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PHYSICO-CHEMICAL ANALYSIS METHODS IN COMBINED DRYING OF TOPINAMBUR RAW MATERIALS

ISMANOVA AZIMA

PhD student, Namangan State Technical University, Namangan, Uzbekistan
Phone.: (0888) 828-2293, E-mail.: azimadolimjanovna@gmail.com
Corresponding author

MELIBOYEV MIRAZAM

Associate Professor, Namangan State Technical University, Namangan, Uzbekistan
Phone.: (0893) 491-4453, E-mail.: mirazamm@bk.ru

Abstract: The article presents methods for the physico-chemical analysis of the composition of topinambur tubers. In this study, combined drying methods, including sublimation (freeze-drying) and convective techniques, were used. Through the comprehensive processing of tuber crops, particularly topinambur (Jerusalem artichoke), waste-free products can be obtained. These products are effectively used as a primary source of raw materials for the food, pharmaceutical, livestock, and agricultural industries. Improvement of the technology for the complex processing of tuber crops, as well as the development of parameters for convective and sublimation drying processes of the primary and secondary mass, ensures high quality and organoleptic characteristics of the dried product. During the drying process, treatment with ascorbic and citric acids increases the drying rate and allows optimization of the critical moisture content.

Keywords: topinambur, Skorospelka, Interes, French White varieties, convective drying, sublimation drying, areometer, refractometer, saccharometer, Kjeldahl method, pH meter, chromatographic analysis, microscopic analysis, moisture, protein, fats, carbohydrates, inulin.

Introduction. According to researchers, the ripening season of topinambur tubers in Uzbekistan usually begins in September–October depending on the region. Topinambur tubers are cultivated in most regions of Uzbekistan, although generally on a relatively small scale.

Method. In order to conduct the research, experimental studies were carried out. Technologies for the complex processing of topinambur tuber crops of the Skorospelka, Interes, and French White varieties were developed. Based on the most optimal technological parameters, the Interes variety was identified as the most suitable for processing, along with raw materials of various shapes.

The mass of the raw materials before and after processing (convective and sublimation drying) was determined using the following formulas.

$$P = Mp / Mu \times 100 \quad (1)$$

Where:

Mn – weight of the samples before the drying process (kg),

Mu – weight of the samples after the drying process (kg).

$$E = Me / Mu \times 100 \quad (2)$$

Where:

Me – weight of the samples before the drying process (kg),

Mu – weight of the samples after the drying process (kg).

$$U = Mcarbohydrate / Mu \times 100 \quad (3)$$

Where:

Mcarbohydrate – weight of carbohydrates in the samples before the drying process (kg),

Mu – weight of the samples after the drying process (kg).

N = Mn / Mu × 100 (4)

Where:

Mmoisture – moisture weight of the samples before the drying process (kg),

Mu – weight of the samples after the drying process (kg).

However, a number of major and minor issues arise in relation to topinambur products, which significantly affect their export potential. In particular, the decrease in demand for these products in foreign countries (mainly in Russia), along with the rapid deterioration of the properties of fruits supplied from Uzbekistan, leads to a reduction in their consumer value and market potential.

Figure 1. Convective Drying Device

1 – fan (condensate pressure), 2–3 – device door, 3 – tray (pallet), 5 – control panel, 6 – chamber

This situation is mainly due to the limited possibilities for processing primary and secondary raw materials of this product. Therefore, eliminating the problems faced by gardeners and farmers who produce these crops in large quantities, as well as improving technologies for obtaining waste-free products through complex processing, has become an urgent task.

The primary and secondary raw materials of topinambur are processed using a combined drying method (thermoradiation and infrared) in the drying equipment of the **"FRUIT DRIED INNO TECH" LLC** enterprise, as shown in Figure 1.

Operating principle of the convective dryer

1. Drying is carried out in the drying chamber at temperatures ranging from **85°C to 110°C**.
2. In the chamber, the product is dried by heating the raw material samples using a heat agent generated by heating elements (TEN) located on the inner walls of the chamber, instead of using a water heat carrier.

The combined drying device presented in Figure 1 is used for drying primary (sliced) and secondary (pressed pulp mass) raw materials of topinambur. Initially, the raw materials are placed on trays. In order to expose the samples to a high-temperature heat agent, the raw materials are pretreated with ascorbic and citric acids**.** This treatment facilitates the breakdown (evaporation) of water molecules in the raw material structure. Depending on the shape and characteristics of the raw material, drying is carried out at temperatures ranging from 85°C to 105°C for 3–5 hours**.**

During the drying process, heat and mass transfer occurs between the heat agent and the raw materials. Therefore, the convective drying process consists of three phases: solid, liquid, and vapor (gas) phases.

One of the advantages of this drying method is that samples treated with **ascorbic acid** maintain **mechanical strength even under high-temperature conditions**.

To analyze the research objects using **physico-chemical methods**, raw materials are processed through various stages such as **cutting into different shapes, grinding, pressing, separating primary and secondary masses, drying, juice extraction, preservation, and other processing techniques**. The obtained raw materials and products are then analyzed using various reagents and laboratory instruments, including **an areometer, refractometer, saccharometer, Kjeldahl apparatus, pH meter, chromatographic and microscopic analysis methods**, among others.

The **physico-chemical parameters of topinambur used in the research** are presented in **Figure 1 below**.

Table 1. Physico-chemical indicators of topinambur used in the research (convective drying method)

№	Name of indicators	Topinambur (before drying)	Topinambur (after drying)
1	Moisture, %	75–80	8–9
2	Protein, g	1.5–2	1.4–1.8
3	Fat, g	0.1–0.2	0.1–0.2
4	Ash (mineral residue), g	1–1.5	0.8–1.3

№	Name of indicators	Topinambur (before drying)	Topinambur (after drying)
5	Inulin, g	10–14	9–13
6	Carbohydrate content, g, %	15–17	13–14.5
7	Dietary fiber, g	1.5–3	1.4–2.5
8	Energy value	70–75 kcal	68–71 kcal

The analysis results of the mass of product samples obtained by drying the primary and secondary raw materials of topinambur using the convective drying method are presented in Table 1 above.

The analysis results of product samples obtained by drying the primary and secondary raw materials of topinambur using the sublimation drying method are presented in Table 2 below.

Table 2. Physico-chemical indicators of topinambur used in the research (sublimation drying method)

№	Name of indicators	Topinambur (before drying)	Topinambur (after drying)
1	Moisture, %	75–80	6–7
2	Protein, g	1.5–2	1.5–2
3	Fat, g	0.1–0.2	0.1–0.2
4	Ash (mineral residue), g	1–1.5	1–1.5
5	Inulin, g	10–14	10–14
6	Carbohydrate content, g, %	15–17	15–17
7	Dietary fiber, g	1.5–3	1.5–3
8	Energy value	70–75 kcal	70–75 kcal

The results of the analysis of the mass of product samples obtained by sublimation drying of primary (sliced) and secondary (pressed pulp) raw materials of topinambur are presented above.

Requirements for the Quality of Raw Materials

To determine the quality indicators of topinambur for storage or further processing, raw materials in the form of whole, sliced, or pressed pulp are accepted. The received raw materials are analyzed for their physico-chemical characteristics and properties using organoleptic (visual and sensory), physico-chemical, and microbiological methods.

Organoleptic (visual and sensory) analysis evaluates the raw materials based on: Shape – appearance, size, and structure;Color – white, yellow, light yellow, etc.;Odor – mild, unpleasant, or other distinctive smells;Taste – sweet, bitter, sour, etc.

Physico-chemical analysis involves processing raw materials through various stages, such as:cutting into different shapes,grinding,pressing,separating primary and secondary masses,drying, juice extraction, canning, and other processing methods.

The obtained primary and secondary raw materials and final products are analyzed using various reagents and instruments, including:areometer, refractometer, saccharometer, Kjeldahl apparatus, pH meter, chromatographic and microscopic methods, and others.

The sugar and acid content of the products is determined using multiple methods, such as pH meters, litmus paper, and binocular analysis. Based on these analyses, the chemical composition of topinambur is determined, including:protein,0.2% fat,17.9% nitrogen-free extract,1.3% ash,16–18% inulin (including sugar content, primarily fructose).These results are used to recommend appropriate drying methods.

Results. The requirements for organic powder obtained from topinambur (by cutting into various shapes such as parallelepiped, cubic, etc., and processing the resulting pressed pulp with ascorbic and citric acids before drying) depend on several factors, including:the primary purpose of using the organic powder (food, medicine, pharmaceuticals, etc.),storage conditions, and fulfillment of consumers' physiological needs.

These factors are crucial for ensuring the quality, stability, and applicability of the final dried topinambur product.

Conclusion. The results of this study indicate that in the processing, freezing, and drying of tuber crops, the chemical composition of the primary and secondary mass of raw materials changes depending not only on the storage period but also on the freezing and drying methods used. The obtained data show that the composition of topinambur samples, including the total carbohydrate content, ascorbic acid, other vitamins, and organoleptic properties, varies significantly depending on the processing techniques applied.

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