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SENSORY EVALUATION AND RHEOLOGICAL BEHAVIOR OF YOGURTS PREPARED FROM GOAT MILK

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Abstract: Goat milk production is a dynamic and growing industry that is fundamental to the wellbeing of hundreds of millions of people worldwide and is an important part of the economy in many countries. The aim of the present paper is scientific development of new technologies for goat milk yogurt with improved sensory and rheological properties. Set-yoghurts produced from goat and cow milk were examined fresh and after cold storage for sensory quality and rheological properties, in accordance with the ISO (Official Methods of Analysis of AOAC International). Rheological investigations consisted of the determination of apparent viscosity and drawings of flow curves. In comparison to cow milk yoghurt, goat milk yoghurt had a better consistency, and was more acceptable sensorially. The apparent viscosity of goat milk yoghurt was more and its flow curve was characterized by a smaller hysteresis loop area than these of yoghurts from cow milk. The reported results on sensory evaluation and rheological behavoir of goat milk yoghurt could guide industry to develop new goat dairy products with improved quality.

Keywords: sensory attributes, rheology, goat milk, youghurt, health benefits.

INTRODUCTION

In recent years, the products based on goat milk have increased in use, those have valuable nutritional properties for humans, especially for children and the elderly (Innocente, N. et al, 2016). Features of the composition and properties of goat milk make the products, in some cases, an effective alternative to cow milk products. Therefore, an important social problem is providing the population with products based on goat milk (Saha, B.N.P., Vasiljevica, T. et al, 2016).

Currently, the theoretical and applied research is insufficient for an objective assessment of the effect of the constituent components of goat milk on the quality of products, which hinders the use of goat milk when creating new generation food products of high biological and nutritional value, including the functional area (Yangilar, F., 2013; Popovici C., Tita M., 2018).

Therefore, in this study was made not only theoretical analysis on the composition and effects of goat milk on the quality of products, but also a series of experimental analysis based on goat milk. The purpose of this study was the development of goat milk yogurt, as it is the most balanced product. It is easily digested and has a high health value. The study determined the chemical composition of goat milk, the physicochemical, organoleptic and rheological quality parameters of the obtained goat milk yogurt samples.

MATERIALS AND METHODS

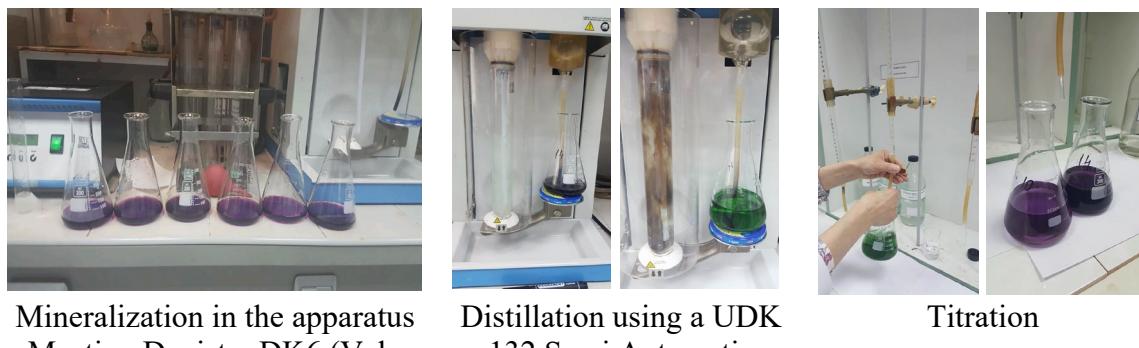
Fat content

This analysis method was performed in accordance with ISO 2446: 2008. Concentrated sulfuric acid was used as the main reagent, which converts insoluble calcium salts of milk into soluble sulfuric acid casein compound. The latter dramatically reduces the amount of adsorption

of fat globules and thereby contributes to their merger. The butyrometer was mounted on a stand and 10 ml of H₂SO₄ was poured. Slightly tilting the device, acid was carefully poured over its wall to 11 ml of a well-mixed product (20 ° C). To avoid mixing the product with H₂SO₄, 1 ml of isoamyl alcohol was added. Butyrometer was taken by the neck and, holding the cork, shaken several times until a homogeneous mass without flakes was obtained in the tube. After that, the butyrometer was placed (holding the stopper down) for 5 minutes in a water bath at 65-70 ° C. Then, the fat released on the butyrometer was counted on a scale.

Protein content

This analysis method was performed in accordance with ISO 8968-1: 2014. The method included 3 main stages: mineralization, distillation and titration (Fig. 1).



Mineralization in the apparatus
Meating Degister DK6 (Velp
scientifica)

Distillation using a UDK
132 Semi Automatic
Distillation Unit

Titration

Fig. 1. The determination stages of protein content in the studied samples

The method included the quantitative determination of nitrogen in the samples under study. The nitrogen contained in the test samples was heated with concentrated sulfuric acid in the presence of catalysts and transferred to ammonium sulphate, the sample itself was completely destroyed. Ammonia was squeezed out of ammonium sulphate with concentrated base, which was distilled into a receiver with a certain volume of titrated acid. Measuring the amount of acid remaining in the receiver after the end of the distillation, the amount of ammonia in the sample was calculated and, therefore, the amount of fixed nitrogen in the sample under study. Calculations are made according to the formula:

$$WN = \frac{1,4007 (Vs - Vb) Mr}{m}, [\%]$$

where, W_N - the mass fraction of nitrogen in the sample, [%],
 Vs - the volume of hydrochloric acid (accurate to 0.05 ml) [ml],
 Vb - the volume of hydrochloric acid (with an accuracy of 0.05 ml), [ml],
 Mr - the molecular weight of hydrochloric acid,
 m - the mass of the test portion (with an accuracy of 0.1 mg), [mg]
 1.4007 - coefficient of calculation for the expression of the nitrogen content in the sample, [%].

Lactose content

The lactose content of the tested samples was determined in accordance with the standard method ISO 22662: 2007, which provides high performance liquid chromatography (HPLC) with refractometric detection.



Fig. 2. System HPLC
Agilent 1100

the tanks: the upper one consisting of milk fat; the middle phase is clear; and sediment - casein. For the determination of lactose, a clear aqueous phase was taken.

The determination method: 10 ml of a clear sample obtained after centrifugation was measured. This sample was filtered through a 0.45 µm membrane. Through a cartridge for filtering C18 was loaded with 10 ml of ethanol and 10 ml of distilled water. Then the sample was passed through a C18 cartridge. After each filtration, the cartridge was washed with 10 ml of ethanol, and then with 10 ml of distilled water. Then 1 ml of a standard solution of lactose, previously prepared at a concentration of 2.4%, was measured and injected into the injection device. When the device lever was moved 90 °, the quaternary pump sucked 10 µl of the solution and switched it into the acetonitrile phase. Further, the separation of water and lactose occurred depending on the retention time. The refractometric detector determined the value of the peak areas of water and lactose, then the information was transferred to the software database. The analysis time was 12 minutes. Therefore, 1 ml of the sample was taken for analysis (clear phase after centrifuging the milk) and subjected to qualitative and quantitative analysis in the same way as the standard solution.

Free fatty acid content

The fatty acid composition was determined on a Hewlett-Packard chromatograph (model 5890, Palo Alto, CA, USA), with a flame ionization detector (FID) and connected to a ChemStation computer (Hewlett-Packard, Palo Alto, CA, USA). This method allows you to set the mass fraction of fatty acids to their total content in triglycerides. The essence of the method consists in the conversion of triglycerides of fatty acids into methyl esters of fatty acids and gas chromatographic analysis of the latter. The separation of fatty acids was carried out depending on the chain length and the degree of their unsaturation, by analogy with their closest standards. The mass fraction of each acid was calculated on the basis of the obtained chromatogram over the areas of the peaks using a standard graph.

Total mineral content

The method of determination is based on the mineralization of the sample of the product at a temperature of $(825 \pm 25)^\circ\text{C}$ and the calculation of the mass fraction of mineral compounds. Two empty crucibles were calcined for 60 minutes in a muffle furnace at a temperature of $(825 \pm 25)^\circ\text{C}$. Then they were placed in a desiccator, cooled to room temperature, and the mass of the crucible was measured. Samples weighing (20.0 ± 0.2) g each were placed in the prepared crucibles and weighed. The crucibles with the contents were kept on an electric stove in a fume hood until the sample was completely charred, avoiding ignition. Then the crucibles were placed in a muffle furnace and kept for 60 minutes at a temperature of $(825 \pm 25)^\circ\text{C}$ until carbon was completely combusted and white ash appeared. Then the crucibles were placed in a desiccator and cooled to room temperature. The cooled crucibles were weighed. The sample was again placed in a muffle furnace and the ashing was repeated, cooled and weighed until the difference in two

Preparation of reagents: using a graded cylinder, 850 ml of acetonitrile were taken and transferred to a 1 liter volume flask, to which 150 ml of water was added, then degassed with helium. The chromatography column of Zorbax SAX NH₂ was splashed with 50 ml of ethanol before passing an 85/15 mixture of acetonitrile/water. The initial flow rate was 0.1 ml / min, then gradually increased to 1.5 ml / min. The control cell of the refractometric detector was washed twice with eluent, left for 15 min to set the background line. The refractometer was set to zero.

Sample preparation: the sample was poured into a 50 ml graded cylinder, then transferred to 2 centrifugation containers of 25 ml and placed in diametrically opposite positions in the centrifuge cells. Centrifugation was carried out for 15 minutes at 8000 rpm. After centrifugation, 3 separate phases were formed in

consecutive weighings was no more than 1.0 mg. The arithmetic average of the last two weighings was taken for the final result of the determination. The mass fraction of ash W1 (%), was calculated by the formula:

$$W_1 = \frac{m_1 - m_2}{m_0} \cdot 100 \quad , [\%]$$

where, m_0 - weight, [g],
 m_1 - mass of crucible with ash, [g],
 m_2 - mass of empty prepared crucible, [g].

Rheological behavoir

Evaluation of the rheological properties of the studied yogurt samples was carried out using a digital BROOKFIELD rheometer model DV-III + (Fig. 3).



Fig. 3. Digital rheometer
BROOKFIELD, model DV-III +

This device allows you to get the most complete description of the structural and rheological properties. The rheological properties were determined in freshly prepared samples and during storage in the speed range 25 - 250. Since the samples structure reached the most stable state in 15-20 hours, studies were performed on the 2nd day after the product was manufactured in the range of shear rates (Dr) from 3 s^{-1} to 1.32 s^{-1} at a temperature of 20°C before and after mechanical appliance.

Sensory evaluation

The organoleptic evaluation includes several samples of yoghurt. A tasting commission consisting of 12 tasters was set up for analysis. Each participant of the tasting was presented with a specially designed tasting sheet, samples of the yoghurts in plastic disposable cups and mineral water.



Fig. 4. Sensory evaluation

Based on the described organoleptic characteristics in the normative-technical documentation for yoghurt, it can be said that in appearance and consistency, yogurt should be a homogeneous mass, moderately viscous, with the addition of thickeners or stabilizing additives, the consistency is gel-like or creamy. The presence insoluble particles characteristic for samples components is allowed. The smell and taste should be clean, sour-milk, without foreign tastes and smells, moderately sweet taste, with the corresponding

taste and aroma of the introduced components. The color should be milky-white or due to the color of the introduced components, homogeneous or interspersed with insoluble particles. Based on the data received from the tasting commission, the assessments were determined for each estimated quality indicator of the yogurt samples studied.

Statistical analysis

Variance analysis of the results was carried out by least square method with application of Microsoft Office Excel program. Differences were considered statistically significant if probability was greater than 95% ($q < 5\%$). All assays were performed at room temperature, $20 \pm 1^\circ\text{C}$. Experimental results are represented according to standard rules.

Results and discussion

Chemical composition of goat milk

In this work, a comparative analysis of the content of fat, protein, lactose, and ash of the goat milk under study was carried out. Table 1 presents the experimental data on the chemical composition of goat milk.

Table 1. The chemical composition of goat milk, g / 100g

No	Name of the component	Content, g
1.	Protein content, g	3.35±0.01
2.	Fat content, g	1.5±0.02
3.	Lactose content, g	4.52±0.01
4.	Ash content, g	0.8±0.01

The lactose content of raw goat milk was determined in accordance with the standard method ISO 22662: 2007, which provides high performance liquid chromatography (HPLC) with refractometric detection. Sample chromatographies of a standard lactose solution, are presented in Fig. 5, 6.

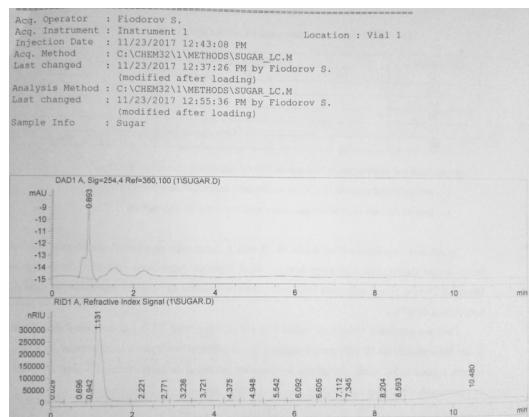


Fig. 5. Lactose determination in the standard solution

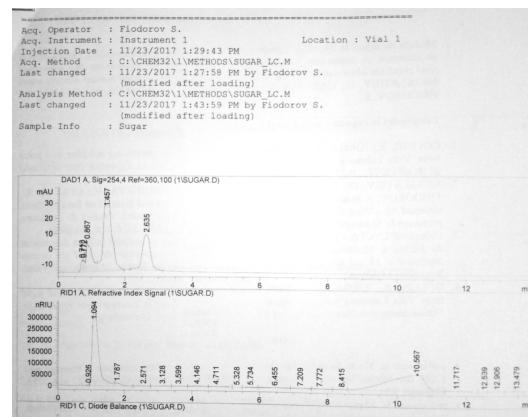


Fig. 6. Lactose determination in the goat milk sample

Goat milk was examined according to the fatty acids content, using the method of gas-liquid chromatography, fig. 7

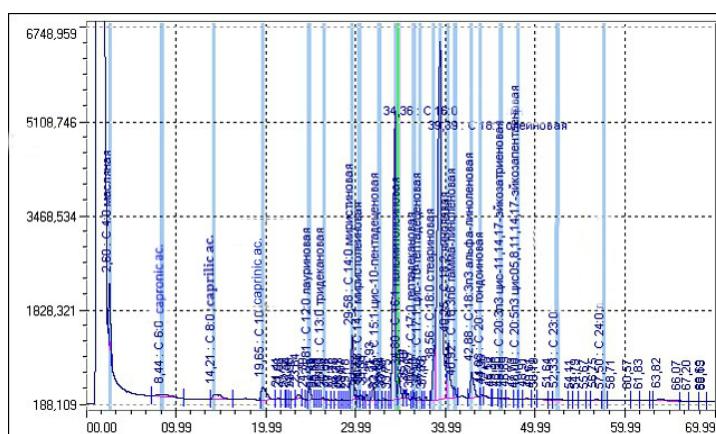


Fig. 7. Goat milk sample chromatography

Development of recipes and technologies for producing yogurt from goat milk

Goat milk, according to its chemical composition is more valuable, in comparison with cow milk. The proteins and fats of goat milk due to the structure of the molecules of these substances

are easily absorbed in the human body. Also a particular interest are the hypoallergenic and biological properties of goat milk. The technology of goat milk products requires serious theoretical and practical study. High-tech food products based on goat milk, cheeses, yogurts and other protein products can provide a rational, complete and healthy diet for the population.

As a result of the enzymatic activity of probiotic microorganisms of the starter, the protein and carbohydrate component of goat milk is modified, which facilitates the easy absorption of goat yogurt by the body. Goat yogurt is a source of calcium and phosphorus, contains valuable animal protein, a number of vitamins (B2 and B12) and mineral compounds (copper, potassium, magnesium, selenium). The microorganisms that make up the starter culture contribute to the normalization of intestinal microflora and prevent the rotting processes development of intestinal contents. Adding fruit and flavorings to yogurt enriches the nutritional and biological value of this product. In the study, based on goat milk, formulations and corresponding samples of yogurt were developed (Fig. 8): cow milk yogurt (control sample), goat milk yogurt, goat milk yogurt with cherry, goat milk yogurt with vanillin, goat milk yogurt with black currant, goat milk yogurt with black currant and vanilla, goat milk yogurt with sugar and vanilla.



Fig. 8. Test samples of goat milk yoghurt

The studied yogurt samples were examined in terms of organoleptic characteristics and rheological properties.

Rheological behavior

The introduction of additional components into the samples is accompanied by a change in such rheological characteristics as effective viscosity and superficial tension. The degree of change of these indicators depends on the quantity of input components and the shear coefficient of the product. The results of studies of the rheological characteristics of compared samples of yoghurt are shown in Figures 9,10.

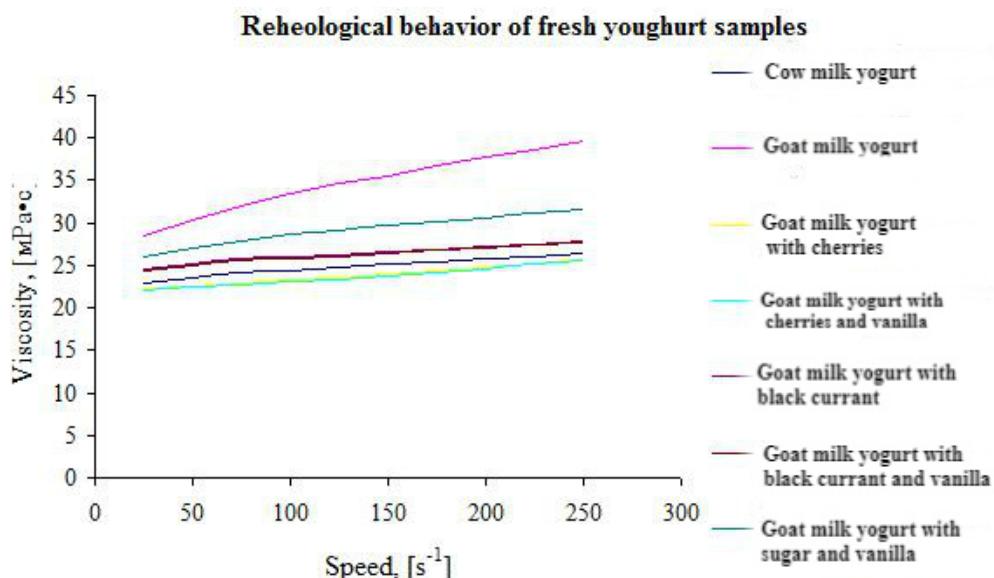


Fig. 9. Rheological properties of fresh yogurt samples

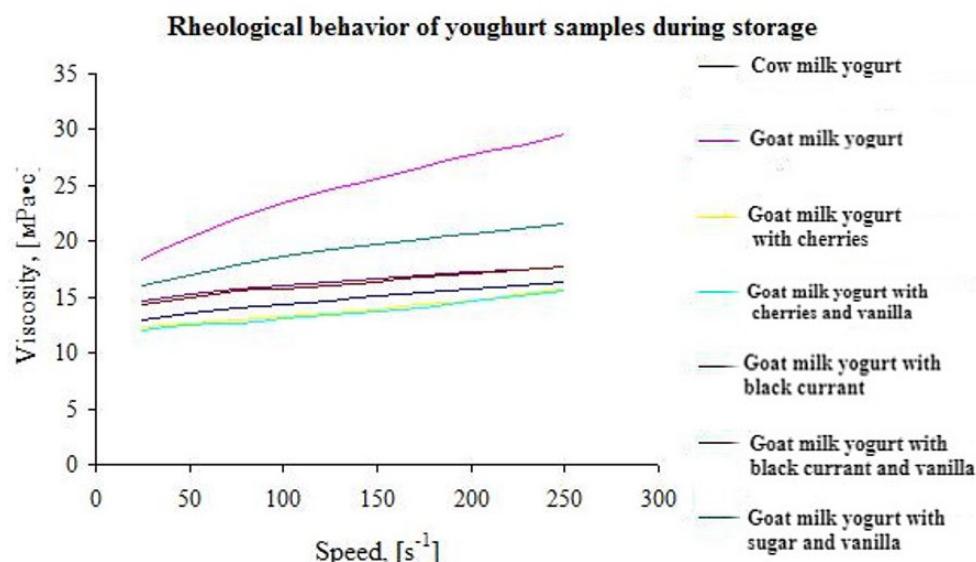


Fig. 10. Rheological properties of yogurt samples during storage.

As can be seen from the experimental results, the degree of viscosity change depends on the speed of rotation and the number of input components. Better maintains rheological properties with increasing speed sample of goat milk yoghurt with the addition of vanilla and fruits. With an increase in yogurt of berry components, the viscosity of yoghurt decreases. It should be noted that the rheograms of the studied yoghurts are close to each other. Thus, with an increase in the rotational speed, the viscosity of the compared samples of yoghurt increases as well to a certain limit, remaining further constant regardless of the change in velocity.

Sensory evaluation

In the study was analyzed organoleptic quality parameters of yogurt samples. A tasting commission was created consisting of 12 tasters. To each participant was presented a specially designed tasting sheet, samples of the yoghurts in plastic disposable cups and mineral water. According to the received data, the final organoleptic sample spectrums were made, which are presented in fig. 11.

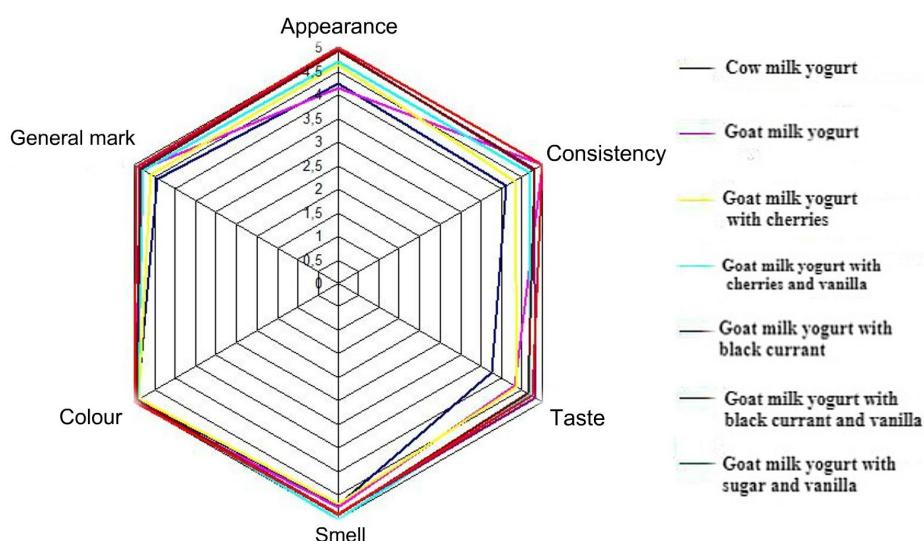


Fig. 11. Organoleptic evaluation of yogurt samples

According to Fig. 11 it can be concluded that goat milk yogurt with sugar and vanilla received the highest score. Almost all members of the commission gave their preference to this

type of yogurt, describing it as the most delicious yogurt. In samples numbered 1 and 2 was noticed a sour taste, according to the commission and scored fewer points. As for the samples of yoghurt numbered 3 and 5, the commission also gave them their preference, but to a lesser extent in comparison with the first sample. For yogurt samples with number 4 and 6, the opinion of the participant commission was divided. Most of the commission expressed its opinion in favor of the fact that these samples of yoghurt have a good consistency, moderately sweet, and for other participants noticed a pronounced taste of vanilla.

CONCLUSIONS

The chemical composition of the goat milk samples was determined, namely, the protein content is 3.35 g / 100 g, the fat content is 1.5 g / 100 g, the lactose content is 4.52 g / 100 g, and the ash is 0.8 g / 100 g. The fatty acid composition of goat milk was studied using gas-liquid chromatography. Experimental data showed the content of 23 fatty acids, represented by saturated, monounsaturated and polyunsaturated fatty acids. Technology process of goat milk yogurts with the berries and other food components have been developed. The rheological properties of yogurt from fresh samples were also studied during storage. The organoleptic properties of the yogurt samples obtained were assessed, which showed that goat milk yogurt with added sugar and vanillin, as well as berries, had the most pleasant taste properties.

ACKNOWLEDGEMENTS

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REFERENCES

- Caleja, C., Barros, L., Antonio, A.L., Carocho, M., Oliveira, M.B.P.P., Ferreira, I.C.F.R. (2016). *Fortification of yogurts with different antioxidant preservatives: A comparative study between natural and synthetic additives*. Food Chemistry, Vol. 210, 262-268.
- Innocente, N., Biasutti, M., Rita, F., Brichese, R., Comi, G., Iacumin, L. (2016). *Effect of indigenous Lactobacillus rhamnosus isolated from bovine milk on microbiological characteristics and aromatic profile of traditional yogurt*. LWT-Food Science and Technology, Vol. 66, 158-164.
- ISO 2446:2008 (IDF 226:2008). *Milk - Determination of fat content*.
- ISO 8968-1:2014 (IDF 20-1:2014). *Milk and milk products - Determination of nitrogen content*.
- ISO 22662:2007 (IDF 198:2007). *Milk and milk products - Determination of lactose content by high-performance liquid chromatography*.
- Popovici, C., Tîta, A.M. (2018). *Goat milk yoghurt with high biological properties*. Proceedings of the 4th International Conference - New Trends on Sensing-Monitoring-Telediagnosis for Life Sciences, 30 August-1 September 2018, Transilvania University of Brasov, Romania, 83.
- Saha, B.N.P., Vasiljevica,, T., McKechnieb S., Donkor, O.N. (2016). *Physicochemical, textural and rheological properties of probiotic yogurt fortified with fibre-rich pineapple peel powder during refrigerated storage*. LWT - Food Science and Technology, Vol. 65, 978-986.
- Yangilar, F. (2013). *As a Potentially Functional Food: Goats' Milk and Products*. Journal of Food and Nutrition Research, Vol. 1 (4), 68-81.