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INVESTIGATION OF TECHNOLOGICAL PROPERTIES OF CELERA ROOT POWDER OBTAINED BY DRYING WITH MIXED HEAT SUPPLY METHOD

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Abstract

To enrich polyphase-type culinary products, dried food products are used - vegetable and fruit powders. These powders are usually obtained by freeze-drying, convective methods, the method of cold spray drying. To perspective methods of drying include drying with mixed heat supply. At the same time, it is promising to use celery root powder in culinary products. The aim of the work is to study the technological properties of celery root powder obtained by the method of drying with mixed heat supply, to predict its behavior in polyphase food systems.

The material for the study was selected fresh celery root variety Diamant, from which obtained a powder form after pre-drying with mixed heat supply, based on the active hydrodynamic and thermal interaction of the drying agent with the object inside a special heat and mass transfer module. The microstructure of reduced celery root powder in water, oil and melted margarine was determined by microscopy, the dispersion of celery powder - by calculating the particle size with an eyepiece micrometer and an optical microscope at a magnification of 400 and 600 times. The moisture absorption coefficient was determined by physicochemical method on the Dogadkin device, moisture-binding capacity by the method of pressing, while emulsifying ability - by the maximum amount of oil introduced into the reduced powder system to achieve coacervation under certain conditions. Fat retention capacity was determined by the principle of the method, which is that under certain conditions oil is added to the vegetable powder and after centrifugation the amount of free oil is determined. Wheat flour was chosen as a control.

The study of dispersion shows that most particles of celery root powder have sizes up to 35 μm - 78 %. Celery root powder can be divided into 3 main fractions: 1) 10 - 25 μm; 2) 25 - 50 μm; 3) 50 - 100 μm. Celery root powder, regardless of dispersion, has a better technological potential according to the studied indicators compared to wheat flour. The technological properties of celery root powder with the highest dispersion exceed the value of the water absorption coefficient by 1.8 times, the moisture-binding capacity by 1.2 times, and fat retention and emulsifying abilities - 1.3 times compared to wheat flour. The maximum values of all studied parameters were found in the sample of celery root powder with the highest dispersion of 10 - 25 μm?. The study of the microstructure revealed the effect on the powder particles surface, which contains the fat phase of the introduced oil and margarine, which

confirms the fat retention capacity of the powder. The obtained data correlate with the results of studying the microstructure of reduced celery root powder in water, oil and melted margarine.

It was found that most of the powder particles have a size of 10 - 25 μm, which is optimal for use in multicomponent food systems, mainly emulsion structure.

***Key words**: Celery root, Dispersion, Moisture absorption coefficient, Microstructure, Fat retention capacity, Emulsifying ability.*

1. Introduction

The issue of reducing calories and at the same time increasing the nutritional value of a wide range of culinary products is relevant today. Promising in this direction is the inclusion of vegetable raw materials, in particular, vegetables in dried form - fine powders, as they contain vitamins, minerals, dietary fiber, antioxidants, and other valuable components [1, 2].

Vegetable powders, in particular, from celery root, are promising and technological raw materials for use in restaurants, act as a concentrate of biologically active compounds and reduce the duration of the technological process of obtaining culinary products of the polyphasic type [3].

To date, vegetable powders are obtained, obtained by freeze-drying, convective, conductive, cold spray-drying methods. However, dried vegetable raw materials obtained by these methods do not always satisfy the technological and consumer properties [4].

Innovative drying methods, which can be used to obtain dried food products with high rehydration properties, include drying with mixed heat supply, based on the active hydrodynamic and thermal interaction of the drying agent with the object, which is inside a special heat and mass transfer module [5].

The work aims to study the technological properties of celery root powder obtained by the method of drying with mixed heat supply, to predict its behavior in polyphase food systems.

2. Materials and Methods

The material for the study was selected fresh celery root variety "Diamant", from which we obtained a powder form after pre-drying with mixed heat supply.

Hardware drying with mixed heat supply is a chamber measurement of 2.0 × 1.0 × 1.5 m, between the double walls of sheet steel with a thickness of 10^{-3} m which is a thermal insulator.

Camera is mounted on a frame that serves as a base for the fan and air injectors. The bottom of the chamber is uninsulated. At the top of the chamber, there is a hatch for loading and unloading products; fan, pipes, heater, and working chamber. The fan motor is outside the camera. The air flow from the fan is directed to the heater, then through the rotary nozzles to the working chamber and at the inlet of the fan, i.e. the airflow is recirculated in the chamber [5].

The microstructure of celery root powder was studied using an optical microscope with transmission light. To prepare the samples, a preliminary reduction of celery powder in water, sunflower oil, margarine at a temperature of 25 ^{0}C with a holding time of 5 minutes was performed. The study of the microstructure of the experimental powder was performed at magnifications of 250 times.

The dispersion of celery powder was determined by calculating its particle size using an eyepiece micrometer and an optical microscope at a magnification of 400 and 600 times. Preparation of samples was performed by applying dry samples to a glass slide.

Using an object micrometer, the size of ocular mesh divisions was determined and the particle sizes of celery powder were determined by counting their sizes in five to seven fields of view of each preparation, followed by mathematical processing [6].

The water absorption coefficient (WAC) of the samples was determined using a Dogadkin device [7], which consists of a funnel connected by the principle of connected vessels with a graduated tube. The water binding capacity (WBC) is determined by the method of pressing [8].

Emulsifying ability (EA) of the powder of dried celery root was determined by the maximum amount of oil introduced into the colloidal system of proteins to achieve coacervation under certain conditions [8].

The principle of the method of determining the fat retention capacity (FR) is that under certain conditions oil is added to the vegetable powder and after centrifugation, the amount of free oil is determined [8].

Wheat flour was chosen as a control.

3. Results and Discussion

The most technological form of application of dried celery root is a powder form, which ensures its uniform distribution throughout the food mass. Usually, in some of technologies of culinary products, in particular, flour culinary and confectionery products, powders are mixed with wheat flour [9].

For the production of such products with high structural-mechanical and taste properties, the particle size of celery root powder was determined.

Obtained research results are presented in Figure 1.

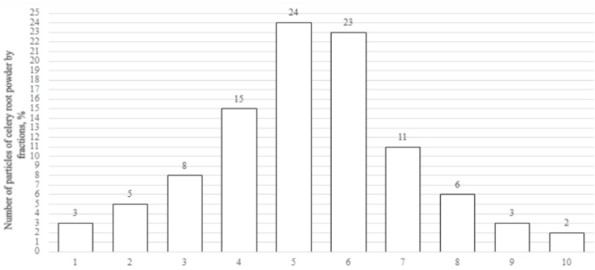


Figure 1. Particle size of celery root powder by fractions: 1. 5 - 10 µm, 2. 10 - 15 µm, 3. 15 - 20 µm, 4. 20 - 25 µm, 5. 25 - 30 µm, 6. 30 - 35 µm, 7. 35 - 40 µm, 8. 40 - 50 µm, 9. 50 - 70 µm, 10. 70 - 100 µm

Figure 1 clearly shows that most powder particles have sizes up to 35 µm - 78%. Only 2 - 6% with a value of 40 - 100 µm. As a result, 3 fractions were isolated in the obtained powder from dried celery root: with high particle dispersion - 10 - 25 µm, medium - 25 - 50 µm, and large - 50 - 100 µm dispersions.

Therefore, celery root powder can be divided into 3 main fractions: 1. 10 - 25 µm, 2. 25 - 50 µm, 3. 50 - 100 µm and used as a convenient technological form when mixed with flour in the manufacture of culinary flour and confectionery and when adding a combination mixture in sauces, gravy, puree soups, etc.

To use celery root powder in product technology, it is advisable to determine the technological potential of this dried plant material, namely: water absorption coefficient, water binding, fat-retaining, and emulsifying ability of powders with different dispersions: 10 - 25, 25 - 50, and 50 - 100 µm. To compare the results obtained as a control sample selected high-grade wheat flour with a particle size of 100 - 150 µm, used in some technologies as a thickener of the food system.

Biopolymers capable of swelling take part in the formation of any food system: proteins, starch, pentosans, various homo- and heteropolysaccharides. Celery root powder consists of 43.6% of carbohydrates, which include starch, fiber, pectin, and hemicellulose. Therefore, these components of the powder will be involved in the absorption of moisture contained in the raw material and added as a prescription ingredient and similarly bind fat and in some way form the structure of the finished product. Given this, it was advisable to determine the ability of the powder to absorb and retain moisture and fat.

The WBC of the powders makes it possible to form a homogeneous polyphase structure of the system and thus extend the shelf life, preventing them from drying out and thus increasing the yield of the product. Thus, according to the literature, in particular, the amount of baking baked semi-finished products with the introduction of fruit or vegetable raw materials will decrease, which is due to their high WBC, which leads to increased yield of baked semi-finished products [10].

The results of research of technological properties: WAC, WBC, FR, EA of powders of dried celery root are shown in Figures 2 - 5, respectively.

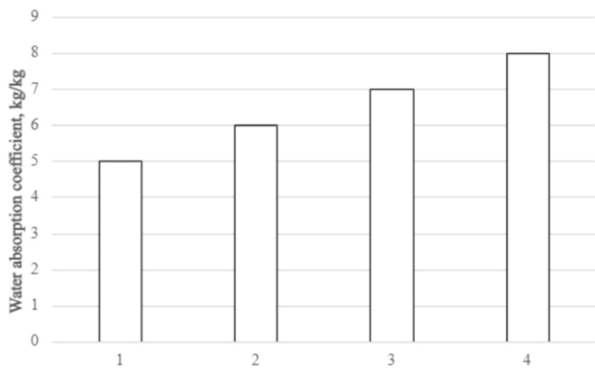


Figure 2. Water absorption coefficient:
1. Wheat flour and celery root powder of different dispersion (2. 50 - 100 µm, 3. 25 - 50 µm, 4. 10 - 25 µm)

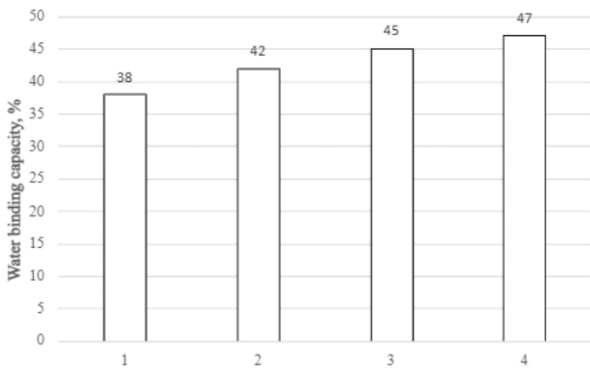


Figure 3. Water binding capacity:
1. Wheat flour and celery root powder of different dispersion (2. 50 - 100 µm, 3. 25 - 50 µm, 4. 10 - 25 µm)

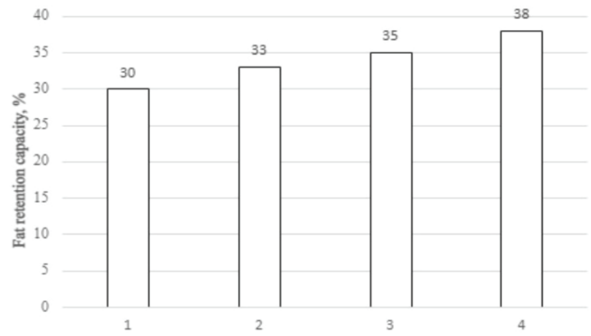


Figure 4. Fat retention capacity:
1. Wheat flour and celery root powder of different dispersion (2. 50 - 100 µm, 3. 25 - 50 µm, 4. 10 - 25 µm)

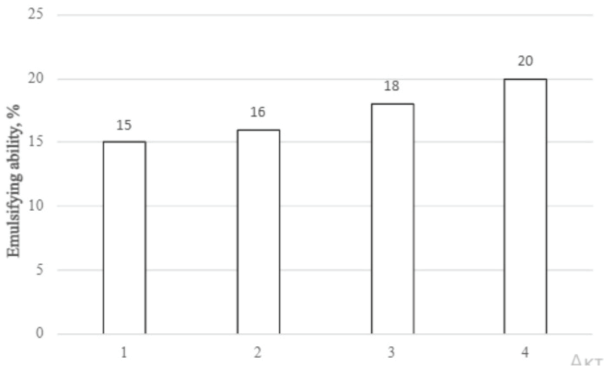


Figure 5. Emulsifying ability:
1. Wheat flour and celery root powder of different dispersion (2. 50 - 100 µm, 3. 25 - 50 µm, 4. 10 - 25 µm)

As can be seen from Figures 2 - 5 powders of celery root, regardless of dispersion, have a better technological potential according to the studied indicators in comparison with wheat flour. The maximum values of all studied parameters were found in the sample of celery root powder with the highest dispersion - 10 - 25 µm.

Thus, the technological properties of celery root powder with the highest dispersion exceed the technological properties of wheat flour by the value of WAC 1.8 times, WB - 1.2 times, FR and EA - 1.3 times.

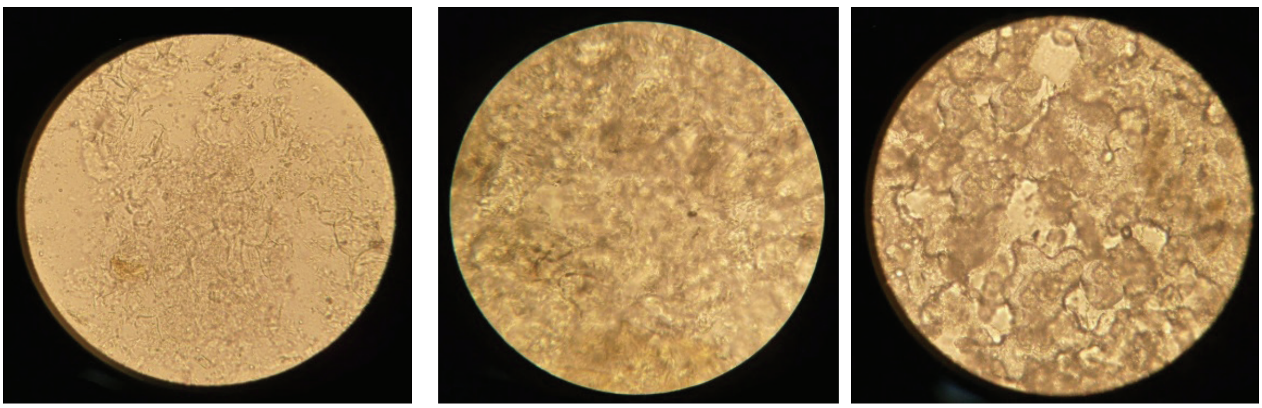
The microstructure of its particles in different polar and nonpolar media clearly explains the properties of the powder with a dispersion of 10 - 25 µm (Figure 6).

Figure 6 shows the restored cells of powder particles in water (a). In Figure 6 (b and c) can be seen that there is a concentration of components of the dispersed phase, concentrated in the form of balls on the surface of individual particles of vegetable powder. According to the characteristics of these balls and the obtained experimental data, the effect on the surface of plant particles, where the fat phase of the introduced margarine is kept, was confirmed, which confirms the fat-retaining ability of the powder.

Thus, it was found that the powder of celery root obtained by drying with mixed heat supply, dispersion of 10...25 µm has higher technological properties, and therefore can be used in the technology of culinary products of a wide range as an innovative ingredient that simultaneously acts as a thickener, structure-forming.

4. Conclusions

- When studying the dispersion of celery root powder obtained by drying with mixed heat supply, it was found that most powder particles have sizes up to 35 µm - 78% and only 2 - 6% with a value of 40 - 100 µm, which are optimal for use and enrichment of culinary products with obtaining the appropriate structural, mechanical and taste properties.
- When determining the technological properties of celery root powder, it was found that the highest values of powder have a dispersion of 10 - 25 µm: water absorption coefficient is 8, moisture binding capacity - 47%, fat retention capacity - 38%, and emulsifying ability - 20%.



a) **b)** **c)**

Figure 6. Photomicrographs of the structure of celery root powder reduced in water (a), oil (b), melted margarine (c)

- Obtained data correlate with the results of studying the microstructure of reduced celery root powder in water, oil, and margarine.

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