Technology and commodity characteristics of extracts and oil cake for food enrichment

S P Zaporozhskaya¹, G I Kasyanov¹, O V Kosenko¹, T A Jum², M V Ksenz² and S I Kucherova¹

¹ Kuban State Technological University, 2, Moskovskaya Str., Krasnodar, 350072, Russia
² Plekhanov Russian Economic University of Economics, Krasnodar Branch, 360, Severnaya Str., Krasnodar, 350015, Russia

E-mail: zsp2279@mail.ru

Abstract. The original technology of obtaining a new class of food additives in the form of \( \text{CO}_2 \) extracts has been developed at the department «Technology of food products of animal origin» in Kuban State Technological University. It was found that after removal of \( \text{CO}_2 \) extractive substances from dry raw material, sterile oil cake is formed, which is a carbohydrate-protein-lipid food additive. One more peculiarity of \( \text{CO}_2 \) oil cake was noted: the pressure in the extraction apparatus suddenly drops from 6 MPa to atmospheric pressure at the end of the extraction process, the solvent located in each particle of raw material boils up sharply, and at the same time, a particle of raw materials is being reground to a nanoscale. If the microorganisms are in the raw materials they are subjected to the same process. The oil cake becomes infection-free after a gas-liquid bursting. The physicochemical properties of \( \text{CO}_2 \) extracts from the dried fruits of actinidia, sea buckthorn, unabi and rosehips were investigated. The extract form, density and refractive index, viscosity and acid number are determined by these characteristics. The oil cake obtained after the removal of \( \text{CO}_2 \)-extractive substances from the raw materials was analysed for their content of the main food components, macro and microelements. The formulation of a meat and vegetable paste enriched with \( \text{CO}_2 \) extracts and \( \text{CO}_2 \) oil cake has been developed.

1. Introduction

Analysis of the effectiveness of technological processes for extracts and their product characteristics allows using that full array for food enrichment. It is possible to objectively assess the technological features of the production of extracts and oil cake from food plant raw materials by referring to the publications of specialists in this field. During the preparation of plant materials for gas-liquid extraction, it is necessary to determine the gentle temperature of drying schedules. The biologically active substances are allowed to preserve to the maximum extent [1]. It is possible to obtain biocorrectors with antioxidant and antimicrobial properties from oil cake and pulp juice production [2].

The specialists of the food profile department of Astrakhan State Technical University offered to optimize the fatty acid composition of products by adding lipid-containing extracts [3]. It was offered to intensify the process of extracting essential components from raw materials by solvents assortment with selective properties [4,7,9,11]. Many authors offered new approaches to create healthy food...
products by balancing the composition with the essential components of animal and plant origin [5,6,11].

The method of electrophysical ways effect on the activation or inhibition of a microbial consortium of raw materials is considered to be very effective [8,14].

Pushmina V.V. and her colleagues from the Siberian Federal University analyzed the chemical composition of local berry raw materials and proposed to use them in the formulations of functional products [10].

The authors pay special attention to the assortment of plant materials for the preparative component separation and use them for patenting formulations and food products enrichment [12,13,15].

Judging by the published scientific and technical information, recently there has been a trend towards more scrupulous evaluation of new technological solutions and commodity characteristics of extracts and oil cake produced with the help of non-traditional selective solvents and used for food fortification.

The goal of the research is to improve technological methods for obtaining and using CO$_2$ extracts and CO$_2$-oil cake from dry fruit raw materials and evaluate their commodity features. The essential tasks are solved to achieve the intended purposes. It is necessary to improve the technological chart of CO$_2$ processing of raw materials, investigate the physicochemical properties of CO$_2$ extracts from the fruits of actinidia, sea buckthorn, unabi and rosehip, and evaluate commodity characteristics of CO$_2$ oil cake fruit after removing CO$_2$-extractives.

2. Theoretical basis

During investigation of kinetics and statistical screening analysis of the extraction with liquid carbon dioxide it was determined the effect of various technological variables, such as temperature, time, solvent volume, particle size and their interaction, on the extraction output. The predictive model was obtained drawing on multiple regression analysis. It describes the output of CO$_2$-extractive substances in terms of technological variables. The optimal substance output from the raw materials was predicted at an extraction temperature of 22 °C, an extraction time of 80 minutes, a petal thickness of 0.18 mm and a solvent hydromodule of 1:20. It was established that the yield of CO$_2$-extractive substances increased with the temperature rise to 28 °C and duration of the extraction, but diminishes with the increase of refined raw materials thickening. The extract was analyzed to study its physicochemical properties (such as acid number, iodine number, peroxide number, viscosity, humidity, refractive index and specific gravity).

3. Materials and methods

The preliminary prepared, dried and ground fruits of actinidia of the «Soroka» variety, sea buckthorn of the «Sokratovskaya» variety, unabi (Zizifus) of the «Yuzhanin» variety and rosehip of the «Vitamin VNIVI» variety grown in Krasnodar Territory are related to the objects of investigation subjected to CO$_2$ extraction. The traditional methods are used to study the list of ingredients of medical plants and food products.

The laboratory research on the extraction of CO$_2$-extractive substances from dry raw materials was made on an experimental extraction plant of OOO «Plasma K». The extraction efficiency is analyzed by mathematical modeling to develop models for process scaling in an industrial environment. The developed models contain characteristics of species mass transfer inside and outside the particles of plant material, and an interfacial balance distribution of species. The model parameters were estimated in accordance with the experimental data. The type of solvent, liquid-solid ratio, and extraction temperature were chosen as technological factors in the extraction of valuable components from raw materials. Producing an effect on the yield, these factors determined the values of the model characteristics. The certain model was adopted to extract the target components. It was based on controlling the process of external diffusion of extracted substances and swelling of particles. At the same time a model of internal diffusion was chosen to describe the process in the case of extraction of total extractive substances.
The model parameters were determined by the least square method using theoretical and experimental data that characterize the yield dynamic of extraction species. Scaling of countercurrent multistage extraction was carried out by processes analyzing the studied level at the laboratory.

4. The results of research
The chart of solvent supply is presented in figure 1.

Figure 1. The schematic structure of the installation for obtaining extracts from plant materials with liquid carbon dioxide: 1 - evaporator, 2 - extractors, 3 - solvent tank, 4 - reducer, 5 - condenser, 6 - reserve tanks for liquid carbon dioxide; 7 - collection of extract

The carbon dioxide was supplied from the cylinder 3 which in the vapour phase through the gear 4 was supplied to the capacitor 5, where (under the influence of low temperature) the condensed carbon dioxide changed into a liquid at a temperature of +5...+7 °C in a container 6 for thermostat control.

The technological extraction process began with the loading of prepared and graded raw materials in mesh cassettes placed inside the extractors 2. The liquid carbon dioxide was pored over from the
containers. For a period of 30 minutes, raw materials were saturated with a solvent, and then a flow extraction process was carried out. The extraction mode: temperature - + 15 °C ... + 25 °C, pressure – 5085-6436 kPa, process duration – 60-120 min.

Table 1 shows the physicochemical properties of CO₂ extracts and CO₂ oil cake.

**Table 1. Physicochemical properties of CO₂ extracts and CO₂ oil cake**

| Name | Appearance, CO₂ extract | Density at 20 °C, g/cm³ | Refractive index nD²⁰ | Acid number, mg KOH, not more than | Viscosity at 20 °C, Pa·s | CO₂ oil cake characteristic |
|------|-------------------------|-------------------------|-----------------------|-----------------------------------|--------------------------|-----------------------------|
| Actinidia, «SOROKA» variety | light green oily liquid | 0.923 | 1.4675 | 4.0 | 0.0803 | Proteins - 4 %, lipids - 0.5 %, carbohydrates - 66 % |
| Sea-buckthorn, «Socratic» variety | oily liquid of light - orange color | 0.917 | 1.4743 | 5.0 | 0.0654 | Proteins - 8 %, lipids - 16 %, carbohydrates - 52 % |
| Unabi, «Yuzanin» variety | oily liquid lemon color | 0.935 | 1.4893 | 4.5 | 0.0583 | Proteins - 3.2 %, lipids - 0.8 %, carbohydrates - 64 % |
| Hiprose «Vitamine» variety of All-Union scientific research vitamin Institute | oily liquid red-brown color | 0.947 | 1.5055 | 3.0 | 0.0644 | Proteins - 3.4 %, lipids - 1.8 %, carbohydrates - 56 % |

Table 2 shows the commodity characteristics of CO₂ oil cake Actinidia, sea buckthorn, unabi and rosehip after removal of CO₂-extractives.

**Table 2. Commodity characteristics of CO₂**

| Index | Oil cake from raw materials after CO₂-extractive substances removal | Actinidia | Sea buckthorn | Unabi | Rosehip |
|-------|-------------------------------------------------------------------|----------|--------------|-------|---------|
| Raw protein, g | | 4 | 8 | 3.2 | 3.4 |
| Digestive protein | | 3.2 | 7.1 | 2.8 | 3.2 |
| Crude fat | | 0.5 | 16 | 0.8 | 1.8 |
| Starch | | 5.5 | 1.7 | 2.7 | 6.2 |
| Cellulose | | 15 | 9.3 | 18 | 23 |
| Ash | | 5.2 | 4.9 | 5.1 | 5.8 |

**Macroelements**

| | Potassium | Calcium, g | Sodium | Phosphorus |
|-------------------|-----------|-----------|--------|------------|
| 1.04 | 0.61 | 0.02 | 0.82 |
| 0.92 | 0.58 | 0.02 | 0.91 |
| 1.32 | 0.30 | 0.07 | 0.80 |
| 1.13 | 0.31 | 0.93 | 0.73 |

**Microelements**

| | Manganese | Copper | Selenium | Zinc |
|-------------------|-----------|--------|----------|------|
| 2.49 | 0.51 | 0.02 | 4.23 |
| 2.36 | 0.23 | - | 5.31 |
| 2.63 | 1.20 | 0.03 | 6.07 |
| 2.28 | 0.52 | - | 5.32 |

Analysis of the chemical composition of CO₂-oil cake Actinidia, sea buckthorn, unabi and rosehip, showed the possibility of using them as enrichment agents for the composition of a whole group of food products.

Table 3 shows the composition of the meat and paste, enriched with CO₂ extracts and CO₂ oil cake.
Table 3. Formulation for meat and vegetable paste, enriched with CO₂ extracts and CO₂ oil cake

| Ingredients                                                                 | Weight content % |
|----------------------------------------------------------------------------|------------------|
| Minced meat from boiled Turkey and chicken (1:1)                           | 60               |
| Fried Veshenka mushrooms                                                    | 10               |
| Boiled cauliflower                                                         | 6                |
| Boiled quinoa                                                              | 8                |
| Fried onion                                                                | 5                |
| Olive oil with CO₂-extracts of Actinidia, sea buckthorn, unabi and rose hips| 4                |
| CO₂-oil cake of Actinidia fruit                                            | 5,2              |
| Edible salt                                                                | 1,8              |

The meat and cereal paste, made in accordance with the recipe, has a balanced chemical composition, high taste characteristics and high-energy value.

5. Conclusion

The scientific novelty and theoretical value of the research is to develop a systematic approach to modeling and control of technological processes for obtaining CO₂ extracts and CO₂ oil cake from fruit raw materials.

An algorithm of determining the optimum technological mode of the CO₂-processing was developed. As a result, a high-quality product is obtained in a short period of time.

The practical significance of the research is to develop raw materials processing and preparation, support system of intelligent decision-making at the optimal technological mode for the extraction of valuable components from dry fruits raw materials: actinidia, sea buckthorn, unabi and hiprose.

The accuracy and validity of the research results are confirmed by the correct theoretical and experimental methods for substantiating the results, as well as the agreement of the research results with experimental data.

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