichert Value	Percentage of	
				FFA as oleic acid (max.)	Moisture (Max.)
1	Andhra Pradesh	40.0 to 43.0	24	3	0.5
2	Andaman & Nicobar Islands	40.0 to 43.0	24	3	0.5
3	Arunachal Pradesh	41.0 to 44.0	26	3	0.5
4	Assam	40.0 to 43.0	26	3	0.5
5	Bihar	40.0 to 43.0	28	3	0.5
6	Chandigarh	40.0 to 43.0	28	3	0.5
7	Chattisgarh	40.0 to 44.0	26	3	0.5
8	Dadra and Nagar haveli	40.0 to 43.0	24	3	0.5
9	Delhi	40.0 to 43.0	28	3	0.5
10	Goa	40.0 to 43.0	26	3	0.5
11	Daman & Diu	40.0 to 43.5	24	3	0.5
12	Gujarat				
12a	Areas other than cotton tract areas	40.0 to 43.5	24	3	0.5
12b	Cotton tract areas	41.5 to 45.0	21	3	0.5
13	Haryana				
13a	Areas other than cotton tract areas	40.0 to 43.0	28	3	0.5
13b	Cotton tract areas	40.0 to 43.0	26	3	0.5
14	Himachal Pradesh	40.0 to 43.0	26	3	0.5
15	Jammu & Kashmir	40.0 to 43.0	26	3	0.5
16	Jharkhand	40.0 to 43.0	28	3	0.5
17	Karnataka			3	0.5
17a	Areas other than Belgaum district	40.0 to 43.0	24	3	0.5
17b	Belgaum district	40.0 to 44.0	26	3	0.5
18	Kerala	40.0 to 43.0	26	3	0.5

19	Lakshwadeep	40.0 to 43.0	26	3	0.5
20	Madhya Pradesh				
20a	Areas other than cotton tract areas	40.0 to 43.0	26	3	0.5
20b	Cotton tract areas	41.5 to 45.0	21	3	0.5
21	Maharashtra				
21a	Areas other than cotton tract areas	40.0 to 43.0	26	3	0.5
21b	Cotton tract areas	41.5 to 45.0	21	3	0.5
22	Manipur	40.0 to 43.0	26	3	0.5
23	Meghalya	40.0 to 43.0	26	3	0.5
24	Mizoram	40.0 to 43.0	26	3	0.5
25	Nagaland	40.0 to 43.0	26	3	0.5
26	Orisssa	40.0 to 43.0	26	3	0.5
27	Pondicherry	40.0 to 44.0	26	3	0.5
28	Punjab	40.0 to 43.0	28	3	0.5
29	Rajasthan				
29a	Areas other than Jodhpur District	40.0 to 43.0	26	3	0.5
29b	Jodhpur District	41.5 to 45.0	21	3	0.5
30	Tamil Nadu	41.0 to 44.0	24	3	0.5
31	Tripura	40.0 to 43.0	26	3	0.5
32	Uttar Pradesh	40.0 to 43.0	26	3	0.5
33	Uttarakhand	40.0 to 43.0	26	3	0.5
34	West Bengal				
34a	Areas other than Bishnupur sub division	40.0 to 43.0	28	3	0.5
34b	Bishnupur sub division	41.5 to 45.0	21	3	0.5
34	Sikkim	40.0 to 43.0	28	3	0.5

34.4 PRODUCT DESCRIPTION AND CHEMICAL COMPOSITION OF GHEE:

Ghee could be in liquid, semisolid and some time in solid state based on the storage temperature. Ghee made from buffalo milk is whitish with greenish tinge and that of cow milk is golden yellow colour. It is usually prepared form cow milk, buffalo milk or mixed milk.

Composition: Ghee is a complex lipid of glycerides (majorly triglycerides), free fatty acids, phospholipids, sterols, sterol esters, fat soluble vitamins, carbonyls, hydrocarbons, carotenoids, (only in ghee derived from cow milk). Its detailed chemical composition is given below.

Table 34.2 Chemical composition of ghee

Constituents	Cow milk ghee	Buffalo milk ghee
Fat (%)	99 – 99.5	99 – 99.5
Moisture (%)	<0.5	<0.5
Carotene(mg/g)	3.2-7.4	-
Vitamin A(IU/g)	19-34	17-38
Cholesterol (mg/100g)	302 – 362	209 – 312
Tocopherol(mg/g)	26 – 48	18 – 31
Free fatty acid (%)	2.8	2.8

Source: (R.P.Aneja *et al.,* Technology of Indian milk products, Dairy India publication. Section 3.4: Fat rich dairy products, page 187.)

Milk fat contains at least 500 fatty acids and fatty acid derivatives with 4 – 20 or more carbon atoms in their chain. The fatty acid may saturated or unsaturated and usually contains an even number of carbon atoms. Composition of fatty acid also varies between buffalo milk fat and cow milk fat. Following table shows detailed composition of buffalo milk and cow milk fatty acid composition.

Table 34.3 Fatty acid composition of ghee

Fatty Acid (%)	Buffalo milk fat	Cow milk fat
Butyric	4.4	3.2
Caproic	1.5	2.1
Capric	1.3	2.6
Lauric	1.8	2.8
Myristic	10.8	11.9
Palmitic	33.1	30.6
Stearic	12.0	10.1
Oleic	27.2	27.4
Linoleic	1.5	1.5
Linolenic	0.5	0.6

Source: R.P.Aneja *et al.,* Technology of Indian milk products, Dairy India publication. Section 3.4: Fat rich dairy products, page 186.

Lesson-35

Methods of ghee preparation

35.1 INTRODUCTION:

Ghee production is the largest segment of milk utilization in India. Most of the dairy plants have ghee production facility to meet the demand of the market as well as to utilize the excess fat in profitable manner. Since simple technology involved in ghee production and relatively less investment for ghee production unit as already plant have steam boiler with them. Method of production varies from small scale to large scale. Cost reduction on energy consumption for production of unit quantity of ghee is the recent trend and equipments are designed to meet the requirement. Following are the various processes available in the industry to make ghee including Desi method which is following largely at rural household level.

35.2 METHODS OF PREPARATION:

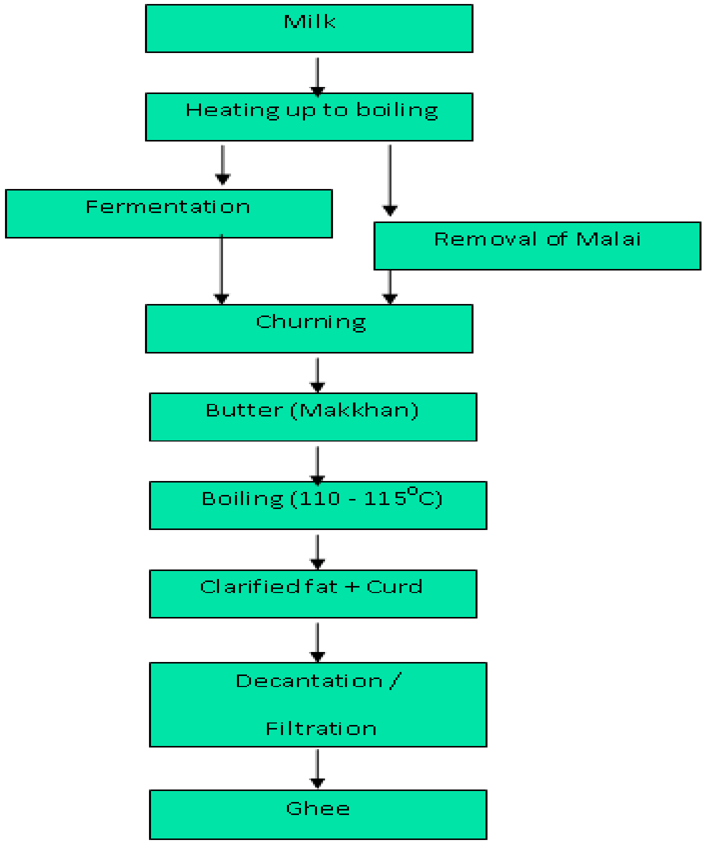
The principle involved in ghee preparation include;

1. concentration of milk fat in the form of cream or butter.
2. Heat clarification of fat rich milk portion and thus reducing the amount of water to less than 0.5%.
3. Removal of the curd content in the form of ghee residue.

There are five methods of ghee making:

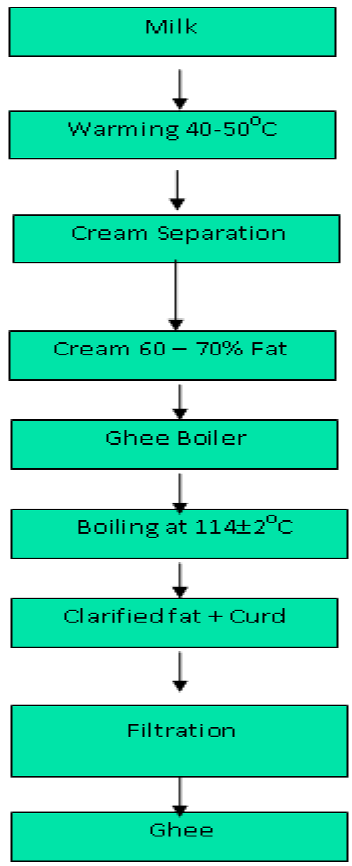
i. Desi or Indigenous Method
ii. Direct Cream Method
iii. Creamery Butter Method
iv. Prestratification Method
v. Continuous Method

35.3 DESI METHOD:



This was the practice from age-old days in rural areas where excessive milk will be cultured and kept for overnight for fermentation. Resultant curd was churned using hand driven wooden beaters to separate the milk fat in the form of desi butter. Some follow slightly different method wherein milk is heated continuously to about 80^0C, the malai (creamy layer) that forms over the surface was collected manually. This malai is then churned to get the desi butter. After collection of desi butter over a period of time, this butter is melted in a metal pan or earthenware vessel on an open fire. Extent of frothing is an index to judge when to terminate heating. Heating should be stop when sudden foaming appears and leave the contents undisturbed after heating. Curd particles starts settling down over a period of time and decant the clear fat carefully. In this method it is possible to achieve only 75 – 85% fat recovery.

35.4 DIRECT CREAM METHOD:



This method involves separation of cream of 60 to 70% fat from milk by centrifugation process, fresh cream or cultured cream is heated to 114±2^{0}C in a stainless steel, jacketed ghee kettle. This kettle is fitted with an agitator, steam control valve, pressure and temperature gauges. A movable hollow stainless tube centrally bored for emptying out the contents or alternatively provision can be made for tilting device on the ghee kettle to decant the product. Heating is discontinued as soon as the colour of the ghee residue turns to golden yellow or light brown. Usually, first plenty of effervescence accompanied by a crackling sound in the preliminary stages of boiling but both gradually subsides when the moisture content decreases. When almost all the moisture is evaporated, the temperature of the liquid medium suddenly spurts up and care has to be exercised at this stage to control the heating. The end point is indicated by the appearance of second effervescence, which is subtler than the first one accompanied by the browning of curd particles. At this stage the typical ghee flavour emanates and this indicates that the final stage in the preparation of ghee.

Advantages of this method are:

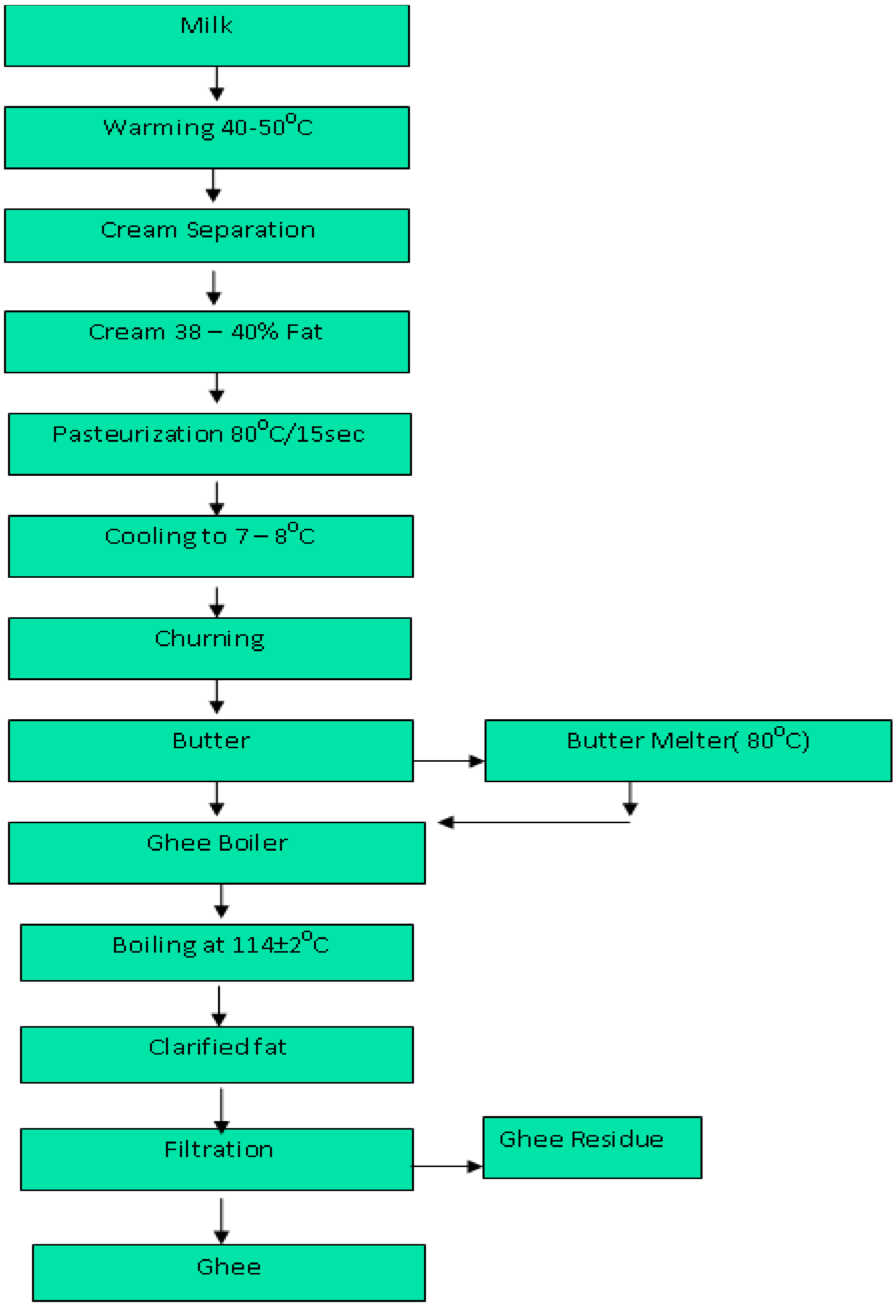
1. No need for butter production prior to manufacturing of ghee.

Limitations:

1. Long heating time to remove the moisture.
1. High content of serum solids in the cream may also produce a highly caramelized flavour in the ghee.

2. 4 – 6% loss of butter fat in the ghee residue & during the handling operations.
3. So, 70 – 80% fat cream is recommended to minimize both fat loss and steam consumption

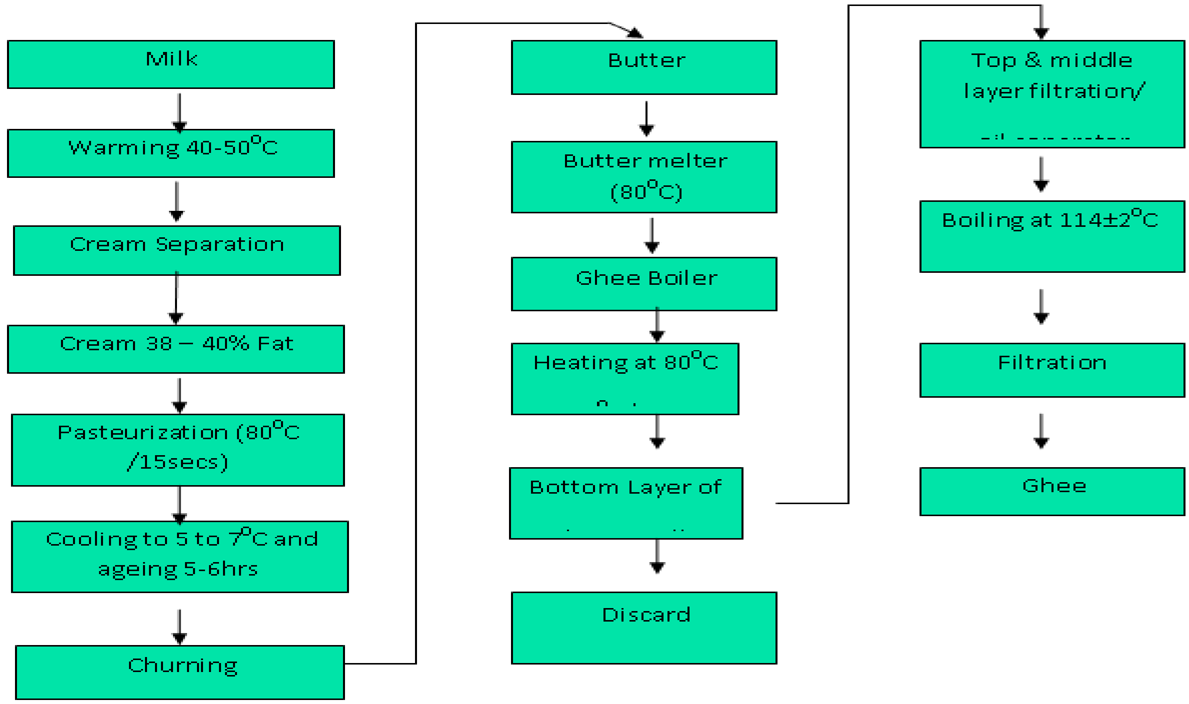
35.5 CREAMERY BUTTER METHOD:



This is the standard method adopted in most of the organized dairies. Unsalted or white butter is used as raw material. Butter mass or butter blocks are melted at 60°C to 80°C in butter melter. Molten butter is pumped into the ghee boiler where final heating will be done using steam as heating medium. Increase the steam pressure to raise the temperature. Scum which is forming on the top of the surface of the product is removed from time to time with the help of perforated ladle. Moment of disappearance of effervescence, appearance of finer air bubbles on the surface of the fat and browning of the curd particles indicates to stop heating. At this stage typical ghee aroma is produced.

Final heating temperature is adjusted to about 114±2⁰C.To get the cooked flavour, heating beyond this temperature is also being in practice. Ghee is filtered via oil filter into the settling tank.

35.6 PRE-STRATIFICATION METHOD:



Butter is produced from aged cream of 38 to 40% fat using continuous butter making machine or batch churn. Butter is then transferred to butter melter, and melt at 80⁰C. This molten butter is kept undisturbed in a ghee kettle or boiler at a temperature of 80-85⁰C for 30 min. Here, in ghee kettle, stratification of mass takes place, product stratifies into 3 distinct layers. Denatured protein particles (curd particles) and impurities are collected on top layer and floats on surface. Middle layer consists of clear fat and bottom layer consists of buttermilk serum carrying 80% of moisture and 70% of solods-not-fat contained in butter.

The bottom layer is then carefully removed without disturbing the both top and middle layers. Middle layer, largely consists of fat is heated to 114±2⁰C along with top layer of floating curd particles and denatured protein. This step is necessary to develop characteristic ghee aroma. Milder flavour ghee can be produced, since most of the curd content is removed before final clarification temperature of ghee.

35.6.1 Advantages of pre-stratification method:

n Removal of buttermilk (bottom layer) eliminates prolonged heating for evaporation of the moisture

n Formation of significantly low quantity ghee residue

n Low quantity of ghee absorbed into ghee residue so less fat loss along with ghee residue

n Production of ghee with lower FFA and acidity

35.7 CONTINUOUS METHOD:

This method was developed to meet the requirement of high volume production and to overcome the limitation of batch method. Limitations of batch method are as follows:

- n Requires high energy, due to low heat transfer co-efficient
- n Cleaning and sanitation of equipments, not satisfactory
- n Equipments and process unsuitable for large volume of production
- n Floor becomes slippery due to ghee spillage
- n Handling losses are more

So, continuous method was invented and has following benefits;

- n Better control on quality of the product
- n Only small hold-up of raw material in the plant at any time and hence no chance for whole batch getting spoiled
- n Contamination by handlers can be eliminated
- n CIP can be possible
- n No foaming of the product during production

Butter is heated in a butter melter to molten state and then transfer into balance tank, and pumped further to scraped surface heat exchanger(SSHE), followed by flashing in vapour separator. And this heating in SSHE and flashing are repeated in next two stages to reduce the moisture level. Ghee is then pass through centrifugal clarifier where residue will be removed. Clarified ghee is stored for filling and packing.

35.8 GRANULATION AND COOLING OF GHEE:

Granulation is important criterion of quality; higher temperature of clarification gives better grain size due to high phospholipids content.

35.8.1 Phenomenon: Completely melted ghee on cooling to prevailing Indian temperatures, can assume the form of large, coarse grains suspended discretely or in clusters in a liquid phase. The process of crystallization is initiated with the formation suitable nuclei. Rate of cooling strongly influences the rate nucleus formation. Stirring or agitation and seeding (at the rate of 1 – 3%) encourage the nucleus formation. For better granulation, ghee should be slowly cooled to 28^0C in 2-3 hours time and agitation is required during granulation to form smaller granules.

35.8.2 Causes of granulation: the partly granular form assumed by ghee is primarily due to certain content of glycerides of higher melting saturated fatty acids, especially palmitic & stearic. Thus buffalo milk ghee show predominant granulation than cow milk ghee.

35.9 YIELD:

The yield of ghee from cream or butter is influenced by fat content of raw material. Factors which influence the yield are listed below.

35.9.1 Factors influencing yield:

Following factors influence the yield of ghee,

1. Method of production: The fat recovery in indigenous method is lowest in range of 80-85% in creamery butter method it ranges from 88-92% and highest in direct cream method ranging from 90-95%.

2. The fat content of the raw material used: Higher the fat content higher will be the yield and vice versa.

3. Quality of milk or cream: If the acidity of milk or cream intended to use in ghee production is higher then fat losses in ghee residue will be higher , thus it reduces the yield.

4. Fat recovery from ghee residue: Scientific reports suggest to extract as much as fat from ghee residue by dissolving ghee residue in hot water followed by filtration and centrifugation. By this method, it is possible to extract the fat from ghee residue and that fat can be added back to cream or butter melter.

35.10 USE OF SUBSTANDARD MILK FOR GHEE PRODUCTION:

India is a tropical country, where in ambient temperatures touches the mark of 40°C in summer. Collection system for raw milk in rural area is still carried out at ambient temperature. Especially in summer while collecting the milk cans from ton-of places causes acidity of milk to increase and results in souring of milk. This milk cannot be useful for making market milk or for thermal process.

Therefore, there is a need to utilize, this milk for products preparation. Where in it does not affect such the quality of end product. So, in commercial dairy plants such milk is diverted and collected separately based on platform tests (COB, sensory etc…). This sourced milk is collected in balance tank and circulated using high sped pump. This causes the breakdown of far globule membrane and release the fat. After a circulation of 30 min milk is kept undisturbed. This facilitates the separation of cream base or gravity. Then this cream is used for ghee production directly or collected over-a-period of time and neutralized to produce butter from this cream. This butter will be used for ghee making.

35.10.1 Quality of ghee made from substandard milk: Ghee manufactured from neutralized milk or cream may differ from that prepared from fresh milk. Major differences reported are as follows.

Table 35.1 Quality difference between fresh milk ghee and acid milk ghee

Parameter	Fresh milk ghee	High acid milk ghee
Liquid portion	Less	More
Colour units	High	Less

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Lesson-36

Quality and Grading of Ghee

36.1 INTRODUCTION:

Competition in the organized ghee production sector leads to create brand value to the product. This brand value comes with quality and special features associated with the product. Today, consumers are much aware of the brand quality through media. Manufacturers or producers are looking forward continuously for innovations that helps to create market for their product, may be through mode of packing, through product aesthetic quality.

36.2 GHEE COMPOSITION AND CHANGES DURING MANUFACTURE:

Ghee majorly consists of milk lipids and richest source of milk fat of all Indian Dairy products. The constituents of ghee tend to vary with the method of its manufacture. Chemically ghee is a complete lipid of glycerides, 97-98% triglycerides. Small amount of di-and mono-glycerides are also present in traces. Also cow milk ghee is different from buffalo milk ghee in terms of its composition. Chemical composition of cow milk ghee and buffalo milk ghee are given in table 36.2.

Fatty acid composition of buffalo milk ghee also varies from cow milk ghee. The amount of butyric acid is significantly higher in buffalo than in cow ghee. The levels of short chain fatty acids caproic to myristic are significantly higher in cow than buffalo ghee where as levels of palmitic and steoric are higher in buffalo than in cow ghee. Major fatty acid in buffalo and cow milk fat is given in table 36.3.

Ghee made from buffalo milk is white (lack of carotenoids) with greenish tinge and that made from cow milk is golden yellow. The characteristic colour of buffalo fat has been attributed to "tetrapyrozole" pigments- "biliverdin and bilivubin" this pigment is conjugated to a protein in milk, but is released during the manufacturing process of ghee making. Thus, imparting yellowish-green colour to buffalo ghee.

During manufacturing, water gets evaporated and fat present in the cream or butter getting concentrated (curd particles (MSNF present in cream or butter) starts settling at the bottom during clarification process. Flavour formation in ghee happens during fermentation of cream and during clarification process. Colour development and granulation also happens during clarification for the subsequent packaging of ghee.

36.3 FLAVOUR FORMATION IN GHEE:

Free fatty acids, carbonyls and lactones are the major groups of compounds contributing to ghee flavour. The flavour profile is affected by method of preparation temperature of clarification and storage period.

36.3.1 Carbonyls: The quantity of carbonyls is directly proportional to the temperature of clarification. 'Head space' and 'volatile' carbonyl content of fresh desi cow ghee is higher that of buffalo ghee, where as total carbonyl content of fresh desi buffalo; whereas total carbonyl content of fresh desi buffalo ghee is higher than that of cow ghee. Carbonyl content found to increase during storage.

36.3.2 Lactones: The lactone level in buffalo ghee has found to be higher than that in cow ghee. It was the highest in direct cream (DC) ghee, followed by creamery butter (CB) and lowest in desi ghee. The lactose level in butter (12 ppm) increased 1.9, 2.4, 2.8 and 3.0 fold on clarifying at 110^{0}C, 120^{0}C, 140^{0}C and 180^{0}C respectively. Clarification butter at 100-120^{0}C doubles the lactones level from butter. The lactone level in ghee showed a significant rise on storage.

36.4 FLAVOUR COMPONENTS OF GHEE:

Table 36.1 Major flavor components in ghee

Components	Cow ghee	Buffalo ghee
Total carbonyls (m/g) Alkan-2-ones = 90% Alkanals = 6% Alk-2-enals = 2% Alka-2, 4 dienals = 2%	7.2	8.64
Volatile Carbonyls (m/g)	0.33	
Head-Space Carbonyls (gas stripped) m/g)	0.035	0.027

Formation of flavour components are due to

(i) Heat interaction between the native carbohydrates and protein system of cream;

(ii) Due to heat effect on the unfermented residue as well on fermented metabolic products formed by ripening process.

Cream constituents like lactose, citrate and glucose were responsible for the increase in ghee flavour components. Flavour in ghee is the resultant of four different mechanisms, they are

(i) Hydrolysis – Free fatty acid formation

(ii) Oxidation – Saturated and unsaturated aldehyde, ketones, alcohols and hydrocarbons.

(iii) Decarboxylation – Alkan-2-Ones

(iv) Dehydration and Lactonization – Lactones

36.4.1 Texture of ghee:

When ghee is stored at room temperature, it crystallizes into three distinct fractions or layers, **(i)** Oily **(ii)** granular semi-solid at the bottom and **(iii)** hard flakes portion floating on the surface and sticking to the sides of the container.

According to *Singhal et al.* Layer formation in ghee could be prevented by storing it at 20^0C or below immediately after preparation. Ghee thus solidified could subsequently be stored at higher temperature without formation of layer. The liquid portion of ghee varies with storage temperature, shape and size of container, repeated heating and agitation, ripening of cream/butter, storage and handling, external seeding etc.

36.4.2 Market Quality of Ghee:

Consumer judge the quality of ghee base on its inherence flavour, colour and appearance. Ghee should have characteristic pleasant, nulty, slightly cooked rich aroma. Ghee flavour is best described as lack of blandness, sweetly rather than acid. Golden yellow to light yellow colour of ghee is appreciated largely. Granular appearance of the product rather more score as it is important quality as well as purity preventer of ghee.

Apart from above sensory characteristics, its chemical and other physical preventers are evaluated to judge the quality of ghee and also to prevent adulteration of ghee.

(i) Refractive Index: It is the ratio of the velocity of light in vacuum to the velocity of light in the sample medium. More generally, it is expressed as the ratio between the sine of the angle of incidence to the sine of the angle of refraction when a ray of light of a definite wave length wave length (usually 589.3 m the mean of the D-lines of sodium) passes from air into the fat. In case of milk fat reading is normally made at 40°C using Abbe refractometer and its values range from 1.4157 to 1.4566. This value is low in comparison to the other fats and oils. The RI if ghee is influenced by both the molecular weight and the degree of saturation of the component fatty acids. RI could be used as indicator of adultration.

(ii) Iodine Number: It is defined as number of grams of iodine absorbed by 100 g of fat under specified conditions. Thus constant is a measure of the unsaturated linkages present in a fat. The iodine number for milk fat falls within the range of 26 to 35 which is low in comparison to other fat and oils. This is estimated using Wig's method. One molecule of halogen compound is absorbed by each unsaturated linkage and the absorption is expressed as the equivalent number of grams of iodine absorbed by 100 g of fat.

(iii) Reichert-Meissl Number (RM Number): This is defined as number of ml of n/10 Sodium hydroxide required to neutralize the steam volatile water soluble fatty acids distilled from 5 g of ghee under precise conditions specified in the method. It is primarily measure of butyric acid and caproic acid. The value for milk fat ranges between 17 to 35 and it is above that of all other fats and oils. Therefore, milk fat contains more of these acids than any of the fats.

(iv) Polenske Number: It is defined as number of ml of N/10 Sodium hydroxide required to neutralize the steam volatile water insoluble fatty acids distilled from 5 g of fat under precise conditions specified in the method. Caprylic acid, capric acids which are somewhat steam volatile but longely insoluble in water are indicated mainly in Polenske number and it ranges from 12 to 24 for milk fat.

(v) Saponification Number: It is defined as the number of milligrams of potassium required to saponify one gram of fat. The value ranges from 210 to 233 and more often falls in the range of 225 to 230. This constant is an indication of the average molecular weight of the fatty acid present. Saponification value is more useful in detecting the presence of minerals oils such as liquid paraf fims in ghee as they are not acted upon by alkali and such a sample doesn't form a homogeneous solution on saponification.

(vi) Melting Point: Melting point for milk fat ranges from 30^0C to 41^0C as reported in literature.

36.5 FACTORS AFFECTING THE MARKET QUALITY OF GHEE:

(i) Raw-materials (Milk, Dahi, Cream, Butter) used for ghee making:

Milk used should be clean, fresh and strained. Use of ripened cream, butter improves the flavour score of ghee.

(ii) Method of preparation and temperature of clarification:

Flavour compounds of ghee vary according to its method of preparation. For example desi methods have more volatile Carbonyl compounds than cream method. Temperature of clarification also has influence on the quantity of Carbonyl compounds and lactones formation during ghee production.

(iii) Type of feed:

It is the main factor affecting variation in fatty acid composition of milk fat. Roughages in the feed mainly consist of cellulose contribute to the formation of fatty acid of 4 to 16 carbon chain length and lipid content of the feed contributes to the formation if long chain fatty acid if C_{16} and above. Animals fed with cotton seed meal will have high amount of C_{1010} and C_{1210} fatty acids.

(iv) Season:

In winter and monsoon, the granulation is more due to changes in the fatty acid profile. Winter ghee showed higher acidity, melting point and grain size where as in summer the saponification value was found to be higher.

36.6 GRADING OF GHEE:

The quality of ghee can be judged by physical and chemical analysis. Customer can only perceive appearance, taste and aroma of ghee. Therefore grading i.e. classification according to its quality and purity is necessary to assure the customer. The Agricultural Produce (Grading & Marking) Act, 1936 empowers the Central Government to fix quality standards, known as 'AGMARK' standards and to prescribe terms and conditions for using the seal of 'AGMARK'. The word 'AGMARK' is a derivative of "Agricultural Marketing".

36.6.1 Objectives of AGMARK:

i. To assure the consumer a producer of pre-tested quality and purity

ii. To enable manufacturers of high grade product to obtain better returns

iii. To develop an orderly marketing of the commodities by eliminating malpractices when transferring from producer to consumer.

AGMARK is a certification mark of Government of India to ensure the purity and quality of Agricultural and allied products in India. The Act empowers the Directorate of Marketing and Inspection to

- Fix grade designation indicating the quality of the produce
- Define the quality indicated by each grade designation
- Specify the grade designation mark to represent particular grade designation
- Specify the manner in which the article could be packed, sealed and marked and
- Authorize a person or a body of persons to use the grade designation marks under prescribed condition.

36.6.2 AGMARK Ghee Specifications

Grade designation marks for ghee- The grade designation mark shall consist of a label specifying the name of the commodity, grade designation and bearing a design consisting of an outline map of India with the word "AGMARK" and the figure of rising sun with the words produce of India and resembling the design as set out as follows.

Table 36.2 AGMARK grades of ghee

Grade	Letter and Circular border colour
Special	Red
General	Green
Standard	Chocolate

- The labels shall be printed on the watermark paper of the Government of India and shall have a micro tint back ground bearing the words "Government of India" in olive green color
- Each label shall have printed thereon a serial number along with a letter or letters denoting the series, e.g. A054987.
- Each label shall have printed thereon the approximate weight content of the package on which it is affixed.

36.6.3 Design of Label

1. Special Grade 2. General Grade 3.Standard Grade

The word 'Regional' shall be printed on each label used on a package of the ghee not conforming to the normal physical and chemical constants specified as follows.

Table 36.3 AGMARK standards of ghee

Parameters	Special Grade	General Grade	Standard Grade
Baudouin Test	Negative	Negative	Negative
Butyro-refractomer reading at 40^0C	40.0– 43.0	40.0– 43.0	40.0– 43.0
Reichert Meissl value	Not less than 28.0	Not less than 28.0	Not less than 28.0
Polenske value	1.0 – 2.0	1.0 – 2.0	1.0 – 2.0
Moisture content	Not more than 0.3%	Not more than 0.3%	Not more than 0.3%
Percentage of Free Fatty Acid (as oleic acid)	**Not more than 1.4**	**Not more than 2.5**	**Not more than 3.0**

For cotton tracts areas such as part of Saurshtra and Madya Pradesh following standards are applicable.

Table 36.4 AGMARK standards for ghee produced in cotton tract areas

Parameters	Special Grade	
	Winter	Summer
Baudouin Test	Negative	Negative
Butyro-refractomer reading at 40^0C	41.5 – 43.0	42.5 – 45.0
Reichert Meissl value	Not less than 23.0	Not less than 21.0#
Polenske value	0.5– 1.2	0.5 – 1.0

Moisture content	Not more than 0.3%	Not more than 0.3%
Percentage of Free Fatty Acid (as oleic acid)	Not more than 1.4	Not more than 2.5

General and Standard grade have Percentage of Free Fatty Acids (as Oleic acid) shall not exceed 2.5 and 3.0 respectively.

According to the law it is not compulsory for every trader and manufacturer, to get his produce certified under AGMARK symbol. Presently it is only a voluntary scheme of the Government.

36.7 REQUIREMENTS OF HIGH GRADE GHEE:

Consumer judges the quality and accepts it on the basis of three main attributes, taste and aroma(flavour), granularity and colour.

1. Flavour: High grade ghee should have natural sweet and pleasant odour, an agreeable taste and it should be free from rancidity and any other objectionable falvour. A pleasant, nutty, slightly cooked aroma is appreciable in the product.
2. Texture: Large uniform grains with very little liquid fat is desirable, greasy texture is objectionable. Upon melting ghee should be clear, transparent, free from sediment and foreign colouring matter.
3. Colour: The colour should be uniform throughout, it should be bright yellow for cow milk ghee and white with or without a yellow or greenish tint for buffalo milk ghee.

36.8 SCORE CARD OF GHEE:

Ghee can be evaluated using the following score card

Table 36.5 Score card of ghee

Parameters	**Score**
Flavour	45
Texture	10
Acidity (Olieic)	25
Colour	10
Freedom from suspended matter	5
Package	5

36.9 DEFECTS IN GHEE AND THEIR PREVENTION:

Possible defects in ghee are listed in below table with their causes and prevention. Defects are categorized according to the sensory characteristics such as flavor related, texture related and appearance related.

1. Flavor Defects

Defects	**Causes**	**Prevention**
Smoky	Smoky fire used for boiling of milk/cream/butter	Use non-smoky fire for boiling milk/cream/butter
Overcooked Or bunt	Excessively high temperature of clarification	Optimum temperature of clarification of ghee
Undercooked	Excessively low temperature of clarification	Optimum temperature of clarification of ghee
Rancid	Fat hydrolysis due to lipase action in milk/cream/curd/butter/ghee	Inactivation of lipase by proper heat treatment Clarify at optimum temperature which ensures minimum moisture content in ghee
Oxidized/oily/ metallic	Fat oxidation due to direct contact of milk/curd/cream/butter/ghee with copper or iron, exposure of these product to sunlight	Storage of the milk/curd/cream/butter/ghee in properly tinned or aluminum alloy/ss vessels Filling ghee upto the brim to minimize the headspace & use opaque containers Avoid ghee storage at high temperature (>210C) & avoid long storage

2. Texture Defects

Defect	**Causes**	**Prevention**
Greasy	Rapid cooling of hot ghee after clarification	Slow cooling of hot ghee after clarification
	Subjecting ghee to further heating and cooling treatment after preparation	Avoid further heating and cooling of ghee after preparation

3. Appearance Defects

Defects	Causes	Prevention
Burnt colour	Excessively high temp. of clarification	Optimum temp. of clarification of ghee
Higher Sediment	Incorrect straining of ghee	Correct straining of ghee

36.10 ADULTERANTS IN GHEE:

Adulteration of ghee in India is more prevalent especially in unorganized sector. Being the most expensive fat people started to adulterate the product to make profits. Major adulterants of ghee are as follows:

i. Vanaspati (Hydrogenated vegetable oil). Because of close resemblance in its texture most commonly used this as adultrant to ghee.

ii. Refined (de-odourized) vegetable oil.

iii. Animal body fat.

Government has made it compulsory that all Vanaspati must contain a maximum of 5% of Sesame oil which can be identified in ghee by a simple colour test (known as Baudouin test). By means of this Adultration of ghee with Vanaspati ti an extent of 3% can be detected.

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Lesson-37

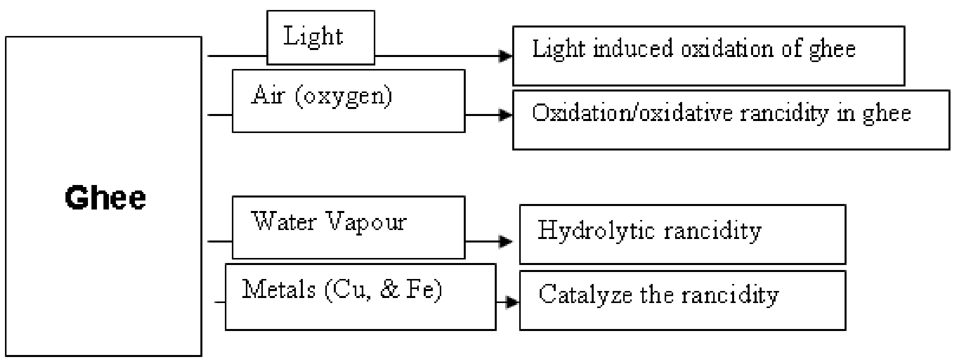
Packaging and Storage of Ghee

37.1 INTRODUCTION:

Ghee has a long keeping quality; it can be stored for 6 to 12 months under ambient temperature provided proper packaging and filling. Ghee should be filled upto the brim in a rust free tin cans/container for bulk packing. Regular pack sizes available in the market are 15 lit, 5 lit, 1 lit and 500 ml. Self standing laminates are used for 14 lit and 500 ml packs which have barrier to moisture, air and light. Exposure of ghee to sunlight for a long time also causes oxidation and produce off flavors in the ghee.

37.2 PACKAGING OF GHEE:

Exposure of ghee to light, air, water vapour and metals causes deterioration of ghee as shown below:



So, packaging material should prevent the entry of light, air, water vapour and contact with metals. Minimum or no head space should be provided while filling, better to fill the product upto the brim of the container.

Glass bottles Food grade plastic containers such as high density polyethylene pouches, laminates with metallic layer support (aluminum) and tin cans are in use for packaging of ghee.

37.2.1 Tin Cans: Lacquer coated tin cans are used for bulk pack of 15 lit & 5 lit can should be sealed properly to prevent the entry of oxygen as it causes oxidation in the product during storage. It is very essential that tin cans be properly lacquered because rusted cans are liable to accelerate the lipid deterioration. Only drawback in tin cans is the cost. Higher cost renders its use and to search for cost competitive packaging material.

Glass bottles: Glass bottles provide excellent protection to the product quality as they do not react with the food material. Glass bottles can be used for high-speed operations, but are not in much use for bulk or large size packaging of ghee because of their fragility and high weight. Since ghee is an expensive commodity and all consumers can not afford to buy large size packs, some of the ghee producers have started packaging ghee in glass bottles for retailers in sizes of 100g to 500g.

Semi-rigid containers: Semi-rigid plastic containers are replacing tin plate containers. These are mainly made from high density polyethylene (HDPE). The advantages of using these containers are lightweight, economical and transport-worthy. These are of several types viz., blow moulded HDPE (high density polyethylene), PET (polyethylene terephthalate) bottles, PVC (poly vinyl chloride) bottles, lines cartons and tetra packs. Blow moulded HDPE are, available in form of bottles (200, 400g), jars (1 kg and 2 kg), and jerry cans (2kg, 5 kg, and 15 kg). PET bottles have excellent clarity odour free and have gas barrier properties. All these semi-rigid containers have good scope for packaging of ghee and butter oil.

Flexible films/pouches/laminates: Flexible pouch may be made from laminates or multi layer films of different composition. The pouch may be in the form of pillow pouch or as self-standing pouches. The most attractive feature of packaging ghee in flexible pouches is that they are cheapest than any other packaging system. The selection of laminate or a multi layer film is governed primarily by the compatibility of the contact layer, heat-sealing ability and heat-seal strength and shelf life required. The indigenously available flexible materials, which have very good values for the above, mentioned properties are HDPE, polypropelene, Aluminium foil, Nylon, PVC, Polyester and numerous laminates of flexible films. Sachets made from a laminate of PVDC/ PVC Al foil/PP (polyvinyliedene chloride/aluminium foil/polypropylene) are suitable or long-term storage of butter oil and ghee.

Desirable characteristics of packaging material for ghee

- Packaging material should not react with ghee
- Easily available at low cost
- It should be non toxic
- It should not allow printing ink to penetrate into the product
- It should protect against tempering
- It should have good barrier properties against spoilage causing agents
- It should withstand wear and tear during transportation

37.3 STORAGE OF GHEE:

At higher temperature of storage, development of oxidized flavor especially with ghee which has appreciable initial acidity is more pronounced. At Lower (refrigerated) temperature storage, although it delays acid development there by prolongs shelf life but it imparts greasy and pasty texture to ghee. So, storage temperature of 21^0C is recommended. Ghee can be stored up to 12months at 21^0C.

37.4 KEEPING QUALITY:

It is the duration in which product is acceptable for safe consumption as well no abrupt changes in its aesthetic quality and chemical quality. Ghee is more prown to oxidation induced changes during storage. Several factors influence the keeping quality of ghee and are listed below.

37.5 FACTORS INFLUENCING KEEPING QUALITY OF GHEE:

(1) Temperature of storage: Higher the temperature of storage. Lower will be the keeping quality and vice versa.

(2) Initial moisture content: Higher the initial moisture content. The lower the keeping quality and vice versa.

(3) Initial acidity: Higher the initial acidity, lower the keeping quality and vice versa.

(4) Exposure to metals: When ghee comes in contact with metals especially iron and copper, its keeping quality gets reduced. Since these is an act as catalytic agents for oxidation.

(5) Exposure to light: Greater exposure to sunlight causes oxidation of ghee and thus reduces the shelf life.

(6) Method of packaging: Higher the air-content in the head-space the lower will be the keeping quality.

37.6 PRESERVATION OF GHEE:

First and foremost thing to preserve ghee is to packaging air tight container. Ghee is very much susceptible to oxidation. Reaction of oxygen with unsaturated fat, aggravated by metallic contamination or sunlight, is a major cause for spoilage. Further to extend the shelf life of the product antioxidants can be added. Butylated Hydroxy Anisole (BHA) at concentration of not exceeding 0.02% can be added. In recent time, use of ghee residue to extend the shelf life ghee has been a practice. Phospholipids present in ghee acts as antioxidants and preserve the ghee. It is reported that some curry leaves and betal leaves were also tried to extend the shelf life of ghee.

37.7 MARKETING OF GHEE:

Recent times several multinationals like Britannia & Nestle enter into the business of ghee manufacturing and marketing. India Amul and Sagar ghee is popular brand names marketed by GCMMF. Mother Dairy also have good market share of ghee. Apart from these several national chains one is selling ghee under their own brand names. Local players specific to version also have good market share. Local merchants also sell desi ghee in unorganized sector.

Ghee in India is used for cooking or frying medium, as it enriches the taste of food. Ghee in melted form is used for garnishing vice or spreading lightly on chapattis. Ghee has been a regular export item from India; presently ghee is exported to Nepal, Bangladesh middle-east countries.

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Lesson-38

Butter oil

38.1 INTRODUCTION:

In countries like India, butter oil has huge market potential since it overcomes the storage difficulties and the associated cost of low temperature storage. Butter oil can be stored at ambient temperature for longer duration. It requires less storage space compare to butter. Anhydrous milk fat(AMF) is the other term for butter oil, it contains less moisture(around 0.1%) then butter oil(around 0.4%).

38.2 DEFINITION:

According to FSSR-2011 Butter oil and Anhydrous Milk fat / Anhydrous Butter oil means the fatty products derived exclusively from milk and/ or products obtained from milk by means of process which result in almost total removal of water and milk solids not fat. It shall have pleasant taste and flavour free from off odour and rancidity. It shall be free from vegetable oil/ fat, animal body fat, mineral oil, added flavour and any other substance foreign to milk. It may contain permitted food additives such as antioxidant ascorbyl stearate(500mg/kg maximum), Propyl gallate, Octyl gallate, Ethyl gallate(1000mg/kg maximum for each)and Butylated hydroxy anisole(BHA, 175mg/kg maximum). It shall conform to the following requirements.

Table 38.1 FSSR-2011 Standards for butter milk

Sl. No.	Parameter	Butter oil	Anhydrous milk fat / Anhydrous Butter oil
1	B.R reading at 40°C	40-44	40-44
2	Moisture m/m	Not more than 0.4%	Not more than 0.1%
3	Milk Fat m/m	Not less than 99.6%	Not less than 99.8%
4	Reichert Value	Not less than 24	Not less than 24
5	F.F.A as oleic acid	Not more than 0.4%	Not more than 0.3%
6	Peroxide Value (milli equivalent of Oxygen/ Kg fat)	Not more than 0.6%	Not more than 0.3%
7	Boudouins Test	Negative	Negative

38.3 PRODUCT DESCRIPTION:

Looks similar to ghee, pale yellow liquid, majorly constitute of milk fat. Alternatively it can be called as anhydrous milk fat (AMF). According to FAO/WHO AMF should have min 99.8% fat.

38.4 REQUIREMENT OF HIGH GRADE BUTTER OIL:

1. Fat should be pure
2. Stable against oxidation
3. Moisture content should not exceed 0.1%
4. Product should have deep yellow colour if it is form cow milk fat and white with green tinge from buffalo milk fat
5. It should have chareceristic bland smell.
6. It should have fine crystalline texture
7. It should be packed in suitable clean container/laminate and packaging material should have good barrier properties against transmission of oxygen/air, moisture and light. If tin cans are used they should be rust free.

38.5 METHODS OF PREPARATION:

38.5.1 Industrial production of butter oil from cream(By demulsification)

Raw cream of 35 – 40% fat content is pasteurized through plat heat exchanger or tubular heat exchanger. Then it passes through cream concentrator (essentially cream separator) to achieve a fat percent level of around 75%. Here we can store the cream as intermediary storage. Cream is then fed to homogenizer for phase inversion (it breaks the fat globule membrane to release the fat). After phase inversion product again pass through centrifugal concentrator where the cream fat level is rise to 99.5%. Heating will be done at 95 to 98^{0}C in a plate heat exchanger. Reduce the moisture content of the product to 0.1% in vacuum chamber followed cooling to ambient temperature through PHE. Flow diagram depicted figure 38.1

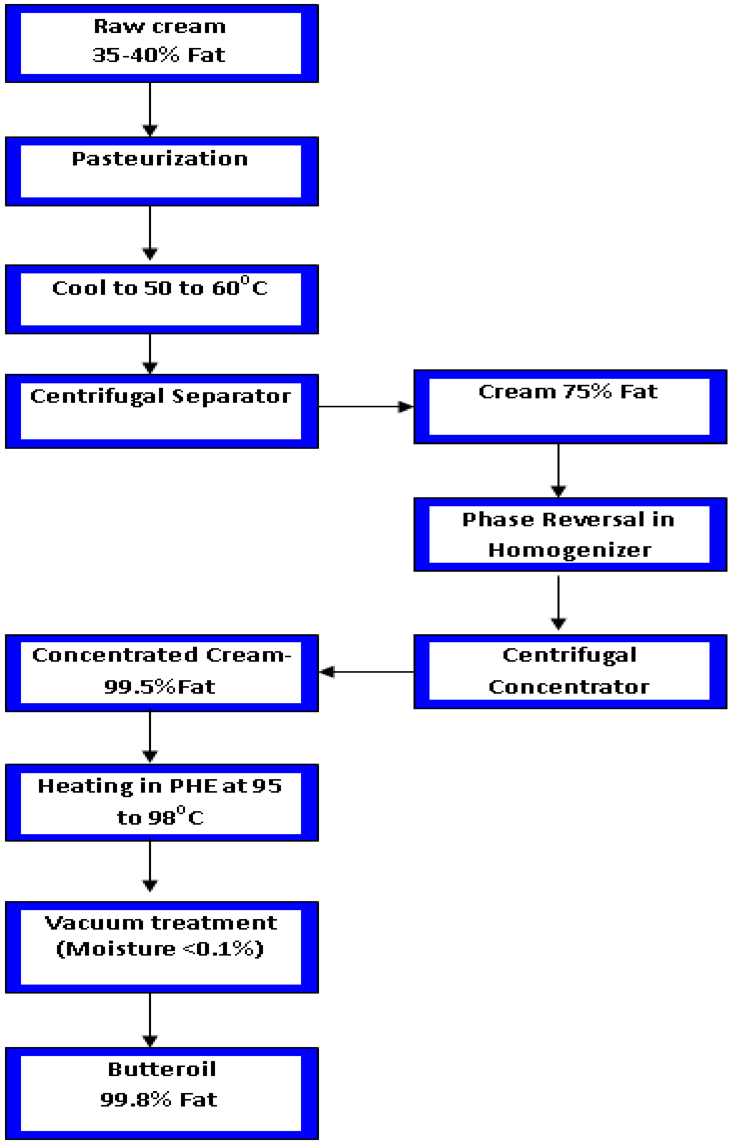

Fig. 38.1: Industrial production of butter oil from cream

38.5.2 Industrial production of butter oil from butter

Butter is transferred to butter melting vat, where it is heated to 60^0C to 80^0C.Transferred to holding tank, where it is hold for 20- 30 min to facilitate protein aggregation. Then butter melt is transferred to centrifugal concentrator, where light phase is concentrated to 99.5% fat. Concentrated light phase is then pumped through plate heat exchanger (PHE) where it is heated to 90-95^0C. Then to vacuum chamber for final moisture adjustment then back to PHE for cooling to 35 – 40^0C for packing. Flow diagram depicted figure 38.2.

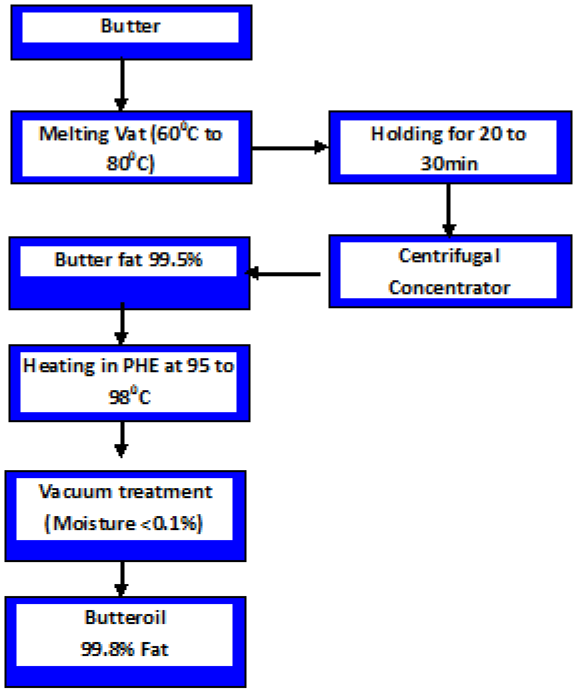

Figure 38.2.Industrial production of butter oil from butter

38.6 PACKAGING AND STORAGE:

Butter oil is filled in containers of various sizes. Filling should be done up to the brim in the container in such a manner as to exclude maximum oxygen. For households and restaurants containers of 1 kg to 20 kg are available. For industrial uses drums of minimum 180kg are also available. An inert gas, nitrogen, is used for packing to prevent oxidation.

Butter oil can be stored at ambient temperature since it contains very low amount of moisture, expected shelf life of product at this storage temperature is about one year.

38.7 JUDGING:

Following score card may be used for judging.

Table 38.2 Score card for butter oil

Parameter	Perfect Score
Flavour	45
Texture	25
Acidity(Oleic)	15
Colour	10
Package	5
Total	100

Procedure of examination:

1. Examine container for cleanliness
2. Open the container and examine for aroma and colour
3. Pour small sample and observe the texture
4. Taste the sample and record
5. Determine the acidity(% oleic acid) and record

38.8 DEFECTS:

Attribute	Defect	Cause(s)	Prevention
Colour	Brownish	Presence of over-heated curd particle	Adapt proper clarification & filtration
Texture	Coarse	Slow rate of cooling	Increase the rate of cooling
Flavour	Rancid	Fat hydrolysis due to lipase action	Inactivate lipase by adopting proper pasteurization temperature for cream
	Oxidized/oily/metallic	Contamination with copper or iron, exposure to sunlight	Avoid contact surfaces of iron/copper containers and exposure to direct sunlight

38.9 USES OF BUTTER OIL:

It is used in the production of recombined milk. It can also be used in the manufacture of ice cream and in the confectionery industry. Butter oil is also utilized in the production of various types of fat spreads.

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