STUDY OF THE DYNAMIC VISCOSITY OF THE FILLING FOR THE PRODUCTION OF JELLY BARS

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Abstract

The article is devoted to the study of the influence of concentrations of recipe components and temperature on the dynamic viscosity of model solutions based on agar when fillings for the production of jelly bars are made.

The dynamic viscosity of model systems "agar-water", "agar-water-glycerin", "agar-water-glycerin-honey", "agar-water-glycerin-honey-sesame flour" was experimentally investigated using a rotary viscometer.

The effect of glycerin, honey and sesame flour on the dynamic viscosity of agar is scientifically substantiated. It was also established that the addition of 0.3% glycerol to the agar-based solution increases its viscosity and contributes to the formation of a significant number of intermolecular hydrogen bonds. When honey is added in the amount of 25±2%, the desired stable structure of the filling is formed.

Keywords: dynamic viscosity, filling, agar, glycerin, honey, sesame flour, model systems, jelly bar.

Introduction. Confectionery industry is one of the main galleys of the food industry. For the sake of virobnitstva borrows another space from the world, shards vibrate close to two thousand kinds of different malt. It’s important to take revenge on carbohydrates, that, killing the lives of people and children (improper eating, ecology, stress), it is necessary to more rationalize eating, vicarious syrovina, rich in life and biologically active speeches. In the middle of a wide range of candies, jelly bars are especially occupied by jelly bars, which are often served as a snack. Oskilki spozhivachi zvjayut especially respect for the organoleptic power of the products, before us stands the task of taking the product with the vidpovidnymi organoleptic and technical power.

Viscosity is an important technical property for bar filling, as it acts as a structural-mechanical barrier during the formation and destruction of the gel structure, which determines its stability. It is caused by the internal forces of adhesion between molecules and characterizes the resistance of their mass under the influence of external forces. The gel mass in production goes through the process of mixing, pumping, pouring, which leads to its destruction. The degree of damage depends on many factors - the amount of dry matter, the composition and ratio of recipe ingredients, temperature, etc. [1, 2].

The viscosity, structure, thermoreversibility and stability of hydrocolloid dispersion solutions depend on their type and concentration, temperature and duration of solidification, pH of the medium, as well as the presence and concentration of additives. To achieve the desired level of viscosity, most polysaccharides have a concentration range of 0.1 to 3%. When using finely dispersed powders, gel formation occurs within 20-40 minutes (for most polysaccharides). It should be remembered that the speed of particle swelling strongly depends on the intensity of mixing and the temperature at which the system is exposed [3, 4].

Implementation of scientific principles of changing the properties of agar and combining it with other food products, such as glycerin, will create a class of new food products with qualitatively changed functional properties [5].

During the analytical review, it was found that the studies related to the determination of rheological properties, namely the dynamic viscosity of gel-like systems in the literature are fragmentary. This determines the relevance of the chosen direction.

Analysis of recent research and publications. Many domestic and foreign scientists studied the rheological properties of agar solutions [1, 2, 3, 4, 5, 6].

During the review of foreign and domestic literary sources, it was established that a lot of attention was paid to the issue of the effect of temperature on the viscosity of agar solutions, as well as the effect of other auxiliary components on them.

Scientists [6] conducted research on rheological properties - the viscosity of agar gels and the effect of disaccharides (sucrose) and monosaccharides (fructose) on them. It was investigated that the viscosity of the agar gel structure of 1% concentration ($\eta 0$) is 38.113 Pa×s. This strength of the structure of 1% agar gel is explained by the fact that the high concentration of agar contributes to the strong stabilization of the layer of the dispersed medium between the agar molecules and their aggregates, and thanks to this, the particles of the dispersed phase are in direct contact, this contributes to the formation of the strongest and at the same time fragile agar structure gel 1% concentration..

Factors affecting the viscosity of agar solutions, which mainly include concentration and temperature, are studied in [7]. In the course of the study, it was established that the concentration of agar, water hardness and temperature of the solution have a significant effect on the viscosity of the agar solution, while the pH of the solution does not have a significant effect on the viscosity.

The aim of the authors of the article [8] was to study the rheological properties of agar-agar solutions prepared using water exposed to an electromagnetic field with a frequency from 30 to 170 MHz. The research was conducted at the following temperatures: 25, 35, and 45 °C, the concentration varied from 0.1 to 0.7%, and the shear rate was within the range of 100–1000 s−1. It has been studied that in the vast majority of cases, a decrease in the viscosity of solutions is observed as a result of the influence of temperature and the electromagnetic field. The temperature dependence of viscosity for solutions subject to and not subject to the influence of an electromagnetic field has a multidirectional nature and depends significantly on both the concentration of the solution and the shear rate at which the measurements were made.

A group of scientists [9] studied the rheological characteristics of honey and the effect of temperature on viscosity. The results showed that the honey used in this study showed pseudoplastic flow properties. The influence of temperature on the viscosity of honey showed that the viscosity of honey decreases with increasing temperature.

The authors of the article [10] determined the dependence of the shear stress on the shear rate and calculated the effective dynamic viscosity of water-agar (WA), water-gelatin (VZh) and water-agar-gelatin (WZH) systems in the range of shear rates 17- 1021 s−1 and in the temperature range 298-323 K. The obtained dependences of the effective viscosity for the specified systems decrease with increasing temperature and shear rate. At temperatures above 315 K, there is a weak dependence of viscosity on the shear rate, which is characteristic of Newtonian fluids.

Rheological properties of agar hydrogels were investigated in the work [11]. Agar gels were prepared by mixing an aqueous agar-agar solution with glycerol, sorbitol, citric acid, sodium citrate, and sodium chloride in various concentrations. Sodium citrate, citric acid, and their mixture had the most significant effect on the viscosity of agar gels. The addition of citric acid to the agar-gel composition reduced viscosity, and the addition of sodium citrate increased it.

The aim of this study. The purpose of the article is to study the influence of concentrations of recipe components and temperature on the viscosity of model solutions when fillings for the production of jelly bars are made.

Results and discussion. Agar 1200 TM "Fujian Province" (China), food glycerin TM BASF (Germany), sunflower honey and sesame flour TM "Korysne Boroshno" (Ukraine) were used in the research, and distilled water was used to prepare solutions.

The "agar-water-glycerol" system was prepared as follows. The weight of the dry component was poured into water at a temperature of 20±2 °C, mixed, after which glycerin was added and left to swell for 30-40×60 c. Next, this solution was heated in a water bath at a temperature of 85-95 °C until the agar completely dissolved. After the agar was completely dissolved, honey (model solution "agar-water-glycerin-honey") and sesame flour (model solution "agar-water-glycerin-honey-sesame flour") were added to the solution and thoroughly mixed. The study of the effect of gels was determined on a rotary viscometer.

To establish a rational concentration of the main recipe components of the jelly bar (agar, glycerin, honey, sesame flour), the dynamic viscosity of the solutions was studied (Fig. 1...Fig. 3).

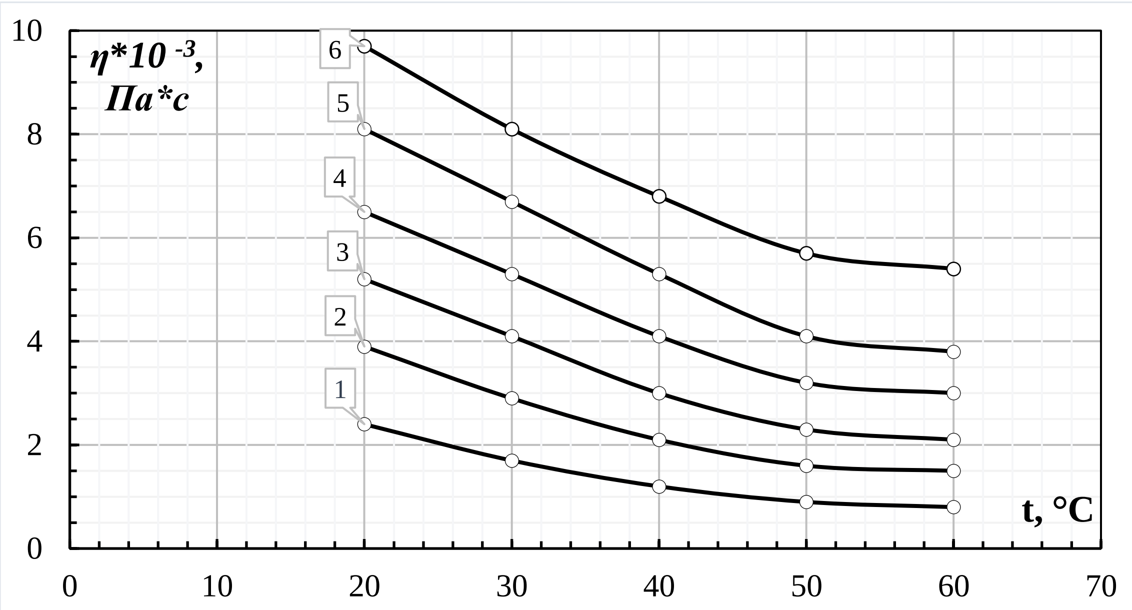

Figure 1. The effect of temperature on the dynamic viscosity of the "agar-water" solution at an agar concentration of 1 %; in the composition with glycerol, %: 1–control; 2–0.1; 3–0.2; 4–0.3; 5–0.4; 6–0.5;

The curve in Figure 1 shows an increase in the viscosity of the "agar-water-glycerol" solution from 2.4±0.2 Pa×s to 9.7±0.2 Pa×s with the addition of glycerin from 0.1 ... 0 .5% in steps of 0.1%. The viscosity of the solution containing 1% agar without the addition of glycerol was 2.4±0.2 Pa×s. When adding 0.1% glycerol to the solution, the viscosity increased to 3.9±0.2 Pa×s. When the glycerol content increased to

0.2%, the viscosity increased to 5.2 Pa×s. Further application of 0.3, 0.4 and 0.5% glycerol led to an increase in viscosity by 6.5±0.2; 8.1±0.2 and 9.7±0.2 Pa×s, respectively.

It was determined that the viscosity of the "agar-water-glycerin" system increases by 2.5 times when glycerol concentrations above 0.3±0.02% are added, which may be due to the synergistic interaction of glycerol with agar, which contributes to the formation a large number of intermolecular hydrogen compounds. An increase in the concentration of glycerol leads to an increase in the rate of cross-linking of the structure and a too rapid increase in strength, which complicates the mixing process.

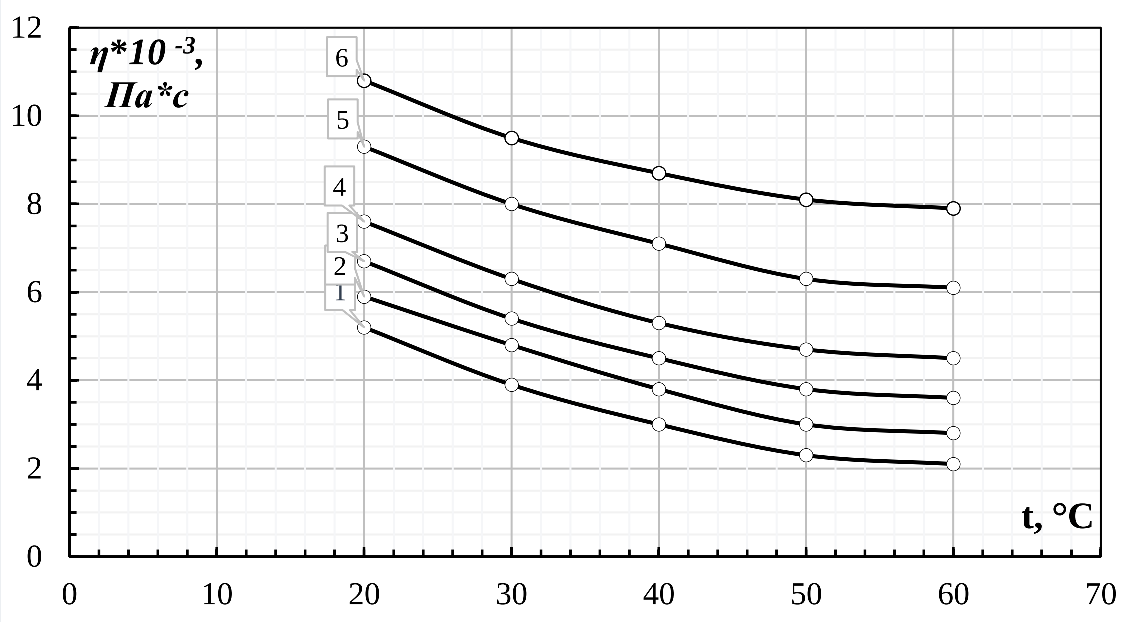

Figure 2.
The effect of temperature on the dynamic viscosity of the "agar-water-glycerin" solution at an agar concentration of 1.0%; glycerin 0.3%; with the addition of honey, % : 1 – control; 2 - 15; 3 - 20; 4 – 25; 5 - 30; 6 - 35

As can be seen from Figure 2, with an increase in the honey content, the viscosity of the solution increased from 5.2±0.2 Pa×s to 10.8±0.2 Pa×s. The viscosity of the solution containing 1.0% agar, 0.3% glycerol without the addition of honey was 5.2±0.2 Pa×s. When adding 15%, 20% and 25% honey to the solution, its viscosity increased by 5.9±2.0; 6.7±0.2 and 7.6±0.2 Pa×s. Further use of 30% and 35% honey leads to an increase in viscosity by 9.3±0.2 and 10.8±0.2 Pa×s, respectively.

It was established that the addition of honey in an amount less than 20±2% or more than 30±2% does not form the desired stabilizing structure of the filling. Increasing the honey content leads to a significant increase in viscosity and an overly sweet taste.

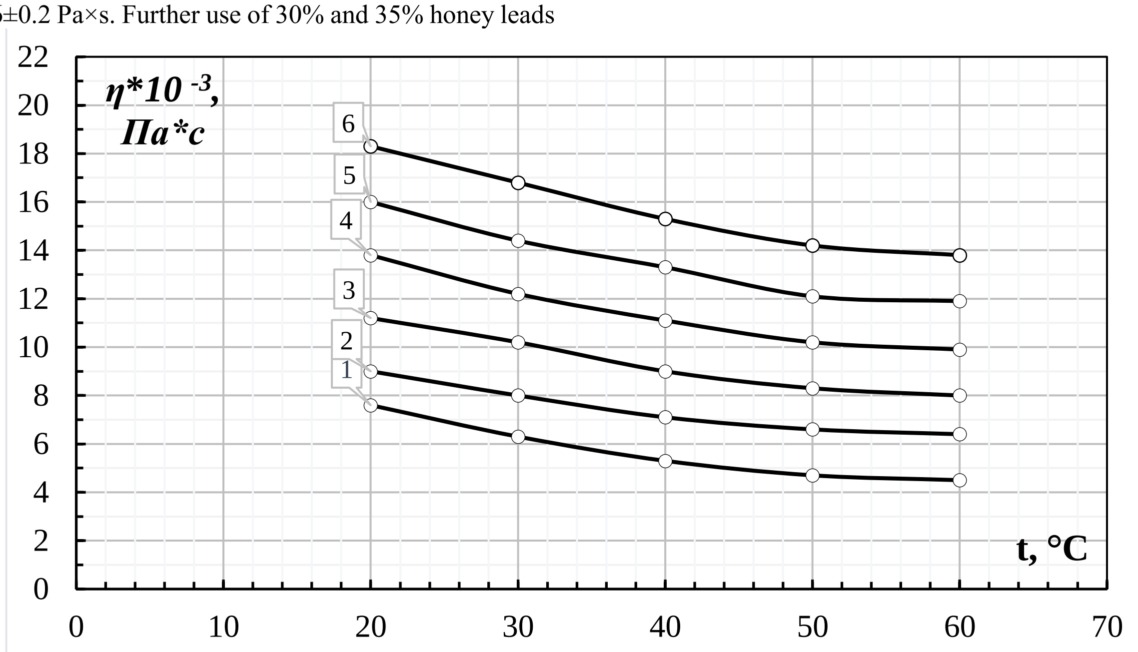

Figure 3. Effect of temperature on the dynamic viscosity of the "agar-water-glycerin-honey" solution at an agar concentration of 1%; glycerin 2%; honey 25% with the addition of sesame flour, %: 1 – control; 2 - 10; 3 - 20; 4 - 30; 5 - 40; 6 - 50.

The curve in Figure 3 shows an increase in the viscosity of the "agar-water-glycerin-honey" solution from 7.6±0.2 to 18.3±0.2 Pa×s, when sesame flour is added in the interval 10...50 % in steps of 10%. It was found that the viscosity of the solution containing 1% agar, 2% glycerin and 25% honey without the addition of sesame flour is 7.6±0.2 Pa×s. When 10, 20, and 30% sesame flour is added to the solution, its viscosity increases by 9.0±0.2; 11.2±0.2 and 13.8±0.2 Pa×s. Further addition of flour in amounts of 40 and 50% leads to an increase in viscosity by 16.0±0.2 and 18.3±0.2 Pa×s, respectively.

It was established that the addition of sesame flour in an amount of less than 30±2% does not lead to the formation of the desired structure of the filling. An increase in the flour content by more than 30±2% leads to the appearance of a bitter taste and a significant increase in the viscosity of the filling.

In order to confirm the rational concentration of the main recipe components of the jelly bar, which are involved in the gelation processes, a study of the dynamic viscosity (Fig. 4) of "agar-water", "agar-water-glycerin", "agar-water-glycerin- honey" and "agar-water-glycerin-honey-sesame flour" at concentrations of agar 1%, glycerin 0.3%, honey 25%, sesame flour 30%, in the temperature range of 20...60 °C.

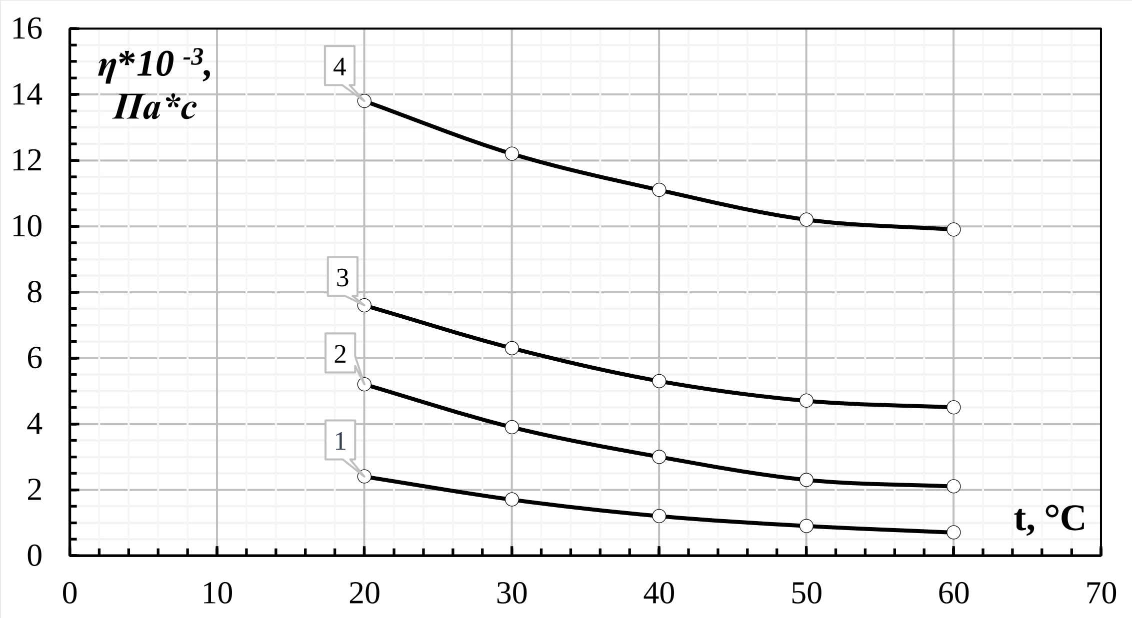

Figure 4. The influence of temperature on the dynamic viscosity of solutions: 1 - "agar-water", 2 - "agar-water-glycerol", 3 - "agar-water-glycerol-honey", 4 - "agar-water-glycerol - honey-sesame flour"

It was found that increasing the temperature in the range of 20...60 °C reduces the dynamic viscosity of the "agar-water" solution by 1.7±0.2 Pa×s, adding glycerol increases the dynamic viscosity to 5.2±0.2 Pa×s at a temperature of 30 °C. The addition of honey and sesame flour leads to an increase in viscosity by 7.6±0.2 Pa×s and 13.8±0.2 Pa×s, respectively, at a temperature of 30 °C.

When less than 1% agar is added, the filling does not acquire the desired structural properties. When adding more than 1.0% of agar, the structure of the filling becomes too elastic, which complicates the further production of bars.

The addition of glycerin in the amount of more than 0.3% leads to a significant increase in the viscosity of the filling, the speed of structural cross-linking and an excessive increase in strength, which complicates the process of mixing the solution for further preparation of the filling.

Reducing the content of honey and sesame flour to less than 25±2% and 30±2%, respectively, leads to a decrease in the amount of dry substances. An increase in the number of the above-mentioned components leads to a deterioration of the taste properties of the finished products.

Conclusions. The influence of concentrations of formulation components and temperature on the viscosity of model systems "agar-water", "agar-water-glycerin", "agar-water-glycerin-honey", "agar-water-glycerin-honey-sesame flour" was studied.

It was found that the addition of 0.3% glycerol to the agar-based solution increases its viscosity, probably due to the synergistic interaction of glycerol with agar and contributes to the formation of a significant number of intermolecular hydrogen bonds.

Therefore, the increase in the viscosity of model systems due to the influence of glycerin occurs due to the binding of free moisture, which provides increased structural viscosity of the filling.

It was also established that when adding honey in the amount of 25±2%, the desired stable structure of the filling is formed. Increasing the honey content leads to a significant increase in viscosity and an overly sweet taste.

The obtained results are of practical importance for calculating and establishing the concentration range of recipe components in the process of production of filling for agar-based jelly bars.

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