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TECHNOLOGY FOR LYOPHILIZED FUNCTIONAL PRODUCT PRODUCTION ON THE BASIS OF BUFFALO COLOSTRUM

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Abstract

A technology for obtaining a new lyophilized functional product with healthy qualities - "FucoSTEM" has been created. Its composition includes sources of useful and biologically active ingredients of various origins. The bioformula of the new bioproduct was complied with the requirements for physiological activity, harmlessness and microbial stability. The main parameters of the process of freeze-drying of 4 main components of the composition of the product - colostrum, chokeberry juice, beta-glucans and fructooligosaccharides were established, and their phase behavior at low and high temperatures was studied. Analysis of the thermal curves, obtained by differential scanning calorimetry, provides information on enthalpy, melting temperatures and crystallization, thus proving that an endothermic phenomenon between -5°C and -40°C is observed, which corresponds to the melting of the samples.

Key words*: lyophilized product, buffalo colostrum, freeze drying.*

INTRODUCTION

Modern guidelines in the science of nutrition are characterized by a emphasized orientation on the to increasingly widespread application of natural remedies of protecting human health in the form of functional foods, probiotics, biological stimulators, regulators and more. Biologically active foods are a new and promising direction. These are foods, enriched with dietary fiber, oligosaccharides, various probiotic bacteria, vitamins, mineral substances and other useful ingredients, which regulate functions in the organism and improve the health status of the consumers. In modern industry more and more diverse in recipe composition biologically active foods are being developed (Ferronatto et al., 2021; Cerda-Opazo et al., 2021; Segura-Badilla et al., 2020; Ivanova et al., 2020; Tondt and Bays, 2022; Tran et al., 2022).

The method of freeze-drying (lyophilization) is used for the production of most of them. It combines two methods of preservation - freezing and drying under vacuum at temperatures that do not disturb the micro and macrostructure of the product. The increased interest in lyophilized foods is explained by the high quality of the final product, with their fully preserved taste qualities, color, aroma, nutritional and biological value, their lightness, long-term storage and convenience in transportation and marketing (Moayyedi et al., 2018; Achouri et al., 2021; Xin et al., 2022).

Buffalo colostrum represents a natural raw material with valuable qualities, that can be used to obtain various functional foods. There are data in the literature on scientific developments related to colostrum from cows, goats, but there is not enough information about buffalo colostrum. There is no information on the development and/or existence of functional foods and other bioproducts based on this type of colostrum. In recent years, results have been published on the presence of active substances in buffalo colostrum that have a protective effect (Rohit et al., 2012; Ashok & Aparna, 2017).

Aronia fruit is among the richest sources of polyphenols and has a high antioxidant potential (Llorent-Martínez et al., 2013; Štepec et al., 2020; Sidor & Gramza-Michałowska, 2019). It has been found to contain many other useful nutrients - antioxidants, vitamins, etc., which is why it is included to the so-called "superfoods" with unique health qualities.

The authors present a technology for the production of a new lyophilized bioproduct

"FucoSTEM", based on buffalo colostrum, with included sources of useful, physiologically active and building substances of different origin. Another of our scientific publications presents the results of organoleptic, physicochemical, biochemical and microbiological studies of this lyophilized functional product (Loginovska et al., 2021). This publication shows data related to the technology of obtaining this bioproduct. The optimal technological parameters of the sublimation drying process have been determined, in order to obtain a final product with low moisture content and preserved biologically active properties.

MATERIALS AND METHODS

The recipe of the new functional food, as mentioned in our other publication (Loginovska et al., 2021), includes natural raw materials - buffalo colostrum, chokeberry, fucose, xylitol, mannitol, β - glucans, fructooligosaccharides, sodium citrate.

The liquid components - colostrum and chokeberry juice are lyophilized, such as the process includes the following technological stages:

- *Freezing* - conducted in refrigerated chambers with forced convection of the air environment at a temperature from -25°C to -30°C, in continuation on minimum of 24 hours. Liquid raw materials (colostrum and chokeberry juice) are frozen in special trays for freeze-drying, with a layer thickness of 10-15 mm.
- *Determination of the mode parameters of freeze-drying by differential scanning calorimetry (DSC)* - Measurements were made with DSC 204F1 Phoenix (Netzsch Geräebau GmbH, Germany). The samples (about 10 mg) were enclosed hermetically in aluminum crucibles. An empty, hermetically sealed crucible was used as a reference. Initially, the samples were cooled to -60°C at a rate of 5 K/min, then were heated to 200°C at a rate of 10 K/min. The water content was determined by the peak of water crystallization (about 0°C temperature). The processing of the experimental thermograms was done with the help of specialized software to the Proteus Analysis tool (Netzsch, Germany).
- *Sublimation drying* - the process was carried out in a laboratory sublimation installation of the company "Hochvakuum-TG-16.50" with conductive heating of the plates during the initial drainage of water at -22°/-25°C and residual pressure in the sublimator in the range of 10^{-1}-10^{-2} mm Hg and desorption (after drying) by heating under deep vacuum. The temperature on to drying is +30°C.

RESULTS AND DISCUSSIONS

1. Determination of the prescription composition of a lyophilized product "FucoSTEM" - qualitative and quantitative selection of the constituent components of the product

The bioformula of the new functional product is compliant with the requirements for physiological activity, harmlessness and microbial stability. Its composition includes sources of useful and biologically active ingredients of various origins. The selection of the components and their quantity are in accordance with the need to obtain a lyophilized product with a balanced composition and high biological and energy value (Table 1).

Table 1. Component and quantitative osition of lyophilized product "FucoSTEM"

Component	Quantity, g	Content,%
Colostrum	20	10
Chokeberry (juice)	30	15
Fucose	20	10
Xylitol	40	20
Mannitol	40	20
Beta-glucans	10	5
Sodium citrate	10	5
Fructooligosaccharides	30	15
Total:	200.00	100

The product is prepared and adapted for use by a wide range of users, including children.

2. Determination of the optimal technological parameters to carry out the process of freeze-drying of the liquid components of the composition of "FucoSTEM" to obtain a final product with

low moisture content and preserved biologically active properties

Technological factors have especially important meaning for the successful implementation of the lyophilization process: freezing temperature, temperature on to drying, package and storage conditions. These indicators were tracked during the respective stages of freeze-drying.

To determine the regime parameters of freeze-drying and the maximum storage of the biological completeness of the raw materials, in advance were determined the main parameters of freeze-drying of 4 main components of the composition of the product - colostrum, chokeberry juice, beta-glucans and fructooligo-saccharides, and their phase behavior at low and high temperatures was studied.

Thermograms of their phase transitions were obtained by differential scanning calorimetry (Figures 1-4). The analysis of the thermal curves gives information about the enthalpy, melting temperatures and crystallization.

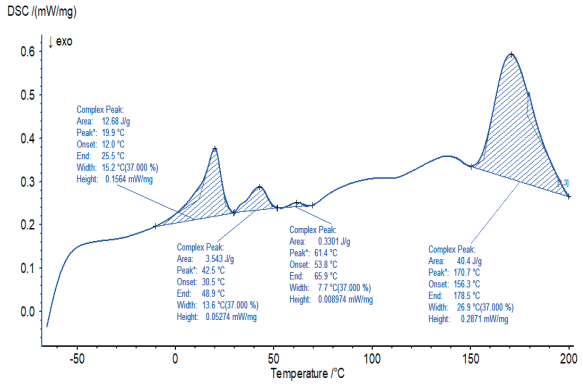

Figure 1. Thermogram of the phase transitions in colostrums

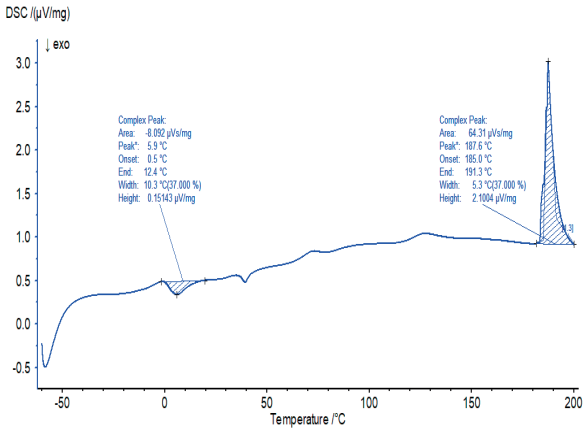

Figure 2. Thermogram of the phase transitions in chokeberry

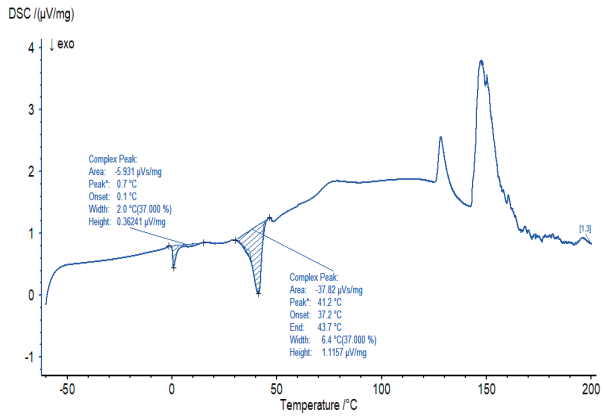

Figure 3. Thermogram of phase transitions in fructooligosaccharide

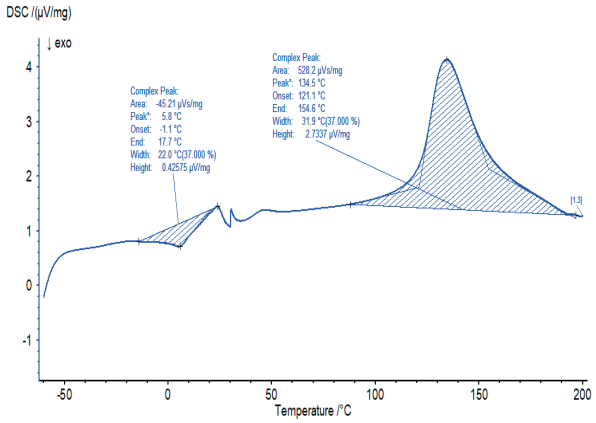

Figure 4. Thermogram of phase transitions in beta-glucan

The analysis of the obtained thermograms shows, that they have an analogous type - an endothermic phenomenon is observed between -5°C and -40°C, which corresponds to the melting of the samples. Temperature of initial melting (Tim) is about -5°C. Up to -80°C no change in the heat capacity and respectively vitreous transition is observed. This allows the raw materials to be frozen under standard conditions in the freezer and no lower temperature processing is required.

Freeze drying - The temperature regime of the freeze-drying was programmed so as to obtain an optimal drying speed, which to ensure good quality of the final product. The drying temperature during the conducted technological tests is +30°C.

During lyophilization, the implementation of the process was monitored in all phases and mainly in the main ones - sublimation and drying.

Summarized expression on the results of the technological tests related to the complete

freeze-drying cycle of the products are presented in Table 2.

Table 2. Parameters of the process of freeze-drying of raw materials colostrum and chokeberry juice

Parameters / measure	Colostrum	Chokeberry juice
I. Layer thickness/ mm	10-12	10
II. Freezing		
1. Freezing temperature/°C	-25 to -30	-25 to -30
2. Eutectic temperature/ °C	-21	-28
III. Freeze drying		
1. Load of bearing surface/kg/m^2	9.67	10.02
2. Drying temperature/ °C	-22 to -25	-22 to -25
3. Temperature in the desublimator/°C	-55 to -60	-55 to -60
4. Partial pressure/Pa	from 20.0 to 25.0	from 20.0 to 25.0
5. Pressure in the chamber/Pa	from +20 to +25.0	from +20 to +25.0
6. Temperature until drying/°C	+30	+30
7. Duration of the process/h	40	48
8. Residual moisture content /%	2.51	3.25

The results in the table show that the dried raw materials (buffalo colostrum and chokeberry juice) after freeze-drying have a minimum residual moisture content (2.51 and 3.25%).

3. Technological scheme for obtaining lyophilized product "FucoSTEM"

The technological process of obtaining the bioproduct "FucoSTEM" is presented in Figure 5.

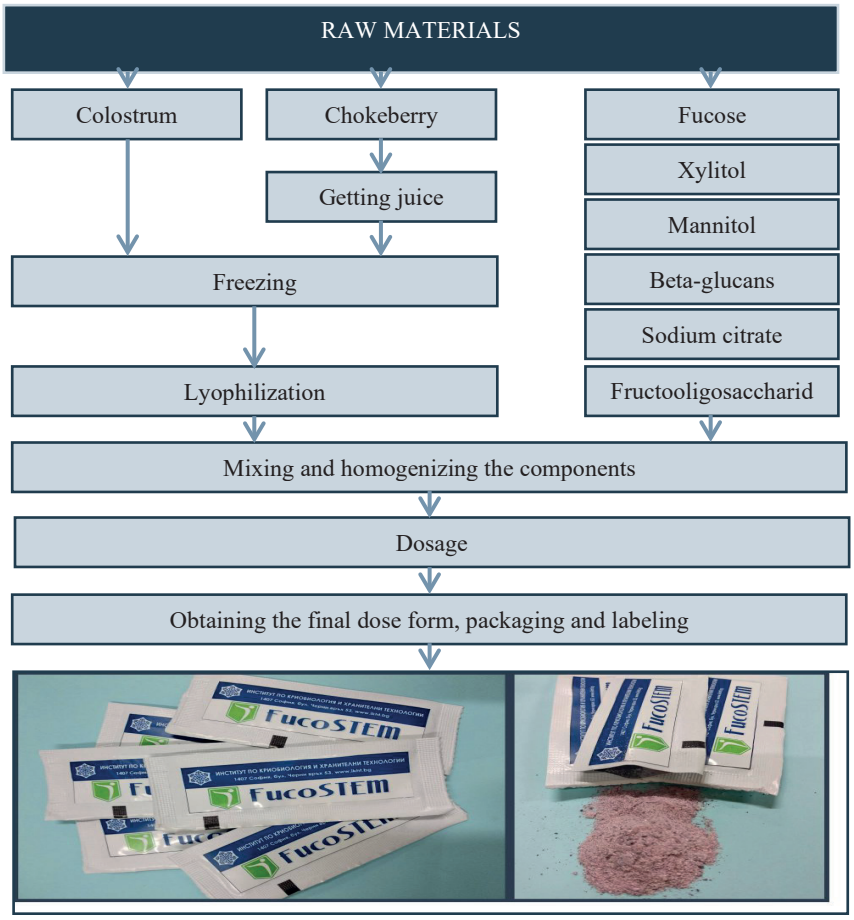

Figure 5. Technological scheme for obtaining lyophilized functional bioproduct "FucoSTEM"

The individual powder components of the product were mixed to obtain a homogeneous substance dosed in a sachet for a one-time reception from 2 g. The sachets were packed in a three-layer foil, which is water, gas and light-tight. They were placed 10 count in a cardboard box.

CONCLUSIONS

A technology for the production of a functional product "FucoSTEM" has been created according to a predetermined health focus. The composition of the new product includes sources of useful and biologically active ingredients of various origins. The selection of the component composition is consistent with the need to obtain a final product with a balanced composition and high energy and biological value.

The main parameters of the process of freeze-drying of 4 main components of the product - buffalo colostrum, chokeberry juice, beta-glucans and fructooligosaccharides were established, and their phase behavior at low and high temperatures was studied.

The thermal curves, obtained by differential scanning calorimetry give us information about the enthalpy, melting temperatures and crystallization.

An endothermic phenomenon between -5°C and -40°C was found, which corresponds to the melting of the samples. Temperature of initial melting is about -5°C. Up to -80°C no change in the heat capacity and respectively vitreous transition is observed.

The raw materials for the new product are lyophilized, which guarantees high quality and long-term shelf life.

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