Study of the effect of chia seeds (Salvia Hispanica L.) on structural-mechanical characteristics of a cream-blown paste for candies

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Abstract. The influence of whole and crushed chia seeds on the characteristics of unstructured and structured cream-blown candy paste made with different gelling agents (agar, pectin and modified starch) was investigated. It was found that when adding an additive, the viscosity of unstructured candy pastes changes insignificantly. The adhesion of unstructured cream-blown candy pastes at the maximum dosage of chia seeds increases by 7.2... 8.5%, depending on the type used by the gelling agents. Modern equipment usually has an anti-adhesive coating. Therefore, a slight increase in the adhesion index will not affect the performance of the technological process. It is noted that the introduction of chia seeds causes an increase in the density and strength of the structured candy pastes. According to the maximum investigated dosage of the additive, they do not meet the requirements of regulatory documents in terms of density and have unfavorable organoleptic characteristics. To ensure the high quality of cream-blown candy pastes, it is recommended to introduce whole chia seeds in an amount of 50% of the mass of dry egg albumin, and chopped seeds in an amount of 40% of the fat mass with a corresponding decrease in their prescription content.

1 Introduction

According to statistics, a significant segment of the domestic confectionery industry is the production of sweets. Current trends in the candy industry are largely focused on creating safe and healthy products, which are sold by improving its nutritional composition, reducing fat and sugar content, replacing technological additives of synthetic origin with natural, etc. [1]. The use of non-traditional vegetable raw materials in the technology of confectionery, which is characterized not only by a high content of physiologically useful substances, but also by the presence of compounds with functional and technological properties that positively affect the processes of structure formation of confectionery pastes and quality of finished products.

A promising ingredient for the confectionery industry is chia seeds (Salvia hispanica L.), the high nutraceutical potential of which is due to the presence in its composition of biologically valuable proteins, ω-3 fatty acids, dietary fiber, vitamins, minerals, polyphenols and other important nutrients in significant amounts for the body [2, 3]. In 2009, Salvia hispanica L. was approved by the European Parliament as a new food product due to its wide range of useful properties and hypoallergenicity [4]. Nowadays, chia seeds are used to improve the nutritional and biological value of bakery [5], confectionery [6], pasta [7], sausage [8] and other food products. The use of this additive in such technologies allows to regulate the prescription composition, structure and consistency of products, increases their yield, reduces energy value and extends shelf life.

In [9] we studied the technological potential of the use of Salvia hispanica L. in the technology of cream-blown candies. According to the results of research, it is recommended to use chia seeds whole and crushed in the manufacture of such pastes. At the stage of obtaining a fatty semi-finished product, it is advisable to use crushed chia seeds. It is recommended to first mix it with margarine, and then emulsify with moisture-containing raw materials. This method of seed application allows maximum use of fat-emulsifying and fat-retaining properties of the additive. Whole seeds should be applied at the stage of whipping the protein mass after pre-hydration at a hydromodule of 1:10 for 10 minutes. Whole chia seeds improve the foaming ability of a solution of dry egg albumin and increase the stability of whipped protein masses, while its dosage should not exceed 50% by weight of protein.

However, when developing a new technology of cream-blown candies, it is important to ensure the possibility of its hardware implementation, which largely depends on the structural and mechanical characteristics of the candy pastes.

In view of this, the purpose of the presented research was to determine the structural and mechanical characteristics of cream-blown candies with different dosages of chia seeds.

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2 Experimental

Samples of cream-blown candies with the addition of whole and crushed chia seeds were used as research materials. The introduction of whole chia seeds was carried out at the stage of obtaining a whipped protein semi-finished products in the amount of 30, 40 and 50% by weight of dry egg albumin. The crushed seeds were added at the stage of obtaining a mixture of fat with condensed milk in the amount of 30, 40, 50% by weight of fat. The prescription dosage of albumin and fat was reduced by an appropriate amount. Control samples were cream-blown candy masses without chia seeds, made on various gelling agents (agar, pectin and modified starch).

The effect of the additive on the quality indicators of unstructured and structured cream-blown candy pastes was determined.

The structural and mechanical properties of unstructured pastes were evaluated in terms of viscosity and adhesion. The quality of structured cream-blown candy pastes was evaluated by adhesion, density, strength and organoleptic characteristics.

Viscosity measurements were performed on a Reutov rotary viscometer. The adhesive strength was determined on an adhesiometer by the force of separation of a certain mass of product from the surface of the plate of the device, which simulates the surface of the process equipment. Determination of strength was carried out on a Valent device. The determination was carried out by weight (in grams) at which the destruction of the sample structure occurs. Density was calculated by the ratio of product weight to volume. Organoleptic assessment of the quality of the structured candy pastes was performed according to DSTU 4683:2006 on the indicators: colour, structure, smell and taste.

The study of structural and mechanical properties of unstructured pastes was carried out at a temperature of 55…60°C, which corresponds to the temperature at which they are formed according to the technological scheme. At this stage, it is important to evaluate the viscosity of the system and its adhesive strength.

This is due to the fact that during the implementation of the technological process, the candy pastes interact with the surface of the working parts of machines and mechanisms and changes in these indicators may require reconfiguration of equipment to ensure the stability of dosing and forming operations.

An important indicator that justifies the use of a certain method of forming candy bodies is the viscosity of unstructured cream-blown candy pastes (Table 1).

It has been found that with the addition of up to 40% whole and up to 30% crushed chia seeds, the viscosity of the masses decreases slightly. With a further increase in the amount of additive, the value of this indicator increases and at the maximum dosage exceeds the viscosity of the control sample by 3.3…4.2% (depending on the type of gemstone).

The adhesion strength of unstructured cream-whipped candies with increasing chia seed content in the system increases (Table 2) and in samples with the maximum content of additives exceeds the control by 7.2…8.5% depending on the type of gelling agent used.

It is established that structured cream-blown candy pastes are characterized by smaller values of the indicator of adhesive strength in comparison with unstructured (Table 3).

Table 1. Viscosity of unstructured cream-blown candy pastesat a temperature of 55… 60°C (p≤0,05, n=5, y=3,0…4,5%).

Samples of unstructured cream-blown candy pastes	The viscosity of the samples, Pa • s		
	With agar	With pectin	With modified starch
Without additive (control)	162,3	158,2	186,1
With the addition of chia seeds, %: whole[a] /crushed[b]			
30 / 30	160,1	156,0	183,7
30 / 40	158,3	154,1	181,4
40 / 30	161,6	157,1	184,9
40 / 40	162,7	158,8	186,4
40 / 50	165,2	162,9	190,4
50 / 40	163,8	160,3	188,1
50 / 50	167,9	164,8	192,2

a % by the weight of dry protein

b % by the mass of fat

Table 2. Adhesion strength of unstructured cream-blown candy pastes at a temperature of 55…60°C (p≤0,05, n=5, y=3,0…4,5%).

Samples of unstructured cream-blown candy pastes	Adhesion strength of samples, Pa		
	With agar	With pecti n	With modified starch
Without additive (control)	582,6	605,3	720,8
With the addition of chia seeds, %: whole[a] /crushed[b]			
30 / 30	585,4	620,2	726,3
30 / 40	590,2	626,1	732,5
40 / 30	585,4	615,8	728,5
40 / 40	603,1	636,0	745,3
40 / 50	615,3	645,4	761,8
50 / 40	608,8	642,3	754,6
50 / 50	624,4	657,2	778,5

a % by the weight of dry protein

b % by the mass of fat

However, in structured pastes, as well as in unstructured, there is a tendency to increase the adhesive strength in the case of increasing the dosage of chia seeds. In particular, in the samples with the maximum content of the additive, the growth of the adhesion index relative to the control is 13.4… 16.0% depending on the type of gelling agent.

At the next stage of research, the effect of chia seeds on the density (Table 4) and strength (Table 5) of structured cream-blown candy pastes was evaluated.

The results of the research showed that the addition of 30% of whole and 30% of crushed seeds helps to reduce the density of cream-blown candy pastes by 4.2…5.1% depending on the type of gelling agent. By increasing the seed dosage to 40% for the whole and up to 40% for the crushed value of the density index increases slightly, but does not exceed the control sample. Candy pastes with the maximum content of additives have a density value of

4.3…7.5% higher than the corresponding control samples. According to the technological documentation, the density index for whipped semi-finished products on agar or pectin should not exceed 620 kg/m^3, and for whipped semi-finished products on modified starch – 950 kg/m^3. Samples with the addition of 50% whole and 50% crushed chia seeds do not meet these requirements.

Table 3. Adhesion strength of structured cream-blown candy pastes (p≤0,05, n=5, y=3,0…4,5%).

Samples of structured cream-blown candy pastes	Adhesion strength of samples, Pa		
	With agar	With pectin	With modified starch
Without additive (control)	275,3	262,9	380,7
With the addition of chia seeds, %: whole[a] /crushed[b]			
30 / 30	280,4	265,3	384
30 / 40	290,6	272	396
40 / 30	283,4	267,9	388
40 / 40	301,9	284,5	413,2
40 / 50	308,6	289,3	426,8
50 / 40	303,8	280,2	420,3
50 / 50	312,1	303,4	441,7

a % by the weight of dry protein

b % by the mass of fat

Studies of the strength of structured cream-blown candy pastes (Table 5) showed that for samples with a minimum content of additives, the value of this indicator is within the error of the experiment (the difference with the control is 1.1…1.7%).

Samples with the addition of 40% whole and 40% crushed chia seeds in terms of strength exceed the control by 6.9… 8.6% depending on the type of gelling agent. At the maximum dosage of the additive, the strength of the structured cream-blown candy pastes in comparison with the control sample increases by 12.9…14.4%.

Table 4. Density structured cream-blown candy pastes with the addition of chia seeds (p≤0,05, n=5, y=3,0…4,5%).

Samples of structured cream-blown candy pastes	Density of samples, kg/m^3		
	With agar	With pectin	With modified starch
Without additive (control)	600,0	590,0	935,0
With the addition of chia seeds, %: whole[a] /crushed[b]			
30 / 30	575,0	560,0	890,0
30 / 40	570,0	565,0	920,0
40 / 30	565,0	560,0	910,0
40 / 40	590,0	570,0	930,0
40 / 50	620,0	615,0	950,0
50 / 40	620,0	610,0	950,0
50 / 50	645,0	630,0	975,0

a % by the weight of dry protein

b % by the mass of fat

Evaluation of organoleptic quality indicators of structured cream-blown candy pastes showed that with increasing the dosage of the additive the colour becomes darker, the number of inclusions of seeds increases, the nutty taste and smell are enhanced. It was found that the samples with the addition of up to 50% of whole and up to 40% of crushed chia seeds are characterized by a fine-porous structure and pleasant taste properties. The structure of the samples with the maximum content of additives is the most compacted, the porosity becomes uneven, the consistency becomes viscous, which is not typical of cream-blown candy pastes.

Table 5. Strength structured cream-blown candy pastes with the addition of chia seeds (p≤0,05, n=5, y=3,0…4,5%).

Samples of structured cream-blown candy pastes	The strength of the samples, g		
	With agar	With pectin	With modified starch
Without additive (control)	580,0	700,0	870,0
With the addition of chia seeds, %: whole[a] /crushed[b]			
30 / 30	590,0	710,0	880,0
30 / 40	610,0	730,0	910,0
40 / 30	610,0	725,0	905,0
40 / 40	630,0	750,0	930,0
40 / 50	650,0	770,0	960,0
50 / 40	640,0	765,0	950,0
50 / 50	660,0	790,0	995,0

a % by the weight of dry protein

b % by the mass of fat

3 Results and discussion

Studies of the viscosity of unstructured cream-blown candy pastes (Table 1) showed that the control samples (without additives) made on agar or pectin are characterized by lower values of this indicator than the control sample made on modified starch. Therefore, their formation is carried out by smearing, and the formation of candy masses on the modified starch – by extrusion. The decrease in the viscosity of cream-blown candy pastes when added to 40% of whole and up to 30% of crushed chia seeds is associated with a greater saturation of air bubbles. This is due to the positive effect of whole chia seeds on the foaming ability and stability of whipped protein semi-finished products [9]. The obtained effect is explained by the fact that complexes of protein-anionic polysaccharides (in this case – mucous substances of chia seeds, the amount of which is 4…6% by weight of seeds [10]) show higher surface-active properties than a single protein [11]. Further increase in the dosage of the additive causes an increase in the value of this indicator due to the decrease in the concentration of protein substances in the system, sedimentation deposition of seeds and the interaction of its mucous substances with the liquid phase of candy pastes. However, the difference between the viscosity values of the control samples and the samples with the maximum investigated chia seed content is within the relative measurement error. That is, using chia seeds, the formation of cream-blown candy pastes will be carried out in the same way as the corresponding control samples – smearing for pastes on pectin or agar and extrusion for pastes on modified starch.

The increase in the adhesion strength of unstructured cream-blown candy pastes with increasing dosage of chia seeds (Table 2) can be explained by the fact that the introduction of additives during whipping pastes forms

more air bubbles with a greater degree of dispersion, which increases the contact area. The candy pastes wet better the surface of the contacting material, providing a more complete contact with the maximum filling of the micropores on the surface and, as a consequence, there is a strengthening of the adhesive contact. Due to the fact that modern equipment usually has an anti-adhesive coating, a slight increase in the adhesion index should not affect the process.

The lower value of the adhesion index of structured cream-blown candy pastes compared to unstructured (Table 3) is explained by the completion of the structuring of hydrocolloids, accompanied by moisture binding and hardening of the gel framework. The mass changes from the colloidal state to the bound-dispersed state, as a result, cavities are formed in the adhesive joint at the interface, as a result of which the actual contact area decreases. Increasing the adhesive strength of structured cream-blown candy pastes, on the one hand, can cause an increase in the adhesion of the pastes to the knives when cutting layers on the bodies, but in industries usually use knives made of anti-adhesive materials, or covered with special films, or knives with ultrasonic vibrations.

On the other hand, when glazing, the increase in adhesive strength can be considered as a positive factor – it will lead to a tighter connection between the body and the glaze. The glaze has not only aesthetic and taste properties. It also protects the body of candies from premature moisture loss and re-contamination - candy pastes have a fairly high humidity (26.0 ± 3.0)% and contain protein, which creates favorable conditions for the development of microorganisms.

The decrease in the density of cream-blown candy pastes with the introduction of 30% whole and 30% crushed chia seeds (Table 4) is due to its high foaming, fat-retaining and fat-emulsifying properties [9]. The increase in density in the case of a further increase in the dosage of chia seeds can be explained by the sedimentation deposition of the additive due to its higher density (1.069 g/cm^3) compared to the candy mass [12]. To some extent, this explains the increase in the strength of the samples with the additive (Table 5). In addition, the mucous substances of chia seeds are able to form gels. Due to the fact that the prescription amount of gelling agents in the preparation of cream-blown candy pastes did not change, this leads to an increase in the total number of gelling agents in the system, which also increases the strength of the test samples.

Evaluation of organoleptic quality indicators of structured cream-blown candy pastes showed that the samples with the maximum content of additives are characterized by excessively compacted strong structure, uneven porosity and viscous consistency.

That is, ream-blown candy pastes with the addition of whole chia seeds in the amount of 50% by weight of dry egg albumin and crushed seeds in the amount of 50% by weight of fat do not meet the requirements of regulatory documentation on the value of density and organoleptic characteristics.

Thus, it is recommended to add to the cream-blown candy pastes whole chia seeds in the amount of 50% by weight of dry egg albumin, and crushed – in the amount of 40% by weight of fat with a corresponding decrease in their prescription amount. However, product quality implies its ability to retain its properties for a regulated period. That is, further studies of changes in the quality characteristics of ream-blown candy pastes with the addition of chia seeds during storage are promising.

4 Conclusion

A study of the effect of whole and crushed chia seeds on the structural and mechanical properties of cream-blown candy pastes was carried out.

It was found that the viscosity of unstructured cream-blown candy pastes with the addition of whole and crushed chia seeds changes insignificantly. That is, their formation will be carried out in the same way as the corresponding control samples – smearing for the masses on pectin or agar and extrusion for the masses on the modified starch.

The adhesive strength of unstructured cream-blown candy pastes in the case of adding chia seeds is slightly increased. However, modern equipment usually has an anti-adhesive coating, so a slight increase in adhesion should not affect the process.

In structured cream-blown candy pastes, as well as in unstructured, there is a tendency to increase the adhesion index in the case of increasing the dosage of chia seeds. This will help to strengthen the connection between the body and the glaze during glazing.

It is noted that the introduction of chia seeds causes an increase in the density and strength of structured cream-blown candy pastes. At the maximum investigated dosage of the additive, they do not meet the requirements of regulatory documentation in terms of density and have unfavorable organoleptic characteristics. To ensure high quality cream-blown candy pastes, it is recommended to add whole chia seeds in the amount of 50% by weight of dry egg albumin, and crushed – in the amount of 40% by weight of fat with a corresponding reduction in their prescription content.

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