Вдосконалена система обігріву роторного плівкового апарату забезпечить прийнятний тепловий режим для виробництва композицій високоякісних багатокомпонентних природних паст. Підібрано рецептуру пасти з урахуванням оздоровчих властивостей, яка складається з яблука, журавлини та глоду. Визначено вплив кожної з домішки на зміну структури отримуваної продукції та підтверджено максимальне збереження природних цінностей в кінцевому багатокомпонентному напівфабрикаті

Ключові слова: природна сировина, роторно-плівковий апарат, інтенсифікація, структурно-механічні властивості, кольороутворення

Усовершенствованная система обогрева роторного пленочного аппарата обеспечит приемлемый тепловой режим для производства композиций высококачественных многокомпонентных природных паст. Подобрана рецептура пасты на основе оздоровительных свойств, которая состоит из яблока, клюквы и боярышника. Определено влияние каждого компонента на изменение структуры получаемой продукции и подтверждено максимальное сохранение природных ценностей в конечном многокомпонентном полуфабрикате

Ключевые слова: природное сырье, вакуумный пленочный аппарат, интенсификация, структурно-механические свойства, цветообразование

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IMPROVEMENT OF A ROTOR FILM DEVICE FOR THE PRODUCTION OF HIGH-QUALITY MULTICOMPONENT NATURAL PASTES

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1. Introduction

Fruit and berries are of great importance to provide people with high-quality and varied nutrition; they, however, cannot be stored for a long time under conditions that are usual for the period of their gathering. It is possible to prolong their shelf life by processing them in different ways.

One of such techniques is to obtain natural vitamin carriers – fruit-berry semi-finished products (puree and pastes). It is necessary to use efficient equipment during production of pastes in order to provide optimum thermal modes with the aim of preserving qualitative characteristics at the main stages of production. The main stage of production is the concentration of fruit-berry puree that can be carried out in a rotor film device under conditions of increased heat transfer coefficients.

Enhancing biological value and medicinal-prophylactic properties of pastes is possible by blending raw materials into multicomponent fruit-berry semi-finished products, which would improve their attractiveness for consumers. One of the main tasks during blending is the selection of formulation components with natural energy value and attractive organoleptic properties. Since useful products do not always have pleasant basic properties, such as color, there occurs the need to study color formation at different stages of production of fruit-berry semi-finished products under conditions of properly treating them with heat.

Thus, it is an important task to ensure competitiveness of the produced high-quality fruit-berry pastes and to decrease costs of raw materials, as well as reduce resource utilization for production. This necessitates the need to extend the range of products of plant origin by using fruits, berries, vegetable raw materials, etc.

2. Literature review and problem statement

Given the fertility of land in Ukraine, it is possible to gather about 2 million tons of natural fruit-berry raw materials annually; however, only 50 thousand tons are actually gathered [1, 2]. In some cases, the cultivated fruits and berries with a high content of useful substances are planted [3]. The main reason for such a situation is the lack of innovative techniques for processing natural raw materials. Existing equipment for the production of natural semi-products (purees, pastes, etc.) is characterized by a significant duration of thermal treatment, high energy and metal consumption, which leads to substantial losses of BAS.

The most rational way to intensify the processes of treatment of natural raw materials is the introduction of innovative techniques and equipment, the use of which will

ensure guaranteed production of high-quality semi-finished products at minimal consumption of resources [4].

The main disadvantage during production of multi-component semi-finished products is significant losses of BAS when raw materials are thermally treated. First, it concerns the concentration whose duration in most evaporators can take from 100 to 400 min; in this case, losses of vitamin C may amount to 30...80 % [5].

One of the promising techniques to intensify the processes of natural raw material concentration is the use of a film flow of liquid products, under the influence of gravity, centrifugal forces, and accompanying steam flow that occur in the rotor film devices (RFD). The use of RFD would make it possible to reduce significantly the duration of thermal treatment of products, to decrease the loss of BAS, to reduce dimensions of equipment and bring down maintenance costs, thereby excluding spoiling the products and their losses [6]. Given the transience of technical progress, even the effective varieties of RFD may offer the ways for structural modernization, which are primarily related to the system of heating and the geometric shape of blades [7].

The existing RFD use in most cases either the steam or electric heating system with the application of various intermediate heat carriers. These combinations made it possible, over a long time, to ensure acceptable heat exchange coefficient through a wall to the raw material that is being concentrated. These heating systems are characterized by inertia, complexity of maintenance, metal consumption and, therefore, considerable dimension and weight parameters and costs [5, 6]. That is why there occurs the need to search for the ways of an innovative approach to these shortcomings by using modern low-inertial and less metal-consuming infrared heaters that are now produced even at the territory of Ukraine [7].

When manufacturing multicomponent fruit-berry semi-finished products, it is necessary to consider medicinal-prophylactic properties of fruit and berry raw material, specifically, the content of biologically active substances (BAS), pectins, and to maintain the total acidity value at the level of 3.3...3.7 pH [6, 8]. In this case, determining the influence of biological substances on human health requires considerable attention because at present there is no unified procedure for its analysis. Competitiveness at consumer markets should also be taken into account, not only because of an increase in energy value of the product, but also because of attractive nutritious properties, such as physical appearance, color, taste, and flavor [9]. For example, when manufacturing bars based on fruit pastes, it is difficult to obtain the color and taste that are attractive to consumer, since it is necessary to take into consideration the influence of properties of each component and their mass content on the resulting color formation and taste.

It is the color that mainly characterizes quality of fresh raw materials and products, derived after technological operations [10]. This necessitates the study of methods for changing the color formation aimed at searching for the universal technique, which is a complicated technical task. There are a lot of methods for determining color formation, including organoleptic, instrumental methods, etc. [11]. Each of the known methods, however, has its own advantages and disadvantages, which requires their constant improvement and creation of universal devices. At present, production processes of various pastes, which in most cases require much time to process the technological data acquired, are optimized, based on sensory analyses [12]. To simplify the obtained data processing, specialized devices are developed for sensory estimation of products quality [13]. They, however, have a rather narrow range of food products in their computer database, and therefore are not universal.

Improvement of concentration equipment and substantiation of the production technique is a relevant task in the production of high-quality multicomponent natural semi-finished products. Applicable heating regimes and formulation ratios of components must be taken into consideration. It is also necessary to determine general quality indicators of the obtained semi-finished products. At present, monitoring of the quality of multicomponent compositions is increasingly conducted by using portable infrared spectrometers [14]. The data obtained will make it possible to optimize technological parameters for processing natural raw materials, define the color of products depending on the content of components at various production stages and ensure the guaranteed high quality of food products on their base. However, there is no a unified procedure for determining the color of food products.

Thus, there is a need in innovative approaches to improving existing devices for the concentration of raw materials in order to produce high quality products, which is expedient to obtain through artificial enrichment of compositions by their blending with a variety of natural raw materials, which is characterized by high content of BAS and medicinal-preventive properties. It is also necessary to examine the obtained structure of products after blending, as well as a change in color formation at all stages of the production of multicomponent compositions taking into account the effect of each natural component. Consideration of all the specified requirements will ensure the extension of assortment of high-quality multicomponent natural pastes.

3. The aim and objectives of the study

The aim of present study is to improve a rotor film device for the implementation of the proposed technique for producing high-quality multicomponent natural pastes with medicinal-preventive properties. This will make it possible to improve technical parameters of equipment, specifically to ensure an acceptable temperature mode for concentration, a decrease in metal consumption of structures, as well as extend the assortment of high-quality multicomponent natural pastes, based, for example, on apple, cranberry, and hawthorn.

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

– to perform the intensification of a heat exchange system by using an infrared electric heater, which would enable a decrease in metal consumption of RFD;

– to propose a technique for producing multicomponent natural pastes with a high content of BAS and medicinal-preventive properties;

– to determine influence of each component on a change in structural-mechanical properties of the obtained multicomponent compositions;

– to confirm the retention of quality characteristics of multicomponent natural purees and pastes by analyzing their color.

4. Materials, methods of research into multicomponent natural compositions, and the experimental setup

Experimental research into improvement of the equipment and the technique for producing high-quality multicomponent natural pastes was carried out at the laboratories at Kharkiv State University of Food and Trade (Ukraine).

Detailed description of the experimental setup of a rotor film device, as well as materials and methods of research into compositions of multicomponent natural semi-finished products, are given in paper [15].

5. Improvement of RFD and the technique for producing high-quality multicomponent natural semi-finished products

It was proposed to intensify the concentration process by attaining the required technological parameters through the improvement of a heat exchange system of RFD. This would make it possible to produce multicomponent natural pastes with an elevated content of BAS and medicinal-preventive properties.

Improvements were carried out using, as an infrared heater, a flexible film resistive electric heater of the radiation type (FFREHRT), which enables a similar geometrical shape of the device [16]. Its use made it possible to decrease inertia and metal consumption of the basic structure of RFD, as well as to simplify its automation system.

Fig. 1 shows the improved rotor film device.

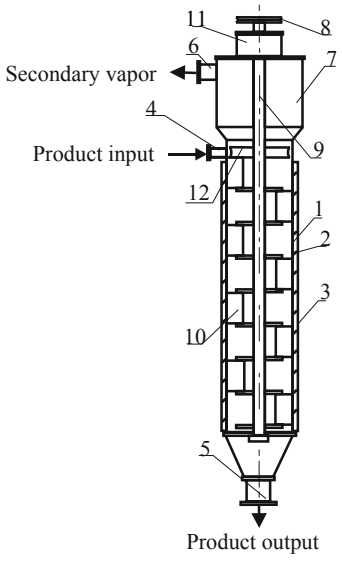

Fig. 1. Setup of the rotor film device: 1 — casing of device; 2 — FFREHRT; 3 — insulating material; 4 — product input nozzle; 5 — product output nozzle; 6 — output of secondary vapor; 7 — separator; 8 — drive pulley; 9 — rotor shaft; 10 — hinge blade; 11 — rotating shaft sealing system; 12 — distributive ring

The proposed setup consists of a casing of rotor evaporator 1, flexible film resistive electric heater of radiation type 2 whose outer surface is wrapped with insulating material 3, nozzles of product input 4 and output 5, nozzle of the secondary vapor output 6, separator 7, drive pulley 8, shaft rotor 9, equipped with hinge blades 10, and rotating shaft sealing system 11 with distributive ring 12.

The structure operates in the following way. A product, for example a multicomponent natural puree, is fed to the input nozzle, located in the upper part of casing 1. After that, puree arrives in distributive ring 12, where it is shaped in the form of a liquid film on the heat exchange surface. Heating of the operation surface is carried out by FFREHRT 2. The outer surface of FFREHRT is wrapped with insulating material 3.

Rotor 9, equipped with rotating shaft sealing system 11, has hinge blades 10, mounted on it, which move a thin film of the product to discharge nozzle 5.

The improvement enables intensification of the process of concentration of natural raw material by ensuring uniformed heating of the operation space of the device and by employing acceptable temperature mode (50...60 °C). In this case, a decrease in resource consumption, in the dimensional and weight characteristics of RFD is provided, and therefore, the cost of such devices, as well as maximal retention of the quality of processed raw material. The formulation ratio of natural components in multicomponent compositions, given in Table 1, was proposed in order to test the improved RFD.

Table 1

Formulation ratio of natural components in multicomponent compositions

Composition formulation	Composition (sample)		
	1a	1b	1c
Apple	60	65	55
Cranberry	30	25	40
Hawthorn	10	10	5
Control, %	100	100	100

According to the developed technique, ripe fruits of cranberry and hawthorn are washed, examined, their sterns and pits are removed [17]. The fruits of cranberry and hawthorn are blanched separately in 1...2 % solution of citric acid at temperature of 60...70 °C for 3...6 min in the multifunctional device in order to stabilize the polyphenolic complex and to soften the fibers [5]. Then, they are pulped, removing skin and pits at a double pulping machine with sieve diameters of 1.0...1.2 and 0.4...0.6 mm. The skin and pits with the residual pulp are boiled for 4...8 min; the obtained mass is repulped at the same machine in order to increase the output of finished products and enable a waste-free technology [5].

Apple puree is prepared according to the acting technological instructions for producing the fruit and berry purees [5].

Next, the mass from cranberry and hawthorn, the pulped mass of concoction from the skin and pits of these berries, and apple puree is mixed and stirred. Blending of natural components was carried out in accordance with the proposed formulation ratio of the raw materials in compositions with a different mass content (Table 1). Their color formation will be subsequently examined in order to confirm maintaining the quality of the obtained semi-finished products.

The resulting mass was preheated to a temperature of 35 °C and boiled in RFD at a temperature of 50...60 °C for 0.65...0.8 min to the content of 25...30 % of DM. Next, the mass obtained is packaged at a temperature of 55 °C, sealed, sterilized, and marked. Applying moderate temperatures during concentration (50...60 °C) prevents significant losses of biologically valuable substances and helps maintain medicinal-prophylactic properties.

Based on the result of experimental research, it was found that in the course of blending multicomponent natural purees, the strength of the resulting structure changes. This is due to the redistribution of moisture by the forms of bonds, which affects a change in the structural-mechanical properties of a semi-finished product [16]. This prompted us to study a change in the properties of puree-like compositions according to the formulation ratio (Table 1) applying the proposed technique.

Apple raw material was used as a control sample when examining structural-mechanical properties of multicomponent puree-like semi-finished products. Based on the result of research, the curves of DFD with a distribution of pores by the radius, shown in Fig. 2, were derived for the samples of compositions with a different content of natural raw materials.

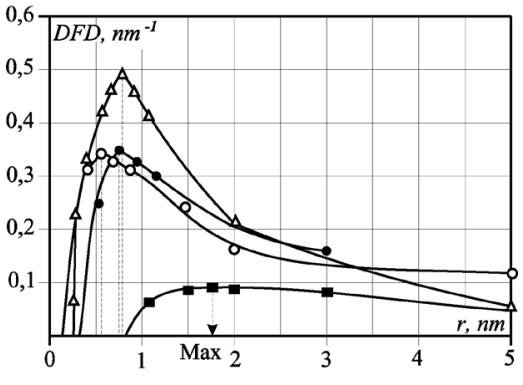

Fig. 2. Differential function of distribution of pores by radii in multicomponent natural puree according to formulation ratio: ○ – (1a) 60 % of apple, 30 % of cranberry, 10 % of hawthorn; △ – (1b) – 65 % of apple, 25 % of cranberry, 10 % of hawthorn; ● – (1c) – 55 % of apple, 40 % of cranberry, 5 % of hawthorn; ■ – control (100 % of apple raw material)

An analysis of the obtained diagrams of DFD for the proposed components in the composition and the dense arrangement of DFD curves makes it possible to make a conclusion about the absence of a dominating impact from any of the samples when changing the content of components.

This indicates insignificant changes in the dispersion of the resulting food mass in the proposed formulation ratios. A comparison of the maximum values of DFD for the examined multicomponent samples confirms an increase in the dispersion compared with control. Specifically, it was established that the maximal values of DFD for the studied samples shift toward small radii of pores by 2...2.2 times.

Based on the results of mathematical processing, the procedure for which is given in paper [18], we calculated the values of mean radii of microcapillaries in multicomponent natural compositions. For composition No. 1a, $\overline{r}=1{,}51$ nm, for No. 1b, $\overline{r}=1{,}69$ nm, for No. 1c, $\overline{r}=1{,}7$ nm. The resulting values for the radii of pores ($\overline{r}$) confirm that the dispersion in the studied samples differs insignificantly.

By comparing the effect of adding cranberry on dispersion of the obtained puree, taking into account the valued obtained for the mean radii of microcapillaries, it is possible to argue that an increase in the dispersion of the obtained puree is observed at an increase in the content of cranberry from 25 to 30 % (compositions 1b and 1a). At an increase in the content of cranberry up to 40 %, on the contrary, we observe a decrease in dispersion. Given that the mean radii of puree in compositions 1a, 1b, and 1c differ by 10 %, the effect of the concentration of cranberry components on the strength of the resulting food mass is minimal.

Therefore, it was confirmed that the estimation of dispersion of a multicomponent natural puree for the mean radius of pores $\overline{r}$ allows determining and comparing the effect of each component on the obtained dispersion and structure of a semi-finished product.

To confirm retention of BAS and medicinal-preventive properties of multicomponent natural compositions of pastes at different stages of their production, we studied color characteristics in stages.

Determining color characteristics of each component in the puree-like form (apple, cranberry, and hawthorn) was studied at the first stage.

Based on the results, it was established that apple is characterized by high values of reflection coefficient in the greenish-yellow component, which is explained by the greenish-yellow coloration of its flesh. Low values of reflection coefficients for cranberry and hawthorn are explained by the bright red and orange colors compared to apple.

Rational wavelengths that are responsible for the dominating tone, and color tone purity in the samples, were established. For apple, it is 573.8 nm with a tone purity of 65.6 % and corresponds to greenish-yellow color. For cranberry, it is 597.7 nm; a tone purity of 77.8 % characterizes bright red color. For hawthorn, tone purity is 89.1 % (590 nm), color is orange.

The second stage implied determining and analysis of color characteristics of the resulting multicomponent natural puree (Table 2) upon blending components according to formulation, Table 1.

Table 2

Characteristics of color of samples of compositions of multicomponent natural puree (Sr=0.05, n=5, p=0.95)

Experimental samples of compositions of multicomponent natural puree	Color coordinates			Length of dominating wave	Brightness	Color purity	Visual characteristics of samples color
	x	y	z	λ_{nm}	T, %	P, %	
Sample 1a	4.50	2.95	0.75	610.8	35.9	76.4	reddish-orange
Sample 1b	3.79	2.39	0.75	614.5	34.5	70.7	reddish-orange
Sample 1c	4.73	3.03	0.78	616.1	37.6	78.1	reddish-orange

The wavelength, which dominates the sample of puree 1a, is 610.8 nm and characterizes the reddish-orange color with a color tone purity of 76.4 %. For samples 1b and 1c, it is 614.5 and 616.1 nm, respectively. For sample 1b, the value of tone purity at 70.7 % corresponds to reddish-orange color. The tone purity of 78.1 % in sample 1c characterizes the reddish-orange color.

The third stage implied obtaining color characteristics of the compositions of multicomponent natural pastes using the known content of components (Table 1). Concentration of multicomponent natural puree was carried out in accordance with the technological process, specified in the methods of research.

Analysis of the obtained reflection spectra made it possible to establish that the minimal component of blue color (z) for paste sample 1a was 0.489, samples 1b and 1c are characterized by values of 0.777 and 0.528, respectively (Table 3).

The wavelength, which dominates in paste sample 1a, is 610 nm and corresponds to reddish-orange color with a tone purity of 77.6 %. For pastes 1b and 1c, it is 613.4 and 614.1 nm, respectively. For sample 1b, the value of tone purity at 64.0 % corresponds to reddish-orange color. Sample 1c is also characterized by reddish-orange color because it has tone purity at the level of 78.9 %.

Comparison of the visual color characteristics of the samples (Tables 2, 3) confirms the retention of colors in the puree prior to thermal treatment, and concentrated pastes. Retention of color characteristics during concentration confirms minimal physical-chemical changes during thermal treatment and maximal retention of BAS, as well as medicinal-prophylactic properties, of the finished product – a paste. This has become possible due to the use of the improved RFD.

Table 3

Characteristics of color of experimental samples of compositions of multicomponent natural pastes by different content of components (Sr=0.05, n=5, p=0.95)

Experimental samples of compositions of multicomponent natural pastes	Color coordinates			Length of dominating wave	Brightness	Color purity	Visual characteristics of samples' color
	x	y	z	λ_{nm}	T, %	P, %	
Sample 1a	3.05	2.02	0.49	610	36.1	77.6	reddish-orange
Sample 1b	2.12	2.00	0.77	613.4	34.7	64.0	reddish-orange
Sample 1c	3.17	2.04	0.53	614.1	37.7	78.9	reddish-orange

The final stage of the study on confirming the quality of the obtained semi-finished products implies conducting sensory evaluation of the resulting finished product of multicomponent natural pastes according to the procedure of the European organization for quality control of food products. Results of expert assessment are given in Table 4.

Table 4

Results of expert assessment of quality indicators of multicomponent natural pastes by samples of compositions

Example	Quality indicators of multicomponent natural pastes, point					Total score, point
	Physical appearance	Consistency	Color	Taste	Odor	
Samples of compositions of multicomponent natural pastes						
sample 1a	10	15	9	10	5	49
sample 1b	9	14	9	9	5	46
sample 1c	9	14	8	8	4	43
Prototype (paste from apple, quince, and elderberry)	10	14	9	10	5	48

Data analysis indicates the best quality of the multicomponent natural paste with the introduction to the total mass of raw materials of 60 % of apple puree, cranberry in the amount of 30 %, hawthorn in the amount of 10 % (sample 1a). The introduction of cranberry and hawthorn in large quantities negatively affects the taste properties of products, if they are introduced in smaller quantities, it leads to a decrease in food value and worsens organoleptic characteristics of the product.

6. Discussion of results obtained when producing high-quality multicomponent natural semi-finished products using the improved RFD

The results obtained are explained by the efficiency of the proposed technical solution that implies the improvement of a heat exchange system at RFD by using FFREHRT, as well as by employing the applicable thermal mode (50...60 °C) for the concentration of multicomponent natural semi-finished products.

The applicable technical characteristics of the chosen FFREHRT made it possible to obtain such a result because it is characterized by low temperatures at its surface (35...70 °C), low inertia and metal consumption, it can repeat the geometry of the operating chamber of devices and is easy to automate. That is why its application is promising as it allows decreasing the inertia and metal consumption in basic designs of RFD and ensuring the required temperature mode of concentration.

The presented technique for producing multicomponent natural pastes according to the formulation ratio will enable obtaining combined natural semi-finished products with a high content of BAS and medicinal-preventive properties. An analysis of the combined semi-finished products according to DFD will make it possible to determine and compare effect of each component on the obtained dispersed structure of a semi-finished product.

The benefits of present research as compared to existing analogues include, first of all, the creation of an applicable technological solution for the intensification of heat exchange at RFD, which would enable a significant enhancement of technical parameters of these devices and a decrease in their cost. Implementation of the proposed formulation composition of a multicomponent natural paste and the improved design of RFD in the food industry will ensure production of high-quality semi-finished products with a significant content of BAS and medicinal-preventive properties.

Obtaining fruit multicomponent compositions was studied earlier at the classic design of RFD [6]. In this case, heating of its working chamber was carried out by an electric spiral electric heater and intermediate fluid PFSM. Such a heating system was characterized by inertia, metal consumption, non-uniformity of heating, complexity of operation and automation. These technical drawbacks were eliminated by the proposed innovative solution.

When preparing fruit multicomponent compositions, little attention was paid to the food value of obtained semi-finished products. That is why an example of the formulation ratio of the paste, based on apple, cranberry and hawthorn, was proposed. The selected components are characterized by a significant content of BAS and medicinal-preventive properties. The presented solution for determining the structure of semi-finished products depending on the mass content of each selected component would make it possible to define the obtained structure of natural compositions in advance.

With respect to the results of retention of color characteristics and quality indicators of the multicomponent semi-finished products, it is possible to consider that the improved design of RFD does not have any technical drawbacks identified so far. However, it is worth noting that the application of the results obtained is possible only in the case of a necessity to study the obtained structural-mechanical properties of natural compositions with other components. Further research is planned into production of high-quality natural semi-finished products without the removal of pits. This would ensure artificial natural enrichment of products to be obtained with a variety of useful substances, as well as waste-free production.

7. Conclusions

1. We have improved a heat exchange system of rotor film devices (RFD) by using, as a heater, a flexible film resistive electric heater of the radiation type (FFREHRT), which repeats the geometry of a working chamber of the device. This ensures the applicable temperature mode (50...60 °C), a decrease in resource consumption, dimensional and weight characteristics of RFD, and hence the cost of such devices.

2. We have substantiated a technique for the production, as well as a formulation ratio of multicomponent natural pastes, based on apple, cranberry and hawthorn. The selected components are characterized by a considerable natural content of BAS and medicinal-preventive properties.

3. The influence of mass share of each component on a change in the structural-mechanical properties of the obtained natural multicomponent semi-finished products was established. An increase in the dispersion of the obtained puree at an increase in the content of cranberry from 25 to 30 % was confirmed. On the contrary, the dispersion decreased at a subsequent increase in the content of cranberry to 40 %.

4. We have confirmed the retention of color characteristics of multicomponent compositions of puree prior to concentration and of the obtained pastes in the acceptable temperature mode (50...60 °C). Therefore, the content of BAS and medicinal-prophylactic properties were preserved in the paste of the reddish-orange color that is attractive to consumer.

References

1. Shazzo R. I., Ovcharova H. P. Produkty detskoho pitaniya iz rastitel'noho i miasnoho syr'ia infrakrasnoi sushki // Khranenie i perabotka sel'khozsyr'ia. 2005. Issue 1. P. 50–52.
2. Kasiianchuk V. D., Kovach M. M., Kasiianchuk M. V. Perspektyvy vykorystannia dykoroslykh plodiv, yahid i hrybiv v umovakh Prykarpattia dlia vyhotovlennia produktsii likuvalno-profilaktychnoho pryznachennia [Prospects for the use of wild fruits, berries and mushrooms in the conditions of the Precarpathian region for the production of products for treatment and prophylactic purposes] // Naukovyi visnyk NLTU Ukrainy. 2013. Issue 23.7. P. 151–156.
3. The development of plants for the production of concentrated pastes of fruit and vegetable raw materials / Magomedov G. O., Magomedov M. G., Zhuravlev A. A., Lobosova L. A. // Proceedings of the Voronezh State University of Engineering Technologies. 2015. Issue 3. P. 13–16.
4. Technology concentration of fruit and vegetables / Magomedov G. O., Magomedov M. G., Astredinova V. V., Litvinova A. A. // Proceedings of the Voronezh State University of Engineering Technologies. 2012. Issue 4. P. 86–89.
5. Vasilinec I. M., Saburov A. G. Rotornye plenochnye apparaty v pishchevoy promyshlennosti. Moscow: Agropromizdat, 1989. 136 p.
6. Progressivnye protsessy kontsentrirovaniya netraditsionnogo plooovoshchnogo syr'ia: monograph / Cherevko A. I., Kiptelaia L. V., Mihailov V. M., Zagorulko A. E. Kharkiv: KhSUFTT, 2009. 241 p.
7. Monocrystal. Heating systems. URL: http://monocrystal.com.ua/index.php
8. Biological activities of selected polyphenol-rich fruits related to immunity and gastrointestinal health / Denev P., Kratchanova M., Ciz M., Lojek A., Vasicek O., Nedelcheva P. et. al. // Food Chemistry. 2014. Vol. 157. P. 37–44. doi: 10.1016/j.foodchem.2014.02.022
9. Development of novel fruit bars by utilizing date paste / Parn O. J., Bhat R., Yeoh T. K., Al-Hassan A. A. // Food Bioscience. 2015. Vol. 9. P. 20–27. doi: 10.1016/j.fbio.2014.11.002
10. Pathare P. B., Opara U. L., Al-Said F. A.-J. Colour Measurement and Analysis in Fresh and Processed Foods: A Review // Food and Bioprocess Technology. 2012. Vol. 6, Issue 1. P. 36–60. doi: 10.1007/s11947-012-0867-9
11. Dubinina A. A., Shcherbakova T. V., Seliutina H. A. Estimation of the color of products from vegetable raw material with use of the SP-method // Progressive engineering and technology of food production, restaurant business and trade. 2010. Issue 2 (12). P. 429–435.
12. Optimization of olive-fruit paste production using a methodological proposal based on a sensory and objective color analysis / Vicario I. M., Escudero-Gilete M. L., Mel ndez-Mart nez A. J., Heredia F. J. // Grasas y Aceites. 2009. Vol. 60, Issue 4. P. 396–404. doi: 10.3989/gya010509
13. Advanced Taste Sensors Based on Artificial Lipids with Global Selectivity to Basic Taste Qualities and High Correlation to Sensory Scores / Kobayashi Y., Habara M., Ikezazki H., Chen R., Naito Y., Toko K. // Sensors. 2010. Vol. 10, Issue 4. P. 3411–3443. doi: 10.3390/s100403411
14. Monitoring multicomponent quality traits in tomato juice using portable mid-infrared (MIR) spectroscopy and multivariate analysis / Ayvaz H., Sierra-Cadavid A., Aykas D. P., Mulqueeney B., Sullivan S., Rodriguez-Saona L. E. // Food Control. 2016. Vol. 66. P. 79–86. doi: 10.1016/j.foodcont.2016.01.031
15. Application of rotated film apparatus at production of multi-component fruit pasts / Cherevko O., Mykhaylov V., Zagorulko A., Zahorulko A. // EUREKA: Physics and Engineering. 2018. Issue 2. P. 21–27. doi: 10.21303/2504-5695.2018.00596

16. Zagorulko A. M., Zagorulko O. Ye. Hnuchkyi plivkovyi rezystyvnyi elektronahrivach vyprominiuiuchoho typu: Pat. No. 108041 UA. MPK H05B 3/36, B01D 1/22, G05D 23/19. No. u201600827; declareted: 02.02.2016; published: 24.06.2016, Bul. No. 12. URL: http://uapatents.com/5-108041-gnuchkijj-plivkovijj-rezistivnijj-elektronagrivach-viprominyuyuchogo-tipu.html
17. Zagorulko O. Ye., Zagorulko A. M., Filonenko A. O. Method of manufacture of fruit-fresh paste: Pat. No. 119164 UA. MPK A23L 21/10. No. u201703852; declareted: 19.04.2017; published: 11.09.2017, Bul. No. 17. URL: http://base.uipv.org/searchINV/search.php?action=viewdetails&IdClaim=239139
18. Zagorulko A. M., Kiptela L. V., Zagorulko O. Ye. Method of determining the strength of the multicomponent structure of plant pastes: Pat. No. 103094 UA. MPK (2015.01) A23B 7/00. No. u201413136; declareted: 08.12.2014; published: 10.12.2015, Bul. No. 23. URL: http://base.uipv.org/searchINV/search.php?action=viewdetails&IdClaim=218265

Охарактеризовано харчові плівки на основі полісахаридів. Досліджено наступні характеристики даних плівок: паропроникність, механічну міцність на розрив та прокол, вязкість плівкоутворюючого розчину. З цією метою в якості плівкоутворюючого матеріалу було застосовано ефір целюлози, карбоксиметилцелюлоза. Відповідно в якості розчинника використовувались дистильована вода, а в якості пластифікаторів – гліцерин, сорбіт та пропіленгліколь

Ключові слова: плівкоутворюючі покриття, пластифікатор, термін зберігання м'яса, синергізм, альгінат натрію, гідроколоїди

Охарактеризованы пищевые пленки на основе полисахаридов. Исследованы следующие характеристики этих пленок: паропроницаемость, механическая прочность на разрыв и прокол, вязкость пленкообразующего раствора. С этой целью в качестве пленкообразующего материала был применен эфир целлюлозы, карбоксиметилцеллюлоза. Соответственно в качестве растворителя использовались дистиллированная вода, а в качестве пластификаторов – глицерин, сорбит и пропиленгликоль

Ключевые слова: пленкообразующие покрытия, пластификатор, срок хранения мяса, синергизм, альгинат натрия, гидроколлоиды

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EFFECT OF PLASTICIZERS ON THE QUALITATIVE INDICATORS OF FILM-FORMING COATINGS FOR THE PROTECTION OF CHILLED MEAT

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1. Introduction

Continuous quality assurance and safety of products (chilled meat and meat products) is a top priority for specialists in the meat industry. Fresh meat has a very limited shelf life, which creates difficulties for manufacturers and poses a potential threat to consumers. Given this, selling meat products is geographically restricted by the place of production while transportation and storage requires special conditions.

In the process of storage and processing meat can be subjected to various types of damage: tanning, mucus forming, mold, rotting, change in color. The specificity of storing meat in semi-carcasses is the fact that not so many protection techniques are applicable. Given a complex geometric shape of a semi-carcass, the use of traditional packaging means