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The production of Cheddar cheese

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Abstract

Cheddar cheese is a hard, ripened cheese with a long shelf life and without any surface Flora. It is common in the world due to distinct taste, aroma and flavour. Cheddar cheese was firstly manufactured in the town of Cheddar; England. But now it is manufactured in many parts of the world. Cheddar cheese making is a complicated process including many processing steps and biochemical transformations. Therefore; composition, yield and quality of the cheese are affected. It is produced through acidification then concentration of milk following gel formation with rennet. *Lactococcus lactis subsp. cremoris* and *Lactococcus lactis subsp. lactis* are the main cultures used for cheddar cheese manufacturing in combination for initiating acidification. Other strains of *Lactobacilli* are used for improving the flavour and also to accelerate cheese ripening. Cheddar cheese ripening includes degradation of proteins and fats via enzymatic digestion in addition to the fermentation of lactose.

Introduction

Cheddar is a very popular cheese and is probably one of the most consumed cheese type worldwide (British Cheese Board, 2013, Bylund, 1995). Cheddar has its origin in Somerset in England where it has been produced since the middle ages (British Cheese Board, 2013). The cheese has most likely got its name from the town of Cheddar where originally caves were used to store the cheese during ripening (British Cheese Board, 2013). The caves provided a very good environment for the maturation of the cheese due to the caves humidity and its constant temperature (British Cheese Board, 2013). Nowadays cheddar cheese is produced not only in England but in most parts of the world and the manufacturing technique of the cheese has developed a lot since the production of the early cheeses from the 12th century.

The purpose of this study is to define the main characteristics of cheddar cheese, describe the modern process line of this kind of cheese and also describe how the different unit operations in the process affect the quality of the final product. The report also aims to identify and discuss the critical control points of the product line of cheddar cheese with respect to both the safety and the quality of the product.

Characteristics of cheddar cheese

Cheddar cheese were traditionally produced as large cylindrical shaped loafs with a weight of around 30 kg but nowadays in the modern industrial process the cheese is instead formed into rectangular blocks to facilitate the handling of the cheese (Walstra et al., 2006). A cheddar cheese has a long shelf life and the colour of the cheese may range from white or ivory to light yellow or orange (The Codex Alimentarius Commission, 2013, Walstra et al., 2006). The cheese does not possess any surface flora and are available for consumers to buy both with and without a rind (Walstra et al., 2006, The Codex Alimentarius Commission, 2013).

Cheddar is a ripened cheese that consists of approximately 55% of moisture on a fat free basis (MFFB) which classifies the cheddar as a hard cheese (Bylund, 1995). Due to the use of homo-fermentative starter cultures the cheddar cheese does not possess any gas holes which provides the cheese with a closed structure (Bylund, 1995). The texture of cheddar is firm and

short, in other words the consistency of the cheese is a bit stiff and nearly crumbly (Walstra et al., 2006). There are many factors that affect the consistency of the cheddar cheese. Two of these factors are the production steps of cheddaring and the addition of salt to the cheese curd before the cheese is pressed (Walstra et al., 2006). These two production steps are considered to be very characteristic for the production of cheddar-types cheese and both procedures have an effect on the texture of the cheese (Walstra et al., 2006). The cheddaring affects the structure of the cheese by making the closed structure of the cheese more enhanced due to the removal of entrapped air from the cheese (Walstra et al., 2006). The addition of salt to the cheese curd on the other hand affect the consistency of the cheese as the salt content has an impact on the firmness of the cheese (Walstra et al., 2006). The salt content in a cheddar cheese should be between 1,75-1,95% as a lower salt content gives the cheese too soft consistency whereas a higher salt content gives the cheese too hard consistency (Walstra et al., 2006, Bylund, 1995). The pH is also a parameter that has a clear effect on the texture of the cheddar cheese (Walstra et al., 2006). Traditional cheddar has a pH of around 4,9 but nowadays there are cheddars present with a pH up to 5,3 (Walstra et al., 2006). The higher the pH the softer the texture of the cheese becomes (Walstra et al., 2006).

The taste of cheddar develops during the ripening of the cheese and therefor the flavour of the cheddar cheese is depending on the time of the maturation (Walstra et al., 2006). A cheddar with a short ripening time has a mild creamy taste whilst a more mature cheddar has a more complex slightly nutty flavour (British Cheese Board, 2013).

Unit operation

The manufacturing of cheddar is a quite complex process and it includes many manufacture steps and unit operations, each of them influence the final characteristics of the product. See figure 1 for an overview of the process.

Selection of milk

The composition of the cheese milk determines the property of the cheese especially the content of fat, protein, calcium and pH (Fox et al., 2000).

Pasteurization

Cheddar cheese can be made both from raw or heat treated milk. Cheddar from raw milk develops cheddar flavour soon whereas cheddar from pasteurized milk takes comparatively double time to reach to cheddar characteristics flavour (Fox, 1993). Singh et al., (2003), in their review generalized that pasteurized milk prior to acidification influence proteolysis during cheddar cheese ripening.

For Cheddar Cheese heat treatment (temperature) /time is usually 72-73 °C/15-20 seconds. This is enough for eliminating pathogenic organism that exist in the raw milk, and it is enough to inactivate alkaline phosphatase. (Walstra et al, 2006). Pasteurization is very important parameter and it is recommended to be highly controlled for mainly two reasons.

- (a) If low temperatures or shorter time are applied, will not effect properly on microorganism and thereby defects in the quality of the final product and
- (b) If high temperatures or longer time are applied, whey proteins are to high denaturated influencing the coagulation process. (CHR Hansen, 2002)

Starter culture

High amount of starter culture is need because of fast acidification required in cheddar making. Selection of the appropriate starter culture is crucial in cheddar making since the heat resistant and less CO₂ production of less required feature of the acidification processes in cheddar making (Walstra *et al.*, 2006).

Several requirements need to be achieved by adding starters. It is very important that starter has characteristics such as: phage resistant, quick acid production and rapid grow. The most often a mixture of single strains is used in order to satisfy all the demands. Another characteristic is that the culture should not produce bitterness in the cheese.

In the production of Cheddar two strains are mainly used: (Walstra *et al.* 2006)

Lactococcuslactis ssp. lactis, and *Lactococcus lactis ssp cremoris*. The first strain is more heat resistant but also tends to produce bitter peptides while the other strain is not so heat resistant and during scalding is not multiplying and is not producing bitter peptides. *Lactococcus lactis ssp cremoris* also play an important role in ripening, especially flavour. Related to flavour also *lactobacilli* are been used.(Walstra *et al.* 2006)

Renneting- 35 min

The enzymes used for milk coagulation eliminate the caseino- macropeptide 'hairs' from k-casein and there by paracasein micelles start to aggregate. The role of the acid produced by lactic acid bacteria is to dissolve the calcium phosphate from the micelles and the electric charge is neutralized. Aggregation influences the formation of protein network. Fat globules and milk serum are wrapped in the network. (Walstra *et al.*2006)

Cutting 10 min

Very important for the cheese yield is the moment of cutting the gel. When the gel is weak it has the syneresis is not pronounced and fat and protein are lost with the way. If the gel is too hard, the curd is broken and also the fat and protein are lost. For Cheddar cheese the cut size is relatively small 5-10 mm, typical for hard cheeses. (CHR Hansen, 2002)

Stirring/scalding 30 min/ 40°C

The curd in the whey is continuously stirred until sufficient acid has been produced and whey is separated from the curd (Walstra *et al.* 2006).

For controlling the water content the duration of stirring and scalding temperature are of paramount importance. It should be around 40°C (Walstra *et al.* 2006).

Curd particles contract when heating and thereby moisture is expelled. The activity of culture is influenced by the temperature since *Lactococcus lactis ssp. cremoris* not growing when scalding while *Lactococcus lactis ssp. lactis* is more heat resistant (Walstra *et al.* 2006).

Cheddaring

Cheddaring is one of the unique steps in making cheddar type cheese. In which blocks of curds are piled on top of each other to expel moisture. Then the curds are milled and ground into small pieces, molded and pressed to give a crumbly texture to the final cheese (Meier, J, 2013). The whey is drained off and the curd mass cut into large strips that are piled up. The portion fuses again and then spread slowly into thinner slabs that are turned cut again into strips and piled up (Walstra *et al.*, 2006). According to Walstra *et al.* (2006), acid production during cheddaring is of paramount importance. When pH is dropping the curd expels whey and the importance of acidification here, affects the final moisture and the texture of cheese (CHR Hansen, 2002).

Milling

The curd is cut into strips about the size of a finger (Walstra *et al.* 2006). If the curd is cut finely there will be a loss of fat and curd fine. Course cutting result in less diffusion of salt (salt diffusion requires long time and result non homogeneous cheese texture as a result local death of LAB (Walstra *et al.*, 2006).

Mixing

The salt retards the growth of lactic acid bacteria (Walstra *et al.*, 2006). Salting is performed in cheddar cheese making by mixing dry salt with broken or milled curd at the end of manufacture (Singh *et al.*, 2003). Ten minute is necessary for mellowing (salt absorption) during salting. The curd is salted, and the salt curd mixture is pressed in molds. It helps to have a normal close texture of cheese and is done for 30 min at 40 °C (Walstra *et al.*, 2006).

Pressing

In the past, the salted curd is putted into molds and pressed. The inconvenience is that long pressing time and high pressure is needed. Nowadays, the pressing is carried out under vacuum and lower pressures needed. Low pH and temperature affects the texture of the cheese (Walstra *et al.*, 2006).

Waxing/packaging

The pressed cheese is wrapped in plastic foils (Walstra *et al.*, 2006).

Curing

Generally, curing takes place at 8 °C from 2 to 10 months, the period influencing the flavour (Walstra *et al.* 2006).

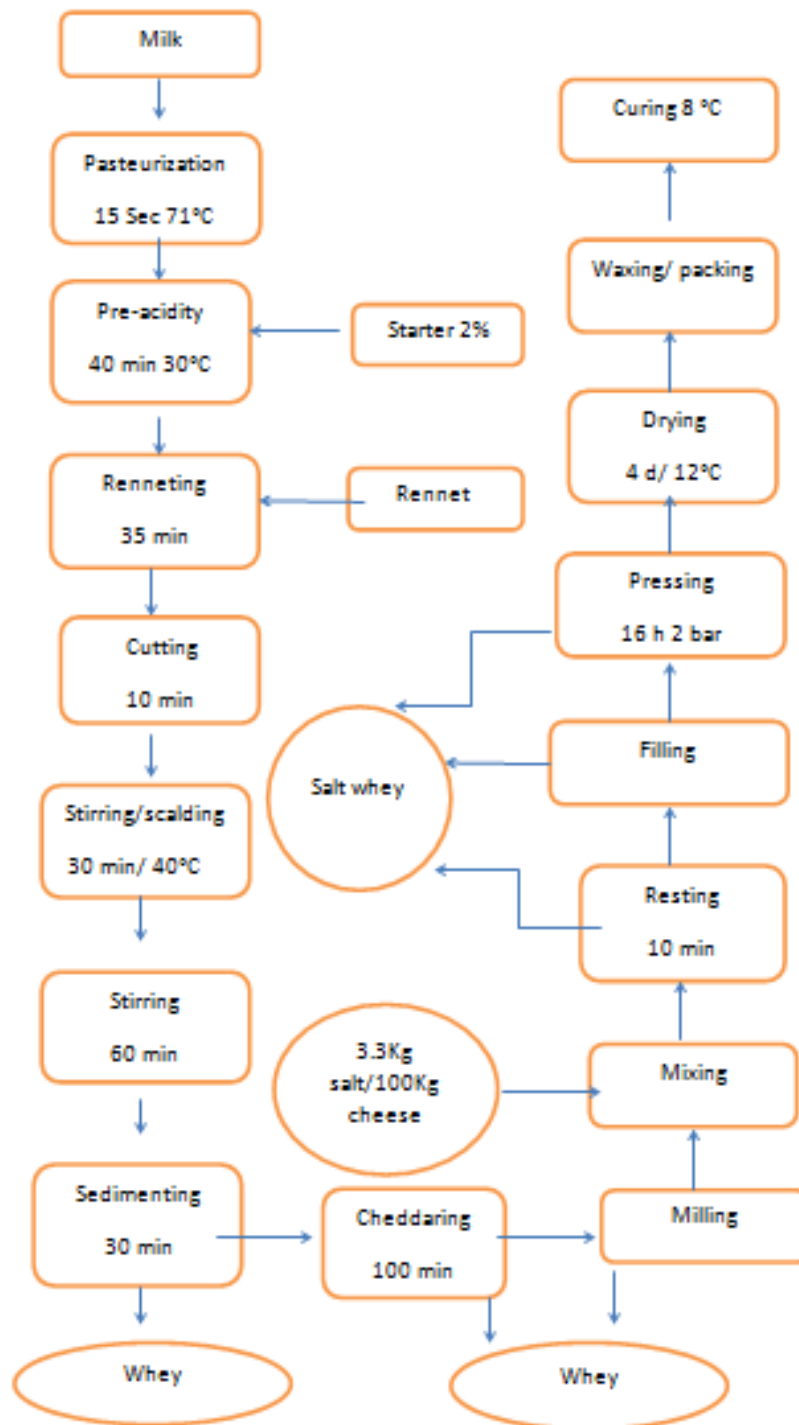


Figure 1. Flow sheet showing the manufacturing of cheddar cheese (Walstra *et al.*,1999).

The Hazard Analysis and Critical Control Point (HAACP) concept

In the food industry today approaches based on good manufacturing practice are being superseded by application of the Hazard Analysis Critical Point (HAACP) concept. This has improved on traditional practices by introducing a more systematic rule based approach for applying our knowledge of food microbiology to the control of microbiological quality. The same system can also be adopted with physical and chemical factors affecting food safety or

acceptability, but It should also be remembered that HACCP is primarily a preventative approach to quality assurance and as such it is not just a tool to control quality during processing but can be used to design quality into new products during their development (R Adams et al.,1999) .

In recent years however national and international bodies seem to have settled on agreed definition based on seven essential principles of HACCP system.

Identification of Critical Control Points (CCPs) in Cheddar Cheese

Once the hazard analysis has produced a list of the potential hazards, where they could occur, and measures that would control them, Critical Control Points (CCPs) are identified. A CCP is identified as allocation ,step or procedure at which some degree of control can be exercised over a microbial hazard ;that is ,the hazard can be either prevented or eliminated, or reduced to acceptable levels .Loss of control a CCP would result in unacceptable risk to the consumer or product (R Adams et al.,1999).

Hazard: Biological (*Staphylococcus aureus*: enterotoxin)

This is a major pathogenic microorganism in the cheddar cheese making and Control Measure is applied in the inhibition of growth by lactic acid production during fermentation (Schmidt et al.,) Therefore he fermentation step, where the starter microorganisms grow and produce lactic acid, can be identified as a CCP. However, the process of setting Critical limits and monitoring is not as clear as in the previous trends.

Pasteurization

The pasteurization is a CCP. The time and temperature should be controlled to ensure a high and safe product. The main risk of insufficient heating is inadequate destruction of enzymes and microorganism that can spoil the product or can be harmful for consumers. If the temperature is too high it affects the quality of the product negatively and this is due to high amount of denatured whey proteins affecting the coagulation. (Walstra *et al*, 2006) Therefore, the pasteurization parameters should be controlled as the heating and its intensity affect the type and extent of the bacterial flora of the milk, the growth rate, and the enzymatic activity, the activity of the lipase, the rennetability of the milk, the tendency to show syneresis, and the retention of serum proteins in the cheese. For production of the cheddar cheese the raw milk is pasteurized at 72 0c for about 15 seconds (Walstra *et al*., 1999).

Addition of starter culture and renneting process

The curd making should be as brief as possible for economic reasons and this requires a very fast acid production. Therefore, fast growing, rapidly acid producing, and phage resistant bacteria are needed. This combination of requirement is hard to fulfil; for that reason, mixtures of single-strain, fast starters are generally employed and rigorous measures has to be taken

- To ascertain enzymes used are safe and suitable to enhance the ripening process

- To prevent contamination of the starters by phages.
- In keeping safety during addition of secondary starters of selected *lactobacilli* for flavour production.

Therefore CCPs in the cheddar cheese production is applied to control the amount of the starter cultures i.e., 2 % of the milk and also the amount of added rennet (Walstra *et al.*, 1999).

Cutting, stirring, and scalding.

From the quality point of view these steps could be CCP because the moisture content can be affected by the parameters: cut size of the curd, stirring intensity, temperature and time. Therefore these parameters should be rigorously controlled. (Walstra *et al.*, 2006)

Salting

The amount of salt should be controlled and is a CCP. Successive salt absorption “mellowing” should be met unless excess salt would be lost during milling and pressing.

Acid production is insufficient if the cheese contains over 5 to 5.5% salt in water, whereas at less than 4.5% salt concentration the lactic acid bacteria ferment too fast (Walstra *et al.*, 1999). In either case the flavour development is unsatisfactory and contaminating organisms have a greater chance of growing, which may cause strong off-flavours. Walstra *et al.*, (1999) in their review stated that 3.3 Kg salt is added for 100 kg of cheese in the production of cheddar cheese. Therefore, the critical control points to be controlled here is the percentage of salt in water content of the curd.

Pressing

If the pressing is insufficient the structure of the final product may be affected negatively. The pressing time, the applied pressure and the temperature of the curd is important to ensure a good quality of the product. Therefor from a quality point of view the pressing could be a CCP and the tree mentioned parameters should be controlled. (Walstra *et al.*, 2006)

Ripening

In order to control the flavour development, the colour and the taste it is important to control the time, temperature and humidity of the curing. Therefor the these parameters are identified as CCPs which should be controlled in order to guaranty the quality of the product. (Walstra *et al.*, 2006)

Conclusions

The manufacturing of cheddar is a complex a process that includes many manufacture steps and unit operations which all affect the quality of the product. In order to ensure a safe and high quality product it is important that each step is performed properly and is controlled in a sufficient matter.

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