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CHEESE WITH REDUCED SALT CONTENT

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Abstract **–** Nowadays, there is growing awareness about reduced fat food as well as free fat products. Low fat milk products, particularly low and salt cheese represent a good choice for the development of new products with functional properties. Consumers are always looking forward to desirable and healthy products. Therefore, consumer's demand for low-fat/calorie products has significantly raised in an attempt to limit health problems, to lose or stabilize their weight and to work within the frame of a healthier diet. Removing all or only part of the fat and salt from cheese can negatively affect its taste, texture, and functionality. Many of the low-fat and salt cheeses have an uncharacteristic taste, greater transparency, less melting, rubbery and resinous texture. To overcome these shortcomings, during the production of low-fat and salt cheese, safe and convenient ingredients have been introduced in the dairy industry that improve its texture and taste, increase its shelf life, improve its appearance, while the product is not inferior to the characteristics of the standard type of cheese. However, despite the efforts made to improve the sensory and functional properties of low-fat and salt cheese, it is a general finding that users are still skeptical about its selection and consumption. To that purpose, reducing fat and sodium in cheese and maintaining its safety and quality continues to be a challenge for the dairy industry in highly developed countries.

Keywords – Fat, Salt, Cheese, Health, Dairy Industry

INTRODUCTION

The dairy industry in the world has been making efforts for a long time to expand the assortment and placement of dairy products based on the wishes and demands of consumers. About that, significant product category based on market research of the products expressed health and dietary nutritional aspects, which include fortified and dietary products, products with probiotic effects and organic farming products (Puđa et al, 2004). Low-fat and dairy products, including reduced-fat and salt cheeses in fat content have been a very popular group of products with constant in recent years by the trend of increasing demand and consumption, especially in the developed countries of the world. The largest market for reduced-fat and salt cheeses is the United States where these cheeses in 1998 comprised about 20% of all cheese sales (Mistry,2001). In Great Britain, although the growth rate is higher for low-fat and salt cheeses compared to full-fat cheeses, their consumption is still at a very low level and is only 8% of the total consumption of cheeses (Banks, 2004). Our dairy industry has not yet developed procedures for the production of cheeses with reduced fat and salt content. In order to expand their range and to satisfy the demand for domestic products, it is necessary for our dairy industry to start with the introduction of technologies for the production of these types of cheese. Observing the needs, using and the possibility to buy cheese with a low content of salt and fat forms the framework for the development of new dairy products intended for the domestic market. Removing all or part of the fat and salt from the cheese can negatively affect its taste, texture, and functionality. Many of the low-fat and salt cheeses have increased transparency, low melting point, rubbery and resinous texture and uncharacteristic taste (Pelivanoska, 2016). One of the final steps in the cheese-making process is the addition of salt. Salt is the main source of sodium in cheeses. Regardless of when or how salt is added to cheese, it is used for at least 6 purposes in its production and ripening, and they are:

1. stimulation of syneresis and control of the final moisture content in the cheese,
2. control of metabolism and survival of starter bacteria,
3. impact on secondary starter bacteria that can grow and produce different flavors during cheese ripening
4. control of enzyme activity in the final product,
5. control of the texture of the final product, and
6. regulating the desired taste of the cheese.

This shows that salt cannot be completely eliminated from cheese production, but it can be reduced to a certain concentration. In order to reduce the amount of salt, so that it does not adversely affect the taste of the cheese, it is necessary to increase the moisture content and reduce the amount of fat. The results of the trials indicate that a salt concentration of 2.2 or 2.6% could be optimal, while lower salt concentrations may be undesirable in low-fat cheese. These results show that a reduction of salt content by 25% (eg from 1.8% to 1.4%) can be noticed by consumers and this can negatively affect the acceptance and consumption of this type of cheese (Mistry and Kasperson 1998).

Numerous researches have been carried out on different types of cheeses, such as cedar, mozzarella, feta, white cheese in brine, ricotta and others which contributed to get the product acceptable and desired characteristics. Today, the greatest commercial importance has soft, acid-coagulated cheeses with reduced fat and salt content like quark and cottage cheese that have been largely accepted by a large number of consumers in their daily diet.

MATERIALS AND METHOD

Importance of salt in cheese

The use of salt (NaCl) as a food preservative dates back to prehistoric times and, together with fermentation and dehydration, is one of the classic methods of food preservation. Salt, as a preservative, was very often used during the ancient and medieval periods, when it was a staple of trade, and was used in the form of currency as a substitute for other goods and labor. It may be strange that at the beginning of civilization man discovered that by applying salt food preservation can be achieved, because this method, unlike fermentation and dehydration, is not a natural way of preserving food, but requires human action. The level (%, w / w) of salt in the cheese ranges from 0.7 in Swiss to 6 in Domiati cheese. According to Naguib et al., (1979), salt, together with a certain pH value, water activity and redox potential, contribute to the minimization of spoilage and prevention of the growth of pathogenic microorganisms in cheese. In addition to its preservative effect, NaCl plays two important roles in food. Kaplan (2000), points out that a person needs 2.4 g of sodium, that is, 6 g of NaCl per day. Although this requirement can be met through Na naturally found in food, added NaCl is still the main source of salt in the modern western regional diet. In fact, Western regional diets contain about two to three times more Na than is needed. According to Abernety (1979), excessive doses of Na have toxic, undesirable effects, among which high blood pressure and increased calcium excretion can lead to osteoporosis. In many Western countries there is an interest in the production of cheese with a low Na content which is only suitable for a certain part of the population. The third major characteristic of NaCl in food is its direct contribution to flavor. Saltiness is highly valued and is considered one of the four primary flavor characteristics of cheese. The main effects of salt include:

1. promoting syneresis and controlling the final moisture content of the cheese,
2. control of metabolism and survival of starter bacteria,
3. impact on secondary starter bacteria that can grow and produce different flavors during cheese ripening,
4. control of enzyme activity in the final product,
5. control of the texture of the final product and
6. regulating the desired taste of the cheese.

The importance of salt in cheese production

The presence of salt in cheeses significantly contributes to the development of their sensory properties. However, in addition to the influence on the taste, the presence of salt in cheeses directly or indirectly affects numerous processes that occur during their ripening. It can be said that salt affects almost all the necessary elements for obtaining the desired quality in cheeses. The influence of salt during ripening includes the following aspects:

sensory and nutritional properties of cheese,

• development and activity of the cheese microflora (stimulating and inhibitory effects),

• inhibition of the activity of individual enzymes in the cheese,

• regulation of water content,

• influence on the status of proteins.

Nutritional aspect of salt in cheese

The main role of salt in the diet is to provide the necessary amount of sodium for the normal course of metabolic processes in the body. The average physiological need of the human body ranges from 4-5 g of sodium per day, that is, 10-12 g of salt. Salt intake during one day is about 8-15 g Na/day, which is about 2-4 times more than the actual need. Excessive intake of sodium in the body can cause various physiological disorders such as: hypertension, osteoporosis, etc. The tendency of modern diet therapy is to reduce the intake of salt in the diet, and thus to reduce the consumption of cheese. However, reducing the salt content can affect its quality, as well as canning, ripening, cheese dough texture and more. For this purpose, quite modern scientific and technological procedures are used in the production of cheese. Current research, which is aimed at reducing the salt content of cheese, particularly addresses issues regarding: flavor modification, substitution of NaCl with other salts such as KCl, $MgCl_2$, $CaCl_2$, use of food additives and supplements that they mask the taste that occurs by reducing the salt content.

Influence of salt on the sensory properties of cheese

A very important property of salt is its direct influence on the taste of the product. The characteristic salty taste of salt occurs as a result of the presence of sodium, since other salts such as potassium chloride salts have a significantly different taste. Unsalted cheeses have a bland and watery taste, unacceptable even for people who do not consume salt. Also, the potential appearance of bitterness in cheese is usually closely related to salt concentration, with oxidative bitterness increasing with increasing salt concentration, while hydrolytic bitterness increasing with decreasing salt concentration in cheese. Reduced-fat cheeses often have a bitter taste that can be reduced to some extent by increasing the salt content of the cheese. The color and softness of the cheese dough are also significantly related to the salt content of the cheese.

Influence of salt on the ripening of cheeses

Cheese ripening includes complex biochemical, physical and microbiological changes that are interdependent and that contribute to the formation of the characteristic sensory properties of cheeses. The indicated changes are realized under the influence of numerous ripening agents that include coagulants, native milk enzymes, starter enzymes and secondary microflora. The activity of individual agents depends to a greater or lesser extent on the concentration of salt and water (S/V). Coagulants (primarily chymosin), depending on the type of cheese, are responsible for the primary proteolysis during cheese ripening and with their activity they degrade, especially αs1-casein, resulting in molecules with a large molecular mass and high electrophoretic mobility. The degradation of αs1-casein is greatly influenced by salt concentration and pH. A higher concentration of S/V slows them down, while acidification, i.e. lowering the pH value, accelerates the proteolytic changes in the cheese. A salt concentration of up to 5% stimulates the activity of chymosin on αs1-casein. A higher concentration of salt inhibits the degradation of αs1-casein, so cheeses with a higher salt content are characterized by slower ripening. However, high salt concentration does not completely prevent the influence of chymosin, so that even at a S/V concentration of 20%, αs1-casein is still degraded. The ripening of unsalted cheeses is characterized by the formation of a higher content of water-soluble nitrogenous substances, which indicates a higher activity of enzymes in such conditions. Pepsin activity is less sensitive at higher salt concentration in cheese. The proteolytic activity of pepsin in the degradation of αs1-casein is also present at a higher salt concentration (5-20%), but a certain dependence of the enzyme activity on the salt concentration is still observed. Proteolysis of β-casein, in contrast to αs1-casein, is highly dependent on salt concentration. The proteolytic activity of the enzyme of this part of the casein is significantly inhibited at a salt concentration of 5%, while at a concentration of 10% it stops completely. During the ripening of cheddar, and in the complete absence of salt, the proteolysis of β-casein is less pronounced than the proteolysis of αs1-casein. The moderate concentration of salt in cheese additionally inhibits the degradation of β-casein. Adding a certain amount of salt (increasing the strength of the ionic system), causes significant conformational changes in the protein molecules, due to which the attractive forces between the enzyme and the substrate decrease, which causes a decrease in the extent of proteolysis. In individual groups of cheeses, plasmin plays a significant role in the proteolytic role during their ripening. This is especially pronounced in Swiss cheeses, cheeses with surface microflora and cheeses with white mold, in which an increase in pH occurs during their ripening, which contributes to a greater activity of this enzyme in milk. Since plasmin is more thermally stable than chymosin, it plays a significant role in the ripening of cheeses that use high reheating temperatures during their production.

The influence of salt on the water activity in cheese

The water in the cheese is found in three different states, namely:

- bound water, which constitutes the structural element of cheese dough,
- hygroscopic water, which is bound to the cheese dough particles with the help of attractive forces,
- free water, which moves freely and can be easily removed from the cheese.

During the salting process, salts diffuse into the cheese and water migrates from the cheese, which reduces the free water content and concentrates the dry matter in the cheeses. In this way, salting affects the activity of water in cheeses. The exact answer about the influence of salt on the activity of water in cheese is still not fully defined and largely depends on the research method. Puđa (2009), presents data from Geurts et al., who performed measurements of the content of water that does not dissolve salt (NaCl) and determined that the salt concentration in the interval 5-15% has a very small, almost negligible influence on the content of the bound water in the cheese. On the other hand, some authors, who performed tests based on the measurement of the content of water that does not dissolve lactose, determined a significant influence of salt on the content of bound water in cheese. The same author points out that the salt content in cheese affects the aw value, which has been experimentally proven. At a salt concentration of 1.44%, aw is 0.95, while at a salt content of 0.7%, aw is 0.98. These results indicate that increasing the salt content in the cheese decreases the water activity. When studying the aw value of cheeses, many authors used their experimental results to determine the dependence between the aw value of different cheeses and their composition. In that way, a large number of experimentally derived equations were developed that relatively successfully describe the dependence of the aw value in cheeses on the parameters of their properties. The influence of the salt content on the bound water content during the salting of cheeses is a very complex problem considering the fact that the salt itself has a large water binding capacity. In addition, certain things occur during salting, such as: binding of part of the water to the proteins, which results in the dilution of the salt in the free water phase of the cheese, an increase in the aw value and a decrease in the hydration of the proteins.

The influence of salt on the activity of microorganisms

The breakdown of residual lactose during cheese ripening is significantly dependent on the salt and water content (S/V) of the cheese dough. A S/V content of about 5% for most types of commercial starter cultures represents a limiting value that inhibits their growth and activity. A content higher than 5% S/V inhibits the metabolism of the starter cultures, resulting in an increase in the residual lactose content and a higher pH value of the cheese, thereby deteriorating its quality. The S/V content of cheese largely determines the growth and activity of starter bacteria. In general, cheeses with a lower S/V content help the development of the starter microflora. Certain species of the genus Lactoccocus, which are commonly used as starters in the production of several types of cheese, show different tolerances at different salt concentrations. Thus, for example, L. lactis ssp. cremoris is sensitive to higher salt concentrations. A salt concentration higher than 2% for most bacteria represents an inhibitory limit. L. lactis spp. lactis shows activity even at 4% NaCl. In contrast to the starter microflora, non-starter lactic acid bacteria (NSBMK) are significantly more resistant to elevated S/V concentration. Most of NSBMK belongs to lactobacilli (Lb. casei, Lb. plantarum, etc.). In Swiss cheeses, the S/V content affects the level and development of propionic bacteria during their ripening, while a lower content of 2% S/V has no effect. A salt level of 3.5% significantly reduced their growth, while a level of 5% S/V completely stopped the growth of propionic bacteria.

The influence of salt on physical changes of proteins and functional properties of cheeses

The presence of salt in cheese affects the solubility of proteins, and thus the texture of the cheese. Calcium ions represent structural elements of the protein matrix, and their bivalent nature contributes to protein aggregation. By reducing calcium ions from the protein matrix and replacing them with monovalent sodium ions, a strong hydration effect is achieved that basically reflects the degree of protein solubility. The hydration effect of paracasein is particularly pronounced at a 5% salt solution, a pH value of 5.25 and a temperature lower than 100C. One of the characteristic situations, in which the influence of salt on the physical properties of the protein can be clearly seen, is during the production of cheeses in brine. During this kind of production, the decrease in the pH value of the cheese is realized in the very brine in which the cheese ripens. Therefore, the interval of pH value of 5.3-5.1 is particularly significant. At this pH interval, there is a significant loss of calcium and its transition into a dissolved form. The presence of a salt concentration of 5%, which is a common salt content during the ripening of this type of cheese, causes an additional loss of calcium from the matrix, with a simultaneous high hydration of the protein. The loss of calcium and the high hydration of the cheese dough lead to the softening of the cheese dough and the transition of part of the proteins to the water phase. The low temperature additionally stimulates the dissolution of the proteins. In such a situation, great economic losses can occur. In regular production, where there is no stoppage in fermentation, the cheese dough softens slightly while it is in the critical pH value, but with a further increase in acidity, the cheese dough reduces hydration, which makes the cheese firmer, thus avoiding losses in production.

The effect of salt on the microstructure of cheese

As a result of its effect on protein hydration, salt has a great influence on the microstructure of cheese. During scanning electron microscopy, Paulson et al., (1998) and Pastorino et al., (2003) observed that the protein matrix of salted fat-free mozzarella cheeses with (0.25% or 3.5%, S /V) or Muenster cheeses with (~1.2%, 3.6% or 6.7% S/V) is more swollen, homogeneous and continuous, while having a higher specific surface area than unsalted types of cheese.

Moreover, unsalted cheeses have large open channels of free serum (whey pockets) distributed throughout the matrix, which give the cheese a dull white color and waxy appearance. In salty cheeses there are fewer such gaps and they are smaller.

The effect of salt on the cooking properties of cheese

In order to create acceptable cooking characteristics in cheeses, especially mozzarella and cheddar, a ripening period is required, the duration of which depends among other things on the type of cheese, production conditions, ripening conditions as well as the specifications set by the consumer. The biochemical and microstructural changes that contribute to the development of the desired cooking characteristics in cheeses are: an increase in proteolysis, casein hydration and non-globular fats, with a simultaneous swelling of the protein matrix and a decrease in the level of aggregation and continuity of the para-casein matrix. Increasing casein hydration increases the water-binding capacity of the protein matrix, improves moisture retention during cooking, disperses proteins more easily in the heated cheese mass, and improves the extensibility of the heated cheese. Moreover, heated mature cheese is less prone to bubbling and charring than fresh cheese. The increase in elasticity in cheese is increased by increasing the released oil and water - binding capacity of the para-casein matrix and by decreasing the level of ES. The protein matrix of salted cheeses is more swollen and uniform than that of unsalted cheeses in which the cracks are considered pockets filled with free unbound water. The processed cheese with a high salt content of (3.04% w/w, on day 2, and 1.7% w/w, on day 16) was characterized by a higher apparent viscosity and a low level of free fat, and it was firm and rubbery. In contrast, cheese with a low interior salt content of (0.38%, on day 2, and 0.9%, on day 16) had a significantly lower apparent viscosity and was smooth, soft, runny and gelatinous. After 16 days, the interior of the molten sample became too soft while the exterior remained unacceptably hard and rubbery. Consequently, Kindstedt and Guo (1997) concluded that a major factor in obtaining the desired cooking properties of mozzarella cheese is an increase in casein hydration to 3-4 % S/V during storage.

CONCLUSION

Reducing the sodium chloride content of cheese represents a particularly significant challenge for cheese makers because salt plays many important roles in cheese. Salt is an integral part of cheese, it is used to maintain the taste, shape, texture, and shelf life by controlling the activities of enzymes and microorganisms. Replacing some of the added sodium chloride in the cheese with other chemicals to give it the perceived saltiness can ultimately be successful, especially with mild-flavored cheese. However, with this approach, cheese makers cannot ensure control of the growth and metabolism of desirable and undesirable bacteria, and it is quite difficult to develop the desired cheese flavor. When it comes to naturally low sodium cheeses there are some that are available to consumers. One of those types is Swiss cheese. In other types of natural and processed cheese, the best option is to replace the sodium salts with a mixture of sodium/potassium salts. However, the use of potassium salts is limited due to the development of metallic, bitter and other undesirable tastes. Other issues to overcome in low sodium cheese include food safety, quality and functionality. With the current FDA 50 rule, the salt level in cheddar, mozzarella, and other processed cheeses will have to be reduced by 55%, 47%, and 80%, all in order to achieve the desired low sodium status. Reducing fat and sodium in cheese and maintaining its quality and safety continues to be a challenge for the dairy industry worldwide. Despite the increasing interest of consumers in this type of cheese, technologies for its production have not yet been developed in our country. Precisely because of that, the production of cheese with reduced fat and salt content should be a challenge for the domestic dairy industry.

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