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Technologies of improvement of rheological characteristics when creating lingonberry sauces

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Abstract. The paper presents the results of studies in rheological characteristics of experimental samples of viscous-fluid products developed using squeezed fruit and berry raw materials. On the basis of a unified formulation and classical technology, the authors developed the recipes of experimental samples, the base of which is a plant heteropolysaccharide based on the main chain consisting of D-galacturonic acid residues connected by an α -1,4-glycosidic bond. An organoleptic assessment was also carried out, rheological curves were constructed showing the nature of the presented samples as non-Newtonian pseudoplastic fluids, profile consistency profiles of four viscous-fluid products were constructed, illustrating the effect of squeezes of their density and density in the composition of each studied sample. The results of the study show the role and importance of determining the optimal component composition for optimizing the technological process for the production of viscous-fluid products and reducing costs in the production of such products without losing their consumer qualities.

1. Introduction

Recently, the growing interest of the Russian population in a healthy lifestyle and nutrition is due, first of all, to the spread of serious diseases such as obesity, diabetes, hypertension, atherosclerosis, heart disease, cancer, etc., to which, according to Rospotrebnadzor 2018, about 63% of deaths are related. [1, 2]. In this regard, one of the directions in the concept of the state policy of Russia in the field of healthy nutrition is the development and implementation of qualitatively new and safe food products that allow preserving and strengthening human health [3-5]. These trends have formed one of the priorities of the modern food industry - the creation of healthy food products from ingredients of natural origin without introduction of artificial food additives.

Changing consumer preferences of Russians contribute to the expansion of the range of a number of familiar products, including dessert sauces, the biological value of which can be increased by using berry raw materials and products of its processing as a flavoring base, including squeezes that are practically not involved in technological processes and either disposed of or used for livestock feed [6, 7], which does not correspond to the conditions of rational processing of raw materials, as squeezes retain the basic properties of raw materials and contain a large amount of vitamins, fiber, mineral and pectin substances. In this regard, it is advisable to include fruit and berry squeezes in food products as a



partial replacement for relatively expensive and seasonal fruit and berry raw materials to reduce costs without losing product quality [8].

2. Materials and methods

The most effective way to achieve the required viscosity in food technology involves pectin - a plant heteropolysaccharide based on the main chain, consisting of D-galacturonic acid residues connected by an α -1,4-glycosidic bond. In this case, the carboxyl groups of the molecule can be partially esterified with methyl alcohol, and the hydroxyls at positions C-2 and C-3 can be acetylated. (Figure 1) [9].

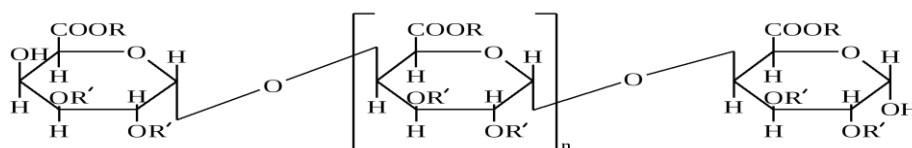


Figure 1. Pectin molecule structure.

where: R = H or CH₃-; R' = H or CH₃CO-; n = 18-1820.

The presence of pectin leads to the formation of additional hydrogen and covalent bonds between the molecules of the ingredients, helping stabilize the structure and improve the consistency of the product. The functional properties of pectin are due to its ability to bind and remove toxic compounds from the body. [9].

The needs of the Russian food industry in this ingredient are satisfied mainly through the supply of apple and citrus pectins from abroad. While in Russia there is a rich raw material base: waste from enterprises processing fruit and berry raw materials and sugar beets, engaged in the production of sunflower oil, and open access to information on proven technologies for producing pectin [10, 11]. Thus, the secondary raw materials of crop production have great potential when used as a source of natural dietary fiber. Particularly noteworthy is the squeezing of fruits and berries, which by their chemical composition retain the properties of raw materials and contain vitamins, fiber, mineral and pectin substances. In this regard, the use of fruit and berry squeezes in the recipe and technology of new types of food products, including functional purposes, is relevant and meets current trends in food science [12].

So, at present, the expansion of consumer preferences of Russians and the popularization of European cuisine have contributed to the emergence of various sauces on the market, including dessert ones. Sauces, as a rule, do not belong to healthy food products due to the high calorie content and low content of vitamins and minerals. To increase the biological value of dessert sauce, we selected berry raw materials and products of its processing, such as pectin and pomace, as a flavoring base. One of the important indicators of the quality of dessert sauce, on which organoleptic indicators depend, and the attractiveness of the product for consumers, is viscosity. [13].

3. Determination of the rheological characteristics of viscous-flowing foods

Based on a unified recipe and the classic technology of fruit sauce [14], we developed the recipes of experimental samples of dessert sauces developed using lingonberries, and studied their quality indicators. The composition and prescription ratio of ingredients are selected empirically, on the basis of regulatory documents and literature data on the optimal amount of sugar, structurant, acid and dry matter content (at least 50%) in the finished product. Sample No. 1 is a control and prepared from lingonberry puree using lingonberry pectin. In samples No. 2, No. 3 and No. 4, lingonberry puree is partially replaced by squeezed lingonberries dried to 9.8% moisture, the dosage of which is calculated according to the content of pectin substances in the finished sauce (table 1).

During the tasting, it turned out that all the samples have the necessary consistency, do not delaminate and do not spread on the surface. A feature of sample No. 1 is a soft consistency, in contrast to samples with pomaces, in which the structure is tender, with the inclusion of lingonberry grains, which does not spoil the taste, but is proof of the naturalness of the sauce. The taste of the samples is pleasant, sweet

and sour, characteristic of lingonberry fruit, in sample No. 1 the taste is most saturated and the aftertaste is longer than in samples No. 2, 3 and 4. Sauces with squeezed lingonberries (samples No. 2-4) have a darker color than in control sample No. 1, ruby color and rich lingonberry aroma. Unlike other samples, specimen No. 4 breaks when draining, grains of pomace are especially noticeable in it. Table 2 presents the results of a tasting evaluation of the samples of sauces on the industry-accepted 25-point scale.

Table 1. Formulations of experimental samples of viscous flowing products.

Ingredients	Sample No. 1	Sample No. 2	Sample No. 3	Sample No. 4
Lingonberry puree, %	51.45	48.57	47.31	46.10
Granulated sugar, %	48.00	45.53	44.35	43.22
Lemon acid, %	0.30	0.30	0.29	0.28
Pectin, %	0.25	0.12	0.05	0.00
Pomaces, %	0.00	5.48	8.00	10.40

Table 2. The results of the tasting evaluation of experimental samples of viscous fluid products.

Name of indicator	Sample No. 1	Sample No. 2	Sample No. 3	Sample No. 4
Appearance	4.8	4.6	4.5	3.7
Taste	4.7	4.5	4.6	3.7
Aroma	4.2	4.4	4.6	4.5
Color	4.6	4.6	4.5	4.3
Consistency	4.7	4.5	4.6	4.0
Total score	23.0	22.6	22.8	20.2

According to the data in table 2, sample No. 4, containing 10.40% of pomace, is inferior to other samples in organoleptic characteristics. The difference in the indicators of taste, “appearance” and “consistency” is especially significant, which can be expressed quantitatively through rheological properties.

The rheological characteristics of the studied samples of dessert sauces were measured using a rotational viscometer "Reotest-2" in mode II B. The result of the dependence of the effective viscosity on shear stress is presented in the graphs of Figure 2.

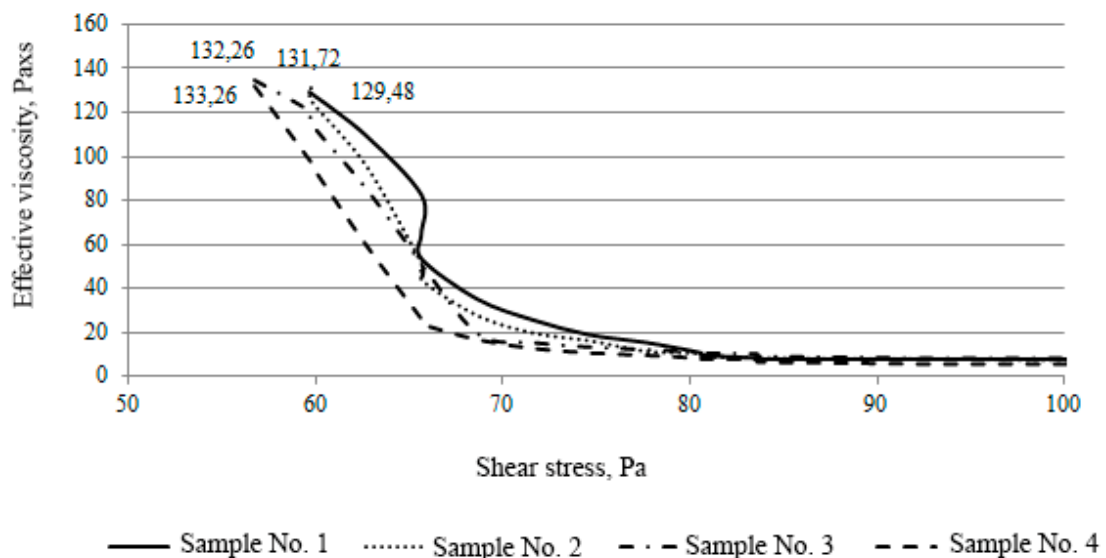


Figure 2. Rheological curves of samples of a viscous fluid product

The shape of the rheological curves of Figure 2 shows that all sauces are non-Newtonian pseudoplastic liquids. Upon reaching maximum Newtonian viscosity: 129.48 Pa×s; 131.72 Pa×s, 132.26 Pa×s and 133.26 Pa×s for samples No. 1, No. 2, No. 3, and No. 4, respectively, the shear orientation of the molecules of the sauce components exceeds the random Brownian motion, and the effective viscosity decreases sharply. Upon reaching the minimum Newtonian viscosity: 6.32 Pa×s, 7.61 Pa×s, 8.54 Pa×s, 8.98 Pa×s for samples No. 1, No. 2, No. 3, No. 4, respectively, the structure of sauces is destroyed, and the viscosity ceases to depend on shear stress, i.e. sauces behave like Newtonian fluids (the graph goes to a plateau). The lower the minimum viscosity value, the stronger the structure.

The data in the figure confirm that the calculation of the amount of lingonberry squeeze according to the content of pectin substances in the finished product was performed correctly: all rheological curves of the samples are of the same nature, and for samples No. 2, No. 3 and No. 4 they are almost identical, i.e. replacing part of the berry puree with pomace does not significantly affect the rheological properties of the sauce.

For a more detailed study of the consistency, the refinement characteristics of this indicator were considered, according to which a profilogram was constructed, illustrating the effect of squeezes and the consistency features of experimental sauce samples (Figure 3).

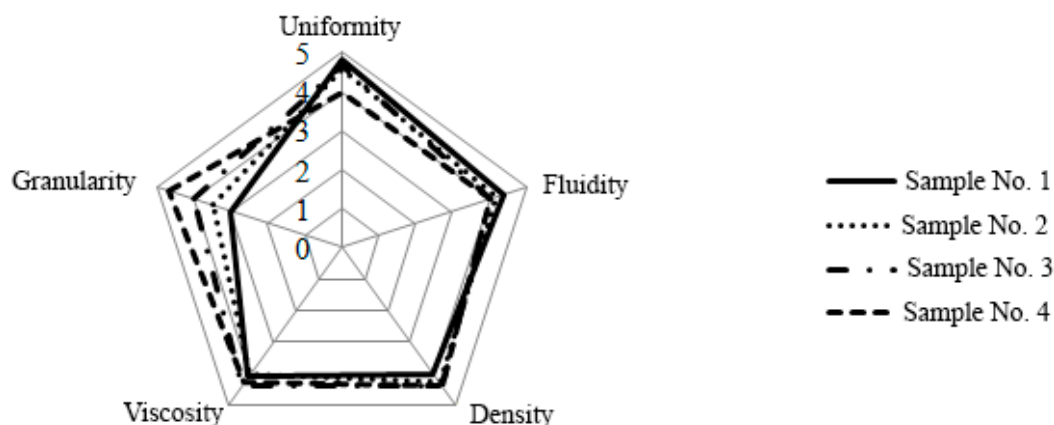


Figure 3. Profilogram of consistency of sauce samples.

According to the data in Figure 3, all samples have a pleasant consistency and have the necessary fluidity, i.e. they will not spread over the dish. However, sample No. 4 is less homogeneous and breaks during spreading, in contrast to other samples; grains of squeeze are more noticeable in this sample.

According to the results of organoleptic evaluation, it was found that an increase in the content of squeezes of more than 8% worsens the perception of taste and sensation in the oral cavity due to the pronounced coarseness of the sauce structure, despite the close values of the rheological parameters of the studied samples.

Due to the fact that squeezes are waste products of fruit and berry raw materials and have a low cost - 8 rubles per 100 g, unlike lingonberry berries - 32 rubles per 100 g (at the prices of 2019), it seemed interesting to calculate the effect of the costs of raw materials for the partial replacement of berry puree with pomace (Figure 4).

Figure 4 shows that when lingonberries are squeezed in concentrations of 8.00% and 10.40%, raw material costs are reduced by 10.00 and 11.75%, respectively.

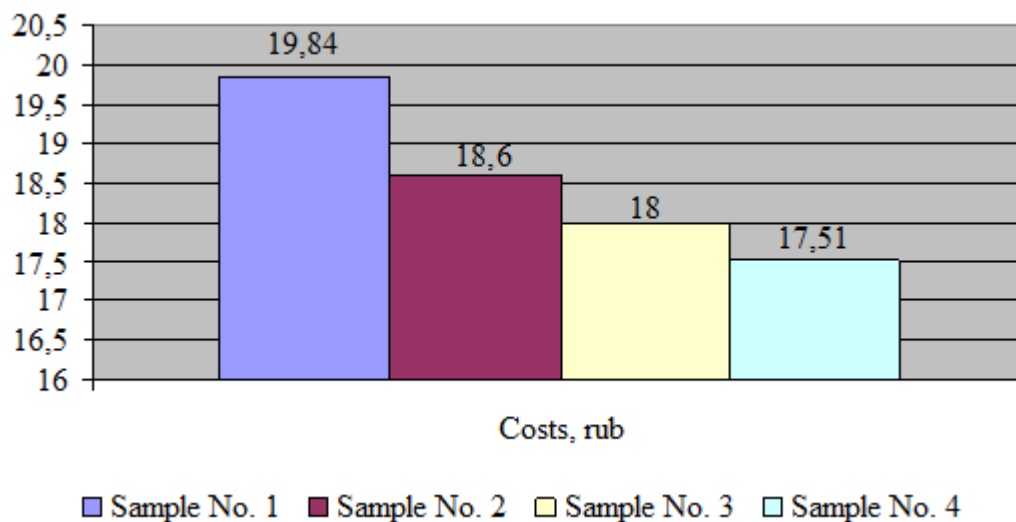


Figure 4. Raw material costs for the production of 100 g of a viscous fluid product, rub.

4. Conclusion

Determining the rheological characteristics of viscous-flowing foods, which include sauces, is crucial for designing recipes and optimizing the technological process (achieving uniformity when mixing components, uniform heating, etc.) [15]. When determining the effective viscosity, all samples of dessert sauces showed high viscoelastic properties, since the destruction of the structure occurred at low values of the minimum Newtonian viscosity (8.98 Pa·s and less). This is due to the ability of pectin to swell upon adsorption of free moisture, which acts as a plasticizer in the structure of food products. The establishment of the optimal temperature regime of the technological process is of no small importance for the rheology of sauces: pectin should not be heated above 80 C, because the molecules of the builder degrade and the jelly loses its strength and collapses [16].

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