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***Slashcheva A. V.**, PhD in Engineering sciences, Associate Professor*
***Bodnaruk O.A.,** assistant*
***Zakusilo T. I.,** a graduate of a master's degree*
***Dengub A. D.**, a graduate of a bachelor degree*

Donetsk National University of Economics and Trade named after Mykhailo Tugan-Baranovsky (Krivyi Rig, Ukraine), e-mail: slashcheva@donnuet.edu.ua

TECHNOLOGY OF THERMO-RESISTANT FILLING WITH BIOPROTECTIVE ACTION FOR CONFECTIONERY PRODUCTS

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***Слащева А. В.,** канд. техн. наук, доцент*
***Боднарук О. А.,** асистент*
***Закусило Т. І.,** здобувач СВО магістра*
***Деньгуб А. Д.**, здобувач СВО бакалавра*

Донецький національний університет економіки і торгівлі імені Михайла Туган-Барановського (м. Кривий Ріг, Україна), e-mail: slashcheva@donnuet.edu.ua

ТЕХНОЛОГІЯ ТЕРМОСТІЙКОЇ НАЧИНКИ БІОПРОТЕКТОРНОЇ ДІЇ ДЛЯ КОНДИТЕРСЬКИХ ВИРОБІВ

***Objective** is to develop a technology for a thermostable filling based on pumpkin and Jerusalem artichoke with a high content of low-esterified pectins, to study its organoleptic indicators and complexing ability for some toxic metals (zinc, nickel, cadmium, lead).*

***Methods.** Sampling was carried out in accordance with the requirements of DSTU ISO 874-2002, sample preparation for laboratory analysis was carried out in accordance with DSTU 7040:2009. The determination of toxic elements was carried out: cadmium – according to DSTU ISO 6561:2004, lead – according to DSTU ISO 6633:2001, arsenic – according to DSTU ISO 6634:2004, zinc – according to DSTU ISO 6636-2:2004, mercury – according to DSTU ISO 6637:2001.*

***Results.** The technology of thermostable filling was theoretically substantiated, the technological feasibility of using pumpkin and Jerusalem artichoke puree in the technologies of thermostable fillings was determined; rational recipes of thermostable filling were determined in order to obtain products with specified structural and mechanical indicators; rational parameters of thermostable filling production were investigated; recommendations for the use of filling in confectionery technologies were developed; protective properties of the new thermostable filling were investigated. Original technologies of confectionery products using thermostable filling "Orange" were developed, namely: shortcrust pastry, crumble, muffin, puff pastry "Orange Flower". The results of the study of the complexing ability in relation to heavy metals (zinc, nickel, lead, cadmium) indicate that cations of all four metals form insoluble complexes with polysaccharides of the filling ingredients, as evidenced by a significant decrease in their concentration in the initial solution. The obtained data allow us to conclude that the use of the developed thermostable filling makes it possible to obtain confectionery products with protective action.*

***Keywords:** technology, thermostable filling, low-esterified pectin, pumpkin, Jerusalem artichoke, complexing ability, bioprotective properties.*

Formulation of the problem. Bakery and flour confectionery products with fillings and layers are in great demand among the population. Taking this into account, domestic and foreign suppliers offer a wide range of fillers for various areas of application, including fillers using modified expensive pectins. Heat-stable fillings, as components of bakery and flour confectionery products, must first of all have a jelly consistency, which is achieved by adding special structure-forming components - pectins, as well as other structure-forming agents [1].

However, the technology for producing heat-stable fillings using highly esterified pectins in their recipe limits their production, since at a sufficiently high gelling temperature of these pectins, very strong gels are formed. At the same time, the heat-stable properties of such gels completely depend on the integrity of their structure, i.e. the destruction of the structure during mechanical action (for example, pumping) leads to a complete loss of heat stability. In this case, the filler on highly esterified pectins boils, deforms and flows out of the product. Therefore, special low-esterified pectins are used for large-scale industrial production. The consistency of these fillers retains its shape under various mechanical influences [2, 3].

Fruits and vegetables contain a large number of biologically active substances and their introduction into various food products in one form or another leads to an increase in nutritional and biological value, as well as a change in the technological properties of the final products. Therefore, both the fruits and vegetables themselves and the products of their processing are often used for this purpose by specialists in the dairy, bakery and a number of other sectors of the food industry [4-6]. The introduction of fruit and vegetable raw materials is carried out in two directions: directly into the product to change the technological parameters or for decoration in the form of fillers or layers. Unfortunately, vegetable raw materials have not found application as heat-stable fillers due to their relatively low functional and technological properties, in particular, gelling ability. The disadvantage of vegetable raw materials is that they contain medium-esterified pectins, which affects the functional and technological properties of fillers based on them. However, vegetable pectins, due to the presence of a large number of free carboxyl and hydroxyl groups, have a more powerful complexing ability with respect to toxic elements, radionuclides, pesticides, phenols, etc., compared to fruit and berry raw material pectins.

Vegetable raw materials also have other advantages: high shelf life, relatively low cost. Pumpkin and Jerusalem artichoke, under appropriate conditions, can be stored for a long time without losing their beneficial properties. Vegetables contain more dietary fiber, in particular, protopectins, compared to fruit and berry raw materials, which allows reducing the amount of artificially introduced components to increase water-binding capacity and form a strong spatial structure when creating filler recipes. Thus, vegetable raw materials may have great potential for use in recipes for heat-stable fillers with increased complexing capacity, provided that an effective method for activating the pectins of this raw material by reducing the degree of esterification is proposed, and the introduction of additional ingredients (except for modified pectin preparations) is scientifically substantiated, allowing the fillers to retain their organoleptic and physicochemical properties under baking conditions at high temperatures.

We propose one of the directions for improving the technology of confectionery products by using thermostable fillings based on plant raw materials with protective properties, namely: pumpkin and Jerusalem artichoke as sources of fiber, low-esterified pectins and carotenoids. Plant fiber and some types of pectins are characterized by the ability to bind poorly soluble complexes of radionuclides, heavy metals, nitrates and other toxic compounds and remove them from the human body, carotenoids are a powerful antioxidant and have immunostimulating and adaptogenic effects.

Analysis of recent research and publications. A number of scientists and researchers are actively involved in the development of protective products, as evidenced by a large number of patents, articles and other scientific works. A significant contribution to the study of these issues belongs to a number of scientists: L.M. Telezhenko, L.P. Malyuk, R.Yu. Pavlyuk, G.P. Khomych, N.M. Osokina, N.I. Tkach, I.V. Pylypenko and others. Most of the developments provide for the introduction of fruit and berry and vegetable raw materials (juices, purees, stews, pomace, powders), vegetable oils, extracts of medicinal herbs, bran of cereal crops, etc. into the formulations [1-4].

Heat-stable fillings are used to make a variety of baked goods, including cookies, muffins, buns, gingerbread, pies, cakes and other products that require flour. Unlike regular fillings, such as classic jam, heat-stable fillings are able to maintain their structure under the influence of high temperatures. This also applies to taste characteristics. They complement baked goods, making them more diverse in terms of taste and consistency. Regular fillings are absorbed into the dough, burn and leak out. Fruit, berry and vegetable fillings are a popular and long-loved semi-finished product in the food industry: their refreshing sour taste and relatively high moisture content favorably emphasize the quality and expand the range of food products. Recently, in the production of flour products, fillings with heat-stable characteristics have become increasingly popular. Such fillings have a pronounced jelly consistency, are made using special technologies with the use of special structure-forming components and retain their properties (shape, texture, mass fraction of dry substances, pH) under normal baking conditions (convection method at a temperature of 210-230 °C for 20 minutes). At the same time, heat-stable fillings are the most difficult in technological terms to produce and use [5]. On the one hand, when using fruit and berry or vegetable fillings, the manufacturer of flour products tries to satisfy the desire of buyers to consume healthier products from natural plant materials while maintaining an affordable price. And on the other hand, an important technological task when using such fillings is to preserve their original volume and consistency, which is associated with the problem of binding fruit / vegetable juice or sugar-fruit syrup, which are formed in excess during heat treatment, and keeping it in a bound state during storage of flour products. Finished heat-stable fillings should have: pronounced color, aroma and taste of the fruit raw materials used; jelly-like consistency and absence of fluidity; preservation of structure during mixing and/or pumping; absence of jelly lumps or clots; characteristic stickiness from the inner wall of the container; absence of syneresis (water release and phase separation) during storage of the filling or under mechanical action; the possibility of use for a wide range of bakery and confectionery products [6, 7].

It is known that low-esterified pectins have a high complexing ability with respect to heavy metals. A promising source of these substances is pumpkin and Jerusalem artichoke, the use of which is limited in the confectionery industry due to the low gelling ability of their pectins, especially in the world of their use as a basis for confectionery fillings. Therefore, the development of new heat-stable fillings based on them is relevant and timely. The developed products can be recommended for therapeutic and prophylactic nutrition in conditions of harmful production and protective nutrition of residents of environmentally hazardous regions with developed industry.

Objective of the article is the development of a technology for a thermostable filling based on pumpkin and Jerusalem artichoke with a high content of low-esterified pectins and research into its quality indicators and complexing ability towards some metals.

Presentation of the main study material. Thermostable fillings are semi-finished products for the production of flour confectionery products (cookies, gingerbread, etc.), which are formed by jigging or co-extrusion, are located inside or on the surface of the products and are intended for baking together with the dough [8].

There are a number of requirements for thermostable fillings, the main ones of which are the following. They must easily form a jelly-like structure, retain their shape during baking – not to spread, not to deform the flour semi-finished product, not to boil [9]. They must also firmly retain moisture during cooling and storage of products. This is achieved by introducing moisture-retaining components into their formulation. To increase the nutritional and biological value, it is proposed to use pectin-containing pumpkin puree and Jerusalem artichoke puree as the main component of thermostable fillings. The presence of carotenoids in the pumpkin puree of the “Prikubanskaya” variety gives the puree a bright orange color, which is also transmitted to the finished thermostable filling and eliminates the use of artificial dyes in this technology. To ensure thermostable, it is proposed to use low-esterified pectin with a degree of esterification of 31-36%, which has a number of advantages compared to other structure-forming agents. Preparation of this thermostable filling includes the following operations: mixing pectin, calcium citrate with 100 g of sugar (from the total amount of sugar); heating the resulting mixture together with the puree until the pectin is completely dissolved; adding the remaining sugar, molasses, setting the required pH value by adding a solution

of citric acid; cooling to a pouring temperature of 50-60°C, pouring the filling. With an overdose of calcium ions, calcium pectinate is formed, which precipitates, the so-called premature gelling occurs. The concentration of calcium citrate in the filling was varied from 0.02 to 0.16%. A sample without the addition of the named salt served as a control.

Based on this recipe, a technological scheme was developed (Fig. 1).

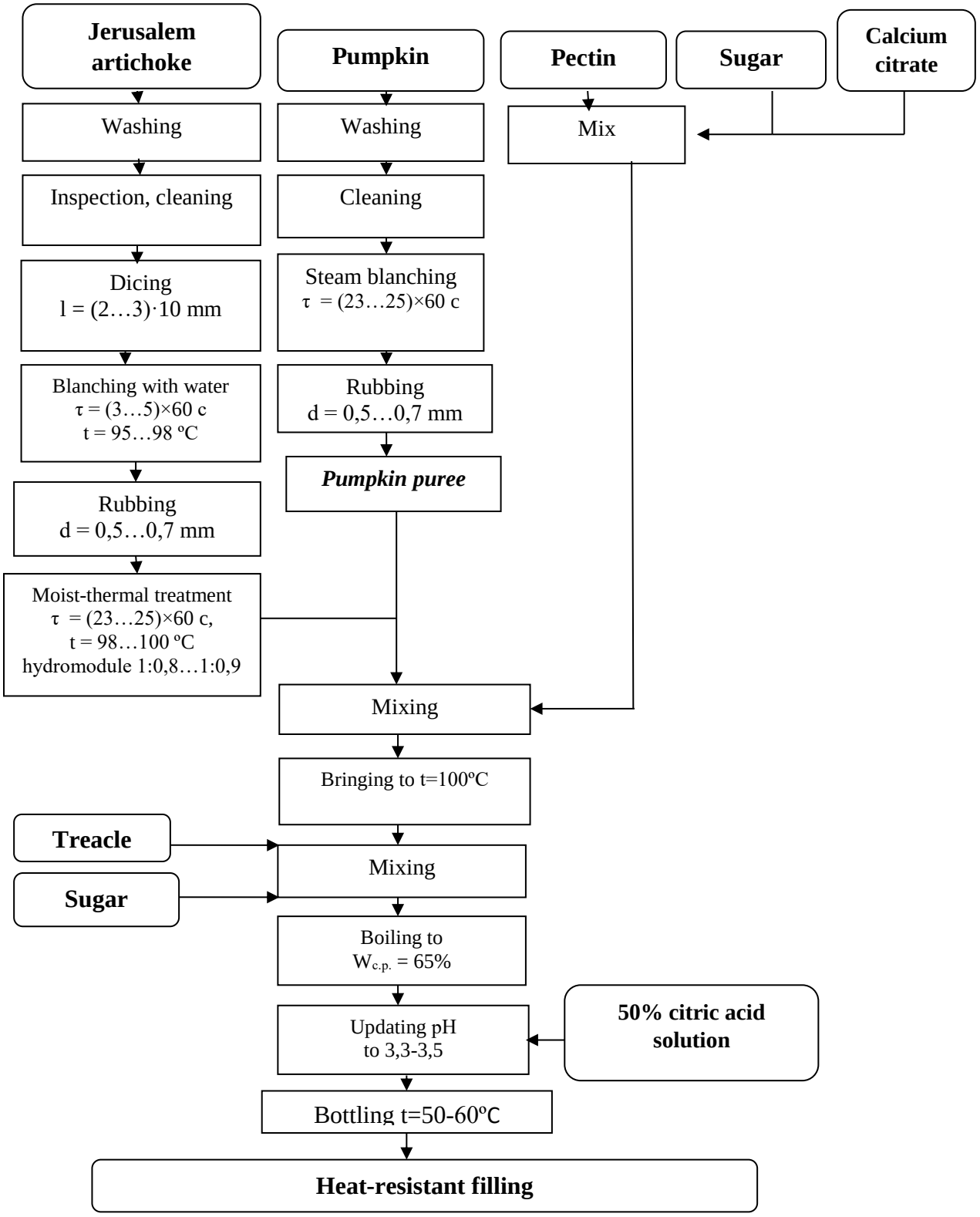

Figure 1 – Technological scheme of thermostable filling

Table 1 – Organoleptic characteristics of thermostable filling

Indicator name	Characteristic
Appearance	Homogeneous mass
Consistence	Homogeneous, dense, plastic
Color	Suitable for the raw material used, glossy
Taste and smell	Sweet, appropriate to the raw materials used, without foreign odor or taste

Original confectionery technologies using the thermostable filling "Orange" have been developed, namely: shortcrust pastry "Orange Dream", crumble "Orange Sun", puff pastry "Orange Flower", "Orange Muffin".

Analysis of literature sources showed that pectin obtained from Jerusalem artichoke, unlike pectin from pumpkin, is capable of forming weak gels, but is characterized by increased complex-forming ability. Therefore, we consider it advisable to combine these types of pectins to obtain a product with high functional and technological properties.

Pectic substances are capable of complexation, i.e., they are capable of entering into insoluble compounds with divalent metal ions. It is known that the complex-forming ability of pectins increases with a decrease in the degree of esterification, since low-esterified pectins have a greater number of reactive bonds not substituted by metaxylated groups [10-12]. Therefore, in the acidic environment of gastric juice (pH=1.8-2.0), low-esterified pectin degrades to a much lesser extent than high-esterified pectin, its activity begins to manifest itself already in the stomach, which means earlier and longer contact with metal ions.

Recently, much attention has been paid to the anticarcinogenic effect of polysaccharides that are able to adsorb various exo- and endotoxins, heavy metals. This property of polysaccharides is widely used in therapeutic and prophylactic nutrition, for example, for the prevention of lead intoxications. We were interested in whether the developed thermostable filling "Orange" has a complexing ability for nickel, zinc, cadmium and lead cations. The thermostable filling from the company "Puratos", widely used in Ukrainian enterprises, was chosen as a control.

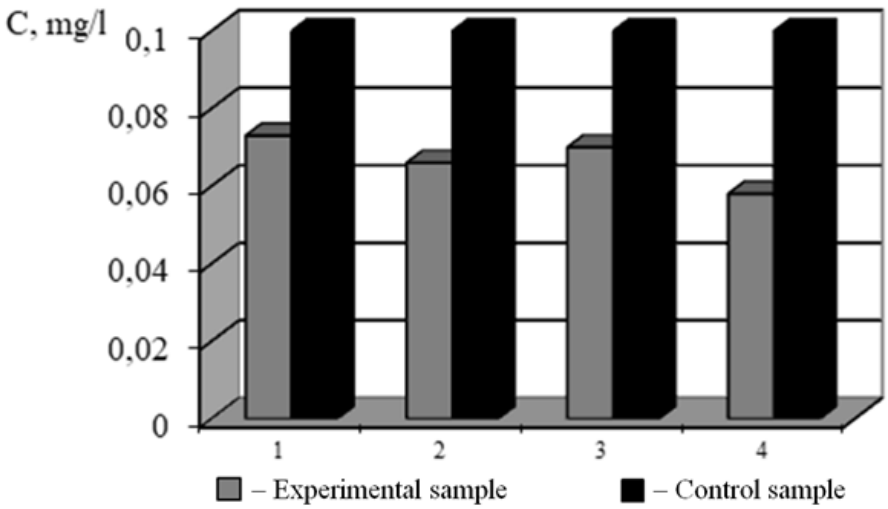

Figure 2 – Dependence of metal concentration in solutions on the presence of a thermostable filling (1 – Zn^{2+} , 2 – Ni^{2+}, 3 – Pb^{2+}, 4 – Cd^{2+})

It was found that cations of all four metals form insoluble complexes with polysaccharides of the filling, as evidenced by a significant decrease in their concentration in the initial solution. The results of this study allow us to conclude that the addition of Jerusalem artichoke to the main raw

material makes it possible to obtain functional products of reduced calorie content with the content of a valuable complex of biologically active substances that contribute to the binding and excretion of toxicants from the human body.

Conclusions. The technology of thermostable filling has been theoretically substantiated, the technological feasibility of using pumpkin and Jerusalem artichoke puree in the technologies of thermostable fillings has been determined; rational recipes of thermostable filling have been determined in order to obtain products with specified structural and mechanical indicators; rational parameters of thermostable filling production have been investigated; recommendations for the use of filling in confectionery technologies have been developed; the protective properties of the new thermostable filling have been investigated. The new product can be recommended for use by all people, but especially those who live in industrial zones or work in hazardous industries. In the future, it is planned to conduct in vivo experiments to identify the radioprotective properties of the filling and the possibility of recommending it for use in areas with increased radiation exposure.

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Мета *– розробка технології термостабільної начинки на основі гарбуза та топінамбуру з високим вмістом низькоетерифікованих пектинів, дослідження її органолептичних показників та комплексоутворюючої здатності щодо деяких токсичних металів (цинку, нікелю, кадмію, свинцю).*

Методи. *Відбір проб проводився згідно з вимогами ДСТУ ISO 874-2002, готування проб до лабораторних аналізів – згідно ДСТУ 7040:2009. Визначення токсичних елементів здійснювалося: кадмію – за ДСТУ ISO 6561:2004, свинцю – за ДСТУ ISO 6633:2001, миш'яку – за ДСТУ ISO 6634:2004, цинку – за ДСТУ ISO 6636-2:2004, ртуті – за ДСТУ ISO 6637:2001.*

Результати. *Теоретично обґрунтувано технологію термостабільної начинки, визначено технологічну доцільність використання пюре гарбуза і топінамбура в технологіях термостійких начинок; визначено раціональні рецептури термостійкої начинки з метою отримання продукції із заданими структурно-механічними показниками; досліджено раціональні параметри виробництва термостабільної начинки; розроблено рекомендації щодо використання начинки в технологіях кондитерських виробів; досліджено протекторні властивості нової термостабільної начинки. Розроблено оригінальні технології кондитерських виробів з використанням термостабільної начинки «Оранж», а саме: пісочний тарт, крамбл, мафін, листкове тістечко «Оранжева квітка». Результати дослідження комплексоутворюючої здатності по відношенню до важких металів (цинку, нікелю, свинцю, кадмію) свідчать, що катіони всіх чотирьох металів утворюють з полісахаридами інгредієнтів начинки нерозчинні комплекси, про що свідчило значне зниження їхньої концентрації у вихідному розчині. Отримані дані дають нам можливість зробити висновок, що використання розробленої термостабільної начинки дає можливість одержання кондитерських виробів протекторної дії.*

Ключові слова: *технологія, термостабільна начинка, низькоетерифікований пектин, гарбуз, топінамбур, комплексоутворююча здатність, біопротекторні властивості.*