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Professional paper

CHANGES IN THE PHYSICO-CHEMICAL COMPOSITION OF MILK AS A RESULT OF THE DEGREE OF CONTAMINATION OF RAW MILK

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ABSTRACT

The quality of raw milk is determined by several factors, including physico-chemical parameters (fats, proteins, lactose, fat-free dry matter, specific gravity), even by the increase in the number of somatic cells (SCC) and the total number of colonies of bacteria (CFU). Somatic cells (SCC) are an important component found naturally in milk, they are excreted during milking and are used as an indicator of the hygienic correctness of milk. The object of analysis in this scientific paper was the changes that occur in the physico-chemical composition of raw milk as a result of the degree of contamination of raw milk. The analysis of the physico-chemical properties of raw milk was carried out in two dairies during one year. Examination of raw milk from dairies is done twice a month, while examination of stored milk is done daily. According to the obtained results, it can be observed that some chemical parameters in milk as a consequence of the degree of contamination show significant changes.
It should be mentioned here that in almost all the samples examined, we had a decrease in the level of lactose, which otherwise is the most stable parameter in milk and can only change due to the amount of water and not due to other parameters. In addition, the bacteria present in milk use lactose for their growth, so the increased number of microorganisms also affects the reduction of lactose.

Key words: physicochemical parameters, raw milk, somatic cells, quality.

INTRODUCTION

Milk contains several hundred different chemical components, of which more than 86 are completely different components (about 20 amino acids, 16 fatty acids, 3 types of carbohydrates, 25 types of minerals, 12 types of vitamins, and 10 types of enzymes). These substances affect the nutritional, physicochemical, and technological properties of milk. The composition of milk is quite variable, depending on many different factors. Different types of milk contain the same ingredients, but they have different proportions and ratios of the ingredients, and therefore their structure is different. A classification of the main components of milk is given in **Table 1.**

Table 1.: *Approximate chemical composition in milk (According to Walstra et al. 1999; Walstra et al., 2006)*

Components	Average Content in Milk (%)	Range [a] (%)	Average Content in Dry Matter (%)
Water	87,1	85.3−88,7	–
Solids-not-fat	8,9	7,9−10,0	–
Fat in dry matter	31	22−38	–

Lactose	4,6	3,8−5,3	36
Fat	4,0	2,5−5,5	31
Protein [b]	3,3	2,3−4,4	25
casein	2.6	1.7−3.5	20
Mineral substances	0,7	0,57−0,83	5,4
Organic acids	0,17	0,12−0,21	1,3
Miscellaneous	0,15	–	1,2

Note: Typical for milk of lowland breeds.
[a] These values will rarely be exceeded, e.g., in 1 to 2% of samples of separate milkings of healthy individual cows, excluding colostrum and milk drawn shortly before parturition.
[b] Nonprotein nitrogen compounds not included.

The chemical composition of milk differs from the chemical composition of other liquids of animal origin, which gives this product a high biological and technological value. It is different, depending on the type and breed of pets. However, these changes occur even for the same members of the same race, which are caused by food, age, disease, and other factors. For this reason, milk control is imperative, both for economic and practical purposes.

The chemical composition of cow's milk is very complex and variable. Fresh milk does not always have the same composition and the amount produced varies depending on the breed. The amount of milk produced, the specific components and their composition are not constant and change under the influence of various factors, which are as follows:

- genetic factors (type, breed and individual characteristics of the animal)
- physiological state of the animal (health state of the animal, stage and order of lactation, characteristics of the mammary gland),
- environment (method and type of feeding, activity and number of daily milkings, season, altitude, ambient temperature, hygiene, maintenance, etc.).

MATERIAL AND METHODS

Examination of the physico-chemical composition of raw milk

Sampling for examination of physico-chemical properties of raw milk from individual milk producers was carried out by dairies according to the *Regulation on requirements for the quality of raw milk, standards for the quality of milk for consumption, milk products and the use of their names, the quality and activity of starter cultures, fresh cheese and other specific substances and the way of their use, the way of supplementary labeling of milk and milk products as well as the permissible weight deviation in relation to the declaration* ("Gazette Official of the Republic of Macedonia" No. 96 /2011).

Examination of the chemical-physical composition of raw milk was analyzed in dairy laboratories. Samples are taken from individual milk producers in sterile plastic bottles in quantities of 60 ml and transported to the laboratory in the dairy. The examination has been realized by random selection. The analysis of the physico-chemical properties of raw milk from dairy is done twice a month, while the examination of raw milk from collected milk is done daily. The examinations were carried out according to the standard MKC ISO 9622 IDF 141C:2013 milk – determination of fat content, lactose, proteins, total dry matter, specific weight, etc.

depending on the needs. Analyzes of the chemical-physical composition of milk were performed with the **Lactoscan** instrument. With this instrument, the chemical-physical compositions of all types of milk (cow, sheep, goat), cream and ice cream mixtures are analyzed. Fats, proteins, lactose, total dry matter etc. are determined. The device works according to the principle of ultrasound analysis of the sample, which is drawn from the vessels using a peristaltic pump installed in the device. After analysis, the sample is automatically returned to the waste container. After 90 seconds of measurement, a new measurement can be made by repeating the same procedure. After the measurement, the device is rinsed with special cleaning tools. The determination of the specific weight of milk is carried out with a **lactodensimeter**. The standard parameters of the examination are: fat, lactose, protein and dry matter, while additional parameters are: dry matter without fat and freezing point of milk.

RESULTS

Table 2., presents the average values of the samples analyzed from the two dairies during the period of one year. In samples of raw cow's milk were determined total bacterial colony count (CFU/ml) and somatic cell count (SCC/ml). Except this, were also examined chemical-physical parameters (fats, proteins, lactose, fat-free dry matter and specific gravity).

***Table 2**.: - Average values of raw milk during the examined period*

	fats (%)	**proteins (%)**	**lactose ((%)**	**FFDM(%)**	**spec. weight/cm^3**	**CFU/ml x 10^3**	**SCC/ml x 10^3**
x̄	3,96	2,86	4,34	7,96	1.02738	363,1	311,2
max.	4,0	3,14	4,56	6,99	1.02955	789,5	731,0
min.	3,80	2,18	3,77	8,6	1.02514	101,5	11,5
SD	0,07	0,27	0,23	0,44	0.00148	224,4	191,2
CV	2%	10%	5%	11%	0.144%	61%	61%

Table 3., presents the results of physicochemical analyses of raw milk samples during the examined period from both dairies in the Tetova region. In these samples were examined fat, protein, lactose, fat-free dry matter and specific gravity.

The average values for the physicochemical characteristics of raw milk from the examined samples are at an unsatisfactory level. That is, according to statistical data, the minimum percentage of milk fat is min.=3.80%, while the maximum percentage of milk fat is max.=4.0%. The lowest protein percentage is min.=2.18%, while the highest protein percentage is max.=3.14%. The minimum percentage of lactose in the examined samples is min.=3.77%, while the maximum percentage of lactose is max.=4.56%. The minimum percentage for fat-free dry matter is min.=6.99%, and the maximum percentage of fat-free dry matter is max.=8.6%. The specific gravity of milk is 1,028-1,034 g/cm^3 at a temperature of 20ºC. The specific gravity of the

examined raw milk ranged from min.=1.02514 to max.=1.02955. The arithmetic mean of fat in raw milk is on average $\bar{x}$=3.96, protein $\bar{x}$=2.86, lactose $\bar{x}$=4.34, fat-free dry matter is $\bar{x}$=7.96 and specific gravity is $\bar{x}$=1.02738 . At the same time, the standard deviation is at a low level, which indicates that there were no major changes in the concentration of these parameters throughout the year. The lowest standard deviation is observed for milk fat, which is SD=0.07, while the highest standard deviation is for specific gravity, which is SD=1.48. The coefficient of variation for milk fat is the lowest and is CV=2%, and for fat-free dry matter is the highest and is 11%.

Table 3: - *Tabular presentation of the physico-chemical composition of raw milk during the examined period*

Ingredients of milk	**min.**	**max.**	**$\bar{x}$**	**SD**	**CV**
fats (%)	3,80	4,0	3,96	0,07	2%
proteins (%)	2,18	3,14	2,86	0,27	10%
lactose (%)	3,77	4,56	4,34	0,23	5%
FFDM (%)	6,99	8,6	7,96	0,44	11%
spec. weight/cm^3	1,02514	1,02955	1,02738	0,00148	0,144%

DISCUSSION

The average values for the physicochemical parameters of raw milk from the examined samples are not at a satisfactory level. The arithmetic average value of fat in raw milk is on average $\bar{x}$=3.96, protein $\bar{x}$=2.86, lactose $\bar{x}$=4.34, fat-free dry matter is $\bar{x}$=7.96 and specific gravity was $\bar{x}$= 1.02738 g/cm^3. At the same time, the standard deviation is at a low level, which shows that there were no big changes in these parameters throughout the year. The lowest standard deviation is observed in milk fat, which is SD=0.07, while the highest deviation is for specific gravity, which is SD=1.48. The coefficient of variability in milk fat is lower and is CV=2%, while in fat-free dry matter it is the highest and is 11%. It is known that there are great changes in the chemical composition of milk. Factors affecting milk composition include breed, genetic variation within a breed, animal health, environment, management and feeding practices. Between and within breeds, milk fat varies more and lactose less (Woodford et al., 1986). Gaunt (1980) states that US cows tend to have lower milk fat percentages. This may be partly due to environmental factors, but there must be some genetic variation within a breed in different countries. Gaunt (1980) states that the repeatability from one lactation to another for the percentage of chemical components in milk is quite high, averaging 0.67. Muir (1996) states that milk contamination, namely an increase in the number of bacterial colonies (CFU/ml) above the permissible limit of 100.000 per milliliter of milk, together with an increased number of somatic cells results in a change in chemical composition and physicochemical properties of milk, which makes it unsuitable for human consumption.

It should be mentioned here that in almost all the examined samples we had a decrease in the level of lactose, which otherwise is the most stable parameter in milk and can change only due to the amount of water and not due to other parameters (UKEssays, 2018). Except this, the bacteria present in milk use it for their growth, so the increased number of microorganisms also affects the reduction of lactose.

CONCLUSION

The total number of somatic cells in milk is an indicator of its degree of contamination, on the other hand, the increase in the number of somatic cells has an impact on the physicochemical parameters in raw milk. Based on the results obtained from the examined samples of raw milk, we can conclude the following:

1. In our examinations that we have noticed, it appears that the percentage of proteins is lower than the average (2.86%). Proteins show marked variations during the examined period, except the autumn and winter seasons where the statistical significance is $p>0.05$.

2. In all the examined samples we had a decrease in the level of lactose. Lactose results throughout the year fluctuate from 3.77% to 4.56%. Throughout the examination period, there was also a significant statistical difference at the $p<0.05$ level, respectively, the lactose levels decreased with the increase in the number of somatic cells.

3. The examined samples show that in the raw cow's milk, the fat has not changed its values. Throughout the year they have been with values of 3.80 to 4.0, that is, the seasonal variations are very small.

4. The obtained results show that the fat-free dry matter throughout the examination has the highest percentage of 8.6%, and the lowest 6.99%. Compared to other physico-chemical parameters, fat-free dry matter has greater annual variations, reaching up to 11%.

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