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DETERMINATION OF PRODUCT YIELD QUANTITY AND QUALITY IN CONVECTIVE DRYING OF LEEK (ALLIUM PORRUM)

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Abstract: This article examines the technology of convective drying applied to the artificial drying of leek varieties and hybrids. During the research, the duration of the drying process, temperature regime, product yield, moisture content, and organoleptic characteristics were analyzed. According to the results, the convective drying method was distinguished by its ability to better preserve the color, taste, and aroma of the product. Furthermore, based on experimental results, the leek variety "Vestal" and the hybrid "Lincoln F1" demonstrated higher quality and yield indicators when dried using the convective drying method.

Keywords: leek, convective drying, moisture content, product yield, quality, organoleptic characteristics.

Introduction Today, the improvement of technologies for the storage and processing of vegetable products is of great importance. Leek contains a wide range of vitamins and beneficial substances; however, due to its short storage life, drying is considered an effective preservation method. Leek (Allium porrum L.) occupies an important place among various vegetable crops in the food industry and in dietary nutrition. It contains proteins, carbohydrates, vitamins of group C and B, as well as minerals, which are beneficial for human health.

At present, the demand for dried fruit and vegetable products is increasing. The storage, drying, and processing regimes of vegetable products form the basis for improving product quality, reducing losses and waste, and decreasing the cost of the final product. It is well known that it is not always possible to sell all food products, including vegetables, at the same time. Therefore, considerable attention is being paid to their complex processing and drying. This not only protects products from spoilage but also enables the production of new products with improved nutritional and taste properties.

In the drying of leek, artificial methods, particularly convective and infrared drying technologies, are widely used. These methods differ in terms of drying rate, product quality, and energy consumption. Therefore, the present study aimed to investigate the drying of different varieties and hybrids of leek using these methods and to determine their efficiency.

The aim of the research is to develop drying technologies for raw materials of different varieties and hybrids of leek using natural and artificial methods with various drying techniques.

The objectives of the research are as follows:

to determine the varieties and hybrids of leek suitable for drying;

to determine the yield of the final dried product and the drying duration when leek raw material is dried by natural methods (in the sun, in solar-panel drying equipment, and in solar-panel drying equipment under shade conditions);

to determine the effect of treating leek raw material with saline solutions (NaCl, $KHSO_3$, $C_5H_8NO_4Na \cdot H_2O$) on the yield and quality of the dried product;

to identify the most optimal drying method for leek when using artificial drying techniques (convective and infrared radiation drying);

to determine the economic efficiency of the yield of dried products obtained through natural and artificial drying of leek;

The research objects were the leek varieties and hybrid, Sizokril, Vesta, Columbus, and Lincoln F_1.

The subject of the research is the primary processing of raw leek material, treatment with saline solutions, and the factors influencing the quality and yield of the final product during the processing of leek varieties and hybrids using different drying methods, as well as the impact of drying technologies.

The research methods were based on GOST 13340.1-77 "Dried vegetables", GOST ISO 2173-2013 "Processed fruits and vegetables. Refractometric method for determination of soluble solids", GOST 32065-2013 "Dried vegetables. General technical specifications", GOST 15467 "Product quality assessment", Shirokov Ye.P. "Organoleptic methods for the evaluation of food products: Terminology" (Moscow: Nauka, 1990), Polegayeva V.I. "Methods for assessing the quality of fruits and vegetables" (methodological guidelines, Moscow, 1978), as well as statistical analysis of research results using Microsoft Excel 2010 and Windows software. Calculations were performed according to the method recommended by B.A. Dospekhov (1985) with a 0.95 confidence level.

Experimental results: It was established that higher product yield and quality were achieved when leek varieties and hybrids were dried using the convective method. Drying of raw material in this method is accomplished through the circulation of hot air. The main parameters of convective drying include air temperature inside the dryer, moisture content, air circulation speed, and drying duration. When samples of leek varieties and hybrids were dried by the convective method, the yield of the dried product ranged from 17.2 to 17.8%. The moisture content of the dried product was within 13.9–14.1%, which depends on the water content of the fresh raw material. It was also found during the experiments that drying leek varieties and hybrids at high temperatures using the convective method led to changes in product yield and a deterioration in organoleptic quality characteristics.

During the experiments conducted, it was determined that the recommended air temperature for drying leek varieties and hybrids in a convective drying unit ranged from 55–65°C, with an air velocity of 1–2 m/s and a drying duration of 6–8 hours. It was also observed that, compared to other artificial drying methods, this method required lower energy consumption, which indicates that economic efficiency can be achieved when drying the raw material using this approach.

For the convective drying of leek varieties and hybrids, a laboratory convective drying unit was used. The operating principle of this drying equipment is as follows: the unit is equipped with an electric heating element; when the device is switched on, the heater is activated and the air temperature inside the chamber begins to rise. The air temperature of the unit is controlled via a digital display located on the exterior of the device. In addition, the unit is equipped with a fan that ensures the circulation of hot air inside the chamber, thereby providing uniform air distribution. As a result, uniform drying of the product placed on trays is achieved at the same drying rate across all layers.

The drying unit is equipped with a thermostat and a temperature sensor, which maintain a constant temperature inside the chamber and prevent overheating. In the conducted experiments, samples of leek varieties and hybrids were selected and brought to the laboratory for convective drying.

The collected samples were first subjected to a sorting process, during which rotten, damaged, and pest-infested parts were removed.

In the next stage, the raw material was subjected to a washing process. In this process, the raw material was washed twice under running water. After washing, it was placed on special mesh trays and air-dried until the surface moisture had completely evaporated.

After the surface moisture had been removed, the raw material was transferred to the cutting section, where the root part, leaf tips, and dried leaves of the leek were removed. During the drying process, leek is processed in two separate parts; therefore, the raw material was divided into the pseudostem (false bulb) part and the leaf part. The pseudostem part was cut into ring-shaped slices with a thickness of 3–5 mm, while the leaf part was cut into rectangular pieces with a thickness of 4–6 mm.

The raw material prepared for drying was evenly spread on trays of the convective drying unit over a special paper layer and placed inside the drying chamber for processing. The chamber was then closed, the temperature was set to 65–70 °C, and the unit was started (Table 1).

The drying duration of the raw material was 6–8 hours, and the process was continued until the product moisture content reached approximately 13.9–14.1%. The yield of the dried product was determined in percentage terms, amounting to 17.2–17.8% for the pseudostem (false bulb) part and 15.1–15.8% for the leaf part.

In laboratory conditions, leek varieties and hybrids were dried in a convective drying unit at an average temperature of 65–70 °C for 6, 7, and 8 hours.

Table 1.

Analysis of the yield of dried product, drying duration, and residual moisture content in the dried product obtained from convective drying of leek varieties and hybrids in a convective drying unit at 65–70 °C (2024–2026).

No.	Indicators	Drying duration 6 hours	Drying duration 7 hours	Drying duration 8 hours
“Vesta”				
1	Raw material amount, kg	10	10	10
2	Pseudostem (false bulb) part, kg	3,50	3,47	3,55
3	Dried pseudostem (false bulb) yield, kg	0,60	0,51	0,39
4	Dried pseudostem (false bulb) yield, %	17,2	14,7	11,1
5	Leaf part, kg	5,87	5,80	5,85
6	Dried leaf part yield, kg	0,88	0,78	0,71
7	Dried leaf part yield, %	15,1	13,5	12,2
8	Initial moisture content of raw material, %	86,9	86,7	86,5
9	Residual moisture content of dried product, %	14,1	11,0	9,7
“Linkolin F1”				
1	Raw material amount, kg	10	10	10
2	Pseudostem (false bulb) part, kg	3,55	3,40	3,48
3	Dried pseudostem (false bulb) yield, kg	0,63	0,47	0,40
4	Dried pseudostem (false bulb) yield, %	17,8	14,0	11,5
5	Leaf part, kg	5,85	5,87	5,80

6	Dried leaf part yield, kg	0,92	0,81	0,70
7	Dried leaf part yield, %	15,8	13,8	12,1
8	Initial moisture content of raw material, %	86,2	86,7	86,4
9	Residual moisture content of dried product, %	13,9	11,3	9,3

During the experiments, the yield of the dried product, the color of the raw material, the drying duration, as well as the initial and residual moisture content of the raw material were investigated. It was established that these parameters varied among the varieties and hybrids; however, the differences were not significant.

The drying process of the raw material was carried out over three different durations, and at each time interval, the yield of the dried product, its moisture content, as well as the external appearance, color, odor, and taste of the dried product were analyzed. Based on these results, suitable varieties for drying were identified and recommended for drying purposes. For the experiment, 10 kg of leek variety raw material was taken and divided into two parts, namely the pseudostem (false bulb) part and the leaf part. The prepared raw material was subjected to drying for 6, 7, and 8 hours.

Samples of the “Vesta” leek variety, when dried for 6 hours, yielded 0.60 kg and 17.2% from the pseudostem (false bulb) part, while the dried leaf part amounted to 0.88 kg and 15.1%. The residual moisture content of the dried product was 14.1%.

Samples of the “Vesta” leek variety, when dried for 7 hours, yielded 0.51 kg and 14.7% from the pseudostem (false bulb) part, while the dried leaf part amounted to 0.78 kg and 13.5%. The residual moisture content of the dried product was 11.0%.

Samples of the “Vesta” leek variety, when dried for 8 hours, yielded 0.39 kg and 11.1% from the pseudostem (false bulb) part, while the dried leaf part amounted to 0.71 kg and 12.2%. The residual moisture content of the dried product was 9.7%.

During our experiments, the hybrid variety “Lincoln F1” of leek, when dried for 6 hours in a convective dryer, yielded 0.63 kg of dried product from the pseudostem (false bulb) part and 0.92 kg from the leaf part. The yield rate was 17.8% for the pseudostem part and 15.8% for the leaf part. The residual moisture content of the dried product was 13.9%.

This indicator shows that when samples of this variety were dried for 7 hours, 0.47 kg of dried product was obtained from the pseudostem (false bulb) part and 0.81 kg from the leaf part. The yield rate was found to be 14.0% for the pseudostem part and 13.8% for the leaf part. The residual moisture content of the dried product was 11.3%.

Based on the results of the conducted experiments, when the hybrid variety “Lincoln F1” of leek was dried for 8 hours in a convective dryer, 0.40 kg of dried product was obtained from the pseudostem (false bulb) part and 0.70 kg from the leaf part. The yield rate was 11.5% for the pseudostem part and 12.1% for the leaf part. In addition, the residual moisture content of the dried product was determined to be 9.3%.

Summarizing the experimental results, samples of leek varieties and hybrids were dried under laboratory conditions in a convective drying unit at different time intervals, namely 6, 7, and 8 hours. For each variety and hybrid, the optimal drying time was selected based on the yield of the dried product and its moisture content, taking into account their chemical properties. This is because the drying time of products is directly related to their initial moisture content, dry matter content, and several other physicochemical characteristics.

According to the experimental results, among the leek varieties and hybrids dried by the artificial convective drying method, the "Lincoln F1" hybrid showed the best results when dried for 6 hours. When the raw material was dried for 7 and 8 hours, it was observed that the residual moisture content of the dried product slightly decreased compared to the 6-hour drying period, which in turn affected the yield of the dried product. In addition, when the raw material was dried for 8 hours in the convective dryer, slight surface scorching was detected on the dried product, which negatively influenced its organoleptic quality characteristics. It was also observed that the residual moisture content of the dried product decreased below the specified level.

During our experiments, the quality variability characteristics of the dried products were analyzed. In the statistical analysis of the obtained experimental results, it is necessary to examine the descriptive quality indicators of dried leek varieties and hybrids, as well as a number of their specific properties.

It is known from the conducted experiments that dried products possess certain quality indicators which are not subject to quantitative measurement and instead reflect purely qualitative characteristics. In other words, sensory attributes of all edible products, such as appearance, taste, odor, color, shape, and marketability, whether present or absent, directly influence their quality evaluation. In the assessment of quality indicators of dried products, two main gradations are typically considered, which are based on the presence or absence of a particular characteristic in the product, i.e., a binary or alternative outcome is observed. During the experiments, in order to determine quality variability, initial observations were organized by grouping and distribution of samples. In this case, when determining the mean proportion of the attributes, the variability of the characteristics and the presence of a confidence interval were taken into account, within which the population proportion is located.

Conclusion: Based on the summarized analysis of the experimental results, it was established that the highest indicators were obtained when the pseudostem (false bulb) and leaf parts of the "Vesta" variety and the "Lincoln F1" hybrid of leek were dried in a convective drying unit.

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