Cheese Ripening Theory

First Edition – June/2002

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INTRODUCTION

Milk from several species may be used in the production of cheese, but cow's milk is the most usual milk source, although goat and sheep milk are fairly common for producing specialty cheeses in many countries. Buffalo milk is also a common source of milk for cheese production in some countries.
In this pamphlet the cheese ripening discussion is based on cow's milk if nothing else is mentioned. The basic principles for cheese ripening are the same no matter which type of milk is used. Quantitatively, however, there can be fairly large differences in how the different cheese ripening parameters work in cheeses made of milk from different species.
From a cheese ripening point of view the most important milk constituents are water, fat, lactose, salts, caseins and whey proteins.

Basically the production of cheese is based on three fundamental processes.

- A concentration of the milk constituents.
- A preservation of the milk constituents.
- A biological/enzymatic modification of the milk constituents.

Concentration

The concentration step is carried out by precipitating the milk casein, either through enzymatic or acid modification. The milk fat together with colloidal salts in the milk will to a large extent be trapped and co-precipitated with the casein.

The casein in milk is in a colloidal state – the casein micelle. The casein micelle is built of submicelles that are held together in the micelle by calcium phosphate and hydrophobic linkages.
The casein in milk is usually subdivided into several fractions of which the most important are α-, β- and κ-casein.

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The caseins carry a net negative charge at the normal pH of milk. They are hydrophobic except for κ-casein, which is hydrophilic due to a surface oriented glyco-macro-peptide. The α-caseins are sensitive to calcium precipitation. The κ-casein is primarily situated on the surface of the micelles and their hydrophilic glyco-macro-peptide is the reason why casein in fresh milk is in a stable colloidal state.

Basically the coagulation of milk is brought about by destabilizing the micelles either by removing the hydrophilic glyco-macro-peptide through enzymatic action (rennet) or by neutralizing the negative charge on the micelle surface (by formation of acid).

In traditional cheese making the resulting three-dimensional casein matrix in which a substantial part of the colloidal milk salts are complexed, entraps about 90% of the milk fat.
The other components of the milk (lactose, soluble salts and whey proteins) are dissolved in the water phase and are removed proportionately with the whey.

Heat treatment of the milk or ultra filtration make it is possible to co-precipitate the whey proteins with the caseins.
This is important because it increases the cheese yield and affects the manufacturing and ripening process significantly.
The degree of concentration is a parameter of fundamental importance to the microbial and enzymatic activities in the cheese and thereby to the ripening process.

Preservation

The preservation of the milk concentrate (cheese curd) is partly brought about by the concentration itself, which lowers the water activity, and partly by the formation of lactic acid by the lactic acid bacteria used to inoculate the cheese milk. Additionally different cheeses are usually salted to various degrees, which also helps in preserving the cheese through lowering the water activity.
In some cheeses salting is the major method of preservation. This is the case for many of the soft cheeses like Feta that originate in the Mediterranean area.

BIOLOGICAL/ENZYMATIC MODIFICATIONS DURING CHEESE RIPENING

Cheese ripening constitutes a long series of primarily enzymatic reactions through which the fresh, concentrated and preserved milk constituents are transformed into cheese. For most cheese varieties casein plays the dominating role in the ripening process, although the fat may be a decisive factor in the ripening of specific cheese varieties like blue-mold cheeses and specialty cheeses made from goat or sheep milk.

Milk fat is degraded by various lipases (esterases) into free fatty acids, which may be further degraded into aromatic compounds by various enzymes.

For most cheese varieties the carbohydrates of the milk (lactose and citrate and carbohydrates liberated from glycoproteins) are converted to lactic acid by the starter culture during the initial fermentation of the cheese milk or are removed by the whey together with the whey proteins and other solutes.
The carbohydrates, however, are important in the ripening of many cheese varieties as they form the basis for eye formation as well as the formation of aromatic compounds. Indirectly the carbohydrates may play a role during ripening by affecting the formation of aromatic compounds through secondary fermentation.

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Milk proteins

About 80 % of the milk proteins belong to the caseins, while the remaining 20% consist of whey proteins (albumins, globulins and various degradation fragments and enzymes).

Except for some fresh cheeses and specialty cheeses produced from ultra filtered milk the whey proteins only play a minor role in cheese ripening.

The caseins are the dominant protein in most cheese varieties although there are exceptions like the Norwegian whey cheese Myseost.

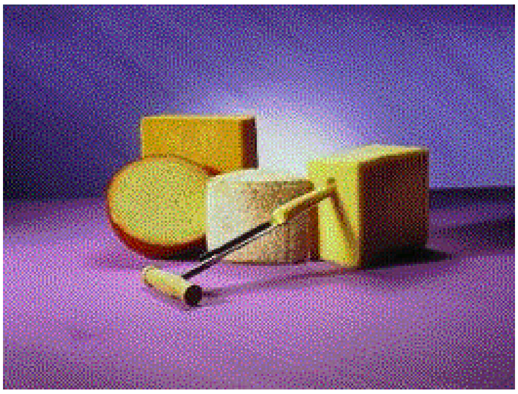
From a cheese ripening point of view the caseins consists of two major fractions: α-caseins and β-caseins.
Both the α- and β-caseins are characterized by their content of fairly hydrophobic peptide sequences.

The α-caseins are degradable by most proteolytic enzymes present in the cheese whether naturally present in the milk (indigenous) or exogenous from the coagulant or starter used during the manufacture of the cheese. They may also originate from the contamination flora always present, which can vary greatly depending on the hygienic conditions during milk production and transport and the storage conditions prior to cheese manufacture.

The β-caseins are fairly resistant to proteolysis by most of the proteolytic enzymes present in the cheese. The milk protease, plasmin, seems to play an important role in the degradation of β-casein.

For both α- and β-caseins the degradation during cheese ripening is characterized by being sequential (proceeding in steps). The first step is the splitting off of fairly large peptides from the proteins. These large peptides are further degraded into smaller peptides of which many have a bitter taste.
The smaller peptides are degraded further into free amino acids that also contribute taste to the cheese.

The processes described until now have only led to the formation of non-volatile compounds that contribute taste to the cheese but very little flavor.
The aromatic compounds are formed during the degradation of the amino acids into a great variety of volatile compounds. More that 100 different volatile compounds were isolated from premium quality Australian Cheddar.



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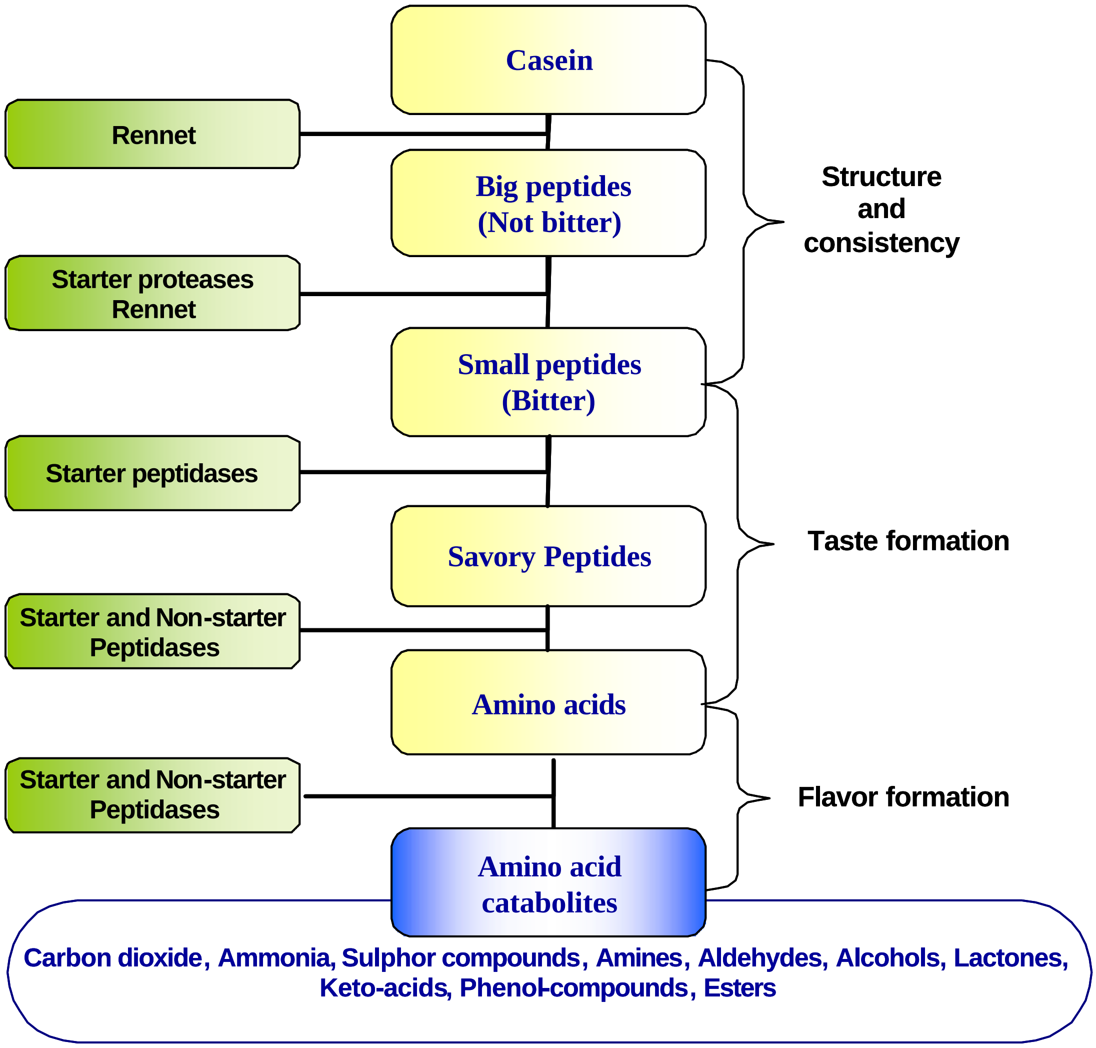
The following figure outlines the steps in the degradation of the caseins in cheese during ripening.



Transformation of casein during cheese ripening

Although there are no strict boundaries for the reactions, the figure shows that the degradation of the caseins during cheese ripening may be subdivided into three main areas:

- An area which primarily affects the structure and consistency of the cheese.
- An area which affects the taste of the cheese (sour, salt, sweet and bitter).
- An area of flavor and aroma formation.

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The three areas are the result of the activity of various enzymes on the milk proteins (caseins) in the cheese.

The first area is a result of proteinase activity. The proteinase enzymes present in the cheese attack the milk proteins and degrade them into smaller fragments called peptides. Many of the peptides and especially those comprising 6 to 10 amino acids - and which also contain hydrophobic amino acids – often possess a bitter taste.

The second area represents the activity of various peptidase enzymes that further degrade the peptides into smaller “savory” peptides and free amino acids.
Free amino acids contribute different flavor notes to the cheese. Often they have a sweet taste.

The third area represents the further degradation of amino acids by various deaminase and decarboxylase enzymes. The result is a long range of volatile aromatic compounds of which many have an extremely strong flavor. Only a few mg of some of these compounds affects the flavor profile of the cheese. To those mentioned at the bottom of the figure could be added various sulfur containing diamines like putrescine, amalgine and cadaverine which in extremely small concentrations contribute to the special “farmhouse” flavor that is appreciated in Cheddar as well as Continental cheeses.

To achieve a high overall quality cheese it is important to have these three areas properly balanced. Consistency, taste and flavor constitute the general quality parameters for all types of matured cheeses.
What differentiates the individual cheeses is the extent and balance within each of these individual areas.

Milk fat

Milk fat exists in the form of a suspension of fat droplets (milk fat globules) covered by a membrane of lipoprotein that keeps the fat in suspension in the milk.

During cheese manufacture the milk fat is trapped in the cheese curd as a result of which about 90% of the milk fat is transferred to the cheese.

Raw milk has a natural content of lipases (indigenous milk lipases). Contaminating flora may also produce lipases. However, in fresh milk the milk fat is protected against these lipases by the milk fat globule membrane.

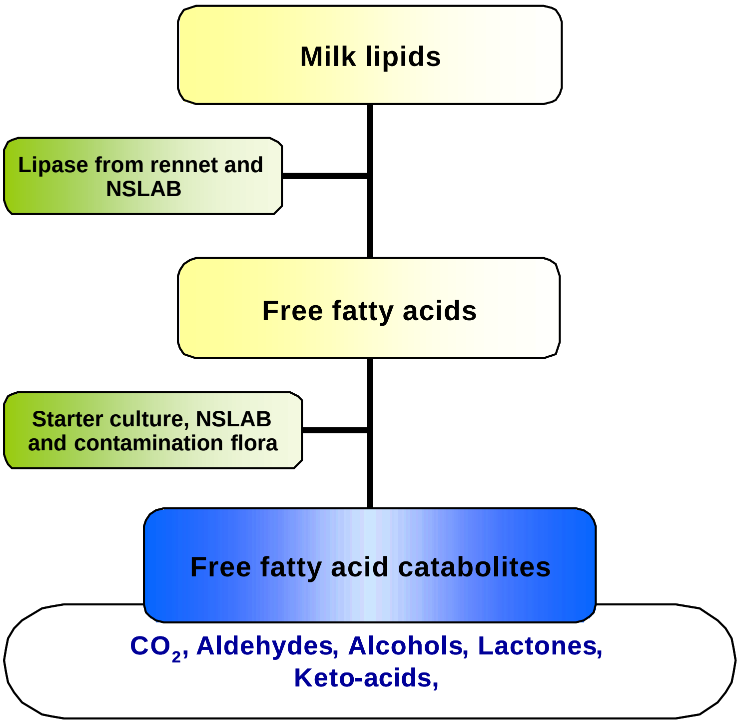
Mechanical treatment of the milk fat globules during milk handling may damage the fat globule membrane and make the fat accessible to the lipases.

Pasteurization of the milk prior to cheese manufacture destroys the indigenous milk lipases while lipases originating form the contaminating flora are usually very heat resistant and will resist the pasteurization temperatures used on cheese milk.

Lipolytic activity is probably the most important factor differentiating cheeses made from raw milk from those made from pasteurized milk.

For certain cheese varieties like blue-mold cheeses, lipolytic activity is decisive for the characteristics of these cheeses. To make the milk fat more accessible to ensure sufficient lipolytic activity, the milk for blue cheese production is standardized with homogenized cream and heat treated at temperatures below normal pasteurization temperatures.

In the manufacture of blue-mold cheeses and also other cheese varieties like Grana and Feta, where a certain lipolytic flavor is wanted, small amounts of lipase enzyme may be added to the cheese milk. During cheese ripening lipolysis may be accomplished by esterase activity from residual milk lipase, esterase activity from the non-starter lactic acid bacteria (NSLAB) and adventitious flora present in the cheese.
Lipolysis during cheese ripening proceeds according to the following figure:



Transformation of milk lipids during ripening

Lipolysis is a major contributor, directly or indirectly, to flavor development in strongly flavored cheeses, eg, Hard Italian, Blue varieties, Feta.

The major flavor effect of lipolytic activity is due to the short chain free fatty acids formed. Butyric, capronic and caprylic acids especially give strong and characteristic flavors.
Free fatty acids, however, may be further degraded to various aldehydes, alcohols, keto-acids that also give characteristic cheese flavors. As an example the ketones 2-heptanon, 2-nonanone and 2-butanone are characteristic cheese aromas especially known from blue vein cheeses.

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Carbohydrates

The dominating carbohydrate in milk is lactose. Apart from lactose, milk contains about 2 grams of citrate per liter and a small amount of carbohydrates integrated in the κ-casein as glycoprotein.

During cheese manufacture the lactose is the basis for the growth of lactic acid bacteria and thereby for the formation of lactic acid and certain aromatic compounds.

From a ripening point of view the carbohydrate catabolism may be divided into two phases – the primary fermentation and the secondary fermentation.

Primary fermentation

The primary fermentation covers the fermentation of the cheese milk taking place in the cheese vat and the fermentation during the first 24 hours or so during which the residual lactose in the cheese is primarily fermented into lactic acid.

During the primary fermentation all lactose is consumed but some or all of the citrate may still be present. In addition some galactose may accumulate if starters containing *S. thermophilus* and/or *Lactobacillus bulgaricus* have been used.

Primary fermentation is by far the most important step in indirectly determining the ripening of cheese but secondary fermentation plays a role in certain cheese varieties like Swiss type cheeses and Mozzarella.

Secondary fermentation

During the secondary carbohydrate fermentation residual citrate is converted to aromatic compounds like diacetyl, alcohol and aldehyde as well as CO_2.

Any galactose is fermented by adventitious non-starter lactic acid bacteria (NSLAB) flora. In Swiss type cheese the propioni bacteria are able to metabolize galactose as well as lactate. Galactose is primarily fermented into acetic acid while lactate is primarily fermented into propionic acid. In this way galactose accumulation may affect the flavor of Swiss type cheeses.

During the ripening process some NSLAB may metabolize fatty acids and amino acids. Carbohydrates liberated from glycoproteins during proteolysis may also be used as a source of energy by NSLAB.

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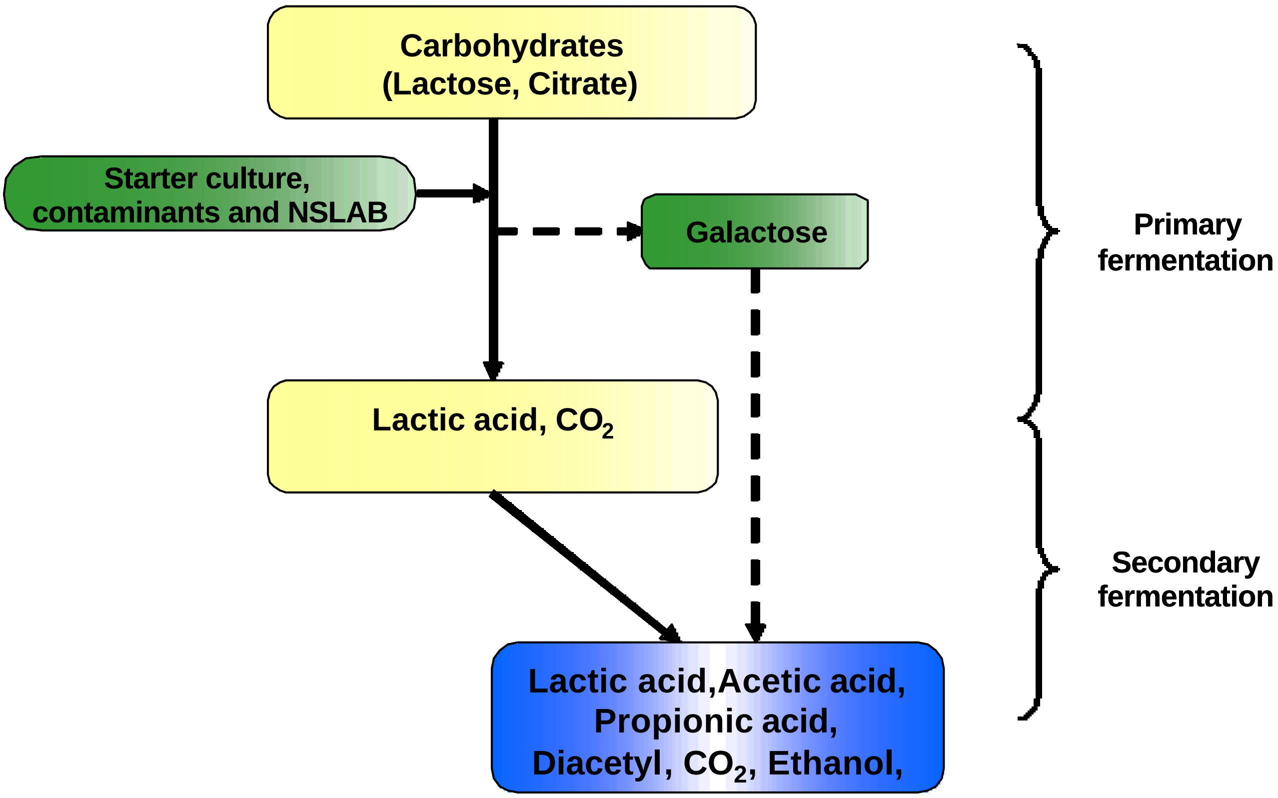
The catabolism of milk carbohydrates can be summarized as follows:



Transformation of carbohydrates during cheese ripening

MODES OF RIPENING

Cheese ripening basically consists of modifying cheese constituents as described, irrespective of how such modifications have taken place. In cheese ripening terminology, however, cheese ripening is usually divided into interior or surface ripened cheese. Surface ripened cheese is divided into smear- and mold-ripened cheeses.

This subdivision does not have clearly defined boundaries, however. Interior ripened cheeses mainly consist of cheeses that are wrapped or packed after manufacture in a way that excludes oxygen from the cheese surface and preserves the conditions on the cheese surface the same as those existing in the interior of the cheese.
Typical examples of interior ripened cheeses are cheeses that are either submerged in brine and stored in barrels, tins or airtight carbon cartons or cheeses that are wrapped in plastic foil directly after production and stored in this way, like rindless varieties of Continental cheeses.
Surface ripened cheeses are all interior ripened as well.

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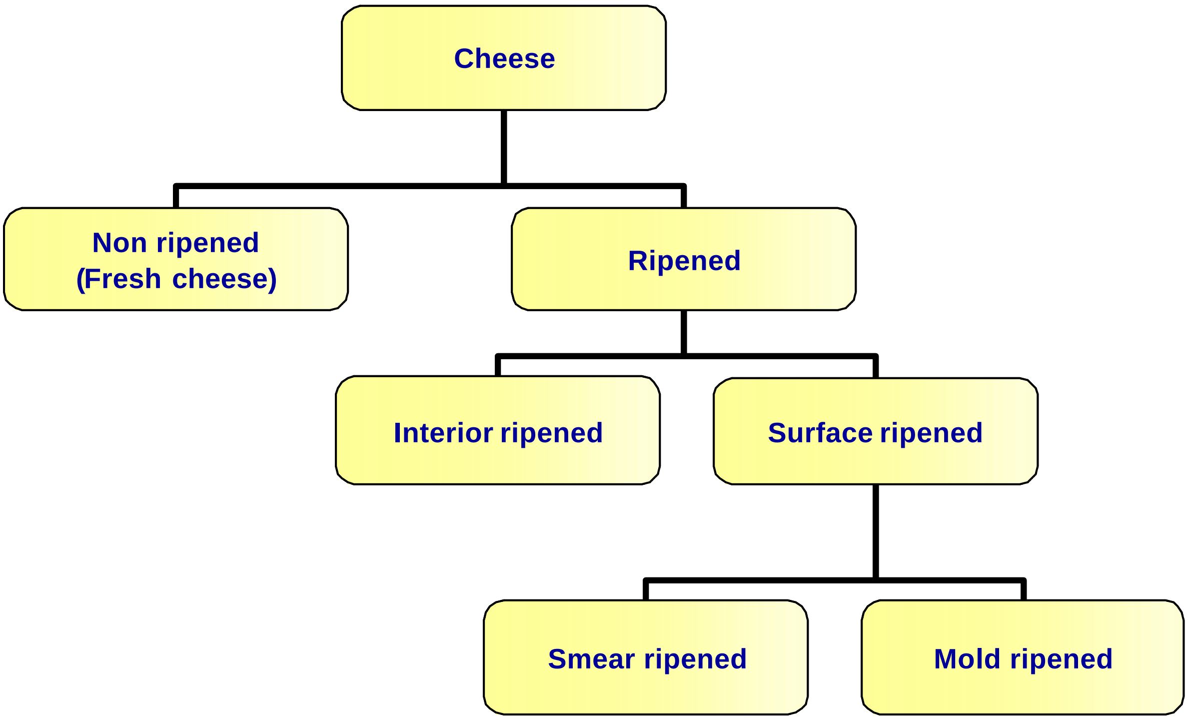
The following diagram groups cheeses according to their mode of ripening:



Types of cheeses in relation to ripening

Interior ripening

Except for some fresh cheese varieties all cheeses are subject to a ripening process by which the cheese constituents are modified or degraded through the action of indigenous milk enzymes, added enzymes and enzymes of microbial origin. Chemical modifications take place in certain cheese varieties (primarily blue vein cheeses). Generally they are rare due to the reducing milieu in most cheeses.

Surface ripening

Over and above the general interior ripening many cheeses are subject to surface ripening.
Surface ripening may again be divided into smear ripened cheeses and mold ripened cheeses.
In this context blue vein cheeses are considered as surface ripened as the mold growth inside the cheese is due to a needle punctuation of the cheese that opens the cheese interior to air and oxygen.

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GENERAL FACTORS AFFECTING CHEESE RIPENING

Microbial quality of the milk

The microbial quality of the milk can affect the ripening of the cheese in several ways.
The degree to which contamination of the milk affects the ripening depends not so much on the amount of contamination but rather on the type of contamination.

Contamination with lactic acid bacteria is not usually a problem. In many cases it is an advantage as it suppresses other contaminants from developing in the cheese. Even though the majority of such microorganisms are killed or inactivated during heat treatment, the few that survive play an important role in the ripening process. Mesophilic lactobacilli seem to be especially important as secondary flora participating in cheese ripening.

The type of contamination that should cause concern for cheese ripening is that from so-called psychrotropic microbes such as Pseudomonas and Alcaligenes. These microorganisms are easily killed by pasteurization, but they produce extremely thermoresistant lipolytic and proteolytic enzymes that are not affected.

Even if it has been shown that cheddar cheese produced from sterile milk does not develop the characteristic full flavor, good hygiene is important to ensure stable quality of cheeses. A certain population of NSLAB is undoubtedly necessary to ensure proper ripening of the cheese.
The problem is to control this flora in relation to both quantity and composition. Cheese parameters like pH, moisture, salt and temperature during ripening seems to a great extent to be able to control the balanced development of the secondary flora during ripening. However the risk that a false flora develops and jeopardizes the cheese quality is too great, and modern dairy plants prefer to control the process as far as possible by adding adjunct cultures during manufacture.

Cheese Storage room

Another significant factor in controlling all parameters in the cheese ripening process is the importance of being able to develop the organoleptic properties of the cheese in a specific direction.

Indigenous milk enzymes

Milk contains more than 30 different enzymes. Many of these are of no importance in relation to cheese ripening but the lipolytic and proteolytic enzymes may play a role depending on the treatment of the milk prior to cheese manufacture.

In cheese made from raw milk the indigenous enzymes (lipase and proteases) play a decisive role. In fact the indigenous enzymes are the main reason for the organoleptic differences between cheese made from raw milk and cheese made from pasteurized milk.

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In cheeses made from pasteurized milk most enzymes are inactivated, but even small amounts of enzymes remaining after heat treatment may play a role, as cheese ripening is a long-term process.

Adventitious microflora

The microflora of cheese milk reflects the one prevailing at the production site. The level of hygiene at the production site and during handling and storage of the milk determines the microbial load of the contaminating flora.

In raw milk the adventitious flora may be quite dominant and even contain pathogenic and/or potentially pathogenic bacteria.
In pasteurized milk, the pathogens should be killed off if a correct pasteurization temperature has been used. 71.7°C for 15 seconds is usually considered sufficient to kill off pathogens.

In blue vein cheeses pasteurization is usually carried out at a lower temperature to preserve some of the indigenous milk lipases. In such types of cheese pathogens may survive, but usually the low pH and high salt concentration in these cheese types causes the pathogens to die out long before the cheese is consumed.

In fresh cheese types and soft cheeses where water activity and pH are high there is a risk that post pasteurization contaminants and eventual survivors may multiply. Generally however pathogens usually cause no problems in semi-hard, hard and very hard cheeses.

Psychrotrops, coliforms and other microbes belonging to the potential pathogenic group may play a role in relation to cheese ripening if they have had the opportunity to produce thermoresistant enzymes in the milk or cheese before they are killed off. Usually adventitious microorganisms of importance to cheese ripening belong to the NSLAB.

NSLAB mostly belong to micrococcus, enterococcus and lactobacillus, but usually those that multiply during cheese ripening belong to the group of mesophilic lactobacilli such as *L. casei*, *L. paracasei*, *L. plantarum*, *L. buchneri* and *L. fermentum*. They may be defined as “contaminants that are able to grow in the cheese”.

Thermophilic lactobacilli are not so common and seem to die out during cheese ripening.

Mesophilic lactobacilli usually reach counts of about $10^8 – 10^9$ cfu/g in 3-month old cheeses.

The hygienic standard at the production site of course plays a role in the development of this secondary flora of NSLAB, but the influence of hygiene is not as great as could be expected. Furthermore the influence of pasteurization seems to be smaller than might be expected. Factors like ripening temperature affect the growth rate of the NSLAB but also seem to play a minor role in determining the final count of these bacteria in the cheese.

The sources of NSLAB vary, but some originate from the farm environment and some from the dairy plant.

There is evidence that NSLAB are able to develop in plate heat exchangers during prolonged operation times.

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NSLAB play an important role in flavor development of ripened cheeses.

Yeast, mold and aerobic microorganisms contaminating the surface of the cheese also belong to the adventitious flora. For some types of cheese such contaminants may cause serious problems as they may be pathogenic. Examples are contamination of soft cheeses with *E. coli*, *Salmonella*, *Campylobacter* or *Listeria monocytogenes*.

Listeria monocytogenes is a particular problem because it is aerobic and both acid and salt tolerant. Listeria comes from the surroundings. It is nearly always a post contamination, which is why pasteurization often has a limited effect in combating listeria. Smearing equipment is often the source of contamination for surface ripened cheeses.

Mechanical treatment of the milk

Mechanical treatment of the milk may affect it and the cheese produced from it in several ways. Most importantly the fat phase of the milk may be mechanically damaged during transportation and pumping, especially if such treatment takes place at temperatures where the milk fat is partially crystallized.
Damaging the fat phase makes the fat accessible to the indigenous as well as any microbial lipases present in the milk causing lipolysis and liberation of free fatty acids. The free fatty acids themselves contribute flavor to the cheese and disturb the fermentation process by inhibiting many of the starter microorganisms.

Mechanical treatment of the milk may also cause a mixing in of air, which stimulates the psychrotropic flora and inhibits the lactic flora. Mixing in of air may cause oxidative changes in the milk that may affect cheese quality.

Water content

Water content or more specific water activity is a major parameter affecting cheese ripening. Water activity (together with temperature and pH) is a decisive factor that determines the speed of ripening. The water activity determines the activity of different microbes in the cheese as well as affecting the activity of the various enzymes.

Metabolites formed during ripening depend on the water activity. Some metabolites act as further accelerators while others act as preservers.
In soft cheeses the majority of microbes present in the cheese, whether added or indigenous, are able to multiply. Protein degradation is extensive and the formation of protein degradation products increases the pH. This will further accelerate the protein degradation and stimulate excessive growth of the proteolytic part of the adventitious flora. As a consequence, soft cheeses mature very fast and their shelf life is short compared to other types of cheeses with lower water activity.

There is a continuous change in the way the cheese ripening proceeds as water activity changes. The other extreme is the hard type cheeses like Grana, Gruyère, Ementhaler etc., which have shelf lives up to several years.

The low water activity in these hard cheese varieties limits the microbial flora to a few species of non-proteolytic sugar fermenting (saccharolytic) microorganisms. The proteolytic microorganisms are not able to grow under these conditions and the saccharolytic microorganisms ensure the production of sufficient organic acids to preserve the cheese further.

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The influence of the water activity mentioned above on the ripening course is decisive for the differences in organoleptic characteristics between cheeses.

Apart from consistency, soft cheeses are characterized by having a flavor dominated by excessive protein degradation – often characterized as sharp, sulfuric, putrid and ammoniac.

Cheeses with moderately low water activity, like Continental cheeses and Cheddar are characterized by having a more acid mellow flavor derived from a balanced activity of proteolytic, lipolytic and saccharolytic enzyme activity.

Hard cheese varieties are characterized by a sweeter and nuttier flavor reflecting the fact that saccharolytic activity is dominant. The formation and transformation of various organic acids, ketones and esters are characteristic for these cheese varieties.

pH

pH and water activity are in a way complementary parameters. During the fermentation of the milk in the vat, the pH is decisive for the water content of the fresh cheese. The water content of the fresh cheese on the other hand influences the final pH of the cheese due to the residual lactose that is proportional with the water content. This may, however, be regulated to a great extent through the dilution that takes place during scalding.

The pH in fresh cheese determines the types of microorganisms that are able to multiply and regulates the activity of the various enzyme activities.

Salt

The salt concentration in the cheese influences cheese ripening. Salt affects the ripening by lowering the water activity in the cheese. If salt is added to the cheese milk or if the curd is salted as in Cheddar cheese, the salt makes the cheese bind more water (whey), which again may give a lower pH in the cheese. The major effect of sodium chloride is that it affects the activity of the various enzymes in the cheese.

Many enzymes increase their activity with increasing sodium chloride content up to about 3% in the water phase, but the effect may vary widely for different enzymes.

Generally speaking salt may result in a lower activity of the starter bacteria relative to the activity of the rennet enzyme.
Salt may therefore slow down ripening speed and give rise to a bitter taste.

Maturation temperature

Maturation temperature is probably the single factor that affects cheese ripening the most. By raising or lowering the temperature, ripening can be accelerated or halted.

The problem in using the ripening temperature as a parameter for controlling cheese ripening is that it is very hard to control the ripening at elevated temperatures. This, together with the great variety in

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temperature optima for the various enzymes, has until now made it more or less impossible to use the temperature parameter to control cheese ripening.

A major problem is that total proteolysis increases much more than the peptidolysis and post amino acid formation of flavor compounds.
This often results in the cheese flavor developing in an unbalanced way. Most often the cheese more or less decomposes with the excessive formation of putrid amines and bitter peptides.

Usually the gross proteolysis is not the limiting factor in developing a full flavor cheese during ripening. The peptidolytic activity and the post amino acid conversions seem to be decisive for the development of a high quality taste and flavor.

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EFFECT OF CHEESE MANUFACTURING INGREDIENTS

Throughout the years research into cheese ripening has resulted in a far greater understanding of the parameters influencing ripening. The effects of the coagulant, the starter and surface cultures especially are better understood.
Briefly the influence of coagulant and starter cultures used in cheese manufacture is as follows:

Coagulant

In most cheese varieties a coagulating enzyme is used to transform the milk into a cheese curd. In the West calf rennet is the most common coagulant but in other parts of the world vegetable coagulants like papain have been used as cheese coagulants. In recent years microbial coagulants have been used for many cheese varieties. The most recent is Chymax®, chymosin produced by fermentation, which is increasing its market share.
Choice of coagulant is important in relation to ripening.

Normal calf stomach rennet mainly contains chymosin that has low proteolytic activity and primarily splits the bonds between the amino acids phenylalanine and methionine in κ-casein. Due to its low proteolytic activity calf stomach chymosin produce few bitter peptides. The proteolysis is fairly slow and easy to control.
With a proper starter culture it is possible to produce a mild cheese with a very pure flavor.

Calf rennet, however, contains varying amounts of pepsin, depending on the age of the calf when slaughtered. Today the content of pepsin in modern rennet preparations is standardized. Generally, the greater the amount of pepsin the stronger and less specific is the proteolysis and the more important it is to compensate for this excessive proteolysis with an appropriate starter or a special “ripening” culture to ensure balanced ripening.

Microbial coagulants are produced in a fermentation process. Usually molds like *Mucor miehei*, *Mucor pusilus*, *Fusarium* or *Endothia paracitica* are used, but microorganisms like Bacillus may also be used.

Microbial coagulants are the most unspecific and strongest coagulants. They usually result in lower cheese yields and the cheeses are liable to become bitter.
Ripening preparations may to a certain degree remedy the problems with bitter taste but the decreased yield is a problem that limits the popularity of microbial rennet. Price versus lower yield is one of the parameters that are decisive for whether or not to choose microbial rennet.
Vegetable rennet like papain has the same disadvantages as those mentioned for microbial rennets and they are rarely used today.

Chymax® produced through fermentation is the most well defined coagulant. It can be used as pure chymosin for producing mild cheeses or be added in a specified amount of pepsin if stronger proteolytic activity is required.

The variety of coagulant used is often related to the cheese type and the starter culture used – eventually it may be possible to achieve the required flavor profile and consistency by using different combinations of coagulant, starter and cheese ripening ingredient (Cheese ripening strains or flavor improving cultures).

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Starter culture

Choice of starter is critical in cheese manufacture. A good starter should be:

- Fast.
- Resistant towards bacteriophages.
- Contribute the right organoleptic characteristics to the cheese during ripening.

These basic requirements are contradictory because high fermentation speed requires a high degree of proteolytic activity in the culture to supply sufficient nitrogen in molecules with low molecular weight for growth.
High proteolytic activity means most often an unbalanced ripening leading to an accumulation of bitter peptides.

Phage resistance pulls in the same direction as many phage resistant strains are resistant to autolysis and therefore do not easily release peptidases into the cheese. As a consequence bitter peptides are not removed and further degradation to amino acids and post amino acid aromatic compounds is slowed down. The cheese becomes bitter and sour with no flavor.

The remedy is to use a mixture of starter strains that has a balanced proteolytic and peptidolytic activity and to choose a coagulant that is not too proteolytic.
The problem with this is that fermentation stability is impaired and the ripening speed is slowed down.

The remedy is to compensate for the lack of peptidolytic activity by using special cheese ripening cultures that only contribute peptidolytic capability without influencing the make process.

Chr. Hansen has put a great deal of effort into developing various ripening cultures that do not disturb the make process but which contribute specific proteolytic and peptidolytic enzymes. The various ripening cultures are tailor made for flavor profile and cheese variety. They may be used singly or in combination. For detailed information please consult the ripening cultures brochure.

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