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Original Scientific Paper

ASSESSMENT OF THE QUALITY OF MILK AND DAIRY PRODUCTS IN THE REPUBLIC OF SERBIA

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Summary

Milk as a foodstuff has great nutritional and physiological importance and occupies a special place in the diet of children, the elderly and sick people. Fermented products are easily digestible and are recommended for people with lactose intolerance. It is believed that the daily intake of these products enables the establishment and normal functioning of the intestinal tract. These products are obtained by fermentation under the influence of lactic acid bacteria. Fermented products include yogurt, sour milk, kefir and fruit yogurt, as well as other types of fermented milk. The production of safe and high-quality food is something that every country strives for, and that is why laws and regulations define the quality standards that food must meet in order to be on the consumer's table. Milk is one of the basic foods in the diet of the population and its quality must be controlled. The aim of this study was to examine the quality of milk and dairy products on market and from imports in the territory of the Republic of Serbia. The material included 70 samples of milk and dairy products. The quality parameters of milk and products were examined according to the Regulation on the quality of dairy products and starter cultures (Official Gazette of the Republic of Serbia 33/2010, 69/2010, 33/2013, 34/2014). The following standard methods were used for testing: SRPS ISO 19660, SRPS EN ISO 8968-4, SRPS ISO 22662/IDF 198. The obtained results showed that 95.71% of the tested samples of milk and dairy products met the criteria prescribed by the Regulation. The quality parameters are satisfactory, but it is recommended to monitor the quality of milk and dairy products, because some of the products did not meet the criteria prescribed by the Rulebook or did not have an appropriate manufacturer's declaration.

Key words: quality, milk, dairy products.

INTRODUCTION

Due to its nutritional and physiological importance, milk as a foodstuff occupies a special place in the diet of children, the elderly and sick people. Milk and dairy products in the human diet, in addition to high-value proteins, also provide easily digestible fats, lactose, minerals, vitamins A and D. Milk contains B2, B6, B12, A, D and K vitamins, as well as calcium, phosphorus, potassium and magnesium, as minerals. Dairy products, such as fermented milk products, which are obtained by fermentation under the influence of lactic acid bacteria, are easily digestible and are recommended for people with lactose intolerance. It is believed that the daily intake of these products enables the establishment and normal functioning of the intestinal tract. Fermented products include yogurt, sour milk, kefir and fruit yogurt, as well as other types of fermented milk.

It is necessary to provide children with not only nutritious but also safe and high-quality nutrition in order to support their growth and development and prevent diseases in adulthood (Armas et al., 2016). Despite being incredibly nutritious and a valuable source of essential macro- and micronutrients for human health, milk and dairy products pose significant health problems, especially for babies and children (Towhida et al., 2021).

Milk and dairy products are known as the most cost-effective foods of animal origin in low- to middle-income countries (Nyokabi et al., 2021; Alonso et al., 2018; Muunda et al., 2021).

Milk production in the Republic of Serbia is one of the most important agricultural branches. The consumption of milk and dairy products is about 190 kg per year per capita. In the last ten years, a decline in the production of pasteurized milk and butter has been observed, the production of cream and cheese is constantly growing, while the amount of production of fermented milk products fluctuates (RZS, 2023).

Since milk and dairy products are associated with food-borne diseases, consumers are concerned about the quality of milk products and the conditions of production (Walstra et al., 2006). Ensuring the quality and safety of milk and dairy products requires the control of different stages of the milk processing chain, from milking the cow to consumption (Babege et al., 2020; Tegegn, 2021).

The production of safe and high-quality food is something that every country strives for, and that is why laws and regulations define the quality standards that foods must meet in order to be on market and on consumers' tables. Milk is one of the basic foods in the diet of the population and its quality must be controlled. In the Republic of Serbia, conditions regarding the quality of thermally processed milk and milk products are prescribed by the Regulation on the quality of dairy products and starter cultures (Regulation, 2010). This Regulation provides the classification, categorization and name of the product, physical, chemical, physico-chemical and sensory properties, as well as the composition of the product, the types and quantities of raw materials, additives and other substances used in the production and processing of the product,

elements of essential technological procedures that are applied in the production and processing of the product, and additional requirements for labeling the product.

The aim of this study was to examine the quality of milk and dairy products on market and from imports in the territory of the Republic of Serbia.

MATERIALS AND METHODS

The material included a total of 70 samples: thermally processed milk (n=8) and dairy products (cheese n=42, kajmak n=2, butter n=3, yogurt and sour milk n=7, “urda“ n=1, milk powder n=3, whey powder n=3, Basque n=1), which came from the territory of the Republic of Serbia, as well as by the method of random sampling from the Horgoš border crossing. All imported samples originated from France, Denmark, Poland, Lithuania, Slovakia, Germany and Hungary. Figure 1 shows the origin of the tested samples of thermally processed milk and dairy products from the territory of the Republic of Serbia.



Figure 1 Origin of milk and dairy products samples from the territory of the Republic of Serbia

In order to test the quality of thermally processed milk and dairy products, the following parameters were tested:

- pasteurized milk: milk fat content by Gerber method, nitrogen content and dry matter,

- cheese: milk fat content by Gerber method and dry matter,
- yogurt and sour milk: milk fat content by Gerber method and pH value (potentiometric),
- butter: milk fat content by Gerber method and dry matter,
- powdered milk: milk fat content by Gerber method, dry matter and nitrogen content,
- whey powder: milk fat content by Gerber method, dry matter and nitrogen content,
- kajmak: milk fat content by Gerber method, dry matter, pH value (potentiometric) and NaCl content by Volhard method,
- cottage cheese: milk fat content by Gerber method and dry matter,
- Basque: milk fat content by Gerber method and dry matter

The samples were tested using the following standard methods:

- SRPS ISO 11870 (ISS, 2014),
- SRPS ISO 8968-4 (ISS, 2016),
- SRPS ISO 6731 (ISS, 2013).

GraphPad ver.3 and MS Excel ver.10 were used for statistical processing of the results, and the Mann-Whitney U test was used for statistical comparison of values that did not have normal distribution.

RESULTS

The obtained results showed that out of 235 analyses, 232 analyzes (98.7%), or 95.71% of the tested samples of milk and dairy products met the criteria prescribed by the Regulation (Figure 2).

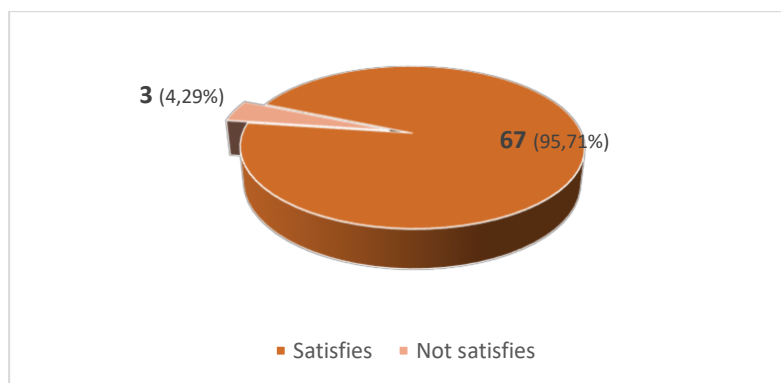


Figure 2 Results of testing the quality of milk and dairy products

The results of testing parameters of milk fat content and protein content in pasteurized milk samples are shown in Table 1. Milk fat ranged from 2.8% to 3.6%, while protein content was measured in the range of 2.9% to 3.3%. Small variations were obtained,

characterized by a coefficient of variation for milk fat of 10% and for protein content of 4.6%.

Table 1 Test results of pasteurized milk

Parameter	Milk fat (%)	Protein content
Number of samples	8	8
Min.	2.8	2.9
Max.	3.6	3.3
$\bar{X}$	3.1	3.1
SD	0.31	0.14
CV (%)	10	4.6

The results of quality testing of 42 samples of cheese, which came from Serbia and were imported, are shown in Table 2.

Table 2 A summary of the examination of cheese quality parameters from Serbia and imports

Parameter	Milk fat (%)	Milk fat in dry matter	Water content in fat-free matter	Dry matter
Number of samples	42	42	30	42
Min.	1	4.75	49.06	21.06
Max.	31	58.66	82	66.15
$\bar{X}$	22.71	42.59	60.39	51.18
SD	7.489	9.756	7.351	12.48
CV (%)	32.98	22.91	12.17	24.39

In the summary of the test results of the quality parameters of cheeses (Table 2), the cheeses are not classified according to the method of obtaining, processing and ripening, and therefore the test results are characterised with considerable variation. From the results of determining the quality parameters of the cheeses, it can be seen that the milk fat content ranged from 1% to 31%, the milk fat content in the dry matter from 4.75% to 58.66%, the water content in the fat-free cheese matter from 49% to 82%, while the dry matter of the cheese had values between 21% and 66%. The coefficient of variation is the highest for the milk fat content (32.98%), and the lowest for the water content in the fat-free matter (12.17%).

The results of testing the parameter of milk fat in dry matter showed that the cheese samples belonged to skimmed cheeses (1%), low-fat cheeses (2%), semi-fat cheeses (15%) and full-fat cheeses (23%), while no sample was categorized as extra-fat cheese (Figure 3).

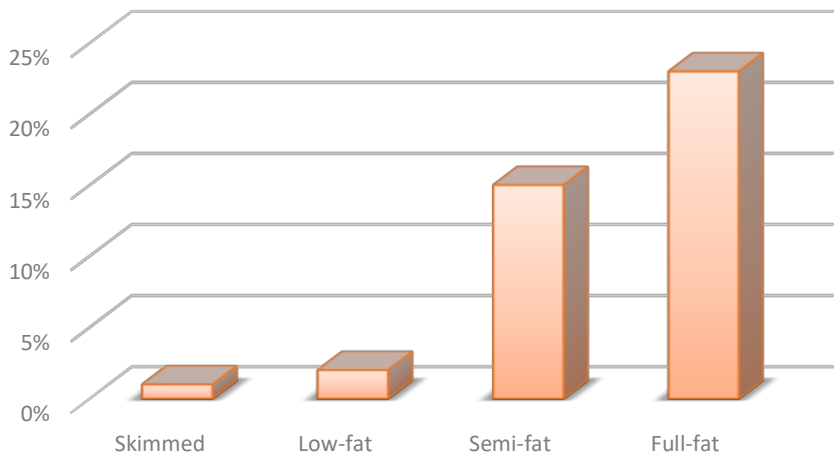


Figure 3 Distribution of cheese samples according to the share of milk fat in dry matter

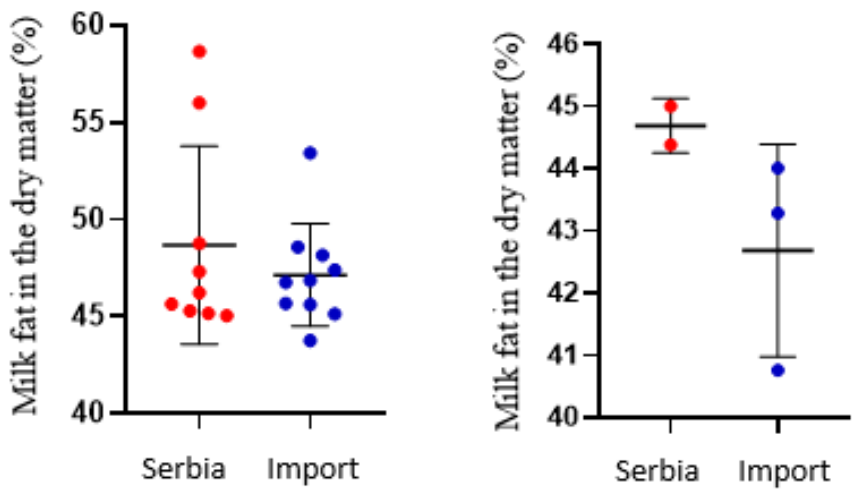
Table 3 The results of testing the quality parameters of cheeses originating from Serbia

Parameter	Milk fat (%)	Milk fat in dry matter	Water content in fat-free matter	Dry matter
Number of samples	29	29	19	29
Min.	1	4.75	53.56	21.06
Max.	30	58.66	82	61.35
$\bar{X}$	20.74	41.02	61.99	47.54
SD	8.232	11.27	7.671	13.26
CV (%)	39.70%	27.47%	12.38%	27.89%

Table 4 The results of testing the quality parameters of imported cheeses

Parameter	Milk fat (%)	Milk fat in dry matter	Water content in fat-free matter	Dry matter
Number of samples	13	13	11	13
Min.	25	40.76	49.06	48.67
Max.	31	53.42	69.36	66.15
$\bar{X}$	27.10	46.11	57.62	59.31
SD	1.79	3.09	6.12	4.29
CV (%)	6.60	6.70	10.63	7.23

Figures 4 and 5 show the distribution of milk fat in the dry matter of semi-fat and full-fat cheeses originating from Serbia and imported.



Figures 4 and 5 Presentation of the distribution of milk fat in the dry matter of semi-fat (left) and full-fat cheeses (right) originating from Serbia and imported ($\bar{X} \pm SD$).

Table 5 shows the results of determining the quality parameters of fermented products (yogurt and sour milk).

Table 5 Results of testing quality parameters of yogurt and sour milk

Parameter	Milk fat (%)	pH
Number of samples	7	7
Min.	0.5	4.2
Max.	11	4.4
$\bar{X}$	4.5	4.3
SD	3.4	0.078
CV (%)	76	1.8

Tables 6, 7, 8, 9 and 10 show the results of testing quality parameters for milk products (butter, milk and whey powder, kajmak, cottage cheese).

Table 6 Test results of the butter quality parameter

Parameter	Milk fat (%)	Fat-free dry matter	Moisture (%)
Number of samples	3	3	3
Min.	84	1.1	11
Max.	88	1.9	15
$\bar{X}$	86	1.4	13
SD	2.3	0.44	1.9
CV (%)	2.6	32	15

Table 7 The results of testing the quality parameters of milk powder

Parameter	Milk fat (%)	Fat-free dry matter proteins	Water content	Protein content
Number of samples	3	3	3	3
Min.	1	29	2.6	23
Max.	28	35	4	33
$\bar{X}$	15	33	3.2	27
SD	14	3.5	0.71	5.3
CV (%)	93	11	22	19

Table 8 Results of testing the quality parameters of whey powder

Parameter	Protein content	Water content	Milk fat (%)	Ash (%)	pH of 10% solution
Number of samples	3	3	3	3	3
Min.	3.2	1.9	0.3	2.8	6.3
Max.	11	3	0.8	7.3	6.5
$\bar{X}$	7.5	2.3	0.6	5.7	6.4
SD	4	0.58	0.26	2.5	0.06
CV (%)	54%	25%	44%	44%	0.94%

Table 9 Results of testing the quality of kajmak

Parameter	Milk fat (%)	Milk fat in dry matter	Dry matter	pH	Salt content (NaCl)
Number of samples	2	2	2	2	2
Min.	57	81	67	6	1.2
Max.	58	87	71	6	1.2
X	58	84	69	6	1.2
SD	0.71	4.4	2.8	0.01	0.03
CV (%)	1.2	5.2	4.0	0.12	2.4

Table 10 Results of testing the quality of “urda”

Milk fat (%)	Milk fat in dry matter	Dry matter
6.5	26.4	24.6

DISCUSSION

The presented results show that all samples of pasteurized milk met the quality criteria prescribed by the Regulation and that no sample contained less milk fat than stated on the product declaration. The protein content corresponds to the average protein content of cow's milk. According to the analysis from 2022, milk production in the Republic of Serbia has stabilized at around 1.5 billion liters thanks to the increase in production per head. However, since the number of heads was reduced, the production also began to decline. In 2021, production was 100 million liters lower (RZS, 2023). All tested cheese samples met the criterion prescribed by the Regulation in terms of dry matter (Regulation, 2010), with a variation in the amount of dry matter of about 24%, which is explained by the fact that the samples were different types of cheese,

which are obtained in different ways (Table 2). The milk fat content, which varied by almost 33%, stands out as the parameter that best describes the variety of cheeses on the market. This difference originates, apart from the characteristics of production, and from the demands of the market, where in the last two decades the demand for cheeses made from skimmed milk with a reduced milk fat content has been growing. Analyzing the test results of cheese samples originating from Serbia, it is noted that the milk fat content ranged from 1% to 30%, the milk fat content in the dry matter from 4.75% to 58.66%, the water content in the fat-free cheese matter from 53.56% to 82%, while the dry matter of the cheese ranged from 21% to 61%. In this case, the coefficient of variation is the highest for the milk fat content (39.70%), and the lowest for the water content in the fat-free cheese (12.38%) (Table 3). If cheeses originating from the Republic of Serbia and imported cheeses are compared, different types of cheeses are represented. All tested imported cheeses have a share of milk fat in dry matter over 40, that is, over 25% of milk fat, so according to the division they are classified as semi-fat and fat cheeses (Figure 3, 4 and 5). As the Regulation defines different cheese quality conditions depending on the production characteristics, it can be concluded that all tested cheeses have adequate quality. Of the examined characteristics, a statistically significant difference was found between domestically produced and imported cheeses in terms of milk fat content ($U=98.5$ $p=0.013$), as well as in dry matter content ($U=62$ $p=0.0003$). These results refer to all tested samples and confirm the difference between the types, origins and types of imported and domestic cheeses. As all tested imported cheeses belonged to the category of semi-fat and fat cheeses, if they are compared with the same category of cheeses produced in Serbia, there is no statistically significant difference in the quality parameters ($p>0.05$). In earlier study obtained in Serbia, cheeses from markets were examined, where the quality parameters of cheeses produced from thermally processed milk and from uncooked milk were determined (Radovanović et al., 2016). The results of those analyzes of cheeses from individual agricultural producers showed lower values for dry matter than the samples tested in this study, i.e. in the case of uncooked milk cheeses, $36.87\pm6.10\%$, while in the case of cooked milk cheeses, this share is expected to be slightly higher, i.e. $41.13\pm4.97\%$. The fat in the dry matter of such cheeses was $56.39\pm9.36\%$ in uncooked milk cheeses, while in boiled milk cheeses the share of milk fat was $42.63\pm17.68\%$, which represents an expected decrease, because small producers separate the cream from boiled milk before making cheese. Our results show an average amount of milk fat of $41.02\pm11.27\%$, which is a result that must be seen in the context of an adequate group of cheeses according to the amount of milk fat. All tested samples of fermented products met the quality criteria prescribed by the Regulation (Regulation, 2010). The obtained values for the tested parameters are significantly lower than those obtained by Golić et al. (2014).

The parameters of the butter quality test were the content of milk fat, water and dry matter (Table 6). The samples were block butter, frozen butter and butter made from pasteurized cream. All samples met the criteria of the Regulation, but all of them had

values of the mentioned parameters higher than the minimum prescribed by the Regulation, which the manufacturers can use in order to extend the shelf life and adequate offer on the market. The parameter that varied the most in the examined butter samples was the content of dry matter without fat (coefficient of variation 32%), which only reflects the different technological procedures of product storage, such as freezing. The milk fat content had a very low coefficient of variation in the tested samples (2.6%), which proves the consistency in standardized butter production. The obtained results are in accordance with the results obtained by Pădureț (2021).

All milk powder samples for testing were imported (Denmark and France). Two samples were declared as whole milk powder, while one sample was defined as skimmed milk powder. One of the mentioned samples declared as whole milk powder contained 14.5% milk fat, which is not in accordance with the provisions of the Regulation, which defines a minimum of 20% milk fat. This product would have to be declared as skimmed milk powder, because it does not correspond to the declaration. Other quality parameters of all tested products were in accordance with the manufacturer's declarations (Table 7).

All whey powder samples were imported (France, Lithuania and Slovakia). Of all the tested dairy products for the purpose of quality testing, the largest share of products that did not meet the criteria came from whey powder samples. Of all the tested samples, only a third (33.3%) met all the prescribed criteria (Table 8). Disagreement with the Rulebook was observed in the criterion of protein content, where only the samples from France had over 11% protein, which represents the prescribed minimum. All other product quality parameters of all tested whey powder samples were in accordance with the requirements of the Regulation.

The results of the kajmak testing included two samples of young kajmak from the Zlatibor region, and both met the quality conditions prescribed by the Regulation. The test results of one "urda" sample (Table 10) met the quality criteria prescribed by the Regulation. Similar results of testing the quality of 14 "urda" samples in Montenegro are reported by Bojanic Rasovic et al. (2017), who proved that the mean value of the dry matter content of "urda" was 42.85%, fat content 21.74%, protein 13.66%, salt 2.67%, fat in dry matter 50.77%, fat in dry matter 21.11% and water content in dry matter of free fat 49.67%.

Basque represents a mature lump in the process of obtaining cheeses from steamed dough such as cheese. Basque quality parameters are not defined by the Regulation, so there are no set limits for the quality parameters of this product.

CONCLUSION

The obtained results showed that 95.71% of the tested samples of milk and dairy products met the criteria prescribed by the Regulation. One sample of milk powder did not correspond to the declaration due to a lower content of milk fat, but it would have met the criteria if it had been defined as skimmed milk powder, because the other tested

parameters were appropriate. Two samples of whey powder did not meet the criteria of minimum protein content, while the other parameters were adequate. The quality parameters of Basque are not defined by Regulation, so there are no set limits for the quality parameters of this product. The quality parameters are satisfactory in the majority of tested samples, but monitoring of the quality of milk and dairy products will continue through monitoring, because some products did not meet the criteria prescribed by the Regulation or did not have an appropriate manufacturer's declaration.

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Conflict of interest statement: The authors declare that there is no conflict of interest

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