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Possibility and prospects of preservation of minor components in technology of fruit raw materials conservation

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Abstract. According to modern research, traditional methods of preserving fruits and vegetables do not allow obtaining products identical to natural products for biological value. At the same time, there is a need to provide the population with minor components of food, including concentrated form. The aim of the study was to preserve the minor components in canned fruit raw materials for a long time. The study was carried out comparing the data of bioflavonoids and vitamin C in fresh oranges and dehydrated oranges (immediately after dehydration and storage for 12 months). The analysis was performed by reversed-phase HPLC on Dionex Ultimate 3,000 chromatograph ('Thermo Scientific', USA) using Luna 5U C18(2) 100A, 5 µm 4.6 mm × 150 mm column ('Phenomenex', USA), system number 125617-12. The identification of components was performed by comparison of retention times of standard flavonoid samples. Dehydration was done by means of resonant IR drying, gradually lowering the temperature from intense (67–75 °C) to soft (32–35 °C) temperature regimes. Analysis of chromatograms of fresh and dehydrated oranges shows that they all have a similar profile, but differ significantly in the content of certain components. The presence of vitamin C 1,926.9 mg per 1 g of dehydrated oranges was noted, which is identical to the content of 10 g of fresh orange. The following flavonoids have been found: prunus and a component related to the polymer form of naringin, the content in 1 g of dehydrated oranges is approximately seven times more than that for 1 g of fresh orange. The loss of vitamin C by 8% during storage of dehydrated orange for 12 months was noted, the amount of flavonoids varies insignificantly by 2–3%.Studies have shown that the technology of dehydration with the help of resonance IR drying allows to keep the minor components in the native state for a long time.

Key words: dehydration, flavonoids, preservation of minor components, vitamin C.

INTRODUCTION

The increase in the consumption of industrially produced food, changes in daily physical activity, and factors that increase oxidative stress lead to the necessity of strengthening of the today people diet by minor components of food.

Flavonoids are one of the important groups related to minor components. These substances are not synthesized in the body and can only be replenished by the

introduction of plant foods (vegetables, fruits and berries) into the diet (Mennen et al., 2008; Tarahovsky et al., 2013).

The question of the effect of flavonoids on the human body remains open to the present time, and what is more, it is known that flavonoids play a vital role in protecting against infections, prevent oxidative stress, contribute to the prevention of neurodegenerative diseases. According to WHO, a person needs to consume at least 400 g of fruits and vegetables per day to prevent cardiovascular diseases, cancer, obesity, and diabetes (Gu et al., 2010; Kontou et al., 2011; Davidson et al., 2016; Mayne et al., 2016).

Often in the modern diet lacks a sufficient number of minor components of food. The main reasons are: irrational living conditions, including inadequate nutrition; irregular working hours and, as a result, eating fast food; lack of quality fruits and vegetables associated with intensive farming and breeding. Taking BADS containing dietary fiber and minor components do not have a significant impact on disease prevention. It should be noted that the complex of native dietary fibers and flavonoids of vegetables and fruits is most effective in the prevention of diseases (Egert, et al., 2011).

According to recent research, the consumption of canned vegetables by salting and marinating, increase the risk of developing cancer (Zakrevsky & Liflyandsky, 2017). The solution to this problem can contribute to the use of new technological methods of preservation of bioactive substances in the production of food. The focus of these studies is aimed at improving accessibility by selecting gentle methods of treatment, one of which is IR treatment (dehydration). A feature of the use of long-wave resonance IR radiation in the food industry is the possibility of penetration of electromagnetic waves into products to a depth of several millimeters to 3 cm, which is 60 times higher than the degree of penetration of conventional heat. The predominant part of radiant energy is resonantly absorbed by water molecules, accelerating the process of dehydration without excessive heating of the product. The study of pulse modes of IR processing showed that the duration of the process and the cost of electricity are reduced by 2–3 times compared, for example, with convective drying.

High density of infrared radiation actively destroys harmful microflora in the product, so that it remains for a long time without deterioration of consumer qualities (Krishnamurthy et al., 2008; Demidov et al., 2015). This technology of dehydration allows preserving vitamins and other biologically active substances contained in the products. Thus, the complex problem of insufficiency of consumption of native fruits and vegetables, and also preservation of nutrients for a long time without creation of special conditions is solved.

The aim of the study was to develop a technology of preservation of fruit raw materials by dehydration to preserve minor components.

MATERIALS AND METHODS

The work was carried out at Saratov State Vavilov Agrarian University and the center for collective use (CCP) of scientific equipment in the field of physicochemical biology and nanobiotechnology ‘Symbiosis’ of the Federal state budgetary institution of science of the Institute of biochemistry and physiology of plants and microorganisms of the Russian Academy of Sciences (IBFM RAS).

The study examined fresh and dehydrated oranges. Dehydration was performed by the method of resonant IR drying on the wavelength of the near- and mid-infrared range of 1.8–3 microns by stepwise lowering of temperature from intense (67–75 °C) to mild (32–35 °C) temperature regimes. For resonant infrared drying, the equipment was used by Sator LLC, equipped with ceramic shell emitters, the design and composition of which are the know-how of this company.

The study was carried out by comparing the data of bioflavonoids and vitamin C in fresh oranges and dehydrated (immediately after dehydration and after storage for 12 months).

The analysis was performed by reversed-phase HPLC on Dionex Ultimate 3,000 chromatograph ('Thermo Scientific', the USA) using Luna 5U C18(2) 100A, 5 μm 4.6 mm ×150 mm column ('Phenomenex', the USA), serial number 125617-12. Identification of the components was performed by comparing the retention times of standard flavonoid samples (rutin in the form of hydrate (≥ 94%, 'Sigma-Aldrich', the USA), quercetin in the form of dihydrate (97%, 'Alfa Aesar', the UK), naringin (≥ 95%, 'Sigma-Aldrich', the USA), apigenin (≥ 97%, 'Sigma-Aldrich', the USA), naringenin (≥ 95%, 'Sigma-Aldrich', the USA).

The resulting material was processed on a personal computer using Stat Plus and Microsoft Excel (Egert & Rimbach, 2015).

RESULTS AND DISCUSSION

Traditional methods of dehydration lead to certain changes and cannot ensure the safety of biological substances. Thus, the proteins contained in the raw material, pectin substances undergo biochemical and colloidal chemical changes that affect the hydrophilic properties of dried products. Thermal drying does not allow obtaining a product with high recovery capacity due to chemical and physical processes with the formation of colloids occurring during drying. Freeze-drying allows preserving the quality of raw materials. Such food concentrates are characterized by high consumer properties. The only drawback is the high cost of processing.

The use of IR-dehydration of fruits in modes that preserve the native component by 80–90% solves several problems at once: the concentration of minor components per kilogram of food substance increases, and food fibers – cellulose, hemicellulose, pectose – remain in the native state, thus providing a substrate for microorganisms.

Technology of production of snack preserved with minor components is standard hydromechanical processing: washing, cleaning and cutting slices with a thickness of 3–4 mm on the disk knife. Dehydration by IR resonance drying, without forced convection. Radiation at the wavelength at the boundaries between the near and middle infrared ranges of 1.8–3 microns, which corresponds to the absorption of electromagnetic radiation by water. It should be noted that the introduction of forced convection will lead to overheating of the product and loss of valuable minor components due to thermal shock. Resonance occurring by the wave exposure prevents the interaction of molecules osmotically and physico-mechanically bound moisture, prevailing in fruit raw materials, with substances in the intact cell structure (Demidov et al., 2015). Thus, the most intense impact of temperature (65–70 °C) occurs in the first hour and due to intense evaporation allows you to remove surface moisture from the orange cantles. In this case, the main moisture remains in excess. Further, the

temperature is reduced to 45–50 °C and most of the moisture removal occurs in this range for 2–3 hours. The last stage of drying occurs at a temperature of 35–38 °C, the residue of osmotically-retained water is removed. The final moisture content of the product is 8–9% with an initial average humidity of 80 ± 2%. The dehydrated product is air cooled to 20 °C and packed in a sealed package. The packaged product was stored without moisture, at the temperature of 20 ± 2 °C and normal atmospheric pressure.

Noted that during dehydration, the mass of the product changes in 7–7.5 times.

A comparative analysis of the content of ascorbic acid (vitamin C) in freshly squeezed orange juice, residue, after extraction and dehydrated orange showed that this method of dehydration allows preserving vitamins as much as possible (Fig. 1). The presence of vitamin C 1,926.9 mg per 1 g of dehydrated oranges was noted, which is identical to the content of 10 g of fresh orange. Losses of vitamin C during storage of dehydrated orange for 12 months amounted to 8%.

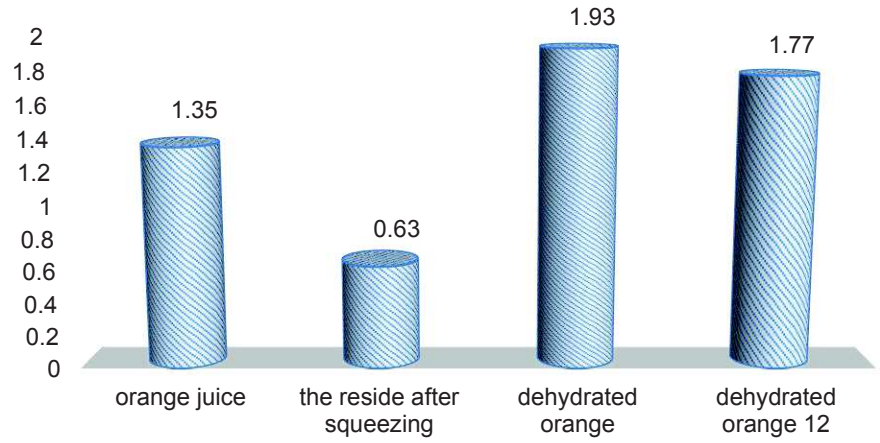

Figure 1. Content of vitamin C, mg per g (for juice and residue after pressing mg per 10 g) 1–3% deviation.

Analysis of chromatograms of orange juice (Figs 2–3), chips (Figs 4–5), the residue of fresh orange after separation of juice (Figs 6–7) shows that they all have a similar profile, but differ significantly in the content of certain components.

In the chromatograms of all the studied samples a group of peaks corresponding to polyphenolic compounds, in particular flavonoids, is observed. Thus, the most representative flavonoid found in the extracts is prunin, which is a monoglycoside of naringenin - Naringenin-7-O-Glucoside (component 18 in Fig. 1, component 17 in Figs 3–5). The retention time (15.00 min) and UV-visible spectrum coincide with those of the component obtained as a result of partial acid hydrolysis of the naringin sample. Component 17 (Fig. 1), component 16 (Fig. 3), component 15 (Fig. 4) has an almost identical absorption spectrum with prunin, however, it is characterized by a slightly shorter retention time (14.60 min) than the standard naringin sample (14.80 min), which allows us to assume that this component is a polymer form of naringin with a low degree of polymerization (dimer, trimer, etc). Component 23 (Figs 2–4), the component 21 (Fig. 6) has similar chromatographic and spectral characteristics with one of the

components detected after acid hydrolysis of naringin, which suggests the presence of aglycone naringenin.

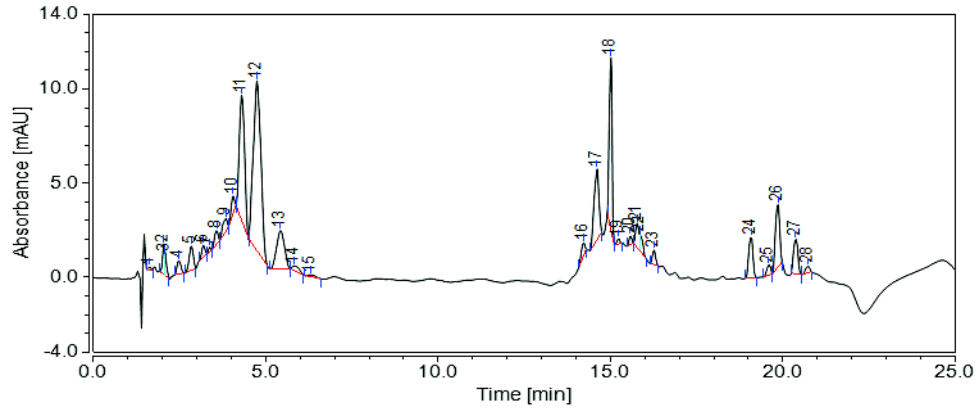

Figure 2. A chromatogram sample of orange juice, integration at a wavelength of 342 nm.

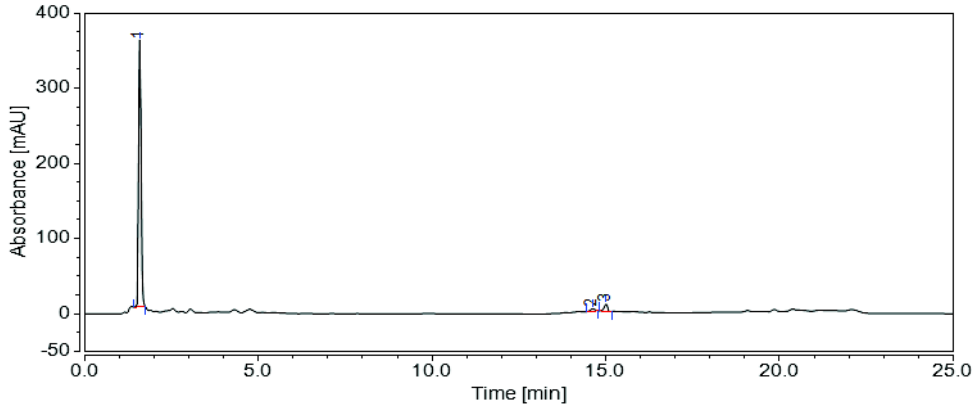

Figure 3. A chromatogram sample of orange juice, integration at a wavelength of 252 nm.

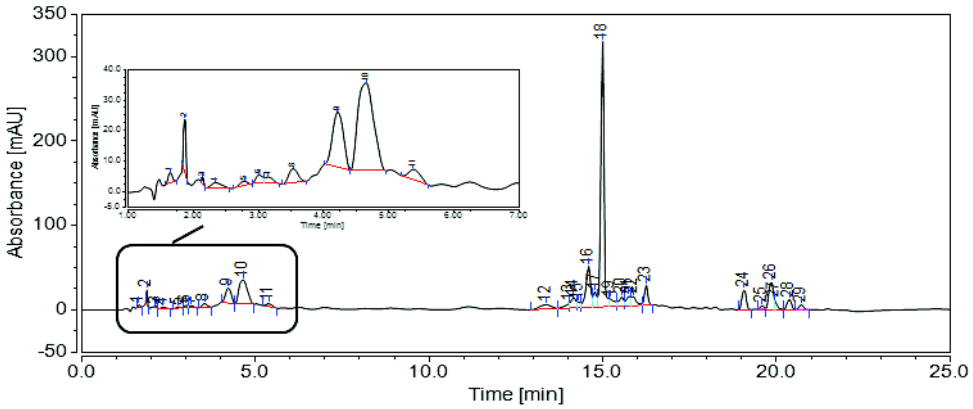

Figure 4. A chromatogram sample of dehydrated orange, integration at a wavelength of 342 nm.

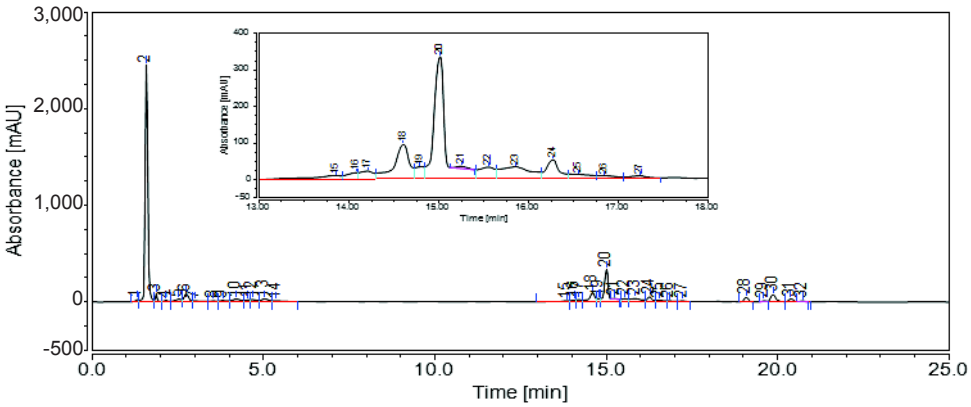

Figure 5. A chromatogram sample of dehydrated orange, the integration at the wavelength of 252 nm.

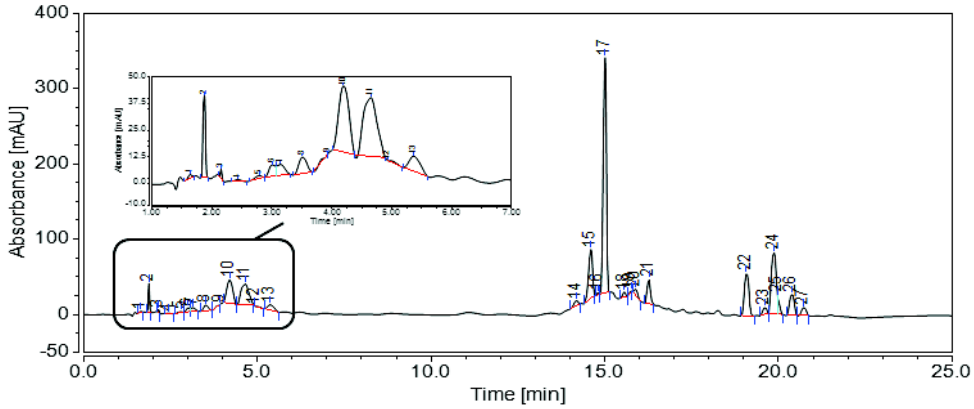

Figure 6. A chromatogram sample of the alcoholic extract of the fresh orange residue after separation of the juice, the integration on the wavelength of 342 nm.

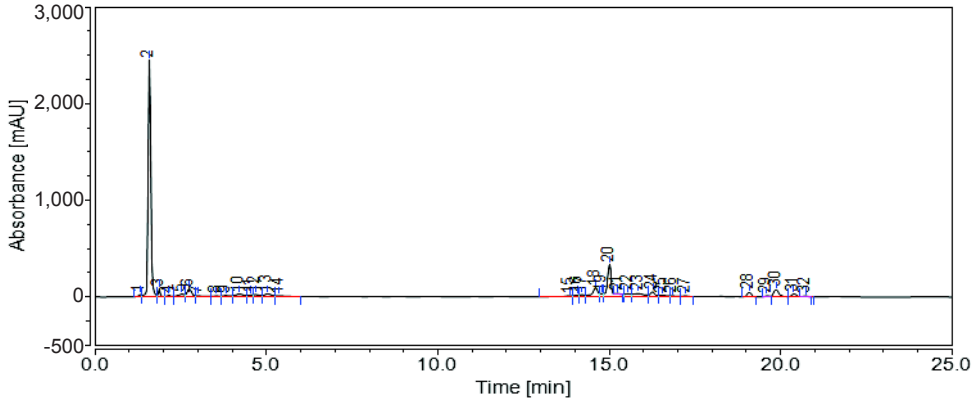

Figure 7. A chromatogram sample of the alcoholic extract of the fresh orange residue after eparation of the juice, the integration at the wavelength of 252 nm.

The amount of detected prunin and the component related to the polymer form of naringin in the dehydrated orange is about seven times more than that for fresh orange. When storing dehydrated orange for 12 months. The amount of flavonoids varies insignificantly – 2–3%.

CONCLUSIONS

The result of the research was the developed technology of dehydration with the use of resonant IR drying and step-down temperature from intense (67–75 °C) to mild (32–35 °C) temperature conditions, which allows you to save the minor components. Analysis of the data of the experiments showed that the content of vitamin C in dehydrated oranges is 10 times higher than in fresh ones. Decoding of chromatograms of objects of research: orange juice, orange chips, the rest of fresh orange after juice separation - shows that all of them have a similar profile and contain a significant amount of polyphenolic compounds – flavonoids. In particular, prunin, which is a monoglycoside of naringenin – Naringenin-7-O-Glucoside. It should be noted that the content of the detected prunin and the component related to the polymer form of naringin in the dehydrated orange is approximately 7 times greater than that for fresh orange. When storing dehydrated orange for 12 months. The amount of flavonoids varies insignificantly – 2–3%, and the 8% loss of vitamin C was detected.

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