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PRODUCTION OF FETA CHEESE WITH A REDUCED SALT CONTENT

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Summary

Sodium chloride (NaCl) is crucial for proper functioning of the organism and plays a key role in many physiological processes. However, excessive sodium intake causes health disorders like elevated blood pressure, heart and cardiovascular diseases. Within the strategy based on lowering the NaCl intake in the Republic of Croatia, thus food production with the lower salt content is encouraged. Cheese is one of the foodstuffs that is widely consumed and has a high ratio of salt especially cheese in brine. This study aimed to investigate whether the replacement of 50% of NaCl with micronized salt in brine influences the physicochemical and sensory properties of feta cheese during maturation. Because of its larger surface area, micronized salt increases the salinity and, thus smaller amounts can be added into the foodstuff compared to the classic NaCl. Analyses of texture, salt content, physicochemical and sensory analyses were performed after 7, 14, 21 and 28 days of cold storage. Based on the results it can be concluded that micronized NaCl may serve as a replacement for NaCl up to 50% without significant change in the physicochemical and sensory properties of the cheese compared to the control sample.

Keywords: Feta cheese, micronized salt, NaCl, texture, sensory analysis

Introduction

Salt (NaCl) is after sugar the second most-used food additive in the food industry. Primary, it has been used as preservative but functional properties and nutritional considerations are now becoming more important in the use of such ingredients in food processing (Dötsch et al., 2009.; Katsiari and Voutsinas, 1998). Excessive sodium intake has become a public health problem since it can lead to the occurrence of hypertension, osteoporosis, and chronic heart diseases (Ferrão et al., 2016). World Health Organization (WHO, 2013) recommends 5 g of salt (equivalent to 2 g of sodium) intake per day. Salt intake in the Republic of Croatia is more than double of the recommendation and it amounts around 11.6 g of salt per day. Due to the pour knowledge, a bad eating habits, the ignorance of the recommendations and to the modern way of life (fast food, processed food, restaurant food), salt causes more harm than good for the human body. WHO estimates that chronic non-communicable diseases, including arterial hypertension, diabetes, obesity, heart, kidney and lung diseases and some types of cancer, are responsible for 86% of premature deaths in Europe. The occurrence of all these diseases as one of the most important risk factors is excessive intake of table salt (He et al., 2011; Blaustein et al., 2012). However, salt is very important in the cheese manufacture, since it controls the water activity and microbial growth, enzyme activity during ripening, curd syneresis, as well as influencing the flavour and texture of cheeses (Cruz et al., 2011). Cheese is consumed in large quantities worldwide, both directly as table cheese and, increasingly, as an ingredient in recipes (Cruz et al., 2011; Bord et al., 2015). Besides its interesting nutritional properties (particularly as a strong contributor to calcium and protein supplies), cheese (also bakery and meat products) is one of the foodstuff with greatest salt content. In fact, only 40 g of cheese which contain 2.00% of salt is equivalent to the 16% of recommended daily salt intake (WHO, 2013). NaCl contributes directly to saltiness in cheese, a flavour that is generally highly appreciated. It contributes indirectly to flavour of cheese by its controlling influence on microbial and enzymatic activities which, in turn, influence lactose metabolism, cheese pH, degradation of fats and casein, and the formation of flavour compounds, such as peptides, free amino acids, and free fatty acids (McSweeney, 2007). The traditional Greek feta cheese that matures in brine and contains 3.50-7.00 % of salt, stands out as a cheese with the greatest salt amount. Since feta cheese is relatively common one in the nutrition, due to the amount of present salt, frequent consumption can result or/and increase the risk of the digestive system diseases and cardiovascular diseases. Due to its frequent usage, efforts are being made to find new solutions in feta cheese production, in order to obtain cheese with sensory and technological characteristics as much as

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same as traditional feta cheese, but with the reduced salt content.

Various substitutions such as potassium chloride, magnesium chloride, calcium lactate or calcium citrate have already begun to be introduced as an alternative to sodium chloride in numerous food industries (Doyle and Glass, 2009; Gimeno et al., 1999). In the production of feta cheese, the tendency is to partially or completely replace the salt (NaCl) from the brine, thereby obtaining a product that will not cause a cost increase in production or change the production process and that will satisfy the needs of the consumers. The major lack of replacing NaCl is appearance of the aftertaste mostly bitterness at concentrations higher than 50% (Gore et al., 2019). Consequently, food industries started to use micronized NaCl. Micronized salt presents microparticles of NaCl crystals and thus increases the salinity due to the larger surface area and therefore, a smaller quantity of micronized salt creates the same salinity taste as higher quantity of classical salt. Compared to the standard salt, which is approximately 500 μm in diameter, the size of the micronized salt is from 10 to 20 μm. The main disadvantage of reducing the salt size is the sticking of fine particles, but solubility remains excellent and it can be easily added to the foodstuff during processing. Micronized salt can reduce salt content from 25 to 50 % in processed food while maintaining salinity and functional properties same as classical salt.

The aim of the present study was to produce feta cheese in brine prepared with micronized salt in amount 50% less salt compared to the control feta cheese. In addition, this work is aimed to observe the influence of the micronized salt in brine toward the ripening, production technology, physico-chemical properties, texture and sensory properties of feta cheese and compare it to the traditionally produced feta cheese with classical NaCl.

Materials and methods

Feta cheese production

The standardized milk (3% milk fat) was pasteurized at 63 °C for 30 min, cooled to 35 °C inoculated with 1% of mesophilic starter culture (Probat 222, Danisco, France) and ripen to obtain the pH around 6.0 units. Then, $CaC1_2$ (10-20 g/100 L milk), KNO_3 (0.01%) and rennet (according to the manufacturer instructions, Medimon, Croatia) were added and mixed well. Coagulation was achieved in about 40 min at 35 °C. After coagulation, the coagulum was cut into the 2 cm^3 cubes, rest for 10 min, and then the cutted curd was left to drain in cheesecloth, transferred into perforated round moulds for pressing. The moulds were inverted three times during the first 3 hours, and two more times until the next day (totally 24 hours at 16 °C). After pressing, cheese was portioned into slices of around 100 g and placed into the brine. The ratio between cheese and brine was 1:4. Control brine was prepared as a 10% solution of NaCl. For production of feta cheese with lower NaCl concentration, micronized salt SODA-LO™ (Tate and Lyle, IL, USA) was used. Since producer of SODA-LO™ recommends 20-50 % less salt use, brine was prepared as a 5% solution, meaning that amount of NaCl was reduced for 50%. Cheese was analysed before brining and after 7, 14, 21 and 28 days of cold storage (6 °C ± 2 °C). Performed analyses were: conductivity, total dissolved matter, acidity, salt content, protein amount, texture and sensory analysis. Experiments were repeated twice and results are shown as mean values.

Physico – chemical and sensory analyses

Conductivity (ms) and Total Dissolved Matter (g/L) were determined by TDS/Conductivity/˚C meter (RS-232 CON 200 series, Oacton, Singapur). They were determined in brine before brining and after 7, 14, 21 and 28 days of cheese brining. Active acidity of brine and cheese was determined by pH meter (WTW Instruments, pH 3110, Germany) and titratable acidity of cheese by Soxlet-Heenkel method (Božanić et al., 2010). The method is based on a titration of 100 g of cheese with 0.1 M NaOH with phenolphthalein as an indicator. Salt was determined according to the previously described method (Božanić et al., 2000). Protein amount in cheese was determined according to the Kjeldal method (Božanić et al., 2010).

Texture measurements in the form of texture profile analysis (TPA) of the samples were performed at room temperature using a texture analyzer (Ametek Lloyd Instruments Ltd., UK) with a 50 kg load cell supported by the software NexygenPlus. Duplicate cubes 10 x 10 x 10 mm were analyzed. The sample was compressed twice to 50% deformation at a crosshead speed of 1 mm/s (resting time between cycles was 5 s), and the following parameters were obtained from force–distance curves: hardness (N), adhesive force (N), cohesiveness, adhesiveness (Nmm), gumminess (N), springiness (mm), chewiness (Nmm), resilience, fracture (N) and stringiness (mm).

The sensory evaluation (weighted points method) of the cheese samples was performed after 7, 14, 21 and 28 days of cold storage. Ten trained analysts have performed sensory evaluation. Properties that were determined were: appearance, colour, consistency, cut, odour and taste. Score for each evaluated property is given in Table 1. Analysts have scored each property with grades from 1 to 5 which were multiplied with the coefficients of significance (Fv). Coefficients of significance were for appearance 0.4, colour 0.2, consistency 0.4, cut 0.6, odour 0.4 and for taste 2. All the experiments were performed twice, and results are shown as average values.

Table 1. Evaluated properties of feta cheese and maximum scores

Properties and its description	Score
Appearance (snow white, homogenous cheese, minor cheese cracks)	2
Colour (porcelain, snow white)	1
Consistency (soft to semi hard creamy texture)	2
Cut (homogenous, possible slight cheese cracks)	3
Odour (sourly and milky, slightly picante)	2
Taste (sour and salt taste, slightly picante)	10
Total	**20**

Results and discussion

Brine for the control sample was prepared as a 10% solution of NaCl (control brine, CS) and brine with micronized salt was prepared as a 5% solution (micronized salt brine, MS) meaning that amount of NaCl was reduced for 50%. Results of electrical conductivity are shown in Fig. 1. Electrical conductivity depends on ions present in the solution and primary depends of the composition of the solution (Norberg et al., 2004). From the Fig. 1 it can be seen that before brining KS had conductivity 104.8 ms while MS brine had 51.2 ms, what was expected since MS had twice lower amount of NaCl. Furthermore, over the cold storage period, electrical conductivity of KS and MS decreases. At the end of cold storage, the drop of electrical conductivity was the highest and it can be explained by migration of NaCl into the cheese.

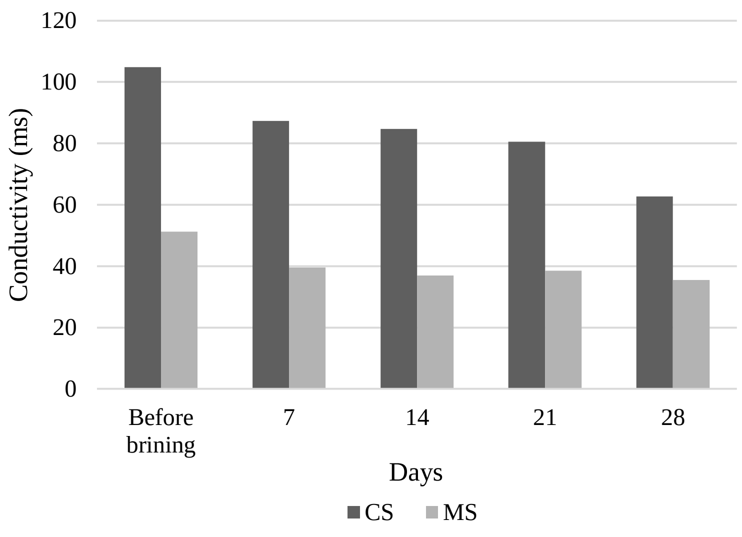

Fig. 1. Conductivity (ms) of control brine prepared with NaCl (CS) and brine prepared with micronized salt (MS) before feta brining and after 7, 14, 21 and 28 days of cold storage

The total dissolved solids (TDS, g/L) determined in brine are shown in Fig. 2 Total dissolved solids are in the correspondence to the electrical conductivity. Before brining KS has 52.7 g/L of dissolved solids and MS had 27.3 g/L of dissolved solids. As well as electrical conductivity TDS decreases during the cold storage period while the major drop was observed at the end of the storage (28^{th} day).

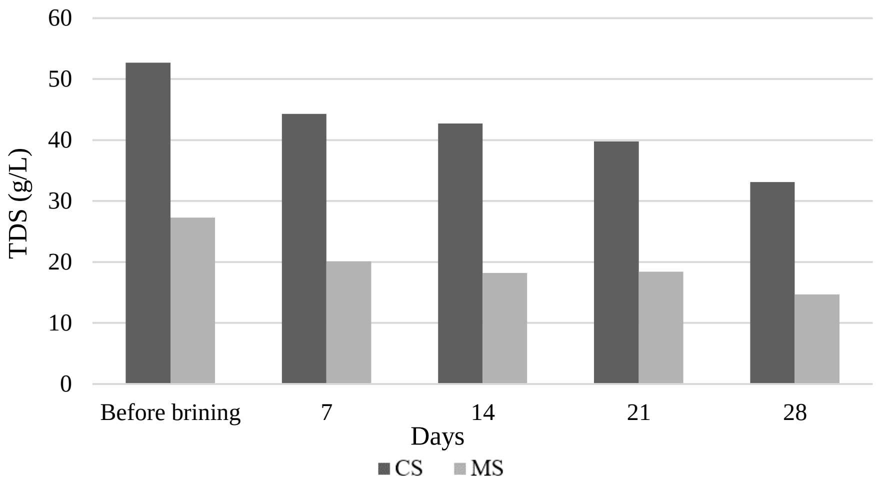

Fig. 2. Total dissolved solids (TDS, g/L) of control brine (CS) and brine prepared with micronized salt (MS) before brining and after 7, 14, 21, 28 days of cold storage.

Table 2 shows the active (pH) and titratable (SH°) acidity of control feta cheese (CF) brined in control brine and feta cheese brined in micronized salt (MF) and active acidity (pH) of CS and MS. From the obtained results it can be seen that both brines before cheese brining had the same pH value and it was 4.70 pH units. During the storage time pH value of control brine increased gradually over storage period for 0.30 pH units while in micronized salt brine the major pH increase was after 7 days of cold storage, also around 0.30 pH units and rest of the storage period pH was constant. Generally, the higher amount of sodium ions brings the lower pH value of the brine (Tratnik and Božanić, 2012). pH value of the control cheese increases over time from 4.85 to 5.23, while pH value of the cheese brined in micronized salt brine was more or less constant and it amounted from 4.85 to 4.89. In control cheese pH was more variable and it can be associate with the higher amount of NaCl in the brine. Titratable acidity expressed as degree per Soxhlet-Heenkel (°SH) decreases over storage period both in control cheese and in cheese brined in the micronized salt where the decrease was greater in the control sample and at the end of storage time control sample had 35.9 °SH while cheese brined in micronized salt had 68.8 °SH. The difference between samples is because of the different amount of the NaCl in the brine and in the cheese.

Table 2. Acidity (pH) of control brine (CS) and brine prepared with micronized salt (MS) and acidity (pH, °SH) of control cheese (CF) and cheese brined in micronized salt brine (MF) during 28 days of cold storage

		Before brining	7	14	21	28
CS	**pH**	4.70	4.77	4.88	4.91	4.99
MS	**pH**	4.70	5.03	5.10	5.05	5.01
CF	**pH**	4.85	4.87	5.00	5.13	5.23
	°SH	83.2	46.5	34.8	30.0	35.9
MF	**pH**	4.85	4.85	4.62	4.82	4.89
	°SH	83.2	60.8	69.6	57.6	68.8

Fig. 3 shows the changes in the salt content of the control cheese (CF) and the cheese brined in the micronized salt brine (MF) during 28 days of cold storage. In the control cheese, the amount of salt increases over storage time from 5.28% to 6.20%, while in the MF cheese amount of the NaCl was slightly decreased from 2.65% at the 7th day to 1.95% at the 28th day of cold storage. From the salt amount analyses, it can be seen that the amount of NaCl in the MF cheese 7th day is more than twice lower compared to the CF cheese, and at the end of storage period it is three times lower. According to the sensory score (Table 4), MF cheese got the maximum score for the taste with a comment that there is no difference between CF and MF cheese. Micronized salt due to its smaller particles increases the surface area and thus increases the salinity of the cheese and smaller amount of NaCl is present in the final product.

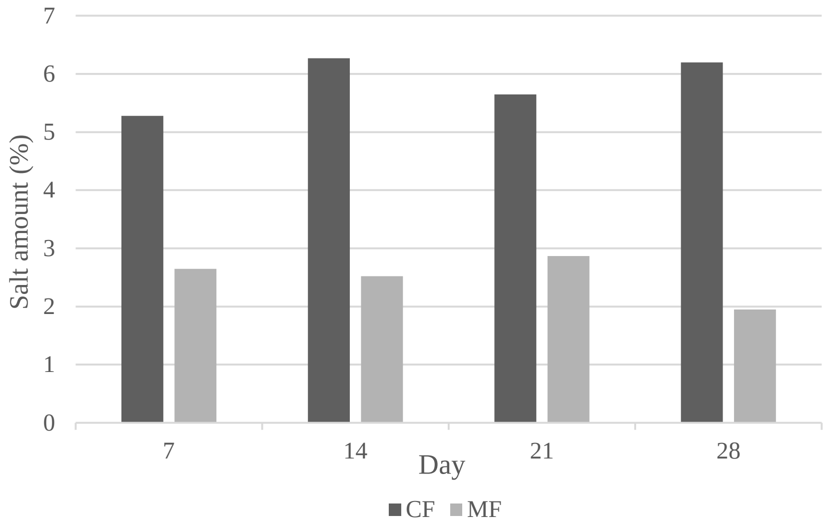

Fig. 3. Salt amount (%) in control cheese (CF) and cheese brined in micronized salt brine (MF) after 7, 14, 21 and 28 days of cold storage

Fig. 4 shows the protein amount before brining and after 28th days of cold brining in control cheese (CF) and cheese brined in micronized salt brine (MF). Before bringing the amount of proteins in the cheese was 21.80 %. In both cheese samples, the protein content decreases significantly after 28 days of brining, and it was 10.56% for CF cheese and 8.90% for MF cheese. Protein drop is a consequence of cheese ripening regarding to the biochemical processes such as glycolysis, proteolysis, lipolysis resulting with numerous secondary degradation products (amino acids and fatty acids). During the secondary degradation taste and aroma of the cheese is formed (Tratnik and Božanić, 2012).

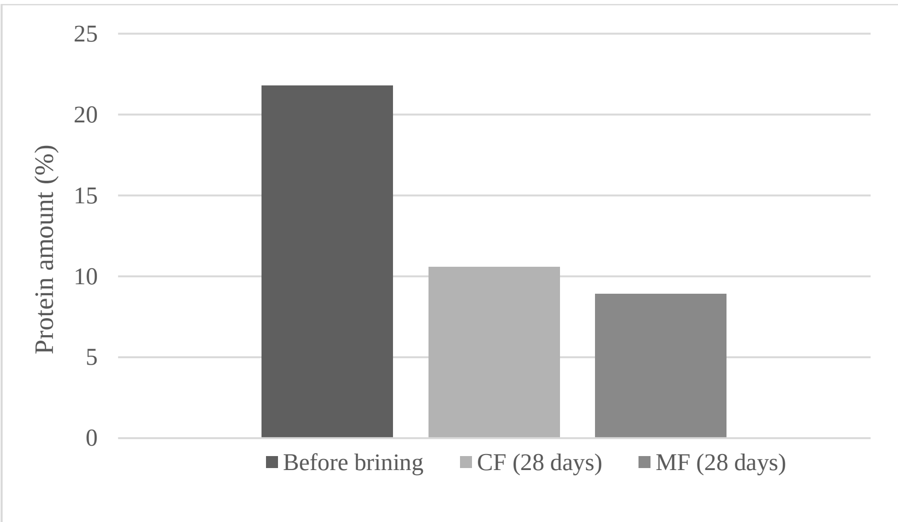

Fig. 4. Protein amount in cheese before brining and after 28 days of cold storage in control cheese (CF) and in cheese brined in micronized salt brine (MF)

Table 3 shows the results of textural analysis of control cheese (CF) and cheese brined in micronized salt brine (MF). Textural properties that were determined are: hardness (N), adhesive force (N), cohesiveness, adhesives (Nmm), gumminess (N), springiness (mm), chewiness (Nmm), resilience, fracture (N) and stringiness (mm).

The main difference between samples was among hardness, gumminess, adhesives and chewiness. After 7 days of brining, hardness of CF cheese was 10.35 N while hardness of MF cheese was more than twice higher and it amounted 21.95 N. Hardness of the cheese is directly related to the NaCl content in the cheese. Literature indicated that higher percentages of salt in brine developed a harder cheese with higher salt content (Ayyash and Shah, 2011). From obtained results in this research, cheese with micronized salt had the higher hardness. Reason for that could be that micronized salt, due to its smaller particles and bigger surface area, increases the aggregation or hydration of casein and cause an increase in the hardness (Akan and Kinnk, 2018; Guinee and O'Kennedy, 2007; Pastorino et al., 2003). Hardness was over the storage period decreased and it was 8.74 N for CF cheese and 5.21 N for MF cheese.

The adhesives was opposite among the CF and MF cheese. In the control cheese adhesives at the 7th day of storage was 0.51 Nmm and at the end of storage period was 1.01 Nmm, meanwhile MF cheese had 1.04 Nmm after seven days and 0.46 Nmm after 28 days of cold storage. Furthermore, gumminess and chewiness of the samples show the same trend as adhesives.

Table 4 presents the sensory score for the control cheese (CF) and the cheese brined in the micronized salt brine (MF). Generally, from the results it can be seen that total score for the MF cheese is higher during the storage period compared to the CF cheese. The main difference between cheese samples were in the colour and consistency. Control cheese got the lower score for colour at 21st and 28th day with a comment that it was too yellow for feta cheese. MF cheese got the lower score for consistency with a comment that it is too hard. This comment is in correspondence with the textural analyses (Table 3) where is obtained that MF cheese had the higher hardness compared to CF cheese.

Table 3. Textural properties of control feta (CF) and feta brined in micronized salt brine (MF) after 7, 14, 21 and 28 days of cold storage

	CF				MF			
Day	**7**	**14**	**21**	**28**	**7**	**14**	**21**	**28**
Hardness (N)	10.35	10.44	11.09	8.74	21.95	8.18	8.64	5.21
Adhesive force (N)	-0.15	-0.18	-0.51	-0.31	-0.46	-0.11	-0.16	-0.13
Cohesiveness	0.28	0.31	0.29	0.35	0.32	0.24	0.25	0.22
Adhesives (Nmm)	0.51	0.63	0.59	1.01	1.04	0.44	0.53	0.46
Gumminess (N)	3.00	3.45	3.31	8.21	6.96	1.98	2.14	1.17
Springiness (mm)	-3.01	-2.61	-3.89	-1.72	-1.75	-3.70	-0.99	-5.69
Chewiness (Nmm)	15.92	13.29	8.16	39.34	32.37	7.89	10.73	3.00
Resilience	0.27	0.28	0.19	0.28	0.26	0.24	0.38	0.18
Fracture (N)	10.05	8.91	9.75	19.64	6.95	7.37	8.46	4.58
Stringiness(mm)	8.04	4.35	2.91	4.32	4.82	7.43	5.61	8.69

Table 4. Sensory analysis (appearance, colour, consistency, cut, odour, taste) of control feta (CF) and feta brined in micronized salt brine (MF) after 7, 14, 21 and 28 days of cold storage

	Day	**Appearance (max 2)**	**Colour (max 1)**	**Consistency (max 2)**	**Cut (max 3)**	**Odour (max 2)**	**Taste (max 10)**	**Total (max 20)**
CF	7	1.9	1.0	1.9	3.0	2.0	9.0	18.9
	14	1.9	1.0	2.0	3.0	1.9	9.5	19.3
	21	1.9	0.4	1.9	3.0	2.0	8.9	19.1
	28	1.9	0.9	1.9	2.8	2.0	9.2	18.7
MF	7	2.0	1.0	2.0	3.0	2.0	10.0	20.0
	14	2.0	1.0	1.9	3.0	2.0	10.0	19.9
	21	2.0	1.0	1.8	3.0	1.9	10.0	19.7
	28	2.0	1.0	1.8	3.0	1.8	10.0	19.6

Conclusions

Excessive sodium intake has become a public health problem since it can lead to the occurrence of hypertension, osteoporosis and chronic heart diseases. Besides its nutritional properties (particularly as a strong contributor to calcium and protein supplies), cheese (also bakery and meat products) is one of the foodstuff with greatest salt content. The traditional Greek feta cheese that matures in brine and contains 3.50-7.00 % of salt, stands out as a cheese with the greatest salt amount. Usage of micronized salt due to its larger surface area can reduce salt content from 25 to 50 % in processed food while maintaining salinity and functional properties same as classical salt. According to the obtained results the main differences between control cheese and cheese brined in micronized salt brine was in its texture. Cheese brined in micronized salt brine had increased hardness, gumminess, fracture and adhesive force over the storage period compared to control cheese. Also, the colour of micronized salt brine was turbid over the storage period and control brine was transparent. Total sensory score of cheese brined in micronized salt brine was generally higher compared to the control cheese and consequently it can be concluded that micronized salt can be used in the production of feta cheese and thus amount of NaCl can be reduced for 50%. Obtained results are promising in the production of feta cheese with lower amount of NaCl (1.95%) where physico-chemical and technological parameters not differ from the traditional feta cheese production.

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