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# COLOR CHARACTERISTICS OF DRIED THREE-COMPONENT FRUIT AND BERRY PASTES

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**Abstract.** Color characteristics of compositions of three-component fruit and berry pastes before and after infrared drying are determined. The compositions were prepared on the basis of apples, cranberries, and hawthorn with increased nutrition value and therapeutic and prophylactic properties, according to the suggested recipe. The ratio of the components in the first composition is 60 : 30 : 10, in the second, 65 : 25 : 10, and in the third, 55 : 40 : 5. The resulting compositions were controlled by the control (apple paste). To dry the compositions obtained, it is proposed to use a roller IR dryer based on a flexible resistive film electric heater of emitting type. The prepared paste compositions are reddish-orange according to the color characteristics determined. Color characteristics of dried three-component fruit and berry pastes are also determined. The wavelength of composition 1 is 498 nm, and those of compositions 2 and 3 are 620.5 and 589.4 nm, respectively. The first composition is bluish-purple, with tone purity 34.7%. Composition 2 is red (34.8%), composition 3 is bluish-red (34.6%). The comparison of the color characteristics of compositions of three-component fruit and berry pastes before and after infrared drying as for the brightness and tone purity of the samples indicates a slight change in brightness within 2–6%. Reduction of the color purity to almost a half is due to the drying shrinkage of the mass of raw materials and obtaining a visual color of the compositions that is attractive for a consumer. According to the results of expert evaluation of the quality indices of dried three-component fruit and berry paste compositions, a certain advantage is determined of the dried composition with the following ratio of components in the recipe: apple, cranberry, hawthorn – 60 : 30 : 10 (composition 1). The suggested compositions of dried three-component fruit and berry paste are recommended for use in food rations as an independent product, as well as for manufacturing flour products, soft drinks and spirits, confectionery and bakery products.

**Key words:** color, fruit and berry raw material, paste, IR-drying, spectrum, change, quality.

# КОЛЬОРОВІ ХАРАКТЕРИСТИКИ СУШЕНИХ ТРИКОМПОНЕНТНИХ ПЛОДОВО-ЯГІДНИХ ПАСТ

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**Анотація.** Визначено кольорові характеристики композицій трикомпонентних плодово-ягідних паст до та після ІЧ-сушіння. Композиції готували на основі яблук, журавлини та глоду із підвищеним вмістом харчової цінності та лікувально-профілактичними властивостями, відповідно до запропонованого рецептурного складу. Для сушіння запропоновано використовувати вальцьову ІЧ-сушарку на основі гнучкого плівкового резистивного електронагрівача випромінювального типу за низького температурного режиму (45°С) та товщини шару сировини на рифленій поверхні барабана 1 мм. Визначені якісні показники сушених трикомпонентних плодово-ягідних паст шляхом аналізування їх кольорових характеристик та експертним оцінюванням за органолептичними показниками. Запропоновані сушені трикомпонентні плодово-ягідні пасти рекомендовано до застосування у раціонах харчування як самостійний продукт, а також для виробництва борошняної кулінарної продукції, безалкогольних та горілчаних напоїв, кондитерських і хлібобулочних виробів.

**Ключові слова:** колір, плодово-ягідна сировина, паста, ІЧ-сушіння, спектр, зміна, якість.



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## Introduction. Formulation of the problem

When manufacturing food of natural origin, maximum preservation of biologically active substances (BAS) and high quality are necessary at all processing stages. In order to preserve the original properties of a plant material, drying is mostly used, in particular for powdered, semi-finished, pre-concentrated multicomponent fruit and berry pastes [1].

The manufacturing of combined food products based on dried three-component fruit and berry pastes will broaden the range of products of natural origin that have high nutritional value and therapeutic and prophylactic properties necessary for daily consumption [2].

One of the determinants of the quality of food products made from plant raw materials is the color and the degree of its preservation during processing (mechanical, thermal, etc.). It is possible to obtain a color attractive for consumers by combining different types of plant material with high content of biologically active substances (BAS) and energy value. All this proves how relevant it is to study color formation when manufacturing dried three-component fruit and berry semi-finished products based on pastes, with favorable temperature regimes of processing [3].

## Analysis of recent research and publications

As a rule, while manufacturing dried natural semi-finished products, no attempts are made to increase the content of BAS artificially or to raise energy value of the resulting products. However, eliminating this disadvantage is quite a simple technological problem, which can be solved by combining various natural raw materials (according to the BAS content) in the composition. While doing that, it is necessary to take into account the microbiological composition of each component, its acidity, and saturation with the color-forming pigment [4].

The simplest solution in manufacturing dried multicomponent fruit and vegetable semi-finished products is the modernization of technological concentration lines, since it is advisable to dry a pre-concentrated semi-finished product, e. g. paste, to a powder-like state in acceptable thermal regimes, with its simultaneous disinfection. This, in its turn, will ensure not only the expansion of the range of dried products with high BAS concentration as compared to the initial raw materials, but will also allow economizing on its transportation and storage. However, there arises an equipment problem of not enough effective dryers for drying pastes with their simultaneous disinfection, primarily infrared dryers [5–6].

In the production of dried multicomponent fruit and berry pastes, a vital task is to determine objectively, while performing technological operations, the color-forming properties of the compositions and their impact on the overall quality index [7].

In many technologies of manufacturing dried fruit and berry powders, considerable attention is paid to innovative resource-saving technologies [3]. However, their constant development and improvement of technology make it necessary to use modern technologies, provided that there exists no single approach to manufacturing semi-finished products yet [1]. In addition, at present, providing people with high-quality natural semi-finished products artificially enriched with vitamins and having therapeutic and prophylactic properties is a problem of major importance [4]. It is solved by combining a certain number of different natural raw materials in a composition with its detailed study for the quality achieved and for the principles of color formation in the process of mixing [7]. In many cases, in the process of blending, manufacturers do not only try to increase artificially the natural content of vitamins in compositions, but to obtain a color attractive for consumers [3]. As a result, there is a necessity to find modern methods, innovative and simple, of determining changes in color formation in the resulting compositions at all stages of their preparation. There is no single way of studying color formation changes. The same holds true for equipment and technology that are constantly changing in the course of scientific progress [8]. That is why our research work is to meet the above-mentioned needs and solve the problems in the production of blended dried three-component fruit and berry pastes with the use of modern innovative infrared dryers (the changes in color formation of the resulting compositions being determined depending on the fraction of the mass content of each component in the composition).

The data obtained will allow optimizing the technological parameters of processing natural raw materials, determining the color of the products (taking into account the compositions' recipes), and ensuring the guaranteed quality of food products that have a color attractive for consumers [9].

**The purpose** of the research consists in determining the color characteristics of dried three-component fruit and berry pastes and their qualitative estimation.

To achieve this, the following problems of determining the color were solved:

1. determining the color characteristics of three-component fruit and berry pastes before and after IR drying till the recommended ratio of components in the recipe is reached;

2. determining the qualitative characteristics of dried three-component fruit and berry pastes by analyzing their color.

## Research Materials and Methods

Experimental research on determining the color of dried three-component fruit and berry pastes was conducted in the laboratories of Kharkiv State University of Food Technology and Trade. Three-component fruit and berry paste based on apples, cranberries and hawthorn, with the ratio shown in Table 1, was used as a starting material for drying.

**Table 1 – The ratio of three-component fruit and berry paste**

| Components | Paste composition (sample) | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | Control |
| Apples | 60 | 65 | 55 | 100 |
| Cranberries | 30 | 25 | 40 | – |
| Hawthorn | 10 | 10 | 5 | – |

The compositions of three-component fruit and berry pastes containing 28–30% of dry matter (DM) were dried in a roller IR dryer based on a flexible resistive film electric heater of an emitting type (FRFEHofET), at a low temperature (45$^{o}$C), and with 1 mm thick raw material layer on the grooved drum. The suggested apparatus has a chopping mechanism located in the offloading part of the dryer, which allows obtaining a powdered fraction of the dried semi-finished product. IR drying was carried out until, finally, the semi-finished product contained 4–6% of moisture. Then, it

was packaged into light-reflecting leak-proof polyethylene bags.

The mass fraction of dry substances was determined according to State Standard 28561-90.

The diffuse reflection of the samples was investigated on a SF-2000 spectrophotometer, with further mathematical analysis of the obtained spectra of the samples to determine the nature of color formation in the tricolorimetric coordinate system X, Y, Z. The color forming parameters were determined by the ICE method (International coordinate system CIE) [10–12].

The quality of the dried three-component fruit and berry pastes obtained was determined by expert assessment of the organoleptic parameters according to the methodology of European Food Quality Control Organizations. During the evaluation, independent experts were selected, who tasted the product samples to test them by the five main parameters: appearance, consistency, color, taste, and smell. The samples were also compared with the prototype of dried three-component fruit and berry paste based on apples, quince, and black elderberry. Then, the experts gave scores for each sample and summed up the results to determine the best sample of dried three-component fruit and berry semi-finished products.

## Results of the research and their discussion

The first stage of the research is obtaining the color characteristics of the compositions of three-component fruit and berry pastes before drying, according to a certain ratio of the components (Table 1, Fig. 1). Analysis of the obtained reflection spectra of the three-component pastes compositions has shown that the minimum component of the blue color (z) for paste sample 1a is 0.485, and compositions 1b and 1v are characterized by the values of 0.771 and 0.530, respectively (Table 2).

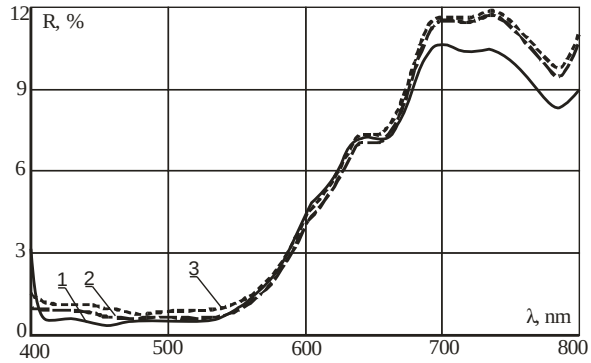


**Fig. 1. Spectra of reflection for composition samples of three-component fruit and berry pastes: 1 – sample 1; 2 – sample 2; 3 – sample 3**

The determined wavelength prevailing in paste sample 1 is 610.8 nm, and the tone purity is 77.8%. For paste 2, the wavelength is 613.1 nm, the tone purity is 64.6%; and for sample 3, it is 614.5 nm, with the tone purity 78.1%. All experimental compositions of pastes were reddish-orange.

**Table 2 – Color characteristics of the experimental samples of the compositions of three-component fruit and berry pastes with different content of components**

| Experimental samples of the compositions of three-component fruit and berry pastes | Coordinates of color | | | Dominating wavelength | Brightness | Color purity | Visual characteristics of the color of the samples |
|---|---|---|---|---|---|---|---|
| | x | y | z | $\lambda_{nm}$ | T,% | P,% | |
| Sample 1 | 3.05 | 2.02 | 0.48 | 610.8 | 36.3 | 77.8 | Reddish-orange |
| Sample 2 | 2.89 | 2.05 | 0.77 | 613.1 | 34.1 | 64.6 | Reddish-orange |
| Sample 3 | 3.21 | 2.04 | 0.53 | 614.5 | 36.9 | 78.1 | Reddish-orange |

The second step was determining the color characteristics of the samples of dried three-component fruit and berry pastes (Fig. 2), made in accordance with the recipe ratios previously suggested at the first stage. The three-component fruit and berry pastes were dried according to the technological process described in the methods of research.

During the research, the reflection spectra of the compositions were obtained (Fig. 2). Their analysis has shown that the minimal component of blue (z) for sample 1 is 0.271, and for samples 2 and 3, respectively, it is 0.350 and 0.284 (Table 3).

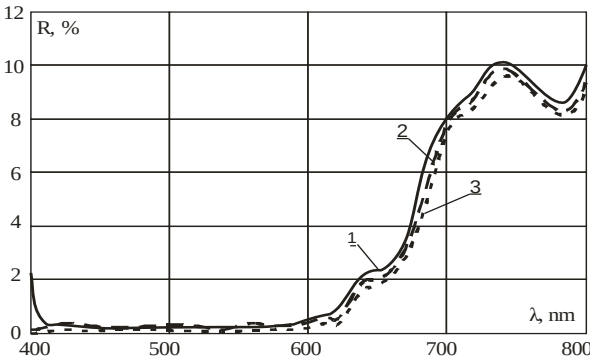


**Fig. 2. Spectra of reflection of dried three-component fruit and berry pastes: 1 – sample 1; 2 – sample 2; 3 – sample 3**

The wavelength characteristic of the sample of dried three-component fruit and berry paste 1 is 498 nm, which corresponds to the bluish-purple color with tone purity 34.7%. For samples 2 and 3, the wavelengths are 620.5 and 589.4 nm, respectively. For sample 2, the value of tone purity (34.8%) corresponds to the red color. Sample 3 is characterized by the bluish-red color, because its tone purity is 34.6%.

Comparing the visual properties of the colors, namely the brightness and purity of the paste samples before and after drying (Tables 2, 3), it can be con-

cluded that the brightness slightly weakens within the range of 2–6%. The color purity, in its turn, reduces almost in half, which is explained by the loss of the mass of raw materials while drying and by more heat treatment procedures, although the color of the samples is achieved that is attractive for consumers.

The final stage of the research was to determine the quality of the obtained compositions of dried three-component fruit and berry pastes by the methodology of the European Organization for Food Quality Control. The results of the expert evaluation are presented in Table 4.

**Table 3 – Color characteristics of the experimental samples of dried three-component fruit and berry pastes with different content of components**

| Samples of dried three-component fruit and berry pastes | Coordinates of color | | | Dominating wavelength | Brightness | Color purity | Visual characteristics of the samples |
|---|---|---|---|---|---|---|---|
| | x | y | z | $\lambda_{nm}$ | T,% | P,% | |
| Sample 1 | 0.615 | 0.387 | 0.271 | 498 | 30.4 | 34.7 | bluish-purple |
| Sample 2 | 0.606 | 0.435 | 0.305 | 620.5 | 32.3 | 34.8 | red |
| Sample 3 | 0.611 | 0.408 | 0.284 | 589.4 | 33.1 | 34.6 | bluish-red |

**Table 4 – Results of the expert evaluation of the quality parameters of dried three-component fruit and berry pastes**

| Example | Indicators of quality of dried three-component fruit and berry pastes, points | | | | | Overall grade, points |
|---|---|---|---|---|---|---|
| | Appearance | Consistence | Color | Taste | Smell | |
| Dried three-component fruit and berry pastes | | | | | | |
| sample 1 | 10 | 15 | 9 | 10 | 5 | 49 |
| sample 2 | 9 | 14 | 8 | 9 | 5 | 45 |
| sample 3 | 9 | 13 | 7 | 8 | 4 | 41 |
| Prototype | 10 | 14 | 9 | 9 | 5 | 47 |

According to the results of the evaluation, sample 1 has the best quality of dried three-component fruit and berry pastes, containing 60% of apple, 30% of cranberry and 10% of hawthorn raw material. Larger or smaller quantities of cranberries and hawthorn resulted in changes of the organoleptic characteristics of the product, and, consequently, of the nutritional value in general.

After the analysis of the research results presented in the article for the color characteristics depending on their recipe ratio of three-component fruit and berry pastes dried at low temperatures in a roller IR dryer based on FRFEHofET, it became possible to determine the prevailing wavelengths and tone purity for concentrated pastes containing 28–30% of DM and for dried pastes with the 4–6% of DM.

By comparing visual characteristics of the colors, namely their brightness and tone purity, in the samples of the pastes before processing and drying, it is possible to speak of a slight change in brightness ranging 2 to 6%. The reduction of the color purity almost to a half can be explained by drying shrinkage of the mass of raw materials and more heat treatment, although an attractive color of the samples is achieved.

According to the results of the evaluation of dried three-component fruit and berry pastes' quality, a semi-finished product has a certain advantage with the following ratio of components: apple, cranberry, hawthorn – 60 : 30 : 10 (sample 1). The introduction of larger or smaller quantities of cranberries and hawthorn results in changes of the organoleptic characteristics of the product, and, consequently, of the nutritional value as a whole.

The suggested dried three-component fruit and berry pastes are recommended for use in food rations as an independent product, as well as for manufacturing flour products, soft drinks and spirits, confectionery and bakery products.

**Approbation of the research results.** The results of the work have got utility model patents of Ukraine No. 119164– "Method of fruit and berry paste production", No. 119166 – "Roller IR dryer for drying natural pastes (purée) into powdered semi-finished products". Besides, the technical documentation for the roller IR dryer based on FRFEHofET has been approved.

The license agreement for temporary possession of the utility model patent of Ukraine No. 119166 "Roller IR-dryer for drying natural pastes (purée) into powdered semi-finished products" by RPC VOSTOK-ALPHA Ltd. was concluded.

## Conclusions

1. Three-component compositions of fruit and berry pastes based on apples, cranberries and hawthorn, with different mass content of each component, have been made according to the recipe ratios. The ratio of the components for the first composition is 60 : 30 : 10, the second, 65 : 25 : 10, and the third, 55 : 40 : 5. The resulting compositions were controlled by the control (apple paste). The resulting paste compositions are characterized by the reddish-orange color and the following parameters, according to the color characteristics determined: the wavelength of composition 1 is 610.8 nm, with the tone purity 77.8%; the wavelength of composition 2 is 613.1 nm, with tone purity 64.6%; and for composition 3, they are, respectively, 614.5 nm

and 78.1%. The color characteristics of dried compositions of three-component fruit and berry pastes are also determined. The wavelength of composition 1 is 498 nm, and in compositions 2 and 3, the wavelengths are 620.5 and 589.4 nm, respectively. The first composition is bluish-purple, with tone purity 34.7%. Composition 2 is characterized by the red color (34.8%), and composition 3, by the bluish-red color (34.6%).

2. The comparison of the color characteristics of three-component compositions of fruit and berry pastes before and after IR drying, as for brightness and tone purity of the samples, suggests a slight change in brightness (2–6%). The color purity reduced almost to a half can be explained by drying shrinkage of the mass of raw materials, and by achieving the compositions' visual color attractive for consumers.

3. According to the expert evaluation results of quality indices of fruit and berry pastes' dried three-component compositions obtained in a roller IR dryer based on a flexible resistive film electric heater of emitting type at a low temperature (45$^{o}$C), with a 1 mm thick layer of raw material, an advantage is determined of a semi-finished product with the recipe ratio of the components – apples, cranberries, and hawthorn – being 60 : 30 : 10 (composition 1). This composition received 49 points from the experts.

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