Sveriges lantbruksuniversitet
Swedish University of Agricultural Sciences

Faculty of Natural Resources and Agricultural Sciences
Department of Food Science

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– Their origin and importance for cheese production

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– Dess ursprung och betydelse för ostproduktionen

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Sammanfattning

Mikrofloran i mjölk har många olika funktioner som påverkar ostens slutliga kvalitet. Det finns en lång tradition av att tillverka ost och länge har man gjort ost utan att tillföra extra bakterier. Syftet med detta arbete är att sammanfatta hur mjölkens naturliga bakterieflora påverkar ostens kvalité och att jämföra skillnader mellan ostar tillverkade av opastöriserad mjölk och ostar gjorda av pastöriserad mjölk. Detta sker genom sammanställning av litteratur som berör ämnet. Resultatet av denna litteraturstudie visar att det finns många olika bakterier som kan existera i mjölk och dessa kan påverka osten på olika vis. Dessa bakterier inkluderar: lactobacillus, lactococcus, streptokocker, leuconostoc, enterokocker, propionsyra bakterier, klostiridier och psykrotrofer. Dessa bakterier kan komma från en stor variation av källor: från den omgivande miljön, utfordringen av djuret eller från djuret själv. Dessa bakterier påverkar osten på olika vis. De kan bidra med positiva effekter såsom förbättrad smak, textur och aromer men även negativa effekter så som oönskade smaker och defekter t.ex gasbildning. Eftersom de flesta av bakterierna dör under pastöriseringen uppstår skillnader mellan ostar gjorda på opastöriserad respektive pastöriserad mjölk, framförallt i form av smakskillnader. Opastöriserad mjölk har ofta en starkare, mer karaktäristisk smak men det finns risker att patogener, som kan vara hälsoskadliga och i vissa fall till och med dödliga, kan finnas i mjölken. Ost tillverkad av pastöriserad mjölk har däremot inte samma intensiva smak utan, generellt sett, en mildare smak. Pastöriserad mjölk resulterar i ost som även är mer säker eftersom patogener är eliminerade. Ostar gjorda på pastöriserad mjölk blir även mer uniforma då man kan kontrollera exakt vilka bakterier som tillsätts vilket ger samma resultat mellan ystningar. Det är trots detta svårt att säga vilken ost som är den bästa. Allt beror på vad som vill uppnås med osten och vad konsumenten vill ha - något som kan variera beroende på vilken kultur man befinner sig i.

Nyckelord: Mikrobiota, mjölksyrakultur, mjölk, ost, ostproduktion, pastörisering, opastöriserad mjölk, ostkvalité, ostmognad.

Abstract

The microflora in milk has various different functions that affect the quality of the cheese. The tradition of making cheese is very old and for most of that time cheese has been made without adding bacteria. The aim of this essay is to summarize how the natural bacteria in the raw milk affect the quality of the cheese and to compare the differences between raw milk cheeses and pasteurized milk cheeses. This was achieved by studying literature on the subject and concluding the gathered data. The results show that various bacteria that can grow in milk may affect the cheeses in numerous ways. The ones mentioned are: lactobacillus, lactococcus, streptococci, leuconostoc, enterococci, propionibacteria, clostridia and psychrotrophic bacteria. These bacteria originate from various sources; for example, from the surrounding environment, the feed of the animals and from the animal itself. These bacteria may affect the cheese in numerous ways. Firstly, they can affect the cheese positively: e.g. by improving taste, texture or aroma. Secondly, they can also affect cheese negatively: e.g. giving rise to unwanted taste and defects like gas blowing. Due to these bacteria being killed during pasteurization there is a difference between raw milk cheese and pasteurized milk cheese, mainly in taste. For example, raw milk cheeses generally have a more distinct flavor but they also come with the risk of having harmful or even deadly pathogens in them. On the contrary, pasteurized milk often has a milder taste. Furthermore, there is also a higher degree of uniformity between batches due to the fact that the microflora in them is consistent, and therefore gives similar results each time. To conclude, it is difficult to determine which type of cheese that is optimal. It all depends on the purpose of the cheese and the preference of the consumer - something that can be heavily influenced by culture.

Keywords: microorganisms, milk cultures, milk, cheese, cheese production, pasteurization, raw milk cheese, cheese quality, cheese ripening

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1 Introduction

1.1 Background

The making of cheese is an old traditional method to conserve milk. For many hard cheeses, including Cheddar, Swiss cheese and Gouda, the ripening is dependent on the activity of microorganisms (Cogan, 2011). Sometimes these bacteria originate from the milk itself. The composition of bacteria that exist in raw milk is complex and can vary greatly depending on different factors. Additionally, there are different kinds of natural raw milk bacteria that can affect the cheese in different ways, both positively and negatively. Many of these bacteria are killed during pasteurization. Pasteurization is the process of heating milk to the point where most bacteria is killed, apart from the spore creating bacteria (Nationalencyklopedin, 2016).

The most common way to make cheese today is through the use of pasteurized milk. Since bacteria have been killed in the process, starters are added to replace the desired bacteria that have been lost. The composition of these starter bacteria varies depending on what kinds of traits that are sought after in the final product. For example, cheese that is made from raw milk contains numerous bacteria that have a larger variation in effects on the finished product. This work will mainly focus on these bacteria and what they contribute with, but also the difference between raw milk cheeses and pasteurized milk cheeses.

1.2 Aim of the study

To understand differences between raw milk cheese and pasteurized milk cheese it is important to know the microflora of the milk and how these bacteria affect the cheese. This essay means to conclude how bacteria may affect the cheese quality. The focus lies on the bacteria that exist in the milk and can survive in the cheese but also the differences between raw milk cheese and cheese made from pasteurized milk. This essay will not cover mold or fungi. The primary questions this essay seeks to answer are:

- What affects the microflora of milk?
- Where do these bacteria originate?
- What types of bacteria can be found in milk?
- How do they affect the cheese?

2 Method

This is a literature study where most of the content comes from databases that are listed at the SLU library webpage. For example, Google Scholar has been used amongst other databases. The following words were used in the search: microorganism/ microbiology/ culture/ nonstarter microorganisms/ lactic acid bacteria/ microbiota. Milk / raw milk / non pasteurized milk/ unprocessed milk. Quality/ texture/ taste. Cheese/ cheese ripening. By the use of these sources a conclusion was made and summarized in this essay.

3 Bacteria that are important for the quality of cheese

3.1 Bacteria in milk

Milk has a very high nutritional value and can therefore support a large variation of microorganisms that may affect the quality of the cheese (Quigley et al., 2013). Raw milk in itself contains a wide spectrum of microorganisms (Vacheyrou et al., 2011). Some of the nutrients in milk are easily available for the microorganisms from the beginning, while others are provided as a result of metabolic processes of different microorganisms (Quigley et al., 2013).

3.1.1 What affects the microflora of milk and where do the bacteria originate?

The microflora that can be found in milk can come from a big variation of sources. This can be both from plants and animals as long as they are able to adapt to the environment in the milk (Quigley et al., 2013). For example, one factor that has been observed to affect the microflora of the milk is whether the animal has been fed outdoors or indoors. The concentration of *Staphylococcus spp.* was found to be higher if the animal was fed outdoors rather than indoors. Other factors that can affect the microflora of the milk include the type of environment that the animal lives in (Bonizzi et al., 2009) and the lactation stage of the animal (Callon et al., 2007). Furthermore, microorganisms can also originate from the digestive tract of animals and find their way to the milk through contact with feces (Quigley et al., 2013). Another factor that has been found to affect the microflora is the pH of the cheese. The closer the pH was to 7.0, the higher the total count of bacteria in the cheese (Lindhagen and Lundberg, 2011).

3.1.2 What type of bacteria can be found in milk that affect the cheese fermentation?

The most common type of bacteria that is discussed when it comes to fermentation of milk is LAB (Lactic Acid Bacteria)(Quigley et al., 2013). These are gram positive, acid tolerant and strictly fermentative cocci and bacilli (Broadbent et al., 2011). The LAB's major function in the cheese is to produce lactic acid from lactose thereby decreasing the pH of the cheese curd (Cogan, 2011). Cow milk contains a large population of LAB. This includes: *Lactobacillus, Lactococcus, Streptococcus*, *Leuconostoc* and *Enterococcus* (Quigley et al., 2013). These will be discussed in their own chapters.

LAB are often used as starter bacteria; however, most of these bacteria also exist in the milk naturally. LAB that are not added as starters are often referred to as NSLAB (nonstarter lactic acid bacteria). They are mainly facultatively heterofermentative. In addition, they can also be salt and acid tolerant (Cogan, 2011). Therefore, they are able to adapt to the environment in the cheese during ripening even when the nutrients are reduced and the pH and moist levels are low (Cogan, 2011). Consequently, they are found in almost all cheeses that have been ripened for a longer period of time (McSweeney, 2011). The diversity of NSLAB can vary greatly. The composition is difficult to control and can be affected by various factors such as if the milk has had some kind of heat treatment (Broadbent et al., 2011). NSLAB are often found in cheese naturally or in milk that has been recontaminate in the factory where the cheese is produced. In addition, there are also NSLAB that can survive pasteurization (Cogan, 2011).

In the process of cheese ripening, the number of NSLAB is often low in the beginning but then rapidly grow within the cheese during the ripening process (Cogan, 2011). For example, pH, moisture level and salt content have been shown to affect the growth rate of the NSLAB in Cheddar cheese. Also, the growth rate seemed to be independent on the concentration of residual lactose content (Broadbent et al., 2011). Since some NSLAB are difficult to control in the making of cheese and their presence may cause variability in quality between different cheeses, adjunct cultures may be added to keep the unwanted NSLAB under control (Broadbent et al., 2011). When it comes to their contribution to the cheese, parts of NSLAB metabolic pathways are a bit unclear since they can survive in the cheese, even though all lactose has been used (Cogan, 2011). NSLAB also die off more slowly than starter bacteria (Cogan, 2011).

NSLAB can affect the cheese taste in three different ways. Firstly, they can amplify an already existing taste. Secondly, they can contribute with a non-typical (although still wanted) taste for that cheese. Lastly, they can contribute with unwanted flavors. These types of influences are generally called neutral, positive, or negative influence (Broadbent et al., 2011).

During cheese ripening different compounds are formed that may affect the cheese positively. All LAB are able to degrade proteins and lipids in milk and therefore produce various end products that contribute to the final taste, aroma and texture of the cheese (Quigley et al., 2013). Their proteolytic abilities may be weaker than the abilities of other microorganisms but still contribute to the cheese (McSweeney, 2011). For example, they produce diacetyl (butter flavor), ethanol (fruit taste) and lactic acid isomers that impact on the acidity of the cheese. Furthermore, they do contribute to the cheese by the formation of amino acids (McSweeney, 2011).

There are strains that produce compounds that may affect the cheese negatively. Two known unwanted LABs are *Lactobacillus brevis* and some subspecies of *Lactobacillus casei* (Christiansson, 2003). Some heterofermentative lactobacilli can even cause the production of late gas production in cheddar type cheeses. This is due to that these bacteria produce CO_2 from galactose or lactose during the ripening process. *Lactobacillus brevis* and *Lactobacillus fermentum* are example of a gas producing bacteria. They are rarely present in cheese that has been made from pasteurized milk but can be a common bacteria found in raw milk cheeses (Sheehan, 2011). Another defect that bacteria may cause in the cheese is the formation of crystals of calcium lactate that may resemble the appearance of mold (Broadbent et al., 2011).

One type of compounds that affects the cheese quality greatly is amines. These are produced by strains with decarboxylases that, together with amino acids, produce the amines (McSweeney, 2011) in raw milk cheeses (Bachmann et al., 2011). For example leucine, isoleucine and valine give the cheese a wide variation in flavor compounds such as various acids, aldehydes and alcohols which gives the cheese a more complex taste (Broadbent et al., 2011). Additionally, volatile amines may also contribute to the cheese with fruity and alcoholic flavor notes. However, there are also unwanted defects. For example, triethylamine has a fishy odor (Le Quéré, 2011). There are also tyrosine, histidine, and tryptophan amines that are called biogenic amines that in high concentrations may cause serious physiological effects (McSweeney, 2011) What kind of amines that are produced is dependent on the NAD^+/ NADH equilibrium (Broadbent et al., 2011).

3.1.3 *Lactobacillus*

Lactobacilli are usually found in carbohydrate rich environments which includes raw milk (Quigley et al., 2013). They may recontaminate the milk through contaminated equipment, biofilms or personnel (Sheehan, 2011). In most cases, they are isolated from raw milk. However, in cheese production, where the cheese is made from pasteurized milk, special lactobacillus strains are added to ensure that the ripening is completed and to compensate for the bacteria lost due to pasteurization (Broadbent et al., 2011). Moreover, some of the *Lactobacillus* can survive pasteurization (Jordan and Cogan, 1999). These are mainly the aerobe lactobacilli but it is the facultative anaerobe bacteria that can grow in the anaerobic cheese (Christiansson, 2003). Mesophillic lactobacilli can also grow during the ripening process in pasteurized long-ripened cheese since they also can survive the pasteurization (McSweeney, 2011). Some of these can become the dominant microorganism during the ripening of cheese (Henri-Dubernet et al., 2008).

Strains belonging to the lactobacillus genera that are important for cheese production are: *Lactobacillus helveticus*, *Lactobacillus delbrueckii ssp. bulgaricus* and *Lactobacillus delbrueckii ssp. lactis* (Naser et al., 2006). *Lactobacillus helveticus* was isolated from an Emmentaler cheese in 1919 (Naser et al., 2006) and has various traits which makes it effective to use when producing cheese. This includes production of intracellular enzymes providing increased taste of bitterness and a prominent typical cheese taste (Quigley et al., 2013).

3.1.4 *Lactococcus*

The genus *Lactococcus* contains seven species with two subspecies. Of these mainly *Lactococcus lactis ssp. lactis* and *Lactococcus lactis ssps. cremoris* may be located in cheese that is made from unpasteurized milk. Many other lactococci are commonly used as starter bacteria (Quigley et al., 2013). Generally, they lack virulence genes that gives them GRAS (Generally Regarded As Safe) status (Wegmann et al., 2007).

Among lactococci there are several strains that may affect the cheese. For example, *Lactococcus lactis* is often included in starters to produce diacetyl, acetoin, 2,3-butanediol, and CO_2 that contribute to the final quality of the cheese (McSweeney, 2011). Some citrate-positive lactococci can also give the cheese early gas defects. For example *Lactococcus lactis cremoris* may lead to early gas defects through the production of CO_2 from citrate (Sheehan, 2011). Another example of a lactococci is *Lactococcus raffinolactis* that may be present in raw milk, but is normally not used in the dairy industry due to its lack of caseinolytic activity (Holler and Steele, 1995).

In the cheese, lactocooci help to produce sulfur in the cheese that is a compound that is more common in raw milk cheeses (Bachmann et al., 2011). Sulfur originates from methanethiol and is associated with the cheese and garlic aroma that is typical in, for example, Cheddar and Limburger (Le Quéré, 2011).

3.1.5 Streptococcus

The genus *Streptococcus* include 97 species and 17 subspecies (Quigley et al., 2013). Some of these are heat-resistant and can grow at temperatures up to 45C°, including the ability to survive pasteurization (Sheehan, 2011). Hence, they exist in cheese made from pasteurized milk (Christiansson, 2003). The streptococci give the cheese an unclear and yeasty flavor (Sheehan, 2011).

One example of a *Streptococcus* that can grow in milk is *Streptococcus thermophilus*. This bacteria is one of the heat resistant streptococci that can survive pasteurization. Gouda cheese made with milk containing 1 million *S. thermophilus* /ml can have a concentration up to 100 million – 1 billion/g Streptococcus thermophiles (Christiansson, 2003).

3.1.6 Leuconostoc

Leuconostoc include 23 species and 4 subspecies. *Leuconostoc* is not a group commonly found in milk; however, there are some species that can be found in milk. Most common are the species *mesenteroides* and *pseudomesenteroides*. These bacteria do not survive pasteurization but can grow in raw milk cheeses where they produce CO_2 gas that may give eyes in the cheese (Quigley et al., 2013).

3.1.7 Enterococcus

Enterococci are commonly found in raw milk cheeses and often originate from the intestines of the animal (Lindhagen and Lundberg, 2011). Another common way for these bacteria to enter the milk is through the milking facility (Gelsomino et al., 2002). Therefore, enterococci are a major component in the natural cultures that are involved in raw cheese fermentation. They contribute to the ripening of the cheese and also the taste and texture of the cheese (Foulquié Moreno et al., 2006). Also, it has been discussed that they may have some probiotic abilities in the cheese (Cogan, 2011). However, some strains may be pathogenic and are therefore not wanted in the cheese (Cogan, 2011). Although they are more common in raw milk cheeses, they can also be found in cheese made from pasteurized milk since some strains can survive the heat of a pasteurization (Cogan, 2011).

Cheeses that are produced in southern Europe often contain a higher number of enterococci. Additionally, they can be added via starters that are used for traditional cheese making if they are not already present in the milk. Therefore, they may in some cases be considered starter bacteria (Cogan, 2011). Examples of enterococci that can be found is cheese are: *Enterococcus faecalis, Enterococcus faecium, Enterococcus durans, Enterococcus italicus* and *Enterococcus mundtii*. *Enterococcus faecalis* and *Enterococcus Faecium* are the most common of these (Franciosi et al., 2009).

3.1.8 Propionibacterium

Propionibacterium (PAB) include 2 different groups. The first one is the 'acnes group' that is commonly found on human skin. The second group is the dairy or classical propionibacteria (Quigley et al., 2013) and these are naturally occurring in milk (Grappin and Beuvier, 1997). The dairy propionibacteria group contains four species: *Propionibacterium freudenreichii, Propionibacterium acidipropionici, Propionibacterium jensenii* and *Propionibacterium thoenii* (Quigley et al., 2013).

Propionibacterium can grow in cheeses with low acid content and low salt content and the growth rate of these bacteria increase with the ripening temperature (Sheehan, 2011). In the cheese they ferment lactic acid and produce propionic and acetic acids (Cogan, 2011; Sheehan, 2011). *Propionibacterium* therefore play an important role in cheese ripening. They create the typical sweet, nutty taste in Swiss-type cheese and can also contribute with late gas in the cheese (Sheehan, 2011) due to CO_2 production (Cogan, 2011), which also is typical for Swiss-type cheese. They can also grow in Gouda cheese types with the same result of eye creation, although in Gouda these eyes are not wanted (Sheehan, 2011).

Propionibacterium freudenreichii is used as a starter in Swiss-type cheeses. It was isolated from Emmental cheese and gives the characteristic cheese holes and contributes with flavor (Quigley et al., 2013). It can be present naturally in the cheese but nowadays it is added to the milk via starter cultures (Cogan, 2011).

3.1.9 Clostridium

Clostridium are anaerobic spore forming bacteria which can originate from silage (Sheehan, 2011). In some cases, it is forbidden in Switzerland to feed silage to the cows whose milk is going to be used to produce milk since it is a potential source of *Clostridium* (Cogan, 2011).

In the cheese clostridia spores may develop to vegetative cells that ferment lactate and produce acetic and butyric acids, CO_2 and H_2 (Sheehan, 2011). The butyrate causes off flavor in the cheese (Cogan, 2011). The gas may cause defects, i.e. late gas blowing. This appears as cracks in the cheese, or in extreme cases, as bursting (Sheehan, 2011). Low pH of the cheese however inhibits growth of the larger part of the clostridia. There are, however, some bacteria, that can survive this conditions. For example can *Clostridium tyrobutyricum* survive in this environment and grow in cheese (Jordan and Cogan, 1999).

Clostridium tyrobutyricum, Clostridium butyricum, Clostridium beijerinckii or Clostridium sporogenes may be responsible for different types of defects in the cheese. Swiss-type cheeses are especially sensitive to these bacteria since they have a higher ripening temperature and a low concentration of salt and acid (Sheehan, 2011).

3.1.10 Psychrophic bacteria

Another group of bacteria that is common in milk is psychrotrophic bacteria, which can survive colder temperatures. If allowed, they can reach up to 10^6–10^7 CFU g^{-1} in cheeses (Quigley et al., 2013). However, the composition of the species in the cheese is often diverse and is seen as an indicator of bad hygiene practice (Quigley et al., 2013). They contribute to the color, odor and volatile compounds of the milk (Quigley et al., 2013).

Coliform bacteria are rod shaped bacteria that is gram-positive, oxidase-negative and non-spore-forming. It may grow aerobically or facultatively anaerobically if bile salts are present. In contribution to the cheese they produce acids but may also give the cheese a defect which gives the cheese taste of yeast and through fermentation lactose create CO_2 that gives early gas blowing (Sheehan, 2011). Bacillus, however, can be found in milk since it creates spores. Therefore, a high bacillus number in the cheese is a sign of low cheese quality and they also give the cheese a bitter taste. One example is *Bacillus polymyxa*, which can give unwanted fermentation, but it is rare in cheese since these bacteria may have trouble to grow in anaerobe environments (Christiansson, 2003).

3.2 How do the microorganisms contribute to the cheese?

It is more common to use pasteurized milk when making cheese. Pasteurization is used to kill different bacteria. These include pathogens and spoilage bacteria but it also kills bacteria that normally occur in raw milk that could have contributed to the wanted traits of the cheeses. Therefore, starter cultures are used to replace the lost bacteria. Starter cultures have been modified to contain the wanted bacteria in right correct proportions and are added to the milk to get the desirable cheese traits. Their main role in the cheese is to contribute with desired flavors and aromas, but also with texture (Quigley et al., 2013). Both wanted and unwanted bacteria can survive the pasteurization of the milk and therefore end up in the cheese. These are mainly bacteria that come from the genus *Bacillus* and *Clostridium*, as described above. There are also bacteria that can handle higher temperatures even though they do not create spores. These include *Microbacterium lacticum, micrococcus, Streptococcus thermophilus enterokocus* (Christiansson, 2003).

3.2.1 How is cheese produced?

Cheese is produced by pasteurizing the milk and then standardizing the fat percentage in the milk. Next, starters are added, then rennet to coagulate the curd. The curd is then cut and stirred during heating to induce syneresis and make cheese grains. Whey is removed. The cheese grains are pressed together into the cheese and the cheese is put in a brine to get a protective rind from, for example, dehydration. Finally the cheese is aged for a varying period of time depending of the type of cheese (Nationalencyklopedin 2016). Rennet cheese is matured for at least two weeks up to a maximum of two years (McSweeney, 2011). When raw milk cheeses are made, the spontaneous fermentation of the LAB in the raw milk is used. After this, the cheese is pressed and salted (Bachmann et al., 2011).

The number of LAB that is added as starter is often high in the beginning of the ripening process but decrease during the ripening. NSLAB and other bacteria in the milk will grow and at some point outnumber the added bacteria (Grappin and Beuvier, 1997).

3.2.2 How do the bacteria grow in the cheese? What do they contribute with?

When curd turns into cheese it goes through three different larger changes. Firstly the metabolism of lactose, lactate and citrate, secondly the lipolysis and metabolism of fatty acids and lastly the proteolysis and catabolism of amino acid. Microorganisms in the cheese produce lactose, lactate and citrate through their metabolic pathway. Lipolysis and proteolysis is also performed by enzymes in milk and the microorganisms in the cheese (McSweeney, 2011). However, the metabolism of the residual lactose has to take place twelve hours by the starter bacteria. If fermentable carbohydrates still exist in the cheese these can be used to create unwanted secondary fermentations in the later stages of ripening, affecting the quality of the cheese greatly (McSweeney, 2011). This means that the amount of lactose in the cheese affects the final taste. Low lactose cheese has a cleaner and milder flavor. However, high-lactose cheese has a stronger and more prominent flavor that probably is an effect of the lower pH that can be reached (McSweeney, 2011).

3.2.3 Differences between types of cheeses

The exact composition of bacteria in the milk and their interaction with each other greatly affects the development of the cheese (Quigley et al., 2013). The conditions within the cheese change steadily during the ripening which is dependent on what type of cheese that is in the making. For example, the pH of Dutch- and Swiss-type cheeses increase during ripening to around 5.8, while the pH within cheddar does not differ greatly during the ripening (McSweeney, 2011). When it comes to differences between pasteurized and raw milk cheeses there are no big differences in changes in texture between the cheeses (Bachmann et al., 2011). However, the raw milk cheeses often have a stronger taste than the cheeses that are made from pasteurized milk. (McSweeney, 2011) The cheese also has more intense flavors (bitter, acrid and tart (Enelius and Dahlgren, 2012). Due to this, some cheeses are still made from raw milk. For example, some cheese variations from Europe are only made from raw milk, e.g. Comté, Roquefort and Camemberg de Normandic (Bachmann et al., 2011).

While the microflora in raw milk varies and therefore may give different results between batches, pasteurized milk cheeses have a more uniform taste (Bachmann et al., 2011; Broadbent et al., 2011). The pasteurized milk, however, fails to produce some of the flavors that the raw milk can, but the raw milk cheeses may also have flavors that are unwanted (Bachmann et al., 2011). As a result of this, adjunct cultures are sometimes added to the raw milk to decrease the risk of unwanted microbes in the milk, while still getting the positive effects of using raw milk (McSweeney, 2011). The two factors of raw milk or pasteurized milk and what kind of cheese that is discussed both affect the cheese quality. For example an unpasteurized cheddar is more bitter and more tart, while a pasteurized cheese generally have a more sweet taste (Enelius and Dahlgren, 2012). er, pasteurized milk cheeses may contain fewer pathogens but have a modified biochemistry and microbiology that will also affect the result of the cheese. They also tend to contain more water than the raw milk cheeses. It also may matures earlier due to enhanced enzymatic activity (Bachmann et al., 2011).

3.2.4 Gas defects in cheese

Gas production will impact on the cheeses' texture, e.g, formation of eyes, cracks or holes. How these holes can come to look all depends on the type and amount of gas that is produced: CO_2 or H_2 (Sheehan, 2011), but also at what point during the ripening process they appear. Gas may be split up into two categories: early gas and late gas production (Sheehan, 2011). Early gas appears within the first few days of the ripening, i.e. within 24-48 hours. It can be observed as a high amount of small holes in the cheese curd. It is often a sign that coliforms, yeast or heterofermentative lactic acid bacteria are present in the cheese. It is more often a problem in soft and semisoft cheeses since they have higher pH, shorter ripening time, higher water activity and lower salt concentration, but it may occur in hard cheeses as well (Sheehan, 2011). On the contrary, late gas appears during the later stage of ripening: between a few weeks to 4-6 months of cheese ripening. These kind of holes often appear as a result of *Clostridium tyrobutyricum*, heterofermentative or salt-tolerant lactobacilli, heat-resistant streptococci or propionic acid bacteria (Sheehan, 2011). The impact of gas blowing on the cheese can vary but Swiss- and Dutch-type cheeses are generally more sensitive to gas blowing than other types (Sheehan, 2011). Late gas blowing is especially troublesome in Swiss-type cheeses due to that clostridia can grow in hot environments (Cogan, 2011). The bitter taste is another defect in cheese. It is usually an effect of the presence of short hydrophobic peptides. These are a common quality defect in Cheddar, Gouda, and other internal bacterially ripened cheeses (McSweeney, 2011).

4 Discussion

There are a lot of different bacteria that can be found in raw milk and all of these have different metabolism and different traits that can affect the cheese quality. Even bacteria from the same genus can be quite different, and some might be wanted in the cheese, while others are not. Consequently, it may be difficult to separate the wanted bacteria from the unwanted bacteria as they share a lot of other traits.

It is close to impossible to precisely control the microflora in raw milk. It is possible to influence this by controlling things like hygiene, location and exposure to other microorganisms. However, there are other factors that are more difficult to control. For example, the weather, as different bacteria have different temperature and humidity requirements. The climate where the cheese is made can of course also affect the microflora. It may also be controlled by, as mentioned in the result, controlling the silage of which the animals are being fed and whether they may go outside or not. Nevertheless, there are too many factors to consider to get the exact microflora that is wanted in the cheese just by exposing it to the right elements.

Most of the identified, wanted and common bacteria have been isolated to be used as a starter. These bacteria have then been modified to suit the needs. This is something that should be able to be done for the other bacteria that are considered to be wanted bacteria in raw milk cheeses. This means that if you identify the complex microflora in raw milk, it should be possible to make a typical raw milk cheese by using pasteurized milk and the correct microorganisms.

Today it seems like many of the raw milk bacteria are a bit of a mystery. For example, do they keep on growing even after their main substrate is used up? If that is the case, it is unclear what they live off. This is also an argument as to why it should be hard to make raw milk cheese of pasteurized milk. Furthermore, as discussed previously, this culture is extremely complex and there are probably a lot of small bacteria in the mixture that have not even been identified that contribute to the cheese. This is probably what makes it an extraordinary difficult task to accomplish.

Many of the defects that have been brought up are clear defects, for example the dangerous amines. However, there are some compounds that are created that are seen as defects in some cheeses and as something desired in other cheese types. For example, the gas production that creates holes in the cheese can be seen both positively and negatively. This makes it even more difficult to find the exact composition of the “perfect cheese starter”. Is it really worth not pasteurizing the milk before cheese production, with the added risk of all these pathogens that may end up in the cheese? There are various kinds of dangerous compounds that could be deadly in to larger amounts. Is it possible to be careful enough and keep it clean enough where the milk is being handled, to make sure that bacteria will not contaminate the milk? This is a hard task since bacteria exist everywhere. Also, since milk is such a good medium it allows a wide variety of organisms to grow in it. But if these bacteria later on have the ability to grow in the cheese has also to be considered.

One of the most common things that the costumer wants is that the food they buy tastes the same way every time, especially if the cheese is a staple in their diet and not something more exotic. This would be extremely difficult to achieve with raw milk due to all the different factors that affect the microbial composition of the milk.

Even though pasteurized milk cheese seems like the better choice when it comes to cheese making there are still bacteria that may survive pasteurization and these may become a problem later on in the production. Even if all the microbes in the cheese are identified, and a perfect starter culture is produced, the composition of other things in the pasteurized milk cheese has still change.

For example, more lactose means more taste; which also indicates that even though raw milk cheeses generally taste more, this is not always the case. Also, the fact that different people and cultures want different traits in their cheese might become an obstacle. Some cultures prefer a stronger but a bit unclear taste while others want a more mild taste in their cheese. To put it simply: There is no such thing as the cheese that is perfect for everyone, not a pasteurized one or a raw milk one.

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