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.

MATERIALS

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: 60x40 mm; the hopper capacity–up to 6 liters; the voltage–220 V; the power consumption–1800 W; the rotor speed–3000 rpm; the dimensions: 550 * 350 * 1000 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.

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.

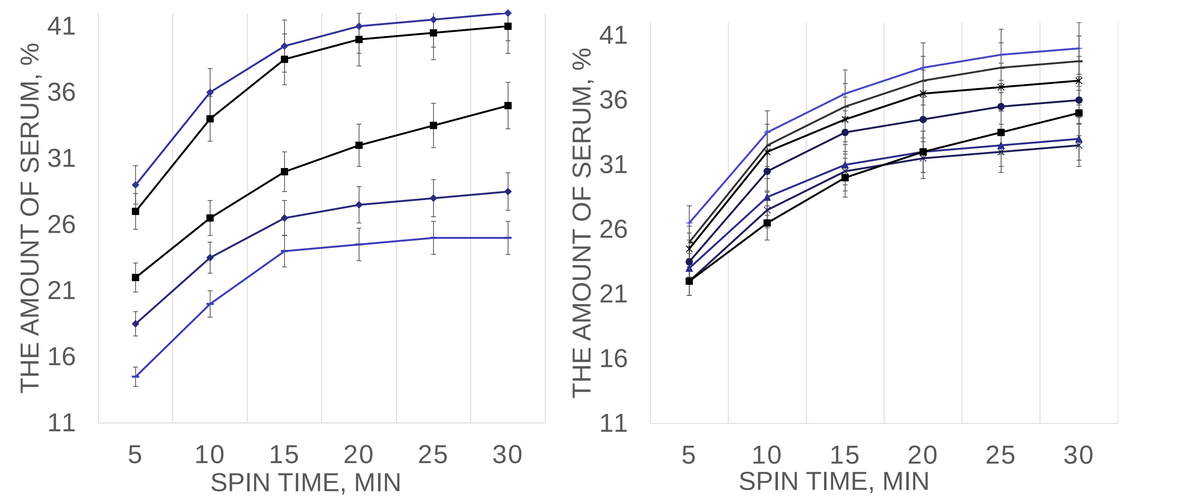

Figure Water–holding capacity of yogurt with fillers. Figure a: – 5% oat bran, – 5% chia seed, – control, – 3% chia seed, – 3% oat bran; Figure b: – 5% 1:1, – 5% 4:1, – 5% 9:1, – control, – 3% 1:1, – 3% 4:1, –3% 9:1.

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 E., 1922); Caisson equation (Mills C.C., 1959); Hershel–Bulkley equation (Hershel W.H.& Bulkley R.,1926).

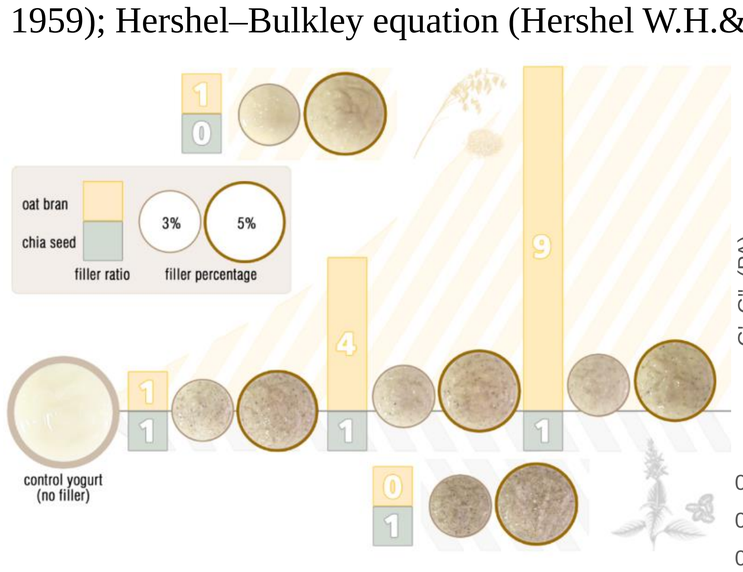

Figure The organoleptic assessment of the yogurt samples with oat– chia composites

Table 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
η_{max}/ η_{min}, Pa*	43.6	43.6	47.5

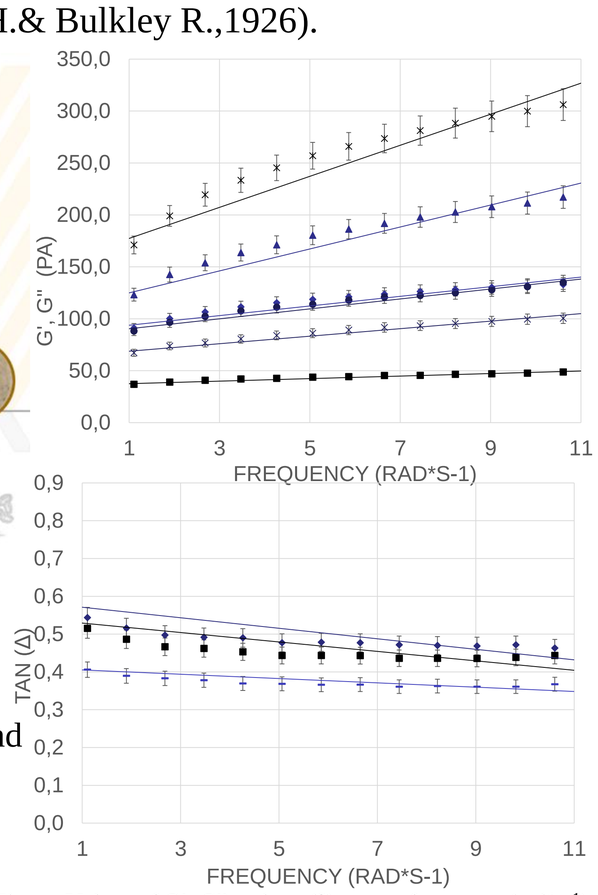

Figure Values of G’, G” and tan (δ) versus frequency (rad*s^{-1}). Figure a: – G’ control, –G” control, –G’ 3%, – G” 3%, – G’ 5%, –G” 5%; Figure b: – tan(δ) control, – tan(δ) 3%, – tan(δ) 5%

Table 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

Table The biological value of the lipid component of the samples

Samples	Fat content, %	Content of fatty acids, g/100g 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

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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