Technologies for the production and application of food supplements based on fruits cryopowders

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Abstract. The article presents material on the production of a new class of bio-correctors in the form of cryopowders from fruit raw materials grown in the Adler district of the Krasnodar Territory. Fruits of shadberry, feijoa and persimmon are chosen as research objects. Fruits have high characteristics of quality, but low shelf-life. The chemical composition of fruits contains a significant amount of easily digested carbohydrates, vitamins, macro and micronutrients. The dependence of the moisture content of fruit raw materials on the duration and speed of low-temperature drying is investigated. Mathematical substantiation of the freezing process and the contribution of dry substance heat capacity, ice and water to the heat generated during the water crystallization are given. The technological apparatus scheme for the production of cryopowders from fruit raw materials has been improved. It is based on raw material dehydration in a gaseous nitrogen environment, shock low-temperature freezing of research objects and ultrafine grinding of pre-prepared and dried raw materials in a liquid nitrogen environment.

1. Introduction

Fruits of shadberry, feijoa and persimmon are grown in the Southern Federal District of the Krasnodar Territory [1, 10]. Their chemical composition is considered to be unique. However, the shelf life of such fruits is limited to 3-6 days, so producers of agricultural raw materials have the objective to find cost-effective ways of processing. Such methods include the use of electromagnetic fields and cryotechnologies [2, 6]. The hygroscopic research of drying objects is carried out to prepare for removing moisture from the fruit. And the components forming organoleptic characteristics of fruits are investigated [3, 4].

The most progressive method of long-term storage of fruit raw materials is gentle low-temperature drying and freezing in an environment of liquid nitrogen [5]. If the producers find an acceptable way of drying fruits, they offered it to use for the enrichment of bakery products composition [7-9]. The
products of shadberry fruits processing are known as the best enriching agent of marmalade composition [10].

The specialists of Voronezh state University of engineering technologies declared about the positive effect of non-traditional herbal additives on the biotechnological characteristics of flour [11]. The cultivation in a protected ground or organic garden is considered the most important dilemma in the environmentally safe production bio-corrector from fruits [12].

Thus, according to the opinion of reputable experts, the authors made a decision to improve the technology for producing and using bio-corrector based on cryopowders from fruits of shadberry, feijoa and persimmon grown in the Krasnodar Territory.

2. Research objectives

The main goal is to improve the technology for producing bio-correctors based on cryopowders of shadberry, feijoa and persimmon and give suggestions on their application for enriching the composition of food products.

For achieving this goal, the tasks are solved on the substantiation of the selection of raw materials for bio-corrector production, the selection of the optimal method of low-temperature drying, the improvement of the technological apparatus scheme for cryopowders production, offers to include the bio-corrector in the composition of bakery products.

3. Materials and methods

The criterion for the selection of raw materials for research is an increased content of water and fat-soluble vitamins and antioxidant substances.

The objects of the research are selected fruits of the «Zvezdnayanoch» variety of shadberry, feijoa fruits of the «Krymskyranniy» variety, persimmon of the “Veber” variety grown in the farms of the Adler Experimental Station of the All-Russian Research Institute of Plant Production named after N.I. Vavilov.

«Enocolouring from the skin of red grapes» is used in the investigation. It is made under the technology of the North Caucasian Federal Scientific Center for Horticulture, Viticulture, and Winemaking.

A flavouring in the form of cinnamon CO2-extract of according to Technical Regulations 10.89.15-478-02067862-2019 “CO2-extracts from plant materials,” produced at the extraction plant of OOO “Company Caravan,” light water, with a reduced content of deuterium, was produced according to Technical Regulations 20.13. 61-492-02067862-2020; the food additive "Fruit cryopowders" is made under Technical Regulations 9223-00.

4. Results of research

Table 1 provides information on the chemical composition of the shadberry fruit «Zvezdnayanoch» variety, the «Crymskyranniy» feijoa fruit, and the «Veber» persimmon fruit.

According to the data of Table 1, almost all essential food and biologically active substances are in the chemical composition of fruits selected for research.

However, such valuable fruits for the human body have a limited shelf life and cannot be used all year round.

To obtain long-term storage products, the authors offered pre-prepared fruits to dry in the modernized dryer "Isidri", using hot nitrogen vapours as a drying agent.
Table 1. The chemical composition of fresh fruits of shadberry, feijoa and persimmon

| Components       | Component contain, g/100 g | shadberry | feijoa | persimmon |
|------------------|-----------------------------|-----------|--------|-----------|
| Water            | 79,6                        | 83,2      | 81,4   |           |
| Proteins         | 1,33                        | 0,71      | 0,5    |           |
| Fats             | 1,49                        | 0,42      | 0,40   |           |
| Carbohydrates    | 18,48                       | 8,81      | 15,3   |           |
| Dietaryfibers    | 2,3                         | 6,4       | 1,6    |           |
| Organic acids    | 0,6                         | 1,2       | 0,1    |           |
| Ash              | 0,93                        | 0,38      | 0,62   |           |
| β-carotin        | 10,91                       | 0,20      | 1,20   |           |
| Thiamine         | 0,04                        | 0,006     | 0,02   |           |
| Riboflavinium    | 3,54                        | 0,02      | 0,03   |           |
| Choline          | 0,31                        | 0,43      | 7,60   |           |
| Pyridoxine       | 0,003                       | 0,067     | 0,120  |           |
| Ascorbic acid    | 3,6                         | 33,2      | 17,0   |           |
| Tocopherols      | 1,13                        | 0,17      | 0,52   |           |
| K                | 167                         | 172       | 200    |           |
| Ca               | 41,9                        | 17,3      | 127,0  |           |
| Mg               | 24,4                        | 9,3       | 56,1   |           |
| P                | 20,2                        | 19,4      | 42,2   |           |
| Na               | 0,5                         | 3,2       | 15,2   |           |
| Fe               | 96                          | 32        | 17     |           |
| J                | 130                         | 140       | 60     |           |
| Co               | 10                          | 1,4       | 3,6    |           |
| Mn               | 1,42                        | 0,08      | 0,3    |           |
| Se               | 0,04                        | 1,8       | 0,6    |           |
| Zn               | 17                          | 0,6       | 0,1    |           |
| Calorific value, kcal |                  |           |        |           |

Figure 1 shows the dependence of moisture content on the drying time.

Figure 1. Dependence of the moisture content of fruits of shadberry, feijoa and persimmon on the duration of drying: 1 – persimmon, 2 – feijoa, 3 – irga.
The kinetic dependence of moisture content change on the duration of moisture removal process indicates different forms of free and bound moisture content in individual raw materials. An analysis of the kinetic curves of the dependence of moisture content on the drying rate of fruits of shadberry, feijoa and persimmon indicates a significant difference in the rate of moisture removal from fruits with different chemical composition.

The dried product is cryopreserved in an environment of liquid nitrogen, followed by crushing in a cryomill.

Fruits of shadberry, feijoa and persimmon are frozen in an environment of liquid nitrogen at temperatures from minus 100 to minus 190 °C, and then they are ground in a cryomill. Table 3 shows the technological apparatus scheme for the production of cryopowders from fruit raw materials.

![Figure 2](image1.png)

**Figure 2.** Dependence of moisture content on the drying speed of fruits of shadberry, feijoa and persimmon: 1 – persimmon, 2 – feijoa, 3 – irga.

The scheme shown in Figure 3 allows processing various types of agricultural raw materials into cryopowders. The obtained cryopowders have a high degree of biologically active substances bioavailability for the human organism. Table 2 shows the chemical composition of fruit and berry.
cryopowders.

Table 2. The chemical composition of cryopowders

| Product    | Water % | Proteins % | Fats % | Carbohydrates | Ash % | K mg% | Ca mg% | Mg mg% | P mg% | B mg% | B2 mg% | C mg% |
|------------|---------|------------|--------|---------------|-------|-------|--------|--------|-------|-------|--------|-------|
| Shadberry  | 6,3     | 9,0        | 0,5    | 67,2          | 12,0  | 5,0   | 1590   | 380    | 146   | 259   | 0,6    | 0,4   | 83     |
| Feijoa     | 7,2     | 4,3        | 0,4    | 74,8          | 9,6   | 3,7   | 420    | 390    | 320   | 89    | 0,1    | 0,4   | 89     |
| Persimmon  | 6,9     | 4,1        | 0,3    | 69,6          | 12,6  | 6,5   | 2345   | 170    | 102   | 118   | 0,1    | 0,3   | 125    |

The possibility of using cryopowders from fruits of shadberry, feijoa and persimmon to enrich the chemical composition of spice cakes has been established. Table 3 shows the recipe for spice cakes “Frukrovye”.

Table 3. Mass composition of spice cakes “Frukrovye”

| Raw materials         | Traditional formulation | Mass, kg |         |         |         |         |         |         |         |
|-----------------------|-------------------------|----------|---------|---------|---------|---------|---------|---------|---------|
|                       |                         | With cryopowder |         |         |         |         |         |         |         |
|                       |                         | shadberry  | shadberry feijoa | shadberry persimmon |
| 2nd grade flour       | 100                     | 96        | 96      | 96      |
| Granulated sugar      | 35 (fordoughandglaze)   | 35        | 35      | 35      |
| Molasses              | 45                      | 45        | 45      | 45      |
| Margarine             | 2                       | 2         | 2       | 2       |
| Melange               | 2                       | 2         | 2       | 2       |
| Vegetable oil         | 0,55                    | 0,55      | 0,55    | 0,55    |
| Ammoniumcarbonate     | 0,8                     | 0,8       | 0,8     | 0,8     |
| Bicarbonate of soda   | 0,4                     | 0,4       | 0,4     | 0,4     |
| Aromatizer: CO2 - cinnamon extract | In the dough and syrup for glazing | In the dough and syrup for glazing | In the dough and syrup for glazing | In the dough and syrup for glazing |
| Redgrapeskinextrac t  | In the dough and syrup for glazing | In the dough and syrup for glazing | In the dough and syrup for glazing | In the dough and syrup for glazing |
| Light water (capacity for moisture) | 20-25 l               | 20-25 l   | 20-25 l | 20-25 l |
| Cryopowder            | -                       | 4         | 4       | 4       |
| Output of finished products | 175-178                | 179       | 180     | 179     |
| Shel life at t=20° and humidity 70 %, days | 19                    | 24        | 26      | 24      |
| Tastingscore, points  | 4,2                     | 4,4       | 4,3     | 4,5     |

According to the data of Table 3, the spice cakes enriched with cryopowders of shadberry feijoa and persimmons have a longer shelf life and are characterized by increased organoleptic properties.
5. Discussion of results
The authors' idea is improving the technology for producing food additives in the form of cryopowders can be referred to innovative technical solutions. The research on obtaining a new class of bio-correcrors – cryopowders from fruit raw materials grown in the Adler district of the Krasnodar Territory, gives the opportunity not to import expensive western products of this class. Due to fruits of shadberry, feijoa and persimmon have high-quality indicators; the obtained dehydrated bio-corrector possess increased nutritional and biological value.

6. Conclusion
The research has been carried out to obtain a new class of food additives in the form of cryopowders from fruit raw materials grown in the Adler district of the Krasnodar Territory. Fruits of shadberry, feijoa and persimmon as objects of research have high-quality indicators, but low shelf life. The chemical composition of fruits contains a relatively high amount of vitamins, macro and microelements. The dependence of the moisture content of fruit raw materials on the duration and speed of drying is determined.

The mathematical substantiation of the heat capacities contribution of dry substances ice and water to the heat generated during crystallization of water is carried out.

A technological apparatus scheme is developed to produce cryopowders from fruit raw materials, which differs from the known technical solutions by dehydration of raw materials in an inert gas environment, shock low-temperature freezing, and ultrafine grinding in a liquid nitrogen environment.

The chemical composition of cryopowders is investigated and the recipes for spice cakes “Fructovye” are developed on light water, with a natural enocoloring, a CO2 extract of cinnamon and finely ground fruits of shadberry, feijoa and persimmon. The organoleptic analysis confirms the high taste advantages of the new product.

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