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THE EFFECT OF PHYSICAL PROPERTIES OF DATE FRUIT ON THE DRYING PROCESS: COMPOSITION AND PROCESS ANALYSIS

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Abstract. This article analyzes the physicochemical properties of date fruit and the changes that occur during the drying process. The high moisture content of the fruit makes it highly perishable, causing several difficulties in storage and transportation. Therefore, quality drying of dates is the most important technological solution for creating additional food products and extending shelf life. The study analyzed the content of substances such as water, sugars, fiber, vitamin C, beta-carotene, and polyphenols in dates, as well as physical properties like density, volume, and surface hardness. It is stated that each of these indicators directly affects product quality during the drying process, and improperly selected drying regimes can lead to color loss, texture damage, or degradation of bioactive components. Hence, the article highlights drying methods and their combined techniques to improve drying efficiency. The results obtained are of scientific and practical significance in developing optimal technological solutions for date processing.

Keywords: date fruit, drying technology, physical properties, bioactive substances, moisture content, drying regime, combined drying, product quality.

ВЛИЯНИЕ ФИЗИЧЕСКИХ ПОКАЗАТЕЛЕЙ ФИНИКОВОЙ ФРУКТА НА ПРОЦЕСС СУШКИ: АНАЛИЗ СОСТАВА И ПРОЦЕССА

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Introduction. Date fruit (Diospyros kaki) is considered one of the ancient and valuable fruits in the world. The date palm belongs to the family Ebenaceae and is a subtropical tree or shrub species cultivated as a fruit tree. About 500 species are found in tropical and subtropical regions. It is grown in China, Japan, Mediterranean countries, Australia, the USA, the Caucasus, and Central Asia. A single tree can yield up to 250 kg of fruit. Currently, five varieties of dates are cultivated in the southern and central regions of our country. It stands out for its high nutritional value, sweet taste, and rich biologically active compounds. Date fruit contains many essential components for the body, such as natural sugars, fiber, vitamin C, carotenoids, and antioxidants, making it one of the important fruits for healthy nutrition. However, one of the main problems of the date fruit is its high initial moisture content, usually ranging between 65–85%. In firmer varieties, it may be slightly lower, around 50–60%. Such high moisture leads to rapid spoilage, microbiological contamination, and losses during transportation. Therefore, drying plays an important role in the long-term storage of dates, their transportation from one

place to another, and processing into value-added products such as dried dates, powder, and puree [1,2].

Scientific research method. Date fruit is a highly perishable product due to its high moisture content and delicate structure. During the drying process, several physicochemical properties of the dates, such as moisture, density, volume, texture, and color, undergo significant changes, which directly affect the quality of the final product. For example, improperly selected drying methods or parameters can cause the product to darken in color, harden in texture, sugars to crystallize, or bioactive compounds to degrade. The harvested fruit loses its quality within a short time, which necessitates storage and processing technologies [2]. Specifically, drying methods are considered the most effective solution for long-term storage of dates and preservation of their valuable properties. The application of modern drying technologies, such as microwave, infrared, vacuum drying, or their combinations, helps obtain high-quality dried products. In particular, combined drying methods, such as microwave + vacuum, not only reduce drying time by 40–60% but also better preserve the bioactive components and physical properties of the product. A thorough study of the physicochemical composition and physical properties of date fruit serves as the basis for understanding changes during the drying process and developing optimal technologies. Therefore, determining the physical and compositional properties of date fruit and analyzing the drying process based on these data is of current scientific and practical importance [4].

The chemical composition of date fruit plays a crucial role during drying. The main component of the fruit is water: the moisture content of freshly harvested dates is usually around 65–80%. Additionally, dates are rich in natural sugars such as glucose, fructose, and sucrose, which give the fruit its sweet and pleasant taste. The date fruit also contains fiber (approximately 1.5–3%), vitamin C (20–70 mg/100 g), and beta-carotene (0.1–0.5 mg/100 g). Moreover, dates contain antioxidant compounds such as polyphenols and tannins, which are beneficial to health and influence the drying process to some extent. During drying, tannins break down, leading to positive changes in the fruit's taste and texture [1,4,5].

Research results. The physical properties of dates determine their adaptability to drying. The average mass of freshly harvested date fruits ranges from about 100 to 250 grams. They mostly have a round or slightly flattened shape, with a diameter reaching up to 5–10 cm. The density of fresh dates is approximately 0.9–1.1 g/cm³. Unripe dates are firmer, while ripe ones are soft and elastic. Before drying, surface hardness is measured, and an appropriate drying regime is selected. Due to the high moisture content and elastic texture of the date fruit, a significant reduction in volume and changes in surface structure are observed during drying. Therefore, selecting the right drying conditions allows for maximum preservation of the fruit's shape, color, and nutritional content. The following table presents the main compositional and physical characteristics of the date fruit (Table 1).

Parameter	**Value**	**Notes**
Moisture content	65–80 %	Depends on the ripeness level
Dry matter content	20–35 %	Mainly consists of sugars and fiber
Natural sugars (glucose, fructose, sucrose)	12–20 %	Provide sweet taste and energy source
Fiber	1.5–3 %	Beneficial for the digestive system
Vitamin C	20–70 mg/100 g	Amount depends on variety and ripeness
Beta-carotene	0.1–0.5 mg/100 g	Has antioxidant properties
Density	0.9–1.1 g/cm³	Affects drying and freezing characteristics
Fruit mass	100–250 g	Depends on variety and growing conditions

Diameter	5–10 cm	Important for appearance and drying process
Surface hardness	Soft to hard	Varies according to ripening stage

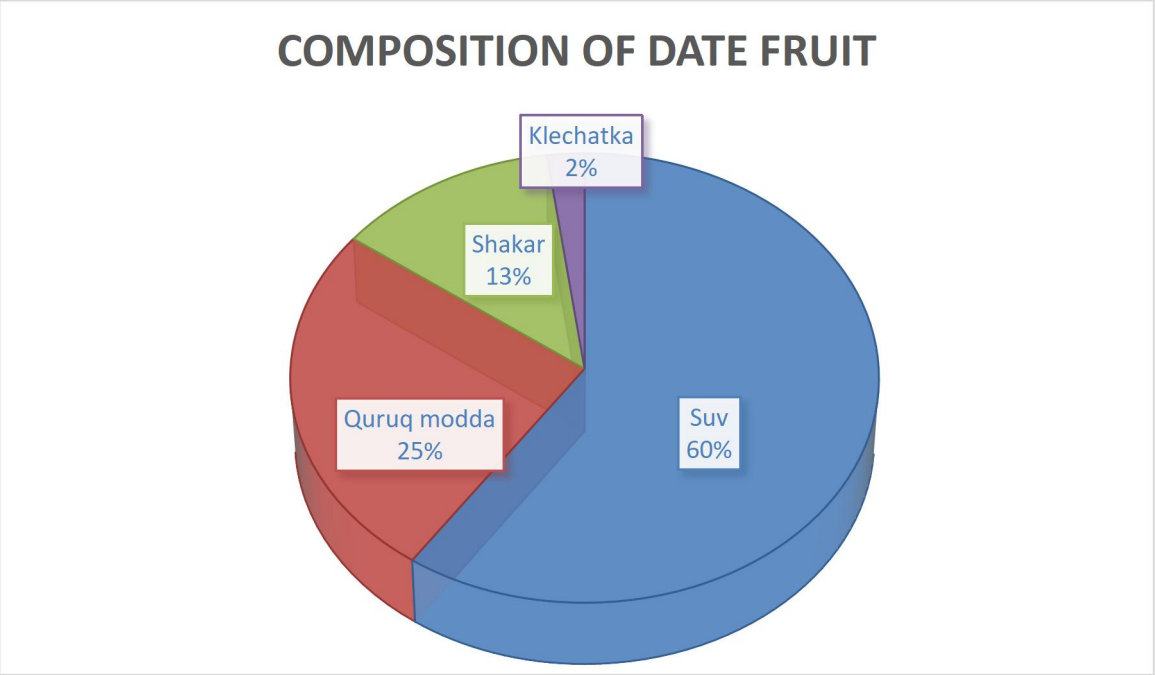

Figure 1. Main compositional components of the date fruit

As seen from the graph, the main component of date fruit is water, averaging around 70%. This is a very high figure, causing the fruit to spoil quickly and requiring special technologies for storage. Therefore, during the drying process, the first priority is to reduce the water content in the date fruit. The dry matter content is approximately 30%. Dry matter mainly consists of natural sugars, fiber, vitamins, and other biochemical compounds. The relatively high concentration of these substances directly contributes to the nutritional value of the dried date product. Sugars (glucose, fructose, sucrose) make up about 15% of the date. This level ensures that the date remains sweet and very useful for consumption even after drying. As the water content decreases during drying, sugar concentration relatively increases, and the fruit dries naturally sweet. Fiber is about 2.5%. Although this is a relatively small amount, it positively affects the digestive system and enhances the value of the dried product as a healthy food.

When developing drying technology for dates, it is important to consider their high-water content and to remove moisture as quickly and efficiently as possible. Sugars and dry matter help ensure the fruit's sweetness, energy value, and long shelf life after drying. If drying conditions are selected incorrectly, for example, if the temperature is too high, vitamin C and some antioxidants may degrade. Therefore, choosing a moderate drying regime is advisable.

The physical properties of dates directly affect the duration, efficiency, and final quality of the drying process. Because the water content is high, the evaporation rate is intense at the beginning of drying. In the initial stage, water near the surface evaporates easily, but over time, diffusion of water from internal layers slows down. Thus, water is removed quickly at first, but drying slows down and requires more time in the final stage. In fruits with high density, water diffusion from the inside to the outside is more difficult. In such cases, air temperature must be carefully selected because very high temperatures can speed up evaporation but may also harden the surface and hinder water release. This phenomenon is called the "drying crust."

The surface area of the date fruit directly affects its drying speed. Smaller and thinner sliced fruits dry faster due to larger surface area, whereas drying whole fruits with smaller surface area takes longer. Ripe, soft dates lose water more easily because their cell walls are elastic. In unripe, hard fruits, water release during drying is more difficult. In such cases, it is advisable to treat the dates with various substances before drying.

Conclusion. The high nutritional and biological value of date fruit makes it an important food product from the perspective of processing and storage technologies. According to the research results, the water content in dates is very high, which leads to rapid spoilage and a shortened shelf life. Therefore, developing an effective drying technology that removes water from dates without compromising quality is an urgent issue. The analyses presented in this article show that the physical properties of dates — such as density, weight, diameter, surface hardness, and shape — directly influence the duration of drying, heat exposure, and the quality of the final product. Changes such as volume reduction, alteration of surface structure, and degradation of bioactive compounds during drying determine the product quality.

Additionally, the chemical composition — natural sugars, fiber, vitamin C, beta-carotene, and polyphenols — defines not only the nutritional but also the functional properties of the dried product. If drying conditions are chosen improperly, losses of vitamin C and phenolic compounds can be significant. Therefore, as recommended in the article, combined drying methods are considered the most effective. In summary, a deep study of the physicochemical properties of date fruit and scientific analysis of their impact on the drying process is crucial for improving product quality, shelf life, and energy efficiency. The results of this research serve as a practical foundation for developing drying technologies for dates.

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