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EFFECT OF MILK FAT CONTENT ON THE QUALITY CHARACTERISTICS OF FRESH CHEESE

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ABSTRACT

Milk fat is a very important ingredient in milk and plays a significant role in cheese production. The aim of this study was to examine the effect of fat content in milk on the quality characteristics of produced fresh cheese. For the purposes of this work, three cheese samples from milk with different fat content (1.5%, 2.8% and 3.2%) were produced. To define the quality of produced cheeses, the following analyzes were performed: determination of moisture, ash, protein, fat, chloride content, determination of acidity, pH measurement, water activity measurement, instrumental color measurement, instrumental texture measurement and sensory analysis. Based on the obtained results, it was determined that the fat content in milk had a statistically significant ($p<0.05$) effect on the physico-chemical and sensory properties of fresh cheese. Increasing the fat content in milk leads to an increase in the dry matter and fat content, as well as a decrease in the total water and protein content in the cheese. Instrumental measurements of color and texture showed that the increase in fat content in milk causes an increase in lightness (L* value) and an increase in the value for hardness of the analyzed cheeses. It can be concluded that the higher content of milk fat has a positive effect on the quality of fresh cheese, especially on the sensory properties. Sensory analysis showed that sample 3, which was produced from milk with the highest fat content, was the most acceptable and had the highest scores for the observed sensory properties.

Keywords: milk fat, quality, cheese.

INTRODUCTION

Milk as a foodstuff is of great importance in human nutrition. Knowledge of the composition and physicochemical properties of milk is important both from the point of view of nutritional and physiological value, as well as the processing of milk into quality products. Large quantities of milk are processed to produce various kinds of cheese. Cheese is one of the most important and well-known dairy products obtained by coagulation of milk along with the separation of whey. It is one of the quality foods of great nutritional value. Today, cheese is an important food in the human diet. It is also increasingly important as it represents the cultural and traditional mirror of a country (Popović-Vranješ, 2015). The quality of cheese depends on a variety of factors, some of which are raw milk composition, technological process parameters, bacteria species, storage, transportation, and delivery conditions (Rotaru, Mocanu, Uliescu, & Andronoiu, 2008; Suliman, Abdalla, & El Zubeir, 2013; Bojanić-Rašović et al., 2013). The nutritional value of cheese consists in the fact that it contains many milk ingredients in a concentrated form, in the highest percentage of proteins, minerals, vitamins and fats.

Milk fat is a very important ingredient in milk and plays a significant role in cheese production. During milk coagulation, the milk fat fits into the formed gel and is thus retained in the cheese. However, it does not participate in the formation of the protein matrix. The basic function of milkfat in cheese production is reflected in its contribution to the sensory properties of cheese (Puđa, 2009; Araque, Darre, Ortiz, Massolo, & Visente, 2017). As the fat content increases, the taste and firmness of the cheese improve. It adds to the quality and a larger amount of curd giving a special flavour and aroma to the products (Singh, & Cadwallader, 2008; Parodi, 2009). Milk fat

is characterized by easy digestibility that grows by decomposition during cheese ripening. Fat is not only a source of energy but also a carrier of fat-soluble vitamins. In addition, fat plays an important role in supplying the body with essential fatty acids (linoleic, linolenic, and arachidonic) (Popović-Vranješ, 2015).

Milk from different animals and with different fat content can be used for cheese production. Consumer awareness of dietary fat has increased and the demand for low-fat foods, including cheese, has grown substantially (Suliman et al., 2013; Araque et al., 2017). Many developed countries produce hard and semi-hard cheeses with a reduced fat content of the prescribed standard to reduce the intake of fat in the human body (Ardö, 1997; Sánchez-Macías et al., 2010; Caro et al., 2011; Davis, Yen, Dong, & Blayney, 2011). However, fat reduction negatively affects sensory properties and alters biochemical reactions in cheese (Banks, Brechany, & Christie, 1989; Araque et al., 2017).

This study aimed to examine the effect of fat content in milk on the quality of produced fresh cheese.

METHODS AND MATERIALS

For the purposes of this work, three cheese samples from milk with different fat content (1.5%, 2.8% and 3.2%) were produced. For the production of sample 1, milk with 1.5% milk fat was used (manufacturer: 'zbregov fresh milk, Vindija d.d. Varaždin), for sample 2 milk with 2.8% milk fat was used (manufacturer: Meggle fresh milk, Meggle Mljekara doo Bihać), and for sample 3 milk with 3.2% milk fat was used (producer: 'zbregov fresh milk, Vindija dd Varaždin). All milk samples were purchased at a local supermarket and stored at 4 °C until processing.

Milk was heated to the appropriate temperature (90 °C) and citric acid (in the amount of 0.3%) was used to coagulate the milk. After the addition of acid, the mixture was mixed well and rested for 10 min to obtain curd. The resulting curd was filtered through gauze into a strainer. The hot drained curd was weighed and 1.5% of salt was added in it. After salting and mixing, the curd was placed for pressing in a mould. The pressing took one hour, and the load was 2 kg per one kilo of cheese. The finished cheese was cooled in a refrigerator to +4 °C and stored at the same temperature until the analysis.

Actual cheese yield was calculated as the weight of cheese (kg) obtained from 100 kg of milk, expressed in percentages (Sabadoš, 1996).

To define the quality of produced cheeses, the following analyzes were performed: determination of moisture, ash, protein, fat, chloride content, determination of acidity, pH measurement, water activity measurement, instrumental color measurement, instrumental texture measurement and sensory analysis.

The moisture content and the total solids content of the cheese samples was determined by drying at 103±2ºC to constant weight (Institut za standardizaciju BiH, 2006). The total content of ash was also determined gravimetrically after heating of sample in a muffle furnace (Micronal) at 550°C (Carić, Milanović, & Vucelja, 2000). The content of proteins was calculated by determination of total nitrogen by Kjeldahl method, and it was converted to total crude protein using a nitrogen conversion factor of 6.38 for milk proteins (IZSBiH, 2015). Determining the content of fat in cheeses was performed by acid-butyrometric method (IZSBiH, 2012; IZSBiH, 2019). The chloride content was determined by potentiometric titration (Institut za standardizaciju BiH , 2015). Water activity (a_w) was measured by direct readings in AW Meter (Novasina LabMaster-AW 1119971). The acidity of the cheese was determined by the Soxhlet Henkel method (Carić et al., 2000). Measuring the pH value in cheese was performed in a cheese solution prepared by mixing equal amounts of cheese and water (Carić et al., 2000) using a pH meter (Hanna instruments, HI 2211). Sensory evaluation of selected quality indicators of tested cheese samples was performed by a team of five trained evaluators. A 5-point hedonic scale (1=very considerable deviation from the expected quality to 5=no deviation from the expected quality) was used to evaluate appearance, colour, consistency, odour and flavour (IZSBiH, 2011).

Instrumental colour measurement was performed using a spectrophotometer CM-2600d (Konica Minolta Sensing Inc., Japan), with 8 mm port size, illuminant D65 and a 10° standard

observer, and after standardisation of the instrument with respect to the white calibration plate. Colour parameters, expressed as CIE L*, a* and b* values, were determined as indicators of lightness, redness and yellowness, respectively. The measurements were performed on the outside surface and on the cut surface immediately after cutting the cheeses.

The cheeses hardness was determined mechanically by the Texture Analyzer TA.XT plus (Stable Micro Systems), which measures the shear force needed to cut the sample. Warner-Blatzler shear force was used with the HDP/BSK knife cutting blade. The load cell was 25 kg, the speed was 4.00 mm s−1, and the distance was 20.00 mm. The test samples were prepared by cutting rectangular forms from the cheese (1×1 cm, length 5 cm) on which the measurement was performed. The instrument measures the force (kg) needed to move the knife cell a certain distance (mm) into the cheese.

All analyses were performed with three repetitions except for instrumental colour and texture measurement, as well as sensory analysis of the cheese. Instrumental measurement of colour and texture was performed with 10 and sensory analysis of cheese with five repetitions. The results of this study are presented as mean values ± standard deviations. One factor analysis of variance (ANOVA) and Tukey's post hoc test were performed using the IBM SPSS Statistics for Windows, version 22.0 (Armonk, NY, United States). Significance was established at $\alpha<0.05$.

RESULTS AND DISCUSSION

Based on the obtained results, it was determined that the fat content in milk influenced the yield of produced cheeses. The yield is the amount of cheese produced from a certain amount of milk. Sample 3 had the highest yield (18.25%), which was produced from milk with 3.2% fat, while the lowest yield (16.35%) was found in sample 1, which was produced from milk with 1.5% fat (Figure 1). 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, particularly 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, Coulon, & Pradel, 2001; Bojanić-Rašović et al., 2013; Savić, Radović, & Ilić, 2015).

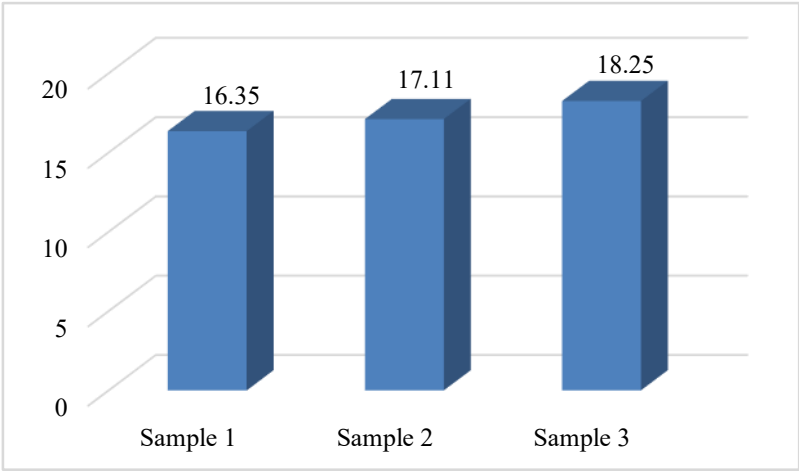

Figure 1. The yield of cheese.

Table 1 shows the chemical composition of the analysed cheeses. Based on the obtained results, by increasing the content of milk fat in milk, the amount of water in the cheese decreases. Sample 1, which was produced from milk with 1.5% fat, had the highest water content (65.31%), while the lowest water content (60.45%) was found in sample 3, which was produced from milk with 3.2% fat. In addition, sample 1 had the lowest dry matter content (34.69%), while the highest dry matter content (39.55%) was found in sample 3. The water content in the non-fat matter of

cheese ranged from 71.64% (sample 1) to 72.74% (sample 3). According to the Rulebook on the quality of dairy products (Pravilnik o proizvodima od mlijeka i starter kulturama [POPMSK], 2011), cheeses with a percentage of water in the non-fat matter from 69 to 85% are classified as fresh cheeses. Therefore, it was confirmed that the tested samples belonged to the group of fresh cheeses.

Milk fat is extremely important for the consistency and sensory properties of cheese. As the milk fat content increases, the aroma, consistency, and quality of the cheese improve. The first sample of cheese had 8.84% fat. The second examined sample had 14.18% fat, and the third 16.90%. Therefore, the increase in the content of fat in milk leads to an increase in the amount of fat in cheese. Accordingly, sample 1 had the lowest fat content in dry matter (25.48%), while the highest fat content in dry matter was found in sample 3 (42.73%). According to the mentioned Rulebook (POPMSK, 2011), and according to the content of milk fat in the dry matter, cheeses are classified as extra fatty, with over 60% fat, whole fat containing from 45 to 60% fat, fatty from 25% to 45%, semi-fat containing 10% to 25%, and lean, with less than 10% fat in the dry matter. Since the amount of milk fat in the dry matter of the analysed cheeses ranged from 25.48% to 42.73%, they were also classified as fatty cheeses.

The proteins in cheese come from milk proteins, which are of great biological value. The protein content affects the sensory properties of the cheese as well as its nutritional value. Mature cheeses have a higher protein content compared to fresh cheeses. They contain all the essential amino acids in a ratio that is close to the proteins for the synthesis of which they are used in the human body (Maćej, Jovanović, Seratlić, & Barać, 2004). The results obtained in this paper show that the increase of fat content in milk decreases the protein content in cheese. Thus, the protein content in sample 1 was 19.58%, in sample 2 it was 17.49%, and 16.90% in sample 3.

Minerals are expressed as a percentage of ash. In this study, it was determined that with the increase in fat content in milk, the ash content in cheese slightly increased. Samples 1, 2 and 3 had 2.29%, 2.31% and 2.49% ash respectively.

The chloride content of the samples was 2.03% in sample 1, 2.13% in sample 2, and 2.04% in sample 3. Chlorides in cheese come from the salt that is added during cheese production. The salt affects the taste of the cheese, and the separation of whey from the cheese regulates the ripening of the cheese. Salt also serves as a preservative as it enables extended storage of cheese.

Table 1. Chemical composition of analyzed cheeses.

Parameter (%)	**Sample 1**	**Sample 2**	**Sample 3**
Water	$65.31^{a} \pm 0.21$	$62.32^{b} \pm 0.12$	$60.45^{c} \pm 0.19$
Dry matter	$34.69^{a} \pm 0.21$	$37.68^{b} \pm 0.12$	$39.55^{c} \pm 0.19$
Water in the fat-free substance of cheese	$71.64^{a} \pm 0.22$	$72.62^{b} \pm 0.16$	$72.74^{b} \pm 0.22$
Fat	$8.84^{a} \pm 0.25$	$14.18^{b} \pm 0.46$	$16.90^{c} \pm 0.44$
Fat in dry matter	$25.48^{a} \pm 0.71$	$37.63^{b} \pm 1.23$	$42.73^{c} \pm 1.10$
Proteins	$19.58^{a} \pm 0.08$	$17.49^{b} \pm 0.05$	$16.90^{c} \pm 0.15$
Ach	2.29 ± 0.02	2.31 ± 0.06	2.49 ± 0.26
Chlorides	2.03 ± 0.01	2.13 ± 0.09	2.04 ± 0.01

$^{a-c}$ mean values with different letters in the same row differ statically significantly with 95% probability ($p < 0.05$)

Table 2 shows the values of water activity (a_w), pH value and acidity of the tested cheese samples. Using the water activity value, it is possible to estimate how much free water is available for the metabolism of the present microorganisms. This means that water activity is a suitable parameter to control the growth and development of microorganisms. A_w value of 0.92 and 0.96 is

required for normal bacterial activity (Adams, & Moss, 2008). The water activity in the tested cheese samples ranged from 0.944 (sample 3) to 0.947 (sample 1). This indicates that the tested cheeses are a suitable medium and a very sensitive food for the development of microorganisms.

The pH value represents the active acidity of the cheese. It is of great importance in cheese production because it affects the elasticity of the cheese mass, the sensory properties, and other physical properties of the cheese. Sample 2 had the highest pH value (pH=5.48) and sample 1 had the lowest (pH=5.31). The titratable acidity of cheese was determined by titrating the sample with bases, most often NaOH with the addition of phenolphthalein indicators. By determining this acidity, measured was the latent acidity derived from non-dissociated acidic constituents having a large buffering capacity. The acidity was most pronounced in sample 1 (44.24˚SH), then samples 2 (43.60˚SH) and 3 (41.60˚SH).

Table 2. a_w value, pH value and acidity of analyzed cheeses.

Parameter	Sample 1	Sample 2	Sample 3
a_w value	0.947 ± 0.001	0.946 ± 0.002	0.944 ± 0.001
pH value	5.31^{a} ± 0.01	5.48^{b} ± 0.03	5.34^{a} ± 0.02
Acidity (°SH)	44.24^{b} ± 0.34	43.60^{b} ± 0.57	41.60^{a} ± 0.00

$^{a-b}$ mean values with different letters in the same row differ statically significantly with 95% probability ($p < 0.05$)

Table 3 shows the values of the measured color parameters on the surface and in the cross section of the tested cheeses. Instrumental color measurements on the surface and cross-section of the cheese showed that in sample 2 and sample 3 there was an increase in brightness (L*), while in sample 1 slightly lower values for light were measured. Negative values for the parameter a* indicate the presence of a greenish color shade and the absence of red color shade. The values of the parameter a* on the surface of cheeses ranged from -0.50 (sample 2) to -1.30 (sample 1), and on the cross-section from -0.54 (sample 2) to -1.25 (sample 1). Positive values of the parameter b* tell us about the presence of yellow color. The highest b* value on the surface of the cheese had sample 2 in the amount of 12.14, while the lowest b* value had sample 3, namely 10.89. In the cross-section of cheese, the yellow color is most represented in sample 2 (b*=12.42), followed by sample 3 (b*=11.23), while in sample 1 it was least represented (b*=11.15).

Table 3 also shows the average values obtained by instrumental measurement of the texture of the tested cheese samples. The hardness of the cheese depends on its composition, ie. of the water content in the cheese. Cheeses with a lower water content have higher strength and a higher shear force is required to cut them, while cheeses with a higher water content have lower strength and less shear force is required to cut them. The highest value for texture was shown by sample 3, and the lowest by sample 1. The measured values for hardness in tested samples ranged from 0.1263 kg (sample 1) to 0.1592 kg (sample 3).

Table 3. Instrumentally measured color and texture parameters of analyzed cheeses.

Sample	Colour parameters on the surfaces			Color parameters on the cross section			Hardness (kg)
	L*	a*	b*	L*	a*	b*	
1	91.72[a] ± 0.42	-1.30[a] ± 0.04	11.88[b] ± 0.31	92.50[a] ± 0.30	-1.25[a] ± 0.03	11.15[a] ± 0.25	0.1263[a] ± 0.0044
2	93.61[b] ± 0.23	-0.50[b] ± 0.03	12.14[b] ± 0.28	93.59[a,b] ± 0.78	-0.54[c] ± 0.06	12.42[b] ± 0.63	0.1486[b] ± 0.0070
3	94.11[c] ± 0.09	-0.70[c] ± 0.02	10.89[a] ± 0.13	94.00[b] ± 0.19	-0.71[b] ± 0.03	11.23[a,b] ± 0.32	0.1592[b] ± 0.0153

[a-c] mean values with different letters in the same column differ statically significantly with 95% probability ($p < 0.05$)

The following sensory properties were examined in all analysed samples: appearance (external appearance and cross-sectional appearance), colour (surface and cross-section), odour, flavour, and consistency. The results of the sensory analysis are shown graphically in Figure 1. Sample 3, which was produced from milk with the highest fat content (3.2% milk fat) was evaluated best. All samples received a score of 5.00 for appearance. The colour of the surface and cross-section was best in samples 1 and 3, while sample 2 was more yellowish. In all three samples, the odour is acceptable and characteristic of the given product. The highest (5.00) for flavour was given to sample 3, sample 2 earned a somewhat lower score (4.50), while the lowest score (4.00) was given to sample 1. Consistency in sample 1 was rated 4.50 because it was stickier than the other samples. Sample 2 received a score of 4.70 for consistency. Sample 3 had a slightly harder consistency and was less sticky, and received a maximum score of 5.00.

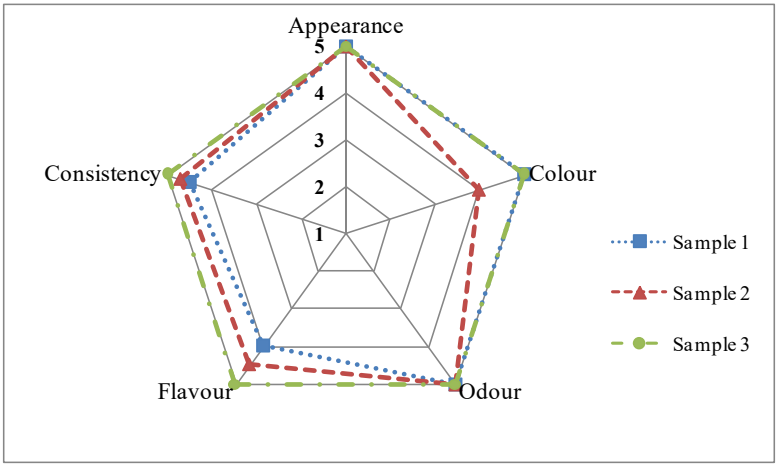

Figure 2. Graphic presentation of the results of sensory analysis of tested cheeses.

The quality characteristics of cheeses are related to the chemical composition of milk and the production process (Maćej et al., 2004; Fox, Guinee, Cogan, & McSweeney, 2016; Araque et al., 2017). Lou, & Ng-Kwai-Hang, (1992) also reported that higher fat levels in milk gave higher fat, and lower protein and moisture contents in cheese. Similar results were published by Lelievre (1983) and Gilles and Lawrence (1985), who found that fat retention in cheese was associated with protein and fat content in milk. Sánchez-Macías et al. (2010) reported that fat reduction of handmade raw milk cheeses produced using traditional methods had important effects on the chemical composition, pH, texture, and colour of the resulting cheese product. As fat was reduced in milk, cheese yield decreased, and protein and moisture percentages increased in cheese.

According to the research by Bojanić-Rašević et al. (2013), the quality of cheese, nutritional value, and physical and chemical composition of cheese depend largely on the fat content. 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. The authors of this paper concluded that the protein to fat ratio in milk influenced the decline of fat, protein, dry matter and yield of cheese, and the increase in moisture content in cheese. Suliman et al. (2013) recommend the production of low-fat cheeses to increase revenue for the producers and give healthy images for the consumers. They reported that, during storage, the fat levels of Sudanese white cheese showed significant differences in the content of total solids, protein, fat, ash, acidity, and total volatile fatty acids. It was also found that the volatile fatty acids increased with the increase of the milk fat. Araque et al. (2017) evaluated the influence of milk fat content and coagulant type on Ricotta yield and physical, chemical, and sensory properties. The authors found that fat-free Ricotta was harder and whiter than reduced-fat or full-fat Ricotta. Ricotta produced from low-fat and whole milk showed no differences in acceptability, indicating that fat content could be substantially reduced without impairing quality. Suliman et al. (2019) concluded that the level of fat content affected the Sudanese cheese acceptability and properties, although the cheese made from 1% fat milk had a higher content of sodium, calcium, and phosphorus content. However, the cheese made from 2% fat milk showed the superior scores, while the cheese made from 1% fat milk had the poorest ranks for overall acceptability, texture, flavour, and taste.

CONCLUSIONS

Based on the obtained results, the fat content in milk had a statistically significant ($p<0.05$) effect on the physico-chemical and sensory properties of fresh cheese. It can be concluded that the higher content of milk fat has a positive effect on the quality of fresh cheese, especially the sensory properties. Sensory analysis showed that sample 3, which was produced from milk with the highest fat content, was the most acceptable and earned the highest scores for the observed sensory properties.

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