

IMPROVEMENT OF THE MANUFACTURING METHOD OF SEMI-FINISHED FRUIT AND VEGETABLES OF A HIGH DEGREE OF READINESS

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Abstract

The method of production of concentrated fruit and vegetable semi-finished product based on apples, Jerusalem artichoke and quince has been improved. Selected components of plant raw materials are chosen due to the presence of such useful substances as pectins, vitamins, minerals, etc. The obtained semi-finished products of a high degree of readiness are semi-finished products with a natural nutrient composition. A feature of the proposed method is the use of low-temperature modes of concentration and drying of raw materials. For the developed method, the hardware set of the line with the use of advanced thermal equipment was selected. Chopped raw materials are blanched in a universal multifunctional device: apple and Jerusalem artichoke in a steam environment (103 °C and 108 °C) for 4 and 8 minutes. Quince is blanched under conditions of pre-exposure in a 0.1 % solution of citric acid in an aqueous medium at a temperature of 75...80 °C (4...8 min.).

Concentration to a pasty state takes place in the improved design of the rotary-film apparatus with a reduced processing time of 0.75...1.25 s to a DM content of 28...30 %. To obtain a powdery state, a cylindrical IR dryer was used for drying to the final moisture content at the level of 4...6 % DM. It is also possible to dry the extracts formed after wiping the raw materials to a final moisture content of 10...13 % DM in an IR dryer. The use of low-temperature regimes in the range of 45...60 °C helps to obtain high-quality semi-finished products with maximum preservation of the initial properties of raw materials. By means of organoleptic evaluation, the best experimental sample with the content of blend components was found: apple 40 %; Jerusalem artichoke 35 %; quince 25 %. Developed semi-finished products are additives or fillers in various food products to improve their nutritional value.

Keywords: fruit and vegetable semi-finished product, concentration, drying, paste, powdered fraction, apple, Jerusalem artichoke, quince.

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1. Introduction

The ever-increasing interest of the population in products containing natural ingredients requires the improvement of methods of production of semi-finished products [1]. A special place among natural ingredients is occupied by semi-finished products from fruits and vegetables with

a wide range of their applications [2]. In the food industry, concentrated vegetable semi-finished products are used in confectionery, dairy, bakery and other industries. The consumption of such food products prevents many diseases, increases the immune system, and contributes to strengthening the health of the population [3].

An urgent task of the food industry is the development of resource-saving methods of production of semi-finished products of plant origin with the necessary predefined properties to increase the activity of the body's protective forces and normal human life [4]. It is known that fruit and vegetable raw materials contain a large amount of vitamins, mineral and pectin substances, phytosterols, etc. [5].

There is a growing trend in the production of various plant-based concentrated semi-finished products in paste and powder form, which is due to their high content of physiologically functional ingredients [6]. The use of innovative thermal equipment with the use of gentle temperature regimes creates conditions for the preservation of useful substances in semi-finished products. The high-quality semi-finished products obtained in this way are good components or the basis of confectionery, bakery, dairy and meat products, fast food products, production of tablets, granules, herbal teas [7].

The widespread introduction of new methods and hardware design of the production of fruit and vegetable semi-finished products with a high degree of readiness will contribute to the expansion of the range of food products based on them with high nutritional and biological value.

An irreplaceable natural resource for expanding the range of food products, which are distinguished by increased nutritional and biological value, are various fruits and vegetables [8], the processing of which allows obtaining pastes and powder-like fractional semi-finished products and finished products.

The production of vegetable pasty and powder-like semi-finished products of a high degree of readiness for a wide range of applications makes it possible to ensure the population's consumption of such products more evenly throughout the year and to create the necessary reserves. Concentrated semi-finished products in the form of blended multicomponent pastes and powders are indispensable natural components with a large number of various useful substances, which also contribute to structure formation and improve the color and taste of food products [9, 10].

The aim of research is to improve the method of production of fruit and vegetable semi-finished product with a high degree of readiness based on apple of the "Antonivka" variety, Jerusalem artichoke of the "White" variety, and quince of the "Aromatna" variety. The obtained paste is a semi-finished product for independent use and as a natural nutrient admixture in the recipes of various food products (confectionery, meat, dairy, etc.), ensuring the minimization of the use of synthetic recipe components.

The rational introduction of fruit and vegetable semi-finished product with the selected recipe ratio and predicted structural and mechanical properties allows to increase the nutrient composition of food products, thereby increasing the nutritional value. Forms the original organoleptic properties of the semi-finished product in blending conditions and preserves natural ingredients due to gentle heat and mass exchange operations, increasing the competitiveness of the production complex [11].

Apples have a bright taste and unique aroma. They contain 26 mg of vitamin C, 0.7 g of dietary fiber, and other bioactive components that are so necessary for humans. The low percentage of sugar in the apples of the "Antonivka" variety is an indisputable factor and indicates a small proportion of calories and the benefit of the fruit is 44 kcal [12].

Jerusalem artichoke is a natural source of various nutrients necessary for the formation of a healthy diet, and cranberry has natural curative and preventive and original organoleptic properties. In particular, the energy value of 100 g of Jerusalem artichoke is 57.3 kcal. Jerusalem artichoke tubers have a significant content of natural nutrients, including (per 100 g): protein 2 g, inulin 14–20 g, sugar substitute – fructose 2.56 g, phytosterols 9.0 mg, vitamins (B1, B2, B3, B6, B9, C, PP), etc. [13]. Clinical studies have shown that inulin has pronounced prebiotic properties, is able to lower the level of glucose in the blood, regulate the pH of the intestine, ensuring full absorption of calcium.

The quince fruit contains biologically active substances, including a large amount of malic, citric and tartaric acids. Yes, quince contains (per 100 g): dietary fiber 3.6 g, vitamin C 15...23 mg, there is also iron, zinc, phosphorus, copper, calcium, pectins. Bright yellow fruits contain vitamins C, E, B1, B2, B6, PP and provitamin A in their composition, have antioxidant, antiviral properties. 100 g of the product contains only 57 kcal [14].

In order to achieve the goal of improving the method of producing semi-finished fruit and vegetables with a high degree of readiness based on apple, Jerusalem artichoke and quince, it is proposed to use gentle heat and mass exchange operations. This will make it possible to obtain original competitive semi-finished products of a high degree of readiness with increased nutritional value, original organoleptic properties for increasing the therapeutic and preventive diet without synthetic components in food products [15].

2. Materials and methods of research

The ripe fruit and vegetable raw materials used during the research were collected in the Kharkiv region in 2022, in particular: apple of the “Antonivka” variety, Jerusalem artichoke of the “White” variety, and quince of the “Aromatna” variety, providing natural fruit and vegetable semi-finished products with a high degree of readiness (Fig. 1).

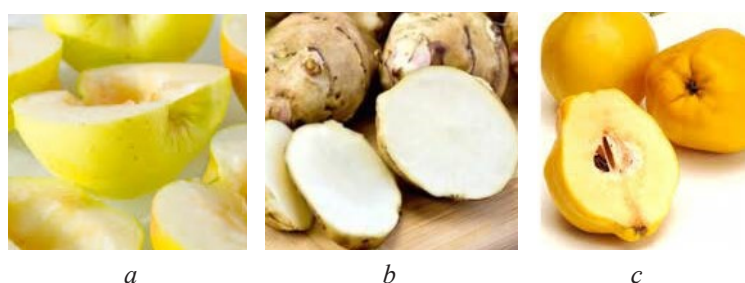


Fig. 1. Appearance of fruit and vegetable raw materials: *a* – apple of the “Antonivka” variety, *b* – Jerusalem artichoke of the “White” variety, *c* – quince of the “Aromatna” variety

Obtaining a fruit and vegetable semi-finished product with a high degree of readiness based on apple, Jerusalem artichoke and quince was implemented according to the proposed basic technological scheme based on gentle heat and mass exchange operations (Fig. 2). At first, ripe raw materials were sent to washing machines, followed by inspection to reject unsuitable raw materials for technological processing. After that, fruit and vegetable raw materials were cut on universal combined devices in the form of rectangles with geometric dimensions of $0.02 \times 0.015 \times 0.03 \cdot 10^{-3}$ m to speed up and improve the quality of further thermal operations.

Chopped raw materials are pre-blanching in a universal multifunctional device: apple and Jerusalem artichoke in a steam environment at temperatures of 103 °C and 108 °C for 4 and 8 minutes, respectively. Quince is blanched under the conditions of preliminary exposure in a 0.1 % solution of citric acid in an aqueous environment at a temperature of 75...80 °C for 4...8 minutes.

After a gentle short-term blanching, the fruits are rubbed on a double rubbing machine to obtain a homogeneous puree-like structure with dimensions from $0.3 \cdot 10^{-3}$ m to $0.6 \cdot 10^{-3}$ m, followed by homogeneous mixing according to the recipe ratio (Table 1).

Table 1

Recipe ratio of multi-component mashed semi-finished products

Recipe and component composition, %	Blend		
	A	B	C
Apple	35	40	45
Artichoke	35	35	35
Quince	30	25	20
Control	100	100	100

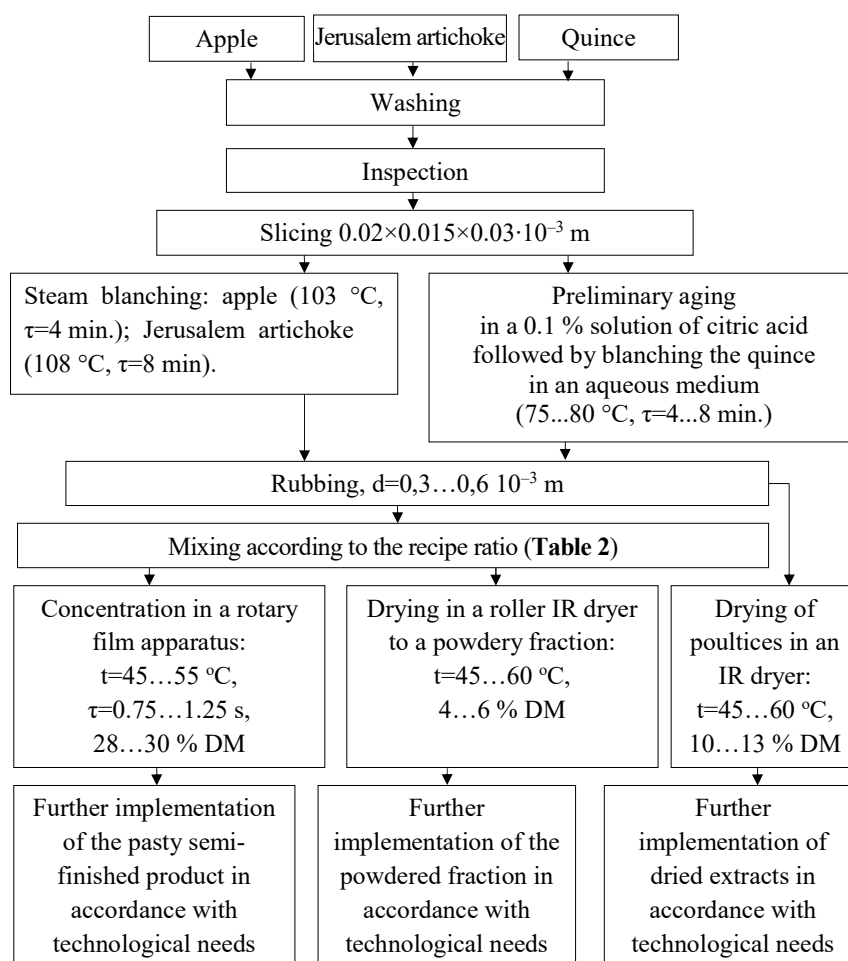


Fig. 2. Schematic diagram of the production of semi-finished fruit and vegetables with a high degree of readiness based on apple, Jerusalem artichoke and quince

A homogeneous blend of fruit and vegetable raw materials according to the proposed technological process can be used for the following heat and mass exchange operations:

- concentration in a rotary-film apparatus at a temperature of 45...55 °C, for 0.75...1.25 seconds and obtaining a dry matted (DM) of 28...30 %;
- drying in a roller IR dryer to a powdery fraction at a temperature of 45...60 °C and a final moisture content at the level of 4...6 % DM;
- drying in an IR dryer at a temperature of 45...60 °C to a final moisture content of 10...13 % DM.

The obtained fruit and vegetable semi-finished products with a high degree of readiness based on apple, Jerusalem artichoke and quince have a final consistency from a pasty semi-finished product to fractionally dried. This will ensure the expansion of the spectrum of use when entering various recipes of food products and increase the competitiveness of these products. The use of gentle heat and mass exchange processes will ensure maximum preservation of natural nutrients in an independent semi-finished product of a high degree of readiness.

Determination of the organoleptic properties of the obtained semi-finished products of a high degree of readiness based on apple, Jerusalem artichoke and quince was carried out by an expert commission of 5 members of the State Biotechnology University.

3. Research results and their discussion

Ripe raw materials (apples, Jerusalem artichokes, quinces) for the production of semi-finished fruit and vegetables with a high degree of readiness enter the container dumper 1. It is loaded

into the universal washing machine 2, where it is cleaned of extraneous impurities and enters the inspection **Table 3** for rejecting unfit raw materials for technological processing.

Cleaned raw materials are directed to a cutting machine with a universal cutting mechanism 4, where it is cut into a rectangular shape with geometric dimensions of $0.02 \times 0.015 \times 0.03 \cdot 10^{-3}$ m for intensification of further thermal operations. After slicing, the fruits undergo preliminary blanching in a universal multifunctional device 6. Apple and Jerusalem artichoke in a steam environment at temperatures of 103 °C and 108 °C for 4 and 8 min, respectively. Quince is blanched in apparatus 5 in a water environment at a temperature of 75...80 °C for 4...8 min, while pre-curing it in a 0.1 % solution of citric acid.

After blanching, the fruits are rubbed on a double rubbing machine 7 to obtain a homogeneous puree-like structure (0.3...0.6 10^{-3} m), with subsequent homogeneous mixing, according to the recipe ratio (**Table 1**) using a paddle mixer 8. A homogeneous fraction according to with the help of gear pumps 9, it is directed to concentration in the rotary-film apparatus 10 at a temperature of 45...55 °C, for 0.75...1.25 seconds. and obtaining a content of 28...30 % DM. After concentration, the mixture is dried in a cylindrical IR dryer 11 to a powdery fraction at a temperature of 45...60 °C, 4...6 % DM and an IR drying apparatus for pomace 12 at a temperature of 45...60 °C to a final moisture content of 10...13 % DM. The basic equipment scheme for the production of semi-finished fruit and vegetables with a high degree of readiness based on apple, Jerusalem artichoke and quince is presented in (**Fig. 3**).

Packaging of fruit and vegetable semi-finished products of a high degree of readiness is carried out in the universal packing and packaging device 13, which allows simultaneous sterilization of pasty semi-finished products and fractional dried semi-finished products in a light-proof container with further sale.

The organoleptic properties of the obtained fruit and vegetable semi-finished products of a high degree of readiness of pasty and dried fractional powder-like semi-finished products were determined (**Table 2**).

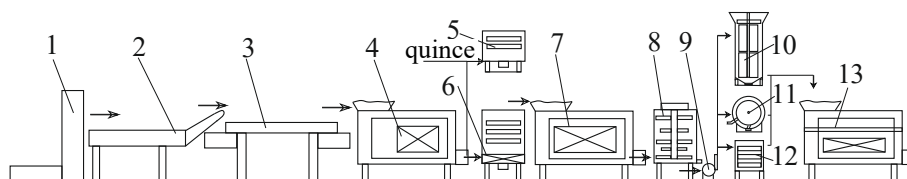


Fig. 3. Basic equipment scheme for the production of semi-finished fruit and vegetables with a high degree of readiness based on apple, Jerusalem artichoke and quince: 1 – container dumper; 2 – universal washing machine; 3 – inspection table; 4 – cutting machine with a universal cutting mechanism; 5 – apparatus for holding in 0.1 % solution of citric acid; 6 – universal multifunctional device; 7 – double wiping machine; 8 – a mixer from a paddle stirrer; 9 – gear pump; 10 – rotary film apparatus; 11 – roller IR dryer; 12 – IR drying apparatus; 13 – universal packaging machine

Table 2

Organoleptic evaluation of pasty and dried fractional powdered semi-finished products

Indicator		Characteristics		
		A	B	C
Appearance	paste	Homogeneous rubbed pasty paste without extraneous inclusions		
	powder	Homogeneous finely dispersed powdery mixture		
Taste and smell	–	The pronounced taste and smell of quince, pleasant apples, Jerusalem artichoke is almost unnoticeable	Pleasant harmonious taste of quince and apples, Jerusalem artichoke is almost not felt	Perceptible smell and taste of quince, pleasant apples, Jerusalem artichoke is almost not felt
Color	paste	Yellow-beige	Light yellow-beige	Beige
	powder	Yellow-brown	Dark yellow-beige	Dark beige
Consistence	paste	Pasty		
	powder	Powdery		

Analyzing the organoleptic properties of the obtained experimental samples of pasty and dried fractional powdered semi-finished products revealed that all samples have good indicators. But in terms of color and taste-aromatic indicators, sample B with the content of apple 40 %, Jerusalem artichoke 35 % and quince 25 % has the advantage.

One of the limitations of the presented research is the need to observe the hardware and technological foundations of the implementation of the proposed method of manufacturing fruit and vegetable semi-finished products with a high degree of readiness, and their neglect will lead to a decrease in the competitiveness of the obtained products.

Prospects for further research will consist in the formation of recommendations for the further rational use of the obtained fruit and vegetable semi-finished products of a high degree of readiness in various recipes of food products.

4. Conclusions

The selection of the components of fruit and vegetable raw materials was carried out under the conditions of taking into account the content of useful substances, pectin, vitamins, minerals, etc., to form an improved method of production of semi-finished fruit and vegetable with a high degree of readiness based on apples, Jerusalem artichoke and quince. To obtain a fruit and vegetable semi-finished product with a high degree of readiness based on fruit and vegetable raw materials, a basic technological scheme of production using gentle heat and mass exchange operations is proposed. A rational selection of the equipment complex of the technological line was carried out with the use of advanced thermal equipment that can provide gentle heat treatment. In particular, concentration to a pasty state occurs in the improved design of the rotary-film apparatus with a reduced processing time of 0.75...1.25 seconds to the 28...30 % DM. To obtain a powdery state, a cylindrical IR dryer was used for drying to the final moisture content at the level of 4...6 % DM. It is also possible to dry the extracts formed after wiping the raw materials to a final moisture content of 10...13 % DM in an IR dryer. The use of low-temperature regimes in the range of 45...60 °C helps to obtain high-quality semi-finished products with maximum preservation of the initial properties of raw materials. By means of organoleptic evaluation, the best experimental sample with the content of blend components was found: apple 40 %; Jerusalem artichoke 35 %; quince 25 %. The developed semi-finished products can be recommended as an additive or filler in various confectionery products in order to improve their nutritional value.

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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The study was performed without financial support.

Data availability

Data will be made available on reasonable request.

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References

- [1] Pylypenko, O. (2017). Development of Ukrainian food industry. Scientific Works of NUFT, 23 (3), 15–25. Available at: http://nbuv.gov.ua/UJRN/Npnukht_2017_23_3_4
- [2] Bucher, T., van der Horst, K., Siegrist, M. (2013). Fruit for dessert. How people compose healthier meals. *Appetite*, 60, 74–80. doi: <https://doi.org/10.1016/j.appet.2012.10.003>

- [3] Munekata, P. E. S., Pérez-Álvarez, J. Á., Pateiro, M., Viuda-Matos, M., Fernández-López, J., Lorenzo, J. M. (2021). Satiety from healthier and functional foods. *Trends in Food Science & Technology*, 113, 397–410. doi: <https://doi.org/10.1016/j.tifs.2021.05.025>
- [4] Misra, N. N., Koubaa, M., Roohinejad, S., Juliano, P., Alpas, H., Inácio, R. S. et al. (2017). Landmarks in the historical development of twenty first century food processing technologies. *Food Research International*, 97, 318–339. doi: <https://doi.org/10.1016/j.foodres.2017.05.001>
- [5] Cherevko, O. I., Mykhailov, V. M., Kiptela, L. V., Zakharenko, V. O., Zahorulko, O. Ye. (2015). Protsey vyrobnytstva bahatokomponentnykh past iz orhanichnoi syrovyny. *Kharkiv: KhDUKhT*, 167.
- [6] Marcus, J. B. (2013). Life Cycle Nutrition: Healthful Eating Throughout the Ages. *Culinary Nutrition*, 475–543. doi: <https://doi.org/10.1016/b978-0-12-391882-6.00011-x>
- [7] Ruiz Rodríguez, L. G., Zamora Gasga, V. M., Pescuma, M., Van Nieuwenhove, C., Mozzi, F., Sánchez Burgos, J. A. (2021). Fruits and fruit by-products as sources of bioactive compounds. Benefits and trends of lactic acid fermentation in the development of novel fruit-based functional beverages. *Food Research International*, 140, 109854. doi: <https://doi.org/10.1016/j.foodres.2020.109854>
- [8] Pap, N., Fidelis, M., Azevedo, L., do Carmo, M. A. V., Wang, D., Mocan, A. et al. (2021). Berry polyphenols and human health: evidence of antioxidant, anti-inflammatory, microbiota modulation, and cell-protecting effects. *Current Opinion in Food Science*, 42, 167–186. doi: <https://doi.org/10.1016/j.cofs.2021.06.003>
- [9] Asortyment plodovo-yahidnykh konserviv. Available at: <https://foodtechnology.pro/tehnologiya-pererobki-plodiv-ta-vochiv/asortiment/asortyment-plodovo-yagidnih-konserviv>
- [10] Mykhailov, V., Zahorulko, A., Zagorulko, A., Liashenko, B., Dudnyk, S. (2021). Method for producing fruit paste using innovative equipment. *Acta Innovations*, 39, 15–21. doi: <https://doi.org/10.32933/actainnovations.39.2>
- [11] Pavlyuk, R. Yu., Cherevko, A. I., Ukrainets, A. I. et al. (2003). Novye fitodobavki i ikh ispol'zovanie v produktakh pitaniya. *Kharkiv; Kyiv: Khar'k. gos. un-t pitaniya i trgovli; Kievsk. nats. un-t pisch. tekhnologiy*, 287.
- [12] Jourden, S., Bureau, S., Le Bourvellec, C., Vidal, R. (2022). Impact of an additional grinding step before apple cooking on environmental, nutritional and sensory qualities of puree: a case study for organic apple. *Applied Food Research*, 2 (1), 100077. doi: <https://doi.org/10.1016/j.afres.2022.100077>
- [13] Bilenka, I., Lazarenko, N., Zolovska, O., Dzyuba, N. (2019). Complex processing of Jerusalem artichoke into functional products. *Food Science and Technology*, 13 (4). doi: <https://doi.org/10.15673/fst.v13i4.1559>
- [14] Al-Zughbi, I., Krayem, M. (2022). Quince fruit *Cydonia oblonga* Mill nutritional composition, antioxidative properties, health benefits and consumers preferences towards some industrial quince products: A review. *Food Chemistry*, 393, 133362. doi: <https://doi.org/10.1016/j.foodchem.2022.133362>
- [15] Zhakova, K., Mironova, N. (2017). Novye razrabotki funktsional'nykh produktov. *Nauka i innovatsii*, 171. Available at: <https://cyberleninka.ru/article/n/novye-razrabotki-funktsionalnyh-produktov>

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