Paper 7: Technology of Milk and Milk Products

Module no. 13: Defects in fat-rich dairy products

Introduction

The fat-rich dairy product includes cream, butter (white and table), anhydrous milk fat, ghee and fat spreads. Usually high fat containing dairy products are prone to deterioration in its quality during storage, especially due to auto-oxidative reactions.

Defects may develop in any of these products and the factors that can cause such changes can occur due to:

(i) Changes in the raw material used for fat-rich dairy product manufacture
(ii) Manufacturing protocol which was not adhered to as per 'Standard operating procedures' and
(iii) Changes during storage, including the type of packaging materials utilized at a given storage condition

The defects in fat-rich dairy products have been discussed at length here below.

I. Defects in market cream

There are several types of market cream viz., half cream, single cream, coffee cream, cultured cream, whipping cream, heavy whipping cream, aerosol cream, double cream, clotted cream and high fat creams (i.e. plastic cream).

Flavour defects in cream

Any of the flavor defects that was inherent in whole milk, tends to be perceived even in the separated cream. Rather volatile constituents that are fat soluble, tends to be more concentrated in the fat portion, increasing the perception of such defects i.e. oxidized flavor. Some of the flavor defects that have been associated with cream are feed, acid, cooked, malty, musty, utensil, weed, bitter and oxidized/rancid. The description of such flavor defects have been dealt while discussing flavor defects in Table butter.

Specific defects in cream

Some of the defects encountered in a specific cream type is discussed herein.

Feathering in coffee cream: The function of cream is to provide an attractive appearance to the coffee with an appropriate modification in flavor. Coffee stability, which is of outstanding importance for the quality of this product, means the degree of resistance against coagulation or 'feathering'. The hot, acid condition in coffee provide an alien environment for cream, and protein precipitation may occur with the release of free fat (referred to as 'feathering') and a reduction in the whitening effect. If the protein present is insufficient to cover the entire surface of the fat/oil droplets during homogenization, a so-called bridging flocculation (feathering) may take place.

Serum leakage, creaming, reduced overrun in whipping cream: The serum leakage defect usually occurs with partial churning (overwhipping) and leads to an unattractive 'pool' around the whipped cream or 'sogginess', when applied to cakes.

Prolonged whipping would result in too large clumps of fat globules leading to rupture of bubble enclosing lamella, initiation of bubble coalescence, and a reduction in overrun. The irreversible phase inversion into a greasy water-in-oil emulsion becomes visible as butter granules.

An unfavorable creaming and separation of serum can be delayed by a lower fat content (legally limited), additives (i.e. addition of carrageenan, emulsifiers and protein ingredients), or homogenization after UHT treatment. Use of carrageenan (mixture of kappa and iota) helps in delayed creaming during storage and reduced draining of the whipped cream.

Syneresis and aged flavour in cultured cream: Use of casein/caseinates and hydrocolloids in preparation of cultured cream helps in avoiding the 'syneresis' of such products during its usage.

In directly acidified sour cream, especially after 2 weeks of storage, enzymes from the culture can start producing an 'aged' flavor as a result of proteolysis.

'Oiling-off' in plastic cream: In case of freezing of cream (for preservation) followed by thawing (for ease of incorporation during its usage), the milk fat globule membrane which covers the fat to form 'fat globules' in cream may get destabilized (due to puncturing by spiny ice crystals) to manifest as 'oiling-off' upon thawing. This is especially so since the SNF portion is low in such high-fat cream, making the fat prone to de-emulsification during handling.

UHT creams: Light and/or oxygen may induce oxidation of unsaturated fatty acids, leading to flavor degradation of stored UHT cream. Homogenized cream is particularly susceptible to the action of light.

Microbial defects in cream: Lipolytic rancidity can be induced by extracellular bacterial lipases of *Pseudomonas* spp. and other Gram-negative (G-ve) psychrotrophs. In many cases, these lipases are not inactivated by pasteurization and may even be present in UHT cream (e.g., lipases of *Pseudomonas fluorescens*). Extracellular proteinases of G-ve psychrotrophs may be very heat-stable and can show activity even after in-bottle sterilization of cream. Phospholipases, proteinases, and glycosidases from psychrotrophic *Pseudomonas, Citrobacter*, and *Enterobacter* may act synergistically in damaging the fat globule membrane. The aggregation of fat globules, which produces ***'bitty cream'*** defect, has been linked to the specific activity of phospholipase from *Bacillus cereus*. Psychrotrophic spore formers in raw milk such as *Bacillus* spp., which cause sweet coagulation, can survive pasteurization, and also heat-resistant spores may occur in UHT cream.

Bacillus cereus causes defects in high-temperature treated cream including sweet curdling (curd formation with no acid production). It also produces lecithinase, an enzyme that degrades fat globule membranes resulting in fat aggregation in cream (bitty cream).

II. Defects in Table butter

The ideal characteristics of a well made Table butter is first described below.

Colour and appearance: A uniform light, pale yellow color seems to most often the demand of the consumers. As a rule, the shade of butter color is a natural shade of yellow. Such a yellow color is commonly associated with milk fat, especially if the intensity is no higher than the natural color of the butter produced when cows consume green feed as a source of roughage (higher carotene content imparted to milk fat).

Flavour: High-quality butter should have a mild, sweet, clean and pleasant flavor, and a delicate aroma. Cultured cream butter is expected to exhibit a distinct culture flavor and an aroma with moderate levels of diacetyl, the delightful buttery-like aroma as the principal component. A slight to definite level of 'cooked' flavor is allowed and often preferred in butter.

Body and texture: The body of good-quality butter should be firm and exhibit a distinct waxy, close-knit texture. When broken, the appearance of quality butter should present a somewhat jagged, irregular, wrought iron-like surface.

The butter tends to be harder (firmer) in the winter season due to a smaller amount of oleic acid in the triglyceride structure. Generally, milk fat is softer in the summer because it contains a larger proportion of oleic acid.

The technological advances in butter manufacturing have substantially reduced defects that were previously attributable to substandard workmanship. Continuous churns have served to significantly reduce 'personnel errors' through semi-automation and better and more reliable process control.

Colour defects in butter

Wavy, mottled, streaked, color specks, bleached, dull, pale; lack of color uniformity, mold or yeast discolouration, uneven colour, unnatural colour, high colored surface compared to butter underneath, etc.

Faulty butter making workmanship, particularly over- and under-working of butter during the manufacture, is responsible for most color and appearance defects. The size, number, and distribution of water droplets markedly influence the color of butter. The same color aberrations are apparent in whipped butter because of the size of air cells and dispersion. Microorganisms, including mold, can cause serious quality deterioration problems in butter. Butter that is inadequately protected against moisture evaporation tends to exhibit an **intense or high-colored surface**.

The more common color defects of butter can be eliminated by proper working at the time of manufacture. A color defect may serve as a hint for possible flavor defect. The color attribute '**mottled**' refers to spots of lighter and deeper shades of yellow, caused by an uneven distribution of moisture due to insufficient working. '**Streaks**' are recognizable as an area of light color surrounded by more highly colored portions. '**Waviness**' is an unevenness that appears as waves

of different shades of yellow. Insufficient blending of two different butter sources is the usual cause.

Flavour defects in butter

Most of the frequently encountered butter off-flavors are derived from the cream. Some off-flavors may result from faulty cream or milk; handling, processing, or churning; and certain other flavor defects may develop in the finished butter. Butter flavor defects that may be derived wholly or in part from cream include: acid, barny, cheesy, coarse, feed, foreign, fruity, metallic/oxidized, old cream, onion/garlic, rancid (lipase), scorched, unclean, unnatural, and yeasty.

Other flavor related defects that may be encountered include flat, high salt, musty, neutralizer, old cream, storage, unclean/utensil, whey, yeasty, etc.

Acid: An acidic or sour off-flavor in butter usually develops from either churning high-acid cream, over-ripened cream, excessive use of lactic starter culture, or excess retention of buttermilk in the butter wherein lactose can be fermented. An acid off-flavor in butter is characterized by a biting tart taste on the sides of the tongue, as well as an associated aroma, due to the presence of volatile acidic components.

Cheesy: A 'cheesy' off-flavor in butter has a striking resemblance to the aroma and taste of ripened Cheddar cheese. The cheesy off-flavor is persistent; the mouth definitely fails to 'clean-up.' Quite often a bitter aftertaste will accompany this defect, due to proteolysis. If butter has developed mold growth even if mycelia only, metabolites may give the butter the flavor of Blue cheese and even develop a rancid flavor; thus cheesy or cheesy/rancid could be the appropriate flavor descriptor.

Coarse: Butter which lacks that sweet, pleasing, delicate flavor that is generally associated with fresh milk fat is generally criticized as being 'coarse' in flavor. The butter seems to lack the overall pleasant flavor sensation or the balanced taste and aroma characteristics.

Cooked: A cooked flavor in butter can be described as a smooth, nutty-like, custard-like character, is produced by pasteurizing sweet cream at a relatively high temperature. It is rather desirable to have a definite cooked flavor in freshly churned butter. Butter exhibiting a slight to definite 'cooked' flavor 'cleans up' completely and leaves absolutely no aftertaste, other than a rather pleasant one.

Feed: The presence of different 'feed'-derived off-flavors can usually be detected by the aroma and verified on the palate when the butter is melted. With most feed flavor defects, the mouth usually clean up quite soon after the sample is expectorated. Most forms of dry feeds, such as hay, grain concentrates, citrus pulp, silage, green alfalfa, and various grasses generally lead to 'normal' feed flavor note in butter. Even when fed in large quantities, these feeds only have a slight objectionable effect on butter flavor. Green alfalfa tends to produce a characteristic, mild, sweet flavor (with a possible bitter-sweet tinge). When cows are placed on fresh grass pasture in spring or early summer, the butter produced may exhibit a characteristic 'grassy' off-flavor.

Proper feeding routines for dairy cows can do much to eliminate or minimize feed off-flavors in butter. Generally, if cows are not fed between 0.5 and 3.5 h of milking time, feed off-flavors are substantially minimized in butter.

Flat: Butter that simply lacks a characteristic, full, pleasing 'buttery' flavor is criticized as being 'flat'. The flat defect is associated with the lower flavor profile of lightly salted or unsalted butter. In a product with a flat flavor defect there is little or no characteristic butter flavor. A flat defect is generally caused by an apparent lack of volatile acids or low content of other flavor compounds like diacetyl, other carbonyls, and various volatile compounds that are partially responsible for a desirable 'buttery' flavor.

Dilution of churning cream with water or excessive washing of butter granules during manufacture and/or low salt content may result in a flat flavor. Pasteurizing to develop a cooked flavor in cream is one simplest expedient for masking the flat flavor defect in butter.

Foreign: Atypical off-flavors derived from the careless use of cleaning and sanitizing chemicals, absorption of combustion products, odors absorbed from gasoline, iodine, kerosene, fly spray, paint, varnish, etc., are unacceptable in butter. Even atmospheric vapors from these kinds of compounds can be a serious problem in terms of possibly imparting 'foreign' or chemical-like off-flavors.

Malty: The 'malty' off-flavor that is occasionally encountered in butter resembles the odor of malted milk. The flavor sensation extends throughout the entire tasting period and generally persists after the sample has been expectorated. The malty off-flavor results from the outgrowth of *Lactococcus lactis* ssp. *maltigens* in either milk or cream that has been cooled inadequately.

Metallic: This off-flavor is the flavor sensation perceived when a copper penny is held between the teeth. This flavor defect conveys a slightly astringent and puckery sensation to the mouth interior. The metallic note may be detected as soon as the butter is placed into the mouth. This off-flavor persists after the sample has been expectorated; a somewhat bitter taste or other objectionable aftertaste may appear at the end of the tasting period. This off-flavor is a precursor to 'oxidized' off-flavor.

Neutralizer: The presence of a 'neutralizer' off-flavor in butter can be observed immediately after the sample has melted in the mouth. The aftertaste of added neutralizer in butter is persistent. This flavor note may be soda cracker-like or somewhat alkaline, suggestive of bicarbonate of soda or similar compounds. The soda neutralizers may also produce a bitter-like aftertaste, sometimes referred to as 'limey'. A neutralizer off flavor in butter results from the addition of concentrated solutions of neutralizer needed to counter high levels of lactic acid formed in the cream.

Oxidized: The oxidation of unsaturated fatty acids to form a group of aldehydes in butter creates a series of different off-flavors viz., oxidized. Different flavor sensations are perceived in various stages of development of oxidized butter, such as metallic, oily, tallowy, painty and/or fishy. The term oxidized best describes the metal-induced form of oxidized flavor that is common to milk

and other dairy products. A characteristic cardboard-like flavor and often an associated puckery mouth feel are the usual distinguishing features. The so-called oily stage, painty, and fishy off-flavors in butter are uncommon with current cream and butter manufacturing and handling practices.

Rancid (lipase): The 'rancid' off-flavor of butter is unmistakably objectionable, and may be soapy and/or bitter. Rancidity of butter somewhat resembles the strong, disagreeable off-flavor of darkened, decayed nuts, baby breath, gym bags, or dirty sneakers. The odor is pungent and is that of volatile short-chain fatty acids. Often this off-flavor gives the taste impressions of soapiness and frequently, definite or intense bitterness. A rancid off-flavor is the result of hydrolysis of milk fat through the enzymatic action of lipase, which liberates fatty acids. A rancid off-flavor is attributed to the free, short-chain fatty acids and the resultant salts of these fatty acids (e.g., technically a soap).

Pasteurization of cream that contains high levels of free fatty acids does not eliminate the rancid off-flavor, but a vacuum pasteurization treatment will significantly decrease the level. A characteristic of the rancid off-flavor is a certain astringent mouth feel, perceived at the base of the tongue and upper throat. This mouth feel persists after the sample has been expectorated.

Storage: Butter held for considerable time (> 6 months to several years) in frozen storage may gradually absorb odors from the storeroom environment. Under these circumstances the delicate flavor characteristics of butter are lost and the consequent flavor deterioration is referred to as the 'storage' defect. After extended storage, butter made from fresh, clean flavored, sweet cream seems to undergo this chemical change much more slowly than butter that was made from lower quality cream.

Unclean/utensil: The 'unclean/utensil' off-flavor is indicative of poor cream handling conditions and/or improper sanitary care of the storage and production equipment in which the cream and butter are processed. Slow cooling rates of the milk or cream, and/or elevated storage temperatures promote the outgrowth of spoilage bacteria (psychrotrophs). Sometimes this flavor defect is referred to as an 'unclean' or 'dirty dishrag' off-flavor. This off flavor persists for some time after the sample has been expectorated.

Weedy: 'Weedy' off-flavors in butter typically result from churning cream that has an absorbed weed flavor, which sometimes occur due to seasonal pasture feeding patterns. Some weeds are more common in early spring, when cows are in weed-infested pastures, while other weeds seem more prevalent in late summer or fall.

Yeasty: A 'yeasty' off-flavor is detected in the early stages of development by its typical fruity, vinegary, yeasty, and/or bread dough aroma, which is apparent when the sample is first taken into the mouth. As the sample melts, the odor becomes more and more distinctly yeasty. By-products formed by yeasts that have grown in poorly handled, abused cream are responsible for this off-flavor.

Fishy flavor: This type of defect may develop in Table butter upon storage, especially in the one having high salt content and made from cultured cream (i.e. ripened). Hydrolysis of phospholipid to form trimethylamine is one of the reasons attributed for the 'fishy' flavor defect in butter.

Body and texture defects in butter

Manufacturing steps that influence the body and texture of butter include: (i) time and temperature of tempering of the cream; (ii) churning temperature; (iii) extent of working; (iv) the method of adding coloring and salt; and (v) the manufacturing equipment and churning methods used.

The example of body-texture defects that have been associated with Table butter include short, crumbly, leaky, gummy, mealy or grainy, weak, sticky, etc.

Crumbly: The fat crystals in a 'crumbly'- or 'brittle'-textured butter lack cohesion and do not hold together. Some of the butter usually adheres to the back of the trier and reflects a rough ragged appearance. A 'crumbly' butter appears dry and readily falls apart, rather than appearing waxy and homogenous when pressure is applied to the plug. Finished butter that has been warmed and then cooled slowly to develop large crystals may become crumbly. Crumbliness in butter maybe as a result of relatively large fat crystals and a deficiency in liquid fat.

The temperature to which cream is cooled after pasteurization, the length of the holding period, and churning practices are factors to be considered in limiting this defect.

Greasy: A 'greasy' butter may be identified by the extreme smoothness and immediate melting when a sample of butter is placed into the mouth. This defect may be suggested by the extreme ease with which a trier sample is removed from the product. Instead of a clean, clear feeling in the mouth after expectorating, the mouth may be left with a sensation of greasiness. The most likely cause of greasiness is overworked butter, particularly when the body of the butter is too soft. A higher proportion of low-melting point triglycerides (TG) are responsible for this defect. This defect is more prevalent in the summer months.

Gummy: 'Gummy' bodied butter tends to stick to the roof of the mouth and may leave a gum-like impression. This defect is more prevalent during the winter months. Gumminess is due to an abnormally high percentage of high-melting TG, which causes a firmer milk fat and can interfere with butter spreadability. Slow cooling of cream, a higher churning temperature, and a longer working time aids in control or minimization of this defect.

Leaky: Butter that exhibits beads or droplets of moisture on the plug and/or the back of the sampling trier is criticized as being 'leaky'. Such butter fails to retain moisture within the product mass due to the larger size of water droplets. Leakiness is usually caused by insufficient working of butter. Butter that has been in frozen storage for a period of extended time will tend to show some degree of leakiness. To minimize the problems associated with this defect, cubes of frozen butter when printed should first be microfixed, a process that softens the thawed butter and re-establishes the water-in-oil emulsion.

The incidence of 'leaky butter' has decreased with advent of continuous butter churn. However, traces of free moisture can occasionally be found in cold butter.

Mealy/grainy: A 'mealy'/'grainy' texture is easily recognized when a sample of partially melted butter is compressed between the tongue and roof of the mouth or a distinct 'grainy' sensation is perceived. This is considered a somewhat serious defect. Such butter lacks a smooth, waxy texture. A mealy texture may be caused by improperly neutralized high-acid cream, allowing milk fat to 'oil-off' at some stage in the pasteurization process, or adding too much oiled-off rework.

Short: A 'short' body refers to butter that lacks the desirable characteristics of plasticity and waxiness. This defect is noted when the plug has a tendency to break sharply when moderate thumb pressure is applied or even when a plug is removed from the block. A short-textured butter exhibit marked brittleness. Other factors that may be involved in short-textured butter are (i) high-melting point fats, (ii) extremely low curd content in butter, (iii) manufacturing processes wherein part of the milk fat is melted, and (iv) rapid cooling of freshly made butter to an extremely low temperature.

Sticky: A 'sticky' bodied butter adheres to the trier and appears to be quite dry. Usually it is difficult to secure a uniform, smooth-surfaced plug from such butter. The butter plug will appear 'ragged' or 'rough'. When crumbly or brittle-textured butter is overworked, the entire mass tends to become sticky. A sticky body and crumbly texture are often present concurrently in butter. A sticky body is observed most frequently in late fall and winter when there is a greater predominance of high-melting TG in churning cream. Hence, a sticky body is primarily a feed-related defect; it appears to be more prevalent in areas where alfalfa is the major roughage fed to milk cows. Various temperature treatments of cream and butter, as well as churn working conditions, seem to markedly affect the occurrence of 'sticky' defect.

Weak: A 'weak' body is typically indicated by a quick meltdown or an exaggerated softness of the butter, when it is exposed to room temperatures. A weak-bodied butter often produces an imperfect plug; there is a tendency for the trier to 'cut in' on the plug. When the ball of the thumb is pressed against a plug of 'weak' butter, difficulty is often encountered in defining a distinct 'breaking point' for the plug. A weak body is due to a state of incomplete milk fat crystallization which may be caused by inadequate tempering of pasteurized cream, or due to a relatively high proportion of low-melting TG in the cream. Churning at too high a temperature and incorporating too much air or nitrogen during whipping may also lead to a weak-bodied butter. However, a weak-bodied butter generally spreads well.

Miscellaneous defects

Butter defects caused by lipases or bacteria present, though initially not perceptible, may cause deterioration during storage and thus reduce the shelf life. On cold storage, auto-oxidation is the main limiting factor which depends on the copper present, the level of which greatly depends on the conditions of manufacture.

III. Defects in Fat spread

The general prerequisites for high-quality spread-type products are: desirable flavor and appearance, the absence of off-flavors, quality of workmanship, and product performance in terms of intended functional properties viz., melting, spreading and non-burning when used for frying.

***Rancidity**:* Use of polyunsaturated fatty acid (PUFA) oils, contact of fat with metal ions e.g. Cu, Fe, etc., and exposure to light are the factors that favour rancid spoilage of fat spreads.

***Oiling-off/Wheying off**:* Improper emulsion, improper and insufficient use of emulsifiers and emulsifying salts, insufficient stabilizer used, and improper fat crystallization are the factors that may lead to 'oiling-off' of fat spreads.

***Spreadability**:* Spreadability is an important property of 'fat spreads'. Usually, blending of milk fat with vegetable oils/fats (permitted by laws) enables obtaining Fat spread with superior spreadability, which competes with Table butter (containing exclusively milk fat) with regard to 'spread' quality. However, improper formulation (desirable is to use fat blend having optimal 'solid fat content' under refrigeration), improper fat crystallization (as dictated by 'tempering' process in Fat spread manufacture) and fluctuating storage temperature are some of the major causes for the reduced 'spreadability' of fat spreads.

Microbial spoilage: The major commercial spoilage risk with low-fat spreads is that of mould spoilage, particularly by those species of *Penicillium* and *Cladosporium*, which can grow under cold storage conditions. Care is needed not only in the hygiene of the packaging operation, but also in the procurement and handling of the packaging materials. Addition of potassium sorbate tot the aqueous phase, though less effective at pH 6.4 than at pH values below 6, provides a significant measure of protection to the product. Lack of filtered air in the manufacturing room, improper emulsion of fat/water, and keeping more headspace in package are some factors that favours microbial spoilage.

IV. Defects in ghee

Ghee is pure fat (Min. 99.7% fat, Max. 0.3% moisture) and hence stable against microbial spoilage. However, defects due to manufacturing, improper package used and storage conditions are still the possibility.

***Rancidity**:* Some of the causative factors for ghee (milk fat) undergoing rancidity include lipase action (incidence is low), oxidation of fat (more chances) through exposure to light and contact with metal ions e.g. Cu, Fe, etc.

***Greasy texture**:* Granularity of ghee at ambient temperature is taken as an important quality attribute by the consumers. Rapid cooling of hot ghee after clarification or even subjecting ghee to further heating and cooling after preparation may lead to 'greasy' ghee which is not liked by the consumers. Ghee made by 'Desi method' tends to give better granular texture than that made by 'Creamery butter' and 'Direct cream' methods.

The granular form of ghee is primarily due to a certain content of glycerides of higher melting saturated fatty acids, especially palmitic and stearic. The impairment of crystal formation appears to be associated with the possible volatilization of some short-chain FFA. Heating ghee to clarification temperature, followed by rapid cooling, yields small grains in ghee; however, if the same ghee is held for crystallization at a temperature about 1^{o}C above the melting point of ghee (29^{o}C for cow ghee) a large number of big grains results. Cold storage of ghee should be avoided, since it leads to a loss of granularity and the development of a waxy consistency in the stored product.

***Dark/Burnt colour**:* Excessive high temperature (> 120^{o}C for some period) of clarification of ghee can lead to 'dark brown' coloured ghee. Ghee prepared by 'Direct cream' method may produce 'Burnt' colour and flavor, if optimal agitation and scraping is not followed during heat desiccation.

***Sediment in ghee package**:* Incorrect straining of ghee can lead to appearance of 'ghee residue' as sediment at the bottom of the ghee package. This decreases the consumer appeal for the product.

V. Defects in Anhydrous milk fat

Anhydrous milk fat (AMF) is a pure fat (Min. 99.8% fat, Max. 0.1% moisture) hence microbial spoilage is not a problem. However, problem due to oxidation of milk fat can be a problem, if raw material quality is not checked and proper inert gassing during packaging in drum is adhered to.

Rancidity: Improper handling of raw material (cream, white butter), exposure to light, contact with metal ions e.g. Fe, Cu; and improper inert gassing can be some of the causes for problem of 'rancidity' in AMF.

***Dark colour**:* The evaporation of last traces of moisture from the separated oil takes place through heating under vacuum, where the temperature during evaporation of water is < 65^{o}C. Improper vacuum during vacuum evaporation of water from separated oil can lead to 'darker colored' AMF.