УДК 664.8.022:635.25-027.33 DOI 10.36910/775.24153966.2025.83.23

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ТЕХНОЛОГІЧНІ АСПЕКТИ ПІДВИЩЕННЯ ЕФЕКТИВНОСТІ ВИГОТОВЛЕННЯ ОБСМАЖЕНОГО ТА ПРОТЕРТОГО НАПІВФАБРИКАТУ З РІПЧАСТОЇ ЦИБУЛІ

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В роботі представлено результати досліджень технологічного процесу та обґрунтування прийнятих заходів по удосконаленню лінії виробництва обсмаженого та протертого напівфабрикату з ріпчастої цибулі. Аналіз роботи даної лінії на Черкаському виробничому підрозділі товариства з обмеженою відповідальності «Віджи Продакшн» групи компаній «Верес» дозволив виявити ряд суттєвих недоліків в її роботі. За результатами аналізу було обґрунтовано, розроблено та впроваджено удосконалену лінію з суттєво покращеними технічними характеристиками.

Ключові слова: *ріпчаста цибуля, процес чищення, продуктивність, обсмаження, теплоносій, протирання, ікра.*

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TECHNOLOGICAL ASPECTS OF IMPROVING THE EFFICIENCY OF MANUFACTURING ROASTED AND GRATED SEMI-FINISHED PRODUCTS FROM ONIONS

The paper presents the research results on the technological process and justification of measures taken to improve the production line for roasted and grated semi-finished products from onions. Analysis of the operation of this line at the Cherkasy production unit of the limited liability company "Vidzi Production" of the "Veres" group of companies revealed a number of significant shortcomings in its operation. Based on the results of the analysis, an improved line with significantly enhanced technical characteristics was substantiated, developed, and implemented. The improvement in characteristics was achieved through the introduction of more efficient roasting ovens, root cutting machines, and cleaning machines.

Keywords: *onion, peeling process, productivity, frying, heat carrier, grating, caviar.*

Statement of the problem.

The food industry in Ukraine has traditionally been one of the main and most important sectors of the agro-industrial complex (AIC). The canning industry is one of the main branches of the food industry, which makes it possible to reduce the time spent on cooking at home, diversify the public catering diet, and provide the population with products made from raw materials that grow only during a certain period of the year. The products of the canning industry make it possible to provide highly vitaminized nutrition. When properly processed and refined, they not only retain their nutritional qualities for a long time, but also improve them. One of the main tasks of canning is to reduce the activity of the external environment and water, and to destroy or suppress the action and development of microorganisms and their spores. Various canning methods are used to preserve the nutritional value of food products [1].

The Ukrainian canning industry needs radical modernization through the introduction of modern technological equipment. Such equipment should be based on advanced engineering solutions that will increase productivity, ensure environmentally friendly production, and make efficient use of resources. Practical experience confirms that the most effective areas for capital investment in the food industry are the reconstruction and technical re-equipment of existing production facilities. This approach allows for the renewal of the material and technical base in a significantly shorter time frame and the development of new capacities at a lower financial cost compared to the construction of new facilities.

Given these challenges, this study aims to improve the quality of roasted and grated semi-finished onion products, which are an important ingredient in the production of eggplant and zucchini caviar at canning factories.

Analysis of recent studies and publications. The problem of improving nutrition has prompted innovative research by many scientists, in particular M. Bomba and S. Kolodiy assessed the possibility of adapting high-calorie traditional domestic dishes to the requirements of dietary nutrition in connection with the deterioration of the population's health [2]. It should be noted that V. Ivanchenkov and Z. Chekhovich considered the issue of promoting healthy eating through the prism of innovation and stable economic development of Ukrainian enterprises [3]. N. Dudenko and V. Olkhovska were engaged in the development of vegetable caviar with increased nutritional value [4]. The most popular is zucchini caviar. It contains zucchini, 25% tomato paste, carrots, onions, sugar, table salt, oil, ground red pepper, and ground black pepper. The problems of mechanization of canning industry equipment, in particular the cleaning and separation of edible and inedible parts of raw materials, and the heat treatment of plant products, have been studied in the works of the following domestic and foreign scientists: M. Aminov, A. Gladushnyak, M. Dikis, I. Kolesnik, E. Kovalenko, A. Malsky, Yu. Skrynnikov, N. Feshchenko, V. Voroshchuk, M. Shynkarik, O. Datsyshyn, G. Goncharenko, and others [5]. However, despite the significant amount of work

done, many components of zucchini caviar production lines do not fully meet modern requirements in terms of their technical and technological characteristics. Taking this into account, the analysis of technological processes and the improvement of the components of the production line for fried and grated semi-finished products from onions based on this analysis ensures more efficient and higher-quality production of semi-finished products for zucchini and eggplant caviar.

Purpose of the article. Based on the analysis of the parameters of the existing technological process, improve the production line for roasted and grated semi-finished products from onions in order to increase the efficiency of manufacturing a high-quality product, which is an important component of canned zucchini caviar and eggplant caviar.

The main material.

Today, the following trends and priorities have emerged worldwide: further growth in agricultural raw material yields, development of animal husbandry, expansion of product range, improvement of quality, nutritional value, and taste characteristics of food products, introduction of competitive and cost-effective technologies, reduction of the technological cycle and intensification of technological operations, rational use of primary and secondary raw materials. The implementation of these directions is possible only through the analysis of modern methods of technological impact on food products and the selection of the optimal organization of the technological flow [6].

Fruits and vegetables are an indispensable source of easily digestible carbohydrates and physiologically active substances (vitamins, polyphenols, mineral compounds, natural antioxidants, and dietary fiber). The medicinal properties of many types of fruits, vegetables, and berries have been known since ancient times. However, their shelf life is limited, and as it increases, losses in weight and quality increase, as do storage costs. The purpose of canning is to convert raw materials that are unstable during storage into products with a long shelf life. The production of canned foods significantly reduces the loss of agricultural raw materials, ensures a year-round supply of a wide range of fruit and vegetable products to the population, and reduces the labor and time required for food preparation, army rations, and food in extreme conditions (during long expeditions). Depending on the initial raw materials and the quality requirements for the expected product, a technological scheme for processing or canning is selected. There are many ways to preserve fruit and vegetable products – drying, cooling, freezing, preserving with salt, sugar, acids, etc. The most reliable method is to store products in airtight containers using heat treatment (sterilization or pasteurization) [6].

Vegetable caviar is a cold appetizer, usually in the form of a salad, made from ground vegetables or mushrooms. Among canned vegetables, zucchini caviar is the most popular. To prepare caviar, fried, mashed semi-finished products are used, made from zucchini, eggplant, carrots, and onions. Tomato paste, oil, salt, sugar, pepper, and garlic are also added to make vegetable caviar. Spices such as paprika, coriander, bay leaves, and vinegar for preservation may also be added.

For the production of semi-finished products, assembly lines are used, which are located in the preparation department of the vegetable caviar production workshop.

The line for preparing onion semi-finished products for the production of vegetable caviar (zucchini and eggplant) at the private enterprise Vidzhi Production LLC, which is part of the Veres group of companies (GC), is shown in Fig. 1.

The line operates as follows: onions are delivered to the vegetable caviar production workshop in nylon nets and loaded into a calibration machine 1, where they are sorted into three size fractions, which are then conveyed via trays to three belt conveyors 2. The belt conveyors feed the onions to the onion end trimming device 3, which then feeds them to the cleaning machines 4. The cleaned onions are fed to the inspection conveyor 5, where workers select unpeeled onions and return them to the cleaning machines. The cleaned onions are fed to a washing machine 6 and then to a shredding machine 7. An elevator 8 feeds the chopped onions into a roasting oven 9. A screw conveyor 10 feeds the roasted onions into a grinding machine 11 and then into a grating machine with a collection container 12. Grated onion (semi-finished onion product) from a collection container is fed by a screw pump 13 into a device for mixing vegetable caviar components (grated semi-finished products: zucchini or eggplant; carrots; onions; tomato paste; sugar; salt; sunflower oil; spices) and is fed into the apparatus for mixing vegetable caviar components.

The recording and analysis of the operation of each component of this line revealed a number of shortcomings that significantly limit the line's productivity. Namely:

– low productivity of onion trimming devices and high dependence on operator skill;

– unstable quality and low productivity of the oven for roasting onions;

– unreliability and low quality of peeled onions from onion peeling machines;

– manual collection of waste from cutting ends and peeling onions into containers;
– a large number of operators and auxiliary workers (14 people).

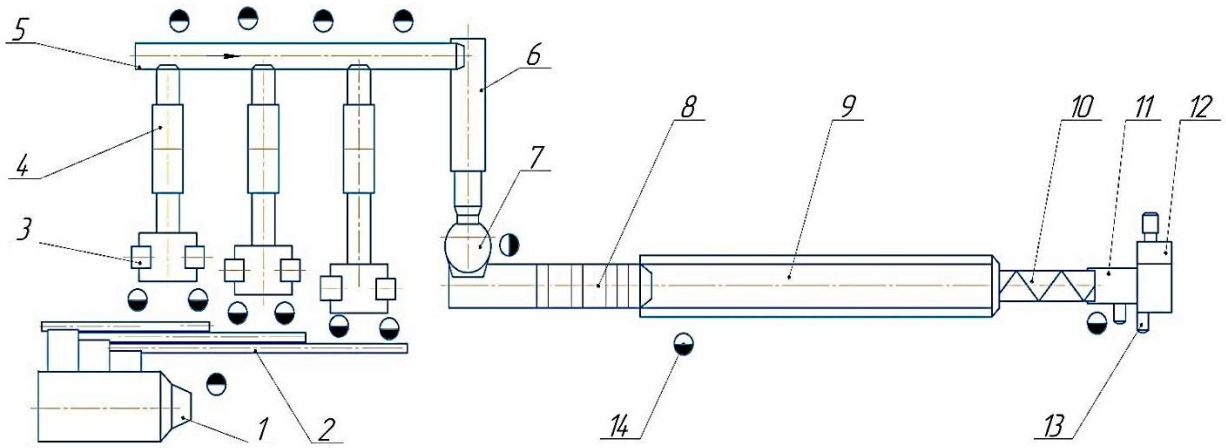


Fig. 1. **Structural diagram of the onion semi-finished product preparation line at the private enterprise Vidzhi Production LLC, Veres Group**

1 – calibration machine; 2 – belt conveyors; 3 – onion end trimming devices; 4 – onion cleaning machine; 5 – inspection conveyor; 6 – washing machine; 7 – shredding machine; 8 – elevator; 9 – roasting oven; 10 – screw conveyor; 11 – grinding machine; 12 – grating machine with collection container; 13 – screw pump; 14 – operator

Eliminating the identified deficiencies requires determining the necessary technical characteristics of the equipment to be replaced and, accordingly, developing, manufacturing, or purchasing such equipment. The key machine in the production line is the oven for roasting onions. It is this machine that provides the productivity necessary for the effective implementation of the technological process of producing zucchini or eggplant caviar. The necessary technical characteristics developed for the design of an improved oven are given in Table 1.

Table 1

Justified technical characteristics of the oven for roasting onions

Characteristics	Indicators
Productivity, kg/hour	1000
Heating surface, m²	22
Average amount of oil in the furnace, kg	450
Steam consumption at pressure, 1÷2 MPa	720
Roasting duration, min	5,22
Belt speed, m/s	0,05÷ 0,2
Water consumption entering the cooler, m²/hour	1
Daily productivity coefficient (calculated) when frying zucchini	2
Daily productivity coefficient (calculated) when frying eggplants	0,6
Pressure tank capacity, m³	0,8
Filter tank volume, m³	0,8
Calculated power of electric motors, kW	3.35
Overall dimensions: length, mm width, mm height, mm	 5200 1800 2210
Weight, kg	61001,1

In accordance with the specified technical characteristics, designers at Veres Group developed design documentation, and an improved furnace was manufactured in the Group's mechanical workshops (Fig. 2).

In this oven, vegetables are fried using an intermediate heat transfer medium that comes into contact with the product, which is vegetable fat (sunflower oil). In turn, the oil is heated by steam.

Processing is carried out at a relatively high temperature of 120°C to 160°C. Under the influence of

heat, a number of interrelated physical and physicochemical processes take place in the product, resulting in the removal of part of the moisture, absorption of oil, volume shrinkage of the product, gas release, increased pressure inside the samples, increased porosity, and changes in the density and heat capacity of the product. The speed of the processes occurring in the product depends on the shape and size of the product pieces, the temperature of the oil, the conditions of heat exchange between the oil and the product, and a number of other factors.

Fig. 2. **Improved oven for roasting onions at the ChVZ LLC "Vidzi Production" of the Veres Group**

Based on the results of the production line analysis, it was decided to replace the washing machine equipment and mechanize the removal of onion cleaning waste (stems, rhizomes, husks, and other foreign impurities). To this end, a machine for cutting onion ends and a machine for peeling onions were developed, and various standard and non-standard transport and buffer (auxiliary) equipment was used.

A machine with new design solutions was developed for trimming the rhizomes and stems of onions, which increases the machine's productivity, improves the quality of onion end trimming, and reduces waste [5, 7]. The technical characteristics are presented in Table 2.

Table 2

Justified technical characteristics of a machine for cutting the roots and stems of onions

Specifications	Indicators
Productivity, kg/hour	500
Number of carousels, pcs	2
Number of heads on the carousel	12
Average onion weight, kg	0,06 – 0,075
Machine productivity, pcs/min	120
Number of carousel revolutions, min^{-1}	6
Type of traction chain for onion carriers	ПР-38,1
Electric motor power, kW	1,1

A machine with new design solutions was developed for peeling onions from husks. The machine can be successfully used in lines for preparing fried and grated semi-finished products from onions in the preparatory departments for processing raw materials at canning factories. Based on the calculation of design and kinematic parameters, the technical characteristics of the developed machine for peeling onions from husks are given in Table 3.

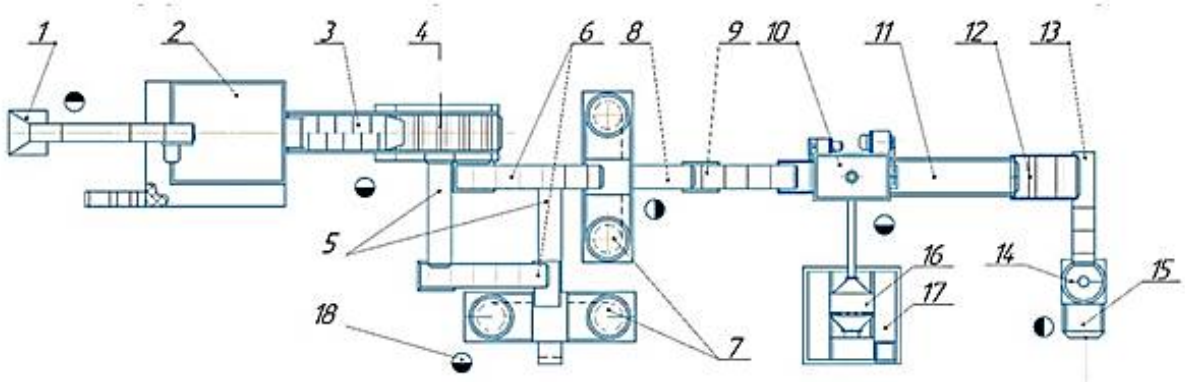
The structural diagram of the modernized production line is shown in Fig. 3. The modernized production line for semi-finished products from onions works as follows: onions are delivered to the vegetable caviar production workshop in nylon nets, loaded by elevator 1, and fed into hopper 2. From the hopper, elevator 3 feeds the onions into the calibrating machine 4, where they are separated into two

fractions according to size. From the calibrating machine, belt conveyors 5 and elevators 6 feed the onions to the onion end trimming machines 7. Then, the onions are fed by belt conveyors 8 and elevator 9 to the cleaning machine 10. The cleaned onions are fed to the inspection conveyor 11, where workers select uncleaned onions and return them to the cleaning machine. The cleaned onions are fed into a washing machine 12 and elevators 13, and then into a shredding machine 14.

Table 3

Justified technical characteristics of a machine for cleaning onions from husks

Specifications	Indicators
Productivity, kg/hour	1000
Number of screw revolutions, min^{-1}	3,2
Translational velocity of onion, m/s	0,02
Average onion weight, kg	0,06 – 0,075
Screw drive power, kW	0,18
Type of gear motor	NMRV050
Power of the abrasive roll drive, kW	1,1
Type of gear motor	МЦ2С-63-71-1,1
Type of drive chain for screw drive	ПР-19,05-3780



1 – elevator; 2 – hopper; 3 – elevator; 4 – calibration machine; 5 – belt conveyors; 6 – elevators; 7 – onion trimming machines; 8 – belt conveyor; 9 – elevator; 10 – onion cleaning machine; 11 – inspection conveyor; 12 – washing machine; 13 – elevator; 14 – shredding machine; 15 – belt conveyor; 16 – fan; 17 – hopper; 18 – operator

Fig. 3. **Structural diagram of the modernized production line for semi-finished onion products at the private enterprise Vidzhi Production LLC, Veres Group**

The rest of the semi-finished product manufacturing process is the same as before the reconstruction. The chopped onions are fed by a conveyor to a new roasting oven, and the roasted onions are fed by a screw conveyor to a crusher and then to a grinding machine with a collector. The grated onions (semi-finished onion product) are fed from the collection container by a screw pump into the vegetable caviar mixing machine (grated semi-finished products: zucchini, pumpkin or eggplant, carrots, onions; tomato paste; sugar; salt; sunflower oil; spices). The husks from the onion cleaning machine 10 are fed by fan 16 into hopper 17.

Thanks to the introduction of the modernized line, the number of operators and auxiliary workers on the line has been reduced from 14 to 9 people.

Conclusions.

1. Based on the results of a detailed analysis of the parameters of the existing technological process for preparing semi-finished onion products for the production of vegetable caviar (zucchini and eggplant) at the private enterprise Vidzhi Production LLC, a number of shortcomings were identified that significantly limited the productivity and efficiency of the line.

2. To eliminate the identified shortcomings, the technical characteristics of the oven for roasting onions, the machine for cutting the roots and stems of onions, and improvements were made to the production line for roasted and grated onion semi-finished products.

3. The modernized production line for onion semi-finished products at the private enterprise of Vidzhi Production LLC of the Veres Group using newly developed machines with proven technical characteristics,

which has increased process productivity, ensured more stable product quality, and reduced the number of employees.

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