The Effect of Different Starter Cultures on Water Phase Salt Content in White Brined Cheese Production

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Abstract: The present paper is focused on the water phase salt content of three variants of white brined cheese samples manufactured with different starter cultures. White brined cheese is Macedonian traditional product with specific taste and quality parameters. In this research work, the influence of three different starter cultures of three white brined cheese variants (A, B, C) has been examined in order to assess their water phase salt content dynamics. The starter cultures used in this study included, variant A (SMCH-5) that contained: *Lactobacillus bulgaricus, Streptococcus thermophilus* and *Lb. acidophilus*; the variant B (Choozit Feta A) contained: *Lactococcus lactis* ssp. *lactis*, *L. lactis* ssp. *cremoris, Strep. thermophilus, Lb. bulgaricus* and *Lb. helveticus;* while the variant C (MOTC 092 EE) contained: *L. lactis* ssp. *lactis, Strep. thermophilus, Lb. bulgaricus, Lb. helveticus* and *Lb. casei*. The main aims of this study were to investigate the effects of the above mentioned three different starter cultures on the water phase salt content during the process of ripening of white brined cheese. No significant effect on the water phase salt content during the fermentation process among all three white brined cheese variants (A, B and C) produced by different types of starter cultures was found. The water phase salt contents in all the three variants were in the range of 5.45-5.56%.

Keywords: Milk, white–brined cheese, starter cultures, water phase salt content, dynamic.

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1. Introduction

Demand for dairy products and their derivatives is continuously increasing with increasing global population (Hofmeyr, 2019). Meeting growing demand for dairy products will continue to be a challenge for global food security and achieving Sustainable Development Goals (SDGs) (Ghandhi and Zhou, 2014; Ghose, 2014; Smith et al., 2013).

Cheese is made from the curds produced from coagulated milk. Being a product of fermented milk cheese contains high levels of milk fat, however it contains lower lactose contents (Bintsis and Papademas, 2017; Mihretie et al., 2018; Sánchez-Muñoz et al., 2017). White brined cheese is a product that is manufactured in different countries of various regions (Gharibzahedi et al., 2018; Papademas et al., 2019), given several names including Feta, Telemes (Greece); Telemea/Branza de Braila (Romania); Bjalo salamureno sirene/Bjalo sirene (Bulgaria); Belo salamureno sirenje (N. Macedonia); Mohant (Slovenia); Sjenicki, Homoljski, Zlatarski, Svrljiški (Serbia); Pljevaljski, Polimsko Vasojevaski, Ulcinjski (Montenegro); Travnicki/Vlasicki (Bosnia-Herzegovina); Beyaz peynir, Edirne peyniri (Turkey); Liqvan, Iranian white (Iran); Brinza (Israel); Akawi (Lebanon); Domiati, Mish (Egypt), (Alichanidis and Polychroniadou, 2008).

White brined cheese belongs to the group of cheeses that ferment in brine solution in anaerobic conditions and is characterized with acid-salty flavor, no rind, no gas holes or other openings should be present in the cheese mass, usually has white color and the texture should be smooth and soft (Makarijoski, 2019). All parameters that are measured during the production process are important and each of these show the correctness of white brined cheese manufacturing process. Various factors influence cheese production, including pH, water phase salt content, heat etc (Finnegan et al., 2018; Kilcawley et

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al., 2018; Sung and Collins, 2000).

The growth and activity of lactic acid bacteria (LAB) is determined by water phase salt content. During the ripening process of white brined cheese, the residual lactose gets converted into L-lactate because of low water phase salt content and low number of non-starter lactic acid bacteria (Fonseca et al., 2015; Gobbetti et al., 2018; Hickey et al., 2018). When the ripening temperature and the number of non-starter bacteria are higher, then significant amount of D-lactate will be produced (Blaya et al., 2018; Duru et al., 2018; Puđa, 2009). According to Kozev (2006), the water phase salt content ranging from 1 to 1.5% stimulates the growth and development of LAB. In contrast, when the water phase salt content is between 2 - 3%, the growth of LAB slows down. Moreover, when the content is between 3.5 to 5.5%, a greater decrease in the metabolism and activity of LAB is noticed, as well. Furthermore, the water phase salt content over 6.5% completely stops the fermentation process and activity of LAB.

2. Materials and Methods

2.1. Materials

White brined cheese was manufactured from pasteurized cow milk in a local dairy plant “Milkom" - v. Nogaevci, Gradsko, R. Macedonia. The raw milk was supplied from Gradsko region in Macedonia. The chemical composition of the milk used for the manufacturing of white cheese was 12.13% total solids, 3.70% fats, 3.21% proteins, 0.67% ash, and 4.55% lactose. The pH of the milk was 6.49. The milk was pasteurized at 72°C for 15 seconds and cooled at 34°C. The curding was done at 34ºC.

The following starter cultures were used: for white brined Cheese-Variant A- SMCH – 5, for white brined Cheese-Variant B- Choozit Feta A and for white brined cheese Variant C - MOTC 092 EE. In addition, $CaCl_2$ (0.02%) and blego color 10 mL/100 L milk was added in each treatment. The cow milk was coagulated with chymosin rennet (Chymax Extra Powder 1.5 g/100 L milk) completed in 45 min.

Furthermore, the curd was cut into cubes of 1x1x1cm^3, allowed to rest for 5 minutes, and pressed in cheese molds for 3 hours. The cheese blocks thus obtained were placed in tinned cans filled with brine solution (approximately 8g NaCl/100g water). During the ripening period of 30 days, the cheese was held at 15-17°C. After 30 days, the samples were kept at 2-4°C for the remaining period of this study.

2.2. Methods

The determination of the salt content in cheese was performed using the method of Sabadoš (1996). Dry matter was determined by the method of Carić et al., (2000). In addition, the water content was calculated by difference method. Moreover, the water phase salt content was calculated using the method of Kozev (2006), according to which, the cheese salt content was divided by cheese water content and multiplied by 100. Furthermore, the standard statistical method (Najchevska, 2002) was used for statistical presentation of the analyzed data, as well as F-test for analysis of the variance in tested cheese variants. The results are presented as mean value ± SD (n=4).

3. Results and Discussion

The water phase salt content regarding the examined three varieties of white brined cheese was presented in Table 1 and Fig. 1.

Table 1. Water phase salt content in white brined cheese production

Variant A (SMCH - 5)				
	1 day	**10 day**	**30 day**	**60 day**
Mean	3.44	4.13	4.89	5.45
Min	3.11	3.87	4.62	5.16
Max	3.75	4.64	5.27	5.77
Sd	0.259	0.316	0.250	0.229
Cv	7.527	7.652	5.103	4.204
Variant B (Choozit Feta A)				
	1 day	**10 day**	**30 day**	**60 day**
Mean	3.60	4.48	5.07	5.46
Min	3.24	4.15	4.75	5.29
Max	3.96	4.79	5.28	5.63
SD	0.339	0.286	0.229	0.161
Cv	9.422	6.379	4.520	2.954
Variant C (MOTC 092 EE)				
	1 day	**10 day**	**30 day**	**60 day**
Mean	3.66	4.57	5.19	5.56
Min	3.43	4.41	5.01	5.30
Max	3.95	4.80	5.37	5.87
SD	0.209	0.155	0.169	0.243
Cv	5.725	3.386	3.270	4.374

* Mean (Mean value), Min (Minimal value), Max (Maximum value), SD (Standard deviation), CV (Coefficient of variation), Number of samples (n=4);

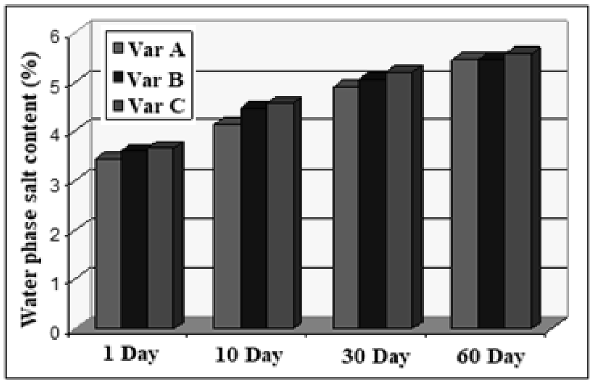

Fig. 1. Water phase salt content in three variants white brined cheese.

The water phase salt content of the white brined cheese cultured with the starter culture var. C at the first day of production was the highest (3.66%), followed by var. B (3.60%), and var. A (3.44%), respectively (Table 1). In the further period of ripening, a continuous increase of water phase salt content was noticed in all three variants.

According to Puđa (2009), *L. lactis ssp. lactis* is especially sensitive to the increased salt concentrations, while *L. lactis ssp. lactis* may also be active at 4% NaCl. Non-starter LAB are resistant to increased concentrations of water phase salt content, and the important representatives in this group include *Lb. Casei* and *Lb. plantarum.*

Similarly, after 10 days at 15-17°C, trend remained similar, as the water phase salt contents in Variant C were again the highest (4.57%), followed by var. B (4.48%), and var. A (4.13%), respectively. In addition, the same trend was also observed for water phase salt contents after 30 days at 15-17°C, as Variant C showed the highest values (5.19%), followed by Variant B (5.07%) and Variant A (5.45%), respectively. Finally, the results for storage at 2-4°C for 60 days were also similar to those of lesser number of storage days, as the highest value was observed for Variant C (5.56%), followed by Variant B (5.46%) and Variant A (4.89%), respectively. From these results, it was evident that the value of water phase salt content Variant C was higher than Variant B and Variant A during the ripening process. The metabolism and growth of LAB decreases with the increase in percentages of water phase salt content, hence the highest growth could be perceived in case of Variant A, followed by Variant B and Variant C, respectively.

On the other hand, water phase salt contents of the cheese samples during the ripening at different storage temperatures increased with increasing the number of storage days, initially for a period of 30 days at 15-17°C, and then at 2-4°C for the remaining period of this study. In Variant A, the lowest water phase salt contents were observed at 10 days (4.13%), followed by at 30 days (4.89%) and 60 days (5.45%). Similar dynamics of water phase salt content were also noticed in case of Variant B, for which 4.48% water phase salt contents was observed after 10 days, followed by 5.07% at 30 days and 5.46% at 60 days, respectively. Similar results were observed in case of Variant C, as well. The water phase salt content of Variant C after 10 days of ripening was 4.75%, after 30 days of ripening was 5.19% and after 60 days of ripening was 5.56%.

From these results, it was evident that the value of water phase salt content continuously increased during the ripening process. The development and activity of LAB decreases with the increase in percentages of water phase salt content. This phenomenon was noticed in all the three variants (Variant A, Variant B and Variant C) in this study.

These results for water phase salt content were set within the range limits of the results presented by Anifantakis, (1998) for feta cheese 5.27%. The results presented in this experiment were quite similar to those provided by Hayaloglu et al., (2002). Their values for water phase salt content in Turkish white brined cheese were in the range limits of 4.3-9.9%. In addition, higher results for water phase salt content were reported by Kostova, (2013) in traditional white brined sheep cheeses. The author found that in ripened brine sheep cheese, water phase salt content was between 7.42 to 11.07%, mainly because of higher concentration of salt in those samples, i.e. from 4.38 to 5.43%.

Table 2. Analysis of variance for the water phase salt content of white brined cheese

Source of variation	Sum of squares (SQ)	Degree of freedom (DF)	Variance	F-value
Total	1.9332	14		
Between groups	0.2940	2	0.1470	ns3.05
In groups	1.6392	12	0.1366	

Controlling this parameter, the dynamics of the milk acid fermentation can be monitored, so that necessary technological changes can be made. It should be noted that the salt concentration in brine should be 2% higher than the water phase salt content in cheese in order to produce quality product, (McSweeney, 2007). The Fisher test presented in Table 2 showed a lower F-value from the tabular values at both levels. These results revealed that the three starter cultures used in this study had no significant effect on the water phase salt content of the cheese.

4. Conclusion

No significant effect on the water phase salt content during the fermentation process among all three white brined cheese variants (A, B and C) produced by different types of starter cultures was found. Hence, the starter cultures used in this study did not influence the water phase salt content during the process of fermentation of white brined cheese at different storage temperatures kept for 60 days. The water phase salt contents in all the three variants were in the range of 5.45-5.56%.

List of Abbreviations: CV, Coefficient of variation; LAB, lactic acid bacteria; NaCl, Sodium chloride; SD, Standard deviation.

Competing Interest Statement: The authors declare that they have no competing interests regarding the publication of this paper.

Author's Contribution:
M.B., S.P., and G.D. involved in the conception, design of the study. M.B., V.K.H, and Dj.T., performed experiment; all authors were involved in data collection, analysis, interpretation and manuscript writing.

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