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STRUCTURAL AND MECHANICAL PROPERTIES OF TURKISH DELIGHT PRODUCTION USING FRUIT AND VEGETABLE PASTE

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Abstract

The purpose of the study is to determine the structural and mechanical properties of Turkish delight based on the fruit and vegetable paste made from pumpkin, quince and apples, made according to the developed technology. The developed method of production of Turkish delight with fruit and vegetable paste allows to achieve a double effect of the introduction of technology, namely to increase the content of functional ingredients in Turkish delight, as well as to achieve a technological one. Which consists in improved structural and mechanical properties of the locum mass and the finished product, and also allows to achieve original sensory characteristics without the use of dyes and flavorings. The significant content of pectin substances (4.31 % per 100 g) in the fruit and vegetable paste made it possible to achieve a reduction in the recipe content of starch in the technology of Turkish delight. This was confirmed by determining the structural and mechanical properties of the mass and the finished product. Thus, the rational content of starch is set at the level of 80 % of its prescription amount. According to the nature of the curves of the dependence of viscosity on the shear rate and the presence of the ultimate shear stress, locum mass belongs to non-ideally plastic solids. The viscosity index of the locum mass sample with paste and reduced starch content by 20 % has a value similar to the control. Also positive is the shortening of the process of cooking the locum mass in a vacuum-evaporator by 15...20 minutes due to its higher initial dry matter content compared to the control sample. The determination by an expert group of scientists of the indicators of quality in terms of structure and appearance according

to a five-point rating showed that the obtained Turkish delight with paste has better indicators. The developed Turkish delight technology can be recommended for healthy nutrition.

Keywords: Turkish delight, fruit and vegetable paste, viscosity, strength, density, structure formation.

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1. Introduction

Attractive colors, various shapes and unsurpassed sweet taste are the main characteristics that make them chosen and loved by both adults and children. Along with this, confectionery products have a high content of carbohydrates, fats and quite often contain a significant amount of additives that are used to improve organoleptic quality indicators. In recent years, an increasing number of consumers around the world prefer healthier and more natural confectionery products. At the same time, the products must have high quality indicators, such as taste, color, structure and appearance.

Turkish delight is a confectionery product, a representative of the group of oriental sweets, which has existed since ancient times and has a wide geography of consumption at the national and international levels [1]. Turkish delight is marmalade-type products, the basis of which is white sugar and corn starch, with the addition of citric acid [2]. The individual characteristics of Turkish delight are formed by other raw materials added as additives: vanillin, rose oil, fruit and berry puree, tangerine powder, dried walnut kernels, cocoa powder, roasted sunflower kernels, plum extract [3]. For all types, a rectangular or square shape, a surface sprinkled with powdered sugar is provided [2, 3]. At the same time, it is often possible to encounter the fact that manufacturers, trying to make products cheaper, instead of natural raw materials, use various additives that imitate these tastes and colors.

Although the traditional Turkish delight recipes contain starch, sugar and water as raw materials, it is this product that creates opportunities for the development of new types of functional sweets. Raw materials of vegetable origin can be a source of physiologically functional ingredients for oriental sweets.

A modern trend in the development and improvement of confectionery technologies is the use of plant raw materials with a double effect. Thus, plant additives are introduced to give products functional properties that can have a beneficial effect on human health, as well as technological ones – to improve structural-mechanical properties (viscosity, strength) and organoleptic properties (color, taste).

Thus, the technology of making Turkish delight with the addition of cherries and black grape syrup in the amount of 2.5 %, 5.0 %, 7.5 % was proposed. The authors proved the improvement of the structural-mechanical and organoleptic indicators of Turkish delight. Along with this, the use of cherries and grape syrup made it possible to enrich the products with polyphenols and antioxidants, that is, to give them functional properties [4].

The Turkish delight technology has been developed with the addition of different concentrations of cherries and dogwood, which contain healthy components and natural coloring pigments. These fruits were used to enrich Turkish delight with functional substances, as well as to ensure natural color and taste with high quality characteristics [5]. This is also confirmed by studies [5], where the addition of 4.4 and 12.2 % of dogwood pulp obtained in industrial conditions is proposed. The improvement of organoleptic and structural-mechanical quality indicators of Turkish delight with dogwood pulp was established.

Dogwood puree has found its application in domestic technology, but it is already a battered Turkish delight. The authors suggested a partial replacement of apple puree with non-traditional – dogwood puree. This contributed to increasing the nutritional value of Turkish delight (by the content of potassium, iron, ascorbic acid) and improving the structural and rheological characteristics of the developed products [6].

Quince pulp is used as a food ingredient in Turkish delight technology due to its aroma, color and high nutritional value, primarily pectin substances. The addition of 10 and 15 % of quince

pulp contributed to the preservation of physico-chemical quality indicators, increased elasticity and organoleptic indicators, which allows the production of products without artificial dyes and aromatic substances [7].

The possibility of using carob, orange and carrot pulp as food industry waste, which is rich in dietary fiber and other useful components and beneficial to human health, in the production of Turkish delight was studied. Turkish delight was made by replacing part of the locum mass with dried and crushed carob, orange and carrot pulp in amounts of 3 %, 6 % and 9 %. This contributes to the increase in the content of functional ingredients while maintaining high quality, while it is possible to reduce the sugar content in Turkish delight by 7.8 %, 8.1 % and 8.2 %, respectively [1].

Pomegranate fruits and products of its processing (juice and pomegranate seeds) have been widely used in Turkish delight technologies [8–10]. The use of the entire assortment of these raw materials proved the perspective of using pomegranate and its processing products as both a functional ingredient (high content of antioxidants) and a technological one (improvement of organoleptic and structural-mechanical properties) in Turkish delight technologies.

The possibility of using green tea in Turkish delight technology to improve its biological value has been determined. The use of green tea makes it possible to give good organoleptic properties to Turkish delight and to enrich it with vitamins P, C, group B [11].

The analysis of the given data shows the importance of the formation of the structure of Turkish delight. Other ways to ensure a good Turkish delight structure are the use of citrus pectin, microbial polysaccharides [12, 13], modified starches from various grain crops [14], etc. as gelling agents. Thus, during the production of Turkish delight, it is proposed to add diluted soap wort concentrate and reduced soap wort powder, which are obtained by extracting the roots of soap wort in boiling water and are used to improve the color, volume and structural and mechanical properties of some food products. Based on the results of the research, it was found that in terms of color and appearance indicators, all Turkish delight samples meet the requirements of regulatory documentation [15].

Therefore, the development of Turkish delight technologies as a natural food product containing functional ingredients is relevant. The search for new types of plant raw materials as a source of bioactive ingredients for the food industry is one of the primary tasks.

Previous studies [16] substantiated the technology of Turkish delight with a multi-component fruit and vegetable paste made from apples, quince, and pumpkin, which was made using energy-saving equipment. The use of fruit and vegetable paste allows to enrich Turkish delight with a number of functional ingredients, to achieve the effect of a natural product due to the absence of additives. Along with this, the multi-component nature of pastes made from vegetable raw materials creates wide prospects for expanding the range of Turkish delight by changing one ingredient to another. However, one of the issues that arises is the formation of stable structural and mechanical properties of the locum mass and, as a result, the finished product. Especially if it is possible to change the quantitative composition of starch and non-starch polysaccharides in the recipe composition of Turkish delight due to the use of plant raw materials, additional research is needed in this direction.

In this regard, the goal is to determine the influence of fruit and vegetable paste on the structural and mechanical properties of locum mass and finished products.

2. Materials and methods of research

As a control sample, the existing technology of Turkish delight production was used, which includes the following components: sugar, berry or citrus puree (with the addition of citric acid), starch, dye and flavoring. To make a test sample of Turkish delight in the given recipe, puree, dye and flavoring were replaced with fruit and vegetable paste made from pumpkin, quince and apples. Determination of dynamic viscosity and ultimate shear stress of locum mass was carried out on a rotary viscometer Rheotest-2 manufactured in Germany. The measurement error of which is no more than 1 %. The density was measured by a pycnometer with a known volume at a specified temperature and mass of the material under study. Adhesion indicators were determined by an adhesiometer using a method based on the displacement of the adhesive seam when an external force is applied. Sensory evaluation was carried out by an expert group of scientists on a five-point scale.

3. Research results and their discussion

An important indicator during the production of Turkish delight is the structure formation, which is ensured by the content of starch and puree in its recipe. In the developed technology for the production of Turkish delight, puree (berry, fruit or citrus) is replaced by a paste-like concentrated semi-finished product, which is made by reasoned selection of raw materials [16]. Due to the content of a significant amount of pectin substances in the paste-like semi-finished product (4.31 % per 100 g), it is proposed to reduce the starch content in the developed Turkish delight technology to 70 % of the prescribed amount. The starch paste is loaded into a vacuum evaporation apparatus [17], with constant stirring gradually add boiled 70 % sugar syrup to the content of dry substances and mix until a homogeneous consistency is formed, then boil. After that, a paste-like semi-finished product made of pumpkin, quince and apples, acid is added and the mass is concentrated to a mass fraction of dry substances of 80...82 %, the resulting locum mass is poured into molds for proofing. A feature of the proposed technology is the absence of dye and flavoring, the technological effect of which is provided by the use of fruit and vegetable paste.

To determine the optimal percentage content of starch in the developed Turkish delight technology, the structural and mechanical indicators of locum mass samples were studied with a complete replacement of puree for a pasty semi-finished product and a reduced content of the recipe amount of starch from 100 to 70 % (**Fig. 1**).

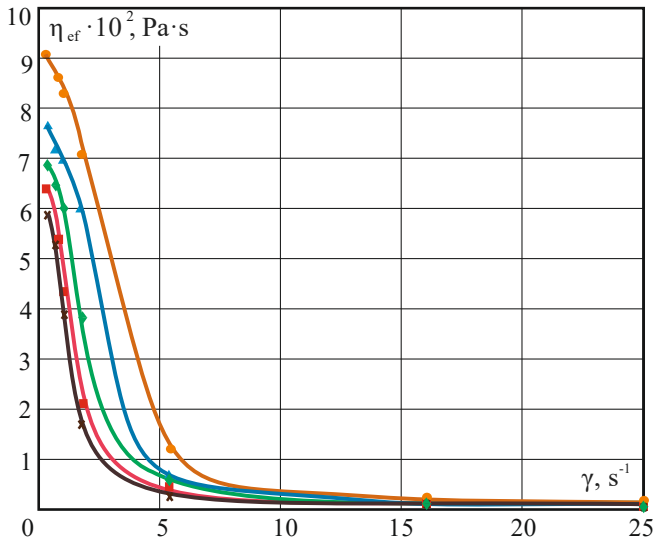

Fig. 1. Dependence of the viscosity of locum mass samples on the shear rate at a temperature of 27...30 °C: ■ – control; mass with fruit and vegetable paste and starch content, %; ● – 100; ▲ – 90; ♦ – 80; ✕ – 70

An experimental sample of Turkish delight with 100 % replacement of mashed potatoes with a concentrated fruit and vegetable semi-finished product has the maximum viscosity of the intact structure at the beginning of the application of the shear force – 907 Pa·s. When the percentage of starch content decreases, the viscosity of the locum mass samples decreases. At a starch content of 70 %, the viscosity is less than that of the control sample, so its further reduction is not advisable. The optimal percentage value of the amount of starch is chosen to be 80 % at a viscosity of 690 Pa·s. These results are confirmed by previously obtained data on the strength of ready-made Turkish delight with a decrease in the amount of starch [16].

Therefore, as a result of the study of the structural and mechanical properties of the locum mass, let's consider the optimal amount of reducing the starch recipe by 20 %.

An important aspect during the production of fruit and vegetable semi-finished product is the use for concentration of the improved design of the rotary evaporator, which allows the process to be carried out for a short time of up to 30 seconds and, unlike traditional evaporators, has a re-

duction in the specific consumption of raw materials. In comparison with a vacuum evaporator of periodic action, the reduction of specific heat consumption reaches 30 %.

Therefore, the use of a concentrated fruit and vegetable pasty semi-finished product made using low-temperature temperature regimes in Turkish delight technology not only enriches its nutritional value, but also helps shorten the cooking process while simultaneously saving energy. Reduction of the process of cooking the locum mass is achieved due to its higher initial content of dry substances compared to the control sample. That is, the cooking time of the recipe mixture in the vacuum evaporation apparatus is reduced by 15...20 minutes. It should be noted that the technological and equipment potential of the production of fruit and vegetable paste allows to concentrate it to a DM content of up to 70 %. The use of highly concentrated up to 70 % DM paste in Turkish delight technology will allow to shorten the process of cooking the recipe mixture even more significantly. Along with this, one of the processes that takes place is an increase in the content of structure-forming pectins, which makes it possible to achieve a decrease in the percentage of starch.

Summary data of the structural and mechanical characteristics of locum mass are given in the **Table 1**.

Table 1

Structural and mechanical parameters of locum mass samples

Indicator	Control (no additives)	Locum mass with fruit and vegetable paste and a 20 % reduction in the recipe amount of starch
Ultimate shear stress, Pa	213.8±1.06	227.7±1.13
Dynamic viscosity, Pa·s	648.0±3.24	690.0±3.45
Density, g/cm^3	1.41±0.05	1.45±0.05
Adhesion, kPa	7.12±0.35	7.14±0.35

The test and control samples of locum mass have a shear limit stress that characterizes their belonging to a non-Newtonian fluid, namely to non-ideally plastic solids. The ultimate shear stress of the experimental sample is higher by 13.9 Pa, which indicates its stronger structure. This is also confirmed by the index of dynamic viscosity of the locum mass with paste, which is greater and differs by 6.4 % from the control.

Samples of Turkish delight with fruit and vegetable paste and controls have the ultimate shear stress, which characterizes their belonging to a non-Newtonian liquid, namely to non-ideally plastic solids. The ultimate shear stress of the experimental sample is higher by 13.9 Pa, which indicates its stronger structure. This is also confirmed by the index of dynamic viscosity of the locum mass with paste, which is greater and differs by 6.4 % from the control.

In terms of density and adhesion, the samples have almost the same indicators, which indicates the absence of problems during molding, that is, the products will be easier to remove from the molds and less deformed during transportation.

The obtained data on the locum mass were confirmed by determining the strength, structure and appearance indicators (**Table 2**)

Table 2

Indicators of the quality of Turkish delight samples

Indicator	Control	Turkish delight with fruit and vegetable paste and a 20 % reduction in the recipe amount of starch
Strength, kPa	36±0.5	38±0.5
Structure and appearance	4.55±0.05	4.87±0.06

The sample with the addition of 80 % starch has a strength close to the control and equal to 38 kPa. Therefore, based on the results of determining the structural and mechanical indicators of the locum mass and finished products, let's consider it rational to completely replace the puree with fruit and vegetable paste and reduce the recipe amount of starch by 20 %.

According to the evaluation of the structure and appearance, on a five-point scale, the Turkish delight with paste has better indicators. Thus, the developed technology for making Turkish delight contributes to the formation of a stronger structure with increased viscosity and ultimate shear stress.

Among the limitations of the research is the approbation of the obtained results only on the proposed fruit and vegetable pasty semi-finished product, which in turn allows to obtain the predicted structural and mechanical indicators. Therefore, during practical implementation with the use of other prescription fruit and vegetable pastes, it is necessary to determine the changes in structure formation in advance. Further research will be aimed at forming a generalized informative base regarding the influence of the content of the amount of fruit and vegetable pasty semi-finished products in the production of Turkish delight, taking into account the quality and color properties obtained.

4. Conclusions

A method of production of Turkish delight with fruit and vegetable paste made from pumpkin, quince and apples is proposed. This makes it possible to achieve a double effect of the introduction of the technology, namely to increase the content of functional ingredients in Turkish delight, as well as to achieve a technological one. It consists in improving the structural and mechanical properties of the locum mass and the finished product, as well as achieving original sensory characteristics without the use of dyes and flavors. The significant content of pectin substances (4.31 % per 100 g) in the fruit and vegetable paste made it possible to achieve a reduction in the recipe content of starch in the technology of Turkish delight. This was confirmed by determining the structural and mechanical properties of the mass and the finished product. Thus, according to the nature of the curves of the dependence of viscosity on the shear rate and the presence of the ultimate shear stress, it is established that the locum mass belongs to non-ideally plastic solids. The viscosity index of the locum mass sample with paste and reduced starch content by 20 % has a value similar to the control.

Conflict of interest

The authors declare that there is no conflict of interest in relation to this paper, as well as the published research results, including the financial aspects of conducting the research, obtaining and using its results, as well as any non-financial personal relationships.

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Data availability

Data will be made available on reasonable request.

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