DETERMINATION OF COLOR FORMATION OF MULTICOMPONENT FRUIT AND VEGETABLE PASTES AND DRIED POWDER FRACTIONS DURING LOW TEMPERATURE TREATMENT

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Abstract

The aim of the work is to determine the color formation of multicomponent fruit and vegetable pastes and dried powder fractions at the stages of low-temperature pre-concentration and drying, as one of the factors, maintaining the quality of the products.

In the production of organic plant semi-finished products an important factor is the implementation of high-quality technological operations, including heat and mass transfer, which affects the final organoleptic characteristics of products. It is important to take into account the color of raw materials at the stages of blending puree in the production of paste and powder semi-finished products, which requires the introduction of a unified method for assessing the color of raw materials at each stage of the technological operation.

An analysis of traditional methods for determining color formation has been performed, as a result of which it has been found, that the most effective method of evaluation is digital, based on photo processing of the prototype. According to this method, the evaluation of color formation in the manufacture of semi-finished fruits and vegetables in accordance with the proposed recipes has been conducted. Color indices of multicomponent pastes and dried fractions based on them for three prototypes were obtained. The brightness of all samples of pastes is in the range – 36.4… 37.0 % with a purity of tone 64.7… 78.2 %, which corresponds to the reddish-orange color, was obtained. After drying the test samples of pastes to the dried fraction, it has been found, that the brightness, depending on the percentage of raw materials in a sample falls in the range of 30.5… 33.2 %, at that the coloration corresponds to colors from bluish-purple to bluish-red with a purity of tone within 34.7… 34.9 %. As a result of evaluation of organoleptic indicators, it has been found, that according to the presented research samples, the best indicators have a sample with 40 % of raw apples, 20 % of pumpkin, 30 % of cranberries and 10 % of hawthorn. The obtained research data will be useful in the development of methods for the production of semi-finished products from vegetable raw materials. The applied digital method of color determination differs in simplicity and economy in comparison with colorimetric and spectrometric.

Keywords: color formation, low-temperature processing, fruit and vegetable semi-finished product, fruit and vegetable paste, powder fraction.

1. Introduction

During the production of organic semi-finished products, an important factor, influencing the final quality, is the use of resource-efficient hardware and technological solutions. Qualitative

organoleptic parameters of finished products will depend on the chosen method of processing of vegetable raw materials for each technological operation: grinding, preliminary and basic heat treatment in general. The main organoleptic indicator, which not only reflects the influence of temperature regimes and working bodies of machines and devices, but also is the primary choice of the consumer, it is possible to consider the color of the product. It is especially important to take into account the color of raw materials at the stage of blending vegetable purees during the formation of multicomponent mixtures for the production of pasty semi-finished products for a wide range of applications with predetermined indicators. Therefore, when developing the technology of production of vegetable semi-finished products and the corresponding hardware design, it is necessary to have a simple and unified way to evaluate the color formation of raw materials at each stage of the technological operation. This is due to the fact that it is the color transformations of raw materials that characterize the process of physicochemical changes and loss of physiologically functional ingredients (PFI) during the technological processes of processing plant materials and their subsequent storage. This approach determines the search and analysis of existing methods for determining the color of food products and semi-finished products from organic plant materials to obtain a real quality of the impact of its processing. One way to solve this problem is to study the effectiveness of the introduction of simpler computerized methods of qualitative analysis of raw materials.

Organic plant raw materials are increasingly used in the food industry, it is used to make a variety of high quality products for daily and long-term consumption [1]. The problem of food production from plant raw materials is its sensitivity to various factors (oxygen, sunlight, injuries during transportation, etc.), as well as the impact of technological operations (washing, grinding, heat and mass transfer, etc.) [2]. These factors significantly affect the quality of food products from organic plant materials, which contains many high-quality substances, characterized primarily by organoleptic characteristics, including color.

Standards of Ukraine [3] and the European Union consider color to be one of the important organoleptic indicators of organic food products. Detection of unevenness and significant changes in the color of food products from plant raw materials indicates non-compliance with the regime parameters of certain stages of the technological process, which leads to physicochemical changes and losses of valuable substances in raw materials and directly in the final food product. Therefore, the identification and analysis of existing methods for determining the color of food products from plant materials is an urgent task.

The color of finished food is one of the most important selection criteria that influence consumer decisions and ultimate competitiveness. Color is usually measured with colorimeters, a color spectrophotometer, paper indicators, and so on. In [4] the data of the analytical review of the most important aspects of colorimetric detection and current instrumental equipment for recording analytical responses on microfluidic paper analytical devices (μPAD) are presented. The physical basis of color and its use for analytical information are presented and discussed, which allows us to identify methods for obtaining images, including scanners, smartphones, LEDs and visual detection. The research provides examples of programs in various fields, including environmental monitoring, clinical diagnostics, pharmaceutical chemistry, forensic science and food quality control. In [5] the data of two test observations on the study of the influence of consumer decisions during the preparation of fries from fresh potatoes are presented. In both tests, color was of paramount importance to volunteers in deciding to discontinue the frying process, confirming the importance of color of consumer choice and therefore product competitiveness.

[6] notes the recent use of computer-aided technology, which is reliable and can be implemented as an alternative to conventional color measurement methods. In particular, the economical computer vision system for measuring color using various cameras is in great demand. In [7] the method of digital image processing for quantitative determination of dyes in food samples is presented. It is noted, that traditional methods of color determination are expensive to implement and time consuming, which complicates the instantaneity of obtaining real-time results directly during the implementation of technological processes. One of the solutions to simplify the detection of color changes, it is proposed to use a flatbed scanner with subsequent analysis of the original RGB image in other color spaces to visualize the results.

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[8] compared computer vision and colorimeter systems for their ability to measure the color of twenty-seven different types of milk and dairy products. It has been found, that the colors, obtained by the computer vision system, are more similar to the color of a sample, visualized on a monitor, compared to the samples, created by the colorimeter, with values of 83.3… 100.0 % depending on the dairy product. Confirming the relevance of the use of digital methods for determining changes in color in various areas of production, home life and more.

Studies of color changes are relevant even when using modern technologies of food production based on information methods. In particular, [9] investigates the study of four-dimensional changes in color and taste of quality foods, printed on a 3D printer in response to external or internal pH stimulus. Prototypes, obtained by 3D printing of multi-smart materials, consisting of a combination of red cabbage juice, vanilla powder, potato starch and various fruit juices, were used. The ability to print 3D of red cabbage juice and vanilla powder under the influence of various concentrations of potato starch was studied for the first time.

After that, the changes in color, texture, aroma (using the electronic nose) and taste (using the electronic language), caused by the stimulus, were determined. The results showed that the color of the 3D printed product changed from blue (control sample) to red, purple, blue, blue-green and green-yellow when sprayed with solutions with pH from 2 to 10, respectively. In addition, clear differences in aroma and taste profiles were found between pH samples, in particular dried samples of 4D products showed color and anthocyanin stability during storage for three weeks. It has been noted, that color determination is important for the production of healthy foods, even printed on a 3D printer. This will ensure that producers obtain the desired and attractive to consumers organoleptic properties, while increasing the functional and physiological properties. Thus, forming the relevance of the direction of scientific and practical research to determine color formation at any technological stage of production in real time, using simple modern digital equipment.

The purpose of the article is to determine the color formation of multicomponent fruit and vegetable pastes and dried powder fractions at the stages of low-temperature pre-concentration and drying, as one of the factors, maintaining the quality of the products.

To achieve this goal, the following tasks were solved:
– to analyze modern methods for determining the color of food products in terms of its simplicity and cost-effectiveness;
– to establish the color formation of multicomponent fruit and vegetable pastes and dried powder fractions.

2. Materials and methods of research

Known colorimetric and spectrometric methods for studying the color of food products during various technological operations. The measurement of color indicators by the method is performed by determining the coordinates of the color, which then allows you to calculate other values in accordance with the previously obtained spatial values of color. Determination of color coordinates is possible directly due to three-color colorimetry, or calculation based on diffuse reflection or transmission spectra [10].

Spectrometric analysis is based on a set of qualitative and quantitative determination of the composition of the object, which is based on the study of the spectra of interaction of the test sample with radiation, including spectra of electromagnetic radiation, acoustic waves, mass and energy distribution of elementary particles, etc. [11, 12]. The spectrometric method is considered the most rational in comparison with colorimetric. However, it should be noted, that the subsequent processing of the reflection spectra and the corresponding calculations of the color parameters of food products based on organic plant raw materials are quite complex and require time for their processing.

It is also known, that vegetable raw materials and food products have spectral-optical indicators: the degree of reflection, transmission and absorption of raw material samples of the corresponding waves [13]. Spectrophotometers, which are rather expensive measuring devices, are used to measure the spectral and optical parameters of raw material samples.

The analysis of computer-digital methods of research of color of vegetable raw materials, which is based on use of more economically accessible cameras, and also free programs on process-

ing of the received digital images, namely "ColorPix", "Photoshop", "Colors 2.2", Exotic Colors, etc.), has been carried out.

The method itself consists of computer processing of a color digital photo of a prototype of raw material or product, obtained in any period of technological processing: grinding, concentration, etc. The resulting digital photograph is embedded in a computer program, such as Photoshop, and is used to process a CIE-compliant photo sample in RGB color mode [14]. This analyzes the nature of the color of the sample during its processing.

The studies of the color of dried multicomponent fruit and vegetable pastes were carried out according to the developed method according to three recipes with different percentages of raw fruits and vegetables, as shown in **Table 1**.

Table 1
The composition of multicomponent fruit and vegetable pastes

Component composition	Paste composition (sample)		
	1a	1b	1c
Apple	40	50	35
Pumpkin	20	15	20
Cranberry	30	25	40
Hawthorn	10	10	5

Preliminary concentration of multicomponent fruit and vegetable pastes was carried out on a rotary film evaporator at a pressure of 13…14 kPa for 1…1.5 min, followed by drying in a roller infrared (IR) dryer based on a flexible film resistive radiator type electric heater (FFRRTEH). Low-temperature drying was carried out at 45…48 °C and the thickness of the raw material layer was 2 mm. The device is equipped with a grinding device, which is located in the unloading section of the dryer and allows you to get the powder fraction of the semi-finished product. Infrared drying was carried out to the final moisture content at the level of 5...6 %. Apple raw materials and the corresponding semi-finished product were used as controls. The mass fraction of dry matter was determined according to DSTU 8449: 2015 [15].

3. The results of the study and their discussion

Color indicators of compositions of multicomponent fruit and vegetable pastes and dried fractions on their basis were obtained, according to the given ratio of components (**Table 1**). Indicators of brightness and purity of color of samples of multicomponent pastes were received. The minimum brightness index is inherent to a sample of paste 1a – 36.4 % with a purity of 77.9 %, and compositions 1b and 1c are characterized by values of 34.2 and 37.0 with a purity of tone as 64.7 and 78.2 %, respectively (**Table 2**). The visual evaluation of the color of all test samples showed that they all have a reddish-orange color.

It has been found, that the brightness of a test sample of dried multicomponent fruit and vegetable paste 1a is 30.5 % and corresponds to a bluish-purple color with a purity of 34.8 %. Samples 1b and 1c, respectively, have a brightness of 32.4 and 33.2 %. For sample 1b, the value of tone purity of 34.9 % corresponds to red. Sample 1b is characterized by a bluish-red color, as it has a purity of tone at the level of 34.7 % **(Table 2)**.

The comparative analysis of the colors of concentrated and dried test samples in terms of brightness and purity of tone **(Table 2),** characterizes a slight change in brightness in the range from 2 to 6 %. The purity of the color is reduced by about half, which is due to the implementation of the drying process and heat and mass transfer operations for concentration and additional drying.

The expert commission of the State Biotechnological University (Kharkiv, Ukraine), consisting of five experts, carried out the organoleptic evaluation of dried fractions in accordance with the current methodology of the European Organization for Food Quality Control **(Table 3)**.

According to the expert evaluation of experimental samples of dried fractions, the best indicators are inherent to sample 1a, with a content of 40 % of raw apples, 20 % of pumpkin, 30 % of

cranberries and 10 % of hawthorn. Other ratios of components have more attractive organoleptic characteristics, but the color may also be attractive to consumers.

Table 2

Color indicators of prototypes of multicomponent fruit and vegetable pastes

Samples	Brightness	Color Pureness	Visual color o samples
	T, %	P, %	
Multicomponent fruit and vegetable pastes			
Sample 1a	36.4	77.9	Reddish-orange
Sample 1b	34.2	64.7	Reddish-orange
Sample 1c	37.0	78.2	Red-orange
Dried multicomponent fruit and vegetable pastes			
Sample 1a	30.5	34.8	bluish-purple
Sample 1b	32.4	34.9	red
Sample 1c	33.2	34.7	Bluish-red

Table 3

Results of the expert evaluation of fractions of dried multicomponent fruit and berry pastes

Dried fractions	Evaluation quality parameters, points					Total mark, point
	Outlook	Consistence	Color	Taste	Smell	
Sample 1a	10	14	9	10	5	48
Sample 1b	9	13	8	9	5	47
Sample 1c	9	12	7	8	4	40
Prototype (dried paste from apples, blackberries and blueberries)	10	14	8	9	5	46

The obtained experimental studies allowed to establish the color characteristics of the prototypes of fruit and vegetable semi-finished products, made by resource-efficient technology. The determined color indicators of the paste samples and the dried fraction indicate that the proposed low-temperature concentrations of concentration and drying contribute to the preservation of quality indicators at all stages of production. The color change of concentrated pastes from reddish-orange to bluish-purple after drying in a roller dryer is due to their dehydration and longer exposure to low temperature treatment.

The proposed method of digital determination of color formation allows to estimate color changes of raw materials at any stage of technological processing, in particular heat and mass transfer based on computer processing of the photo of the research raw material with further processing in graphics programs, such as "Photoshop". The results of changes in the color of raw materials by the digital method are different from traditional methods, easy by processing the data and do not require the use of spectrophotometers, which do not allow to detect color changes in real time. The limitations of the proposed method for evaluating the color of fruit and vegetable semi-finished products include the need to use high-quality photographic equipment. Experimental studies confirm the effectiveness of the digital method on the example of color determination in vegetable semi-finished products. They allow to use this technology in various technological processes for definition of degree of preservation of color of the processed raw materials, and consequently quality of the received products.

4. Conclusions

The analysis of traditional methods of determining color formation has been carried out, as a result of which it has been established, that the most effective method of evaluation is digital, based on the analysis of a photograph of a prototype. According to this method, the evaluation of color formation in the manufacture of semi-finished fruits and vegetables in accordance with the proposed recipes has been carried out. Color indices of multicomponent pastes and dried fractions based on them were obtained. Sample paste 1a has a minimum brightness of 36.4 % with a purity of 77.9 % and a reddish-orange color. After drying, the brightness of the test sample of the paste for 1a is 30.5 % and corresponds

to a bluish-purple color with a purity of 34.8 %. Samples 1b and 1c have a brightness of 32.4 and 33.2 %, respectively. For sample 1b, the value of tone purity of 34.9 % corresponds to red. Sample 1b is characterized by a bluish-red color, as it has a purity of tone at 34.7 %. As a result of evaluation of organoleptic indicators, it has been found, that according to the presented research samples, the best indicators are inherent to a sample with 40 % of raw apples, 20 % of pumpkin, 30 % of cranberries and 10 % of hawthorn. The obtained research data will be useful in the development of methods for the production of semi-finished products from vegetable raw materials. The applied digital method of color determination differs in simplicity, mobility, speed and economy in comparison with colorimetric and spectrometric. It allows you to evaluate the color of food materials at any time during their production, by photographing raw materials and analyzing them in a computer program, such as Photoshop.

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