Drying methods and health benefits of capparis spinosa fruits

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Abstract: This article analyzes the multi-stage ripening processes of Capparis spinosa fruit and its chemical composition. Various methods of drying ripe fruits, such as sublimation, lyophilization, sunlight, shade, and artificial drying, and their effects on the yield and quality of the resulting product were analyzed. As a result of the study, data were obtained on the potential use of dried Capparis spinosa as a raw material in the food and pharmaceutical industries, with an assessment of the economic efficiency of this fruit, as well as its health benefits for humans.

1 Introduction

The Capparaceae family includes perennial herbs and shrubs. Their leaves are simple or claw-like, arranged alternately, and often lack side leaves. The flowers are bisexual, solitary, or arranged in spreading inflorescences. The calyx has four lobes, and the corolla has four petals arranged diagonally. The plant's reproductive structure is diverse, with one or two upper nodes, varying numbers of cells, and multiple seed buds. It is an insect-pollinated plant with a bent seed pod, which can be sac-like or berry-like, and splits open when mature.

A characteristic feature of the family is that the end of the flower stalk extends into a long filament called a gynophore, which supports the pistil. This feature is also present in other members of the family. Although their flower structure resembles that of crucifers, Capparaceae differ in lacking side leaves [1-3].

The genus Capparis comprises around 150 species. Capparis spinosa and Capparis rosanova are two species that occur naturally in Uzbekistan. The first recorded reference to the caper plant appears in Abu Ali ibn Sina's "The Canon of Medicine," which explores the plant's health benefits for humans.

Capparis spinosa, also known as the caper plant, is a perennial species distinguished by its thorny structure, large white or pink blooms, and a profound root system that extends 10-12 meters. It is farmed in many European countries, including Spain, Italy, and France, as well as on a limited extent in North America. Despite this, the cultural varieties, cultivation techniques, chemical composition, and processing technologies for the food and pharmaceutical industries remain under-researched.

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According to Rhizopoulou and other scientists, Capparis spinosa is adapted to arid and semi-arid climates, thriving in summer even in dry regions. It is recognized for its drought resistance, requiring a semi-arid climate with an average annual temperature above 14°C and annual rainfall of at least 200 mm [4-5].

The Capparaceae family comprises 850 species distributed among 40 genera of dicotyledonous xerophytic plants. Members of this family are primarily located in warm, tropical, and subtropical climates, with certain species residing in lowland habitats. The majority of species flourish in arid ecosystems, particularly in Africa. The Capparis genus contains over 300 species, whilst the Cleome genus encompasses around 200 species.

The caper plant, or Capparis spinosa, is a perennial herb that grows like a shrub and has branches that can grow up to 2.5 meters long. Its leaves are round to egg-shaped, 5-6 cm in size, and green. The plant has one pair of spines between the leaves. Its flowers are large, white or pale pink, and actinomorphic. The fruit is a red, fleshy, multi-seeded berry. It is commonly found in desert zones, hills, roadsides, and on walls among crops.

Capparis spinosa is indigenous to the Mediterranean region, southern Europe, the Caucasus, and Central Asia, encompassing Uzbekistan, Pakistan, and India. It is resilient to heat and drought, capable of flourishing in adverse environmental circumstances that would be inhospitable to other shrubs. The fruits are predominantly disseminated by avian species and other fauna [4-5].

2 Methods

There are both natural and man-made ways to dry crops. Natural methods include drying with air and solar energy (helio-drying), while artificial methods include drying with convection, infrared, conductive, acoustic wave, and vacuum techniques.

When drying fruits and vegetables, it's very important to make sure that microorganisms don't grow and biological processes don't happen. To keep bacteria from growing, the most moisture that can be in the air is 30%. For yeast bacteria, it is 15 to 20%. When the moisture content of dried goods is between 15 and 25 percent, they can be stored well without going bad.

The methods and conditions for drying medicinal plant products are important to fully preserve all organic substances within them. In preparing organic powder from the fruit of the Capparis spinosa plant (kavar), factors such as the degree of grinding and the moisture level are critical in determining the amount of waste produced. High moisture content during processing increases friction between grinding machine parts, leading to higher waste. Conversely, low moisture content can result in excessive dust and burns during grinding, increasing losses and reducing product yield [6-9].

During the research, four drying methods were used for technically ripe kavar fruits. The study evaluated the quantity, quality, chemical composition, crushing time, degree of crushing, yield, technical loss, and other relevant indicators. Technically ripe fruits were harvested, sorted, and washed. They were mechanically cleaned, then sliced into 3-, 4-, 5- and 6-mm thick pieces.

Drying methods were based on theoretical concepts related to the ripening phases and chemical composition of kavar fruit. To develop effective drying methods and technology, the drying temperature and time were studied in three replicates for each method. The fruits were harvested from experimental fields at NamMTI, the Scientific Research Diagnostic Center, and farms in Chust District. Dry product yield and differences compared to control variants were analyzed.

The materials underwent drying using four methods: sun drying (control), shade drying (experimental), lyophilization-sublimation, and a specialist GP-80SPU dryer. Each method processed ten kg of product. The products were sorted, sanitized, sliced into 4 mm pieces,

and dehydrated. In the control scenario, 10 kg of dried product yielded 2.2 kg, representing 22%, with the drying process spanning 65 to 68 hours at a natural air temperature of 25 to 28°C.

The experiment's findings demonstrated that shade drying produced 23-28% dried product over a period of 75-77 hours at temperatures between 17-20°C. The specialized drying cabinet required 45 to 48 hours at 70°C, while lyophilization-sublimation drying, executed in two phases, demanded 50 to 52 hours and produced 23% of the dried product. The first step was cooling the product to a temperature range of -40 to -45°C. It was subsequently sublimated under vacuum to retain its advantageous components.

The experiment revealed that fruits harvested in summer and dried using sun and lyophilization methods, as well as fruits harvested in fall and dried using lyophilization and the GP-80SPU dryer, had a yield that was 1–6% more than the control option.

Table 1. Effect of drying methods of kavar fruit on product yield.

Option	Product, kg	Drying temperature and time (minutes)		Obtained dried product		Difference ±
		0C, t	time	kg	%	
Sun (St)	10	25-28	65-68	2,2	22	
Shade drying	10	17-20	75-77	2,8	28	+6
lyophilization	10	-45	50-52	2,3	23	+1
GP-80SPU dryer	10	70	45-48	2,4	24	+2

It is possible to dry in the sun used for control, and its product yield is 22%, which is 6% less compared to the experimental option, and a certain effect on the quality indicators of the product was observed. It was found that due to certain level of carbohydrates (fructose) in the product, the color of the product oxidized by free oxygen in the air becomes dark. (figure 1-2)

Fig. 1. Dried fruit in direct sun.

Fig. 2. Dried fruit in lyophilization method.

Based on quality indicators and the chemical composition of dried products, they can be utilized in the food industry as biologically active substances (BAS) in the production of bread and bakery items. To achieve this, dried kavar fruits were ground into powder using MLU-1 mills or similar grinding equipment.

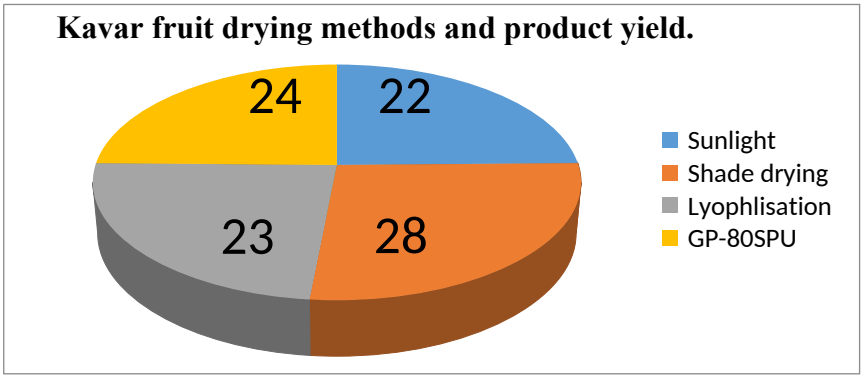

Fig. 3. Kavar fruit drying methods and product yield

During the study, several techniques and technologies were tested for obtaining powder from dried kavar fruits. The comparison focused on both the amount of powder produced and its quality depending on the drying method used. Results showed that solar drying gave the highest yield — 92.8%, which exceeded the control option by 1.9%. In turn, freeze-drying (lyophilization) provided a powder output 0.4% above the control, while the GP-80SPU dryer increased the result by 0.7% (Table 2).

For producing iodine-rich powder through lyophilization, fruits at the stage of technical ripeness were carefully selected, washed, and cut into slices 2–5 mm thick, depending on their size. The sliced material was first kept in a refrigerator at –14°C for six hours. After this stage, dehydration was carried out in a vacuum chamber for about 54–55 hours. Throughout the process, the temperature gradually shifted from –46°C to +46°C, which ensured the complete removal of moisture and preservation of the product.

Table 2. Effect of drying methods on the amount of organic powder output.

Option	Amount of dried product, kg	Organic powder release		The difference from St ±,%
		kg	%	
Sun (St)	2,2	1,9	86,36	
Shade drying	2,8	2,6	92,8	+6,4
Lyophilization	2,3	2,3	100	+13,64
GP-80SPU dryer	2,4	2,0	83,3	+3,02

The dried product was ground and sifted through a mesh with a 0.28 mm diameter. For 25 to 30 minutes, the powder was chilled with cold air at a temperature of -40 to -45°C. This cooled powder was subsequently used in the preparation of medicines and food products.

In industrial processing, products are typically sterilized using thermal methods. However, heating at high temperatures can reduce the beneficial properties of the chemicals contained in the products. Such methods are less effective for medicine preparation. The lyophilization method, on the other hand, is highly effective and promising, particularly for the development of medicines.

Scientific sources indicate that lyophilized products are currently supplied to countries such as Hungary, Spain, and Russia for use by special units and astronauts.

The research results demonstrated that the chemical substances in the powder prepared by the lyophilization method remained unchanged (Table 3).

Table 3. Chemical composition of "Iodocaparin" powder prepared by lyophilization method

Option	Amount in 100 g product mg/gr					
	Protein	Glycoside (caparidin)	Iodine	Rutin	Organic acid	Vitamin E
The previous amount of powder	16,0	28,0	28,0	0,32	12,3	12,8
Powder processed by lyophilization method	16,0	28,0	28,0	0,32	12,3	12,8
When heat treated at 700C	13,2	22,0	17,4	0,15	10,1	8,4

In addition to drying methods, the thickness of the cut also significantly affects the quality indicators of the product. Our research revealed how the thickness impacts both the quantity and quality of powder output. Fruits were cut into 2 mm, 4 mm, and 6 mm thicknesses and then dried. A powder was prepared from the dried raw material for the experiments, with the 2 mm-thick cut serving as the control. The findings showed that fruits cut to 4 mm and 6 mm thicknesses produced 2.5% to 3.5% more powder compared to the control.

Technically ripe fruits were processed using three different cutting and drying methods under consistent conditions to investigate the formation time and organic powder yield. The fruits were cut into 4–6 mm thicknesses for the control and 2 mm for experimental options. Observations revealed that the control option, with 2 mm thickness, required 4 days to dry completely, while the experimental options with 4 mm and 6 mm thicknesses took 5 to 6 days. Thicker cuts resulted in longer drying times. Additionally, the level of powder output varied based on the thickness of the product and the cutting method.

In the control option, the powder yield was 8.95 kg from 10 kg of raw material, while the 4 mm and 6 mm options yielded 2.5% to 3.5% more powder compared to the control. (See Table 4)

Table 4. Effect of cutting thickness of kavar fruit on product yield.

Variant	Drying time. (day)	Dried product (kg)	Powder (kg)	Difference±
2 mm(st)	4	10	8,95	
4 mm	5	10	9,28	+0,33
6 mm	7	10	9,22	+0,27

Changes in the amount of powder to the cutting thickness are explained as follows. In the control option, the number of very small particles increased when the cutting thickness was 2 mm. If the cutting thickness is higher, it was found that less powder is obtained than when cutting 4 mm, due to the increase in the number of rotations between the shafts and the increase of secondary products. (Fig. 4)

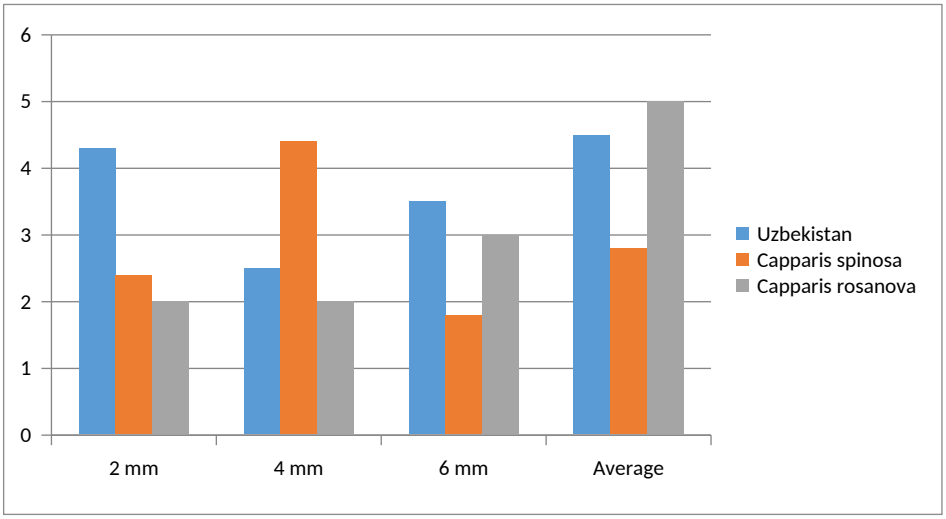

Fig. 4. Effect of cutting thickness on the yield of dried kavar fruit.

Technically ripe fruits selected for preparation of iodine powder from dried kavar by lyophilization method were picked, washed and cut into 2-5 mm thickness depending on the size of the fruit and stored in a refrigerator at -140C for 6 hours. Then it is dehydrated in a vacuum unit for 54-55 hours, during which the temperature rises from -460C to +460C, and during this time the product is fully dehydrated. The dried product was milled and sieved through a sieve with a diameter of 0.28 mm. The finished product was cooled with cold air at a temperature of -40-45 0C for 25-30 minutes. The cooled product was used for the preparation of medicines and food products.

3 Results

We looked at two different options for processing kavar fruit to see which one was more cost-effective.

We bought 120 kg of technically ripe fruit for 5000 soums per kilogram to make the dried kavar. After being sorted, washed, and having the fruit band removed, 100 kg of the product was dried using shade drying, lyophilization, and cabinet drying. 28% (28.0 kg) of the product was lost during the drying process. It cost 700,000 soums to buy and dry the product. The finished dried product cost 25,000 soums per kilogram, but the average selling price was 30,000 soums per kilogram. The sales brought in 1,000,000 soums, which left a net income of 140,000 soums.

The dried kavar fruit was used to make an organic powder that is a biologically active substance in the food and drug industries, including for medicines that contain iodine. To do this, they bought 28.0 kg of dried kavar for 30,000 soums per kilogram, which cost them 840,000 soums. This made 27.2 kg of organic powder, which is a 97% yield. It cost 31,000 soums per kilogram to make organic powder, but it sold for 50,000 soums per kilogram based on demand. The gross income from selling organic powder was 1,360,000 soums, which left them with a net income of 520,000 soums. Using these methods to process products made them profitable between 20% and 61.9% of the time. (See Table 5)

Table 5. Economic efficiency of kavar fruit processing methods.

Variant	Amount of product received for processing, kg	Amount of finished product, kg	Total costs, thousand soums	Cost, kg/sums	Selling price of the product, kg/soum.	Gross income, thousand soums	Net income, thousand soums	Loss, thousand soums	Profitability rate, %
Drying method	100	28,0	700	25000	30000	840,0	140,0	-	20
Method of obtaining organic powder	28	27,2	840	31000	50000	1360,0	520,0	-	61,9

4 Conclusion

Based on a lot of scientific studies and real-world results, we may say the following:

1. Drying Methods: Customers are more likely to buy fruits that have been dried in the shade or via lyophilization. You can get between 21 and 31 kg of dried fruit from 100 kg of fresh fruit.

2. Making Organic Powder: You may produce 97% (27.2 kg) of pure organic powder from 28 kg of dried fruit. You can make a net profit of up to 520,000 soums with this method.

3. Iodine Content and Use: The organic powder has up to 27 mg of iodine in it, which dissolves easily in water. It smells and tastes distinct from other foods, which is helpful for the food sector. You can use it to make bread, other baked goods, and mixed foods for young kids to help stop and treat goiter sickness.

4. Ideas: The organic powder sector should develop natural medications out of organic powder that is high in iodine.

References

1. Afsharypuor S., Jeiran K., Arefian Jazy A. First investigation of the flavour profiles of the leaf, ripe fruit and root of Capparis spinosa var. mucronifolia from Iran. Phytochemistry, **46(3),** 521–524 (1997). https://doi.org/10.1016/S0031-6865(97)00023-X
2. Gull, T., Anwar, F., Sultana, B., Alcayde, M. A. C., Nouman, W. Capparis species: A potential source of bioactives and high-value components: A review. Industrial Crops and Products, **67**, 81–96 (2015). https://doi.org/10.1016/j.indcrop.2014.12.059
3. Zhang Lijia, Pu Yujin, Li Dadong, Miao Lingfeng. Effects of Potassium Silicate at Different Concentrations on the Plant Growth and Physiological Characteristics of Dalbergia odorifera T. Chen Seedlings[J]. Natural Science of Hainan University, **37(1):** 6-13 (2019). DOI: https://doi.org/10.15886/j.cnki.hdxbzkb.2019.0002

4. Rhizopoulou, S. Physiological responses of Capparis spinosa L. to drought. Journal of Plant Physiology, **136(3),** 341–348 (1990). https://doi.org/10.1016/S0176-1617(11)80060-X
5. Rhizopoulou, S., Psaras, G. K. Development and structure of drought-tolerant leaves of the Mediterranean shrub Capparis spinosa L. Annals of Botany, **92(3),** 377–383 (2003). https://doi.org/10.1093/aob/mcg149
6. Jiang Baihui, Ding Yang, Miao Lingfeng, Yang Fan. Effects of Waterlogging and Salt Stresses on the Physiological and Ecological Characteristics of Dalbergia odorifera Seedling[J]. Natural Science of Hainan University, **38(2):** 132-140 (2020). https://doi.org/10.15886/j.cnki.hdxbzkb.2020.0019
7. He Yuning, Chen Kun, He Zhineng, Pan Hongping, Wu Bin. Physiological effects of cadmium stress on Tapes dorsatus[J]. Natural Science of Hainan University, **41(1):** 21-29 (2023). https://doi.org/10.15886/j.cnki.hdxbzkb.2023.0003
8. Huang Jinfu, Zhang Juan, Guo Luyao, Miao Lingfeng, Yang Fan. Effects of Exogenous Spermidine on Photosynthesis and Cell Membrane System of Camellia Oleifera Abel. under Waterlogging Stressed Condition[J]. Natural Science of Hainan University, **38(4):** 325-331 (2020). https://doi.org/10.15886/j.cnki.hdxbzkb.2020.0045