Bulgarian Journal of Agricultural Science, 24 (No 1) 2018, 132–144
Agricultural Academy

A COMPARATIVE ANALYSIS OF PHYSICO-CHEMICAL INDICATORS AND SENSORY CHARACTERISTICS OF YOGURT WITH ADDED HONEY AND BEE POLLEN

ZLATIN ZLATEV*; IRA TANEVA; STANKA BAYCHEVA; MITKO PETEV
Trakia University, Faculty of Technics and Technologies, BG-8602, Yambol, Bulgaria

Abstract

Zlatev, Z., I. Taneva, S. Baycheva and M. Petev, 2018. A comparative analysis of physico-chemical indicators and sensory characteristics of yogurt with added honey and bee pollen. *Bulg. J. Agric. Sci.*, 24 (1): 132–144

The research presents the main physico-chemical characteristics of the analyzed yogurt with or without the addition of honey and bee pollen. An analysis is made of the possibility to predict the organoleptic indicators of yogurts with and without supplements honey and bee pollen using basic physical and chemical indicators. From the comparative analysis between the created yogurts and those distributed commercially is established that the use of honey up to 5% and pollen up to 0.4% improved organoleptic and physico-chemical properties of the final product. The results of these analyzes are confirmed by data found in the literature.

Key words: yoghurt; functional foods; correspondence analysis; sensory evaluation

Introduction

The functional foods are among the new trends in the science of healthy nutrition. In recent years, the group of functional foods as products with a specific beneficial effect on human health, there is a growing share in the food industry. Worldwide production of functional food accounts for about 10% of total food production. The concept of positive (healthy, functional) feed set the beginning in the early 1980s in Japan, where is gained great popularity of the so called functional products.

The European association for Food Safety (EFSA) defines two types of health claims in relation to the supply of functional foods – Increased physiological function and reduction in the risk of disease.

The production of functional foods in Bulgaria are carried out in accordance with the Law on Food of 1999 and Regulation №47/2004 of the Bulgarian Ministry of Health, the requirements for the food additives and the forms that can be used.

There are very close in meaning definitions of the term functional food offered by various research teams. The Institute of Medicine's Food and Nutrition Board defines functional foods as "Any food or food ingredient that may provide a health benefit beyond the traditional nutrients which it contains."

To avoid abuse by manufacturers and retailers with the quality of functional foods, the Council of Ministers of the European Union (EU) adopted a regulation on nutrition and health claims on foods. This regulation deal with all questions about functional foods, their advertising and providing to the attention of consumers.

The researchers (Lomova et al., 2014) define three main qualities that must have functional products:

- Pleasant taste;
- Positive physiological effect on the human body;
- To have nutritional value.

The known literature and research data regarding functional foods and their beneficial impact on various aspects of human health can be summarized in two main directions:

- Effect on various physiological processes and metabolism in the human body;
- Influence on the balance of the microflora in the gastrointestinal tract.

**Corresponding author:* zlatin.zlatev@trakia-uni.bg

For centuries the milk and milk products are used as dietary, prophylactic and therapeutic food. They represent a major part of the so-called "functional foods". By biotech processing not only of carbohydrates, but protein in cow's milk and the addition of plant carbohydrates, fiber, etc., can be obtained functional foods included in the diet shortens the recovery period in severely ill.

The above described is reason to propose the creation of new functional milk-based products (yoghurt) containing bioactive supplements.

Lately conducted increasing number of research on the production of Bulgarian yoghurt with various additives. The aim is to improve the organoleptic and medicinal properties of milk (Mladenov et al., 2015).

The *purpose* of this article is to make a comparative analysis of the sensory characteristics of functional dairy products (yoghurt) with the addition of bee products.

The paper is organized in the following order: A review was made of some research on functional foods yoghurt with apiculture products. Indicated are the material and methods used in the study. Presented are the results for physico-chemical and organoleptic indicators of the the studied products. The data are processed and was made a comparative analysis of the results with those known from the literature.

Related work

The study and application of natural raw materials, their optimal qualitative and quantitative combination are essential for the development of functional products. There are different technological methods for the preparation of yoghurt with the addition of honey and bee pollen.

Functional yoghurt with added honey

Varga L. (Varga, 2006) demonstrate that the addition of honey in yoghurt, in an amount of 1 to 5% does not affect the viability of the bacteria *Streptococcus Thermophilus* and *Lactobacillus.* The amount of honey has no influence on the sensory characteristics, the active acidity and final products in lactic acid fermentation and during storage of the milk for six weeks.

Sert D. et al (Sert et al., 2011) tracked the effects of sunflower honey on physico-chemical, microbiological and sensory characteristics of yoghurt during storage in refrigeration conditions. The water activity decreases according to the addition of honey with a higher concentration at the time of storage (4°C). At the end of fermentation, the pH values of the yoghurt range from 4.33 (no honey) and 4.52 (adding honey up to 6%). The addition of honey in the the yoghurt, affects the viability of starter cultures during fermentation and during storage of samples of yoghurt.

Rashid A. and Er.Thakur (Rashid et al., 2012) after research and analysis concluded that Lactobacillus bulgaricus and *Streptococcus Thermophilus* retain their viability, with the addition of honey in yoghurt in quantities of 5, 10, 15 and 20%. Of all the samples yoghurt that obtained with the addition of 5% honey was evaluated with the highest organoleptic and sensory indicators.

Similar analyzes were made by Bakr I. et al. (Bakr et al., 2015). The authors show that addition of 5% honey of fennel in yoghurt, improve the physico-chemical parameters of the product, increasing its sensory and organoleptic evaluation.

It has been found that high amounts of bee products in milk (honey, royal jelly and bee pollen), influence on other vital activity of lactic acid bacteria. The amount of more than 5% honey slows the vital activity of *Lactobacillus bulgaricus* in yoghurt, after the third day of storage. High amounts of bee pollen over 0.1% inhibitory act on the vital activity of *Streptococcus Thermophilus* (Lomova et al., 2014). Decreased consumption of polyunsaturated fatty acids of the omega-3 series leads to increased incidence of various diseases in humans. These fatty acids are highly susceptible to oxidation and their incorporation into foodstuffs such as yoghurt requires the addition of antioxidants.

Murage W. et al. (Murage et al., 2016) showed that honey and ascorbic acid are good natural antioxidants that prevent lipid oxidation of omega-3 fatty acids added to yoghurt.

The bee pollen and other bee products are gaining more attention as a feed additive due to its high content of carbohydrates (30-50%), proteins, amino acids (25-30%) and lipids (1-20%).

Functional yoghurt with added bee pollen

Khider M. et al. (Khider et al., 2013) investigated bee pollen derived from a variety of plant sources such as corn, clover (*Trifolium alexandrinum*), and date palm (*Phoenix dactylifera*). They proved that bee pollen supplements in milk, reduce fermentation time, increase the content of polysaccharides enhance the growth of the starter culture. The resulting yoghurt with added bee pollen from corn improves texture, reducing syneresis and has a pleasant taste and aroma, while pollen from clover and date palm give the milk sweet taste. Highs and evaluation of aroma and flavor is found in yogurt with added 1% bee pollen.

Lomova N., et al. (Lomova et al., 2014) showed that moisture and particle size of bee pollen influence technological and organoleptic properties of the yoghurt. A good parameters are obtained when the moisture of the bee pollen is of 2 to 4% and a particle size up to 10 μm. It also showed that bee pollen irradiated in advance with bactericidal lamps before adding it to milk reduces the risk of contamination of the product with unwanted microflora.

The enrichment of the fermented milk beverages with bee pollen change the course of the fermentation process, the number of viable bacteria and rheological properties of the products. The addition of 5-7.5 mg/L in milk has better acceptability by consumers (Yerlikaya , 2014).

From the review of the investigated research related to the creation of the yoghurt with added honey and bee pollen can be concluded that:

- In order to improve the physico-chemical and organoleptic parameters of products can be a comparative analysis of the yoghurt distributed commercially and that obtained with the addition of honey and bee pollen;
- In the reviewed publications in analysis of taste evaluations of the yoghurt with added honey and bee pollen, the following methods of analysis: Analysis of variance; Principal component analysis; Partial least squares regression; Generalized Procrustes analysis; Tucker analysis; Parallel factor analysis; a Hierarchical cluster analysis, and combinations of these methods;
- In an analysis of the sensory data have been used Correspondence analysis, through which data from the tasting evaluation shall be presented in a new feature space and analyzed the proximity of the samples to the appropriate organoleptic indicator.
- In processing the results of a taste evaluation, can be used the method of "Partial least squares regression". The method is suitable for predicting the organoleptic performance through data on physicochemical parameters of the test product as pH, titratable acidity, dry matter content, water content (Mladenov et al., 2015).
- There are no known studies relating to the creation of the yoghurt with added bee products from Bulgarian sources. This is a prerequisite to do research on the impact of the addition of such products in yoghurt and their impact on the physico-chemical and organoleptic parameters. The results of these analyzes can be compared with those of other foreign studies found in the literature and indicate guidelines for their application in practice.

Material and Methods

Dairy products used in the study

For the purposes of the study used fresh milk purchased commercially. By dairy analyzer "Milk Analizer Master" with serial number 19161, are determined its physico-chemical indicators. The results of this analysis are shown in Table 1.

The functional dairy products (yoghurt) are produced by classical technology for Bulgarian yogurt (BNS 12:2010) (BNS, 2010).

Table 1
Physico-chemical indicators of milk

Indicator	Fresh cow's milk
Temperature, °C	30.48
Fat content, %	3.60
Non-fat solids	8.90
Density	1.03
Protein	3.20
Salt content, %	0.70
Water content, %	0.00
Freezing Point, °C	0.56

For the purposes of the study have been used bee products – honey (corresponding to BNS 2673-89) and bee pollen from Bulgarian producer (Decree №9, 2005 (Decree, 2005), purchased commercially.

It is used freeze-dried starter culture of a manufacturer from Bulgaria (Lactina, 2016) containing local strains of lactic acid bacteria from the group of *Streptococcus thermophilus* and *Lactobacillus delbrueckii ssp. Bulgaricus*.

For purposes of the analysis were purchased eight yogurts from Bulgarian producers that use technology according to BNS 12:2010. For these samples differences in terms of net weight as measurement and compared to the marking of packages vary to a minimum.

Determination of physico-chemical and organoleptic properties of dairy products

Of functional dairy products and yoghurt commercially available are determined the following physico-chemical parameters:

- Titratable acidity – BNS 1111-80;
- Active acidity – by pH meter (Laboratory pH meter, 2017) (Laboratory pH meter MS 2006) equipped with an electrode (pH electrode Sensorex, Garden Grove, CA, USA);
- Dry matter, % (Dimitrov et al., 2012);
- Vitamin C, mg/100g – GOST 3062.2-98 (GOST,1998);
- Electric conductivity, $mS.cm^{-1}$ – by conductivity meter DM-750 (Conductivity meter, 2017);
- Organoleptic analysis – performed is of eight-grade scale. In the organoleptic analysis participate sensory panel of nine panelists who are not separated by gender and age. Designated organoleptic indicators are: Colour, Surface, Type of the coagulant, Sectional structure, Consistency after breaking, Taste and flavor, Aftertaste.

Statistical analysis

Data analysis was made by the following methods:

- Correspondence analysis (CA) (Kazlacheva, 2011). For realization of this method is used graphical user inter-

face a library in Matlab, developed by Lorenzo-Seva et al (Lorenzo-Seva et al., 2016);

➢ Partial least squares regression (PLSR) (Mladenov et al., 2015). The method is used to predict the sensory data by physico-chemical parameters according to BNS 12:2010;

➢ An indicator of the consistency of the tasting evaluations is the coefficient of variation (CV) (Kazlacheva, 2011; Mladenov et al., 2015).

Results and Discussion

Physico-chemical analysis of the products

A comparison was made between the physico-chemical and organoleptic parameters of the resulting functional yoghurts (with honey and pollen) with yoghurt from different manufacturers purchased commercially. The obtained results are given in Tables 2, 3 and 4.

From the results it is clear that yoghurt with added honey on physico-chemical parameters did not differ significantly from those purchased commercially.

In the yoghurts created with the addition of bee pollen is observed low levels of titratable acidity.

This is probably due to the inhibitory action of bee pollen on the vital activity of *Streptococcus Thermophilus* and *Lactobacillus bulgaricus*, and hence on the proper conduct of lactic acid fermentation. This is confirmed from the data found in the literature (Lomova et al., 2014; Maksimenkov et al., 2016).

Results from organoleptic evaluation of the investigated products

Organoleptic assessment is carried of purchased yoghurts, as well as those obtained with the addition of honey and pollen.

Table 2

Physico-chemical indicators of yogurt with added honey

Sample	Titratable acidity, °T	Active acidity, pH	Dry matter, %	Vitamin C, mg/100g	Electric conductivity, mS.cm^{-1}
Control	110.00	4.40	12.80	0.08	12.83
Sample with 5% honey	90.00	4.40	12.60	0.35	13.05
Sample with 10% honey	96.00	4.40	12.60	0.65	13.51
Sample with 15% honey	98.00	4.48	12.80	0.85	13.79

Table 3

Physico-chemical indicators of yogurt with added bee pollen

Sample	Titratable acidity, °T	Active acidity, pH	Dry matter, %	Vitamin C, mg/100g	Electric conductivity, mS.cm^{-1}
Control	60.00	4.44	12.60	0.10	12.07
Sample with 0.4% bee pollen	65.00	4.43	12.70	0.45	11.03
Sample with 0.6% bee pollen	60.00	4.39	12.85	0.60	12.49
Sample with 0.8% bee pollen	65.00	4.45	12.85	0.95	13.90
Sample with 0.4% bee pollen and Agar-agar	61.00	4.46	12.80	0.50	14.89

Table 4

Physico-chemical indicators of yogurt purchased commercially

Sample	Titratable acidity, °T	Active acidity, pH	Dry matter, %	Electric conductivity, mS.cm^{-1}
№ 1	102.00	4.18	12.82	6.19
№ 2	86.00	4.50	12.40	5.91
№ 3	100.00	4.20	12.60	7.34
№ 4	101.00	4.12	12.60	6.25
№ 5	106.00	4.14	12.65	6.29
№ 6	113.00	4.14	12.80	7.26
№ 7	120.00	4.41	12.80	7.08
№ 8	122.00	4.10	12.80	6.29

Table 5 lists the statistical parameters of organoleptic data for yoghurt distributed commercially. It is seen that in sample 2 and sample 5 has a significant difference in the opinions of evaluators. Only in indicator colour for these two samples, the coefficient of variation is less than 30%.

Table 6 provides statistical parameters of organoleptic indicators of the yoghurt with different percentages of honey. Indicated are mode, average values, standard deviation and coefficient of variation. From the analysis of the obtained data it is established that a coefficient of variation of the opinions of tasters over 30% in a control sample with indicator “aftertaste” and yoghurt with added 15% honey in the indicator “surface”.

In Table 7 are inflicted statistical parameters of the organoleptic indicators of the yoghurt with different percentages of bee pollen. Indicated are mode, average values, standard deviation and coefficient of variation.

Table 5
Statistical parameters of organoleptic data for commercially available yoghurts

Sample	Parameter	Surface	Colour	Type of the coagulant	Sectional structure	Consistency after breaking	Taste and flavor
№ 1	*Mean*	6.71	7.57	6.29	6.29	5.86	6.71
	SD	1.38	0.53	0.95	1.38	1.21	1.70
	CV	20.56	7.06	15.13	21.96	20.74	25.38
	mode	7.00	8.00	7.00	7.00	7.00	8.00
№ 2	*Mean*	4.71	6.29	3.29	3.14	2.57	4.14
	SD	1.98	1.25	1.98	1.35	1.40	2.34
	CV	41.92	19.94	60.14	42.80	54.34	56.49
	mode	4.00	7.00	2.00	4.00	3.00	1.00
№ 3	*Mean*	8.00	8.00	7.71	7.86	7.14	6.86
	SD	0.00	0.00	0.49	0.38	1.21	1.21
	CV	0.00	0.00	6.33	4.81	17.01	17.72
	mode	8.00	8.00	8.00	8.00	8.00	8.00
№ 4	*Mean*	6.71	7.00	6.43	6.00	5.71	6.57
	SD	1.98	1.29	1.62	1.91	1.80	0.79
	CV	29.43	18.44	25.17	31.91	31.49	11.97
	mode	8.00	8.00	7.00	6.00	7.00	7.00
№ 5	*Mean*	5.71	7.02	6.67	7.33	5.88	7.14
	SD	1.38	1.00	1.25	0.75	1.07	0.90
	CV	24.15	14.26	18.69	10.18	18.27	12.60
	mode	7.00	7.00	7.00	8.00	6.00	8.00
№ 6	*Mean*	4.53	7.00	5.67	5.35	4.53	5.37
	SD	1.12	1.00	2.13	1.97	1.50	2.43
	CV	24.74	14.29	37.63	36.89	33.16	45.24
	mode	4.00	7.00	7.00	6.00	5.00	8.00
№ 7	*Mean*	6.18	7.16	7.16	7.33	7.82	7.47
	SD	1.07	0.37	0.69	0.75	0.38	0.77
	CV	17.27	5.20	9.59	10.18	4.81	10.29
	mode	5.00	7.00	7.00	8.00	8.00	8.00
№ 8	*Mean*	7.47	7.84	7.82	7.49	7.00	7.16
	SD	0.51	0.37	0.38	0.50	0.82	0.37
	CV	6.79	4.76	4.81	6.68	11.66	5.20
	mode	7.00	8.00	8.00	7.00	7.00	7.00

mean – average value; mode – mode of the data; SD – standard deviation; CV – coefficient of variation, %

From the analysis of the obtained data it is established that a coefficient of variation of the opinions of tasters below 30% is only the control sample in all of the indicators.

By the indicator "colour" is the sample with 0.8% bee pollen which has a coefficient of variation in the opinions of tasters below 30%.

Table 6
Statistical parameters of organoleptic data of yoghurts with honey

Sample	Parameter	Colour	Surface	Type of the coagulant	Sectional structure	Consistency after breaking	Taste and flavor	Aftertaste
Control	mode	9.00	9.00	6.00	6.00	8.00	7.00	1.00
	mean	9.00	9.00	5.33	6.33	7.67	7.33	3.33
	SD	0.00	0.00	1.15	1.53	0.58	2.08	4.04
	CV	0.00	0.00	0.22	0.24	0.08	0.28	1.21
5% honey	mode	9.00	9.00	9.00	7.00	7.00	5.00	5.00
	mean	9.00	8.33	9.00	7.33	7.00	5.33	5.33
	SD	0.00	1.15	0.00	0.58	0.00	1.53	0.58
	CV	0.00	0.14	0.00	0.08	0.00	0.29	0.11
10% honey	mode	9.00	8.00	7.00	8.00	7.00	8.00	9.00
	mean	8.67	8.33	7.67	7.67	7.33	7.67	8.33
	SD	0.58	0.58	1.15	0.58	0.58	0.58	1.15
	CV	0.07	0.07	0.15	0.08	0.08	0.08	0.14
15% honey	mode	9.00	9.00	8.00	9.00	7.00	9.00	8.00
	mean	9.00	7.33	8.00	8.67	7.33	9.00	8.33
	SD	0.00	2.89	1.00	0.58	1.53	0.00	0.58
	CV	0.00	0.39	0.13	0.07	0.21	0.00	0.07

mean – average value; mode – mode of the data; SD – standard deviation; CV – coefficient of variation, %

By indicator "type of coagulant" samples with 0.8% bee pollen and 0.4% with agar are up to 30% coefficient of variation.

By the indicator "Consistency after breaking" the samples with 0.4% bee pollen and this with agar-agar have coefficient of variation up to 30% in the opinions of tasters.

By the indicator "taste and flavor" samples with 0.8% bee pollen and 0.4% of agar are up to 30% coefficient of variation.

Data from an organoleptic evaluation of the yoghurt commercially available by method "Correspondence analysis"

The results of the data analysis are presented in Figure 1. The graphs show the strength of relationships between the samples of analyzed yoghurt and various organoleptic indicators based on Correspondence analysis. The closer the indicator is designated to a particular sample, the stronger is the relationship between them.

Conversely, the more apart from each other is an indicator from the sample, the weaker is this indicator in particular sample. The closer to the origin of the coordinate system are given metric and the sample, the more frequently they occur in the study.

Table 7
Statistical parameters of organoleptic data of yoghurts with bee pollen

Sample	Parameter	Surface	Colour	Type of the coagulant	Sectional structure	Consistency after breaking	Taste and flavor
Control	mode	8.00	8.00	7.00	7.00	7.00	8.00
	mean	6.83	7.50	7.00	7.00	5.83	7.67
	SD	1.33	1.22	0.89	0.89	2.48	0.52
	CV	0.19	0.16	0.13	0.13	0.43	0.07
0.4% BP	mode	8.00	7.00	6.00	5.00	5.00	7.00
	mean	6.00	5.50	5.33	5.67	5.50	6.33
	SD	2.53	2.43	1.75	1.75	1.64	2.25
	CV	0.42	0.44	0.33	0.31	0.30	0.36
0.6% BP	mode	4.00	6.00	7.00	7.00	7.00	7.00
	mean	5.50	5.00	6.00	6.00	5.67	6.33
	SD	2.51	1.67	1.79	1.79	2.16	2.25
	CV	0.46	0.33	0.30	0.30	0.38	0.36
0.8% BP	mode	4.00	5.00	4.00	4.00	6.00	4.00
	mean	5.00	4.83	5.17	5.00	4.83	5.50
	SD	1.79	1.33	1.17	1.55	1.72	1.38
	CV	0.36	0.27	0.23	0.31	0.36	0.25
0.4% BP and AA	mode	6.00	6.00	5.00	5.00	4.00	4.00
	mean	5.17	5.50	4.83	4.67	4.67	5.50
	SD	2.04	2.17	1.17	1.63	1.37	1.52
	CV	0.40	0.39	0.24	0.35	0.29	0.28

mean – average value; mode – mode of the data; SD – standard deviation; CV – coefficient of variation, %, BP – bee pollen; AA – Agar-agar

By the analysis is established that the second and sixth sample differ in all its organoleptic properties of the other samples. The remaining samples with indicators grouped around origin of the coordinates, indicating that they have the same values of the indicators.

Using statistical parameter mode – the value that occurs most in those from tasters estimates. The results show that sample 2 is diverted by the organoleptic characteristics of the other samples.

Data from an organoleptic evaluation of the yoghurt with added honey by method "Correspondence analysis"

Figure 2 presents the results of the data analysis by method „Correspondence analysis". Using average value of the data is found that the control sample differs significantly by organoleptic indicators of the remaining samples, which is incorporated in different percentage amount of honey. By the graph is also observed that all the samples differ significantly in indicator "aftertaste".

Mode of data from organoleptic evaluation, as in the use of the average value, and here the control sample also differ on characteristics of the other samples. In the same way differences can be observed in indicator "aftertaste".

Data from an organoleptic evaluation of the yoghurt with added bee pollen by method "Correspondence analysis"

Figure 3 presents the results of the data analysis by method "Correspondence analysis". Using average values of the data from organoleptic evaluation, the control and the sample with 0.6% of supplement differ in indicators from the other samples. By the indicator "colour" there are significant differences between the samples analyzed.

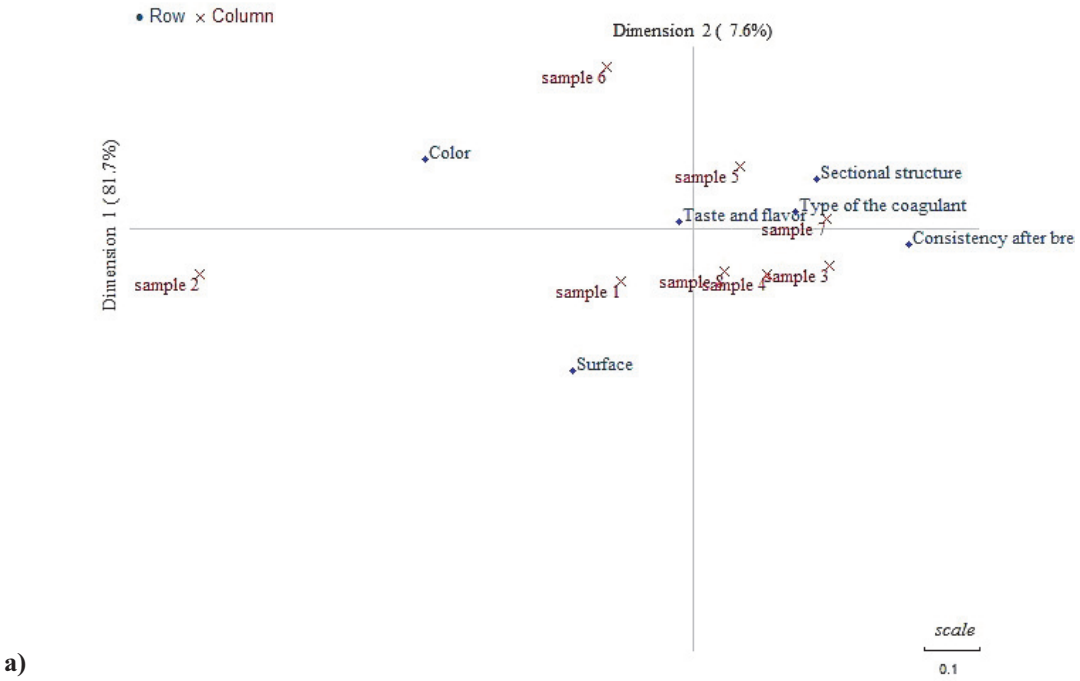
Using the mode of the data is observed grouping of the samples around individual indicators. The control sample and that of 0.4% addition of bee pollen and 0.4% and agar are the best indicators "surface" and "colour". The sample with 0.6% supplement is of best indicators "taste and flavor", "type of the coagulant" and "Consistency after breaking". With good "Consistency after breaking " is a the sample of 0.8% addition of bee pollen.

Prediction of the organoleptic characteristics of yoghurt by physico-chemical indicators

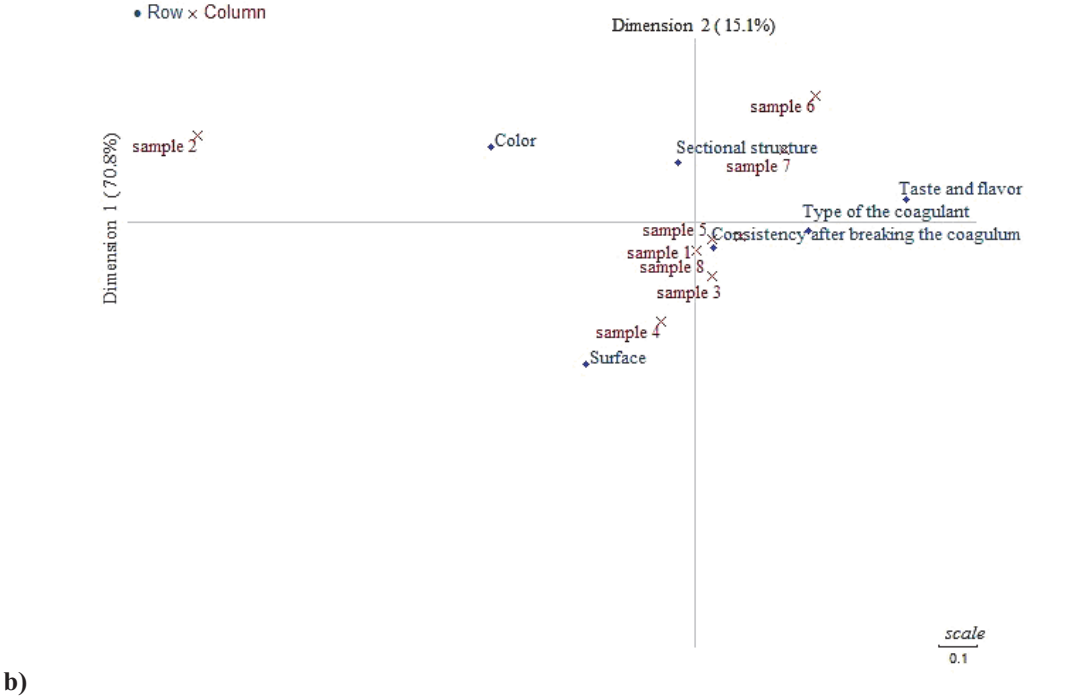
Figure 4 shows the predictive models, as determined by the method „Partial least squares regression" (PLSR) using 7 principal components. The PLSR method is used to predict the quality indicators according to BNS 12:2010 set by the tasters using measurements titratable acidity, active acidity and electric conductivity.

By processing the data obtained the required number of principal components that are sufficient to describe the data in order to predict as the criterion was adopted regression coefficient R^2, and determined the smallest number of components after which this ratio remains at a constant value. The data presented can be described with 4 to 6 main components. Discussed are only those indicators where the regression coefficient is more than 0.65. For the remainder, this coefficient has values $R^2 = 0.31\text{-}0.47$ and they are not taken into account. The results of this analysis are presented in Table 8.

The table shows that the organoleptic indicator „Consistency after breaking" can be predicted up to 71% using average values of physico-chemical indicators: electrical conductivity, acidity active and titratable acidity. The organoleptic indicator "Surface" can be predicted with an accuracy of 0.79%, using physical indicator electrical conductivity of the yogurt.

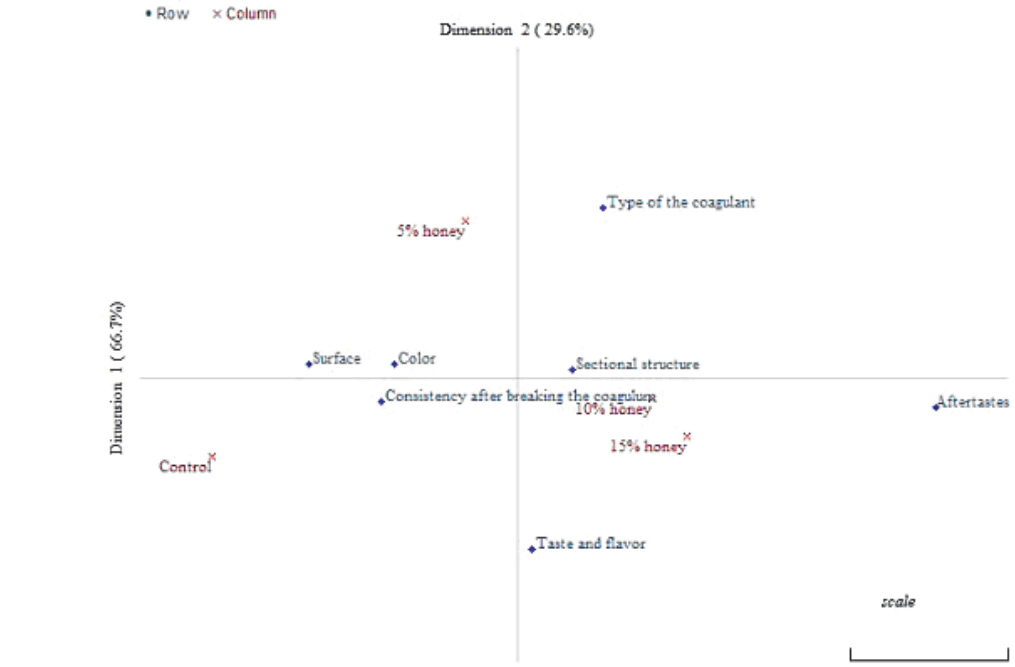


a)

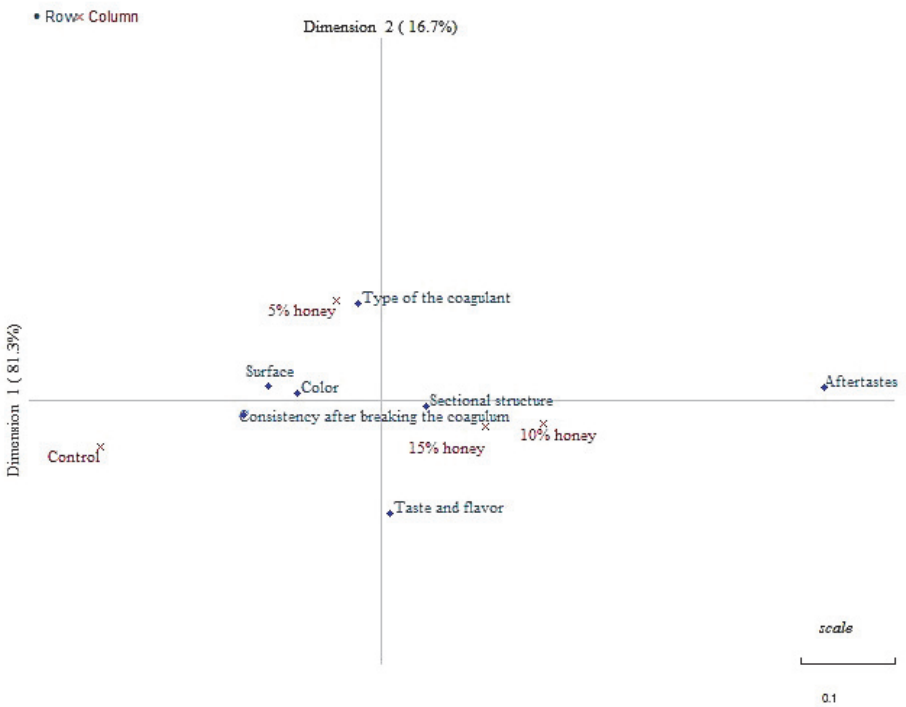


b)

Fig. 1. Results of Data processing of organoleptic data by method "Correspondence Analysis" for commercially available yoghurts;
a) By mean value of the organoleptic data; b) By mode of the organoleptic data

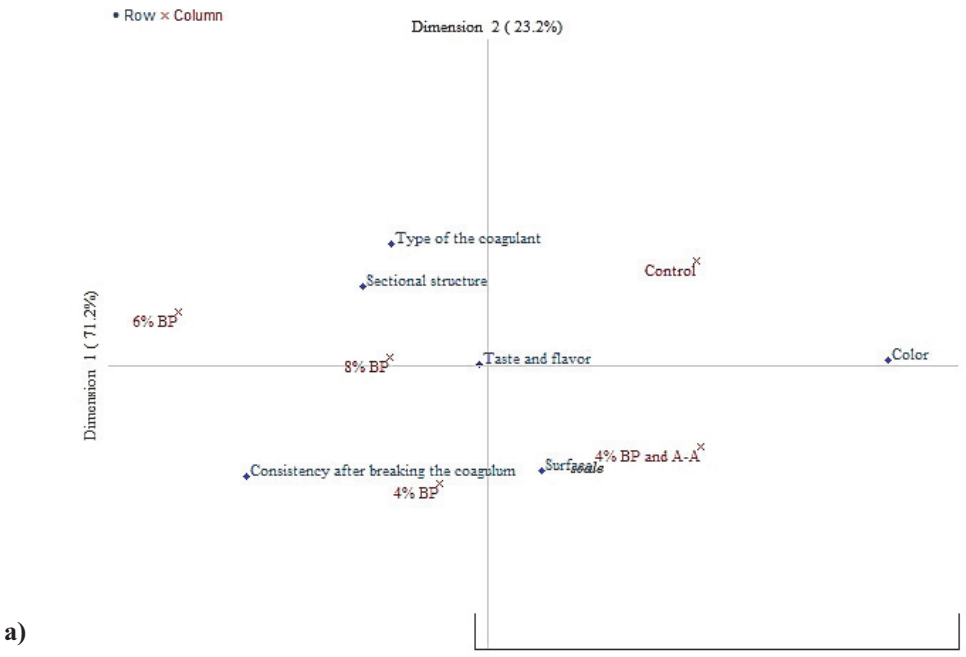


a)

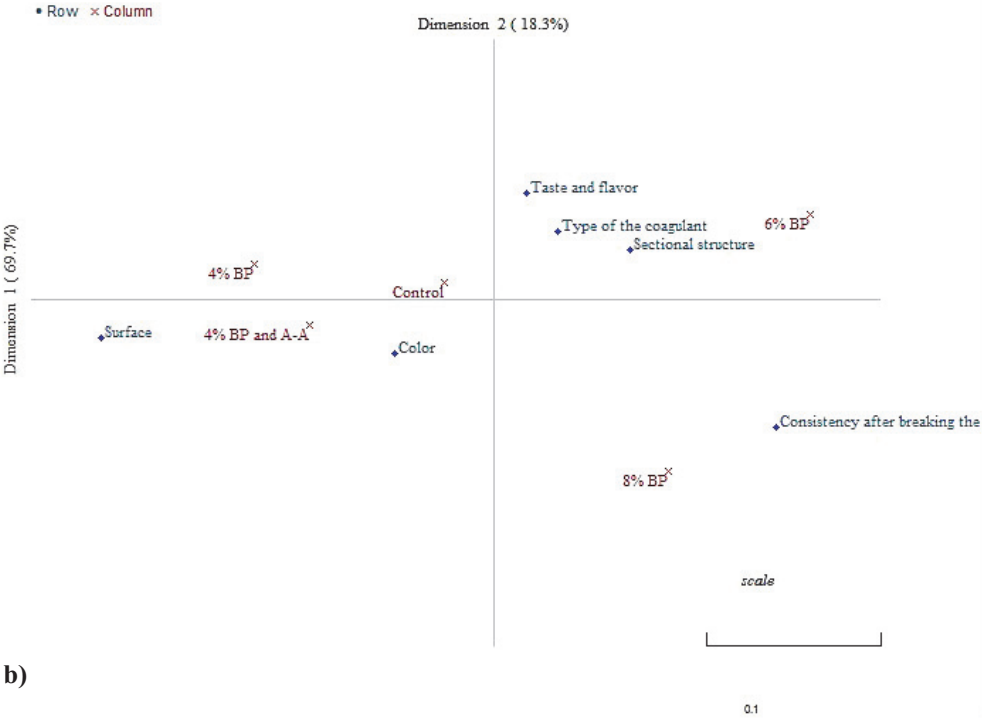


b)

Fig. 2. Results of Data processing of organoleptic data of yoghurts with honey by the method "Correspondence Analysis"; a) By mean value of the organoleptic data; b) By mode of the organoleptic data



a)



b)

Fig. 3. Results of Data processing of organoleptic data of yoghurts with bee pollen by the method "Correspondence Analysis";
a) By mean value of the organoleptic data; b) By mode of the organoleptic data

Fig. 4. Prediction of sensory data by PLS method;
a) Consistency depending on the titratable acidity; b) Taste and flavor depending on the pH

Table 8
Prediction of organoleptic indicators of commercially available yoghurts

Organoleptic indicator R^2		Electrical conductivity			Active acidity			Titratable acidity		
		SSE	RMSE	R^2	SSE	RMSE	R^2	SSE	RMSE	
Colour	*mean*	0.02	0.11	0.11	0.31	0.10	0.19	0.36	0.08	0.20
	mode	0.01	0.02	0.21	0.29	0.07	0.06	0.42	0.04	0.05
Surface	*mean*	0.79	0.03	0.21	0.69	0.09	0.28	0.41	0.12	0.22
	mode	0.45	0.14	0.16	0.11	0.13	0.17	0.22	0.11	0.22
Type of the coagulant	*mean*	0.11	0.07	0.19	0.11	0.14	0.28	0.12	0.13	0.26
	mode	0.11	0.12	0.22	0.53	0.08	0.22	0.52	0.14	0.15
Sectional structure	*mean*	0.68	0.02	0.05	0.54	0.13	0.21	0.43	0.06	0.22
	mode	0.56	0.07	0.17	0.51	0.10	0.14	0.40	0.08	0.08
Consistency after breaking	*mean*	0.79	0.14	0.21	0.78	0.05	0.13	0.71	0.10	0.19
	mode	0.67	0.33	0.45	0.67	0.24	0.28	0.81	0.20	0.29
Taste and flavor	*mean*	0.31	0.21	0.27	0.50	0.21	0.28	0.51	0.18	0.31
	mode	0.29	0.15	0.22	0.44	0.17	0.36	0.64	0.23	0.33

Prediction of the organoleptic characteristics of yoghurt with honey on physico-chemical indicators

The results of the evaluation of the the ability to predict the organoleptic indicators by physico-chemical parameters of yoghurt with added honey are presented in Table 9. The table shows that the indicator "Surface" can be predicted with 81% accuracy in electrical conductivity using an average value of the organoleptic data. By titratable acidity can be predicted "Type of the coagulant" with 80-96% accuracy using average and fashion data organoleptic evaluation for this indicator. By electrical conductivity with 91-98% accuracy, and pH with accuracy of 78% can be predicted "Sectional structure" using both average and mode of the data. The organoleptic indicator "Consistency after breaking" can be predicted by pH with 94% accuracy using mode of the data, while by the titratable acidity this indicator can be predicted with accuracy 84-95% depending on whether it is used mode or average of the data. "Taste and flavor" can not be predicted with accuracy 80-94% on electrical conductivity and active acidity using average and mode of organoleptic data.

Prediction of the organoleptic characteristics of yoghurt with bee pollen on physico-chemical indicators

Table 10 presents the results of the examination of the the possibility to predict the organoleptic indicators by physico-chemical parameters of yoghurt with added bee pollen. It is used the method PLSR. The organoleptic indicator "Consistency after breaking" can be predicted with 70% accuracy by titratable acidity, but with high levels of SSR = 22.63. The "consistency after breaking" can be predicted with accuracy of 72% on average of the organoleptic data using electrical conductivity. This physico-chemical parameter can be used to predict the "taste and flavor" with an accuracy of 75% with a small error values.

Table 9
Prediction the organoleptic indicators of yoghurts with honey

Organoleptic indicator R^2		Electrical conductivity			Active acidity			Titratable acidity		
		SSE	RMSE	R^2	SSE	RMSE	R^2	SSE	RMSE	
Colour	*mean*	0.11	0.05	0.17	0.19	0.00	0.02	0.04	8.00	2.00
	mode	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Surface	*mean*	0.81	0.09	0.21	0.63	0.01	0.02	0.22	36.73	4.29
	mode	0.11	0.05	0.17	0.19	0.01	0.02	0.04	8.00	2.00
Type of the co-agulant	*mean*	0.21	0.09	0.22	0.66	0.01	0.02	0.96	7.22	1.90
	mode	0.08	0.04	0.14	0.38	0.01	0.02	0.80	34.12	4.13
Sectional struc-ture	mean	0.91	0.05	0.15	0.78	0.01	0.02	0.29	43.21	4.65
	mode	0.98	0.01	0.07	0.78	0.01	0.02	0.21	35.4	4.21
Consistency after breaking	*mean*	0.05	0.03	0.11	0.43	0.01	0.02	0.95	9.64	2.20
	mode	0.51	0.14	0.27	0.94	0.01	0.01	0.84	28.97	3.81
Taste and flavor	*mean*	0.49	0.14	0.27	0.05	0.00	0.01	0.16	28.50	3.78
	mode	0.58	0.14	0.26	0.11	0.01	0.01	0.10	18.77	3.06

Table 10
Prediction of organoleptic indicators of yoghurts with bee pollen

Organoleptic indicator R^2		Electrical conductivity			Active acidity			Titratable acidity		
		SSE	RMSE	R^2	SSE	RMSE	R^2	SSE	RMSE	
Surface	*mean*	0.50	2.33	0.88	0.02	0.00	0.01	0.11	10.47	1.87
	mode	0.29	1.92	0.80	0.08	0.00	0.01	0.00	0.00	0.00
Colour	*mean*	0.10	0.87	0.54	0.04	0.00	0.01	0.22	18.35	2.47
	mode	0.42	2.26	0.87	0.01	0.00	0.01	0.14	12.82	2.07
Type of the co-agulant	*mean*	0.28	1.88	0.79	0.14	0.00	0.01	0.32	23.16	2.78
	mode	0.44	2.29	0.87	0.46	0.00	0.02	0.42	26.2	2.96
Sectional struc-ture	*mean*	0.49	2.33	0.88	0.19	0.00	0.01	0.21	17.79	2.44
	mode	0.17	1.33	0.67	0.40	0.00	0.02	0.70	22.63	2.75
Consistency after breaking	*mean*	0.72	1.87	0.79	0.45	0.00	0.02	0.14	12.60	2.05
	mode	0.18	1.37	0.68	0.37	0.00	0.02	0.13	11.84	1.99
Taste and flavor	*mean*	0.44	2.30	0.87	0.08	0.00	0.01	0.22	18.18	2.46
	mode	0.75	1.72	0.76	0.35	0.00	0.01	0.13	12.17	2.014

Comparative analysis of results of evaluation of the yoghurt and milk products with honey and bee pollen

In Table 11 are listed in summary form the results of the study of organoleptic indicators of the yoghurt commercially available and yoghurt with added bee pollen and honey. In the analysis of the results for yoghurt distributed commercially is found that samples 2 and 6 differ in indicators than other yoghurts and they are not taken into account. The six yoghurts commercially available correspond in organoleptic and physico-chemical parameters of the standard BNS 12:2010.

The addition of 5% honey results in an improvement of the organoleptic characteristics of the the resulting milk product compared to a standard yogurt. The higher honey content reduces the quality of the the resulting final product as influencing the structure and its appearance. which is unacceptable to consumers.

Similar results were obtained from (Varga, 2006; Rashid et al., 2012; Bakr et al., 2015) indicating that the content of the honey up to 5% preserves the physicochemical and improves the organoleptic characteristics of the resultant functional product from yoghurt. Significant differences in the assessments of the tasters have at milks with 10 and 15% addition of honey. This is is confirmed by the literature data on the organoleptic assessment (Khider et al., 2013).

Addition of bee pollen 0.4% resulting finished product maintains good organoleptic properties. A higher percentage of bee pollen deteriorates them significantly. The obtained results are comparable to those indicated by (Lomova et al., 2014; Yerlikaya, 2014) indicate that the percentage of bee

Table 11
Comparative Analysis of results from data processing of organoleptic evaluation of yoghurts

Type of the yoghurt Evaluation criterion	Commercially available yoghurt	Yoghurt with added honey	Yoghurt with added bee pollen
Coefficient of variation (CV)	There is a difference of opinion between the tasters at samples 2 and 6	Differences in opinion of the tasters was observed in control and products with the addition of 10% and 15% honey	In the control sample, there was no difference of opinion between the tasters significant differences in opinion about yoghurt with added bee pollen at Surface and Colour
Correspondence analysis (CA)	Sample 2 is characterized by poor organoleptic indicators compared to other samples	The control sample differs in indicators than the samples with the addition of honey	Samples with 0.6% and 0.8% bee pollen have worst organoleptic indicators
Prediction of organoleptic indicators	Next indicators can be predicted: Surface, Sectional structure, Consistency after breaking	Can be predicted: Surface, Type of the coagulant, Sectional structure, Consistency after breaking	Can be predicted: Consistency after breaking, Taste and flavor

pollen 0.1-0.4% improved physico-chemical and organoleptic characteristics of the final product.

By using the coefficient of variation in the milk purchased commercially and those obtained with the addition of honey and bee pollen at small differences of opinion of the tasters was observed in control samples.

With weak organoleptic indicators are milks obtained with the addition of 0.6 and 0.8% bee pollen. This is influence on organoleptic assessment of tasters proven through Correspondence analysis confirmed by (Yerlikaya, 2014).

The results of the cited authors are confirmed by the assessment of the ability to predict the organoleptic indicators by physico-chemical properties of the products examined, which revealed the influence of titratable, active acidity and electrical conductivity on the organoleptic properties of yogurt.

Conclusions

- The research presents the main characteristics of the resulting functional products – yoghurts with added bee products – honey and bee pollen.
- Presented are reference laboratory studies on physico-chemical parameters of the obtained products.
- An assessment is made of the ability to predict the physico-chemical and organoleptic indicators of the functional products.
- From the comparative analysis of the resulting functional products yoghurts produced by BNS 12:2010 and distributed commercially is established that the use of honey up to 5% and pollen up to 0.4% improves the organoleptic and physico-chemical properties of products.
- The results confirm those of other known studies as complement the results for yoghurt produced with Bulgarian bee products and technology in accordance with BNS.

Acknowledgements

Partially exposed materials are research results on the project 6.OUP/ 25.04.2017, "Construction of a laboratory for photogrammetric and remote measurement methods".

References

Bakr, I., T. Mohamed, A. Tammam and F. Gazzar, 2015. Characteristics of bioyoghurt fortified with fennel honey. *International Journal of Current Microbiology and Applied Sciences*, **4** (3): 959-970.

BNS 12:2010 "Bulgarian Yogurt". http://www.bds-bg.org/en (Accessed 15 December 2016)

Conductivity meter DM-750, 2017. http://www.technosens.net/pro04.html (Accessed 12 January 2017)

Decree No.9, 2015. Decree No.9, from 22.06.2005 on the terms and conditions for approval and registration of Processing and wax production of wax bases, and businesses production and marketing of honey and bee products (Bg).

Dimitrov, T., G. Mihailova, P. Panayotov and M. Edgaryan, 2012. Milk and Milk Processing, ISBN 978-954-8835-57-2 (2012).

GOST 30627.2-98, 1998. Dairy products for baby food. Methods for determination of mass part of vitamin C (ascorbic acid) (Ru).

Kazlacheva, Z., 2011. Use of the correspondence analysis in fashion design. *Textile and Apparel*, **7**: 191-196 (Bg).

Khider, M., K. *Elbanna,* A. Mahmoud and A. Owayss, 2013. Egyptian honeybee pollen as antimicrobial, antioxidant agents and dietary food supplements. *Food Sci Biotechnol*, **22** (1): 1-9.

Laboratory pH meter MS2006, 2006. http://www.microsyst.net/ (Accessed 07 January 2017)

Lactina Starter Cultures, 2016. http://lactina-ltd.com/eng/products-zakvaski.php (Accessed 03 December 2016)

Lomova, N., S. Narizhnyi and O. Snizhko, 2014. Yoghurt enrichment with natural bee farming products. *Ukrainian Food Journal*, **3** (3): 415-421.

Lomova, N. and O. Snezhko, 2014. Effect on honey, royal jelly and pollen on biotechnological processes. *East-European Advanced Technology Magazine*, **2** (68): 62-65 (Ru).

Lorenzo-Seva, U., M. van de Velden and H. Kiers, 2016. Simple & multiple correspondence analysis. http://psico.fcep.urv.cat/utilitats/CorrespondenceAnalysis/index.html (Accessed 02 December 2016)

Maksimenkov, R. and B. Krupitzyn, 2016. Indicators of quality changes during storage of yoghurt with the addition of pollen and microbiological assessment. Articles of 67th Scientific Student Conference, Part V, *Voronezh State Agrarian University named of Emperor Peter I*, pp. 30-36 (Ru).

Mladenov, M., S. Penchev and M. Deyanov, 2015. Complex assessment of food products quality using analysis of visual images, spectrophotometric and hyperspectral characteristics. *International Journal of Engineering and Innovative Technology (IJEIT)*, **4** (12): 23-32.

Murage, W., B. Mbatia, E. Muge and M. Mwaniki, 2016. Antioxidative potential of honey and ascorbic acid in yoghurt fortified with Omega-3 fatty acids. *Journal of Microbiology, Biotechnology and Food Sciences*, **6** (1): 702-706, doi: 10.15414/jmbfs.2016.6.1.702-706.

Rashid, A. and E. Thakur, 2012. Studies on quality parameters of set yoghurt prepared by the addition of honey. *International Journal of Scientific and Research Publications*, **2** (9): 1-11.

Sert, D., N. Akin and E. Dertli, 2011. Effects of sunflower honey on the physicochemical, microbiological and sensory characteristics in set type yoghurt during refrigerated storage. *International Journal of Dairy Technology*, **64** (1): 99-107, doi: 10.1111/j.1471-0307.2010.00635.x

Varga, L., 2006. Effect of acacia Robinia pseudo-acacia L. honey on the characteristic microflora of yogurt during refrigerated storage. *International Journal of Food Microbiology*, **108**: 272-275.

Yerlikaya, O., 2014. Effect of bee pollen supplement on antimicrobial, chemical, rheological, sensorial properties and probiotic viability of fermented milk beverages. *Mljekarstvo*, **64** (4): 268-279, doi: 10.15567/mljekarstvo.2014.0406.

Received July, 3, 2017; accepted for printing January, 17, 2018