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THE INFLUENCE OF ULTRAFILTRATION OF EWE'S MILK ON SOFT CHEESES PROPERTIES

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ABSTRACT

Ewe's milk non-concentrated and concentrated by ultrafiltration to 60% of initial volume, was processed into soft cheese. The cheese were stored, in 4°C, for 14 days. The milk, retentate and fresh cheese were analyzed and also cheese after 7 and 14 days of storage were estimated. Organoleptic assessment, yield, physico-chemical properties and texture analyses were done in cheese. It was observed that cheese yield made from ultrafiltrated milk was higher than from non-concentrated milk. The fresh cheese made from concentrated milk contained more: water, total nitrogen compounds and free fatty acids and less fat. These cheese were softer and had higher cohesiveness than cheese made form non-concentrated milk. The ultrafiltration enchanced the cheese properties. All cheese were edible after 14 days of storage.

Key words: ewe's milk, ultrafiltration, retentate, fresh cheese, physico-chemical properties, texture

INTRODUCTION

Membrane technologies are commonly used by dairy industry in milk processing, especially in yogurts and cheese production. The introduction of milk ultrafiltration allowed i.e. for diminishing of amount of processed milk, for diminishing of additives used for milk: cheese starter, rennet, dyes, salt and so on [3, 1]. Some research results show that milk ultrafiltration influences the cheese yield, especially when before ultrafiltration milk is highly thermally processed [7, 3]. Concentration of milk by this method causes the changes in chemical composition and physico-chemical properties of obtained retentate (concentrate). These changes depend mainly

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on the degree of concentration and kind of membranes. Calvo and Espinoza [6] consider that all milk proteins and fat remain in the retentate. Premarante and Cousin [15] have established that as a result of ultrafiltration the content of protein and fat grow proportionally with the degree of concentration, when lactose content falls down and other compounds content i.e. vitamins, amino acids, free fatty acids, grow or fall down what is due to the quantity of these compounds and their connections to proteins and fat of milk. According to Barbano et al. [4] not all proteins stay in the concentrate. These scientists have established the presence of alpha-lactoalbumin and some small amounts of short-chain nitrogen compounds. In the opinion of Barbano et al. [4] the lower content of group B vitamins and of some elements in the concentrate can negatively influence the starters' microbial growths, which are added to form fermented drinks and/or cheese. Srilaorkul et al. [17] research shows that the milk ultrafiltration causes the diminishing in diameters of casein micelles. The changes in the chemical composition and in the physical properties of milk concentrated by ultrafiltration influence also the properties of this milk product.

According to Calvo and Espinoza [6] the ultrafiltration causes the lowering of curd syneresis what influences the quality of produced cheese. Some researchers' reports show that cheese produced from ultrafiltrated milk contain more water and are less hard then cheese produced from not concentrated milk [1, 9, 16].

The aim of this work was to establish to what degree the ewes' milk concentration with ultrafiltration method influences physico-chemical properties, texture and organoleptic score of soft cheese after 1, 7 and 14 days of storage.

MATERIALS AND METHODS

The research material was ewes' milk from experimental farms of Agricultural Academy in Cracow, Poland. The Polish long-fleeced ewes were milked during spring season. The mechanical milking with Alfa-Laval equipment was applied. There were taken 5 probes of tank milk (from chilling tanks) in quantity of 10 l each and the milk was chemically analysed in two hours after milking. The cheese were produced according to subsequent procedure. Milk after cloth filtration was divided into two parts. The first part was not concentrated, the second was heated to 50°C and ultrafiltrated with CH 2A Amicon apparatus, with Hellow Fiber Hi P30-20 membrane, pores of 30 000 Da, at pressure at about 20 psi (1.4 x 105 N/m^2).

The concentration was done up to 60% of initial milk volume. Then both milk - concentrated and not concentrated - were pasteurized in 72°C for 15 s, cooled to 30°C, the mesophilic starter (*Lactococcus lactis* ssp. *lactis*, *Lactococcus lactis* ssp. *cremoris*, *Leuconostoc*) was added. The rennet was added in amount enough to form curd in two hours time. The curd was cut into prisms, at about 2 cm-side dimension, gently mixed for 15 min. And moulded in 10 cm diameter moulds. It was left in the moulds till the subsequent day. Then cheese were taken out of moulds, packed into parchment and stored for 14 days in 4°C.

The analyses of milk, retentate and of cheese after 1,7 and 14 days of storage were performed.

In the milk and in the retentate the dry mass by drying method, the total nitrogen compounds and the casein amount (precipitated with sodium acetate and acetic acid) by Kjeldahl method on Büchi apparatus, the fat level by Gerber method, the lactose amount by Bertrand method, the density by densimeter, the pH by pH-meter, the titronic acidity by Soxhlet-Henkel method were estimated [5, 8].

In the cheese the dry mass by drying method, the fat content by butyrometric method in van Gulik's fatmeters, the total nitrogen compounds by Kjeldahl method, the amount of free fatty acids by Dole method, the titronic acidity by Soxhlet-Henkel method, the pH by pH-meter were estimated [5, 13, 8].

The organoleptic assessment of cheeses was done according to 5-point Kurpisz scale [11]. The texture profile of cheese samples was done with TA-XT2 texture analyzer produced by Stable Micro Systems (Halsemere, Surrey, UK). The measurement device was the aluminum cylindrical plunger type SMS P/50, 50-mm diameter. The cheese probe was cut out in cubic shape, 20-mm side, and pressed with 1m/s speed, with 60% probe compression. The subsequent parameters were obtained in cheese texture profile: hardness, adhesivness, cohesiveness, springiness, chewiness [14, 18], with the Texture Expert Program v. 1.05 - algorithm Fracture TPA. The hardness was determined as the end force required to attain the set compression of cheese probe (this is the point of maximum deflection of the curve during the first pressing cycle). The adhesivness was calculated as the area of minus peak; the cohesiveness was calculated from the ratio of surface areas determined by the curves of the second and first compression. The springiness was calculated from the ratio of time that elapsed

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between the contact of compressing plunger with sample and the end of its motion downward during the second and first compression. The chewiness was calculated by multiplying hardness by cohesivness and springiness. The results were estimated statistically with Statgraphics program v. 3.0.

RESULTS AND DISCUSSION

The ewe's milk for cheese production was characterized by high content of dry mass, total nitrogen compounds and fat (Table 1) and did not differ from data given, in literature, for milk originating from different ewes' breeds [2]. The retentate obtained after concentrating to 60% of initial milk volume, had contained, proportionally to concentration degree, more nitrogen compounds and more fat, although the amounts of above mentioned milk constituents were a bit smaller then it could come out from calculations.

Table 1. The ewe's milk and retentate (concetrated to 60% of initial volume) properties<

Properties	Non-concentrated milk x ± s*	Milk concentrated by UF (retentate) x ± s
Dry mass [%]	18.10 ± 1.75 A	25.76 ± 1.53 B
Total nitrogen compounds [%]	5.69 ± 0.87 A	9.39 ± 0.92 B
Casein [%]	4.48 ± 0.73 A	7.42 ± 0.65 B
Fat [%]	6.9 ± 0.94 A	11.4 ± 0.87 B
Lactose [%]	4.65 ± 0.58 A	3.98 ± 0.56 B
Density g/cm^3	1.034 ± 0.0002 a	1.037 ± 0.0002 b
Titronic acidity [°SH]	9.0 ± 1.11 a	10.3 ± 1.13 b
pH	6.61 ± 0.03	6.60 ±0.05

*** x ± s - average ± standard error**
A,B - statistically highly significant difference between averages marked with different letters in a row (p≤0.01)
a,b - statistically significant difference between averages marked with different letters in a row (p≤0.05)

Calvo and Espinoza [6] and Premaratne and Cousin [15] concluded that the whole amount of proteins and fat had stayed in retentate after concentration, when Barbano et al. [4] considered that some lower molecular weigh proteins like alpha-lactoalbumin and some other nitrogen compounds had migrated to permeate. The dry mass content in the retentate, in comparison to not concentrated milk, grown in the lower extent then concentration itself what was connected with migration of such dry mass components as: first of all some lactose, some proteins, free fatty acids, some vitamins (mostly of B group), some minerals (not connected to proteins) [6, 4, 15].

The cheese were produced from non-concentrated and concentrated milk. Their yield was respectively 39.6 % ± 2.85 and 43.8 % ± 3.12. The yield of cheese obtained from concentrated milk was significantly higher then for cheese produced from non-concentrated milk ($p \leq 0.05$). The results described in this paper are in common with other authors [16, 3, 7] - the ultrafiltration of milk caused rise in cheese yield.

In Table 2 are shown properties for 1, 7 and 14 days cheese produced from non-concentrated and concentrated by ultrafiltration milk.

Table 2. The properties of soft cheeses in 1, 7, and 14 day of storage

Properties of soft cheeses	The period of storage	from non-concentrated milk	from milk concentrated by UF
		x ± s*	x ± s
Moisture [%]	1	67.62 ± 3.21	68.75 ± 2.88
	7	67.42 ± 2.14	68.70 ± 1.95
	14	67.34 ± 2.34	68.72 ± 1.76
Total nitrogen compounds [%]	1	14.85 ± 1.30 a	15.55 ± 1.01 b
	7	14.90 ± 1.23 a	15.65 ± 0.82 b
	14	15.01 ± 0.98 ab	15.69 ± 1.02 b
Fat [%]	1	12.52 ± 2.13 a	11.94 ± 2.21 b
	7	12.71 ± 2.09 a	12.08 ± 1.86 ab
	14	12.76 ± 1.98 a	12.12 ± 1.65 ab

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Table 2 cont.

1	2	3	4
Organoleptic evaluation [score]	1	4.95 ± 0.05 a	5.00 ± 0.00
	7	4.78 ± 0.08 b	4.90 ± 0.05 a
	14	4.63 ± 0.06 c	4.84 ± 0.04 ab
pH	1	4.66 ± 0.12	4.75 ± 0.10
	7	4.60 ± 0.06	4.73 ± 0.08
	14	4.61 ± 0.15	4.69 ± 0.11
Titronic acidity [°SH]	1	52.03 ± 3.21 a	48.98 ± 2.87 a
	7	66.22 ± 3.15 c	75.02 ± 3.48 c
	14	82.21 ± 2.98 b	90.01 ± 3.87 b
Free fatty acids [µEq/g]	1	9.33 ± 1.21 a	9.82 ± 0.99 a
	7	10.62 ± 1.22 a	11.25 ± 1.98 bc
	14	12.02 ± 1.80	13.52 ± 1.97
Hardness TPA [KG]	1	0.69 ± 0.02 a	0.46 ± 0.01 b
	7	0.72 ± 0.03 a	0.47 ± 0.02 b
	14	0.73 ± 0.02 a	0.57 ± 0.03 b
AdhesivnessTPA [KGs]	1	-0.04 ± 0.001	-0.05 ± 0.001
	7	-0.09 ± 0.001	-0.06 ± 0.001
	14	-0.10 ± 0.001	-0.05 ± 0.002
SpringinessTPA	1	0.71 ± 0.03	0.70 ± 0.02
	7	0.66 ± 0.02	0.67 ± 0.02
	14	0.59 ± 0.01	0.64 ± 0.01
Cohesiveness TPA	1	0.26 ± 0.04 a	0.44 ± 0.05 b
	7	0.24 ± 0.03 a	0.33 ± 0.04 a
	14	0.21 ± 0.02 a	0.22 ± 0.02 a
Chewiness TPA [KG]	1	0.13 ± 0.02	0.15 ± 0.01
	7	0.11 ± 0.01	0.09 ± 0.01
	14	0.09 ± 0.01	0.08 ± 0.01

*** x ± s - average ± standard error**
a, b, c - statistically significant difference between averages marked with different letters in a row ($p \leq 0.05$)

The fresh cheese produced from ultrafiltrated milk contained little more water and nitrogen compounds and less fat than cheese made from non-concentrated milk. Although these differences between averages were not statistically significant. Abd El-Salam [1] and Green and Grandison [10] admitted that domiati, feta and cheddar cheese, which had been produced from ultrafiltrated milk, had usually contained more water, less fat than the same cheese obtained from non-concentrated milk. Whereas from Spangler et al. [16] work showed that gouda cheese produced from concentrated by ultrafiltration milk contained less protein than cheese produced from non-concentrated milk. Similarly Nakazawa et al. [12] concluded that quarg obtained from concentrated milk contained less dry matter, nitrogen compounds and fat than quargs produced form non-concentrated milk.

The cheese produced from ultrafiltrated milk were characterized by significantly lower hardness and higher cohesiveness than cheese obtained from non-concentrated milk (Table 2), what was probably connected with higher water capacity and higher amount of nitrogen compounds in from retentate manufactured cheese. Spangler et al. [16] also had found that gouda cheese obtained from non-concentrated milk were harder than cheese from ultrafiltrated milk. They stated that with the rise of degree of milk concentration the cheese hardness also had risen.

One-day cheese from concentrated milk obtained the highest organoleptic score. The chilled storage of cheese influenced the small decrease in all organoleptic scores. All fourteen-day cheese were edible. Cheese from concentrated milk obtained the higher score after 14-days storage than cheese produced from non-concentrated milk. The rise in titronic acidity of cheese was observed during storage period. The higher acidity was measured in cheese from concentrated milk what showed that the more intensive fermentation processes took place there. Premaratne and Cousin [15] concern that lower levels of some group B vitamins and amino acids in the retentate

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from ultrafiltrated milk can inhibit the acidifying bacteria growth. The results obtained in this work did not confirm the data of above-mentioned authors. The storage of cheese influenced the growth of free fatty acids content (Table 2), and that growth was a little bit higher in cheese obtained from concentrated milk what proved the differences in the lypolysis rate in examined cheese. It was established some rise, during 14-days storage period, in hardness of cheese from non-concentrated milk, whereas the concentrated milk cheese were even harder. During storage such texture indicators as chewiness and cohesiveness decreased, and for cheese produced from concentrated milk were lower than for cheese obtained from non-concentrated milk. It can suggest that the texture parameters of cheese produced from ultrafiltrated milk changed in a bit different way than of cheese obtained from non-concentrated milk.

CONCLUSIONS

1. The yield of cheese produced from ewe's milk by ultrafiltration was higher than for cheese obtained from non-concentrated milk.
2. One-day cheese produced from concentrated milk contained more water; nitrogen compounds and free fatty acids and less fat. They were softer and had higher cohesiveness than cheese obtained from non-concentrated milk.
3. The storage of both cheese types influenced the change of their properties, but all cheese were edible after 14 days of storage.
4. The ultrafiltration of ewe's milk influenced positively the quality and shelf life of cheese.

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