FABRICATION OF BRINE – SALTED TELEMEA CHEESE WITH DIFFERENT PROPORTIONS OF NaCl/KCl

Botez Elisabeta[1], Gabriel – Dănuț Mocanu[1*], Doina-Georgeta Andronoiu[1], Oana – Viorela Nistor[1]

[1]*Food Science, Food Engineering, Biotechnology and Aquaculture Department, Facultyof Food Science and Engineering, "Dunarea de Jos,, University of Galati, 111 Domneasca Street, 800201, Galati,Romania, Phone/Fax: +40 236 460165*

[*]*corresponding author: Danut.Mocanu@ugal.ro Georgeta.Andronoiu@ugal.ro*

Abstract. Sodium chloride is an indispensable constituent of white brined cheeses. It is involved in flavor and hardness improving, water activity and bitterness reducing, controls the enzymatic activity and bacterial growth and contributes to cheese preservation. Several studies have shown the negative impact of high sodium chloride content from processed cheeses on the consumers health. The most common additive used to decrease the levels of sodium chloride without affecting the cheese quality is potassium chloride.The effectof total or partial substitution of sodium chloride by potassium chloride on the characteristics of Telemea cheese was evaluated. Proximate composition, sensory evaluation and texture profile were analyzed during ripening at 4°C for 28 days. Telemea cheese was salted using 4 brine solutions (20%, wt/wt) with different concentrations made from different NaCl/KCl combinations as follows: (NaCl (A), KCl (B), 1NaCl:1KCl (C) and 1NaCl:2KCl(D)). The obtained results indicate that potassium chloride is a viable alternative to total or partial replacement of the sodium chloride in Telemea cheese.

Keywords: Telemea cheese, sodium reduction, potassium chloride, sensory, texture

INTRODUCTION

According to World Health Organization the excessive sodium intake has become a public health problem because this can lead to the appearance of chronic diseases, hypertension, and osteoporosis (Ferrão et al., 2016; Golin Bueno Costa et al., 2018).In Romania, sodium intake is estimated over 12 g of salt per day, which is well above of 2 g/day sodium for adults (equivalent to 5 g salt/day), value recommended by the WHO (World Health Organization, 2011; Domnariu et al., 2013; Felicio et al., 2013). Traditionally, salt is used in the cheese-making process as a preservative because controls the water activity and bacterial growth, enzyme activity during ripening, curd syneresis and improve the flavor and texture of cheeses (Ayyash and Shah, 2011).

Brined cheeses are among the oldest known group of cheese ripened and preserved in brine for a significant length of time, i.e. until consumption (Alichanidis and Polychroniadou, 2008; Moatsou and Govaris, 2011).A general classification system of this group of cheeses is: soft cheeses (Mish, Telemea, Feta, Akawi, Baida and Domiati cheeses) and semi-hard cheeses (Halloumi, Magdula and Nabulsi cheeses) (Abd El-Salam and Alichanidis, 2004; Ayyash et al., 2012). Telemea cheese is one of the most consumed cheeses in Romania and according to Tamime (2006) this assortment of brined cheese was originally produced in this country and then spread to other countries (e.g. Bulgaria, Greece, Turkey). One particular salt, potassium chloride has been recognised as a salt substitute to reduce sodium chloride in cheeses.

Moreover, the literature reports several studies on the impact of substituting NaCl with KCl and his effects on Feta cheese (Katsiari et al., 1997; Katsiari et al., 2000), Kefalograviera cheese (Katsiari et al., 1998; Katsiari et al., 2001), Halloumi cheese (Ayyash

and Shah, 2010, 2011a; Ayyash et al., 2011), Nabulsi cheese (Ayyash and Shah, 2011b), and Akawi cheese (Ayyash et al., 2012; Kamleh et al., 2015). In general, those studies present the results of partial or total replacement of NaCl with KCl on the chemical composition, total viable count, proteolysis, sensory properties and texture profile analysis.

Therefore, the objective of this study was to evaluate the effect of the complete or partial replacement of NaCl by potassium chloride on the physicochemical, texture profile and sensory characteristics of Telemea cheese.

MATERIALS AND METHODS

Telemea cheese manufacture

Using the traditional method described by Costin (2003) the Telemea cheese was produced according to Figure 1. Raw sheep milk (20 L) with 7 % fat was pasteurized at 68°C for 20 minutes. Pasteurized sheep milk was cooled to 32°C and inoculated according to manufacturer`s instructions with a lyophilizedstarter culture (FD-DVS FRC-65, Chr. Hansen, Denmark) containing *Lactococcus lactis* subsp. *lactis*, *Lactococcus lactis* subsp. *cremoris*, *Streptococcus thermophilus* and *Lactobacillusdelbrueckii* subsp. *bulgaricus*. 5 mL of diluted chymosin (CHY-MAX® M from *Aspergillus niger* subsp. *awamori*) was used as a coagulant agent.

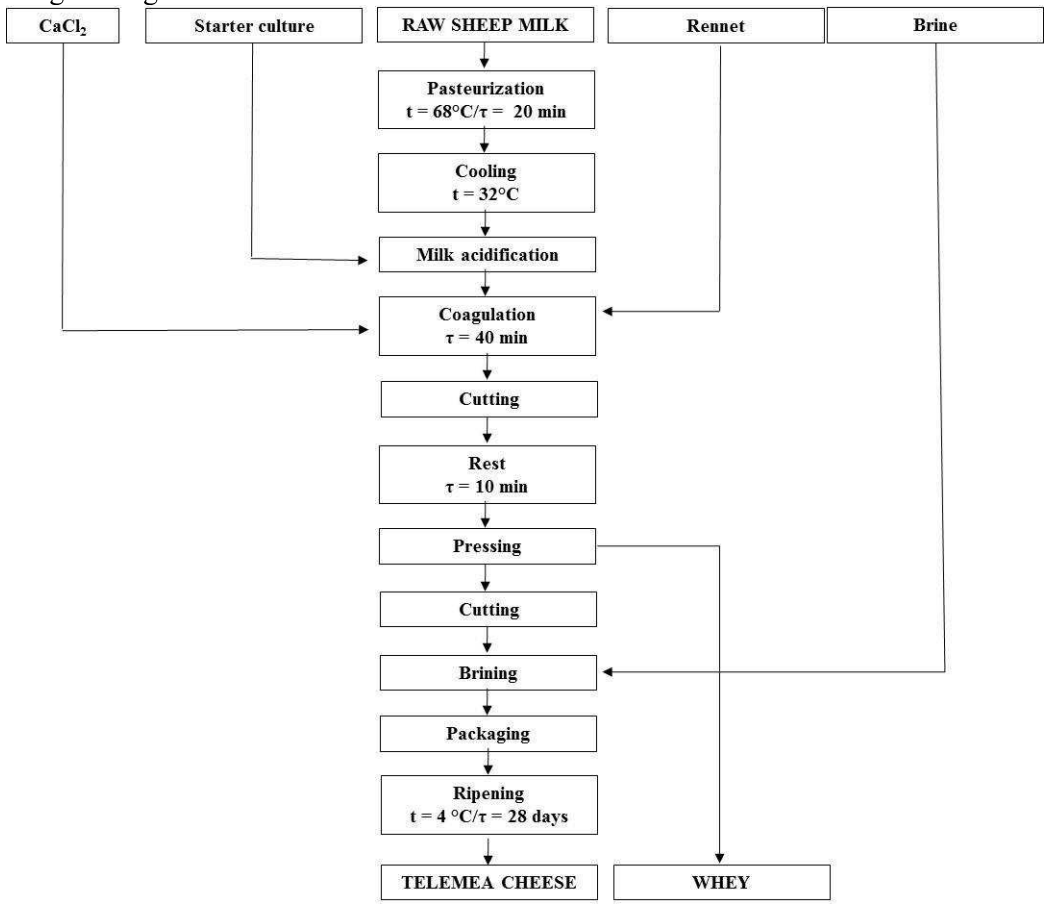

Figure 1. Flow diagram of Telemea cheese manufacture

After coagulation, the curd was cut into small cubes (approximately 2 – 3 cm^3), and allowed to rest for 10 minutes. Rectangular blocks (≈ 150g) of pressed curd were placed into plastic containers using 4 brine solutions (20%, wt/wt) with different concentrations made from different NaCl/KCl combinations as follows: (NaCl (A), KCl (B), 1NaCl:1KCl (C) and 1NaCl:2KCl(D)). The Telemea cheese sample blocks were kept in brine solutions at 4ºC for the ripening period of 28 days.

Physicochemical analysis. Titratable acidity (TA) of Telemea cheese samples was determined according to SR 2418:2008 and expressed as percentage of lactic acid. The pH of cheese samples was measured using a pH meter InoLAB 730, salt and ash contents were measured according to SR EN ISO 5943:2007 and according to SR EN ISO 707-2009, respectively. The fat content of cheese samples was measured according to SR EN ISO 1211:2010, protein content after total nitrogen (TN) determination and water soluble nitrogen (WSN) by the Kjeldahl method (SR ISO/TS 17837:2009) and dry matter according to SR EN ISO 5537:2005. Water activity (a_w) determination was carried out using ROTRONIC HC2-AW-USB (Switzerland)according to the manufacturer's instructions. All physicochemical measurements were done in triplicate.

Texture profile analysis. The texture profile analysis (TPA) was performed at room temperature, according toBourne (1978) using a CT3 Texture Analyzer (Brookfield, UK) at 1, 7, 14, 21 and 28 days of refrigerated storage. Cylinders of 7 × 12 mm (diameter × height) were compressed at 50% of their height using a load cell of 1000 g, pre-test and test speed of 2.0 mm/s, with a cylindrical probe of 25.4 mm in diameter. Two cycles of compression were carried out and the data were collected using TexturePro CT software. Three replicates were performed.

Sensory evaluation. The sensorial characteristics of the Telemea cheese samples, using a consumer acceptability test, were evaluated by 15 untrained panellists (aged 20 – 25 years). Consumers evaluated Telemea cheese samples at 28 days of refrigerated storage, using a 5-point hedonic scale for the following sensory attributes: appearance, taste, odour, colour, and texture (hardness, springiness, chewiness, gumminess and cohesiveness) (Lawless and Heymann, 2010). Before sensorial analysis, the samples were left at room temperature (22°C) for 1 h to equilibrate, cut into small chunks (2 cm^3), placed on white plates and coded with random numbers (Ayyash et al.,2012). Each Telemea cheese sample was examined in triplicate.

Statistical analysis. The data collected were subjected to one-way analysis of variance (ANOVA). Differences were considered significant at $p < 0.05$. All results were presented as mean value ± SD.

RESULTS AND DISCUSSIONS

Compositional and physico-chemical properties. The changes of chemical properties during ripening of Telemea cheese manufactured from raw sheep milk are given in Table 1. The dry matter content of all Telemea cheese samples decreased during ripening period and registered values between40.65 ± 0.15g/100g and41.94 ± 0.14 g/100g at the end of 28 days.During ripening period some factors such as initial moisture, brine concentration, and pH of cheese can affect the values of this parameter. When cheese is placed in brine, a double diffusion process appears: the molecules of NaCl/KCl move from the brine into the cheese while, water diffuses out of the cheese matrix. In this situation, along the ripening period, the values of dry matter and salt content increase, while the moisture content of Telemea

cheese samples is reducing (Rahimi et al., 2013; Farahani et al., 2014; Angheloiu et al., 2016). Khosrowshahi et al., (2006) and Madadlou et al., (2007) reported that dry matter content significantly increased when salt level increased.During the ripening period, the protein and fat content in cheese samples were not significantly different ($p > 0.05$).A similar conclusion was made by Ayyash et al., (2012) and Ayyash and Shah (2010; 2011b) in their studies concerning the effect of complete or partial replacement of NaCl with KCl on various types cheeses (Akawi, Nabulsi and Halloumi).

Table 1.
Physicochemical composition of Telemea cheese samples during storage at 4°C for 28 days

Parameters	Telemea cheese samples			
	A	***B***	***C***	***D***
Dry matter, g/100g	40.65 ± 0.15	41.57 ± 0.16	41.52 ± 0.13	41.94 ± 0.14
Fat, g/100g	20.87 ± 0.15	21.10 ± 0.18	21.43 ± 0.23	21.80 ± 0.30
Proteins, g/100g	16.20 ± 0.11	16.18 ± 0.20	16.17 ± 0.12	16.23 ± 0.21
Ash, g/100g	5.24 ± 0.14	5.42 ± 0.13	5.12 ± 0.11	5.91 ± 0.15
NaCl/KCl, g/100g	4.32 ± 0.11	5.40 ± 0.19	4.22 ± 0.20	4.29 ± 0.12
pH	5.19 ± 0.17	5.24 ± 0.19	5.29 ± 0.13	5.28 ± 0.13
Titratable acidity, g lactic/100g	2.25 ± 0.18	2.27 ± 0.20	2.29 ± 0.13	2.30 ± 0.12
Water activity, a_w	0.9756 ± 0.0006	0.9695 ± 0.0011	0.9761 ± 0.0011	0.9758 ± 0.0007

All values are mean ± SD

For all the Telemea cheese samples, the ash content increased during the ripening period and was between 5.12 ± 0.11 g/100g and 5.91 ± 0.15 g/100g with the highest value in sample D. This results are in agreement with those reported by Ayyash and Shah (2010).

The values of the salt content at the end of ripening period reached a higher concentration for cheese sample B (5.40 ± 0.19 g/100g). The total substitution of NaCl with KCl increased the salt content by 50.92%.The Telemea cheese salted with NaCl/KCl mixtures or with KCl or NaCl present similar physicochemical properties that can be assigned to the fact that technically, the sodium ions have the same effects as potassium ions in the cheese-making process (Katsiari et al., 1998).This results are in agreement with those reported by Katsiari at al., (1997) in the case of partial substitution of NaCl by KCl in Feta cheese and Bakirci et al., (2011) in the case of Turkish white pickled cheese. The evolution of pH in the cheeses was affected ($p < 0.05$) by the type of brine solution and by the ripening time (Thibaudeau et al., 2015). Titratable acidity of the sample increased continuouslythroughout ripening period, while pH values decreased as a consequence of lactose fermentation.Similartrends were observed by Ayyash and Shah (2010) who reported that lactic acid increased significantly during storage of Halloumi cheese kept in brine at 4 °C.The water activity of all cheese samples was significant affected by some important factors such as salting treatment, location, and time.During the ripening time, every Telemea cheese samples reduced its water activity (a_w) to a range of values between 0.9695 ± 0.0011

(formulation B) and 0.9761 ± 0.0011 (formulation C), due to increase in total solid content and presence of salt.

Texture evaluation. The results of the objective evaluation of Telemea cheese texture after 28 days of aging are given in Table 2.Generally, the cheese samples ripened in brine solution B (KCl) were slightly more fracturable, softer, springier, gummier and more chewable compared to other cheese samples.This observation is in agreement with the results of Kamleh et al., (2012) for Halloumi cheese and Ayyash and Shah (2011b) for Nabulsi cheese.

Table 2.

Textural properties of Telemea cheese made with NaCl, KCl or mixtures of NaCl/KCl during storage at 4°C for 28 days

Parameters	Telemea cheese samples			
	A	***B***	***C***	***D***
Hardness, N	3.55 ± 0.27	2.32 ± 0.19	5.47 ± 0.11	2.90 ± 0.11
Cohesiveness	0.33 ± 0.05	0.41 ± 0.08	0.58 ± 0.05	0.45 ± 0.06
Springiness, mm	2.89 ± 0.02	3.07 ± 0.02	3.89 ± 0.13	3.83 ± 0.09
Chewiness Index, N	0.96 ± 0.09	0.98 ± 0.07	1.31 ± 0.04	1.19 ± 0.09
Gumminess, N	1.29 ± 0.12	1.32 ± 0.13	3.69 ± 0.11	1.37 ± 0.11

All values are mean ± SD

This decrease in hardness and chewiness during ripening period is expected due to the enzymatic hydrolysis of αs1-casein, which makes the cheese smoother (Al-Otaibi and Wilbey, 2006; Sobral et al., 2016; Nepomuceno et al., 2016).

Sensory evaluation. The results of the taste panel's assessment of Telemea cheese quality after aging for 28 days are shown in Figure 2.

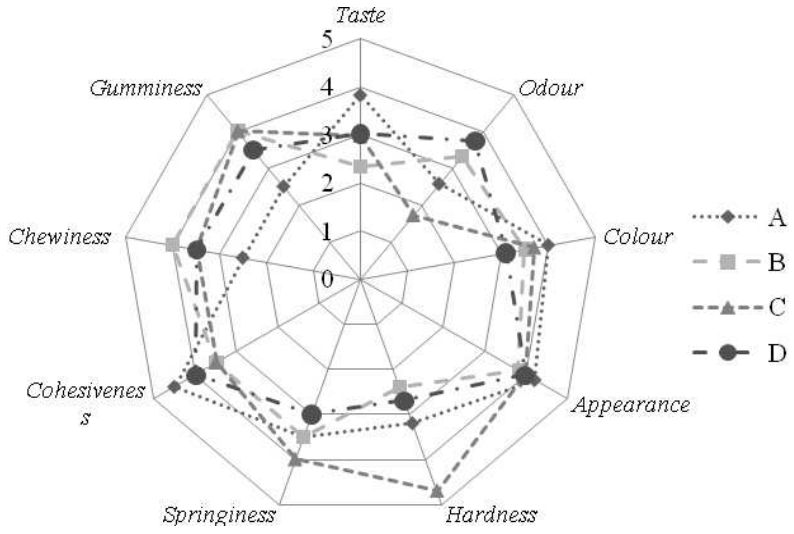

Figure 2 –Sensory evaluation of Telemea cheese sample

Each Telemea cheese sample was appreciated for appearance, taste, odour, colour and texture (hardness, springiness, chewiness, gumminess and cohesiveness).

Regarding the appearance, the cheeses with KCl differed from the other cheese samples possibly due to the greater presence of this salt. The use of chloride salts change the hydration properties of protein and alter the texture of cheeses (Golin Bueno Costa et al., 2018), which is demonstrated by the differences in texture of the cheeses in the present study. The lower odour scores of the Telemea cheese salted with the 1:1 NaCl/KCl mixture remarked in the current study was due to a slightly burning-metallic aftertaste, typical of KCl. Similar results were reported by Katsiari et al., (1998) for Kefalograviera cheese. The values of texture parameters (hardness, cohesiveness, gumminess and chewiness were higher ($p < 0.05$) for the Telemea cheese samples ripened in brine solution A (only NaCl) compared to the Telemea cheese samples ripened in brine solution B (only KCl). The consumers remarked significant changes in textural characteristic of cheese during ripening at 4°C for 28 days ($p > 0.05$), due to the proteolysis process that plays an important role in cheese texture. The results presented in Figure 2 clearly demonstrate that using NaCl/KCl mixtures to obtain Telemea cheese can be a success. Similar results have also been reported by other investigators for various cheese varietes, such as Feta (Katsiari et al., 1997) and Akawi (Ayyash et al., 2012).

CONCLUSIONS

The obtained results in this research allow the production of reduced – sodium Telemea cheese withsimilar characteristics with traditional cheese.This study confirms that potassium chloride is a viable alternative to complete or partial replacement of the sodium chloride in the dairy industry.The partial or total replacement of NaCl by KCl did not interfere in the physicochemical and texture profile of Telemea cheese. The sensory analysis of the experimental Telemea cheeses showed that cheeses salted with NaCl/KCl mixtures or with KCl were found acceptable by the consumers. More research are required to better comprehend the contribution of K ions in the case of Telemea cheese and their impact on proteolytic enzymes.

REFERENCES

1. Abd El-Salam, M.H., Alichanidis, E. (2004). *Cheese varieties ripened in brine*: In: Fox PF, McSweeney PLH, Cogan TM, Guinee TP, editors. Cheese: chemistry, physics and microbiology. Major cheese groups, Vol. 2, 3rd ed. (pp. 227 – 249), London, U.K.: Elsevier Academic Press.
2. Alichanidis, E., Polychroniadou, A. (2008). Characteristics of major traditional regional cheese varieties of East-Mediterranean countries: a review. Dairy Science & Technology (Le Lait), 88(4 – 5), 410 – 495. DOI: https://doi.org/10.1051/dst:2008023
3. Al-Otaibi, M. M., Wilbey, R. A. (2006). Effect of chymosin reduction and salt substitution on the properties of white salted cheese. International Dairy Journal, 16(8), 903 – 909. DOI: https://doi.org/10.1016/j.idairyj.2005.08.006
4. Angheloiu, M., Mocanu, G. – D., Botez, E. (2016). The effect of NaCl substitution by KCl on telemea cheese properties. The Annals of the University Dunarea de Jos of GalatiFascicle VI – Food Technology, 40(2), 20-30.
5. Ayyash, M. M., Sherkat, F., Shah, N. P. (2012). The effect of NaCl substitution with KCl on Akawi cheese: Chemical composition, proteolysis, angiotensin-converting enzyme inhibitory activity, probiotic survival, texture profile, and sensory properties. Journal ofDairy Science, 95(9), 4747 – 4759. DOI: https://doi.org/10.3168/jds.2011-4940

6. Ayyash, M. M., Shah, N. P. (2011a). Effect of partial substitution of NaCl with KCl on proteolysis of Halloumi cheese. Journal of Food Science, 76(1), C31 – C37. DOI: https://doi.org/10.1111/j.1750-3841.2010.01901.x
7. Ayyash, M. M., Shah, N. P. (2011b). The effect of substituting NaCl with KCl on Nabulsi cheese: chemical composition, total viable count, and texture profile. Journal of DairyScience, 94(6), 2741–2751. DOI: https://doi.org/10.3168/jds.2010-3976
8. Ayyash, M. M., Sherkat, F., Francis, P., Williams, R. P., Shah, N. P. (2011). The effect of sodium chloride substitution with potassium chloride on texture profile and microstructure of Halloumi cheese. Journal of Dairy Science, 94(1), 37–42. DOI: https://doi.org/10.3168/jds.2010-3407
9. Ayyash, M.M., Shah, N.P. (2010). Effect of partial substitution of NaCl with KCl onHalloumi cheese during storage: chemical composition, lactic bacterial count, andorganic acids production. Journal of Food Science, 75(6), C525–C529. DOI: https://doi.org/10.1111/j.1750-3841.2010.01691.x
10. Bakirci, I., Kavaz, A., Macit, E.(2011). Effect of different brine concentrations and ripening period on some quality properties of Turkish white pickled cheese. African Journal of Biotechnology, 10(56), 11925 – 11931. DOI: 10.5897/AJB11.647
11. Bourne, M. C. (1978). Texture profile analysis. Food Technology, 32(7), 62–66.
12. Costin, G. M. (2003). Ştiința și ingineria fabricării brânzeturilor, (pp. 400 – 413), Academica, Galați.
13. Domnariu, C. D., Cucu, A., Furtunescu, F. L. (2013). World health organization guidelines on salt intake in adults and children. Acta Medica Transilvanica, 2(1), 166 – 168.
14. Felicio, T. L., Esmerino, E. A., Cruz, A. G., Nogueira, L. C., Raices R. S. L., Deliza, R., Bolini H. M. A., Pollonio, M. A. R. (2013). Cheese. What is its contribution to the sodium intake of Brazilians? Appetite, 66(1), 84 – 88. DOI: https://doi.org/10.1016/j.appet.2013.03.002
15. Ferrão, L. L., Silva, E. B., Silva, H. L. A., Silva, .R., Mollakhalili, N., Granato, D., Freitas, M.Q., Silva, M C., Raices, R. S. L., Padilha, M. C., Zacarchenco, P. B., Barbosa, M. I. M. J., Mortazavian, A. M., Cruz, A. G. (2016).Strategies to develop healthier processed cheeses: Reduction of sodium and fat contents and use of prebiotics. Food Research International, 86, 93 – 102. DOI: https://doi.org/10.1016/j.foodres.2016.04.034
16. Golin Bueno Costa, R., Sobrala D., Martins Teodoro, V. A., Gonçalves Costa Junior, L. C., de Paula, J. C. J., Barroso Landin, T., Braga de Oliveira, M. (2018). Sodium substitutes in Prato cheese: Impact on the physicochemicalparameters, rheology aspects and sensory acceptance. LWT - Food Science and Technology, 90, 643–649. DOI: https://doi.org/10.1016/j.lwt.2017.12.051
17. Kamleh, R., Olabi, A., Toufeili, I., Daroub, H., Younisa, T., Ajiba, R. (2015). The effect of partial substitution of NaCl with KCl on the physicochemical, microbiological and sensory properties of Akawi cheese. Journal of the Science of Food and Agriculture, 95(9), 1940 – 1948. DOI: https://doi.org/10.1002/jsfa.6906
18. Kamleh, R., Olabi, A., Toufeili, I., Najm, N. E. O., Younis, T., Ajib, R. (2012). The effect of substitution of sodium chloride with potassium chloride on the physicochemical, microbiological, and sensory properties of Halloumi cheese. Journal of Dairy Science, 95(3), 1140–1151. DOI: https://doi.org/10.3168/jds.2011-4878
19. Katsiari, M. C., Alichanidis, E., Voutsinas, L. P., Roussis, I. G. 2001. Proteolysis in reduced sodium Kefalograviera cheese made by partial replacement of NaCl with KCl. FoodChemistry, 73(1), 31–43. DOI: https://doi.org/10.1016/S0308-8146(00)00275-2
20. Katsiari, M.C., Voutsinas, L.P., Alichanidis, E., Roussis, I.G. 2000. Lipolysis in reduced sodium Feta cheese made by partial substitution of NaCl by KCl. Internatinal DairyJournal, 10(5–6), 369–373. DOI: https://doi.org/10.1016/S0958-6946(00)00067-421.
21. Katsiari, M.C., Voutsinas, L.P., Alichanidis, E., Roussis, I.G. (1998). Manufacture ofKefalograviera cheese with less sodium by partial replacement of NaCl with KCl. FoodChemistry, 61(1–2), 63–70. DOI: https://doi.org/10.1016/S0308-8146(97)00113-1

22. Katsiari, M.C., Voutsinas, L. P., Alichanidis, E., Roussis, I. G.(1997). Reduction ofsodium content in Feta cheese by partial substitution of NaCl by KCl. InternatinalDairy Journal, 7(6–7), 465–472. DOI: https://doi.org/10.1016/S0958-6946(97)00032-0
23. Khosrowshahi, A., Madadlou, A., Mousavi, M. E., Emam-Djomeh, Z. (2006). Monitoring the chemical and textural changes during ripening of Iranian White cheese made with different concentrations of starter. Journal of Dairy Science, 89(9), 3318 – 3325. DOI: https://doi.org/10.3168/jds.S0022-0302(06)72368-2
24. Lawless, H. T., Heymann, H. (2010). Sensory Evaluation of food. Principles and Practices, (pp. 367), Springer, New York, USA.
25. Madadlou, A., Khosrowshahi, A., Mousavi, M. E., Farmani, J. (2007). The influence of brine concentration on chemical composition and texture of Iranian White cheese. Journal of Food Engineering, 81(2), 330-335. DOI: https://doi.org/10.1016/j.jfoodeng.2006.11.010
26. Moatsou, G., Govaris, A. (2011). White brined cheeses: A diachronic exploitation of small ruminants of milk in Greece. Small Ruminant Research, 101(1 – 3), 113 – 121. DOI: https://doi.org/10.1016/j.smallrumres.2011.09.031
27. Nepomuceno, R. S. C., Costa Junior, L. C. G., Costa, R. G. B. (2016). Exopolysaccharideproducingculture in the manufacture of Prato cheese. LWT – Food Science and Technology, 72, 383–389. DOI: https://doi.org/10.1016/j.lwt.2016.04.053
28. Rahimi, J., Khosrowshabi, A., Moradi, M. M., Mohamadi, H., Abbasi, H., Madadlou, A. (2013). Texture and Chemistry of Iranian White Cheese as Influenced by BrineTreatments. Journal of Food Processing & Technology, 4(4), 219 – 228. DOI: 10.4172/2157-7110.1000219
29. Sobral, D., Costa, R. G. B., Machado, G. M., de Paula. J. C. J., Teodoro, V. A. M., Nunes, N. M., dos Santos Pires, A. C., Soares Pinto, M. (2016). Can lutein replace annatto in the manufacture of Prato cheese? LWT – Food Science and Technology, 68, 349 – 355. DOI: https://doi.org/10.1016/j.lwt.2015.12.051
30. Tamime, A. Y. (2006). Brined Cheeses, (pp. 63 – 68), Blackwell Publishing, Oxford, UK.
31. Thibaudeau, E., Roy, D., St-Gelais, D. (2015). Production of brine-salted Mozzarella cheese with different ratios of NaCl/KCl. International Dairy Journal, 40, 54 – 61. DOI: https://doi.org/10.1016/j.idairyj.2014.07.013
32. World Health Organization, 2011. Review and updating of current WHO recommendationson salt/sodium and potassium consumption. Geneva, Switzerland, available on-line at http://www.who.int/nutrition/events/NUGAG_dietandhealth_subgroup_call_public_comment_scope_of_Na_K.pdf, accessed on 30.11.2018, 17:35.