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THE INFLUENCE OF CHEMICAL COMPOSITION OF MILK ON YIELD OF SEMI-HARD CHEESE

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Abstract: The aim of paper was to examine the impact of the milk quality on yield of semi-hard naturally dried cheese, produced in cheese plant factory ZZ "Cijevna" in Podgorica. Tests were conducted on 6 samples of bulk milk of cows and 6 productive batch of cheese. Chemical tests of the bulk milk have been done on the device MilcoScan 4000, and the determination content dry matter of whey and dry matter of cheese on the device MilcoScan FT 120. Theoretical yield of cheese was determined in two ways: 1) based on the content of fat and protein content in milk and 2) based on dry matter content of milk, dry matter of whey and dry matter of cheese. Actual yield of cheese is determined on the base of the total amount of cheese obtained after pressing and the amount of wasted milk. The average value for the fat content in the examined milk amounted to 3.79%, protein 3.24%, 4.26% lactose and dry matter content without fat 8.24%. The average value for the theoretical cheese yield by first method was 10.65% and by second method 9,30%. The average of actual cheese yield amounted to 11.26%. We found a very high positive correlation between content of fat in milk and actual cheese yield (0.929032) and mean positive correlation between content of protein in milk and actual cheese yield (0.613141), content of lactose in milk and actual cheese yield (0.651317) and between dry matter content in milk and actual cheese yield (0.651956).

Key word: milk, composition, cheese, yield

Introduction

The chemical composition of milk is one of the most important factors in obtaining a products of milk. In order to get good cheese, milk quality must have good physical-chemical properties and that comes from healthy cows. The amount and composition of milk is influenced by numerous factors, such as animal breed, stage and number of lactation, diet, animal age, health status of animals, climate,

way of milk keeping and others. Given that fat and protein (casein) are basic ingredients of cheese, it is their share in the milk of exceptional importance.
According to the *Regulation on quality and other requirements for milk, dairy products, milk products and composite starter cultures, SRJ, 26/2002*, milk of cows must contain at least 3.2% fat, 2.9% protein and at least 8.5% dry matter without fat. The largest share of milk is water and its content varies from 86% to 89%.

In the milk of healthy cows the total protein content varies little during lactation, while the sick cows came to change the quantity and composition of proteins. When inflammation occurs mammary gland, in milk increase volumes of proteins originating from the blood and reduce proteins originating from the udder. Food does not affect significantly the content of proteins in milk, except in extreme starvation *(Katić and Stojanović, 2002)*.
Nutrition is the most important paragenetic factor that affects the amount and content of certain constituents of milk. In terms of maximum consumption of dry matter, fat and protein in milk is increased by 0,2-0,3%. For each percentage increase of protein in cows meal, the amount of protein in milk is increased by 0.02%. Any excessive uniformity of meals in the form of an excessive amount of nutrients, can cause changes in the synthesis of fat and protein in milk *(Adamović et al., 2003)*.

Fat is most variable ingredient of milk and its average content is 3.8%. In addition to milk protein, milk fat is the most important ingredient of milk and cheese, because it affects the taste, aroma and consistency, the flow of cheese ripening and yield. Usually the fat content in milk is increased during dinner milking. For production of cheese is a very important relationship between fat and proteins. Of all the ingredients of milk, lactose is subject to relatively smallest fluctuations during period of lactation. Milk of cows contains 4.7 to 4.9% lactose. In inflammatory processes in the mammary gland, decreases content of lactose in milk.

Casein is the most important protein of milk. The cheese is in fact mostly composed of casein. Casein forms a crude, spreads fat droplets and keeps them during the entire process of processing and ripening of cheese. Switching casein from milk in crude has great economic importance, because of which largely depends on the yield of cheese and its nutritive value. The milk quality in cheese production is great importance, as phase of cheese: coagulation, sineresis, salting and ripening *(Mijačević, 1992; Dozet et al., 1996)*.

Bearing in mind the importance of the chemical composition of milk in cheese production, we investigated the influence of the chemical composition of milk on yield of semi-hard naturally dried cheese.

Materials and Methods

In order to study the chemical composition of milk intended for production semi-hard cheese, a product cheese plant ZZ "Cijevna", Podgorica, during 6 consecutive days taken 6 bulk milk samples of cows. After the transport in cheese plant, milk samples were taken in sterile plastic containers and transported on ice to the laboratory no longer than 1h. Chemical testing of milk were made in the Dairy Laboratory of Biotechnical Faculty, Podgorica, on device Milcoscan 4000, whereby they determined the following chemical parameters: fat content, protein content, lactose content and dry matter content without the fat. Dry matter of whey and dry matter of cheese was also determined in the Dairy Laboratory of Biotechnical faculty on the device Milcoscan FT 120th

Theoretical cheese yield was calculated in two ways: 1) based on the content of fat and protein content in milk and 2) based on the values of dry matter of milk, whey and dry matter of cheese. Theoretical cheese yield on fat and protein content in milk was calculated by formula: R = % of fat + (% of proteins x F). For factor F is taken the value of F factor for trappist cheese which is 2.1. *(Mančić and Mančić, 2005).*

Theoretical cheese yield on the relationship of dry matter of milk, dry matter of whey and dry matter of cheese was calculated according to the formula: *Yield of cheese = T1-T2/T3 x 100,* (T_1-dry matter of milk, T_2 - dry matter of whey and T3 -dry matter of cheese, *Pejić, 1956).*

Actual cheese yield is taken as the weight of cheese obtained from 100l of milk, expressed in percentages. Yield is determined by measuring cheese after removing from the mold and before salting.

Of the statistical parameters were determined: mean (X), maximum (max) and minimum (min) value, standard deviation (SD), correlation and t-test.

Results and Discussion

Results of chemical testing of bulk milk samples of cows are shown in Table 1.

Results shown in Table 1 show that the values for content of fat in milk ranged from 3.71 to 3.91%, protein content of 3.20 to 3.28%, lactose content of 4.21 to 4.34% and content of dry matter without fat of 8.17 to 8.34%. The average value amounted to: the fat content of 3.79%, 3.24% protein content, lactose content of 4.26% and the content of dry matter without fat 8.24%.

Table 1. The results of chemical examination bovine crude bulk milk

Sign of the milk sample	Fat (%)	Proteins (%)	Lactose (%)	Dry matter without fat	Fat : protein ratio
6	3,91	3,27	4,34	8,34	1,19
7	3,77	3,24	4,29	8,27	1,16
8	3,82	3,28	4,31	8,32	1,16
9	3,90	3,28	4,30	8,31	1,18
10	3,80	3,20	4,25	8,18	1,18
11	3,72	3,26	4,27	8,26	1,14
X	3,79	3,24	4,26	8,24	1,16
max	3.91	3.28	4.34	8.34	1.19
min	3.71	3.20	4.21	8.17	1.14
SD	0.067595	0.0276668	0.0400681	0.063058414	0.018348

The results of determination of the theoretical cheese yield based on the content of fat and content of proteins in milk are shown on Table 2.

Table 2. The results of determination theoretical cheese yield based on content of fat and content of proteins in milk

Sign of the milk sample	Fat content in milk (%)	Protein content in milk (%)	Theoretical cheese yield (%)
6	3,91	3,27	10.77
7	3,77	3,24	10.57
8	3,82	3,28	10.70
9	3,90	3,28	10.78
10	3,80	3,20	10.52
11	3,72	3,26	10.56
X	3,79	3,24	10.65
Max	3.91	3.28	10.78
Min	3.71	3.2	10.52
SD	0.067595	0.0276668	0.114192819

The results presented in table 2 show that the theoretical cheese yield based on the average fat content in milk (3.79%) and average protein content in milk (3.24%), amounted to 10.65%.

The results of theoretical cheese yield based on the dry matter of milk, dry matter of whey and dry matter of cheese are shown in Table 3:

Table 3. The results of examination of theoretical cheese yield on base dry matter in milk, dry matter in whey and dry matter in cheese.

Sign of the milk sample	Dry matter of milk (%)	Dry matter of whey (%)	Dry matter of cheese (%)	Theoretical cheese yield (%)
6	12.25	7.11	56.81	9.04
7	12.04	6.98	55.41	9.13
8	12.14	6.99	54.65	9.42
9	12.21	7.03	53.84	9.62
10	11.98	6.85	56.66	9.05
11	11.98	6.97	54.27	8.90
X	12.10	6.988	55.14	9.30
max	12.21	7.03	56.81	9.62
Min.	11.98	6.85	53.84	9.62
SD	0.117132404	0.084951	1.245193	0.271121

The results shown in table 3 show that the theoretical cheese yield based on the values for content of dry matter in milk (12.10%), whey dry matter (6.988%) and dry matter of cheese (55.14%) was 9.30 %.

The results of testing the actual yield of cheese are shown in Table 4.

Table 4. The results of examination of actual yield of cheese

Sign of the cheese sample	Milk quantity(l)	Cheese weight (kg)	Actual cheese yield after pressing (%)
6	482	55.485	11.51
7	401	43.935	10.95
8	389	44.360	11.40
9	382	44.905	11.75
10	371	41.095	11.07
11	461	50.200	10.88
X	414,3	46.66	11.26
max	482	55.485	11.51
min	371	41.095	10.88
SD	45.8243	5.237882	0.278693

The results shown in table 4 show that for the average amount of 414.3 liters of milk and mass of cheese of 46.66 kg, the actual cheese yield amounted to 11.26%.

The results of testing the correlation between chemical parameters of milk and theoretical cheese yield based on the fat content and proteins content in milk and actual cheese yield are shown in Table 5.

Table 5. The description of correlations between chemical parameters in milk, theoretical cheese yield on base content of fat and protein content in milk and actual cheese yield

Correlation	Intensity of correlation	Value for coefficient of correlation
between content of fat in milk and actual cheese yield	Very high-positive	0.929032
between content of protein in milk and actual cheese yield	Middle-positive	0.613141
between content of lactose in milk and actual cheese yield	Middle-positive	0.651317
between content of dry matter in milk and actual cheese yield	Middle-positive	0.651956
between content of lactose in milk and actual cheese yield content of fat in milk and theoretical cheese yield	High -positive	0.87066
between content of protein in milk and theoretical cheese yield	High-positive	0.806896
between content of lactose in milk and theoretical cheese yield	High-positive	0.853095
between content of dry matter in milk and theoretical cheese yield	High-positive	0.872377
between theoretical cheese yield and actual cheese yield	Very high-positive	0.933246
between theoretical yield based on milk dry matter, dry matter of whey and dry matter of cheese and actual cheese yield	High-positive	0.76909.

The results shown in table 5 shows that established a very high positive correlation between fat content in milk and actual cheese yield (0.929032), while the mean positive correlation found between protein content in milk and actual cheese yield (0.613141), lactose content in milk and actual cheese yield (0.651317), and between dry matter content of milk and actual cheese yield (0.651956). We found a very high positive correlation between actual and theoretical cheese yield based on the content of fat and protein in milk (0.933246), while high positive correlation found between actual and theoretical cheese yield based on the dry matter of milk, dry matter of whey and dry matter of cheese (0.76909).

Statistically significant difference is established between the arithmetic means of the theoretical yield based on the content of fat and content of protein in

milk and actual yield, as well as between the theoretical yield based on dry matter of milk, dry matter of whey and dry matter of cheese (the level of likelihood 0.001).

If we take into account the reduction of cheese yield 4-6% after salting, no statistically significant differences between the theoretical value of cheese yield based on fat content and protein content in milk and actual cheese yield (the level likelihood 0.001).

Statistically significant difference was also found between the arithmetic means of the theoretical cheese yield based on dry matter content of milk, dry matter of whey and dry matter of cheese and actual cheese yield. (level of likelihood 0.001). However, if we take into account the reduction in actual cheese yield after salting 4-6% *(Mančić and Mančić, 2000*)**,** no statistically significant difference between the arithmetic means of the theoretical cheese yield based on content of dry matter of milk, dry matter of whey and dry matter of cheese and actual cheese yield (level of likelihood 0.001).

In order to get good quality of cheese, milk must have good physical-chemical properties and must come from healthy cows. The properties and quality of milk, are particularly affected by the climate and soil, because they depend on the composition of plant communities in the suburbs *(Antunac et al., 2008)*.

The obtained high values for fat content (3.79%) and protein content in milk (3, 24%), are matching the requirements of the *Rules on quality and other requirements for milk,* SRJ 2/2000. However, the average value for the content of dry matter without fat was below the minimum allowable value of the same Regulation, and amounted to 8.24%. This variation can be explained by the reduced value for the content of lactose in milk which amounted to an average of 4,26%. Lactose content in milk of healthy cows is greater than 4.69%, so that the low content of lactose in bulk milk indicates poor health of mammary gland, ie. the spreading of mastitis.

In addition to inflammation of the milk mammary gland impacts directly on the reduced synthesis of specific products of mammary gland milk, milk fat, casein and lactose and indirectly affects the enhanced proteolise of casein by plasmin. The concentration of this enzyme was higher in the milk of cows suffering from mastitis *(Grieve and Kitchen, 1985)*.

One of the indicators of disturbances in the composition of milk is a mutual relationship of protein and fat to be moving in the interval 0,8-0,9. This relationship for black-white cows in Holstein type is 0.84, and ranges depending on the lactation of 0,8-0,91. *(Adamović et al., 2003)*.

Our research of bulk milk of cows it was obtained the relationship between fat and protein of 1.16, which may explain the changed composition of milk caused by disturbed secretion. The best results for the quantity of cheese is obtained when the relationship between milk fat and casein in milk small.

Content of milk ingredients is changed during lactation. In the period between 8-10 months of lactation compared to the first month in milk increases dry matter of 1.28%, 0.98% for fat and protein of 0.32%. After the fifth lactation, in addition to falling volumes of milk, and comes to the fall of fat, protein and lactose. Our research has found very high positive correlation between fat content in milk and actual cheese yield (0.929032), while mean positive correlation found between protein content in milk and actual cheese yield (0.613141), lactose content in milk and actual cheese yield (0.651317), and between dry matter content of milk and actual cheese yield (0.651956).

The average value for the theoretical cheese yield based of the content of fat and protein in milk was 10.65%, the theoretical yield based on the dry matter content in milk, dry matter of whey and dry matter in cheese 9.30%. The average actual cheese yield amounted to 11.26%.

We found a very high positive correlation between actual and theoretical cheese yield based on the content of fat and protein content in milk (0.933246), and the high positive correlation between actual and theoretical cheese yield based on the content dry matter in milk, whey and cheese (0.76909).
Statistically significant difference was found between the arithmetic mean of the theoretical cheese yield based on the content of fat and protein in milk and actual yield, as between the theoretical yield based on dry matter of milk, whey and dry matter of cheese and actual cheese yield (the level of likelihood 0.001).

If we take into account the reduction of cheese yield 4-6% after salting, no statistically significant differences between the theoretical value of cheese yield based on the content of fat and protein in milk and actual cheese yield (level likelihood 0.001). We also found a statistically significant difference between the arithmetic mean of the theoretical cheese yield based on dry matter content of milk, dry matter of whey and dry matter of cheese and actual cheese yield. (the level of likelihood 0.001). Because of the reduction of cheese yield after salting 4-6%, no statistically significant difference between the arithmetic mean of the theoretical cheese yield based on the dry matter content of milk, dry matter of whey and dry matter of cheese and actual cheese yield (level likelihood 0.001). These results indicate that on the amount of cheese also affects the percentage of moisture in it. *(Pejić, 1956).*

Quantity and quality of cheese depends on the quantity and quality of milk, processing methods and processes mature. The changes of composition of milk affecting on a lower cheese yield and produced cheeses are low quality. Reduced dry matter content in milk reduces milk nutritive value, and therefore the nutritive value and yield of cheese *(Vajić, 1957, Dozet Natalia et al., 1996, Walstra, 1999).*
Increasing the dry matter of milk without fat by 0.5 %, increases cheese yield by 0.76%. At the same increasing amounts of casein cheese yield is increased by 1,8-

2%. Larger quantities of milk proteins requires and a higher percentage of fat. *(Mančić and Mančić, 2005).*

The amount of cheese that is received from a certain quantity of milk depends on two basic ingredients, of milk fat and specific protein of mammary gland, casein. If the amount of casein and fat in milk has been always in equal relation to one another, the amount of obtained cheese would always match to the amount of fat.

Since the relationship of milk fat: casein to a large extent depends on how much fat in milk exceed in the crude and stay in it all the time for processing. The basic measures to improve the quality and standardization of dairy products are a struggle for quality and standard composition of milk *(Pejić, 1956).*

If the milk is of good quality and if technological processes properly conduct, the largest part of casein over the cheese. Utilization of milk protein for cheese production is almost parallel with the exploitation of dry matter of milk, especially dry matter without fat. Therefore, utilization of dry matter without milk fat today serves as a measure of protein utilization (casein) in the making of cheese.

The most important technological factors that affect yield of cheese are a way of keeping milk, standardization of milk, the concentration of milk for the growth media used for preparation of starter cultures, types of bacteria in starter cultures, the temperature of milk pasteurization, homogenization of milk, the concentration of added calcium chloride in milk, species spread, strength crude, salting method, method of processing of crude, flushing crude, add the salt concentration, loss of moisture during the ripening and so on. *(Lawrence, 1993, Johnston, 1999).*

In production of cheese aspiration is that transition fat in whey be minimized. The reasons for this are that the amount of fat influences the amount of cheese and nutritive value and quality of cheese depend on the amount of fat.

At percentage of fat in milk from 3% is obtained 8.30 kg of cheese, at 3.25% 8.88 kg, at 3.75 % 10.03kg, 10.60kg of 4%, 4.25% 11.17 kg, 11.74 kg of 4.50%, 4.75% at 12.31%, with 5% fat in milk is obtained 12.90 kg of cheese *(Pejić, 1956).*

The amount of fat that is transferred into the whey can be different. Depending on conditions, in average 80-90% of total milk fat is transformed into cheese, which means that in the process of making cheese loses an average of 10-20%.

Theoretical cheese yield was not higher than actual, so applied technological process of production allowed maximum transition of milk constituents in cheese. Cheese yield was most depended on the chemical composition of milk.

Conclusion

The average value for the fat content in the examined milk amounted to 3.79%, protein 3.24%, 4.26% lactose and dry matter content without fat 8.24%. Average value for the theoretical cheese yield based on fat and protein in the milk amounted to 10.65%, and theoretical cheese yield based on dry matter of milk, dry matter of whey and dry matter of cheese 9,30%. The average actual cheese yield amounted to 11.26%. Theoretical cheese yield was not higher than actual, it can be concluded that the applied technological process of production allowed maximum transition of milk constituents in cheese. Cheese yield was most depended on the chemical composition of milk.

Uticaj hemijskog sastava mleka na randman polutrvdog sira

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Rezime

Cilj rada je bio da se ispita uticaj kvaliteta mleka na randman polutvrdog prirodno sušenog sira, proizvedenog u sirari ZZ "Cijevna" u Podgorici. Ispitivanja su sprovedena na 6 uzoraka zbirnog mleka i 6 proizvodnih šarži sira.

Hemijska ispitivanja zbirnog mleka su rađena na aparatu MilcoScan 4000, a određivanje sadržaja suve materije surutke i suve materije sira na aparatu MilcoScan FT 120. Očekivani randman sira je određivan na dva načina: 1) na osnovu sadržaja masti i sadržaja proteina u mleku i 2) na osnovu sadržaja suve materije mleka, suve materije surutke i suve materije sira.

Stvarni randman sira je određen na osnovu ukupne količine sira dobijene nakon presovanja i količine utrošenog mleka.

Srednje vrijednosti za sadržaj masti u ispitivanom mleku iznosile su 3,79%, proteina 3,24%, laktoze 4,26% i sadržaj suve materije bez masti 8,24%.

Izračunata srednja vrednost za očekivani randman sira prvom metodom iznosila je 10.65%, a drugom metodom 9.30%. Prosečan stvarni randman sira je iznosio 11,26%.

Utvrđena je vrlo visoka pozitivna korelacija između sadržaja masti u mleku i stvarnog randmana sira (0.929032) i srednje pozitivne korelacije između sadržaja proteina u mleku i stvarnog randmana sira (0.613141), sadržaja laktoze u mleku i stvarnog randmana sira (0.651317) i između sadržaja suve materije mleka i stvarnog randmana sira (0.651956).

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