Effective Technology For Obtaining Carrot Dye

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ABSTRACT

A resource-saving technology for producing natural dye has been developed. The technology is based on the formation of phase separation in the volume of carrot juice. The technological mode is selected taking into account the maximum conservation of biological active substances of raw root crops. The technology is combined with a natural dye to produce carrot powder and transparent juice used in the food industry. With a modulated juice phase separation unit and a solar drying unit, metrit developed the technology to produce a high-quality powder-shaped dye.

Keywords:phase separations, bond diagram, natural dye, carrot powder, transparent juice, coagulated proteins, temperature control technology.

1. INTRODUCTION

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 of which the market demand for natural dyes increases [1,2]. Natural dyes are applicable both in the food and pharmaceutical industries [3,4]. Sources of natural dyes are plant and animal products containing carotenoids, flavones, anthocyanins, chlorophylls and other coloring pigments. [4,5].

In nature, there are many different dyes. Depending on their properties, they are used in various branches of the national economy. For effective use of dyes, it is necessary to have information about spectral-luminescent, optical and other physical and chemical characteristics. These parameters change under the influence of a number of factors (the nature of the solvent, temperature, concentration, light radiation, etc.) [6-7]. In the food and pharmaceutical industry, natural dyes are usually used as concentrates, pastes, or powders [8-9]. Therefore, natural juices and extracts are subjected to concentration. The process of vacuum evaporation and freeze-drying is expensive and time-consuming [10-11]. However, an increase in temperature (more than 80^0C) can lead to the destruction of the aromatic components of the juice [12-13]. As a result of these processes, the color and taste of the finished product deteriorates [14-15].

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) [16-17]. The authors [18-19] have developed several methods for obtaining yellow dye from carrots. Martin and others [20], a solvent in the acetonitrile group was used as a dye extractant. Water-alcohol vapor, under the current of nitrogen, drives away the extractant. According to another method [21], raw materials are crushed and dried by heat treatment at a partial temperature of 40, 60,

90^0C with a time delay of 2 hours. The carotenoid dye is extracted with heated ethyl alcohol for 24 hours and concentrated under vacuum [22].

A method is known [23] in which a concentrate of carotenoids from carrots obtained by coagulating carrot juice with acid and further washing the extracted coagulate with alcohol [24]. Carotenoid concentrate, also obtained juice from the crushed mass followed by coagulation of proteins with carotenoids fixed on them. With subsequent heating of the juice to the coagulation temperature of 60-700C with the separation of the liquid and solid phases. The proposed method of obtaining dye does not provide for removing the smell of raw materials that create unpleasant taste sensations during the use of colored products. Another disadvantage of the method is that it is multi-stage and resource-intensive. The purpose of this study was to develop a resource-saving technology for obtaining carrot dye, taking into account economic and environmental efficiency.

2. METHODS AND OBJECTS OF RESEARCH

As the object of research, the Carrot variety "Mirzoi red 228"was selected. The concentrations of the dry and coloring matter of the dye were determined by refractometric and spectroscopic methods, respectively. The amount of mono-and disaccharides was determined by a saccharometer (SU 35, Russia), the active acidity was measured by the PH meter EV-74(P25) (Moldova). The density of finished products was determined by measuring the mass and volume. Electronic absorption spectra were measured using a Specord 50 SA and EMC-30 PC-UV spectrophotometer (Analytik jena, Germany), which allow measuring optical density in the range of 190-1100nm. The reflectivity of food products was determined using a spectrometer (SF-18 and pulsar Russia), and mass spectra were obtained (MAT-311 USA).

Installing a juice phase separator.

The unit consists of an insulated base (1) on which the evaporator is fixed (2). three plastic cylinders with diameters of 5 cm are also mounted on the surface of the base of the unit. The height of plastic cylinders is selected so that when installing a transparent cylindrical container (3) above them, there is a gap between the container and the coil. The refrigerant used was a mixture of ethanol and antifreeze, with a negative temperature (up to-15^0C). In the container (3), pour carrot juice for 2/3 of the volume of the transparent container. An axis is installed in the center of the cylinder, along which the current-conducting grid (6) moves freely. A heater (5) is installed on a tripod located near the base of the device (7), which is connected in series via a rheostat (4). The heater uses a DC voltage of 12 W. The coil is equipped with inlet and outlet fittings, through which the refrigerant was supplied.

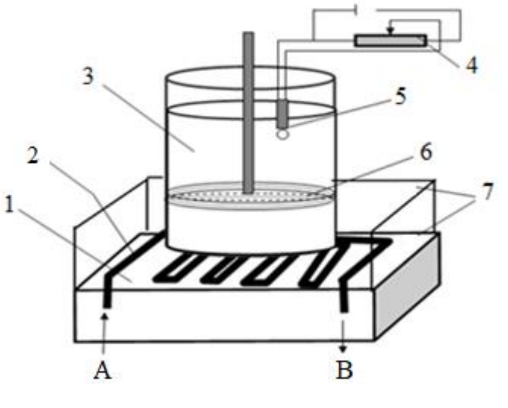


Fig. 1. Schematic diagram of the plant used for separating the phases of carrot juice.

Selecting the temperature mode. The task is solved by the fact that the carrot variety Mirzoi red was previously cleaned of dirt, rotten, green parts and raw materials were crushed into small pieces. The juice was obtained with a concentration of dry matter C=4% by weight. In [25], it was noted that heating carrot juice to a temperature t=70^{0}C leads to the beginning of the phase separation process with further protein coagulation. Taking into account the above, we have studied in detail the influence of temperature and aging time on the state of root juice. Before the study, the obtained juice was stabilized. The juice was stabilized by adding a 5% aqueous solution of Riboflavin with a concentration of $C=4\cdot 10^{-4}$M, as in the case of watermelon dye [26]. Carrot juice consists of: 85,5% water, 1,3% protein, 7% carbohydrates, the amount of carotenoids 9 mg per 100 g of juice. From the analysis of the juice composition, it follows that carotenoids can be fixed on proteins, and they can also be in the form of monomers.

According to [27-32], hydrogen bonds are formed between water molecules, which in turn form a three-dimensional binding structure that functions as a whole. In the case of dilute aqueous solutions of Riboflavin ($C=10^{-5}$M), under the action of elastic forces of hydrogen bonds, the dissolved molecules are displaced in the mesh cavities. At the same time, the grid of hydrogen bonds retains its stable elasticity. An increase in the concentration in the solution leads to an increase in the number of molecules in the cavities of the grid of hydrogen bonds. In this case, it is possible to combine them under the action of intermolecular interactions (MMV). Increasing the temperature of the solution leads to the destruction of the network of hydrogen bonds of water and the number of monomers increases. This leads to the restoration of the intensity and shape of the absorption bands of the monomers of the studied compound.

This explanation is confirmed by spectroscopic studies of the effect of temperature exposure on the absorption spectrum of 1,4 diphenyl butadiene, which is part of the group of arylethylenes, which have a similar structure to carotenoids and differ in the number of ethylene groups. This molecule can be a model compound for the study of carotenoids.

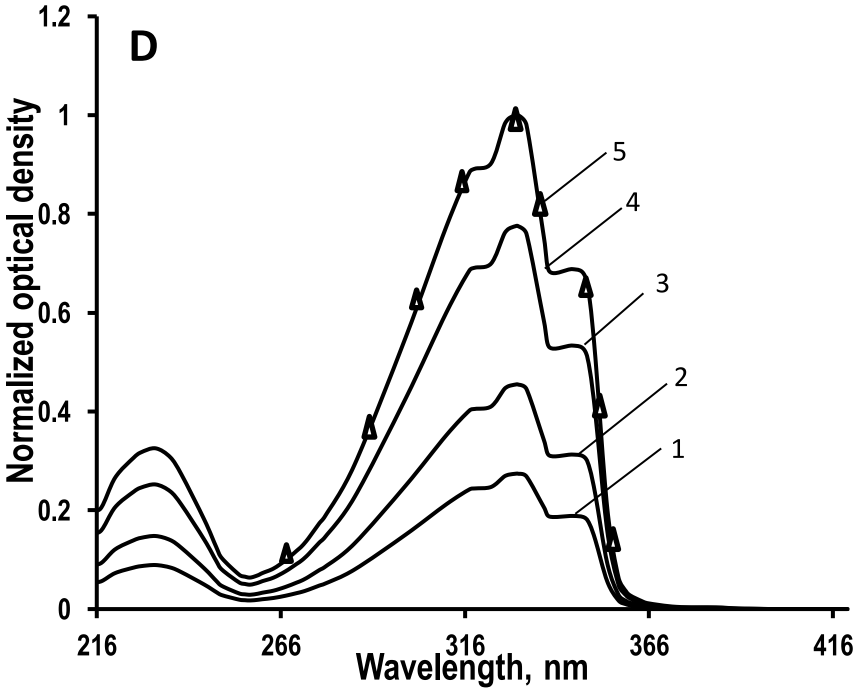
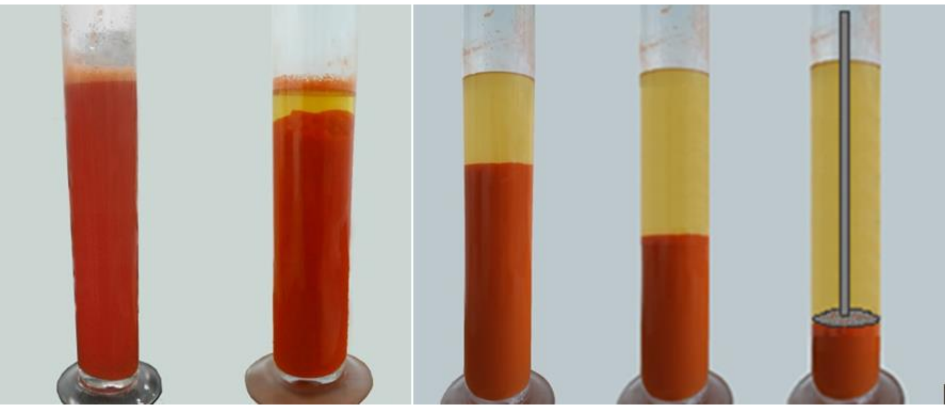


Fig 2. Temperature dependence absorption spectrum of 1,4-diphenyl butadiene in binary mixtures (0.2:0.8) Dioxane+water ($C=10^{-5}$ M) 293 (1) : 313 (2): 343 (3) : 348 (4) and in a dioxane solution of 293K (5).

Figure 2 shows the temperature dependence of the absorption of 1,4-diphenylbutadiene ($C=10^{-5}M$) in dioxane+water solvent mixtures. Curve 1 (figure 2) corresponds to the absorption capacity of self-aggregated diphenylbutadiene molecules at room temperature. Increasing the temperature of the binary solution leads to an increase in the absorption capacity of the solution. (crooked. 2-4 Fig. 2) in this case, the absorption spectrum at a temperature of 348 K coincides with the absorption band of monomer molecules of 1,4-diphenyl butadiene (compare curve.4 and 5 Fig. 2.).



a) b) v) g) d)

Fig.3 Phase separation of heated (T=70÷75^{0}C) carrot juice (a), and after it cooling 40^{0}C (b), cooled to room temperature (C), at t=3÷4^0 C (g) , and after the introduction of a fine mesh into the cylinder (d)

The values of the binding energy of self-aggregated 1,4-diphenyl butadiene molecules (5,8 kJ/mol) were determined from the temperature dependences of the absorption spectrum, which corresponds to the energy of the hydrogen bond. Thus, we found that the main condition for the formation of phase separation in juices is its heating to a temperature of 70÷75^{0}C, which is confirmed by experimental results (see Fig. 3 a, b).

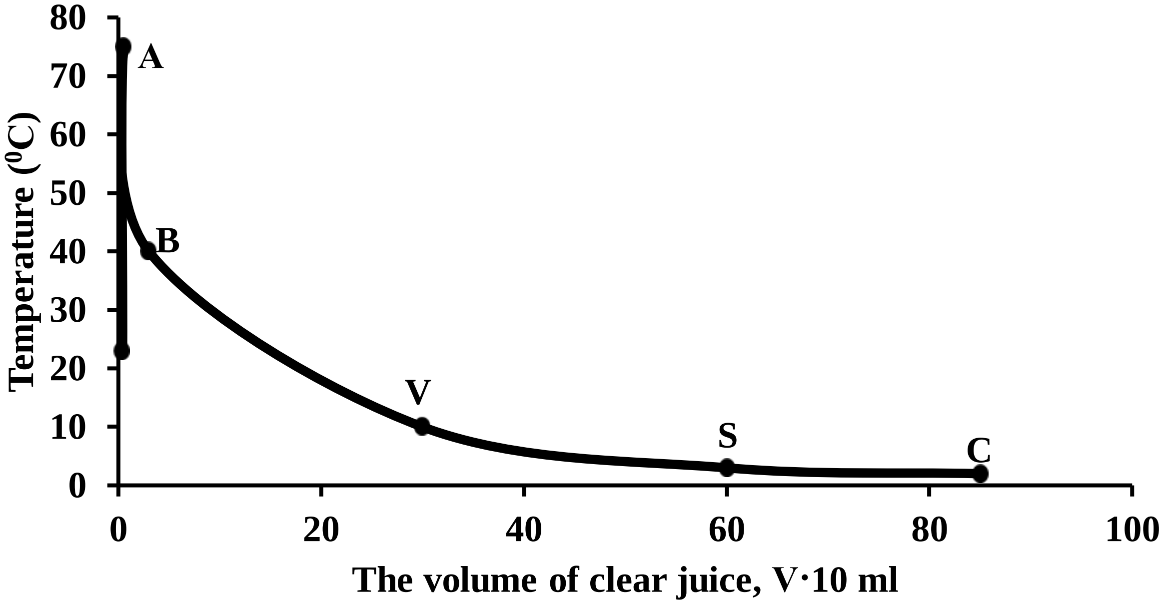
As can be seen from Fig. 3 a, heating the juice to a temperature of 70÷75^{0}C is not sufficient for the emergence and strengthening of the phase separation process in the juice volume. A clear phase separation occurs by heating the juice to a temperature of 70÷75^{0}C and holding it for 15÷20 minutes. This temporary exposure is necessary to balance the heat transfer in the juice volume (fig. 3 b).

Technology for producing carotenoid-containing dye and other food products.

Experimentally obtained carrot juice with a volume of up to one liter, which was heated to a temperature of 70-75^{0}C and kept for 15-20 minutes. Then the juice was cooled to room temperature, and a clear phase boundary was observed in the juice volume (Fig. 3 b.). This process increases as the temperature of the juice decreases. At room temperature, the volume of transparent juice is V_0 =1/3V (Fig. 3 in) where, V is the total volume of juice. Further cooling of the juice to +3 ^{0}C leads to changes. (V_0=600 cm^3 Fig. 3). In these cases, a small-cell grid is inserted into the cylindrical container where the carrot juice is located, and the volume of transparent juice becomes V_0=0,85 V. This volume occurs due to the compaction of the sedimentary part of the juice (Fig. 3 d). The observed process can be characterized by a diagram of the dependence of the volume of the transparent part of the juice on the temperature t=f (V_0) (Fig. 4).

In the diagram below, the OA segment (Fig.4.) corresponds to heating the juice to a temperature of 750C. AB corresponds to a change in temperature during aging, at which the process of formation of transparent juice begins. BV corresponds to a change in the volume of transparent juice during cooling of the juice from 400C to room temperature. The VS segment corresponds to the process of further cooling of the semi-finished product to a temperature of 30C. The SC segment corresponds to the time-keeping of the cooled juice, in which a fine-mesh mesh is placed in a transparent cylinder at the phase interface.

The obtained parameters of the process mode shown in the diagram T= f (V0) are used on the created installation of the phase separator (Fig1). To do this, the stabilized and heated juice was



placed in a transparent cylindrical container (3 Fig. 1).

Fig. 4. Diagram of the dependence of the volume of the transparent part of the juice on the heating temperature.

Coagulation of proteins with carotenoids fixed on them was carried out by heating up to 75^{0}C outside the entire mass of juice for a certain time, while 92% of carotenoids left the solution with flakes of coagulated protein. Then the resulting mixture was settled for 40-60 minutes. When conducting coagulation in milder conditions (at a lower heating temperature of carrot juice), the settling time was significantly increased due to incomplete protein coagulation. Phase separation with the release of carotenoid concentrate was performed as follows. After settling the coagulated protein in a cylindrical container, a horizontal fine-mesh conductive mesh was introduced, having a circular cross-section and the size of the cross-section of the cylindrical container. The mesh was lowered to a layer of coagulated sediment. In this case, the protein was deposited before, the coagulant layer was compacted, its dynamic and diffusive mobility was excluded.[33-41]

The lower part of the solution volume was cooled by placing the container in a tank containing water+ethanol antifreeze mixture, cooled to minus temperature by a coil through which the refrigerant was passed. At the same time, the upper part of the solution volume was heated locally by a spiral heater to a certain positive temperature. At the initial stage of the process of freezing the lower part of the cooled volume of the solution with simultaneous local heating of the upper part of it for a certain time, small coagulated proteins with carotenoids fixed on them were deposited. During the next exposure, the liquid mass of the solution in its lower part began to crystallize, turning into ice. The crystallization front extended upwards and reached the heater. In this case, the layer of protein coagulate was squeezed out by ice. Impurity coloring substances (chlorophyll, etc.), as well as hydrophilic, aromatic, and dissolved gases went up into the heated liquid phase and accumulated in a local volume around the heater. The layer of ice from the conductive grid to the liquid area of the upper part of the volume was transparent, unpainted. The liquid phase of the solution near the heater was drained into a separate container. The conductive grid was heated by passing an electric current through it. At the same time, the ice at its location melted, and the lower layer containing the coagulate was separated from the transparent mass of ice. The net was lifted up and removed from the cylindrical container along with the ice mass on it.


a) *b)*

Fig. 5. Appearance of carrot dye (a) and flour (b)

Thus, a frozen carotenoid concentrate was obtained at the bottom of the container.

The concentration of dry matter in the carrot carotenoid concentrate was 70-80% by weight. the amount of wet coagulate from 40 kg of carrots was 1220-1260g.

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 50-55^{0}C with grinding on a coffee grinder. Thus, a powdery food dye was obtained, the appearance of which is shown in Fig. 5A.

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÷50^{0}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. 5b). The finished product was packed in paper bags weighing 1 kg.

The transparent juice may contain water-soluble components of carrot juice. These include: carbohydrates, organic acids, 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-liter 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.

3. CONCLUSION

A resource-saving technology has been developed to solve the economic and environmental problem. The technology allows you to get high-quality concentrated and powdered natural dye, food powder and transparent carrot juice. The parameters of the process mode are determined based on the graph of temperature dependence on the volume of transparent juice. The identified parameters were used on the model of the phase separator system, which was used to obtain a high-quality carrot dye. This technique eliminates the vacuum evaporation processes and freeze-drying process of the dye. For the purpose of wide application of the developed technology, the authors modeled the juice phase separation unit, which allows to obtain powdered food dye using a heliosushchilny unit located at the Institute. Working in the temperature range 45-65^{0}C.

Authors ' statements

The study consists of the following aspects

1. Developed technology for obtaining powdered brand dye with the exception of vacuum evaporation process and freeze drying process
2. The developed technology is based on the physical process of phase separation of the juice space.
3. Developed a correlation between the heating temperature and the holding time depending on the volume of transparent juice.
4. In one technological mode, three high-quality semi-finished products are obtained: natural dye, carrot powder, and transparent juice that can not be used in the preparation of various food products.
5. Modeled and created by the installation of a phase separating agent juices.

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