



DETERMINATION OF THE EFFECT OF TREATMENT WITH DIFFERENT SALT SOLUTIONS (KHSO_3 , $\text{C}_5\text{H}_8\text{NO}_4\text{Na}\cdot\text{H}_2\text{O}$, NaCl) ON THE QUALITY OF DRIED LEEK

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Abstract: *In the territory of our republic, leek is considered one of the less widely cultivated vegetable crops. Our consumers widely consume leek both in fresh and dried forms. In this article, working solutions of various salts at different concentrations were used during the natural drying process of leek. During the experiment, the effects of these salts on the drying process and the dried product were determined.*

Keywords: *leek, drying, salts, working solution, concentration, product, quality, colour, sunlight, heat.*

Introduction. The most commonly cultivated leek varieties include Bastion, Goliath, Sizokril, and Elefant. The leek variety Linkolin F1 is a hybrid developed in the Netherlands. The Linkolin F1 hybrid variety was included in the State Register in 2014. Under the conditions of Uzbekistan, it is recommended for cultivation in the Tashkent region. Leek, also known as pearl onion, belongs to the family Amaryllidaceae and the genus *Allium*. Leek was first cultivated in Egypt around 3000 BC. Leek is a biennial plant. It produces high yields when grown in fertile soils with sufficient moisture. Leek does not grow and develop well in soils with high acidity. The optimum soil pH should be 6.0–6.5. Leek seedlings are produced in advance by sowing seeds in seedling trays or cassettes in greenhouses. Due to the presence of various beneficial vitamins and mineral compounds in leek, it is considered to have medicinal properties and is recommended for regular consumption and for the prevention of a number of diseases. Leek has high nutritional value and is rich in bioactive and phytochemical compounds. The leaves of leek contain Ca and P, while the false white stem contains vitamins A, B₁, B₂, and C. In addition, leek is considered a potent phytoncide and exhibits activity against bacteria, fungi, and viruses. The chemical composition of leek includes 88% water, 2.0% proteins, fats, and carbohydrates; mono- and disaccharides – 6.5 g, a moderate amount of starch, dietary fiber – 1.5 g, organic acids – 0.1 g, ash – 1.2 g; mineral compounds include sodium – 50 mg, potassium – 225 mg, calcium – 87 mg, magnesium – 10 mg, phosphorus – 58 mg, and iron – 1.0 mg; vitamins include β-carotene – 2 mg, B₁ – 0.10 mg, B₂ – 0.04 mg, nicotinic acid – 0.50 mg, and vitamin C – 35.0 mg. In addition to these compounds, biologically active substances such as quercetin and kaempferol are also present. Powder obtained from dried leek is used in the production of various products, such as bakery products, pasta, and sausages, and imparts a distinctive flavor to these products.

Research objective of the study is to develop drying technologies for the raw materials of different varieties and hybrids of leek using various natural and artificial drying methods.

Research objectives:

to identify varieties and hybrids of leek suitable for drying;

to determine the yield of the finished dried product and the drying duration when drying leek raw materials using natural methods (in direct sunlight, in a solar-panel drying unit, and in a solar-panel drying unit under shaded conditions);

to determine the effect of treating leek raw materials with salt solutions of sodium chloride (NaCl), potassium bisulfite (KHSO_3), and monosodium glutamate monohydrate ($\text{C}_5\text{H}_8\text{NO}_4\text{Na}\cdot\text{H}_2\text{O}$) prior to drying on the yield and quality of the finished product;

to determine the optimal drying method for leek using artificial drying methods (convective and infrared drying);

Research object: The Sizokril, Vesta, and Kolambus varieties and the Lincoln F1 hybrid of leek were selected as the research objects.

Research subject: The subject of the research comprises the factors affecting the quality and yield of the finished product during the processing of leek varieties and hybrids using different drying methods, including primary treatment of the raw material with salt solutions and drying technologies.

Research Methods. During the study, current state standards and methodological guidelines were used to assess the quality parameters of the product during the leek drying process. The quality and safety of dried vegetables were evaluated in accordance with the requirements of GOST 13340.1–77 “Dried vegetables. Methods for determination of moisture content”, GOST 32065–2013 “Dried vegetables. General technical specifications”, GOST ISO 2173–2013 “Processed fruit and vegetable products. Refractometric method for determination of soluble solids”, GOST 8756.2–2017 “Processed fruit and vegetable products. Methods for determination of solids or moisture”, and GOST 15113.4–77 “Food concentrates. Methods for determination of moisture”. The organoleptic evaluation of dried leek in terms of appearance, color, taste, odor, and consistency was carried out in accordance with the requirements of GOST 15467–79 “Product Quality Management. Basic Concepts” and based on the methodological guidelines provided in E.P. Shirokov’s Organoleptic Methods for the Evaluation of Food Products (1990). The consumer value of the dried product was assessed according to the methodological recommendations of V.I. Polegaev’s Methods for Assessing the Quality of Fruits and Vegetables (1978). The experimental results were processed using mathematical and statistical methods. Analysis of variance and the reliability of mean values were calculated in accordance with the recommendations of B.A. Dospekhov’s Methodology of Field Experiment (1985). Statistical processing of the data was performed using Microsoft Excel 2010 and software tools in the Windows environment. The reliability of the results was assessed at a 95% probability level ($P \geq 0.95$).

Research results. In our experiments, leek was dried using a solar-panel drying unit after treating the raw material with various salt solutions, namely sodium chloride (NaCl), potassium bisulfite (KHSO_3), and monosodium glutamate monohydrate ($\text{C}_5\text{H}_8\text{NO}_4\text{Na}\cdot\text{H}_2\text{O}$). The effects of these solutions on product quality and yield were studied. Leek contains a wide range of vitamins, minerals, organic compounds, and essential oils, and these beneficial components are essential for human health.

When leek varieties and hybrids were treated with 1%, 2%, and 3% sodium chloride (NaCl) solutions and dried in a solar-panel drying unit at a temperature of 28–60 °C, the yield of the dried product in the control variant was observed to be 12.5% from the false bulb and 10.7% from the leaf part. When the raw material of the Sizokril variety was treated with a 1%

working solution of sodium chloride (NaCl), the yield of the dried product was 13.2% from the false bulb and 11.5% from the leaf part. Treatment with a 2% working solution resulted in the highest yield and quality of the dried product, with yields of 14.0% from the false bulb and 12.3% from the leaf part. When treated with a 3% working solution, the dried product yield reached 14.5% from the false bulb and 12.8% from the leaf part. When the raw material was treated with a high concentration of salt, an increase in the intercellular osmotic pressure of the raw material was observed, resulting in excessive evaporation of water. In addition, due to the accumulation of a high amount of salt in the raw material, an increase in the weight of the dried product was observed.

In the control variant of the Vesta variety of leek, the yield of the dried product was 12.5% from the false bulb part and 10.7% from the leaf part. When treated with a 1% working solution of sodium chloride (NaCl), the yield of the dried product was 13.4% from the false bulb part and 11.8% from the leaf part. When treated with a 2% working solution, the yield of the dried product was 14.2% from the false bulb part and 12.5% from the leaf part. Treatment with a 3% working solution resulted in a dried product yield of 14.8% from the false bulb part and 13.0% from the leaf part. In the control variant of the Kolmabus variety of leek, the yield of the dried product was 12.5% from the false bulb part and 10.7% from the leaf part. When the raw material was treated with a 1% working solution of sodium chloride (NaCl), the yield of the dried product was 12.7% from the false bulb part and 11.2% from the leaf part. When the raw material was treated with a 2% working solution, the yield of the dried product was 13.8% from the false bulb part and 12.1% from the leaf part. When treated with a 3% working solution, the yield of the dried product was 14.3% from the false bulb part and 12.7% from the leaf part (see Table 1).

Table 1.

Effect of treatment with sodium chloride (NaCl) working solutions at different concentrations on the yield of the finished product during leek drying (2023–2025)

№	Concentration of sodium chloride (NaCl) solution	Sample, kg	Raw Material Waste, kg	False Bulb Part, kg	Leaf Part, kg	Dried product yield	
						False Bulb Part, %	Leaf Part, %
Sizokril							
1	Control	10	0,38	3,50	6,12	12,5	10,7
2	1% Sodium Chloride (NaCl) Solution	10	0,44	3,42	6,18	13,2	11,5
3	2% Sodium Chloride (NaCl) Solution	10	0,41	3,43	6,20	14,0	12,3
4	3% Sodium Chloride (NaCl) Solution	10	0,43	3,45	6,21	14,5	12,8

Vesta							
1	Control	10	0,41	3,65	5,94	12,8	10,7
2	1% Sodium Chloride (NaCl) Solution	10	0,42	3,71	5,93	13,4	11,8
3	2% Sodium Chloride (NaCl) Solution	10	0,40	3,70	5,91	14,2	12,5
4	3% Sodium Chloride (NaCl) Solution	10	0,43	3,73	5,95	14,8	13,0
Kolambus							
1	Control	10	0,45	3,42	6,13	11,6	10,6
2	1% Sodium Chloride (NaCl) Solution	10	0,44	3,47	6,15	12,7	11,2
3	2% Sodium Chloride (NaCl) Solution	10	0,42	3,45	6,12	13,8	12,1
4	3% Sodium Chloride (NaCl) Solution	10	0,45	3,43	6,13	14,3	12,7
Lincoln F1							
1	Control	10	0,36	3,54	6,10	12,9	11,3
2	1% Sodium Chloride (NaCl) Solution	10	0,40	3,92	5,72	13,7	12,0
3	2% Sodium Chloride (NaCl) Solution	10	0,42	3,91	5,70	14,5	12,8
4	3% Sodium Chloride (NaCl) Solution	10	0,41	3,93	5,73	14,0	12,5

In the control variant of the Lincoln F1 hybrid of leek, the yield of the dried product was 12.5% from the false bulb part and 10.7% from the leaf part. When the raw material was treated with 1%, 2%, and 3% working solutions of sodium chloride (NaCl) and subsequently dried, the dried product yield obtained from the false bulb part after treatment with the 1% solution was 13.7%, while the yield from the leaf part was 12.0%. When the raw material was treated with a 2% working solution and dried, the dried product yield was 14.5% from the false bulb part and 12.8% from the leaf part. When treated with a 3% working solution and dried, the dried product yield was 14.0% from the false bulb part and 12.5% from the leaf part.

Potassium bisulfite (KHSO_3) is a potassium salt of sulfurous acid, with the chemical formula KHSO_3 . Potassium bisulfite (KHSO_3) is a white or crystalline substance that is highly

soluble in water and, when exposed to open air, undergoes oxidation and is converted into sulfate. In the food industry, potassium bisulfite (KHSO_3) is used as a preservative, antioxidant, and antifermentative agent during the processing of raw materials, and it prevents the darkening of vegetables during the drying process. During the preparation of samples obtained from leek varieties and hybrids for the drying process, particularly during cutting of the raw material, the cells are cut and damaged. At these sites, the polyphenol oxidase enzyme present in the raw material causes browning of the product.

When the raw material is treated with a 1–3% working solution of potassium bisulfite (KHSO_3), it inhibits the activity of this enzyme and prevents browning of the product. In addition, potassium bisulfite (KHSO_3) acts as an agent that inhibits the growth and development of microorganisms during the drying process of the raw material.

When leek varieties and hybrids were treated with 1%, 2%, and 3% solutions of potassium bisulfite (KHSO_3) and dried in a solar-panel drying unit at a temperature of 28–60 °C, the yield of the dried product in the control variant was observed to be 12.5% from the false bulb part and 10.7% from the leaf part.

When the raw material of the Sizokril variety was treated with a 1% working solution of potassium bisulfite (KHSO_3), the yield of the dried product was observed to be 13.7% from the false bulb part and 12.0% from the leaf part. Treatment with a 2% working solution resulted in the highest yield and quality of the dried product, with yields of 14.2% from the false bulb part and 12.7% from the leaf part. When treated with a 3% working solution, the product yield was 14.7% from the false bulb part and 12.7% from the leaf part. In the control variant of the Vesta variety of leek, the yield of the dried product was 12.5% from the false bulb part and 10.7% from the leaf part. When treated with a 1% working solution of potassium bisulfite (KHSO_3), the yield of the dried product was 13.4% from the false bulb part and 12.1% from the leaf part. Treatment with a 2% working solution resulted in a yield of 14.2% from the false bulb part and 13.0% from the leaf part. When the raw material was treated with a 3% working solution and subsequently dried, the yield of the dried product was observed to be 14.8% from the false bulb part and 13.5% from the leaf part.

During our experiments, the yield of the dried product in the control variant of the Kolambus variety of leek was 12.5% from the false bulb part and 10.7% from the leaf part. The samples obtained were treated with 1%, 2%, and 3% working solutions of potassium bisulfite (KHSO_3) and subsequently dried. The yield of the dried product and its quality parameters were then analyzed. In this experiment, differences were also observed among the experimental variants (Table 2).

Table 2

Effect of Treatment with potassium bisulfite (KHSO_3) working solutions at different concentrations on the yield of the finished Product during Leek Drying (2023–2025)

№	Concentration of Potassium Bisulfite (KHSO ₃) Solution	Sample, kg	Raw Material Waste, kg	False Bulb Part, kg	Leaf Part, kg	Dried yield product	
						False Bulb Part, %	Leaf Part, %
Sizokril							
1	Control	10	0,38	3,50	6,12	12,5	10,7

2	1% Potassium Bisulfite (KHSO ₃) Solution	10	0,40	3,45	6,20	13,7	12,0
3	2% Potassium Bisulfite (KHSO ₃) Solution	10	0,44	3,43	6,20	14,2	12,7
4	3% Potassium Bisulfite (KHSO ₃) Solution	10	0,42	3,44	6,15	14,7	12,7
Vesta							
1	Control	10	0,38	3,50	6,12	12,5	10,7
2	1% Potassium Bisulfite (KHSO ₃) Solution	10	0,42	3,70	5,90	13,4	12,1
3	2% Potassium Bisulfite (KHSO ₃) Solution	10	0,43	3,70	5,90	14,2	13,0
4	3% Potassium Bisulfite (KHSO ₃) Solution	10	0,45	3,70	5,90	14,8	13,5
Kolambus							
1	Control	10	0,40	3,42	6,13	11,6	10,6
2	1% Potassium Bisulfite (KHSO ₃) Solution	10	0,42	3,43	6,10	12,9	11,8
3	2% Potassium Bisulfite (KHSO ₃) Solution	10	0,41	3,47	6,13	14,0	12,8
4	3% Potassium Bisulfite (KHSO ₃) Solution	10	0,43	3,42	6,15	14,5	12,9
Lincoln F1							
1	Control	10	0,36	3,54	6,10	12,9	11,3
2	1% Potassium Bisulfite (KHSO ₃) Solution	10	0,38	3,92	5,72	14,0	12,5
3	2% Potassium Bisulfite (KHSO ₃) Solution	10	0,42	3,91	5,72	15,1	13,5
4	3% Potassium Bisulfite (KHSO ₃) Solution	10	0,40	3,90	5,72	15,0	13,7

Specifically, when the raw material was treated with a 1% working solution, the yield of the dried product was determined to be 12.9% from the false bulb part and 11.8% from the leaf

part. When treated with a 2% working solution, the yield of the dried product was 14.0% from the false bulb part and 12.8% from the leaf part. Furthermore, when the raw material was treated with a 3% working solution, the yield of the dried product was determined to be 14.5% from the false bulb part and 12.9% from the leaf part.

In the control variant of the Lincoln F1 hybrid of leek, the yield of the dried product was 12.5% from the false bulb part and 10.7% from the leaf part. When the raw material was treated with 1%, 2%, and 3% working solutions of potassium bisulfite (KHSO_3) and subsequently dried, the yield of the dried product obtained after treatment with the 1% solution was 12.9% from the false bulb part and 11.3% from the leaf part. When the raw material was treated with a 2% working solution and dried, the yield of the dried product was 15.1% from the false bulb part and 13.5% from the leaf part. When treated with a 3% working solution and dried, the yield was 15.0% from the false bulb part and 13.7% from the leaf part. During our experiments, raw materials of leek varieties and hybrids were treated with 1%, 2%, and 3% working solutions of monosodium glutamate monohydrate ($\text{C}_5\text{H}_8\text{NO}_4\text{Na}\cdot\text{H}_2\text{O}$) for 3–5 minutes and subsequently dried. The yield of the dried product and its quality parameters were analyzed and evaluated based on the experimental results (Table 3).

Table 3

Effect of treatment with monosodium glutamate monohydrate ($\text{C}_5\text{H}_8\text{NO}_4\text{Na}\cdot\text{H}_2\text{O}$) working solutions at different concentrations on the yield of the finished product during leek drying (2023–2025)

№	Concentration of monosodium glutamate solution	Sample, kg	Raw Material Waste, kg	False Bulb Part, kg	Leaf Part, kg	Dried product yield	
						False Bulb Part, %	Leaf Part, %
Sizokril							
1	Control	10	0,38	3,50	6,12	12,5	10,7
2	1% Monosodium Glutamate Solution	10	0,39	3,73	5,88	14,5	12,7
3	2% Monosodium Glutamate Solution	10	0,39	3,73	5,88	17,3	16,0
4	3% Monosodium Glutamate Solution	10	0,39	3,73	5,88	17,6	16,4
Vesta							
1	Control	10	0,38	3,50	6,12	12,5	10,7
2	1% Monosodium Glutamate Solution	10	0,42	3,41	6,17	14,8	13,0
3	2% Monosodium Glutamate Solution	10	0,42	3,41	6,17	17,6	16,5
4	3% Monosodium Glutamate Solution	10	0,42	3,41	6,17	17,8	16,7
Kolambus							
1	Control	10	0,45	3,42	6,13	11,6	10,6
2	1% Monosodium Glutamate Solution	10	0,37	3,95	5,68	13,9	12,1

3	2% Monosodium Glutamate Solution	10	0,37	3,95	5,68	17,5	16,1
4	3% Monosodium Glutamate Solution	10	0,37	3,95	5,68	17,8	16,3
Lincoln F1							
1	Control	10	0,36	3,54	6,10	12,9	11,3
2	1% Monosodium Glutamate Solution	10	0,40	3,37	5,68	16,0	13,5
3	2% Monosodium Glutamate Solution	10	0,38	3,90	5,72	17,9	16,7
4	3% Monosodium Glutamate Solution	10	0,38	3,90	5,72	18,1	16,9

In the control variant of the Kolambus variety of leek, the yield of the dried product was 12.5% from the false bulb part and 10.7% from the leaf part. When the raw material was treated with a 1% working solution of monosodium glutamate and subsequently dried, the yield and quality parameters of the dried product were analyzed. Specifically, the yield was 13.9% from the false bulb part and 12.1% from the leaf part. When the raw material was treated with a 2% working solution and subsequently dried, the yield of the dried product was 17.5% from the false bulb part and 16.1% from the leaf part.

Furthermore, the yield of the product dried after treatment with a 3% solution was determined to be 17.8% from the false bulb part and 16.3% from the leaf part. In the control variant of the Lincoln F1 hybrid of leek, the yield of the dried product was 12.5% from the false bulb part and 10.7% from the leaf part. When the raw material was treated with a 1% working solution of monosodium glutamate and subsequently dried, the yield of the dried product was 16.0% from the false bulb part and 13.5% from the leaf part. When the raw material was treated with a 2% working solution, the yield of the dried product was 17.9% from the false bulb part and 16.7% from the leaf part.

In the experiment, the yield of the product dried after treatment with a 3% salt solution was determined to be 18.1% from the false bulb part and 16.9% from the leaf part. Analysis of the results of the conducted experiments showed that, when leek raw materials were treated with working solutions of three different salts at various concentrations and subsequently dried, the most optimal concentration for all three salts was found to be 2%. Treatment of the raw material with a 2% working solution of these salts prior to drying resulted in higher quality parameters and a higher yield of the dried product.

In particular, these higher values were comparatively evaluated in the Vesta variety and Lincoln F1 hybrid of leek. When leek varieties and hybrids were treated with a 2% working solution of sodium chloride (NaCl) and dried in a solar-panel drying unit, the yield of the dried product was determined to be 14.0% from the false bulb part and 12.3% from the leaf part of the Sizokril variety, while the Lincoln F1 hybrid yielded 14.5% from the false bulb part and 12.8% from the leaf part.

When leek varieties and hybrids were treated with a 2% working solution of potassium bisulfite (KHSO₃) and dried in a solar-panel drying unit, the yield of the dried product obtained from the Sizokril variety was 14.2% from the false bulb part and 12.7% from the leaf part. For the Vesta variety, the yield was 14.2% from the false bulb part and 13.0% from the leaf part.

For the Kolambus variety, the yield was 14.0% from the false bulb part and 12.8% from the leaf part, while the Lincoln F1 hybrid yielded 15.1% from the false bulb part and 13.5% from the leaf part.

When leek varieties and hybrids were treated with a 2% working solution of monosodium glutamate monohydrate ($C_5H_8NO_4Na \cdot H_2O$) and dried in a solar-panel drying unit, the yield of the dried product was determined to be 17.3% from the false bulb part and 16.0% from the leaf part of the Sizokril variety, 17.6% from the false bulb part and 16.5% from the leaf part of the Vesta variety, 17.5% from the false bulb part and 16.1% from the leaf part of the Kolambus variety, and 17.9% from the false bulb part and 16.7% from the leaf part of the Lincoln F1 hybrid (Table 4).

Table 4

When leek varieties and hybrids were treated with solutions of sodium chloride (NaCl), potassium bisulfite ($KHSO_3$), and monosodium glutamate monohydrate ($C_5H_8NO_4Na \cdot H_2O$) and dried in a solar-panel drying unit at a temperature of 28–60 °C, the yields of the dried products were analyzed (2023–2025).

№	Leek Varieties and Hybrid	Sample, kg	Raw Material Waste, kg	False Bulb Part, kg	Leaf Part, kg	Dried product yield			
						False Bulb Part, kg	Leaf Part, kg	False Bulb Part, %	Leaf Part, %
2% Sodium Chloride (NaCl) Solution									
1	Sizokril	10	0,42	3,40	6,18	0,47	0,76	14,0	12,3
2	Vesta	10	0,40	3,70	5,90	0,52	0,73	14,2	12,5
3	Kolambus	10	0,44	3,45	6,11	0,47	0,73	13,8	12,1
4	Lincoln F1	10	0,38	3,90	5,72	0,56	0,73	14,5	12,8
EKF 05						0,5	0,3		
Sx=						0,12	0,14		
2% Potassium Bisulfite (KHSO ₃) Solution									
1	Sizokril	10	0,40	3,43	6,17	0,52	0,85	14,2	12,7
2	Vesta	10	0,37	3,75	5,88	0,58	0,82	14,2	13,0
3	Kolambus	10	0,41	3,41	6,18	0,54	0,88	14,0	12,8
4	Lincoln F1	10	0,35	3,98	5,67	0,64	0,80	15,1	13,5
EKF 05						0,2	0,2		
Sx=						0,23	0,13		
2% Monosodium Glutamate Monohydrate (C ₅ H ₈ NO ₄ Na·H ₂ O) Solution									
1	Sizokril	10	0,39	3,73	5,88	0,64	0,94	17,3	16,0
2	Vesta	10	0,42	3,41	6,17	0,60	1,01	17,6	16,5

3	Kolambus	10	0,37	3,95	5,68	0,69	0,91	17,5	16,1
4	Lincoln F1	10	0,40	3,37	6,23	0,60	1,02	17,9	16,7
EKF 05						0,4	0,5		
Sx=						0,12	0,12		

In addition, the dried products were subjected to organoleptic evaluation by a panel of experts based on their appearance, color, taste, odor, and marketability characteristics.

Conclusion. It was established that pretreatment of leek with working solutions of sodium chloride (NaCl), potassium bisulfite (KHSO₃), and monosodium glutamate monohydrate (C₅H₈NO₄Na·H₂O) at different concentrations prior to drying in a solar-panel drying unit had a positive effect on the yield and quality parameters of the dried product. According to the experimental results, a 2% working solution provided the most favorable results for all the salts studied. The highest yield of the dried product was observed in the Lincoln F1 hybrid treated with a 2% solution of monosodium glutamate monohydrate, yielding 17.9% from the false bulb part and 16.7% from the leaf part.

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