Biotechnology in Animal Husbandry 29 (1), p 145-159 , 2013
Publisher: Institute for Animal Husbandry, Belgrade-Zemun
ISSN 1450-9156
UDC 637.045:043:04'637.354
DOI: 10.2298/BAH1301145B

CORRELATION BETWEEN PROTEIN TO FAT RATIO OF MILK AND CHEMICAL PARAMETERS AND THE YIELD OF SEMI-HARD CHEESE

M. Bojanić Rašović[1], N. Nikolić[1], A. Martinović[1], V. Katić[2], R. Rašović,[3] M. Walcer[4], K. Domig[4]

[1] Biotechnical faculty, Podgorica, Montenegro
[2] Faculty of Veterinary Medicine, Belgrade, Serbia
[3] ZZ "Cijevna, Podgorica, Montenegro
[4] University of Natural Resources and Life Sciences, Vienna
Corresponding author: bojanic.m@t-com.me
Original scientific paper

Abstract: In order to obtain good cheese quality, the milk has to possess good physical-chemical properties and should originate from healthy cows. Since milk fat and milk protein are the main constituents of cheese, their proportion in milk is of particular importance for the product yield and quality. This paper describes studies on the protein to fat ratio of milk and the consequent influence on the chemical composition and yield of semi-hard cheese, commercially called "Montenegrin naturally dried cheese". The tests were conducted on six bulk milk samples and six cheese samples. The milk parameters were analysed by the Milkoscan 400 unit whereas chemical analysis of cheese and whey were carried out with the Milkoscan FT 120 device. The average composition of the cheeses was: 29.27% fat, 21.90% protein, 55.27% total dry matter and 0.78% sodium chloride. The mean value for the content of dry matter without fat was 26%, whereas the fat content of the cheese dry matter was 53.18%, the moisture content in cheese 44.73% and moisture content in fat-free matter 63.24%. There was a medium positive correlation between the ratio of fat to protein in milk and fat content in cheese (r = 0.60309), the ratio of fat to protein in milk and dry matter of cheese (r = 0.57103), weak positive correlation between the ratio of fat to protein in milk and cheese protein (r = 0.48067) and medium negative correlation between the ratio of fat to protein in milk and moisture content in cheese (r = -0.57103). Medium negative correlation was found between the ratio of protein to fat in milk and content of cheese fat (r = -0.56416), the ratio of protein to fat in milk and cheese protein content (r = -0.51899), the ratio of protein to fat in milk and dry matter of cheese (r = -0.53118) and medium positive correlation between the ratio of protein to fat in milk and moisture content in cheese (r = -0.53118). Ratio fat to protein in milk and the actual yield of cheese was determined as medium positive (r = 0.66459) and the ratio protein to fat in milk and the actual yield of cheese as

medium negative correlation (r = -0.67807). The protein to fat ratio in milk influences the decline of fat, protein, dry matter and yield of cheese and increase moisture content in cheese.

Key words: fat, protein, ratio, cheese, yield

Introduction

The chemical composition of milk is one of the major factors concerning the production of fermented dairy products. Since milk fat and protein are main constituents of cheese, the product quality is heavily influenced by their concentrations in milk. Chemical composition and physical properties of milk can vary in a certain range and influenced by various factors and reflected in the properties of cheese. In first place, a good quality and unchanging products can be achieved by using immaculate and standardised milk. The main component determining the quality of milk used for cheese production is the protein content. Milk high in protein, especially casein, results in a high yield and good quality cheese products. The higher the ratio of casein to whey protein in milk, the more suitable it is for cheese production. The fat content is important as well, but especially the comparison with the protein or casein content is of significance. The common proportion of casein to fat is ranging from 0.64 to 0.72 *(Amenu and Deeth,* 2007). The quality of cheese, its caloric and nutritional value, physical properties and the chemical composition of curd and cheese dough depends to a large extent on the fat content. If milk contains more fat than needed for a particular cheese, the whey draining off the curd contains higher fat concentrations, which constitutes a significant economic loss *(Pejić, 1956.)*. Variations in quantity and composition of milk are either caused by dominant inheritance (55%) or by paragenetic factors, among which the most important is feed. Other considerable paragenetic factors are breed, type of feed, stage of lactation, age of animal, milking quality, health, environmental conditions (temperature, humidity, air flow), way of keeping, etc. An indicator of disturbance in the composition of milk is the ratio protein to fat, which should range from 0.8 to 0.9 *(Dozet et al., 1996; Adamović et al., 2003)*. Heritability for the protein to fat ratio is 0.79, indicating the possibility of its genetic changes *(Vos and Groen, 1998)*. The fat content in milk can vary within wide limits, from 2.5% to 5% or sometimes even more. The content of protein in the milk varies to lesser extent in comparison to the milk fat content. The biggest fraction within the protein content is covered by casein, with about 3% overall, whereas albumin and globulin are less frequent, with together about 0.5% *(Mišić-Čubrić, 1971)*. The components of milk are very sensitive indicators for changes or problems in nutrition and the health of cows. The fat content in milk provides information about the creation of acetic acid in the rumen.

Changes in the ratio fat to protein, with protein content equal to or greater than the fat content, indicate that the rumen is not performing properly. The risk of ketosis in cows is determined by the ratio of protein to fat less than 0.75 *(Silva-del-Río et al., 2011).* Reduced fat content can be a problem for entire herds as well as only for individual cows. A ratio of fat to protein in milk from cows of Holstein breed less than 1.0 indicates problems of reduced fat content or syndromes of low fat content in dairy herds. In cases of severe reduction of milk fat content, the ratio fat to protein in milk was lower than 0.8. Inadequate content of cellulose fibre in the diet is the most common reason of low fat content in milk obtained from entire dairy herds. Depending on the diet, the milk fat content can deviate up to 1.0% from the usual value, while the protein content is rarely changing by more than 0.1 to 0.4%. Production of milk with increased fat content is economically not justified hence the total milk production is reduced. Reduced protein content in milk (less than 3.0% for Holstein cows) is usually caused by insufficient amounts of carbohydrates in the diet and less due to lack of protein in the feed. Changes in the concentrations of protein and fat in milk significantly influence the composition of the cheese and its yield. The increase of ratio protein to fat in milk significantly raises the protein, calcium and phosphorus contents in cheese and has an extensive impact on reducing the moisture content of fat-free matter, fat in dry matter and salt content. Those criteria reveal the importance of standardizing protein and fat contents in order to avoid poor quality and incompatibility with product specifications. By applying different ratios of protein to fat in milk, combined with other changes concerning the production, new types of cheeses can be obtained *(Guinee et al., 2007).* Minding the significance of ratio protein to fat in milk intended for cheese production, the objective is to examine the correlation between the ratio of protein to fat in milk on the chemical composition and the yield of extra hard cheese.

Material and methods

Tests were conducted on 6 samples of bulk milk and 6 samples of cheese examined after pressing. Chemical analysis of milk was carried out on the device Milcoscan 400 and for cheese and whey Milcoscan FT 120 device was used.

Actual cheese yield was calculated as the weight of cheese obtained from 100L of milk, expressed in percentages.

For the purpose of comparing the yield of cheeses with different moisture contents, yield was calculated on the straight-out moisture of 38.5% by the following formula: $Y_{ma} = Y_a \; x \; 100 \; - \; M_a/100 \; - M_r$, where M_a is the actual moisture content in cheese and M_r reference value for moisture content (38.5%). In order to compare the obtained yield in relation to the reference protein and fat content of milk, calculated actual yield of cheese was normalized to reference fat content (3.4%) and protein (3.3%), the following formula: $Y_{afpam} = Y_a \; x \; F_{rm} + P_{rm}/F_{cm} + P_{cm}$,

where F_{cm} and P_{cm} values obtained for fat and protein content of milk, and F_{rm} and P_{rm} percentages of fat and protein in the reference milk for cheese production (3.4% and 3.3%) *(Guinee et al., 2006)*.

Several statistical parameters were determined: mean (X), maximum (max) and minimum (min) value, standard deviation (SD) and correlation.

Determining the strength of correlation was done using Čebis's table *(Trbojević, 1986)*.

Results and Discussion

Results of the chemical composition of cow bulk milk are shown in Table 1.

Table 1: Composition of bulk cow milk analysed by Milkoscan technique

Number of cheese samples	Fat (%)	Protein (%)	Lactose (%)	Dry matter without fat (%)	Ratio fat to protein of milk	Ratio protein to fat of milk	The content of protein and fat (g/kg milk)
6	3.91	3.27	4.34	8.34	1.19	0.84	71.80
7	3.77	3.24	4.29	8.27	1.16	0.86	70.10
8	3.82	3.28	4.31	8.32	1.16	0.86	71.00
9	3.90	3.28	4.30	8.31	1.18	0.84	71.80
10	3.80	3.20	4.25	8.18	1.18	0.84	70.00
11	3.72	3.26	4.27	8.26	1.14	0.88	69.80
$\overline{X}$	3.82	3.25	4.29	8.28	1.16	0.85	70.75
max	3.91	3.28	4.34	8.34	1.19	0.88	71.80
min	3.72	3.20	4.25	8.18	1.14	0.84	69.80
SD	0.074	0.030	0.031	0.057	0.018	0.016	0.912

Table 1 shows the results of the chemical analysis of the milk samples. The mean value for the fat content was 3.82%, 3.25% for the protein content, 4.29% for the lactose content and 8.28% for the dry matter content without fat. The mean value for the ratio protein to fat amounted to 0.85 and the ratio fat to protein of milk 1.16. The mean total fat and protein content amounted to 70.75 g/kg of milk.

Table 2: Chemical parameters and yield of cheese, dry matter of whey

Number of cheese samples	Fat (%)	Proteins (%)	Total dry matter (%)	NaCl (%)	Actual cheese yield (%)	Yield moisture-adjusted (to 38.5%)	Yield of cheese normalized to reference levels of protein (3.4%) and fat (3.3%) (%)	Dry matter content in whey (%)
6	30.62	21.82	56.81	0.81	11.51	10.99	10.70	7.11
7	29.18	21.99	55.41	0.88	10.95	10.46	10.47	6.98
8	29.50	21.69	54.65	0.75	11.40	10.89	10.71	6.99
9	28.03	22.02	53.84	0.75	11.75	11.22	10.93	7.03
10	30.26	22.11	56.66	0.71	11.07	10.57	10.62	6.85
11	28.03	21.75	54.27	0.76	10.88	10.39	10.44	6.97
$\overline{X}$	29.27	21.90	55.27	0.78	11.26	10.75	10.64	6.99
max	30.62	22.11	56.81	0.88	11.75	11.22	10.93	7.11
min	28.03	21.69	53.84	0.71	10.88	10.39	10.44	6.85
SD	1.090	0.167	1.245	0.060	0.346	0.330	0.180	0.085

The results in Table 2 reveal that the maximum value for the fat content in cheese after pressing was 30.62%, the minimum 28.03% and the mean value 29.27%. The maximum value for protein content in cheese amounted to 22.11%, the minimum to 21.69% and in average to 21.90%. The maximum value for the content of total dry matter in cheese was 56.81%, the minimum 53.84% and the mean value 55.27%. The maximum value for the salt content was 0.88%, the minimum 0.71% and the mean value 0.78%. The mean value of the actual yield of cheese amounted to 11.26% and the yield adjusted to 38.5% moisture was 10.75%. The mean value for dry matter content in whey was 6.99%.

Table 3: Results of examination content of dry matter without fat, fat in dry matter, cheese moisture and moisture in fat-free dry matter

Number of cheese samples	Dry matter without fat (%)	Fat in dry matter of cheese (%)	Moisture in the cheese (%)	Moisture in fat free dry matter (%)
6	26.19	53.90	43.19	46.10
7	26.23	52.67	44.59	47.34
8	25.15	53.98	45.35	46.02
9	25.81	52.06	46.16	47.94
10	26.40	53.41	43.34	46.60
11	26.24	53.09	45.73	48.35
$\overline{X}$	26.00	53.18	44.73	63.24
max	26.4	53.98	46.16	64.33
min	25.15	52.06	43.19	62.14
SD	0.462	0.740	1.245	0.852

The results in Table 3 show that the mean value for the content of dry matter without fat is 26.00%, the fat content of cheese dry matter 53.18%, the moisture content in cheese 44.73% and the moisture content in fat free dry matter 63.24%.

Table 4: Classification of cheese samples on fat content in dry matter and moisture content in fat free matter

Number of samples	Fat in dry matter of cheese (%)	Moisture content in fat free matter (%)	Classification of cheese regarding % fat in dry matter	Classification of cheese to rheological characteristics (the percentage of moisture content in fat free dry matter of cheese)
6	53.90	62.25	full-fat	Semi-hard
7	52.67	62.96	full-fat	Semi-hard
8	53.98	64.33	full-fat	Semi-hard
9	52.06	64.14	full-fat	Semi-hard
10	53.41	62.14	full-fat	Semi-hard
11	53.09	63.54	full-fat	Semi-hard
$\overline{X}$	53.18	63.24		
max	53.98	64.33		
min	52.06	62.14		
SD	0.400	0.852		

The results in Table 4 show that all investigated samples of cheese belong to the full-fat cheeses by the amount of fat in dry matter, as they contain more than 45% milk fat and the rheological characteristics are typical for semi- hard cheeses since they contain 54% to 69% of water in fat-free dry matter of cheese. Regulations on quality and other requirements for milk, dairy products, composite dairy products and starter cultures can be found in Gazette SRJ No 26/2002 and Gazette SCG, No 56/2003.

The results in Table 5 show that there is a medium positive correlation between the ratio fat to protein in milk and fat content in cheese, the ratio fat to protein in milk and dry matter in cheese, ratio fat to protein in milk and actual yield cheese and a medium negative correlation between the ratio fat to protein and moisture content in cheese. Medium negative correlation was found between ratio protein to fat and the fat content in cheese, the ratio protein to fat and protein content in cheese, the ratio protein to fat and dry matter of cheese, the ratio protein to fat and the actual yield of cheese and medium positive correlation of ratio protein to fat and moisture content in cheese.

Table 5: Results of correlation between ratio protein to fat in milk and chemical parameters and yield of cheese

Correlation between:	Strength of correlation	Correlation coefficient
Cheese fat content and moisture content in cheese	Very strong negative	-0.93040
Fat content in dry matter of cheese and moisture content in cheese	Medium negative	-0.55447
Fat content in dry matter of cheese and moisture content in the fat-free cheese matter	Strong negative	-0.79894
Fat content in dry matter of cheese and moisture content in the cheese	Medium positive	0.59500
Ratio fat to protein of milk and fat in cheese	Medium positive	0.60309
Ratio fat to protein of milk and fat in dry matter of cheese	Weak positive	0.07886
Ratio fat to protein of milk and cheese dry matter	Medium positive	0.57103
Ratio fat to protein of milk and protein content in cheese	Weak positive	0.48067
Ratio fat to protein of and moisture content in cheese	Medium negative	-0.57103
Ratio fat to protein of milk and moisture content in the fat-free cheese matter	Medium negative	-0.51673
Ratio fat to protein of milk and yield adjusted to 38.5% moisture	Medium positive	0.66193
Ratio fat to protein and actual yield of cheese	Medium positive	0.66459
Ratio fat to protein and yield of cheese normalized to reference levels of protein and fat	Medium positive	0.66360
Protein content of cheese and moisture content of cheese	Weak negative	-0.27880
Ratio protein to fat of milk and fat content in cheese	Medium negative	-0.56416
Ratio protein to fat of milk and fat content in dry matter of cheese	Weak negative	-0.02915
Ratio protein to fat of milk and protein content in cheese	Medium negative	-0.51899
Ratio protein to fat of milk and dry matter of cheese	Medium negative	-0.53118
The ratio protein to fat of milk and content of fat-free dry matter of cheese	Weak negative	-0.10092
Ratio protein to fat of milk and moisture content in cheese	Medium positive	0.53118
Ratio protein to fat of milk and moisture content in dry matter without fat cheese	Weak positive	0.48679
Ratio protein to fat of milk and moisture content in the fat-free cheese matter	Weak negative	-0.23407
Ratio protein to fat of milk and the actual yield of cheese	Medium negative	-0.67807
Ratio protein to fat of milk and yield adjusted to 38.5% moisture	Medium negative	-0.67548
Ratio protein to fat of milk compared to yield of cheese normalized to reference levels of protein and fat	Medium negative	-0.69300
Total fat and milk protein (g/kg) and the actual yield of cheese	Very strong positive	0.96174
Ratio protein to fat of milk and fat in dry matter of cheese	Weak positive	0.09399

Table 6: **Results of correlation between chemical parameters of cows bulk milk, cheese and whey**

Correlation between	Intensity of correlation	Values for coefficient of correlation
Fat content in milk and whey dry matter	Medium positive	0.61380
Protein content in milk and whey dry matter	Strong positive	0.80584
Dry matter content of milk and whey dry matter	Very strong positive	0.93568
Protein content of cheese and whey dry matter	Weak negative	-0.45286
Fat content of cheese and whey dry matter	Weak negative	-0.00108
Dry matter content of cheese and whey dry matter	Weak negative	-0.09145
Ratio protein to fat of milk and whey dry matter	Weak negative	-0.23407
Ratio fat to protein of milk and whey dry matter	Weak positive	0.26731
The fat content of milk and whey fat content	Medium positive	0.60570
The fat content of milk and whey protein content	Weak negative	-0.18355
Protein content of milk and whey protein content	Medium positive	0.55103
Protein content of milk and whey fat content	Weak negative	-0.19837

The results in Table 6 show that there is a very strong positive correlation between the dry matter content of milk and the whey dry matter and medium positive correlation between milk fat content and dry matter content of the whey.

During cheese production the milk components get concentrated. Especially the fat and protein contents determine the yield of cheese production, thus affecting the efficiency and effectiveness profoundly. Cheese yield is determined by many factors, such as the composition of milk, milk pre-treatment, the type of rennet, the curd processing and so on. Some properties of milk, particular solubilisation of proteins by the proteolytic activity of plasmin, somatic cell count, pH value, mineral content and urea content affect the yield of cheese production as well *(Verdier-Metz et al., 2001)*.

Fat content in dry matter and moisture content in the fat-free matter are the main determinants for quality of Cheddar cheese and are determined by levels of moisture and protein in cheese. Variations in ratio protein to fat in milk influence the cost-effectiveness of milk production, the composition and quality of cheese. Vast seasonal deviations of ratio protein to fat (~ 0.72 to 1.0) in milk give rise to differences in moisture content in the fat-free matter of cheese, as well as differences in consistency and texture of cheese. The ratio protein to fat in milk was negatively correlated with moisture content in the fat-free matter of cheese and cheese firmness *(Guinee et al., 2007)*. During the study of this work a negative correlation between the ratio milk protein to fat and the moisture in fat-free substance of cheese was obtained (-0.23407) (Table 5). The opposite effect of ratio protein to fat in milk and moisture in the fat-free matter of cheese may due to fat

droplets supressing effect on the permeability of the milk and the curd syneresis. By examining correlations between the ratio protein to fat and moisture in the cheese, we got a medium positive correlation (0.53118). These results are consistent with the results of *Guinee et al., (2007)*, who also received a positive correlation of ratio protein to fat in milk and cheese moisture. These results authors explained thereby that on the moisture content in cheese, besides of fat droplets, influence other factors, such as various technological processes in cheese production, e.g. increasing the pasteurization temperature, pre-acidification of milk before adding rennet, the use of selected starter cultures that produce exopolysaccharides, changes in temperature, pH of the curd, the release of whey, processing curd, etc. *Fenelon and Guinee (1999)* reported that increasing protein content in milk reduces the moisture content in cheese. Despite the higher actual yield and reduced water retention with reduced ratio proteins to fat of milk, the yield normalized to relative humidity decreases. In the tests performed in this study the results are similar. The actual yield increases, but the normalized yield decreases (Table 2).

The ratio protein to fat in milk significantly affects cheese yield and the percentage of fat and water retention in cheese. In particular, this matter influences the fat content in dry matter of cheese and the water content of fat-free matter. This indicates the importance of standardising the ratio protein to fat in order to avoid poor quality and non-compliance with the product specifications. By applying different ratios of protein to fat in milk, combined with other changes in production, new types of cheeses can be obtained.

A ratio of protein to fat in milk between 0.70 and 0.85 results in significantly less fat retention during cheese production compared to cheese produced from milk with a ratio protein to fat between 0.88 and 1 or between 1.01 and 1.15. The increase of ratio protein to fat in milk leads to a significant reduction in the actual yield of cheese *(Guinee et al. 2007)*. These results are consistent with the medium negative correlation between the ratio protein to fat and actual cheese yield gained during this study (-0.67807), (Table 5), which can be explained by the higher content of fat and moisture in the cheese.

The ratio of milk fat to casein has a huge effect on the physical and chemical properties of cheese as well as on the fat content in cheese itself, since it is responsible for the amount of milk fat that remains in the curd. Under the same production conditions and the same technological procedure, cheeses from milk with higher fat content have a finer, softer consistency, while the cheeses obtained from milk with lower fat content have a tough consistency. The amount of moisture in the fresh cheese is of great information value regarding its consistency and process maturity. Cheeses with higher moisture content have distinct milk sugar fermentation. The desired percentage of moisture in the cheese curd can be achieved by processing of milk and curd, as well as by molding, pressing and salting of cheese.

In curd obtained from milk with a higher content of fat, moisture and whey slower segregates. Milk fat mechanically affects the detraction of moisture. Thus the adjustment of milk fat is not only important from an economic point of view but also from a technological point of standardization of properties and quality of the products. Utilization of milk proteins in cheese is in line with the attainment or transfer of dry matter in cheese, in particular fat-free dry matter *(Pejić, 1950).*

Agabriel et al. (1991.) figured out that the ratio of fat to protein in milk from dairy herds from 62 farms ranged between 1.10 and 1.25. This ratio was deviating depending on the farm and month of the investigation. Small variations in the ratio in the months of testing on the same farm can be explained by diverse nutrition. In this study the mean value for the ratio fat to protein in milk was 1.16 and the mean value for the ratio protein to fat in milk was 0.890. *Čejna and Chládek (2005)* examined of the milk of Holstein cows on day 25, 45, 73, 101, 133, 166, 199, 224, 253 and 280 of lactation and the corresponding values for ratio of fat to protein were determined as 1.91, 1.45, 1.38, 1.28, 1.22, 1.14, 1.26, 1.21, 1.09, and 1.18. The quality of the curd obtained from milk in the first stage of lactation was lower. The high value for the ratio fat to protein in the first phase of lactation is caused by deficiency of energy.

The ratio protein to fat of milk for cheese production in Ireland during the period from 2001 to 2003 year, varied from 0.84 to 1.02 while the protein content varied from 2.99% to 3.59% and fat content from 3.26% to 4.2%, depending on the farm, the season and the year. Research shows that for a number of cheeses, produced in Ireland or the UK, ratio protein to fat varies from 0.68 to 0.85, which indicates that the ratio protein to fat in milk varies from 0.81 to 1.02 and supposes that milk for Cheddar cheese production is not generally standardised by ratio protein to fat. Studies in Scotland show similar variations in ratio protein to fat of cheese with values from 0.79 to 0.97. On the contrary investigations concerning milk from the United States show a much lower variation of ratio protein to fat. Variations in ratio protein to fat in milk are the result of natural and seasonal variations of fat protein, casein and lactose in milk, as well as results of stage of lactation, nutrition, etc. *(Guinee et al., 2007).*

Different fat content, and therefore a different ratio protein to fat in milk used in the production of low fat and full fat cheeses significantly affects the composition, yield, rheological and sensory characteristics of cheese *(Guinee et al., 2007).*

Phelan (1981) considers that there is no correlation between the ratio protein to fat in milk (0.9 to 1.01) and fat in dry matter of Cheddar cheese and that variations in fat loss via whey have a greater impact on fat in dry matter of cheese then ratio protein to fat in milk. In the tests performed in this study no correlation between the ratio protein to fat and fat in dry matter of cheese was evident (Table 5). Retention of fat in cheese is influenced by several other unidentified components or properties of milk.

The content of calcium and phosphorus in cheese produced from milk with a ratio protein to fat of 0.70 to 0.85 are significantly lower than in cheeses manufactured from milk with ratio protein to fat of 1.01 to 1.15. This decrease can be explained by reduced protein content regarding the reduced ratio protein to fat in milk.

The four parameters playing a key role in determining the quality of cheese are salt content, moisture content in the fat-free matter, pH value and fat content in dry matter of cheese, which are influencing each other. Hence it is necessary to do some further investigation of the factors influencing the relationship between these four parameters and thus the quality of cheese. Due to the higher fat content in milk, the mean actual yield of cheese obtained from milk with ratio protein to fat of 0.70 to 0.85 was significantly higher (1.0 to 1.4 kg/100kg milk) compared to the cheese obtained from milk with ratio protein to fat of 0.88 to 1.00 or 1.01 to 1.15. Changes in ratio protein to fat in milk may have a different impact on the production of cheese. Natural seasonal variations of ratio protein to fat in milk range from 0.8 to 1.0. This range offers good opportunities for the optimization of cheese production *(Guinee et al. 2007.)*.

Examining the effect of different concentrations of protein and fat milk in the range of 3-4%, *Lou and Ng-Kwai-Hang, 1992b*, found that higher yield of cheese is obtained from milk with higher fat and protein content in milk. A bigger quantity of cheese is obtained at higher ratio protein to fat or casein to fat. The increase in milk fat content leads to an increase in cheese moisture content by 1.23% to 1.37%, depending on the protein content in milk

These results are consistent with the results from this study, where a medium positive correlation could be observed between the ratio fat to protein in milk and fat content in cheese (0.60309), the ratio of fat to protein in milk and dry matter of cheese (0.57103), the ratio fat to protein in milk and moisture content in cheese (0.51678) and a weak negative correlation between the ratio fat to protein in milk and cheese protein (0.48067). Medium negative correlation was found between the ratio protein to fat in milk and fat cheese (-0.56416), the ratio protein to fat in milk and protein cheese (-0.51899), the ratio protein to fat in milk and moisture content in cheese (-0.56140) and medium negative correlation between the ratio protein to fat in milk and dry matter of cheese (-0.53118). The correlation between the ratio fat to protein in milk and the actual yield of cheese was medium positive (0.66459) (Table 5).

Cheese obtained from milk with higher protein concentration (3.0%, 3.2%, 3.4%, 3.6%, 3.8%, 4.0%) contains more protein, less fat and less total dry matter. Cheese obtained from milk with higher fat content has increased fat and decreased protein content. The higher content of fat in milk leads to lower retention of fat in cheese and thus extensive losses via whey *(Lou and Ng-Kwai-Hang, 1992a)*. These results are consistent with the results from this study where medium positive correlation between fat content in milk and whey dry matter and a strong positive correlation between fat content of milk and whey dry matter were obtained (Table

6). Higher protein content in milk leads to greater retention of fat in cheese, or a small loss in the whey. For every percentage increase in milk fat content, the fat content in cheese increases by 4.22% and the protein content in cheese decreases by 2.61%. For every percentage increase in milk protein content, the protein content of cheese increases by 2.35% and the fat content reduce by 6.14%. Cheese produced from milk with a ratio protein to fat near 0.9 has at least 50% fat in dry matter of cheese *(Lou and Ng-Kwai-Hang, 1992a).* The investigations in this study confirm this observation (Table 4).

The ratio fat to protein in milk could be an indicator of the ability of cows to adapt to the demands of milk production and reproductive efficiency in the post partum period resulting in a prolonged postpartum period. *(Podpečan et al., 2010).* The ratio of fat to protein of 1.1 provides over 90% reliable results for the identification of cows in which the interval from calving to conception is shorter than 120 days. In cases where the ratio fat to protein is bigger than 1.44, the reliability of the identification of the above mentioned cows is more than 90%. Ratio fat to protein in cow's milk can also be used in the detection of subclinical ketosis. Subclinical ketosis is indicated when the ratio fat to protein in milk exceeds a value of 1.5 for cows milking 33 to 50 kg *(Gantner et al., 2008).* Dairy cows with a ratio of milk protein to fat less than 0.75 are at risk of ketosis *(Silva-del-Río et al., 2011)*. Increase of milk fat content and increase of ratio fat to protein may be important in assessing the risk of dislocation abomasum *(Geishauser et al., 1998).*

Conclusion

A medium positive correlation was evident between the ratio fat to protein in milk and fat content in cheese (0.60309), the ratio fat to protein in milk and dry matter of cheese (0.57103), as well as a weak positive correlation between the ratio fat to protein in milk and protein of cheese (0.48067) and medium negative correlation between the ratio fat to protein in milk and moisture content in cheese (-0.57103). Medium negative correlation was apparent between the ratio protein to fat in milk and cheese fat (-0.56416), the ratio protein to fat and protein cheese (-0.51899), ratio protein to fat in milk and dry matter of cheese (-0.53118) and a medium positive correlation between the ratio protein to fat in milk and moisture content in cheese (0.53118). The correlation between the ratio fat to protein in milk and the actual yield of cheese was medium positive (0.66459) and the correlation between ratio protein to fat and the actual yield of cheese medium negative (-0.67807). The ratio protein to fat in milk has a negative impact on the content of fat, protein, dry matter, the actual yield of cheese, the moisture content in dry matter without fat, and a positive impact on the moisture content of cheese. According to the regulations on quality and other requirements for milk, dairy products, composite dairy products and starter cultures in Gazette SRJ No. 26/2002

and Gazette SCG No 56/2003 cheeses were classified as full fat, semi-hard cheeses.

Korelacija između odnosa proteina i masti u mleku i hemijskih parametara i randmana polutvrdog sira

M. Bojanić Rašović, N. Nikolić, A. Martinović, V. Katić, R. Rašović, M. Walcer, K. Domig

Rezime

Da bi se dobio sir dobrog kvaliteta mleko mora da ima dobre fizičko-hemijske osobine i da potiče od zdravih krava. S obzirom da su mlečna mast i proteini osnovni sastojci sira, to je njihov udeo u mleku od izuzetnog značaja za kvalitet proizvoda. U radu je ispitivan uticaj odnosa proteina i masti zbirnog mleka krava na hemijski sastav i randman polutvrdog sira, komercijalnog naziva „Crnogorski prirodno sušeni sir“, proizvoda sirare „ZZ“Cijevna“ u Podgorici. Ispitivanja su sprovedena na 6 uzoraka zbirnog mleka krava i 6 uzoraka sira uzetog nakon presovanja. Hemijska ispitivanja mleka su rađena na aparatu Milcoscan 400, a hemijska ispitivanja sira i surutke na aparatu Milcoscan FT 120. Srednja vrednost sadržaja masti u siru iznosila je 29.23%, sadržaja proteina 21.85%, sadržaja ukupne suve materije 55.06% i sadržaja soli 0.80%. Srednja vrednost za sadržaj suve materije bez masti je iznosila 26,00%, za sadržaj masti u suvoj materiji sira 53.18%, za sadržaj vlage u siru 44.73 % i sadržaj vlage u suvoj materiji bez masti 63.24 %. Utvrđena je srednja pozitivna korelacija između odnosa masti i proteina mleka i sadržaja masti u siru (0.603091), odnosa masti i proteina mleka i suve materije sira (0.571035), niska pozitivna korelacija između odnosa masti i proteina mleka i proteina sira (0.48067) i srednja negativna korelacija između odnosa masti i proteina i sadržaja vlage u siru (-0.57103). Srednja negativna korelacija je utvrđena između odnosa proteina i masti u mleku i masti sira (-0.56416), između odnosa proteina i masti i proteina sira (-0.51899), između odnosa proteina i masti i suve materije sira (-0.53118) i srednja pozitivna korelacija između odnosa proteina i masti i sadržaja vlage u siru (-0.531184). Između odnosa masti i proteina mleka i stvarnog randmana sira utvrđena je srednja pozitivna (0.664594), a između odnosa proteina i masti i stvarnog randmana sira srednja negativna korelacija(-0.67807).
Odnos proteina i masti u mleku ima uticaja na smanjenje sadržaja masti, proteina, suve materije i randmana sira i na povećanje sadržaja vlage u siru.

References

ADAMOVIĆ M., LEMIĆ J., MILIĆ B., ADAMOVIĆ O., RADIVOJEVIĆ M. (2003): Novi rezultati o mogućnostima očuvanja sadržaja važnijih sastojaka mleka, Prehrambena industrija, 1-2, 143-149

AGABRIEL C., COUON J.B., MARTY G. (1991): Facteurs de variations du rapport des teneurs en matières grasses et protéiques du lait de vache: étude dans les exploitations des Alpes du Nord, Inra Prod. Anim., 4(2), 141-149

AMENU B., DEETH H.C. (2007): The impact of milk composition on cheddar cheese manufacture, Australian Journal of Dairy technology, 62 (3), 171-184

ČEJNA V., CHLÁDEK G. (2005):The importance of monitoring changes in milk fat to milk protein ratio in Holstein cows during lactation, Journal Central Europe Agriculture, 6 (4), 539-546

FENELON M.A., GUINEE T.P.(1999): The effect of milk Fat on cheddar cheese yield and its prediction, using modifications of the van slyke cheese yield formula, J Dairy sci, 82, 2287–2299

GANTNER V., POTOČNIK K., JOVANOVAC S., RAGUŽ N. (2008): Utjecaj supkliničke ketoze na dnevnu količinu i sastav mlijeka slovenskih Holstein krava, Krmiva 50, (5), 253-259

GEISHAUSER T. D., LESLIE K. E., DUFFIELD T. F.B., EDGE L V.(1998): An evaluation of protein/fat ratio in first DHI test milk for Prediction of subsequent displaced abomasum in dairy cows, can J vet res; 62, 144-147

GUINEE, T. P., B. T. O'KENNEDY, KELLY P. M.(2006): Effect of milk protein standardization using different methods on the composition and yields of Cheddar cheese. J. Dairy Sci. 89, 468–482

GUINEE C. T. P., MULHOLLAND E. O., KELLY J., AND CALLAGHAN D. J. O. (2007): Effect of protein-to-fat ratio of milk on the composition, manufacturing efficiency, and yield of cheddar cheese, J. dairy sci. 90, 110–123

LOU Y., NG-KWAI-HANG K.F.(1992a): Effects of protein and fat levels in milk on cheese and whey compositions, Food Research International, Volume 25 (6), 445-451

LOU Y.,NG-KWAI-HANG K.F. (1992b): Effects of protein and fat levels in milk on Cheddar cheese yield, Food Research International, Volume 25, Issue 6, 437-444.

MIŠIĆ- ČUBRIĆ- D. (1971): Suva materija mleka-važno merilo kvaliteta, Mljekarstvo, 21 (9), 194-200

DOZET N., ADŽIĆ N., STANIŠIĆ M., ŽIVIĆ N. (1996): Autohtoni mlječni proizvodi, Poljoprivredni institut, Podgorica

PEJIĆ O.(1956): Mlekarstvo, II deo, Beograd

PHELAN, J. A. (1981): Standardization of milk for cheesemaking at Factory level, J. Soc. Dairy Technol. 34, 152–156

PODPEČAN O., MRKUN J., ZRIMŠEK PETRA (2010): The evaluation of fat to protein ratio in milk as an indicator of calving to to conception interval in dairy cows using various biostatistical methods, Acta Veterinaria (Beograd), Vol. 60, No. 5-6, 541-550

Regulations on quality and other requirements for milk, dairy products, composite dairy products and starter cultures, Gazette SRJ No. 26/2002 and Gazette SCG No 56/2003

SILVA-DEL-RÍO N. , LAGO A., VERBOORT B., SELVARAJ H.(2011): Milk fat and milk protein to fat ratio in california dairies, university of california, agricultural and natural science, M282; ADSA, cetulare.ucdavis.edu/files/ 114681.pdf (12.01.2012).

TRBOJEVIĆ G.(1986): Osnovi biostatistike, Univerzitet u Beogradu, Veterinarski fakultet, Beograd

VERDIER-METZ I., COULON J.P, PRADEL P. (2001): Relationship between milk fat and protein contents and cheese yield, Anim.Res. 50, 365-371

VOS H., GROEN A.F. (1998): Altering milk protein/fat-ratio: results of a selection experiment in dairy cattle, Livestock Production Science Volume 53 (1), 49-55.

Received 25 September 2012; accepted for publication 20 December 2012