Beans are a rich source of nutrients, including proteins, starch, some unsaturated fatty acids, dietary fiber, vitamins, minerals, and phytosterols. The negative characteristics of beans include the presence in the bran shell of beans of specific substances – antinutrients that can be neutralized during soaking.

The aim of this work was to develop a way to produce canned beans with pre-soaking. A laboratory unit was designed with cold soaking (at a temperature of the surrounding medium of 20 °C), by the hot method (at a temperature of 50 °C) with heating from a spiral, and with electrocontact heating. Experimental studies determined the dynamics of mass change when soaking beans samples of "Rant" variety by various methods. Under the conditions of electrocontact heating, the highest value of the final mass was revealed, 150 % larger than the initial, and the shortest duration of the process (compared to the cold method – 2.25 times less). It is proved that the cold method is the least energy-consuming. Due to its shortcomings in the relatively significant duration and risk of obtaining products of unsatisfactory quality, the use of the cold method is impractical. To implement the hot method, an effective method from the point of view of energy saving is the soaking method under conditions of electrocontact heating, in which the power was 19 % less.

Within the framework of the task set, the organoleptic indicators of finished products "Beans in tomato sauce of the highest grade" were investigated in accordance with DSTU 6074:2009. According to technological advancements, the products compiled with the standard indicators and received the highest ratings, which indicates their high quality

Keywords: bean canning, soaking, mass dynamics, heat transfer, electrocontact, heating, electricity, energy saving, moisture absorption, organoleptic indicators

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DEVISING A TECHNIQUE FOR MANUFACTURING CANNED BEANS WITH SOAKING UNDER THE CONDITIONS OF ELECTRIC CONTACT HEATING

Andrey Shevchenko
PhD, Associate Professor*
Olga Mayak
PhD, Associate Professor*
Bogdan Mykhailov
Master*
Svitlana Prasol
Corresponding author
PhD, Associate Professor*
E-mail: process229@ukr.net
Olena Mykhailova
PhD
Department of Economics and Business
State Biotechnological University
Alchevskih str., 44, Kharkiv, Ukraine, 61002
*Department of Equipment and Engineering
for Processing and Food Industries
State Biotechnological University
Alchevskih str., 44, Kharkiv, Ukraine, 61002

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1. Introduction

An important task in the field of food production is the development of new resource-efficient technologies, technological methods, and methods aimed at obtaining special-purpose products [1, 2]. Such products include food products containing vegetable raw materials that are rich in vitamins, minerals, polyunsaturated fatty acids, dietary fiber, and phytosterols. It is known that when they enter the human body, phytosterols help reduce cholesterol. Phytosterols are found in leguminous crops, in particular beans, therefore, quite interesting from a scientific point of view is the development of a progressive technique for the production of canned beans.

There are known varieties of universal beans “Fantasia”, “Antoshka”, “Rant”, “Secunda”, “Indiana”, which are resistant to common diseases. The chemical composition of beans provides high nutritional value and caloric content. Plant culture contains vitamin complexes, fatty acids, mineral components (sodium, phosphorus, calcium, potassium, titanium, chromium, cobalt, selenium, iron), dietary fiber, starch, and disaccharides. Depending on the type of beans, the quantitative composition of these components may vary. On average, in terms of 100 g of beans, the protein content is 20 g; fat – 2 g; carbohydrates – 47 g. Energy value is within 100...300 kcal.

Beans have special substances as protection – antinutrients – that are isolated in the bran shell or peel. Soaking the beans helps to make the skin of the beans soft, which simulates the germination medium. Under such conditions, antinutrients are neutralized by activating special enzymes and increasing the availability of vitamins and minerals contained in beans.

Soaking the beans is carried out by cold and hot methods.

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The first method (cold) involves filling the container with beans with water with an ambient temperature lasting up to 9 hours. It is impossible to increase the soaking time because the beans can ferment and become unfit for consumption. Also, for soaking, instead of water, they use 1...2 % brine based on table salt (NaCl). When soaked in brine, sodium ions displace calcium and magnesium from the bean peel, so it becomes more permeable, and the liquid easily penetrates into the beans. This method ensures uniform absorption and reduces the duration of the process to 6...7 hours.

The second (hot, thermal) method, due to the possibility of intensifying the process, is more progressive in application. Water or brine heated to 45...50 °C (low-temperature mode) allows soaking in 4...6 hours. The hot method also helps to increase the removal of harmful substances from the beans and gives tenderness to the taste of the finished product.

The method of hot soaking, in most cases, traditionally, is carried out in a container with liquid heat transfer through a dividing wall using heating elements, spirals, steam, etc. In addition, a method under conditions of electrocontact heating (ECH) is potentially effective for ensuring low-temperature conditions during hot soaking. The ECH method differs from the traditional ones by a number of advantages such as a high efficiency (about 95 %), simplicity, and reliability of impled mentation, the possibility of inertial power regulation, etc. To implement this method, the main condition is the presence of a conductive medium, which can be a brine based on NaCl. But there is currently no evidence to substantiate the effectiveness of the hot method of soaking beans under the conditions of ECH and its use.

So, the scientific and applied task associated with the development of a method for the production of canned beans with soaking under the conditions of ECH becomes relevant.

2. Literature review and problem statement

Introduction into the food industry of innovative methods of production of products of processing plant materials into functional special-purpose products will ensure the production of "healthy food" with a high content of nutrients [1]. An important aspect of obtaining high-quality special-purpose products is the preservation of the biological potential of plant materials during its heat treatment, which is achieved by hot soaking, concentration, drying, sterilization, etc. The development of new methods of processing plant materials is carried out taking into account their initial properties through the use of appropriate resource-efficient technological operations with the introduction of innovative developments of thermal equipment [3, 4]. Nevertheless, each individual type of plant material requires the use of methods of preliminary and basic heat treatment using the appropriate technique of heat dissipation. Therefore, the selection and scientific substantiation of the method of processing a particular type of raw materials is the key to obtaining a high-quality product of increased nutritional value [4, 5].

Soaking beans before cooking significantly reduces production time, regardless of the type of beans and the type of water used for cooking. Relevant research is reported in [6], where the cold method is considered. Most importantly, soaking generally reduces cracking or brittle beans and reduces cooking time. Reducing cooking time due to the proposed use of sparkling water can sometimes be associated with additional costs and complication of the process. In addition, in general, soaking and using soda can affect the organoleptic properties of beans. Therefore, the use of such technical solutions is possible only if products of sufficient quality are obtained.

Studies [7, 8] proposed soaking with the use of overpressure. This method can have an effect on the destruction of the integrity of the structure of bean beans. Soaking by ultrasound is also proposed in [9]. The use of such technology complicates the implementation of the process and increases the cost of expensive additional equipment. Consequently, most of these approaches are limited in application and have other obstacles to wider implementation. There are other non-thermal or isothermal technologies, such as a pulsed electric field [10], which unfortunately are not well studied.

Intensification of technological processes, including soaking of beans, is possible using methods of thermal exposure (hot method) on food products and substances. For example, due to the use of inertial film heaters [11] or ECH [12]. Both methods make it possible to reduce the duration of the heating process, easily change the modes to the desired ones, etc. It should be noted that under the conditions of ECH, internal energy is generated in the product for its entire volume and a decrease in energy consumption is observed. According to organoleptic evaluation, products manufactured by techniques with ECH are characterized by positive assessments.

ECH is a progressive way of heating food [13]. The physics of the ECH process consists in the transmission of electric current through a semi-finished product or conductive medium [14, 15]. An important parameter of ECH, which determines the quality of the process, is the frequency of alternating current, which in most cases is equal to industrial 50 Hz [16, 17]. However, the problem that has not been solved by the authors of these works is the lack of elaboration of methods for low-temperature heating of conductive food media to intensify the relevant processes, in particular soaking the beans.

So, there is a problem regarding the implementation of the production of canned beans at the soaking stage. Ensuring the efficiency of the process and guaranteed product quality is possible through the use of ECH, which does not have reliable modes of low-temperature heating during soaking the beans. It is advisable to conduct research on the soaking process under different modes, which will achieve the effect of intensification.

3. The aim and objectives of the study

The aim of this work is to develop a method for the production of canned beans with soaking under ECH conditions. This will make it possible to provide rational soaking parameters in the technology of canning beans with high quality characteristics of the products obtained.

To accomplish the aim, the following tasks have been set:

– to investigate the processes of soaking beans;

– to develop a technological scheme for the production of canned beans with soaking under the conditions of ECH;

– to investigate the organoleptic indicators of the obtained products – "Beans in tomato sauce of the highest grade".

4. The study materials and methods

The object of the study is the beans of the universal variety "Rant" with a relative humidity of 15±1 %, which were

subject to canning with soaking at the stage of preparatory operations; finished products "Beans in tomato sauce of the highest quality".

The main hypothesis of the study is that the implementation of the process of soaking by the hot method with ECH makes it possible to reduce energy consumption and ensure the production of products with high quality indicators.

It was suggested that the use of the thermal soaking method in comparison with the cold soaking method improves the quality characteristics of the raw materials. The use of ECH has a positive effect on electricity consumption, due to the high efficiency of this process.

In order to study the methods of soaking beans, a laboratory unit was designed, shown in Fig. 1. It consists of a working tank 8 formed by the outer 3 and inner 12 casings. To prevent heat loss, thermal insulation is provided 2. The working capacity 8 is filled with a mixture of beans and water (or brine) 9 and on top with the help of a handle 10 is closed with a lid 5, which has a breaking contact. The latter ensures the rupture of the electrical circuit and, accordingly, the shutdown of ECH while protecting the researcher from accidental electric shock. The ECH is provided by a pair of electrodes 6, which are pressed into the detachable electrodes of section 7, through wires connected by switch S1 to the laboratory electric transformer 1. The current strength is measured by ammeter A, voltage – by voltmeter V. Heating is provided by heat transfer by heating spiral 4, to which an electric current is supplied by the power wire from the power control unit 13. The temperature of the mixture 9 is measured with a mercury thermometer 11. The power supply of the electric transformer 1 and the control unit for the heating power of the spiral 13 is carried out from the industrial single-phase power grid.

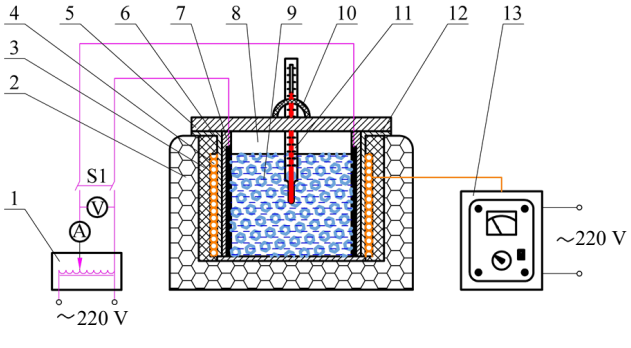

Fig. 1. Laboratory installation for the study of bean soaking processes: 1 – laboratory electric transformer; 2 – thermal insulation; 3, 12 – outer and inner casings, respectively; 4 – heating spiral; 5 – cover; 6, 7 – electrode and electrode section, respectively; 8 – working capacity; 9 – a mixture of beans and water (or brine); 10 – handle; 11 – mercury thermometer; 13 – control unit for the heating power of the spiral

This laboratory unit operates in three modes:

– Mode I involves soaking the beans by the cold method at room temperature (20 °C). In this case, the laboratory electric transformer 1 and the heating spiral 4 must be turned off. During the studies, room temperature liquid is used;

– Mode II is implemented by soaking the beans by the hot method with heating from spiral 4. To do this, after pouring the liquid, we turn on the control unit for the heating power of spiral 13. The power is set in such a way as to reach a predetermined value of the temperature of the liquid. When the temperature of the liquid stops changing, that is, the installation will enter a stationary heating mode, the beans are loaded, which with the liquid form mixture 9;

– Mode III is carried out by soaking the beans with a hot method with ECH. To do this, after pouring the brine, we turn on LATR 1. The voltage on the electric transformer is set so that the brine heats up from the ECH to a predetermined temperature value. When the installation enters a stationary heating mode, the beans are loaded, which form mixture 9 with brine.

Preparatory operations were carried out to study the soaking of beans, in particular, the selection of high-quality beans that were calibrated and had a relatively uniform size. On laboratory scales, the mass of selected beans was determined.

In all studies, water of the same mineral composition was used, which in terms of quality met the requirements of DSTU 7525:2014 "Drinking water. Requirements and methods of quality control". Indicators of water in chemical composition and hardness did not exceed the standard values. If necessary, brine was prepared (the ratio of NaCl to water was 1:49). Liquid of a certain amount (water or brine) was poured into the working tank 8.

The study itself was carried out according to the following method. The soaking time was observed on the stopwatch. The temperature of the liquid, which was supposed to be unchanged, was controlled according to the readings of thermometer 11. Every 15 minutes, with the help of a spoon, beans were taken out of the liquid and their mass was determined on laboratory scales. The heating power was measured with a wattmeter connected to the corresponding electrical circuit. When the weight of the beans stopped changing, research stopped. The results of all measurements were recorded in a journal. According to the data obtained, electricity consumption was calculated and graphs of the dynamics of mass change were built.

The processing of research results was carried out by methods of mathematical statistics and correlation analysis using computer technology. When comparing experimental data, standard errors were taken into account. At the same time, at least five parallel experiments were carried out, from the results of which we found:

– arithmetic mean deviation x

$$x=\frac{1}{n}\sum_{i=1}^{n}x_i, \tag{1}$$

where x_i is the value of the obtained experimental data;

n – number of experiments;

– RMS deviation $S(\bar{x})$

$$S(\bar{x})=\pm\sqrt{\frac{\sum_{i=1}^{n}(\bar{x}-x_i)^2}{n-1}}. \tag{2}$$

The magnitude of the confidence error $\varepsilon(x)$ was determined by:

$$\varepsilon(x)=t(\alpha,\phi)\cdot S(\bar{x}), \tag{3}$$

where $t(\alpha,\phi)$ is the Student's criterion for the value of confidence probability α=0.95 and the number of degrees of freedom $\phi=n-1$, $t(\alpha,\phi)=2.29$.

The relative error (Δx, %) was determined by the formula

$$\Delta x = \frac{\varepsilon \cdot \bar{x}}{\bar{x}} \cdot 100. \quad (4)$$

The study of the quality of finished products was carried out in accordance with the assessment of organoleptic indicators of canned food, given in [18].

5. The results of investigating the technique of production of canned beans with soaking under conditions of electrocontact heating

5. 1. Investigation of the processes of soaking beans

In order to develop a new progressive method of production of canned beans, a study of the processes of soaking prototypes – beans of the "Rant" variety beans under the conditions of cold and hot soaking methods was carried out. The cold method was used in a water medium (samples No. 1) and in a 2 % NaCl solution medium (samples No. 2). The operating temperature of the liquid was 20 °C. The hot method was used with low-temperature heating using a spiral in a water environment (samples No. 3) and in a 2 % NaCl solution medium (samples No. 4); and under ECH conditions (samples No. 5). The operating temperature of the liquid was 50 °C. Soaking with ECH was carried out only with the addition of a 2 % solution of NaCl since the main condition for the flow of electric current is the presence of salt ions. Soaking processes were carried out at a laboratory installation the description of which is given above. Based on the obtained data set, graphs of the dynamics of changes in the mass of beans during soaking by appropriate methods were constructed (Fig. 2).

The resulting dependences have the same shape of curves and at the beginning of the process of moisture absorption by beans are the largest. Then the intensity of moisture absorption decreases. Over time, the moisture content reaches its maximum value and subsequently the mass remains constant. The difference in curves is observed in the intensity of moisture absorption. Thus, from the initial weight of 50 g in the first 2 hours in prototypes, the mass increases: in samples No. 1 – by 80 %, in samples No. 2 – by 100 %, in samples No. 3 – by 120 %, in samples No. 4 – by 130 %, and in samples No. 5 – by 140 %. The final mass of the samples is also not the same. Samples No. 1 showed the smallest value of the final mass, which was 109 g, that is, 118 % of the initial weight in the 9th hour of research. An hour later, the mass of samples increased by only 1 g. Further studies were not carried out, because, firstly, this change is within the scope of the research error, and, secondly, on the surface of the liquid we began to observe characteristic of the fermentation process bubbles. Therefore, due to the inefficiency and risk of obtaining products of unsatisfactory quality, it is not necessary to exceed the soaking time of more than 9 hours.

The largest value of the final mass, which was 126 g, that is, 150 % of the original, was found in samples No. 5, that is, under conditions of hot soaking under ECH conditions. In addition, in this case, the shortest duration was revealed, which was 4 hours. This is 2.25 times less than cold soaking in a water environment; 1.75 times for soaking in a cold way with salt; 1.5 times by the hot method in the water environment and 1.25 times by the hot method with salt.

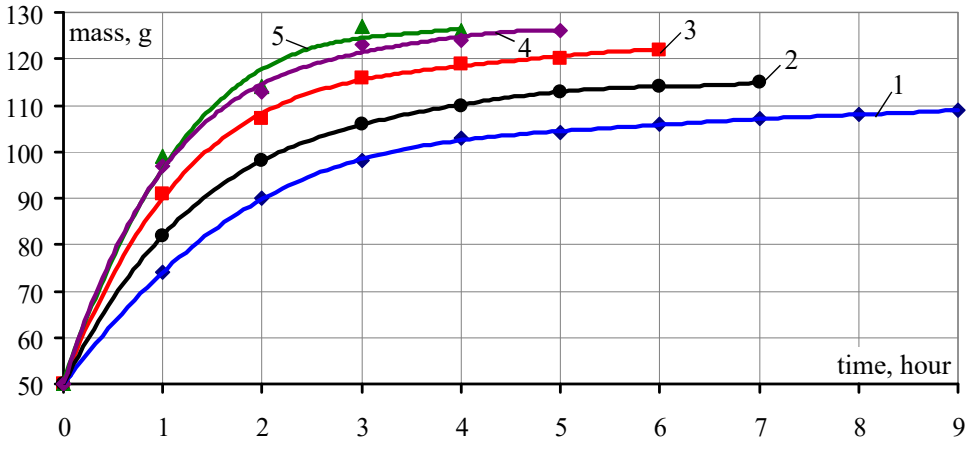

Fig. 2. Dynamics of mass change when soaking the samples of beans: 1 — cold method in the water environment; 2 — cold method in a medium of 2 % solution of NaCl; 3 — hot method in the water environment; 4 — hot method with 2 % NaCl solution in the medium; 5 — hot method under conditions of electrocontact heating

Thus, we have a direct effect on moisture absorption and the duration of the process for the samples of beans depending on the soaking method. The most intensive is the hot technique. The presence of salt is also important for the process, which also affects the rate of moisture absorption and the final mass of the samples. In addition, the implementation of soaking beans is most effective under the conditions of the hot method with ECH.

The efficiency of any technological process is estimated by energy costs for its implementation. In this regard, during the studies, power was measured using a wattmeter and, taking into account the time, the consumption of electricity (W, kWh) for the corresponding processes of soaking beans was determined. The research results are presented in the form of a diagram in Fig. 3.

The least costly, of course, is the cold method, due to the lack of need for heating. Therefore, the consumption of electricity in samples No. 1 and No. 2 W=0 kWh. The use of the same hot method causes certain energy costs. Their greatest value in samples No. 3 W=0.82 kWh. Under the conditions of adding salt, there is a decrease in electricity consumption by 17 %. Since the heating power in both cases was the same (136 W), it is certain that the reduction in electricity consumption was influenced by a decrease in the duration of the process by 1 hour. In the case of using the hot method under ECH conditions, the power was 19 % less and amounted to 110 watts. This difference is explained by the greater efficiency of the ECH process than the efficiency of the heating process by heat transfer from the heating spiral. Under conditions of lower capacity and duration of the process (2 hours less than samples No. 5 and 1 hour less than samples No. 4), the electricity consumption when using the hot method under ECH conditions was the lowest and amounted to 0.44 kWh. So, when using the hot method due to ECH during soaking, you can reduce electricity consumption by up to 46 %.

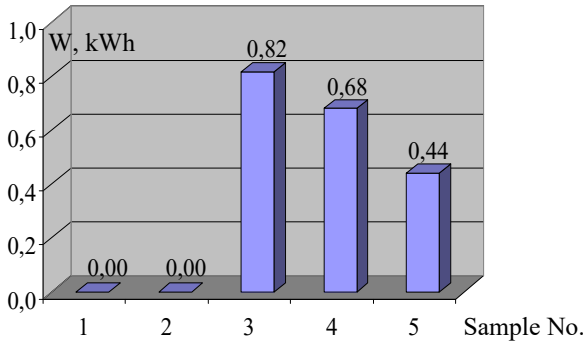

Fig. 3. Diagram of electricity consumption when soaking samples of beans: 1 — cold method in the water environment; 2 — cold method in a medium of 2 % solution of NaCl; 3 — hot method in a water environment;4 — hot method with a 2 % solution of NaCl in the medium; 5 — hot method under conditions of electrocontact heating

Thus, despite the fact that the cold method is the least energy-consuming and given its shortcomings in the relatively significant duration and risk of obtaining products of unsatisfactory quality, its use is impractical. To implement the hot method, which does not have such drawbacks, the soaking method under ECH conditions is effective from the point of view of energy saving.

5. 2. Development of a technological scheme for the production of canned beans with soaking under conditions of electrocontact heating

A technological scheme for the production of canned beans is proposed (Fig. 4), according to which a new technique of soaking is implemented under the conditions of ECH. The following main stages are envisaged: acceptance of beans to the enterprise, preparation of sauce components, preparation of containers, and sterilization of canned food.

The regime parameters of the processes, during production in the proposed way, remain standard, according to DSTU 6074: 2009 Canned food. Canned beans. Specifications [19]. Acceptance of the main raw material means that threshed beans are delivered to the enterprise in boxes. Beans are loaded into a hopper and water is added. A mixture of water and beans is fed to the hopper of the pump, which pumps the beans for cleaning to the vibroselector and washing. Here there is a partial separation of contaminants with water jets and finishing washing in a flotation washing machine. Next, the beans are transported by elevator to the sorting station, where the division is carried out by density and, accordingly, by grade. The next is soaking. To do this, the beans are immersed in a container with an electrically conductive brine, which is replaced every 30 minutes. For 4 hours, soaking occurs by the hot method under ECH conditions. At the same time, the weight of the beans increases by 2.4–2.5 times. With subsequent technological operations, blanching and sterilization, beans' size no longer changes. The operating temperature of blanching is 97–98 °C, the duration of the process is 6 minutes. Then the beans are sent for cooling to a temperature of 20 °C. After that, the water The beans are drained, and the beans are sent for pneumatic post-cleaning. The process takes place automatically; with the help of a directed air flow, the separated peel, slices of crumbled beans, and possible impurities are removed. Then the beans fall on the inspection conveyor.

At the same time, the sauce based on tomato paste is being prepared. It should be noted that the ratio of the components of the sauce may vary and depends on the specific recipe used by the manufacturer. Preparation of the components of the sauce involves placing tomato paste in the cooking boiler and bringing it to a boil.

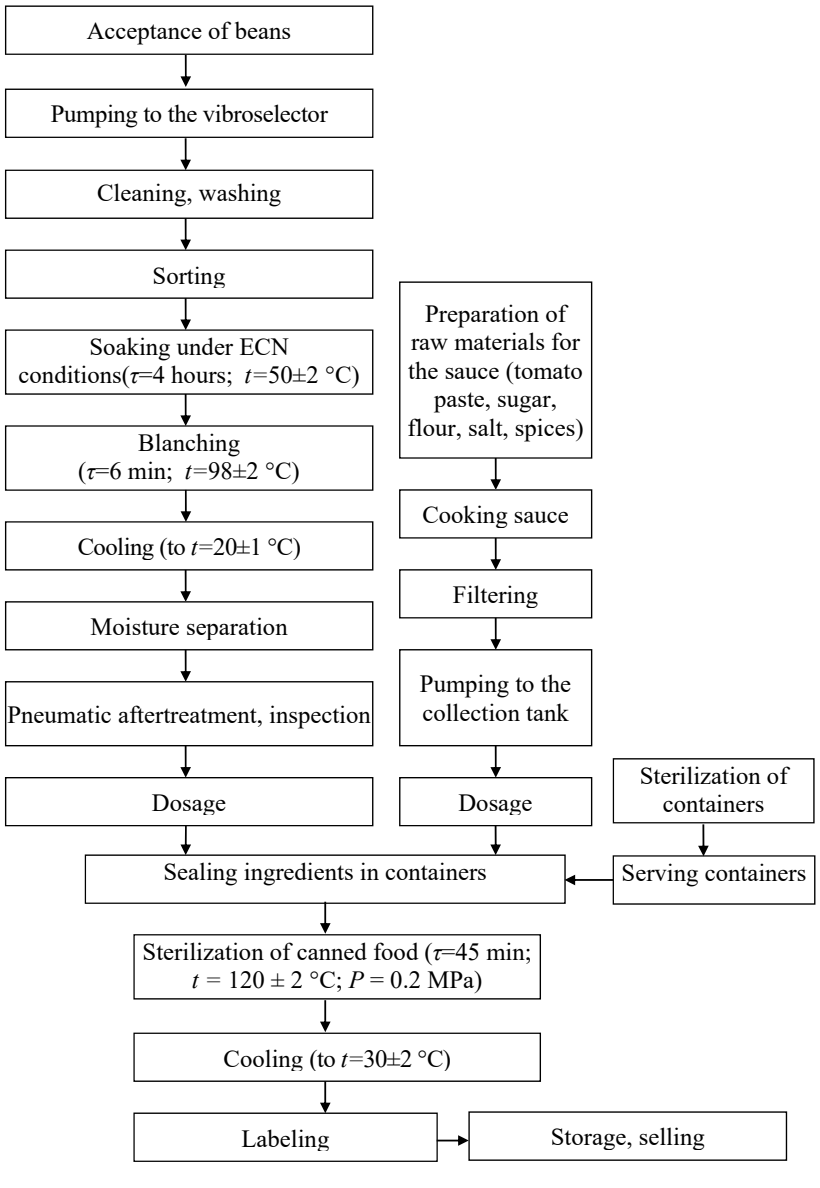

Fig. 4. Technological scheme of production of canned beans with soaking under conditions of electrocontact heating: τ — duration; *t* — temperature; *P* — operating pressure

Sugar, thickener, salt, and spices are mixed together and added to a boiling tomato paste. Cooking the sauce is carried out under the conditions of mixing for 10 minutes. The finished tomato sauce is filtered through a sieve with a hole diameter of 1.2 mm and pumped to the collection container with the possibility of heating before dosing into jars. The maximum storage time of the sauce is 30 minutes.

Preparation of containers involves sterilization of glass jars and their supply to the sealing machine.

Dosing machines fill the cans moving on the belt conveyor with beans and sauce heated to 85 °C. The quantitative ratio when filling cans (beans – sauce) is: beans – 60...65 %; sauce – 35...40 %.

Next, canned beans are sterilized at a temperature of 120 °C (an operating pressure of 0.2 MPa) for 45 minutes. After sterilization, the temperature in the autoclave gradually decreases to 30 °C. Then the cans are sent for labeling, shop storage, and subsequent sale.

5. 3. The study of organoleptic indicators of the prode ucts obtained

A study was carried out on compliance with DSTU 6074:2009 of organoleptic indicators of the products obtained – "Beans in tomato sauce of the highest grade", the proposed method of production of canned beans with soaking under the conditions of ECH ("experiment"). For comparison, products prepared according to the traditional method under the conditions of the hot soaking method (heating with a spiral in a water environment) were used as "control". During the production of the control and samples, beans of the "Rant" variety were used as raw materials. Organoleptic assessment was carried out in points (from 1 to 5 points) taking into account the coefficient of importance of each indicator – appearance, quality of sauce, color, taste, smell, texture. The results of the research are given in Table 1.

Organoleptic characteristics of the products – "Beans in tomato sauce of the highest grade", made in the proposed technique with soaking under the conditions of ECH, corresponded to DSTU 6074:2009 and indicators of products manufactured in the traditional way. It should be noted that in terms of appearance, the experimental product had even better characteristics than control. In particular, the number of beans of a different size and shape in samples is 1.5 times less than that of control samples; the number of beans with cracks but of unlost shape is almost 2 times less. According to technological tests, products received the highest ratings, which indicates their high quality.

6. Discussion of the results of the study of product quality characteristics and combined heat treatment

This paper reports the results of research on the development of a technique for the production of canned beans. Its distinctive feature is the use of a hot soaking method withECH. There is no data in the literature on such an implementation of this stage. Studies have determined the question of the advantages of the method as such.

It has been experimentally proved that the cold soaking method is the least expensive, due to the lack of need for heating, as evidenced by the results presented in the diagram (Fig. 3). The samples did not have electricity consumption under the conditions of using the cold method. The use of the hot technique causes certain energy costs. Their greatest value is in samples under the conditions of the hot method in the water environment. With the addition of salt, there is a decrease in electricity consumption by 17 %. Since the heating power in both cases was the same, it is likely that the reduction in electricity consumption was influenced by a decrease in the duration of the process by 1 hour. In the case of using the hot method under ECH conditions, the power was 19 % less.

Table 1

Evaluation of organoleptic indicators of products "Beans in tomato sauce of the highest quality" according to DSTU 6074:2009

Name of the indicator; importance factor (IF)	Control samples		Prototypes	
	Characteristic	Organoleptic evaluation	Characteristic	Organoleptic evaluation
Appearance; IF – 1,5	In the bulk, boiled beans are homogeneous in size and shape. Beans of a different size and shape – 5 %; with cracks but not lost shape – 9 %; boiled or deformed – 2 %	4	In the bulk, boiled beans are homogeneous in size and shape. Beans of a different size and shape – 3 %; with cracks but not lost shape – 5 %; boiled or deformed – 1 %	5
Sauce quality; IF – 1	Homogeneous viscous tomato mass without signs of delamination	5	Homogeneous viscous tomato mass without signs of delamination	5
Color; IF – 1,5	Suitable for the color of beans: characteristic of this variety. The presence of beans of a different color < 1 %. The color of the sauce is red with orange hue	5	Suitable for the color of beans: characteristic of this variety. The presence of beans of a different color < 1 %. The color of the sauce is red with an orange tinge	5
Taste and smell; IF – 1	Inherent in a mixture of beans and tomato sauce with the aroma of spices. No foreign taste and smell	5	Inherent in a mixture of beans and tomato sauce with the aroma of spices. No foreign taste and smell	5
Consistency; IF – 1	Beans are homogeneous, soft, ready	5	Beans are homogeneous, soft, ready	5

This difference is explained by the greater efficiency of the ECH process than the efficiency of the heating process by heat transfer from the heating spiral. Under conditions of lower power and duration of the process, the consumption of electricity when using the hot method under the conditions of ECH was the lowest. So, when using the hot method due to ECH, it is possible to reduce electricity consumption by up to 46 %.

On the basis of the research, a technique for production of canned beans "Beans in tomato sauce of the highest grade" was proposed. The technique involves the following main stages: acceptance of beans to the enterprise, preparation of sauce components, preparation of containers and sterilization of canned food. Processing bean beans involves the following main steps: soaking using ECH, blanching, cooling, moisture separation, pneumatic aftertreatment, dosing, sealing in containers, sterilization, cooling, labeling of canned food. The schematic diagram of the method of production of canned beans is given in Fig. 4. A feature of this scheme is the implementation of the soaking stage by the hot method under ECH conditions. Due to this, the duration of soaking is a relatively short time – 4 hours (compared to cold soaking, when it can last up to 9 hours). This provides an opportunity to reduce the overall technological process of production.

Organoleptic indicators of the obtained products "Beans in tomato sauce of the highest grade" were investigated, the results are given in Table 1. It is determined that the organoleptic characteristics of products manufactured in the proposed way with soaking under the conditions of ECH corresponded to DSTU 6074:2009 and the indicators of products manufactured in the traditional way. Experiments have shown that the number of beans of a different size and shape in samples is 1.5 times less than that of control samples; the number of beans with cracks but of unlost shape is almost 2 times less, which is explained by the conditions of pre-soaking.

However, there are certain limitations of this study, namely the distribution of the results obtained from pre-soaking to other legumes. This is due to certain features of the composition of the shell and the beans themselves. So, to summarize the results of using pre-soaking, additional experiments are required.

The disadvantages of the study are that the results obtained in practice can be implemented only for relatively small volumes of production. This is due to the fact that the simultaneous soaking of a large volume of raw materials predetermines the use of high voltage to ensure the heating using ECH. It is possible to reduce voltage by increasing the concentration of salt. But such a decision may adversely affect the quality of the final product. The solution to this problem may be the use of several devices for soaking in one technological line.

So, the development of this study may consist in expanding the range of special-purpose products based on plant materials using the soaking method under the conditions of ECH as a new technique of canned beans, reducing the duration of the process and conserving energy. It is possible to develop methods for the production of canned products based on other varieties of beans and legumes. It is also planned to study the processes of internal mass transfer in beans under the influence of ECH, structural and mechanical properties of the product, and other parameters on which the speed of subsequent heat treatment depends. In addition, it is of interest to study the physicochemical and other changes that occur in the process, which are caused by soaking in various ways. Based on the totality of studies, a design and technical documentation for the device for soaking beans by the hot method with ECH will be prepared.

7. Conclusions

1. The process of soaking beans has been investigatg ed – with a cold technique at room temperature, with a hot technique with heating from a spiral, hot with electrocontact heating. As a result, it is proved that the cold method is the least energy-consuming but given the considerable duration and risk of obtaining products of unsatisfactory quality, its use is considered impractical. To implement the hot method, which did not reveal such shortcomings, the method of soaking under conditions of electrocontact heating is effective from the point of view of energy saving.

2. A technological scheme for the production of canned beans has been developed, according to which a new method of soaking under conditions of electrocontact heating is being implemented. The following main stages are envisaged: acceptance of beans to the enterprise, preparation of sauce components, preparation of containers, and sterilization of canned food. Processing eans involves the following main steps: soaking using electrocontact heating, blanching, cooling, moisture separation, pneumatic after-cleaning, dosing, sealing in containers, sterilization, cooling, labeling of canned food.

3. Organoleptic indicators of the obtained products "Beans in tomato sauce of the highest grade" were investigated. It was determined that the organoleptic characteristics of products manufactured in the proposed way, soaking under conditions of electrocontact heating, corresponded to DSTU 6074:2009 and the indicators of products manufactured in the traditional way. Experiments have shown that the number of beans of a different size and shape in samples is 1.5 times less than that of control samples; the number of beans with cracks but of unlost shape is almost 2 times less, which is explained by the conditions of pre-soaking.

Conflicts of interest

The authors declare that they have no conflicts of interest in relation to the current study, including financial, personal, authorship, or any other, that could affect the study and the results reported in this paper.

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Data availability

The manuscript has no associated data.

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