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Rheological and physical–chemical properties of yogurt with oat–chia seeds composites

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Abstract. Currently chia seeds (*Salvia hispanica L.*) are considered as a filler of functional food. However, ground chia seeds have a low viscosity and cohesion properties that are limited its applications. Based on previous data oat-chia seeds composites in different proportions as filler for yogurt have been tested. The investigation of water–holding capacity of samples allowed to select the yogurt with filler in the ratio of 1:1 (oat bran:chia seed) in the amount of 3% and 5% as the most close to the control sample without any filler. The rheological characteristics of yogurt samples were investigated and their thixotropic and viscoelastic properties were identified depending on the amount of filler in the product. The yogurt without any filler had the less thixotropic properties in compare with yogurt with oat-chia seeds composites. The structure recovery of yogurt with 3% and 5% filler was close to 100% and greater than 100% respectively. Based on the data of G' and G" moduli was possible to ascertain the yogurt with filler has more viscoelastic properties compared with yogurt without filler. Yogurt with 5% filler exceeds yogurt without filler in biological value according to the content of essential amino acids and polyunsaturated fatty acids.

Key words: yogurt; *Salvia hispanica L.*, oat–chia seeds composites, rheological properties, thixotropic properties, viscoelastic properties, water–holding capacity.

INTRODUCTION

Yogurt is one of the most popular fermented foods in many countries (Nakasaki et al., 2008). Yogurt is a cultured dairy product that is widely consumed as a healthful and nutritious food and for its sensory properties (Innocente et al., 2016). Yogurt is most commonly produced from cow's milk by slow lactic fermentation of milk lactose under controlled temperature. Starter microflora of yogurt consists of a symbiotic culture of the bacteria *Lactobacillus delbruikii ssp. bulgaricus* and *Streptococcus thermophilus* (Marshall, 1993).

The popularity of yogurt is due to its suitability for combination with various fillings, which provides wide taste properties of the final product. In addition, yogurts, like other milk–based drinks, are a convenient form for creating functional foods–by enrichment with specialized additives or microbiological synthesis in the product itself (Suchkova et al., 2014; Zabodalova et al., 2014). However, natural fillers effect on the consistency of yogurt, often causing syneresis during storage, so various structure stabilizers are widely used in yogurt production, especially stirred yogurt, to prevent syneresis (Kumar & Mishra, 2004). Polysaccharides are widely used for these purposes due to the ability to retain water and to form hydrogels (Gu et al., 2016). Polysaccharides can be used in dairy products to modify the rheological properties (Sanchez et al., 2000). Furthermore, polysaccharides of vegetable sources are becoming increasingly popular due to the increasing number of vegetarians (Karim & Bhat, 2008). Some polysaccharides from plants could serve as therapeutic agents, excipients, thickeners, stabilizers, emulsifiers, encapsulants, coating agents and texture modifiers due to their considerable availability, diverse functionality, non–cytotoxicity and ease of modification (Amal & Ahmad, 2014; Rohart & Michona, 2014; Pang et al., 2016).

Many authors consider chia seeds as raw material with high gelling properties. Chia seed (*Salvia hispanica L.*) polysaccharide is extracted from the chia seed coat Gu et al., 2016). The processed products of chia seed possess excellent water–holding capacity and good stabilizing properties, which are very important for the yogurt production (Segura–Campos et al., 2014). Besides chia seeds are important raw material for functional food due to its health promoting properties (Fernandez et al., 2008). Chia seeds contain of protein (15–25%), fats (30–33%), carbohydrates (26–41%), dietary fiber (18–30%), and ash (4–5%), also a high amount of vitamins, minerals, and antioxidants. However, there are some limitations in the use of chia seeds in food composition due to their small size and hard seed coat, high oil content and cohesiveness (Ixtaina et al., 2008). The research of authors demonstrated the ability to use chia seeds in combination with oat bran (Yakindra et al., 2015).

The oat–chia seeds composites could optimize the original oat bran quality by the nutritional value of chia seeds. Besides the nutritional aspects the oat–chia seeds composites could improve the water–holding capacity, viscoelastic properties of the individual components (oat bran and chia seeds). The physical and chemical properties of oat–chia seeds composites could be valuable for developing a new functional food having desirable texture and improved nutritional value for consumers health (Yakindra et al., 2015).

Thus, the purpose of this research was to explore the possibility of using the oat-chia seeds composites in the recipe of yogurt, in particular, to improve the physical-chemical and rheological properties of yogurt with filler.

MATERIALS AND METHODS

Preparation of oat–chia seeds composites

The oat–chia seeds composites were created by a feasible dry blending procedure. The chia seeds (*Salvia hispanica L.*) were supplied by 'Adowel Inversora S.A.', Eastern Republic of Uruguay. The jet–cooking oat bran (brand '*Mistral*', Russian Federation) was purchased in the trade network. The chia seeds and oat bran were separately ground by industrial grinder Bulava–1, Russian Federation (the specifications: the weight – 20 kg, the capacity–up to 90 kg h^{-1}; the dimensions of the receiving hole: 60×40 mm; the hopper capacity–up to 6 liters; the voltage–220 V; the power consumption–1,800 W; the rotor speed – 3,000 rpm; the dimensions: 550×350×1,000 mm. Ground oat bran and chia seeds were compiled in the following proportions of 1:0; 9:1; 4:1; 1:1; 0:1 and mixed by N–50 Hobart mixer (Canada) for 1 min. The oat–chia seeds composites were ground again by industrial grinder Bulava–1 for 40 s to obtain the desired outlet fractions size less than 1.0 mm.

Yogurt processing

Partially skimmed raw cow's milk (fat content 1.5 ± 0.5%) in an amount of three liters was submitted to heat treatment at 90 °C for 15 min, cooled to 40 °C and inoculated with 0.2 U per kg yogurt culture containing *Lactobacillus delbrueckii subsp. bulgaricus* and *Streptococcus thermophilus* (CBL–1, MARINO, Italy). The yogurt was produced with using the handicraft fermentation equipment (Milk & Cheese M & C100, Modena, Italy) at 41 °C for 4–5 h until a pH value of samples equal 4.24 ± 0.06 was reached (Tamine & Robinson, 2007). After that the yogurt was subsequently cooled to 4 ± 2 °C and used for preparing of the batch of samples. The experiment was included 11 samples: 1–yogurt without filler (control) and 10–yogurt with oat–chia seeds composites in different proportions. All samples were prepared in triplicate.

Preparation of yogurt with oat–chia seeds composites

The oat–chia composites (filler) in the five proportions of 1:0; 9:1; 4:1; 1:1; 0:1 in the amount of 3 and 5% were added in the yogurt to obtain the samples with the filler in the volume of 200 mL. First the samples were stirred manually, then using a Magnetic Stirrer (Ulab us–1550A) at 50 rpm, 20 °C for 10 min. Finally, the yogurt samples were packaged in a volume of 200 mL and stored at 5 ± 1 °C for 21 days. All samples were prepared in triplicate.

Study of organoleptic properties of yogurt with oat–chia seeds composites

The yogurt samples were evaluated by trained panel of 12 members. Twelve panelists (age 22–38 years) familiar with sensory evaluation techniques estimated the sensory properties of the yogurt samples.

Measurement of water–holding capacity of yogurt samples

The study of water–holding capacity of yogurt samples were evaluated using the SIGMA 4–16S at 1,590 × g for 10 min at 20 °C according to the method described by Nadtochii & Koryagina, 2014. This research was conducted as follows: 10 mL test sample was placed into the measuring tube and centrifuged for 30 min, noting the precipitated serum volume every 5 min by stop the centrifuge every 5 minutes and run the test on the same samples. The water–holding capacity of the samples was evaluated by determining the quantity of the separated serum (%) in the process of centrifugation, considering the fact, that the whole sample volume (10 mL) is 100%. Three samples were analyzed per each batch of yogurt.

Post– acidification analyses of yogurt samples

Post– acidification analyses of the yogurt samples were conducted on 0, 7, 14 and 21 days of storage. The pH of the yogurt samples was measured at 20 °C using the digital pH meter (pH 301, Hanna Instruments, Inc., RI, USA) and were carried out in triplicate.

Investigation of rheological properties of yogurt samples

The yogurts samples after being stirred were cooled to 10 °C, which corresponds to the storage temperature of yogurt before the delivery to the consumer. Then the samples of required volume were loaded to the rheometer (RN 4.1, RHEOTEST Medingen GmbH, Germany) with using of coaxial cylinders particularly 4 cm diameter parallel stainless cylinder 3.8 cm outer diameter (housing) and 3.5 cm inner diameter cylinder. All rheological measurements were carried out at 10 °C using circulation system within ± 0.1 °C. The steady shear viscosity of the yogurt samples was measured as a function of shear rates from 0.1 to 10 s^{-1} (in the forward direction). To assess the ability of yogurt to recover of the structure after mechanical impact the samples were left at rest for 15 minutes and then again they were subjected to mechanical stress rates from 10 to 0.1 s^{-1} (in reverse). The frequency sweep test was performed to obtain storage modulus (G') and loss modulus (G'') at frequencies ranging from 1 to 10 rad × s^{-1}. The strain of 0.5%, which was within the linear viscoelastic range, was used for the dynamic experiments. To find the numerical value of the yield point of the samples we used the most popular equations, such as Bingham's equation (Bingham, 1922); Caisson equation (Mills, 1959); Hershel–Bulkley equation (Hershel & Bulkley,1926). The yield point of yogurt was studied by following equations (1–3):

$$\text{Bingham: } \sigma = \sigma_\gamma + \eta_\rho \dot{\gamma} \tag{1}$$

$$\text{Caisson: } \sigma^{1/2} = \sigma_\gamma^{1/2} + (\eta_\rho \dot{\gamma})^{1/2} \tag{2}$$

$$\text{Hershel–Bulkley: } \sigma = \sigma_\gamma + K\dot{\gamma}^n \tag{3}$$

Investigation of biological value of yogurt samples

The biological value of the protein component was evaluated by the generally accepted method of calculation of the essential amino acids scores (FAO, 2007). Besides the indicators of biological value of protein component was investigated such as biological value of protein component (BV, %) and coefficient of differences of amino–acid scores (CDAAS, %) (Nadtochii et al., 2015). This indicator (in days) was calculated by the Eqs 4 and 6:

CDAAS shows the average differences of essential amino acids score (DAAS) as compared to the minimum level of an essential amino acid. The coefficient of differences of amino–acid scores (CDAAS, %) is calculated as follows:

$$CDAAS = \frac{\sum \Delta DAAS}{n} \tag{4}$$

DAAS – difference of amino–acid score of an essential amino acid and a minimum amino acid score was calculated by the Eq. 5, where *n* – amount of essential amino acids equal 9.

$$\Delta DAAS = Ci – Cmin \tag{5}$$

Ci – score of *i* – essential amino acid, %; *Cmin–minimum* amino–acid score, %.

$$BV = 100 – CDAAS, \% \tag{6}$$

The evaluation of the biological value of the lipid component was produced according to FAO, 2008.

Statistical analysis

All experiments were performed with at least three replicates. Data was processed by methods of mathematical statistics at theoretical frequency 0.95. Data was expressed as mean ± standard mean error.

RESULTS AND DISCUSSION

Organoleptic properties of yogurt with oat–chia seeds composites

The yogurt samples with fillers in particularly with oat bran and chia seeds in the proportions of 1:0; 9:1; 4:1; 1:1; 0:1 were investigated (Yakindra et al., 2015). The yogurt without fillers was used as a control sample. Percentage of filler (3 and 5%) was defined as the most commonly used in the formulation of products with different fillers (Nadtochii & Koryagina, 2014). Fig. 1 shows the changes in color and appearance of yogurt samples with different fillers.

The yogurt with filler based on oat bran (1:0) had cream color tone, pronounced odor and taste of oat bran. However, the consistency changes were observed during storage: oat bran settled down to the bottom of a container. Filler based on chia seed (0:1) provided the product gray–cream color tone and excessively gelled consistency, taste and odor of the seeds were neutral, and filler accumulated on the top part of the container during storage, showing a tendency of sample phase separation. The yogurt with fillers based on the priority of oat bran (9:1 and 4:1) showed mostly similar organoleptic properties to the samples with filler based on oat bran. Yogurt with filler based on the same amount of oat bran and chia seed (1:1) demonstrated the absence of exfoliation of consistency and most harmonious organoleptic properties in comparison with the other samples of yogurt with fillers. Moreover, the organoleptic properties of the yogurt samples were most pronounced at adding 5% filler compared with 3% of fillers. The control sample had a dense, homogeneous consistency, without separation of serum on the surface, and white color with cream shade, clean fermented flavor.

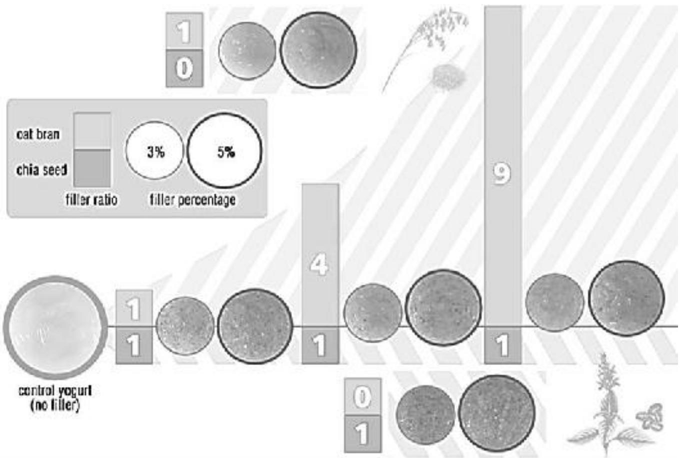

Figure 1. The organoleptic assessment of the yogurt samples with oat – chia composites.

Water–holding capacity of yogurt samples

The ability of the ingredients to retain moisture as the important property in the development of new types of food products, in particular yoghurt is evaluated (Tamime & Robinson, 1999; Lucey, 2002). Water–holding capacity of yogurt without any filler and with fillers in the amount of 3 and 5% are shown in Fig. 2. It should be noted, that the control sample showed more regular release of serum for 30 minutes due to the mechanical action (linear characteristic curves were noted). During the first 15 minutes of the mechanical action yogurt with the filler demonstrated more intensive separation of serum in comparison with the further exposure after 20–30 minutes of centrifugation.

Stirring duration in the production of yogurt with a filler is on average about 20 minutes, so the experiment results about 15–20 minutes of mechanical processing are the most important for technical applications. Fig. 2, a shows the water–holding capacity of yogurt with the addition of 3 and 5% filler on the basis of oat bran or chia seeds (1:0 and 0:1) in comparison with the control sample. The yogurt with chia seed possesses the highest water–holding capacity in compared to the control sample and the sample of yogurt with oat bran filler (Fig. 2, a). In addition, more amount of chia seed filler in yogurt demonstrate the higher level of the water–holding capacity. On the contrary the greater the amount of oat bran filler, the lower the water–holding capacity of the yogurt sample. Fig. 2, b demonstrates the more intensive serum separation of the yogurt sample with oat–chia seeds filler in the proportion of 9:1 and 4:1 in the amount of 3 and 5% in comparison with control samples during of mechanical processing. The oat bran as a part of the filler reduce the water holding capacity of yogurt with the filler (Fig. 2, b). The yogurt with oat–chia filler in proportion of 1:1 in the amount of 3 and 5% is closer to the control sample compared to other samples. In addition, the influence of the amount of filler in this case is not substantial. As a result of studying the samples water–holding capacity, the yogurt with 3–5% oat-chia seeds composites in the ratio of 1:1 is closer to the control samples and this filler proportion was selected for further research.

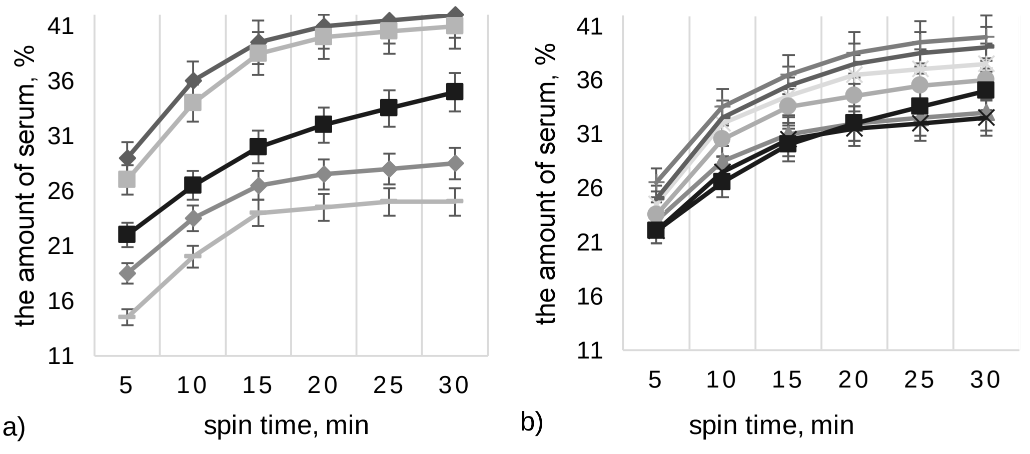

Figure 2. Water–holding capacity of yogurt with fillers: a) – 5% oat bran; – 5% chia seed; – control; – 3% chia seed; – 3% oat bran; b) – 5% 1:1; – 5% 4:1; – 5% 9:1; – control; – 3% 1:1; – 3% 4:1; –3% 9:1.

Post– acidification analyses of yogurt samples

Post– acidification is important quality property for dairy products during storage. Research of differences in the initial pH values and the intensity of pH changes of yogurt samples during storage have been carried out (Fig. 3).

The initial pH of yogurt without any filler was 4.24 ± 0.06 that the lower than in other yogurt with 3 and 5% filler with differences 0.04 and 0.14 respectively. The comparably same decrease in pH level of samples on the 7th day of refrigerated storage (0.01–0.03) was noted. However, the reduction in pH of the yogurt with filler was more intensive compared to the yogurt without filler up to the 14th day of storage, especially for the yogurt with 5% filler. In addition, the intensity of changes in pH of yogurt with filler was less than in control sample during the period from the 14th to the 21st day of storage.

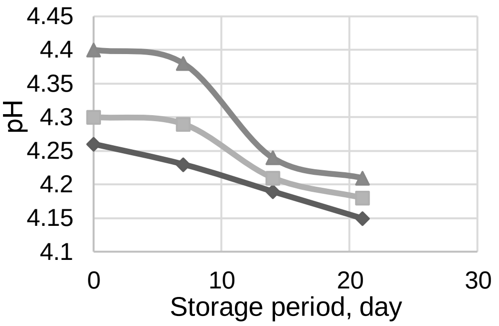

Figure 3. pH changes during storage: –control; –3%; – 5%.

The final pH of the samples was relatively the same, indicating the difference reduce in initial pH of samples. The pH level of yogurt with 5% filler on the 14th day of storage corresponds to the pH of control sample on the 7th day of storage. However, the changes in pH in the yogurt with 5% filler were 2 times higher compared to the control sample during the whole storage period. Obviously, this is due to the fact that the polysaccharides are a substrate for various starter cultures. The yogurt clot with filler based on polysaccharides could activate a further increase of the yogurt starter microflora during storage.

Rheological properties of yogurt samples

Rheological tests are widely used in the food industry for the evaluation of technological and consumer properties of food products (Edvards et al., 2001; Keentok et al., 2002). Analysis of the rheological properties of different food products show that non–Newtonian viscosity properties, availability of yield strength and thixotropy (Haque et al., 2001). Yogurt refers to the group of pseudoplastic liquids with the manifestation of thixotropic properties (Tamime & Robinson, 1999). Complex of the rheological research of the samples have allowed to characterize their resistance to mechanical impact and the ability to restore the structure after the specified time. The rheological properties of yogurt samples were obtained by characteristic curves: the apparent viscosity on the shear rate in the forward direction (in the destruction of the structure) and in the reverse direction (after keeping the samples at rest for 15 minutes); and complex dynamic viscosity, the elastic (storage) modulus (G') and the viscous (loss) modulus (G'') at different frequencies. The values of the yield point for the yogurt samples were calculated.

The yogurt samples demonstrated a nonlinear reducing dependence of the apparent viscosity with the increasing shear rate (Fig. 4). The lack of the linear dependence of the viscosity on the shear rate proves non–Newtonian viscosity properties of yogurt samples

(Malkin & Isayev, 2006). Obviously, yogurt with the filler showed much greater indices of viscosity at initial shear rates in comparison to the control sample. Moreover, when the smaller the shear rate on the samples than the more substantial the difference in the apparent viscosity of the samples. However, the apparent viscosity of the samples was not significantly different at high shear rates (up to 10 s^{-1}). Thus, all samples were demonstrated a decrease in apparent viscosity at the initial stage of research, that confirms the possibility to flow at low shear rate. This is due to the low strength of molecular linkages, that is typical for traditional yoghurt (Gabriele et al., 2001).

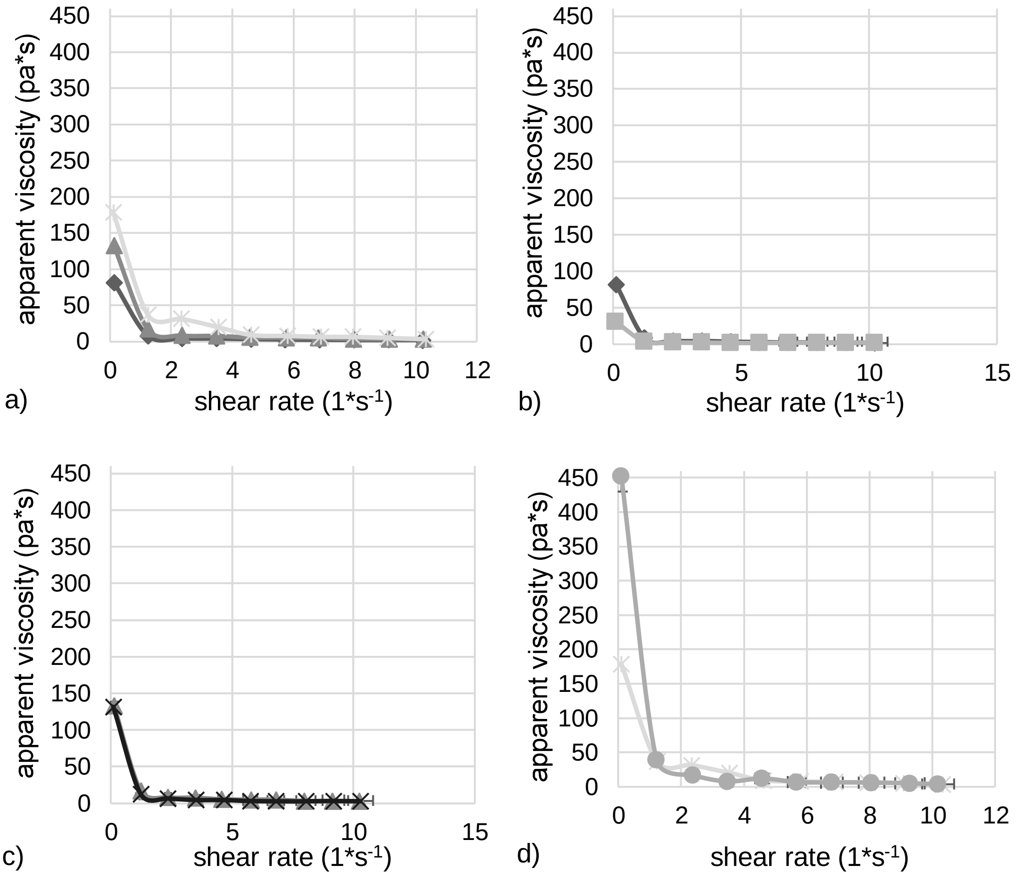

Figure 4. Apparent viscosity yogurt samples versus shear rate (1 s^{-1}): a) – control forward; – 3% forward; – 5% forward; b) – control forward; – control back; c) – 3% forward; – 3%back; d) – 5% forward; – 5% back.

The study of the apparent viscosity of yogurt samples in the reverse direction (at a shear rate of 10 to 0.1 s^{-1}) showed that samples with the filler have the most expressed thixotropic properties. The structure of yogurt sample without filler have been partially restored after holding at rest that is typical for fermented dairy products (Haque et al., 2001). Yogurt sample with 3% filler showed practically 100% restore of the structure. Structure recovering of yogurt with 5% filler had an untypical character for dairy fermented product at low shear rates: the apparent viscosity of yogurt 'in reverse' had higher values in comparison with the viscosity of yoghurt 'in the forward direction'.

Obviously, this was due to the intensification of the intermolecular linkages at interaction of the yogurt with the filler that appears under mechanical action (in gentle conditions) and prolonged holding at rest (for 5 minutes). Such high thixotropic characteristic of yogurt with a filler is typical for foods, which include natural polymeric substances such as oat bran and chia seeds (Yildis & Kokini, 2001).

The differences between the highest and the lowest viscosity values allows to evaluate of yogurt sample structure. The structuring food materials are usually measured by value of order $n \cdot 10^{5-6}$ (Kokini & Plutchok, 1987; Gallegos et al., 1999). Differences between the highest and the lowest viscosity values of yogurt samples were not large to characterize them as structuring food materials (Table 1).

Table 1. The difference between the highest and the lowest value of the viscosity of the samples

Values	Yogurt samples		
	without filler	with 3% filler	with 5% filler
$\eta_{max}/\ \eta_{min}$, Pa*	43.6	43.6	47.5

The yield point indicators are important in terms of practical using of food products (Malkin et al., 2004). The data in Table 2 allows to estimate yield point of yogurt samples. The observed values of yield point of the yogurt samples were different considering different calculation equations.

Table 2. The yield point of the yogurt samples

Equation	The yield point of yogurt, Pa*		
	without filler	with 3% filler	with 5% filler
Bingham	9.6	19.5	49.1
Caisson	8.6	10.9	31.5
Hershel–Bulkley	8.6	12.6	37.8
The average values	8.9	14.3	39.5

Obviously, the yield point value correlates with the share of filler in the product and increases with the amount of filler in the yogurt. Based on the average value of the indicator the highest rate of yield point was marked for yoghurt with 5% filler and was equal 39.5 Pa which exceeded the indicator for yogurt with 3% filler and yogurt without filler in particularly on 25.2 Pa and 30.6 Pa respectively.

To simulate the slow stirring of the product in a reservoir large volume the rheology of yoghurt samples was studied (at the constant strain of 0.5%) with varying frequency. Fig. 5 reflects the dependence of the moduli: G' (an elastic (storage) modulus), G'' (a viscous (loss) modulus) and tan(δ) at frequencies ranging from 1 to 10 rad s^{-1}. All samples exhibited the higher level of modulus G' compared with the modulus G'', that is typical for a yogurt (Malkin & Isayev, 2006). The elastic modulus G' of all samples showed the larger dependence on the frequency than the viscous modulus G''. There was a direct correlation of the modulus G' and increased amounts of filler in the composition of yogurt.

The highest values of the modulus G' were observed in yogurt with 5% of the filler. The intensity of the modulus G' in this sample was increased with higher frequency that exceeded to the others. This can be explained by the polysaccharide's properties of the yogurt filler. The lowest value of the moduli G' and G'' were in the control sample.

The meaning of tan(δ) is the ratio of loss modulus G'' to storage modulus G' (George et al., 2014). In this research the ratio of the energy lost to the energy stored in the yoghurt samples by tan(δ) was investigated (Fig. 5, b). The tan(δ) values demonstrated the different values for samples, particularly all samples showed the reduction of the studied parameter at the beginning (at frequency from 1 to 5 rad s^{-1}), but then it is further nearly unchanged (at frequency from 5 to 10 rad s^{-1}). Yoghurts with filler have a higher tan(δ) value compared to control sample. But there are no significant differences in tan(δ) dependence to the amount of filler in the yogurt, that is confirmed on Fig. 5, a.

Thus, the yogurt with filler had the higher elastic and viscous properties compared with yogurt without filler.

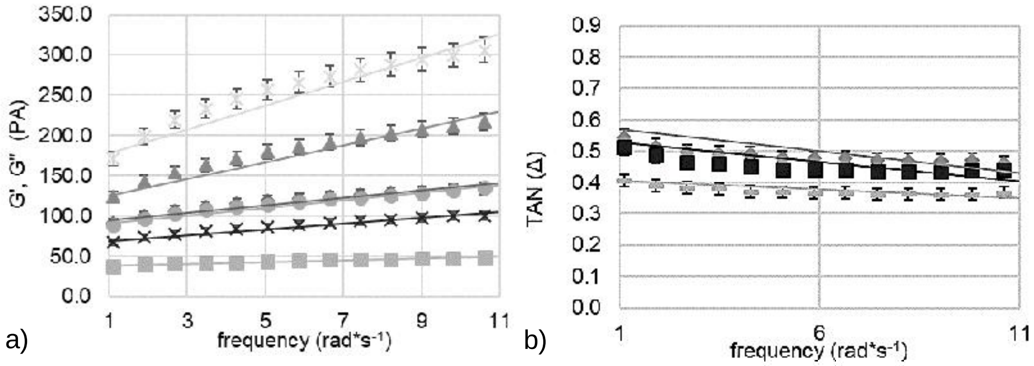

Figure 5. Values of G', G" and tan (δ) versus frequency (rad*s^{-1}): a) – G' control; – G" control; – G' 3%; × – G" 3%; – G' 5%; – G" 5%; b): – tan(δ) control; – tan(δ) 3%; ■ –tan(δ) 5%.

Biological value of yogurt samples

Table 3 data shows the difference in the biological value of the protein component of the yogurt samples. Tryptophan was the limiting amino acid in the yogurt without filler, because its amino acid score was equal 95%. The yoghurt samples with filler did not contain any limiting amino acids. The amino acid score of tryptophan in the yogurt with 3% and 5% filler was 104% and 110% respectively.

Table 3. The biological value of the protein component of the yogurt samples

Essential amino acids	Content of amino acid, g / 100 g protein				Amino acid score, %		
	FAO/ WHO*, 2007	yogurt without filler	yogurt with 3% filler	yogurt with 5% filler	yogurt without filler	yogurt with 3% filler	yogurt with 5% filler
Histidine	1.50	2.48	2.49	2.49	165	166	166
Isoleucine	3.00	5.46	5.40	5.40	182	180	180
Leucine	5.90	10.09	10.03	9.97	171	170	169
Lysine	4.50	8.96	8.87	8.76	199	197	195
Methionine+ Cysteine	2.20	3.87	3.92	3.96	176	178	180
Phenylalanine+ Tyrosine	3.80	10.49	10.45	10.45	276	275	275
Threonine	2.30	4.12	4.09	4.09	179	178	178
Tryptophan	0.60	0.57	0.62	0.66	**95**	104	110
Valine	3.90	8.27	8.19	8.15	212	210	209

*[U.S. department of agriculture].

The coefficient of differences of amino acid score of the samples (CDAAS) for the yoghurt without filler and yogurt with 3% and 5% filler was equal 89%, 80% and 75% respectively. The biological value of the protein component of the samples (BV) was equal 11%, 20% and 25% respectively for the yogurt without filler, yogurt with 3% and 5% filler. The biological value of the protein component of the samples was increased with filler content increasing. The biological value of yogurt samples with 3% and 5% filler was more over 9% and 14% in compared to yogurt without filler. The biological value of the lipid component of the samples was evaluated (Table 4) according to FAO, 2007. The samples total fat included of 20–35% E*; saturated fatty acids (SFA): 10% E; total polyunsaturated fatty acids (PUFA): 6–11% E; n–6 PUFA: 2.5–9% E; n–3 PUFA: 0.5–2% E (*% E–percent of energy).

Table 4. The biological value of the lipid component of the samples

Samples	Fat content, %	Content of fatty acids, g per 100 g lipids				
		SFA	MUFA	PUFA	n–3	n–6
Yogurt without filler	1.55	64.52	27.48	2.84	0.84	2.00
Yogurt with 3% filler	2.07	50.23	23.36	21.21	13.62	7.60
Yogurt with 5% filler	2.42	44.13	21.59	29.07	19.08	9.99

Yogurt without filler contained more SFA, less MUFA, in the minor–PUFA, more than 2/3 of which are omega–6 acids. Fatty acid composition of the filler was represented in the greater degree by PUFA–58.17%, the significantly lesser–MUFA and SFA respectively as 20.66% and 14.86%. Filler introduction in yogurt allowed to optimize the product fatty acid composition by reducing of the SFA content and increasing of the PUFA content.

CONCLUSIONS

The feasibility of using the filler on the basis of oat bran and chia seeds (1:1) in the composition of yogurt formulations is shown. Yogurt with 3–5% of the filler in the recommended proportion (1:1) is most close to yoghurt without filler in the water–holding properties compared to other filler proportions. Study of the rheological properties of the samples showed that the yogurt with the filler has the higher values of effective viscosity and resiliency structure compared to yogurt without filler. Moreover, yoghurt with the filler demonstrates higher values of the elasticity modulus and the elastic modulus compared to yogurt without filler. The developed yoghurt formulation allowed to enhance the biological value of the protein and lipid composition. Adding filler effects, the change of active acidity of the product at the initial stage of its storage. Obviously, the presence of polysaccharide in the filler composition activate yoghurt starter microflora. In a further study the effect of the filler on various types of lactic acid bacteria should be explored. It is also necessary to study the process of collaborative fermentation of the dairy–plant base with the addition of up to 5% filler in the mixture. Perhaps the presence of polysaccharides in the filler will have a positive impact on the enrichment of fermented milk product with bifidoflora.

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