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THE CORRELATION BETWEEN HYGIENIC PARAMETERS OF MILK AND WEIGHT LOSS OF SEMIHARD CHEESE

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Abstract: The purpose of the paper was to examine weight loss and correlation between total bacteria count and the somatic cells count and weight loss of semihard naturally dried cheese, product of dairy plant ZZ"Cijevna" in Podgorica. Weigt loss was calculated on the base of difference in mass of cheese at the beginning of ripening and after specified period of ripening, exposed in percents. Examination of weight loss was done on total six product series of cheese during 60 days of ripening on temperature 14,2^{0}C and RH of 89%. Obtained average values for weight loss of cheese were: after 10 days 4.723%, 20 days 8.789% and after 30 days of ripening 11.020%. Weight loss of cheese in period of ripening 10-20 days was 4.266%, in period 20-30 days 2,445% and in period of ripening 30-60 days 5.507%. The total bacteria count in milk was determined on apparatus BactoScan FC 100 and the somatic cells count on apparatus Fossomatic 5000. The middle positive correlation between somatic cells count in milk and weight loss of cheese in period 1-10 days of ripening (0.69156), as well as middle positive correlation (0.767336) between total bacteria count and weight loss of cheese 1-10 days of ripening were determined. The obtained results show that weight loss of cheese was highest in period 1-10 days of ripening and that there is significant influence of hygienic quality of milk on weight loss of cheese and economy of production.

Key words: total bacterial count, somatic cells, cheese, weight loss, yield

Introduction

The weight loss of cheese during the ripening process is called weight loss, and is an important factor affecting the yield of cheese. Weight loss of cheese

arises partly due to mechanical processes during care and ripening of cheese, mostly as a result of continuous evaporative processes that occur between cheese and the air in the ripening room *(Kirin, 2002)*.

Obtaining the optimal amount of cheese, as well as control of the quantity are very important to achieve economically successful production of cheese. Considering the very high share price of raw milk in the total cost production of cheese, even very small variations in the obtained amount of cheese has a significant effect on the realized profit.

Considering that the price of making cheese is 20% of the price of milk and normal profit 10% of the cost of making cheese, reduced quantity of cheese for 1% makes 50% of normal profit *(Emmons, 1991)*. In addition, changes in the quantity of cheese affect its quality, so that without understanding this relationship can not be achieved optimizing the production of cheese *(Walstra, 2000)*. For these reasons knowledge of the factors that influence the amount of cheese is great importance.

Humidity is the most important factor affecting the amount of cheese, which can be controlled during the manufacturing process. During ripening cheeses lose a significant percentage of water by evaporation. Certain percentage of water is converted to a dry matter of cheese due to hydrolysis, usually proteolysis. Each connection interrupted during hydrolysis involves binding of one molecule of water. On the other hand, during ripening creates carbon dioxide and ammonia, which are mostly lost *(Walstra, 2000)*.

The degree of evaporation depends on the relative humidity in the room for ripening, and the temperature of ripening *(Lawrence, 1991)*.

The difference in moisture content between cheeses from different production lines are due to the variation of parameters of production, seasonal changes in the quality of milk, as well as changes in the characteristics of ingredients (extra material). Seasonal variations in the quality of milk affect the degree of acidification, coagulation characteristics and syneresis and thus directly affect the final moisture in cheese. Tests conducted in the Netherlands have shown that the average standard deviation for the percentage of moisture in cheese Chedar was approximately 1.05%, for Gouda cheese 0.8% and 0.95% Edam *(Lacroix et al., 1991)*.

Salting process leads to the absorption of salt, but also to the mass loss of cheese. This is because the water is removed from the cheese during the process of osmosis. The higher the moisture content in cheese, salt diffusion there is faster *(Srbinovska et al., 2001)*. The size of cheese directly affects the quantity of moisture in it *(Bijeljac et al., 2003)*.

The quality of milk to produce cheese, except of the chemical composition, determine its sanitary quality parameters: total number of microorganisms and somatic cells.

The number and types of microorganisms in raw milk and products of their metabolism have an important role in the formation of organoleptic characteristics and quality of finished products *(Kirin, 2001)*.

The somatic cells count in milk is most often due to increased occurrence of mastitis. The primary changes in the quality of milk due to this disease are manifested by reducing the protein content (casein) and / or fat. Active agents who contribute to the reduction of these components are proteases and lipases originating from milk. It also leads to reduction of lactose and calcium content and increasing of sodium, chlorine and serum proteins content.

Somatic cells present in milk during infection are involved in the transformation of plasminogen into plasmin. This enzyme breaks down casein and thus affect the reduction of the amount of cheese. Thus, somatic cells count indirectly indicates the amount of active plasmin in milk. There is a significant reduction in the casein content when the somatic cells count is over 100.000/ml of milk. Besides the impact on the activation of plasmin, many of somatic cells are damaged and release enzymes and antibacterial components in milk *(Barbano, 2000)*.

Considering the importance of weight loss and hygienic quality of milk in cheese production, we investigated the weight loss and impact of hygienic parameters of milk on the weight loss of semihard naturally dried cheese.

Materials and Methods

Weight loss of cheese is calculated by the difference in weight before the beginning of semihard cheese ripening, and after production of cheese and expressed in percentages.

Cheese ripening was carried out in the ripening chamber on wooden planks, without protective layer, in the environment with 89% RH and a temperature of 14.2^0 C for a period of 60 days.

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

Six of bulk milk samples of cows of six days are tested on total bacteria count and somatic cells count. Samples were transported in laboratory on ice to 1 hour after sampling.

The total bacteria count in milk was determined by the device BactoScan FC 100, and the somatic cells count in the device Fossomatic 5000.

For the obtained results the basic statistical parameters: average (X), maximum (max) and minimum value (min), Sd and the correlation coefficient were determined *(Microsoft Office Excel Programme, 2003)*.

Results and Discussion

Results of measuring the mass of cheese during 30 days of ripening are shown in Table 1. Rresults in Table 1 show that the difference in the mass of cheese in the period 1-10 days of ripening ranged from 0.645 to 3.010kg, 10-20

days from 0.730 to 2.180kg, 20-30 days from 0.395 to 1.205kg and in the period 1-30 days of ripening 1.885 to 6.395kg.

Table 1. The results of measuring cheese mass during first 30 days of ripening

Sign of series	*Number of cheeses*	*Total mass of cheeses during ripening (kg)*				*Difference in mass of cheese at the beginning and on the end of ripening (kg)*			
		1 day	*10th day*	*20th day*	*30th day*	*1-10 days*	*10-20 days*	*20-30 days*	*1-30 days*
6	30	53.055	50.045	47.865	46.660	3.010	2.180	1.205	6.395
7	12	20.180	19. 535	18.640	18.150	0.645	0.895	0.490	2.030
8	12	20.365	19.700	18.795	18.365	0.665	0.905	0.430	2.000
9	12	20.415	19.455	18.670	18.180	0.960	0.785	0.490	2.235
10	12	19.440	18.680	17.950	17.555	0.760	0.730	0.395	1.885
11	12	20.345	18.800	18.025	17.590	1.545	0.775	0.435	2.755
X		25.633	25.336	25.720	25.089	1.264	1.045	0.574	2.883
Max		53.055	50.045	47.865	46.66	3.010	2.180	1.205	6.395
Min		19.440	18.680	17.950	17.555	0.645	0.730	0.395	1.885
Sd		13.4387	13.8194	12.0277	11.7181	0.9182	0.5603	0.3112	1.7477

The results of examination of actual cheese yield are shown in Table 2.

Table 2. The results of examination of actual cheese yield

Sign of cheese	Quantity of milk (L)	Mass of cheese (kg)	Actual yield of cheese 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	5.2378	0.2786

The results in Table 2 show that for average quantity of milk of 414,3 l and mass of cheese 46,66 kg, actual yield of cheese amounted 11,26%.
Results of examination weight loss of cheese in period 1-30 days are shown in Table 3.

Table 3. The results examination weight loss of cheese first 30 days

Sign of series	Weight loss of cheese (%)				
	1- 10 days of ripening	10-20 days of ripening	20-30 days of ripening	1-20 days of ripening	1-30 days of ripening
6	5.673	4.356	2.517	9.782	12.054
7	3.196	4.581	2.628	7.631	10.060
8	3.265	4.594	2.287	7.709	9.821
9	4.702	4.035	2.624	8.547	10.948
10	3.909	3.907	2.200	7.664	9.697
11	7.594	4.122	2.413	11.403	13.541
X	4.723	4.266	2.445	8.789	11.020
Max	7.594	4.594	2.628	11.403	13.541
Min	3.196	3.907	2.2	7.631	9.697
Sd	1.6891	0.2890	0.1770	1.5264	1.5191

The results in Table 3 show that the average values for weight loss of semihard cheese amounted to: for the period of ripening 1-10 days 4.723%, 1-20 days 8.789% and 1-30 days 11. 020 %. The average value of weight loss of cheese in the period 10-20 days of ripening amounted to 4.266% and in the period 20-30 days of ripening 2.445%.

Results of examination weight loss of cheese in the period 30-60 days of ripening are shown in Table 4.

Table 4: The results of examination weight loss of cheese during 30-60 days of ripening

Sign of series	Number of cheeses	Total mass of cheeses during ripening			Weight loss of cheese during 30-60 days ripening
		After 30 days	After 60 days	Difference in mass of cheese during 30-60 days	
6	11	16.340	15.490	0.850	5.201
7	11	16.730	15.765	0.965	5.768
8	11	16.930	16.010	0.920	5.434
9	11	16.820	15.910	0.910	5.411
10	11	16.200	15.190	1.010	6.234
11	11	16.310	15.495	0.815	4.997
X		16.555	15.643	0.912	5.507
Max		16.930	16.010	1.010	6.234
Min		16.200	15.190	0.815	4.997
Sd		0.3078	0.3070	0.0717	0.4393

The results shown in Table 4 show that weight loss of cheese in ripening period 30-60 days ranged from 4.997% to 6.234%, while the average value for weight loss of investigated cheese amounted to 5.507%.

The results of examination of bulk milk samples of cows on total bacteria count and somatic cells count are shown in Table 5.

Table 5. The results of examination of bulk milk samples on total bacteria count and somatic cells count

Sign of milk sample	Total bacterial count x 1000	Total somatic cells count x 1000
6	1156	503
7	2105	444
8	651	552
9	410	552
10	893	489
11	6727	614
X	1990	525
Max	6727	614
Min	410	444
Sd	2393.3520	59.5270

The results in Table 5 show that the average value of total bacteria count amounted to 1.990.000/ml and the somatic cells count 525.000/ml milk.

Results of the correlation between of hygienic parameters of milk and weight loss of cheese are shown in Table 6.

The results in Table 6 show that middle positive correlation was found between of the somatic cells count in milk and weight loss of cheese in period 1-10 days of ripening (0.69156) and middle positive correlation between the total bacteria count in milk and weight loss of cheese in period 1-10 days of ripening (0.767336).

Table 6. Correlation between hygienic parameters of milk and weight loss of cheese and correlation between somatic cells count and actual yield of cheese

Correlation between:	Intensity of correlation	Values for coefficient of correlation
Somatic cells count in milk and weight loss of cheese in period 1- 10 days of ripening	Medium positive	0.69156
Somatic cells count in milk and weight loss of cheese in period 10-20 days of ripening	Low negative	-0.28784
Somatic cells count in milk and weight loss of cheese in period 20- 30 days of ripening	Low negative	-0.18725
Somatic cells count in milk and weight loss of cheese in period 1- 30 days of ripening	Medium positive	0.64732
Somatic cells count in milk and weight loss of cheese in period 30- 60 days of ripening	Medium negative	-0.69243
Total bacteria count and weight loss of cheese in period 1-10 days of ripening	Medium positive	0.76733
Total bacteria count and weight loss of cheese in period 10-20 days of ripening	Low negative	-0.11601
Total bacteria count and weight loss of cheese in period 20-30 days of ripening	Low positive	0.00326
Total bacteria count and weight loss of cheese in period 1-30 days of ripening	Medium positive	0.777787
Total bacteria count and weight loss of cheese in period 1-30 days of ripening	Medium negative	- 0.50956
Between of somatic cells count and actual yield of cheese	Low positive	0.09359

The amount of the obtained cheese depends on a number of factors, such as the composition of raw milk and its hygienic quality, heat treatment and standardization of milk, method of curd processing and conditions of cheese storage.

Kirin (2002) states that the weight loss of trappist cheese after ripening of 30 days is the highest on the traditional way of ripening, during which the cheese is just washed and turned on the shelves (8.974%). The same author in the period 1-10 days of ripening of cheese found weight loss 4.174%, 10-20 days 2.260%, in period 20-30 days of ripening 2.539% and that weight loss after 10 days of cheese ripening was uniform.

In our research we also found the maximum weight loss of cheese in period 1-10 days of ripening (4.723%). However, weight loss of cheese in the period of 10-20 days of ripening was also high and amounted to 4.266%, while in the period of 20-30 days of ripening amounted to 2.445%, which is in agreement with the results received by *Kirin (2002*). Weight loss of cheese investigated in the period 1-20 days of ripening amounted to 8.789%, and in the period 1-30 days of

ripening 11.020%. For the total period of ripening 30-60 days average value for weight loss of cheese amounted to 5.507% (Tables 3 and 4).

Compared to the traditional ripening, *Kirin (2002)* found slightly lower weight loss during ripening of cheese covered by protective grease (7.694%), and lowest weight loss during the ripening of cheese in a plastic bag (0.176%). The author further found that the weight loss of cheese covered with protective grease was also highest in the first 10 days of ripening.

The highest possibility of influence on the weight of cheese is in the first stage of ripening (*Kirin, 2002*). However, our results show that period of ripening 10-20 days is also important for weight loss of cheese.

In our research we obtained the middle positive correlation between of somatic cells count in milk and weight loss of cheese in period 1-10 days of ripening (0.69156) and middle positive correlation (0.767336) between the total bacteria count and weight loss of cheese in period 1-10 days of ripening (Table 6.) These results can be attributed to the negative influence of somatic cells and the total bacteria count on the quality of milk, and thus the composition and properties of the produced cheese. Changes in the composition of milk, which are correlated with an increase of the somatic cells count in milk, significantly affect the coagulation time, curd firmness, increased activity of bacteria, changed the taste of the finished product and reduced yield of cheese *(Niketić et al., 2003)*.

Effect of somatic cells count and the total bacteria count on weight loss of cheese can best be shown through the example of the results for weight loss of cheese of production line number 11, which was significantly higher (7.594% in the period 1-10 days, or 13.541% in the period 1-30 days of ripening) compared to the value of weight loss of cheese other production lines (Table 3). Milk for production of this cheese had the highest somatic cells count (614.000/mL milk) and the highest total bacteria count (6.727.000/mL).

Changes in chemical composition and physical properties of milk caused by mastitis cause the appearance of prolonged coagulation time and a lower hardness of curd. Low hardness of curd after cutting leads to loss of small curd particules. Decomposition of milk casein also affects the process of syneresis during making of cheese and thus result in increased moisture content (*Barbano, 2000*).

Somatic cells count in milk positively related to moisture in nonfat substances of cheese. Curd moisture increased with increasing SCC in milk (Politis and Ng-Kwai-Hang, 1988a).

No significant trend between of somatic cells count and actual yield of cheese. In the case of actual yield, the high moisture content masked the results *(Politis and Ng-Kwai-Hang, 1988b)*. Our results showed that there is not correlation between somatic cells count and actual yield of cheese, too (Table 6).

This facts affects the increased weight loss of cheese produced from milk with an increased somatic cells count. These cheeses at the beginning of ripening contain a higher percentage of moisture in nonfat substances, and therefore will have a greater weight loss during ripening. In addition, leucocytes contain antibacterial components that inhibit the growth of starter cultures during cheese making, which has a significant influence on the properties of curd or cheese.

Microorganisms, their enzymes and other products affect the technological properties of milk *(Oljačić and Kasalica, 2006)*. The most numerous in cooled milk are the psychrotroph bacteria with the number above 10^5/mL of milk which affect the loss of weight cheese (*Kasalica et al., 2005).* These microorganisms by enzymes break down milk proteins, which also resulted in weaker syneresis of curd, a higher content of moisture in cheese, and therefore more weight loss of cheese. Milk intended for cheese production must not contain more than 10^4-10^6/mL psychrotroph microorganisms.

We should have in mind the fact that the milk for cheese production in the manufacturing line number 11 represented a mixture of cooled milk from the previous day and fresh morning milk. Given that households do not have the conditions for cooling milk on the appropriate temperature (lower than 4^0C), during storage of milk a rapid multiplication primarily of psychrotroph microorganisms occures, leading to degradation of milk components by their enzymes. Growth rate of these bacteria is very weak at temperatures up to 4^0C, but progressively increases at temperatures of 5-10^0C, especially at temperatures above 6^0C. Psychrotroph bacteria generation time, depending on temperature, ranges from several hours to about 15 minutes. If mixed fresh milk with milk that is stored 24 hours or longer, and then continued saving, psychrotroph bacteria count increases more rapidly than when stored only fresh raw milk *(Robinson, 2002)*. You should also have in mind that on the temperature of milk storage active proteolytic enzymes are released from damaged somatic cells. By these facts significantly lower weight loss of cheese produced in the production line number 11 can be explained.

The quality of milk is further aggravated if the time of saving cooled milk is longer, if milk comes from cows that were in the late stage of lactation, or from older cows or cows that have suffered mastitis several times. Rapid cooling of milk allows the preservation of enzymes that damage proteins and fats of milk *(Barbano, 2000)*.

The significant influence of the manner and length of storage-cooling of milk on weight loss can be shown through the example of the results for weight loss of cheese from production line number 6. This cheese is also produced from mixture of the cooled milk from the previous day and fresh morning milk. Weight loss of cheese in the period 1-10 days of ripening amounted to 5.673%, in the

period 1-30 days 12.054%, which were also significantly higher value compared to weight loss of cheeses produced only from fresh milk (Table 3).

Milk from which this cheese is produced had a total bacteria count of 1.156.000/mL and somatic cells count 503.000/mL, which are significantly less than the value of milk used for cheese production line number 11 (Table 5).
The results indicate a significant influence of the hygienic quality of milk on weight loss of cheese and therefore on the cost of production.

Conclusion

Weight loss of semihard cheese in period of ripening 1-10 days was 4.723%, 1-20 days 8.789% and during period of ripening 1-30 days 11.020%. In the ripening period of 10-20 days weight loss of cheese amounted to 4.266% and in the period of ripening 20-30 days 2.445%.

We found a middle positive correlation (0.69156) between the somatic cells count in milk and weight loss of cheese in period 1-10 days of ripening and the middle positive correlation (0.767336) between the total bacteria count in milk and weight loss of cheese between 1-10 days of ripening.

Somatic cells and the total bacteria count in milk have a significant impact on weight loss of cheese and therefore on the cost of production.

Korelacija između higijenskih parametara mleka i kala polutvrdog sira

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Rezime

Cilj rada je bio da se ispita kalo i korelacija između ukupnog broja bakterija i broja somatskih ćelija i kala polutvrdog prirodno sušenog sira, proizvoda sirare ZZ „Cijevna“ u Podgorici.

Kalo sira je izračunat na osnovu razlike u masi sira pre početka zrenja i nakon određenog perioda zrenja i izražen u procentima. Ispitivanje kala je vršeno na ukupno šest proizvodnih serija sira u toku 60 dana zrenja na temperaturi od $14,2^0$C i vlažnosti vazduha od 89%.

Dobijene srednje vrednosti za kalo sira su iznosile: nakon 10 dana zrenja 4,723%, 20 dana 8,789% i nakon 30 dana zrenja 11,020%. Kalo sira u periodu 10-20 dana zrenja je iznosio 4,266%, u periodu od 20-30 dana 2,445% i u periodu 30-60 dana zrenja 5,507%.

Ukupan broj bakterija u mleku je određivan na aparatu BactoScan FC 100, a broj somatskih ćelija na aparatu Fossomatic 5000.

Utvrđena je srednja pozitivna korelacija između broja somatskih ćelija u mleku i kala sira u periodu 1-10 dana zrenja (0,69156) i srednja pozitivna korelacija između ukupnog broja bakterija u mleku i kala sira u periodu 1-10 zrenja (0,767336).

Dobijeni rezultati su pokazali da je najveći kalo sira bio u prvih deset dana zrenja i da postoji značajan uticaj higijenskog kvaliteta mleka na kalo sira, a samim tim i na ekonomičnost proizvodnje.

References

BARBANO D. (2000): Influence of mastitis on cheese manufacture, Practical guide for Control of cheese yield, IDF, ISBN 92 9098 033-8, 19-27.

BIJELJAC S., SARIĆ Z., STANIŠIĆ M. (2003): Sirac – prilog poznavanju tehnologije, sastava i kvalitete, Mljekarstvo, 53, 4, 267-280.

EMMONS D.B.(1991): Economic importance of cheese yield, IDF Special Issue 9301, Chapter 1, 10-11.

KASALICA A., MIOČINOVIĆ D., POPOVIĆ-VRANJEŠ A., VUKOVIĆ V. (2005): Značaj psihrotrofnih mikroorganizama u mlekarstvu, Biotechnology in Animal Husbandry, 21, 53-64.

KIRIN S. (2001): Higijenska kakvoća sirovog mlijeka u svjetlu zakonskih propisa, Mljekarstvo, 51, 1, 49-60.

KIRIN S. (2002): Utjecaj načina zrenja na kalo sira Trapista, Mljekarstvo, 52, 2, 155-161.

LACROIX C., VERRET P., EMMONS D.B. (1991): Design of experiments and statistical treatment of yield data, , IDF Special Issue 9301, Chapter 12, 128-148.

LAWRENCE R.C. (1991): Processing conditions, IDF Special Issue 9301, Chapter 7, 64-75.

NIKETIĆ G., KASALICA A., MIOČINOVIĆ D., GAVRIĆ M. (2003): Uticaj mastitisa na podobnost mleka za preradu u sir, Prehrambena industrija, 1-2, 118-120.

OLJAČIĆ E., KASALICA A. (2006): Prisustvo termorezistentnih mikroorganizama u polutvrdom siru tokom skladištenja, Prehrambena industrija, 1-2, 12-14.

POLITIS I., NG-KWAI-HANG K.F. (1988a): Effects of Somatic Cell Count and Milk Composition on Cheese Composition and Cheese Making Efficiency, Journal of Dairy Science, 71, 7, 1711-1719.

POLITIS I., NG-KWAI-HANG K.F. (1988b): Association Between Somatic Cell Count of Milk and Cheese-Yielding Capacity, Journal of Dairy Science, 71, 7, 1720-1727.

ROBINSON K.R. (2002): Dairy microbiology handbook, the microbiology of milk and milk products. Third edition, Wiley-Interscience, John Wiley&Sons, Inc., New York.
SRBINOVSKA S., ČIZBANOVSKI T., DŽABIRSKI V., ANDONOV S., PALASEVSKI B. (2001): Dynamics of salt diffusion and yield of three types of goat's milk cheese, Mljekarstvo, 51, 1, 15-26.
WALSTRA P. (2000): 1. General Principles, Practical Guide for Control of Cheese Yield, IDF – ref. S.I.0001, 6-14.

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