repacking.

Spoilage defects in butter

The defects in butter can be divided into two main types:

I. Defects originating from cream in fresh butter.

II. Defects developing after manufacture (during storage)

I. Fresh butter defects

1. Cream-borne defects

Such flavour defects (microbial and non-microbial) as have been described for cream in the previous chapter are also carried into butter. A few of such defects common in butter are feed, weed, barny, medicinal, cowy, cooked, metallic, cheesy, malty, musty, yeasty, rancid and old cream flavours.

Control. Some processes like vacreation, pasteurization and ripening of cream, washing of butter etc. tend to decrease such defects in the final product. The easy way to avoid these defects in butter is to use a defect-free cream for its manufacture. This will require a strict quality control of the cream before accepting for butter-making.

2. Flat or insipid flavour

Causes.

i) Dilution of cream with water.

ii) Excess washing of butter granules.

iii) Onset of microbial deterioration (some of the pseudomonads bring about the breakdown of diacetyl).

Control. Avoid cream dilution, excessive washing of butter granules and gross contamination.

II. Storage defects

The storage defects in butter are mainly dependent upon the conditions of storage. Defects have been reported to occur even during cold butter storage.

The spoilage of butter during storage may be categorized into following three groups.

1. Chemical (or non-microbial) deterioration: caused due to chemical or other non-microbial interactions.
2. Enzymatic deterioration: caused due to enzymatic reactions.
3. Microbial deterioration: caused due to microbial activity.

However, it is difficult to assign a specific reason to a particular defect since there is generally an overlapping of different causes for producing that defect. Generally, the microbial spoilage can be differentiated from others if the defect can be reproduced in fresh butter by inoculating with a small aliquot of the spoiled one.

1. Chemical (non-microbial) deterioration

Causes. Presence of salt, moisture, lactic acid, sunlight and metal ions (e.g. copper, iron) may induce certain chemical reactions in butter leading to defects like oxidative rancidity or tallowiness, and fishiness etc.

i) Rancidity or tallowiness is caused due to oxidation of fat on expcsure to copper or iron and/or sunlight. Oxidation of fat is also accentuated by presence of low pH and salt.

ii) Fishiness in butter is ascribed to the production of trimethylamine as a result of decomposition of lecithin (favoured by the presence of acid).

Control

i) Avoiding the exposure of butter to sunlight and possible contamination with metal ions would check the chemical defects to a great extent.

ii) Use of alternative method of butter-making, wherein there is direct addition of starter culture, may check defects like rancid flavour.

iii) Unsalted butter is much safer with regard to chemical deterioration.

2. Enzymatic deterioration

Certain enzymes, namely lipases, proteinases and phospholipases cause deterioration of butter during storage. These enzymes in butter comprise of enzymes originally present in milk and/or those produced as a result of microbial activity in milk/cream/butter.

i) *Problems due to lipases*. Among the micro-organisms, most of the psychrotrophic bacteria especially pseudomonads have been known to produce heat stable lipases and proteinases (heating at 100°C for 20 min required to inactivate them), which continue to act even under cold storage conditions, e.g., lipases from *Ps. fragi* cause considerable fat degradation in butter during storage even at -10°C. Apart from bacteria, other organisms like certain yeasts and molds also produce lipases. About 80% lipases of *Pseudomonas* spp.

become contaminated in cream during separation and subsequently passed on to butter resulting in rancidity in less than two days.

Other general microbial lipases are known to be slightly heat stable and are invariably extracellular. Certain bacteria like *Clostridium, Bacillus, Pseudomonas* and *Serratia* species are also known to produce extracellular phospholipases and may cause defects in butter.

ii) *Problems due to proteinases.* Psychrotrophic pseudomonads especially *Ps. putrefaciens* produce proteinases, which are usually heat stable as stated earlier. The ultimate effect of these enzymes is the production of defects like bitter, sour, fruity and unclean flavours when butter is stored in refrigerators or outside.

Control.

i) Avoid excessive microbial activity in milk/cream/butter by discouraging prolonged low temperature storage, during which such enzymes may be produced e.g., the lipase of *Pseudomonas fragi* is preferentially produced at low temperature.

ii) Proper pasteurization of cream will destroy the original milk lipases/ proteinases.

iii) Hygienic measures can avoid post-pasteurization entry of psychrotrophs.

3. Microbial deterioration

Growth of micro-organisms in butter causes a variety of colour and flavour defects. As most of the micro-organisms in cream get killed during pasteurization, the spoilage organisms mainly come through post-pasteurization steps of butter-making. The defects have been mainly attributed to the presence of psychrotrohpic bacteria (lipolytic and proteolytic), yeasts and molds. The psychrotrophic bacteria which primarily come through unhygienic equipment grow during low temperature storage. However, molds create problems at relatively high temperatures as prevalent in India where butter is mostly stored under ambient or not-so-low temperatures.

A. Colour defects (discolouration)

The discolouration of butter may be caused by bacteria, yeasts and molds. It is, however, a major defect caused by mold growth. In this defect, the surface of butter gets discoloured, the colour changes depending on the type of organism involved. However, apart from discolouration the flavour of butter may also be affected.

a) Bacterial discolouration

The causative organism is *Pseudomonas nigrifaciens*. This psychrotrophic organism causes a black discolouration (like greese smudge) in butter stored at low temperatures (optimum temperature for pigmentation is 4°C with 1.5-2.5% salt, i.e., 10-12% concentration in the moisture droplets). In other words this defect is more prevalent in low temperature-stored salted butter. Although this

type of defect appears to be widespread, it becomes evident only in the event of holding of butter at household refrigeration temperature.

Control measures

i) Control of water supply and proper plant sanitation is quite effective since the organism enters butter mainly through wash water and contaminated equipment during pasteurization stages.

ii) Either reducing or increasing the salt concentration in the product from optimum level will help check the defect.

iii) Elimination of excess moisture from butter surface during packaging, e.g., by using dry parchment, checks the defect.

b) Fungal discolouration

Yeasts and molds are usually responsible for butter discolouration. Butter gets discoloured due to surface growth of molds and the defect is also described as 'moldy butter'. This is a major butter defect commonly occurring in India since the prevalent ambient storage conditions encourage heavy mold growth. The mold growth is further favoured if moisture content and acidity in butter are higher. Some psychrotrophic molds like *Alternaria, Harmodendrum Phoma* and *Stemphylium* have been reported to grow in butter (especially unsalted) at low temperatures (5°C). Slight growth may take place at -4°to -6°C, but not at -7° to -9°C. Although cold storage at -18°C did prevent visible growth, storage for 20 weeks under these conditions did not destroy the psychrotrophic molds. The surface growth of molds is due to their strict aerobic nature. The common fungal discolourations observed in butter are black, brown, green or orange depending upon the type of mold (Plate 9.2) or yeast involved as shown below.

Discolouration	*Causative agent*
a) Mold-origin	
i) Black	*Cladosporium*, e.g. *C. herbarum* (usually causes internal discolouration also) *Aspergillus* *Harmodendrum* *Alternaria* *Mucor* *Rhizopus* *Stemphylium*
ii) Brown	*Aspergillus* spp. *Phoma* spp. (muddy brown)
iii) Green and blue green	*Penicillium* spp. *Aspergillus* spp.
iv) Orange and yellow	*Geotrichum candidum*
v) Reddish pink	*Fusarium*
b) Yeast-origin	
i) Black	*Torula* spp.

ii) Pink *Rhodotorula* spp.

Sources of yeasts and molds in butter

Yeasts and molds can enter butter (especially batch manufactured) during processing, handling and packaging, the latter two being more commonly involved. Contaminated air, packaging materials, processing equipments and handlers are some of the major sources of yeasts and molds in butter.

i) *Air-borne contamination.* The air in churn room and packaging room may carry yeasts and molds originating from outside air, if there are direct air currents, lack of proper ventilation and humidity. The mold spores remain floating in outside air especially if there is vegetation in the surrounding. The high humidity encourages growth of molds on various surfaces like walls, fans, ceilings, window panes, etc. which can act as potent sources of mold infection in butter. Aerial contamination may be of serious concern in case of unsalted or low salted butter because of the reason that mold growth is discouraged in presence of salt.

ii) *Packaging materials.* The wrapping butter papers and other packaging materials may contain yeasts and molds if not properly sterilized and if plant atmosphere is contaminated. Apart from this, the improperly cleaned packaging machines may also harbour molds.

iii) *Unclean butter churn.* Improperly cleaned and sanitized butter churn, especially wooden churn, may be grossly contaminated with mold spores. Such surfaces may directly add molds to butter during manufacture.

Other improperly cleaned and sanitized equipments may also introduce yeasts and molds in butter.

Control of yeasts and molds in butter

i) Control of air-borne contamination through following measures.
   a) Avoiding direct and excess air currents
   b) Proper ventilation through use of sterile air filters
   c) Control of humidity in the air
   d) UV light treatment of air above conveyors

ii) *Treatment of packaging materials (wrappers, liners, containers).* Parchment paper used in butter packaging can be treated with any of the following agents.
   - UV exposure
   - Boiling water or boiling salt brine (in case of salted butter)
   - Sorbic acid or sodium/potassium sorbate (0.5% concentration has been found to be effective mold inhibitor when used for treating parchment papers and their use is permissible in some countries)
   - Calcium propionate (trade name: Mycoban) - A 10% solution has been found to be effective in checking mold growth
   - Sodium benzoate

- Dihydroacetic acid
- Antifungal antibiotics like Natamycin (Pimaricin), Nystatin (Mycostatin)

Several studies have been carried out in regard to preservation of butter against mold growth using different chemical agents for treating packaging materials or for spraying butter surfaces (Verma *et al.*, 1987). Some of these agents have been found to be quite effective and are permitted in some countries. However, in general, these are not universally practised in view of the strict regulations in different countries including India against use of such preservatives in butter.

iii) Proper sanitization of various equipments especially butter churn is necessary to avoid mold growth. Use of wooden churns should be discouraged since these are difficult to sterilize properly due to their rough surface with cracks and crevices.

iv) Handlers should be clean in outfit and habits.

B. Flavour defects

Rancid and putrid or cheesy flavour are the most common flavour defects. The other defects may be malty flavour, skunk-like flavour, yeasty flavour etc.

a) Rancid flavour

Butter gets rancid due to microbial, enzymatic or chemical degradation of fat constituents. Following three types of rancidity have been encountered in butter and other fat rich dairy products.

- Hydrolytic rancidity
- Oxidative rancidity
- Ketonic rancidity

Milk or microbial lipases and presence of sunlight and/or metal ions (Fe, Cu) are responsible for rancidity.

i) *Hydrolytic rancidity.* This is due to the action of lipase on fat to produce free fatty acids. The short chain fatty acids (like C_4, C_6, C_8) so produced give rancid flavour, the major contributor being C_4 (butyric) acid.

$$\begin{matrix} CH_2OCOR \\ | \\ CHOCOR \\ | \\ CH_2OCOR \end{matrix} \xrightarrow{\text{Lipase}} \begin{matrix} CH_2OH \\ | \\ CHOH \\ | \\ CH_2OH \end{matrix} + 3\,RCOOH$$

Fat (triglyceride) — Glycerol — Fatty acids

The fat hydrolysis in butter is chiefly attributed to the activity of microbial lipases since milk lipases get inactivated during pasteurization of cream. Lipases as described earlier, are produced by the growth of lipolytic bacteria, yeasts and molds on butter. Many of the fat-splitting micro-organisms are psychrotrophic and are able to grow at temperatures slightly under 0°C and survive cold storage at -10°C. Such organisms origniate in butter from raw cream in raw cream-butter and from contaminated wooden churns or ineffectively chlori-

nated wash water in pasteurized cream-butter. However, processing advancements in butter-making like more hygienic creamery practices, replacement of wooden churns, omission of butter washing stage at some creameries and the development of continuous butter-making processes have greatly contributed towards improving the microbiological quality of creamery butter. Some of the lipase producing organisms which can grow on butter are as follows.

Bacteria	Molds	Yeasts
Ps. fragi	*Geotrichum candidum*	*Candida lipolytica*
Ps. fluorescens	*Cladosporium butyri*	*Torulopsis* spp.
Ps. putida	*Penicillium spp.*	*Cryptococcus spp.*
Achromobacter lipolyticum	*Aspergillus spp.*	*Rhodotorula spp.*
		Saccharomyces fragilis