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Quality characteristics of selected dairy products in Serbia

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Summary

The aim of this paper was to assess and compare the compliance of the chosen quality characteristics of commercially available dairy products with the requirements of the current Serbian legislation. A total of 706 samples of liquid milks (pasteurized and UHT-treated), fermented milks (liquid and solid yoghurt) and milk powders (skimmed and whole milk powder) were collected from the market and analysed for milk fat content, pH value, water content and protein content, depending on the type of product. The obtained results were interpreted in relation to the dairy plants capacities in which the analysed dairy products were produced. Except the fermented milk samples with a declared milk fat content of 3.2 %, all other analysed compositional and quality parameters of the selected dairy products were in compliance with the current legislation. It was observed that dairy plants of smaller capacity had a higher variation of quality characteristics of dairy products.

Key words: quality, fermented milks, liquid milk, milk powder, legislation

Introduction

The dairy industry in the Republic of Serbia is of high economic importance. According to the official statistical data, the total milk production in Serbia is around 1.5 billion L/year. Approximately 700 million L (nearly 50 %) are processed in 200 dairy plants of different capacities (Yearbook, 2011; Analysis, 2012).

Depending on the daily processing capacities, Serbian dairy plants can be categorized as follows: (i) plants with a capacity over 20000 L/day, (ii) plants with capacity below 20000 L/day and (iii) small craft plants with a daily capacity below 3000 L/day. Although the first group represents only 15 % of the total number of dairy plants, it contributes with more than 80 % to the total industrial milk processing (Analysis, 2012).

The structure of the dairy products varies among dairy plants in Serbia and has dramatically changed over the past few years (Popovic, 2009). The biggest dairy processors are focused on the production of liquid milks (pasteurized and sterilized milk) and fermented milks (liquid and solid yoghurts) which accounts for approx. 45 % and 37 % of the total production, respectively. Furthermore, these big plants, after undergoing privatization, increased their production of fermented milks, different kinds of yoghurt, and UHT milks by nearly 10 % and 5 %, respectively, and reduced the production of cheeses. In contrast, middle and small sized dairy plants are mostly focused on the production of dairy products such as cheese and kajmak (Serbian traditional product) etc. which comprise app. 50 % of their production, but still with a significant participation of fermented milks (15-20 %) (Popovic, 2009).

The quality and the safety of dairy products are of highest importance and represent one of the main goals of the dairy industry. Also, they are

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very important from the consumer's point of view, which in recent years pay more attention on a diet and functional products. The modern consumer demands food products of high and constant quality and safety. The composition of food products is very important and must be in compliance with current legislation. Various dairy products (liquid milks, fermented milks, creams and powders, cheeses and whey) were analysed in several countries worldwide (Italy, the Czech Republic, Slovakia, New Zealand, Iceland) with research focusing on parameters like biogenic amines, conjugated linoleic acid, phospho- and sphingolipids, Iodine, minerals, firmness, etc. (Ares et al., 2006; Buňková et al., 2013; Cressey, 2003; Hurley et al., 1990; Prandini et al., 2007; Reykdal et al., 2011; Rombaut et al., 2007).

In relation to the current Serbian legislation, there are four main streams that directly and indirectly describe the quality characteristics of the dairy products. The ordinance on quality of dairy products and starter cultures (Regulation, 2010b) is in large part in compliance with the EU legislation and Codex alimentarius (FAO and WHO, 2011), which directly defines the quality requirements of dairy products. The consumer oriented regulation takes into account the labelling of food products, as well as the protection of consumers, but is indirectly focused on quality characteristics as well (Regulation, 2004; Regulation, 2010a).

The current Food safety law and Veterinary law (Regulation, 2008; Regulation, 2009) stipulates that all food bussiness operators in Serbia must implement the hazard analysis and critical control point (HACCP). Within this concept, one of the mandatory requirements is to clearly define the product specification. The labelling ordinance requires dairy products to declare: the name of the food, a list of ingredients, the amount of an ingredient which is named or associated with the food, appropriate shelf life indication (e.g. 'best before' or 'use by'), any special storage conditions or instructions for use, lot identification used for traceability purposes, the name and address of the manufacturer, packer or retailer and the place of origin (where failure to do so might mislead) (Regulation, 2004). The consumer protection law is mostly based on the rights of consumers in relation to the availability safety, truthful information about and the choice of products with liable quality (Regulation, 2010a).

Although small in volume, Serbian small and medium sized dairy plants represent the majority of enterprises within the dairy sector in relation to the number of employees (Analysis, 2012). Some authors compared production indicators and quality tools in food business operators (FBO), highlighting specific aspects of small and medium sized enterprises (SMEs) but did not focus on the dairy industry (Karipidis et al., 2009; Psomas and Fotopoulos, 2010; Sousa et al., 2005; Van Der Spiegel et al., 2006). Other researchers focused their research on the food safety compliance within the FBOs, with certain emphasis on either the SMEs or the dairy industry (Branquinho et al., 2010; Tomašević et al., 2013; Fielding et al., 2011; Henson and Heasman, 1998; Karaman, 2012; Luning et al., 2013; Yapp and Fairman, 2006).

The authors of this study understand the importance of dairy products' safety, but they focus on the quality characteristics (Figure 1).

The aim of this study was to investigate the particular quality parameters of three types of dairy products that are often consumed in Serbia (liquid milks, fermented milks, milk powders). The analysed quality parameters were chosen depending on

Figure 1. Analytic framework of the research

Table 1. Demographic structure of dairy plants and samples

Daily capacities of dairy plants [L/day]	Dairy plants		Samples							
			Pasteurized milk		UHT milk		Fermented drinks		Milk powder	
	n_d (%)		n (%)		n (%)		n (%)		n (%)	
≤20000	14	(53.85)	66	(46.15)			69	(23.31)	88	(48.89)
20001-99999	7	(26.92)	58	(40.56)	31	(35.63)	161	(54.39)		
100000-199999	3	(11.54)	19	(13.29)			66	(22.30)	92	(51.11)
≥200000	2	(7.69)			56	(64.37)				
Total	26	(100.00)	143	(100.00)	87	(100.00)	296	(100.00)	180	(100.00)

n_d - represents the number of dairy plants; n - represents the number of samples

the requirements of the current Serbian legislation. The first objective was to analyse whether these dairy products are in accordance with legally designated and declared values. The second objective of this paper was to determine relationships between the capacity of dairy plants and the quality parameters of dairy products.

Materials and method

Materials

During a period of 21 months, from March 2011 to December 2012, the commercial dairy products were purchased and analysed for different physical characteristics and chemical composition. Three categories of dairy products were sampled and analysed: liquid milks (pasteurized and UHT milks), fermented milks (liquid and solid yoghurt) and milk powders (skimmed and whole milk powders).

In total, 706 samples of dairy products produced in 26 different dairy plants were collected and analysed (Table 1).

In order to analyse the quality parameters of different dairy products, the obtained results were subdivided depending on the daily processing capacity of a dairy plant. Since there were no products produced in small craft plants, the plants were divided in four categories: (a) below 20000 L/day, (b) from 20000-100000 L/day, (c) between 100000 and 200000 L/day and (d) over 200000 L/day.

Liquid milks

Within the group of liquid milks, two product types were analysed - pasteurized milk (159 samples) with a declared milk fat content (MF) of 2.8 % and UHT milk (87 samples) with a declared MF of 1.5 %, 2.8 % and 3.2 %. There are no limits or ranges covering milk fat content within the legislation, so the dairy plants are allowed to produce liquid milks with different milk fat contents.

Fermented milks

Yoghurt

Within the fermented milks, two types of products were analysed - liquid and solid yoghurt. Both products were declared with a 2.8 % and 3.2 % of MF content. These products were analysed for two quality characteristics - the milk fat content and the pH value, which were defined by their label and the Serbian regulative (Regulation, 2010b), respectively.

The Serbian dairy industry and legislation recognize yoghurt as a fermented milk product which is produced by the activity of symbiotic cultures such as *Streptococcus thermophilus* and *Lactobacillus delbrueckii* subsp. *bulgaricus*. Solid yoghurt is a product obtained by milk fermentation and activity of different strains of mesophilic and thermophilic, homo and heterofermentative lactic acid bacteria (Regulation, 2010b). According to the Ordinance (Regulation, 2010b), the minimal pH value of fermented milks should be 3.8.

Milk powders

Two types of milk powders were analysed - skimmed milk powder (SMP) and whole milk powder (WMP). According to the current regulation, the SMP should have a maximum of 1.5 % MF content while WMP should be produced with MF content between 26 and 42 %. The regulative also prescribed

that these products should have a maximum of 5 % water (W) and a minimum of 34 % proteins in milk solids- non-fat (PSNF) (Regulation, 2010b).

Methods of analysis

The milk fat content (MF) of liquid milks was determined according to the Gerber method (IDF, 2008) and compared with the declared values. The pH value was analysed using the Australian standard (AS, 2010). The milk fat content and the water content of milk powders were analysed by reference methods (ISO, 2008a; ISO, 2004) and proteins by the Kjeldahl method (ISO, 2008b). All chemical analyses were performed in an ISO 17025 accredited laboratory.

Statistical analysis

The main statistical analysis considered the calculation of descriptive statistics. The comparison of values obtained from different samples was performed using one tailed t-test (for two samples). The ANOVA (for more than two groups of samples) was used to test the null hypothesis, assuming that there is no difference between the plants categorized by their daily capacities. For all statistical tests, the statistical significance was set to $\alpha=0.05$. The obtained data were processed using a ©Microsoft Office Pack 2007.

Results and discussion

Liquid milks

Results regarding the MF content of liquid milks are presented in Table 2. Samples of pasteurized milks which were declared to contain 2.8 % of MF were grouped and analysed according to the daily capacities of dairy plants. The obtained results showed that the mean of MF contents in all samples was above the minimal declared value. The variation in the MF content of liquid milks decreased with the increase of the dairy plant capacity. The average MF contents of pasteurized milk samples significantly varied among dairy plants with different capacities ($p<0.05$). Pasteurized milk samples produced in small plants had the highest MF content (3.07 %). In contrast to that, pasteurized milk samples produced in big plants showed negligible deviations of the MF content which was around the declared value.

Results related to the characteristics of UHT milk samples with different declared fat contents (1.5, 2.8 and 3.2 % of MF) are also presented in Table 2. These products are mainly produced in large dairy plants, and to a lesser extent in medium-sized plants (Popovic, 2009). Data of all analysed samples were presented depending on the daily capacities of dairy plants.

Results showed that the average MF content of all samples was above the requested minimum, but close to the declared values. Also, there was no significant difference between the MF content of samples produced in plants with different capacities.

Table 2. Statistical parameters of the milk fat (MF) content in liquid milks

Dairy product	Declared value	Daily capacities of dairy plants [L/day]			
		≤20000 M±St	20001-99999 M±St	100000-199999 M±St	≥200000 M±St
Pasteurized milk	2.8 % MF	3.073±0.228[a, b]	2.954±0.212[a]	2.832±0.071[b]	-
UHT milk	1.5 % MF	-	-	1.625±0.187	1.639±0.059
	2.8 % MF	-	-	2.837±0.081	2.833±0.048
	3.2 % MF	-	-	-	3.221±0.049

M - represents the mean value; St - represents standard deviation; MF - milk fat
Same letter highlights statistically significant difference between different types of dairies
[a] - statistically significant difference between the dairy plants with daily capacities ≤20000 and dairy plants with daily capacities between 20001-99999 L/day
[b] - statistically significant difference between the dairy plants with daily capacities ≤20000 and dairy plants with daily capacities between 100000-199999 L/day

Table 3. Statistical parameters of the milk fat (MF) content and the pH value in fermented milks

Dairy product	Declared value	Daily capacities of dairy plants (L/day)			
		≤20000	20001-99999	100000-199999	≥200000
		M±St	M±St	M±St	M±St
Yoghurt	2.8 % MF	3.124±0.561[a, b]	2.921±0.117[a]	-	2.858±0.045[b]
Yoghurt	3.2 % MF	3.345±0.322	3.331±0.200	-	3.205±0.022 (*)
Yoghurt	pH value (2.8 % MF)	4.291±0.137[a]	4.477±0.181[a]	-	4.394±0.127
Yoghurt	pH value (3.2 % MF)	4.310±0.145	4.322±0.063	-	4.346±0.101
Solid yoghurt	2.8 % MF	-	2.975±0.252	-	-
Solid yoghurt	3.2 % MF	-	3.454±0.438	-	-
Solid yoghurt	pH value (2.8 % MF)	-	4.335±0.157	-	-
Solid yoghurt	pH value (3.2 % MF)	-	4.173±0.158	-	-

M - represents the mean value; St - represents standard deviation; MF- milk fat
Same letter highlights statistically significant difference between different types of dairy plants.
[a]- statistically significant difference between the dairy plants with daily capacities ≤20000 and dairy plants with daily capacities between 20001-99999 L/day
[b] - statistically significant difference between the dairy plants with daily capacities ≤20000 and dairy plants with daily capacities ≥200000 L/day
(*) - statistically significant difference with declared value

Such findings were not surprising since liquid milks are usually produced in big dairy plants which are characterized by proper organization and a higher level of control and product quality.

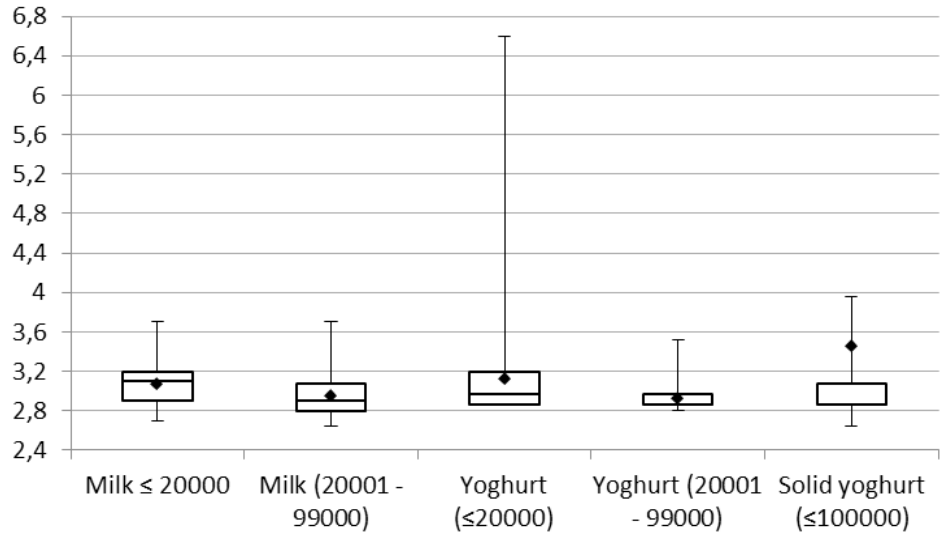
Fermented milks

Milk fat contents of fermented milks with 2.8 % of declared MF were divided in three groups, depending on the capacities of dairy plants (Table 3). All samples were characterized with the MF content above the declared value. However, similar to the data of pasteurized milks fat content, the ANOVA analysis showed a significant difference between samples obtained from dairy plants of different capacities. The range between minimal and maximal assessed values in small dairy plants (≤20000) was very high, more than double of the declared value and showed the highest standard deviation. The average MF content of fermented milks obtained from small size dairy plants was higher than in samples produced in big capacity plants. Such results indicate that middle and big size dairy plants probably have a better control of process parameters, as well as more constant compositional and quality characteristics of products.

Results relating to the milk fat content of fermented milks with the declared 3.2% of MF are presented in the same table (Table 3). All of the analysed samples showed the average milk fat content above the declared values. However, statistical analysis of these data also showed that higher fat content was obtained in samples from small dairy plants in comparison to those from big producers. The difference between the minimal and the maximal assessed values was the highest in small capacity plants, for yoghurt being below 1.0 and being the highest related to solid yoghurt. One-tailed t-test showed that the MF of yoghurt produced by big dairy plants significantly differed from the declared value ($p \leq 0.05$). However, according to the ANOVA results, there was no statistically significant difference between the different groups of dairy plants producing this type of yoghurt.

In order to further interpret data, display and compare the variations (Juran, 1998), a graphical interpretation of the data for products with the declared milk fat of 2.8 % produced in dairy plants with daily capacities ≤100000 L/day is shown in box and Whisker plots (Figure 2). All figures show an upward positive skewness, having the largest dispersion with yoghurt in the smallest dairy plants (≤20000 L/day). The mean of liquid milks and yoghurt are within the interquartile range, while the mean for solid yoghurt samples was out of this range.

The pH values of fermented milks with different fat contents are presented in the same table (Table 3). The current Serbian legislation requires a minimum pH of 3.8 for fermented milks, while the minimal titrable acidity for these products is



Legend - the plot shows five values: the smallest value, lower quartile, median, upper quartile, and largest value: (◆) - represents the mean; boxes presents upper quartile (25 % of data greater than this value) and lower quartile (25% of data less than this value) with median as the line within the box; Whiskers present maximum and minimum values.

Figure 2. Box and Whisker plots of the tested milk fat content in liquid milk samples and fermented milks with the declared milk fat of 2.8% produced in dairy plants with daily capacities ≤100000 L/day

presented as % lactic acid (for yoghurt min. 0.6 %) according to Codex Alimentarius (Codex, 2003). The range between a minimal and a maximal assessed value was below 1.01 for all products. ANOVA analysis of pH values in yoghurt samples with a declared MF content of 2.8 % showed a significant difference between samples produced in dairy plants with capacities below 100000 litres of milk/day. However, the average pH values of fermented milks with a declared MF content of 3.2 % were not statistically different regardless the size of the plants. Acidity of fermented milks (the production of lactic acid or pH) beyond the point of coagulation is monitored principally in relation to consumers' preference. Hence, the selected end point will vary not only from country to country, but also with the type of yoghurt (Tammime and Robinson, 2000). (Valli and Traill, 2005) presented that the cultural diversity still has a significant influence on the consumption of different types of fermented milks. Generally, younger population (consumers aged 18-29 and 30-44) prefers fermented milks with functional properties such as low fat, organic, bio etc.

Milk powders

Samples of skimmed milk powders (SMP) and whole milk powders (WMP) were analysed according to three quality parameters i.e. the MF content, the water (W) content and the content of proteins in milk solids-non-fat (PSNF) which are required by the national ordinance (Regulation, 2010b). As mentioned above, according to the legislation, the contents of water and proteins in milk solids-non-fat should be max. 5 % and min. 34 %, respectively. The milk fat content depends on the milk powder type and should be from 26 to 42 % for WMP and max. 1.5 % for SMP. The current Serbian legislation is in full compliance with EU legislation, which requires the same limits for quality and compositional parameters of this type of dairy products.

For both milk powders, SMP and WMP, the analysis showed that the MF content was within the required values. However, it could be observed that the MF content in WMP was close to the lower limit of values required by the Regulative (~26.5 %). There was no significant difference between WMP samples obtained from different producers. In contrast to that, the MF content of SMP was signifi-

Table 4. Statistical parameters of the milk fat (MF) content, water and proteins in milk solids-non-fat (PSNF) in milk powder products

		Daily capacities of dairy plants (L / day)	
Dairy product	Declared value	≤100000 [M±St]	≥100000 [M±St]
Skimmed milk powder	max 1.5 % of MF	0.946±0.277	0.677±0.239
Skimmed milk powder	Water (max 5 %)	3.711±0.352	4.562±0.272
Skimmed milk powder	PSNF (min 34 %)	37.509±0.635	37.346±0.707
Whole milk powder	26-42 % of MF	26.802±1.070	26.273±0.676
Whole milk powder	Water (max 5 %)	2.173±0.352	3.891±0.478
Whole milk powder	PSNF (min 34 %)	37.497±0.573	37.698±2.261

M - represents the mean value; St - represents the standard deviation
PSNF - proteins in milk solids-non-fat

cantly different between middle and big size dairy plants (Table 4).

The water contents of all analysed samples (Table 4) were below the allowed maximum (<5 %). There was no difference in water contents between SMP and WMP, as well as depending on the size of dairy plant. The water content is one of the most important parameters determining the rate of the undesirable changes in milk powders (Walstra et al., 2006). A higher water content of milk powders (higher water activity) represents a higher risk of microbiological deterioration and favours the occurrence of undesirable chemical reactions (i.e. Maillard reaction). It may occur due to an improper drying process or storage of products. During the production process it is necessary to adjust the water content as high as possible without causing the Maillard reactions to occur too fast. It is believed that the most suitable water content is generally 2.5 to 3 % (Walstra et al., 2006).

The content of proteins in milk solids-non-fat (PSNF) of all milk powders samples are shown in Table 4. The average values in all samples were within narrow limits between 37.35 to 37.70 %, but above the value required by the regulative. Also, it could be observed that there was no significant difference in PSNF of SMP and WMP samples, as well as between samples obtained from different size dairy plants. However, the biggest variation, which is shown by the standard deviation, was found in WMP samples obtained from big dairy plants.

Conclusion

With the exception of fermented milks with a declared milk fat content of 3.2 %, all other analysed compositional and quality parameters of the selected dairy products, including liquid milks (pasteurized and UHT milks), fermented milks and milk powders (SMP and WMP), were in compliance with values required by the current Serbian legislation. Based on that, it can be concluded that, except for fermented milks with a declared MF content of 3.2 %, all producers respect the legislative requirements. However, a higher variation of quality characteristics was found in the small capacity dairy plants, which is caused by inadequate control, by the use of dated equipment or by a lack of knowledge.

Hence, there is an area for improvement regarding the production organization within dairy plants with small capacities. Improvements of these dairy plants should focus on cost reduction and the introduction of techniques in order to achieve better control of all processes. This would result in products of a high and constant quality and safety.

Limitations of the research stem from the use of a convenience sample. Since the dairy products were collected from the market, the current result should not be generalized. Given the great technological and other differences within the dairy plants, more research is necessary to determine if similar results would be derived from different samples across Serbia. Future research should focus on the correlation between quality of final products and raw milks in order to get improved quality of dairy products.

Karakteristike kvalitete izabranih proizvoda od mlijeka u Srbiji

Sažetak

Cilj istraživanja bio je usporediti usuglašenost izabranih karakteristika kvalitete komercijalnih proizvoda od mlijeka sa zahtjevima zakonske regulative Republike Srbije. Uzorkovano je 706 različitih proizvoda i obuhvaćeni su mlijeko (pasterizirano i UHT), fermentirani proizvodi od mlijeka (jogurt i kiselo mlijeko) i mlijeko u prahu (punomasno mlijeko u prahu i obrano mlijeko u prahu). Svi proizvodi prikupljeni su s tržišta a ovisno o vrsti proizvoda, analizirani su mliječna mast, pH vrijednost, udjel vode i proteini. Rezultati su tumačeni u odnosu na kapacitet mljekara u kojima su proizvedeni. Osim u slučaju fermentiranih proizvoda od mlijeka sa sadržajem mliječne masti od 3,2 %, sve ostale karakteristike bile su u skladu s vrijednostima zahtijevanim u zakonskoj regulativi. Istraživanjem je uočeno da su u mljekarama manjeg kapaciteta veća variranja vrijednosti karakteristika kvalitete proizvoda od mlijeka.

Ključne riječi: kvaliteta, fermentirani napici, mlijeko, mlijeko u prahu, regulativa

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