Microbial production of Butter & Buttermilk

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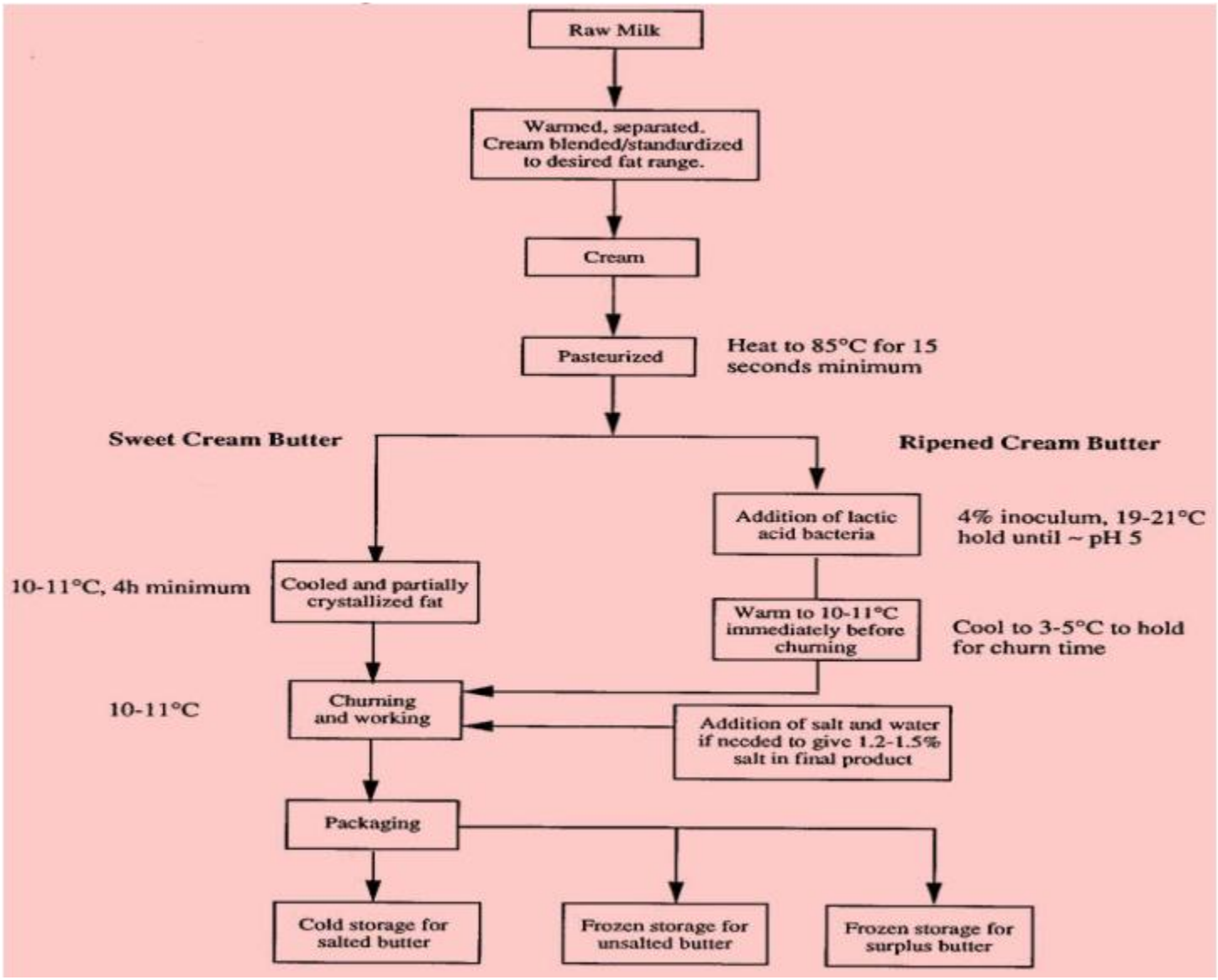
What is Butter?

- Butter is commonly defined as a fat concentrate which is obtained by churning cream, gathering the fat into a compact mass and then working on it.
- It is a water-in-oil emulsion, typically salted Indian butter consisting of at least 80.2% fat, 16% water, 2.5% common salt and 1% curd.

Types of Butter

- Creamery butter (Made in dairy plant)
- Pasteurized cream butter (Made from pasteurized sweet cream)
- Sweet cream butter (Made from sweet cream i.e., acidity not exceeding 0.20%)
- Sour cream butter (Made from sweet cream i.e., acidity more than 0.20%)
- Ripened cream butter (made from ripened cream i.e. inoculation and incubation of cream with a desirable flavour producing butter culture under optimum conditions)

Flow Diagram of Production of Butter



The buttermaking process

- Milk fat is comprised mostly of triglycerides, with small amounts of mono- and diglycerides, phospholipids, glycolipids, and lipo-proteins.
- The trigylcerides (98% of milkfat) are of diverse composition with respect to their component fatty acids, approximately 40% of which are unsaturated fat firmness varies with chain length, degree of unsaturation, and position of the fatty acids on the glycerol.
- Fat globules vary from 0.1 – 10 micron in diameter. The fat globule membrane is comprised of surface active materials: phospholipids and lipoproteins.
- The butter manufacturing process begins with separating cream from milk using a centrifuge or cream separator.
- The cream contains butterfat, which is collected for further processing.
- The cream should be sweet (pH >6.6, TA = 0.10 – 0.12%), not rancid and not oxidized.
- If the cream is separated by the butter manufacturer, the whole milk is preheated to the required temperature in a milk pasteurizer before being passed through a separator.
- The cream is cooled and led to a storage tank where the fat content is analyzed and adjusted to the desired value, if necessary.
- The skim milk from the separator is pasteurized and cooled before being pumped to storage.
- It is usually destined for concentration and drying.
- From the intermediate storage tanks, the cream goes to pasteurization at a temp. of 95^{o}C or more.
- The high temperature is needed to destroy enzymes and micro-organisms that would impair the keeping quality of the butter.

… The buttermaking process

- If ripening is desired for the production of cultured butter, mixed cultures of *Streptococcus cremoris*, ***Lactococcus lactis*** subsp. ***lactis*** var. *diacetylactis*, *Leuconostoc*, are used and the cream is ripened to pH 5.5 at 21^{o}C and then pH 4.6 at 13^{o}C.
- Most flavour development occurs between pH 5.5 – 4.6.
- The colder the temperature during ripening the more the flavour development relative to acid production.
- Ripened butter is usually not washed or salted.
- In the aging tank, the cream is subjected to a program of controlled cooling designed to give the fat the required crystalline structure.
- The program is chosen to accord with factors such as the composition of the butterfat, expressed, for example, in terms of the iodine value which is a measure of the unsaturated fat content.
- The treatment can even be modified to obtain butter with good consistency despite a low iodine value, i.e. when the unsaturated proportion of the fat is low.

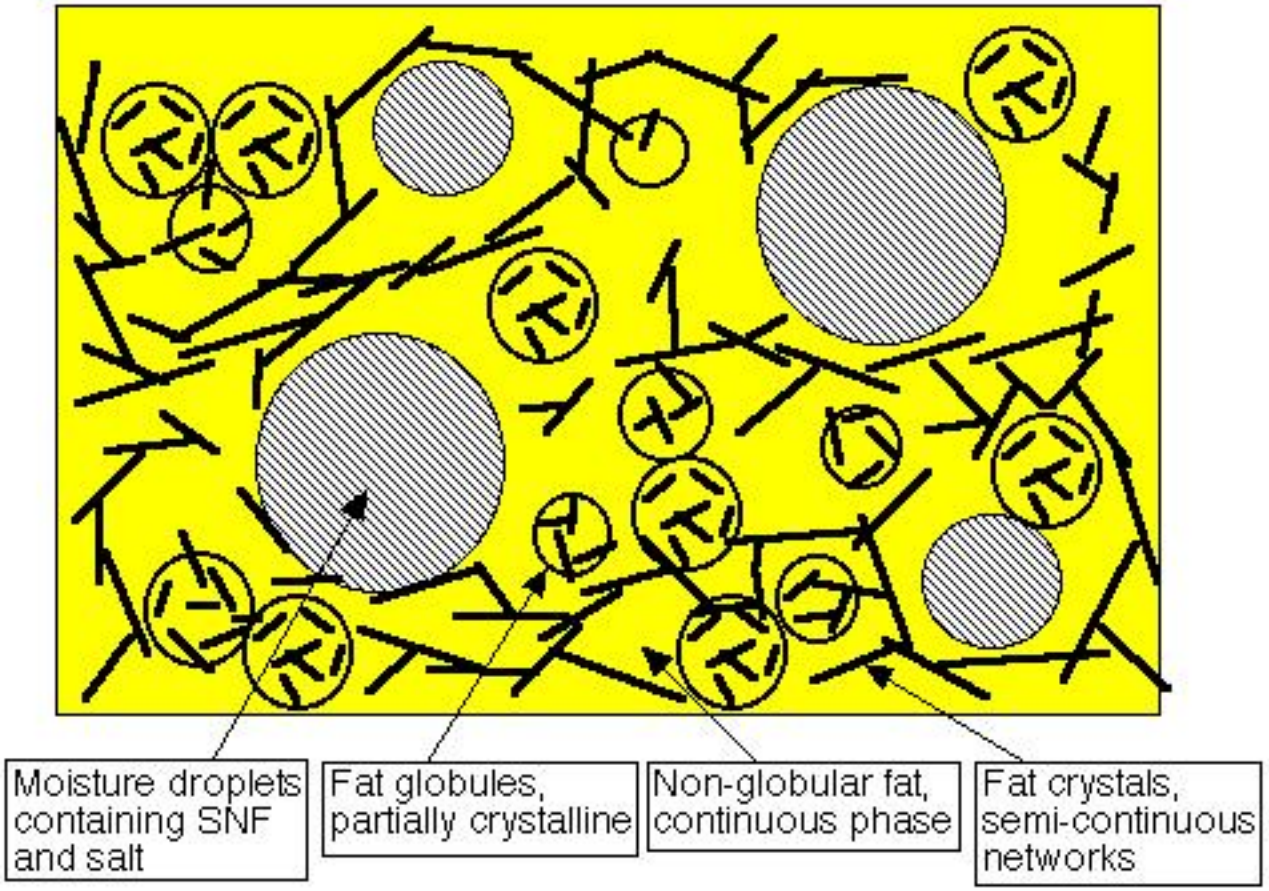
… The buttermaking process

- As a rule, aging takes 12 – 15 hours.
- From the aging tank, the cream is pumped to the churn or continuous buttermaker via a plate heat exchanger which brings it to the requisite temperature.
- In the churning process the cream is violently agitated to break down the fat globules, causing the fat to coagulate into butter grains, while the fat content of the remaining liquid, the buttermilk, decreases.
- Thus the cream is split into two fractions: butter grains and buttermilk.
- It used to be common practice to wash the butter after churning to remove any residual buttermilk and milk solids.
- Salt is used to improve the flavour and the shelf-life, as it acts as a preservative.
- If the butter is to be salted, salt (1-3%) is spread over its surface, in the case of batch production.
- In the continuous buttermaker, a salt slurry is added to the butter.
- The salt is all dissolved in the aqueous phase, so the effective salt concentration is approximately 10% in the water.

… The buttermaking process

- After salting, the butter must be worked vigorously to ensure even distribution of the salt.
- The working of the butter also influences the characteristics by which the product is judged – aroma, taste, keeping quality, appearance and colour.
- Working is required to obtain a homogenous blend of butter granules, water and salt.
- Water droplets decrease in size during working and should not be visible in properly worked butter.
- Overworked butter will be too brittle or greasy depending on whether the fat is hard or soft.
- Some water may be added to standardize the moisture content.
- Precise control of composition is essential for maximum yield.
- The finished butter is discharged into the packaging unit, and from there to cold storage.

Butter Structure



Regulatory Microbiological Standards

Products	Coliform Count	Yeast and Mold Count	SPC
Cream	10/g	<20/ml	$50X10^3/g$
Butter	Absent/0.1 g	20/g	$25X10^3/g$

BUTTERMILK PRODUCTION

Introduction

- Traditional buttermilk is what is left over after butter is made from sour cream.
- During the churning of the milk, the milk fat globule membranes break, making the milkfat curdle together.
- The coagulated milkfat then floats, like butter, on top of the buttermilk.
- Phospholipids from these milk fat globule membranes are very sensitive to oxidation, making the buttermilk spoil quickly.
- Nowadays, for this reason, almost all buttermilk is produced by adding lactic acid bacteria to pasteurized skimmed milk.

Buttermilk production

- In general, skimmed milk is used as a base for buttermilk production.
- This milk must be of a high microbiological quality and not contain any antibiotics or disinfectants.
- For the best flavor it is recommended to use milk with a fat content of at least 1 to 1.8%.
- The flavor of the buttermilk is, to a large extent, determined by the diacetyl production of the lactic acid bacteria.
- To stimulate the diacetyl production by the lactic acid bacteria, often 0.10% w/w of sodium citrate is added.
- To prevent syneresis, stabilizers can be added, like modified starch or carrageenan.

- **Pasteurization**
- Before the milk is pasteurized, 0.1 to 0.2% salt is added, to obtain the desired flavor.
- Before the standardized milk is pasteurized, it is homogenized under high pressure (125 bar), at a temperature of about 49°C, creating small fat globules, which the prevent the fat from floating.
- In order to reduce the bacterial count and increase the viscosity, through denaturation of whey proteins, the homogenized milk is pasteurized at 90°C for 2 to 5 minutes.
- **Cooling**
- After pasteurization step, the milk is cooled to a temperature of between 22.2 and 23.3°C and pumped to the fermentation tank.
- Here, the milk is inoculated with about 1 to 3% of a mesophilic starter, consists of the lactic acid bacteria *Lactococcus lactis* ssp. *lactis*, *Lactococcus lactis* ssp. *cremoris* and *Leuconostoc mesenteroides* ssp. *cremoris*.
- The first-mentioned lactic acid bacteria are responsible for producing lactic acid from lactose, while the latter produces the aroma.

Fermentation

- After adding the mesophilic starter, the mixture is stirred for about 15 to 30 minutes, depending on the type of tank and its agitators, at a high speed.
- After which, the milk is allowed to ferment, and after 12 to 15 hours the pH is measured until a pH of 4.6 is reached.
- At this pH level, casein sinks to the bottom of the tank, making the mixture curdle.
- The milk is then left to rest for about 1 to 2 hours, this will lead to the desired taste and aroma.

Cooling

- After the buttermilk is fermented sufficiently, the buttermilk has to be cooled rapidly.
- In order to prevent post-contamination and to terminate the production of acid.
- This rapid cooling starts with the circulation of ice water between the outer layers of the fermentation tank, for about 10 to 15 minutes.
- Next, the whole is stirred at a high speed until the product has become smooth.
- Then, the stirring speed is reduced and the buttermilk is stirred until it is cooled down to 17°C.

- **Filling**
- For the filling process to start, stirring should be stopped, preventing air from entering the buttermilk.
- The cooled buttermilk is pumped to the filling machine and filled into bottles or cardboard packs.
- **Preservation**
- When the buttermilk has been bottled, it must be stored at 4°C.
- If kept at this temperature, the buttermilk will have a shelf life up 2 to 3 weeks.