Microbial production of dairy cheese

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Introduction

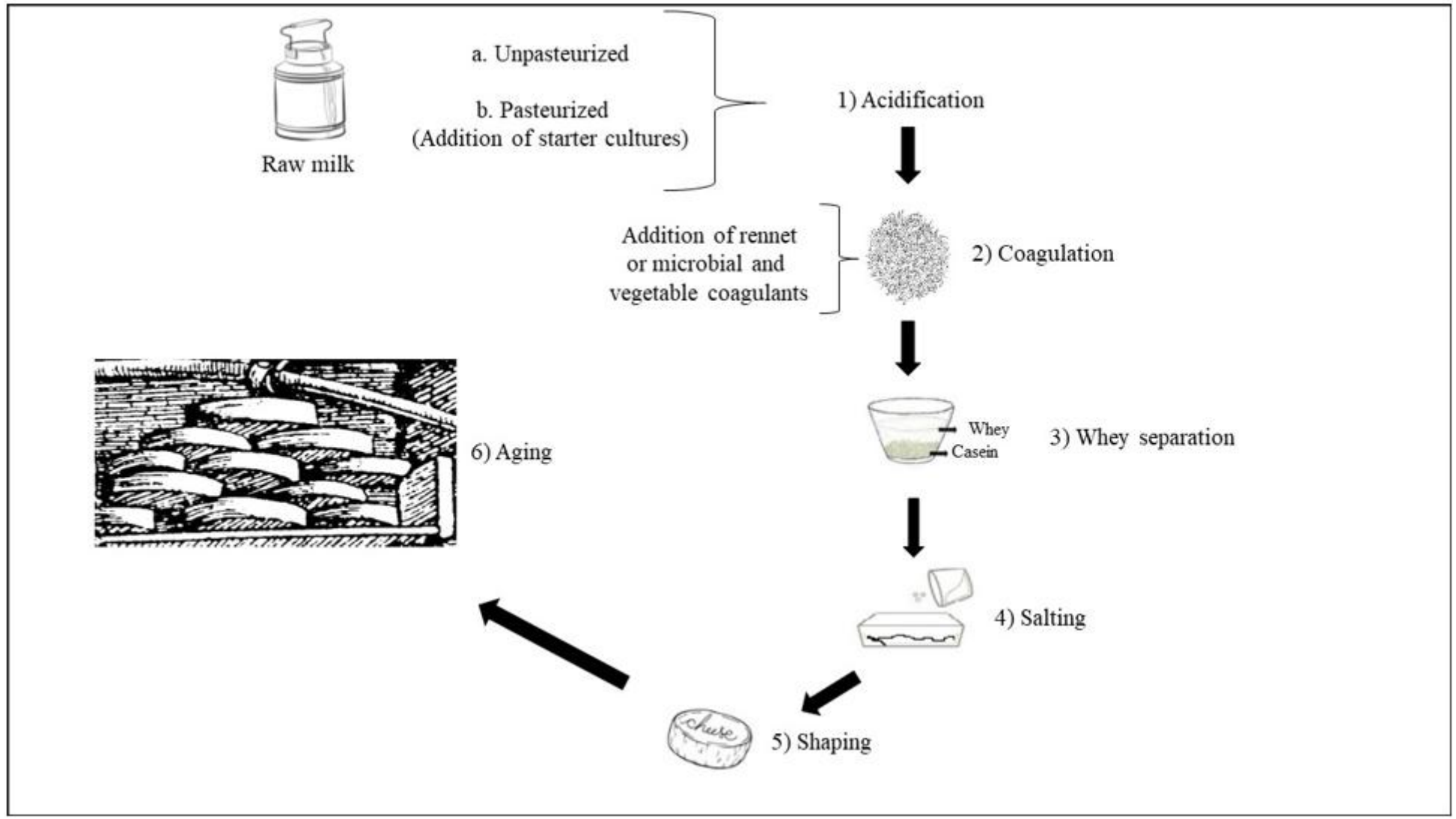
- Among dairy products, cheese is the most varied and widespread.
- Dairy products present differencies in terms of raw materials, process chain, ripening temperature, water activity (aw), pH, environment and contamination by operators, and all these aspects interact closely with microbial communities of dairy products.
- Microorganisms are the key agents in the critical stages of optimizing the overall quality and safety, flavor, appearance and typicality of cheese and dairy products.
- The term cheese describes dairy products with the definition of **“a ripened or unripened, soft, semi-hard, hard, or extra-hard, dehydrated milk-derived product in which the whey protein/ casein ratio does not exceed that of milk”**
- Cheeses comprehend a great variety of forms, sizes, textures, aromas, and tastes.

Types of cheeses

- Cheeses can broadly be categorized into different groups, acid or rennet cheese and natural or processed cheese.
- In acid cheese, acid is added to the milk to make it to coagulate. Some examples of acid cheeses are cream cheese and queso fresco.
- In most types of cheese coagulation is achieved by rennet enzyme together with a starter culture; examples are Cheddar and Swiss cheese.
- The term “natural cheese” is mostly used in the industry referring to cheeses that are directly made from milk.
- “Processed cheese” is made using natural cheese together with other ingredients to change the texture and/or melting properties and increase shelf life of the cheese

Production of cheese

- Production of cheese follows general procedures that include:
  - milk acidification;
  - milk coagulation by adding different agents, to be chosen from animal rennet, microbial or vegetable coagulants;
  - cutting the curdled milk originated by coagulation into small pieces;
  - whey drainage;
  - washing;
  - heating to temperatures between 30 °C and 55 °C;
  - pressing and adding salt at concentrations between 1% and 5% NaCl;
  - shaping;
  - aging with maturation and dehydration of the product (Figure 1).
- Treatments with natural compounds such as immersion in oil, wine or brine, or the addition of ash, flour, spices or vegetable dyes to the packaging of the final product, can also be included.


Raw milk
a. Unpasteurized
b. Pasteurized
(Addition of starter cultures)
1) Acidification
Addition of rennet
or microbial and
vegetable coagulants
2) Coagulation
Whey
Casein
3) Whey separation
4) Salting
5) Shaping
6) Aging

Cheese making

- In a cheese making process the first step is to standardize the milk to optimize the protein to fat ratio to control quality and yield.
- The milk is then pasteurized to kill spoilage microorganisms and pathogens to get a good environment for the starter culture which is added after the milk has cooled down and reached a suitable temperature for the starter culture.
- The starter culture produces lactate and gives the cheese its specific characteristics.
- Non-starter adjunct culture containing mold or bacteria are sometimes added to enhance flavor development in the cheese.
- For coagulation rennet, containing chymosin, is added, which converts kappa-casein to para-kappa-casein forming the curd whereby glycomacroprotein is lost in the whey.
- To accelerate the expulsion of whey from the curd, called syneresis, the cheese is cut into smaller pieces and heated.
- After the whey has been removed and the cheese has reached the desired pH, the cheese is salted by adding salt to the surface or putting the curd into a salt water solution called brine.
- The salted cheese is then stored for maturing depending on the kind of cheese that is desired.

Microorganisms used in Cheese Production

Lactic acid bacteria

- Starter cultures often referred to as “Lactic acid bacteria” are a critical step in cheese manufacturing.
- Lactic acid bacteria convert lactose sugar present in the milk into lactic acid, this is critical in lowering the overall pH of the mixture.
- This lower pH makes it an inhospitable environment for other microorganisms which might spoil the cheese.
- Rennet is then added to the mixture to begin coagulation of milk proteins which begins to form the curd of the cheese.
- The most common types of starter cultures are:
- *Lactococcus lactis,*
- *Streptococcus salivarius,*
- *Lactobacillus delbruckii*
- *Lactobacillus helveticus.*

Microorganisms used in Cheese Production

PROPIONIC ACID BACTERIA

- Another starter culture used is propionic acid bacteria.
- They work by converting acetic acid into propionic acid and $C0_2$.
- Propionic acid is used in a variety of Swiss cheeses, and in particular Emmental cheese.
- The starter bacteria involved in production is *Propionibacterium freudenreichii* which gives the cheese its sharp and distinct flavour.
- *P. freudenreichii* is a gram-positive bacterium that produces bubbles of $C0_2$ gas which causes the distinct eye formation Emmental cheese is famous for.
- It also has various health benefits as it naturally produces a high yield of Vitamin B12.

Why starter cultures are so important:

- Metabolism of lactose which creates lactic acid. As a result of this, the pH of the mixture is low which then minimises the growth of pathogenic microorganisms
- Starter cultures contribute health benefits to the cheese, e.g vitamin production and aid in gut health
- The starter cultures often produce enzymes and metabolic by-products which can give the cheese distinct flavourings.

Importance of molds

- Besides the very important role of bacteria, fungi such as molds also play a key role in the manufacturing process.
- Some of the most common molds used are of the *Penicillium* genus, such as *Penicillium roqueforti and Penicillium camembertii* which are added to the cheese as a secondary fungal starter culture after the lactic acid bacteria.
- *P. roqueforti* is a saprophytic fungus essential for the production of blue-veined cheeses such as Roquefort, Stilton and Danish Blue.
- It breaks down the high amount of lactic acid produced from the starter bacterial culture and further ripens the cheese by proteolytic and lipolytic enzymes.
- This helps to ripen the cheese and help develop the flavours.
- To develop the characteristic blue vein structures, cheese makers often pierce the cheese in several places to allow *P. roqueforti*to grow.

Quality Features and Flavor Development in Cheese

- The active agents at the base of cheese flavour development are enzymatic reactions of microbial origin that create a balance between different components.
- The characteristics of the flavour profile of ripened cheeses are mainly affected by proteolysis of caseins and in some types also by lipolysis.
- The typical cheese flavour results from further degradation of amino acids, due to the pathways for conversion of amino acids by starter bacteria
- LAB uses amino acids for different purposes, to synthesize proteins, as energy source, to obtain the right internal pH in an acid environment, to generate cosubstrates and other complex products.
- The breakdown of proteins by aminopeptidase enzymes is called peptidolysis and is often specific for a group of amino acids with similar properties and is dependent on environmental conditions such as pH, temperature, water activity and availability of co-substrates.
- The breakdown of protein is important for cheese taste and also softens the cheese texture by breaking down the casein network.
- Based on sensory evaluation and chemical analysis of cheeses, various groups of volatile compounds have been identified as being responsible for the final taste and aroma of cheese.
- These compounds comprise fatty acids, esters, aldehydes, alcohols, ketones, sulphur compounds and various other components.
- These nonstarter lactic acid bacteria contributed to the fermentation of residual lactose or other sugars and were involved in citrate, peptide, and amino acid production, including formation of aromatic compounds, as well as contributing to the aging process .
- The yeast *Geotrichum candidum*, formerly *Oidium lactis*, represents a key microorganism in the catabolism of triglycerides and casein and also in cheese organoleptic properties and appearance development.