

**THE METHOD OF OBTAINING CAROTENOID-CONTAINING
DYE AND FOOD ADDITIVES**

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Abstract:

Introduction. *The developed technology for obtaining natural dye is based on the physical process of formation of phase separation observed in the juice space of some vegetables and melons. The technological mode is selected in such a way as to preserve the biological active substances available in the cheese as much as possible. The process of phase separation in the juice space is scientifically justified. It is shown that the resulting natural dye, carrot flour, and transparent juice are applicable in the food industry. In order to widely apply the developed dye production technology, the juice phase separator plant was created. Spectroscopic studies have established that the main coloring pigment of carrot dye is β -carotene.*

Research methods. *For the object of research, Carrots of the variety "Mirzoi krasny 228" were selected. As a stabilizer, drugs with antioxidant properties can be used. Such stabilizers may include concentrated cherry dye, barberry dye, plum dye, an aqueous solution of riboflavin, and onion husk extract. We selected water solutions of riboflavin and onion husk extract as an antioxidant. The choice of these stabilizers was due to the fact that they, along with their antioxidant properties, have absorption bands that coincide with the electron bands of all caratinoids ($\alpha, \beta, \gamma, \epsilon$). To perform the technological mode in the process of obtaining carrot dye, we have assembled an installation in the form of a double cylinder.*

Results and discussions. *The conditions for the occurrence of the phase separation process in the volume of carotene-containing carrot juice are determined. This process consists in heating the juice to a temperature of $T=70^{\circ}\text{C}$ and gradually further cooling. In this case, a large amount of caratinoids is deposited. The scientific explanation of this process was as follows: the main component of the juice is water (80-85 %). H_2O molecules form a hydrogen bond among themselves, the number of these bonds is several million, the ions are concentrated in the form of a lattice with several layers, which in their structure resemble a crystal lattice. Certain parts of the*

defects of these lattices are concentrated in these lattices. These defects can be water-insoluble molecules carotenoid. Self-aggregates of caratinode molecules together with other water-insoluble components of carrot juice are deposited on the bottom of the working cylinder of the experimental setup. This point of view is confirmed by experimental results related to the removal of the absorption spectra of the deposited part and the transparent juice in the juice volume of the working cylinder. The chart is built based on changes in the volume of transparent high space temperature and exposure time. There is a parallelism between the changes in the volume of transparent juice and its optical density as a function of temperature. It is proved that the main coloring pigment of carrot dye is beta-carotene.

Conclusion. A resource-saving technology for processing carrot raw materials with the solution of economic and environmental problems has been developed. The technology allows you to get a concentrated and powdered natural dye, as well as secondary raw materials. Further processing of secondary raw materials produced a finished food product in the form of carrot flour and clear juice, rich in BAS. The developed technology is based on a physical process, related to phase separation in the current space. The conditions for the occurrence of phase separation are revealed. The diagram $V_0=f(t)$ shows that the values of V_0 are directly proportional to the holding time τ and inversely proportional to the change in juice temperature. Spectroscopic studies have established that the main coloring pigment of carrot dye is β -carotene. The chromatographically obtained dye component can be used in the pharmaceutical industry.

Keywords: absorption spectrum, reflection, food dye, carrot flour, transparent juice, coagulated proteins, carotenoids, phase separation, temperature, coagulation, sedimentary part of the juice, cooling.

Introduction. The staining of food products and medicines is widespread and is provided for by the relevant regulatory and technical documentation. The possibility of using certain natural dyes, first of all, depends on the nature of the coloring pigments. Typically, typical chemical reactions are used to identify coloring pigments, which require a lot of money. However, in some cases, along with the absorption capacity, it is advisable to use a complex spectral-optical analysis, which comprehensively characterizes the coloring pigments and accelerates the process of its identification [1].

In recent years, the consumer market is increasingly showing interest in a healthy body. Consumers of food products are no exception, and the market strives for a healthy lifestyle, as a result, the market demand for natural dyes increases [1,2]. Natural dyes can be used in both the food and pharmaceutical industries [3,4]. Sources of natural dyes are products of the plant world and animal husbandry, containing caratinoids, flavones, anthocyanins, chlorophylls and other coloring pigments. [4,5].

Natural sources of yellow dyes are: curcumin (E100), saffron (E164), carrots, pumpkin, and others. It should be noted that curcumin and saffron are precious spices. For example, Spanish saffron is estimated at 15-20 thousand \$ / kg Kashmiri 30,000 \$/kg. Therefore, their use in food technology is difficult [6-7]. Tartrazine

(E102) is a yellow synthetic dye. However, this dye has limitations in its use in the food industry. For example, for coloring confectionery, the volume of the dye used corresponds to 150mg/kg, for caramels 200mg/kg, soft drinks 100mg/l, liquors 150mg/l and for coloring ice cream 150 mg/kg [8]. Therefore, the use of this dye is limited in use for coloring pharmaceutical and food products. The authors [9-10] have shown experimentally and clinically that tartrazine can induce hypersensitivity of the body, which is regarded as side effects. In [10-11], a method for removing or reducing the amount of tartrazine in the patient's body was developed. In the development of these methods, electronic absorption spectra, IR spectra and results of microscopic studies of the affected part of molecular cells were used. However, these studies did not take into account the possibility of self-aggregation or complexation of tartrazine molecules with body cells.

The use of natural coloring pigments not only makes it possible to give a certain color to food products, but also enriches them with biologically active substances (BAS) [12-13]. The authors [14-16] have developed several methods for obtaining yellow dye from carrots. However, these methods are multi-stage and resource-intensive [17]. The purpose of this study was to develop a resource-saving technology for obtaining carrot dye, taking into account economic and environmental efficiency.

Experimental technique and research facilities. The research object was selected Carrot variety "Mirzoi red 228". This product has long been in great demand among the population of the Republic of Uzbekistan, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and has high taste qualities. The concentrations of dry and dye-containing substances were determined by refractometric and spectroscopic methods, respectively. The amount of mono- and disaccharides was determined by a suchometer (SU 35, Russia), and the active acidity was measured by a pH meter. The density of finished products was determined by measuring the mass and volume of the product. The electronic absorption spectra were measured using a Specord 50 SA and EMC-30PC-UV spectrophotometer (Analytikjena, Germany), which allow measuring optical density in the range of 190-1100nm. The reflectivity of the products was determined using a spectrometer (SF-18 and pulsar Russia), and mass spectra were obtained (MAS-1, USA).

The juice was obtained from the carrot variety "Mirzoi red". Before obtaining the juice, the raw material was washed with running water, damaged, blackened, green parts were removed, as well as the tendrils of the root crop. The resulting juice had the following parameters: the juice density of 1,068 g/cm³ and the concentration of dry matter of about 3-5 % by weight.

Choosing a stabilizer. In order to choose a stabilizer for carrot juice, the influence of temperature on its color was studied. This procedure was associated with the technological mode of obtaining the dye. The color parameters were determined by the reflection spectrum ($R=f(\lambda)$) where, "R" is the reflection coefficient of carrot juice. From the obtained dependences ($R=f(\lambda)$), it was formulated that: the reflection spectrum of carrot juice has a wide band in the wavelength range $\lambda=380\div680$ nm. In these cases, there are clearly marked bands with maxima $\lambda_{\max}=410$ and 480nm. Therefore, the reflectivity was determined at a wavelength of $\lambda=450$ nm. The dependence of the reflection coefficient of carrot juice (R_1) on its temperature shows

that heating the juice to a temperature of 40⁰C does not lead to a significant change in the reflection coefficient ($\approx 2\%$). However, further heating of the juice and keeping it in time ($\tau=1H$) leads to a significant loss of color of the product. For example, heating the juice to a temperature $t=70^0C$ and holding it for 60 minutes leads to a loss of color (R_1) by 43 % (see table 1).

Table 1.

Dependence of the reflectivity (R) of carrot juice on the temperature t^0C and the time delay (τ min)

t^0C τ min	R_1 juice	R_2 juice +2%RF	R_3 juice +5%RF	R_4 juice +6%E	R_5 juice +10%E
40 ⁰ C	0,81	0,90	0,95	0,93	0,98
30	0,76	0,85	0,90	0,87	0,93
60	0,74	0,81	0,86	0,82	0,89
50 ⁰ C	0,72	0,89	0,87	0,84	0,90
30	0,79	0,80	0,82	0,81	0,86
60	0,66	0,76	0,78	0,78	0,82
60 ⁰ C	0,63	0,75	0,79	0,76	0,84
30	0,58	0,71	0,75	0,74	0,80
60	0,55	0,67	0,71	0,71	0,76
70 ⁰ C	0,52	0,68	0,73	0,70	0,75
30	0,49	0,65	0,71	0,75	0,72
60	0,46	0,62	0,69	0,63	0,70
% changes (R)	43%	31%	15%	32%	19%
Stability R_1-R_n		12%	28%	11%	24%

The main reason for this degradation of the color of the juice, apparently associated with molecules of dissolved or atmospheric oxygen (O_2). As a result of complex formation of carotenoids with molecular oxygen O_2 , they are oxidized. It should be taken into account that the basic electronic state of molecular oxygen is triplet [19]. As a result of this oxidation, the energy parameters of the electronic transitions of carotenoids decrease and, accordingly, the reflectivity of the juice decreases. Given the above, it was considered that the technological mode of processing carrot juice should be stabilized. Drugs with antioxidant properties can be used as a stabilizer. Such stabilizers can include concentrated cherry dye, barberry dye, plum dye, Riboflavin water solution, onion husk extract [20]. We selected water solutions of Riboflavin ($C=2 \cdot 10^{-4}M$) and onion husk extract as an antioxidant. The choice of these stabilizers was due to the fact that they, along with their antioxidant properties, have absorption bands that coincide with the electron bands of all caratinoids ($\alpha, \beta, \gamma, \epsilon$) [21].

The method of preparation of extract of a peel of onions. To the peeled onion husk petals, the inspected apricot tree bark was added 2 and 3 grams, respectively. They were dispersed crushed and 20ml of distilled water was added to them. The choice of apricot tree bark was due to the fact that the onion peel petals did not stick together when they were extracted. In addition, it is also known that the absorption band of bark extracts satisfactorily coincides with the electronic spectrum of onion

husk extract. The extraction process was carried out on a magnetic stirrer with a temperature of 35-40⁰C. When these stabilizers are added to the juice, the quality indicators of the carrot dye semi-finished product improve (see table 1). As can be seen from table 1, the addition of stabilizers to carrot juice increases its color by 16 and 21 %, respectively, when using an aqueous solution of Riboflavin and onion husk extract. The selected ingredients not only enhance the color of carrot juice, but also protect it from temperature effects. For example, adding 5 % Riboflavin solution and 10 % onion husk solution leads to stabilization of carrot juice by 28 and 24 %, respectively.

Experimental setup. To perform the technological mode in the process of obtaining carrot dye, we have assembled an installation in the form of a double cylinder, the scheme of which is shown in Fig.1.

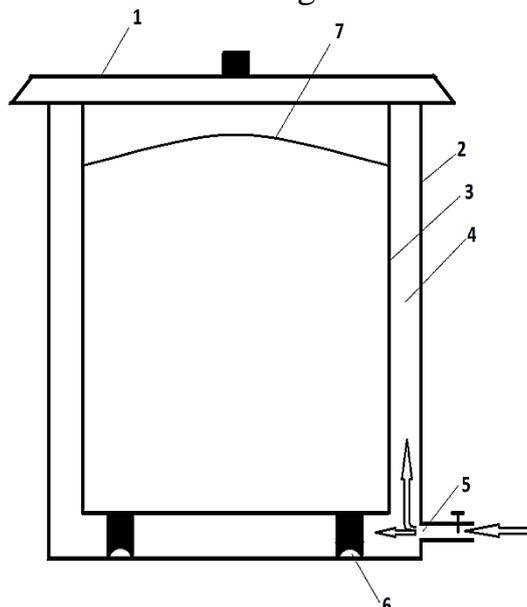


Figure 1. The scheme of installation to obtain the carrot coloring

The installation consists of two cylinders: internal glass (2), height $h_1=50\text{cm}$, diameter $d_1=5\text{cm}$ and external metal (3) $h_2=55\text{cm}$ and $d_2=12\text{cm}$. At the same time, both of these cylinders were closed with a single lid with diameters $d=13\text{ cm}$ (1). A projection with a diameter $d=4,8\text{ cm}$ was constructed on the Central part of the lid, which freely enters the glass cylinder (fig1). The volume (4) with distances of 3-4cm is preserved between the cylinders. This volume is filled with water at the required temperature during the process mode. Water is loaded by means of a fitting (5) mounted on the bottom of the second cylinder. Also on the lower part of this cylinder, two rubber stoppers with a height of 5 cm (6) are fitted. These plugs serve as a support for the inner cylinder (2). In order to measure the temperature of the process mode, an electronic thermometer (8) is used.

The technology of producing dye. In [22], it was noted that heating the juice to a temperature of 70⁰C contributes to the process of phase separation in the studied volume. To conduct the experiment of creating a technological mode, we obtained juice in the volume of 1 liter. Juice production is accompanied by the release of ≈ 800 grams of pomace. Pomace is a waste product of juice production. However, it can serve as a secondary raw material for obtaining carrot flour (see section3). The

necessary amount of stabilizer was added to the juice. The stabilized juice was poured into the cylinder (2) of the experimental unit (fig.1). The unit is covered by a single cover (1). The inter-Cylinder volume was filled with heated water through the connection (5). The water temperature was selected in the range of 68-70⁰C, which was maintained by a thermostat (Thermo S 5P, Germany). As a result, the juice is heated in the temperature range of 65-68⁰C for a time of 30÷50 minutes.

It is experimentally established that heating the juice at a given temperature range of ≈70⁰C does not lead to a significant change in its state (fig.2a). This temperature regime was maintained by the thermostat for 15-20min. Then the thermostat was turned off, resulting in a temporary decrease in temperature. When the juice was cooled, significant changes in its organoleptic parameters were observed. These changes are accompanied by the observation of phase separation on the surface of the juice. It is experimentally established that cooling the juice to 40⁰C contributes to the formation of a phase separation several millimeters thick (fig. 2b). As can be seen from (fig. 2b), a transparent part of the juice is formed on the surface of the experimental volume.

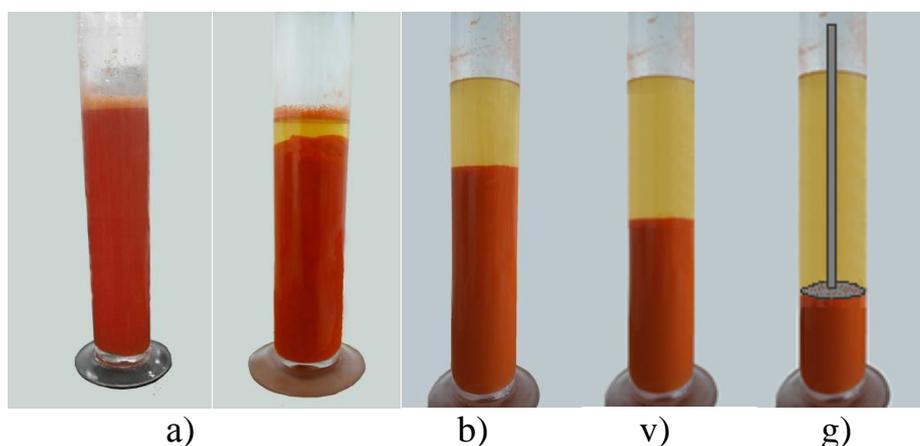


Fig. 2. Phase separation of heated ($T=65\div68^{\circ}\text{C}$) carrot juice (a), and after it cooling 40°C (b), at $t=3\div4^{\circ}\text{C}$ (v), and after the introduction of a fine-mesh cylinder (g)

When the temperature is further lowered to room temperature (20⁰C), the volume of the transparent part of the juice (V_0) is 300ml. In these cases, there is a clear border between the sediment and the transparent part of the semi-finished product (fig. 2v). The sedimentary part of the juice accumulates coagulated proteins, which are part of the root crop. Aggregated coagulated proteins are concentrated at the bottom of the glass cylinder. In order to increase the volume of coagulated proteins and transparent juice, we created conditions for further lowering the temperature. For this purpose, a certain amount of water was removed from the interspatial volume of the two cylinders and replaced with ice cubes. As a result, the water temperature in the interspatial volume dropped to 0⁰C. Lowering the water temperature accordingly led to a drop in the juice temperature from room temperature to 3⁰C. This temperature led to an increase in the volume of transparent juice ($V_0=550$ ml) (fig. 2g). In these cases, a clear boundary between the juice phases in the volume is preserved.

The developed technological mode is confirmed by the diagram of the dependence of the volume of transparent juice on the temperature (fig. 3). In this diagram, the OA segment corresponds to the heating of the juice from room temperature to 65-68⁰C, the AB→BV→BS→SC segments refer to the temporary exposure of temperature changes from 68⁰C to 3⁰C. As a result, the volume of the transparent part of the juice $V_0 = 550\text{ml}$. The total value of these segments corresponds to the final manifestation of the phase separation process in the juice volume. From fig.3 it follows that the technological mode of dependence $V_0=f(t)$ obeys the exponential law. From the analysis of the results recorded in the diagram, it follows that the values of the change in V_0 are proportional to the time of temperature exposures and inversely proportional to the temperature of the juice.

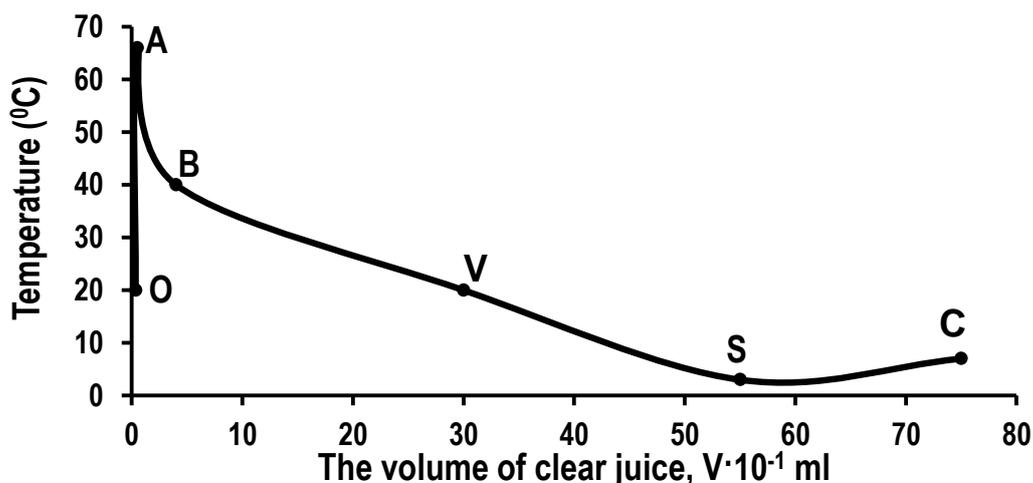


Fig. 3. Diagram of the dependence of the volume of the transparent part of the juice on the temperature

Phase separation in carrot juice contributes to the fact that the main part of the coloring pigments leaves the juice with flakes of coagulated protein. At the same time, some of these proteins float in the volume of transparent juice. These coagulates eventually settle to the bottom of the cylinder container (2). It is experimentally established that the sedimentary part of the juice is in a loose state.

To seal the sedimentary part, a stainless mesh with small-cell holes was inserted into the working cylinder. The mesh size was selected in such a way that it freely entered the inner cylinder (2). we experimentally determined the speed of introduction of the mesh in the juice space. The speed of the mesh movement was $V=3\div 5$ cm/min. This speed value was selected in such a way that the boundary of the phase divisions was preserved both during the introduction of the grid and during the technological mode. When the grid reaches the interface, its speed was reduced by 2 times. In this case, the clear boundary between the phases remains unchanged (fig. 2 g). Then, by siphoning, the transparent part of the juice with a volume of 650-700 ml was removed. It was sent for further processing as a secondary raw material (see section 3). The subcellular volume that was in the sedimentary part of the juice was 300-350ml. The resulting concentrated juice is acceptable for food coloring. The concentration of dry matter of this coloring pigment corresponds to 65-70 %.

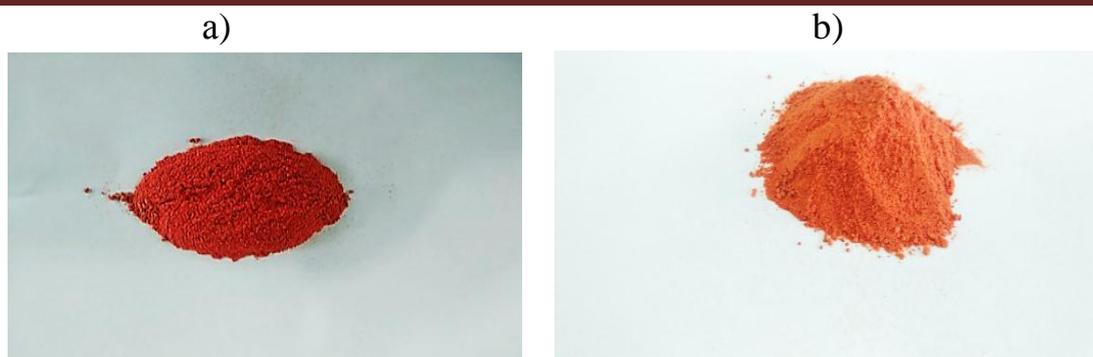


Fig. 4. Appearance of carrot dye (a) and flour (b)

Research shows that the resulting pigment is able to color confectionery cream. It is determined that the required amount of concentrate is 3 % by weight for sufficient color of the product. Similarly, the volume of added pigment for coloring ice cream and national confectionery "halva lavz" was determined. Experimental values of pigment consumption were 2.2 and 3.8 % by weight, respectively. The results indicate that the sedimentary pigment can be used as a dye in the food industry. Then the concentrated dye pigment was dried on a solar drying unit at a temperature of 50-55⁰C with grinding on a coffee grinder. This produced a powdery food dye, the appearance of which is shown in fig. 4.

The Main dye pigments of the dye and recycling of secondary raw materials. Carotenoids are substances from which vitamin A is obtained, which are widely used in medical practice. This substance is found in most plants and in almost all living organisms. The greatest amount of carotenoids is found in carrots and pumpkins, where their content reaches a value of 12-17 %. In nature, there are mainly three types of its isomer, α , β , and γ -carotenoids, which differ in the different arrangement of double bonds and the number of β -ionic rings. All these three isomers are easily soluble in chloroform, carbon disulfide, and benzene, but are slightly soluble in alcohol and insoluble in water [158].

To identify the main coloring pigments of concentrated and powdered dye, the corresponding values of the composition of carrot juice were used. In the volume of 100 grams of carrot juice contains: carbohydrates 12,5 g, fat 0,1 g, protein 1,12 g, dietary fiber 1 g, water 85 g. The juice also contains vitamins A, C, E, PP and trace elements, Fe, K and Mg starch, carotenoids, organic acids. The juice has antioxidant properties [23]. The composition of the concentrated coloring pigment can only be water-insoluble components of the juice. These components include: proteins, dietary fibers, fats, water-insoluble caratinoids ($\alpha, \beta, \gamma, \epsilon$) and some vitamins. These components are precipitated in the process of technological mode, forming a concentrated dye pigment. Of the listed components, carotenoids can be the main coloring pigments of the dye. During the deposition of carotenoids, they can be fixed to proteins or self-aggregated molecules [24]. The associated parts may also contain water-insoluble vitamins and trace elements.

Next, we performed spectral studies of a concentrated food dye with the removal of its absorption spectra (fig. 5. curve 1). As seen in fig.5 absorption spectra of the resulting dye in ethyl alcohol have a wide band in the range of 400÷720nm. Against

the background of this wide band, the maxima corresponding to the following values $\lambda_{\max}=435,615\text{nm}$ appear. Short-wave parts of a wide band can be attributed to water-insoluble caratinoids ($\alpha,\beta,\gamma,\varepsilon$). The maximum absorption bands of these carotenoids are: β -Korotin $\lambda_{\max}=425,450,476\text{ nm}$; α -Korotin $\lambda_{\max}=420,442,472\text{ nm}$; γ -Korotin $\lambda_{\max}=431,462,494\text{ nm}$; ε -Korotin $\lambda_{\max}=414,439,470\text{ nm}$; lycopene $\lambda_{\max}=418,471,501\text{ nm}$. The total values of these bands appear to correspond to the short-wave portion of the broad dye band. The long-wave part of this band seems to belong to chlorophylls a and b, which are products of intensive photosynthesis of caratinoids [25]. The validity of our reasoning is confirmed by the results of work on the chromatographic separation of the resulting dye. Separation of food pigments was performed on column chromatography using sorbents, which were Sefadex G-25 and aluminum oxide. Benzene and ethanol were used as solvents, respectively. The results of the study showed that three mobile zones appear on the column. In this case, one of the components makes up $\approx 90\%$ of the total content of pigments in the column.

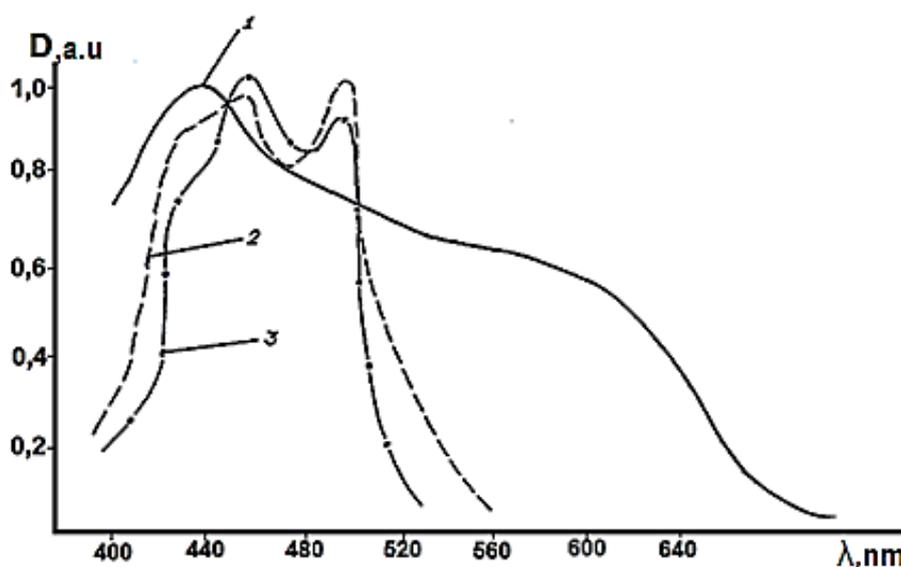


Fig. 5. Absorption spectra of carrot dye (1), chromatographically isolated pigment (2) and β -carotene (3)

Using thin-layer chromatographic separation, we obtained a purified dye pigment (fig. 5, curve.2). As seen in fig.5 the absorption band of the chromatographically purified pigment satisfactorily coincides with the spectrum of TRANS β -carotene (see fig.5-13).

The Nativity of the drug was proved by removing the mass spectra of chromatographically purified pigment (fig. 6). As can be seen from fig.6 the main coloring pigment of carrot dye has a molar mass with a value of 568.428 a.e. m corresponding to the tans of β -karatin.

In the process of obtaining powdered and concentrated carrot dye, secondary raw materials are also released in the form of pomace and transparent juice. In order to strengthen the technology in the direction of economic and environmental development, it was planned to develop a method for further processing of secondary raw materials.

First of all, we evaluated the composition of semi-finished products. The whole Arsenal of vitamins and microelements, as well as fiber, dietary fiber and others

(BAS) can be partially preserved in the composition of pomace. The technology for processing pomace was to stabilize secondary raw materials by adding 5 % onion husk extract. The resulting mixture was loaded into trays in thin layers with a thickness of 2-4 mm. They were dried on a solar drying unit at a temperature of $45\div 50^{\circ}\text{C}$. Drying of the semi-finished product was carried out by mixing the entire mass in a time interval of 15-20min. The result is a finished product with a dry matter concentration of 90 %. The dried product was ground in a mill until the product was obtained in the form of carrot flour (Fig. 4b). The finished product was Packed in paper bags weighing 1 kg.

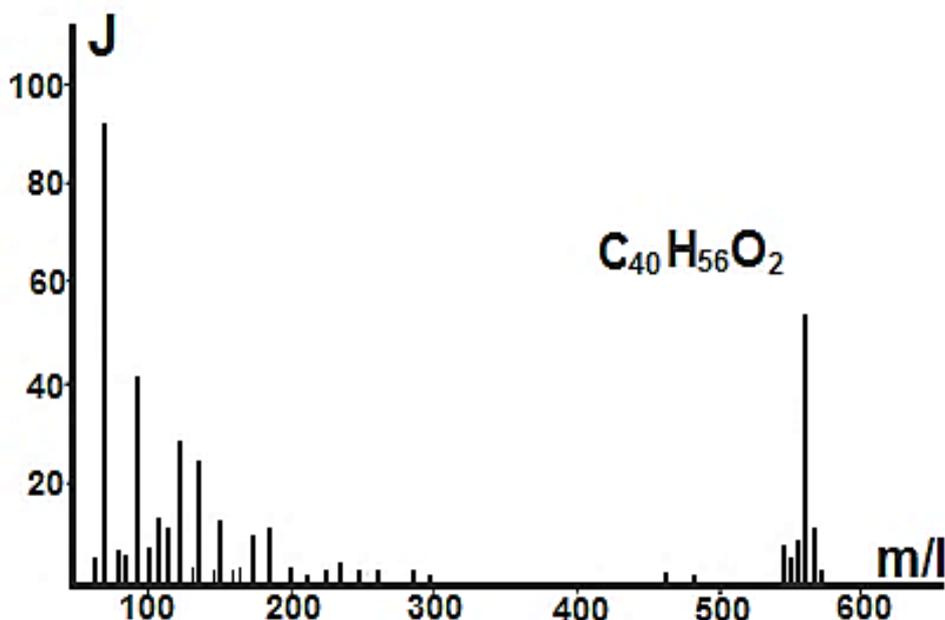


Fig. 6. Mass spectra of chromatographically purified carrot dye

The transparent juice may contain water-soluble components of carrot juice. These include: carbohydrates, organic acid, vitamins and other biologically active substances. Onion husk extract was added to the secondary raw material in an amount of 2 % by weight. Was poured in one-litre jars and sterilized IR gastromania. Ready-made both products are acceptable for use in the food industry for the preparation of confectionery and flour products.

We found that for many food dyes, the values of the quantum yield of fluorescence at room temperature are low and ϕ is in the range of $3\cdot 10^{-4}$ to $1\cdot 10^{-1}$. The exception is food coloring. Another feature of the glow output was that for carotenoid derivatives, depending on the substituted groups and the number of glucosides in the structure of the studied molecules, the "B" value remains almost invariably low. However, for flavone derivatives, there is a significant dependence of the luminescence yield on the substituents and the nature of the glucoside substituted groups. Table 2 Quantum yield of fluorescence of alcoholic solutions of food dyes in the presence of O_2 (B, B, B3, B15) and pumping of O_2 (B,?), at a temperature of 70 K (B,G photochemical reactions of trans-cis (B18) and fluorescence.

Table 2.

Quantum yield of fluorescence of alcoholic solutions of food dyes in the presence of O₂ (B, B_t, B_{ts}) and pumping of O₂ (B₀₂), at a temperature of 70 K (B_t), photochemical reactions of transcis (B_{ts}) and fluorescence of sensitized molecular oxygen (B_{ts})

	Compounds under study	B	B ₀₂	B _t	B _s	B _{ts}
1	1. Vulgaxanthin	0,01	0,11	0,63	0,20	-
2	2. Betanin	0,02	0,08	0,75	0,16	-
3	3. 3,5-diglucoside cyanidin	0,01	0,03	0,65	0,08	-
4	3-rhamnoglucoside pelargonidin	0,01	0,02	0,80	0,02	-
5	3.5 diglucoside malvidin	0,01	0,02	0,51	0,07	-
6	β-carotene	<0,01	0,12	0,01	0,65	0,10
7	α-carotene	<0,01	0,08	0,01	0,70	0,07
8	gamma-carotene	<0,01	0,07	0,01	0,70	0,05

The low quantum yield of the glow of food dyes seems to be associated with competing processes: photochemical trans-cis isomerization reactions, non-rigidity of the molecules, and the influence of dissolved oxygen.

First of all, we studied the processes of photochemical reaction of food coloring molecules and bioactive substances. Studies of photochemical reactions have shown that trans-cis isomerization is inherent only in carotenoid derivatives. It was found that the quantum yield of isomerization B_{ts} for these bioactive molecules is in the range of 0.05-0.1 units.

Another competing process is the non-rigidity of the molecules, the nature of which can be established by low-temperature study of solutions of plant pigments and vitamins, which also allows us to find out the mechanism of chromaticity.

Lowering the temperature of food coloring solutions leads to a slight increase in the yield of fluorescence. With a further decrease in temperature, starting from T=150 K, a sharp increase in yield is observed. This increase in the quantum yield of luminescence continues to a temperature of 70 K. A further decrease in the temperature from 70 to 4.5 K does not lead to a significant increase in the number of luminescence photons and a change in their electronic spectra.

It should be noted that a sharp increase in the quantum yield of fluorescence of solutions with a decrease in the ambient temperature is inherent not only in flavone derivatives. Similar patterns were also observed for anthocyanin derivatives, betalaines (Table 2). At the same time, for carotenoid derivatives, a decrease in the temperature of their solutions does not lead to significant changes in the value of the quantum yield of fluorescence.

The change in the number of photons of luminescent radiation at a lower temperature seems to depend primarily on the nature of the environment and the concentration of the solute. The increase in the number of photons in dilute vitamin solutions can be explained by two reasons. The first is that as the temperature decreases, the rigidity of the molecules can increase, thus the probability of energy

exchange between the vibrational levels decreases, and the output of the glow increases [26].

The second reason may be the influence of molecular oxygen dissolved in the studied solutions of food dyes.

At room temperature, there is a possibility of interaction of vitamin c molecules with O₂ and the formation of short-lived complexes, thus, it is possible to transfer the excitation energy of food dyes to the oxygen molecule with subsequent non-radiative deactivation, respectively, the number of photons of radiation can decrease. When the temperature decreases, the intensity of the chaotic motion of the molecules decreases, therefore, the probability of interaction of the solute molecules with oxygen decreases, which leads to an increase in the number of glow photons [27].

To find out the true reasons that lead to an increase in the quantum yield of the glow, we conducted special experiments on pumping oxygen from solutions of food dyes. Pumping was performed according to the method. The experimental results showed that there is a significant increase in the quantum yield of fluorescence as molecular oxygen is pumped out of the solutions of the studied compounds (Table 2). As can be seen from Table 2.2 according to the values of the growth of the quantum yield of fluorescence with the pumping of O₂ molecules, the studied compounds can be arranged in the following row:

Carotenoid derivatives-betalaine derivatives - anthocyanin derivatives-derivatives. To qualitatively determine the quantum yield of the photosensitized oxygen glow, we conducted studies on a laser fluorimeter. Depending on the absorption spectrum of the sensitizer molecules, the excitation was carried out by lasers: ruby (second harmonic, $\lambda=347$ nm, $\tau_{imp}=30$ ns); neodymium (second harmonic, $\lambda=530$ nm, $\tau_{imp}=20$ ns). Photosensitized luminescence of singlet oxygen ($^1\Delta_g$) from food dye molecules was obtained in deuterated water and deuterated dimethyl sulfoxide. In the table.4 shows the values of the quantum yield of photosensitized singlet oxygen luminescence (Bs) for various food dye molecules. As can be seen from Table 4, for molecules of carotenoid derivatives, betalain derivatives, the values of the quantum yield of the glow $^1\Delta_dO_2$ are high and are in the range of 0,70÷0,16. At the same time, for anthocyanin-derived molecules, the quantum yield of O₂ luminescence is in the range of 0,07-0,02 units. For flavone derivative molecules, the value B=0.03. For molecules of carotenoid derivatives, the effect of molecular oxygen has been studied quite fully, and the authors [28] argue that the oxidation of carotenoids is associated with a large amount of C=C. The high value of photosensitized oxygen for the molecules of corotinoid and betalain derivatives, apparently, is associated with the activity of nitrogen, which is present in the molecules of vulgaxanthin and betanin.

Conclusions. A resource-saving technology for processing carrot raw materials with the solution of economic and environmental problems has been developed. The technology allows you to get a concentrated and powdered natural dye, as well as secondary raw materials. Further processing of secondary raw materials produced a finished food product in the form of carrot flour and transparent juice, rich in BAS. The developed technology is based on a physical process. Related to phase separation in current space. The conditions for the occurrence of phase separation are revealed.

The diagram $V_0=f(t)$ shows that the values of V_0 are directly proportional to the holding time τ and inversely proportional to the change in juice temperature. Spectroscopic studies have established that the main coloring pigment of carrot dye is β -carotene. The chromatographically obtained dye component can be used in the pharmaceutical industry.

The authors Express their gratitude to A.S. Prishchepov, a senior researcher At the Institute of physics of the Belarusian Academy of Sciences, for his help in removing the mass spectrum and participating in the discussion of the results obtained.

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