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Technological Characteristics and Bio-Chemical Composition of Apple Fruit's

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Abstract
Considering their shelf stability, nutritional importance, and export potential, the dried fruit products are growing in significance within the global food systems. As one of the main processing methods, the evaluation of technological characteristics in apple drying, such as size, hardness and dry matter content, is crucial to ensure the quality and efficiency of the resulting product. Although some studies have been conducted, there are still no standard benchmarks to determine the technological adequacy of some apple varieties for drying, especially in the area of the relationship between physicochemical properties and drying results. Therefore, the objective of this study is to better the drying technology through analysis of technological characteristics and biochemical composition of different apple varieties and factors affecting the quality of dried product. Results show that dry matter content, fruit hardness, and size are of significant importance for drying efficacy and subsequent quality of the products, for instance, Saratoni had the maximum dry matter content (14.0%) whereas Rozmarin belyy showed the maximum hardness (7.7 kg/cm²) which leads to larger structural retention. On the other hand, dried forms of genotypes with low dry matter content showed lower quality. The research details several apple varieties tested under the same drying conditions and emphasizes that maximal efficiency is determined by a synergism of many techno-productive traits rather than a useful trait alone. This work indicates that careful choice of varieties and optimization of drying parameters may minimize losses, increase economic efficiency and even contribute to high-value, export-oriented semi-finished product production.

Keywords: Apples, Productivity, Firmness, Quality, Penetrometer, Autumn and Winter Varieties, Size, Dry Matter

1. Introduction

Dried products have become an important part of the global diet and are becoming increasingly important as high-value export commodities. The largest importers of dried fruits and vegetables include China (1,479.3 thousand tons, or 16.9% of world imports), India (899.6 thousand tons, or 10.3%), the United States (445.0 thousand tons, or 5.1%), Japan (355.8 thousand tons, or

4.1%), Pakistan (335.8 thousand tons, or 3.8%), the United Kingdom (222.7 thousand tons, or 2.6%) and Germany (207.0 thousand tons, or 2.4%). The drying process of fruits is important in providing the population with quality food products and contributes to the promotion of healthy eating [1][2]. Drying fruits is an important way to meet the high and growing demand for food by dramatically reducing their shelf life and consumption. It is also important to prepare quality food products from the grown fruits and to ensure their naturalness and the quality of the resulting product. Ensuring quality in food products includes factors such as the appearance of the product, as well as the degree of suitability for consumption and nutritional value. Quality adds dimensions such as physiology, hunger, emotion, consciousness, pleasantness and satisfaction with food to the properties of food. In most cases, the question arises whether these aspects are sensory qualities or food properties. In our opinion, it is appropriate to consider these aspects as emotional aspects of consumers, because after consuming food products, buyers can evaluate aspects such as their nutritional value and their impact on human health. These are emotional assessments of consumers [3]. It should not be forgotten that no matter how high the emotional demand for dried fruits is, their health safety is important first of all. Therefore, great attention is paid to their safety when developing technologies for drying and packaging fruits. According to research, processed fruits, vegetables and other types of agricultural products lose a high amount of nutritional value during processing and drying. Therefore, minimizing the loss of nutritional value by improving processing technologies, as well as increasing the nutritional value and palatability of the resulting semi-finished products, is one of the urgent issues [4].

The purpose and specific issues of the research

It consists in improving technological processes in order to improve the quality of the finished product in drying apples [5].

2. Material and methods

The research was conducted on the following varieties of apples: Borovenka Tashkentskaya, Golden Delishes, Jonathan, Kamola, Kizil taram apple, Gozal, Mantet, Aydin, Pervenets Samarkanda, Renet Simerenko, Rozmarin Bely, Saratoni, Farangiz, Feruza.

The research methodology is as follows:

a) Determination of technical ripening indicators of apple fruits;

b) Research of technical parameters of convective drying of apples in an artificial drying device.

In achieving the above results, scientific conclusions can be drawn by using several methods and comparing the results obtained from them. For example, measuring the isotherm by the isopyetic method [6]. Researchers John Wiley and Son introduced the "Application of Chemical Methods in the Analytical Analysis of Food Products", which is aimed at developing standard methods for the properties of food products. This involves regulating the chemical elements used in drying fruits, standardizing the chemical elements that give a pleasant taste in the composition of the resulting semi-finished products. Currently, the exact criteria and requirements for measuring all the properties of food products have not been fully scientifically proven. Therefore, it is appropriate to develop separate properties for each type. Because dried apples and other types of fruits differ sharply in their characteristics due to their different composition. Also, food products obtained by drying apples of different varieties differ in their size and hardness, depending on the characteristics of the fruits. This requires different drying processes and storage technologies for dried fruits [7].

3. Result and Discussion

Technological characteristics are of great importance in the industrial drying process of apples. These characteristics play an important role in maintaining product quality and increasing the efficiency of the drying process. The following factors directly affect the drying process:

Hardness level — The firmer the texture of apples, the better their shape and structure are preserved during the drying process. Fruits with low hardness can be deformed during drying, which negatively affects the appearance of the finished product [8].

Size — The size of the fruit determines the speed and uniformity of its drying process. Larger fruits take longer, while smaller ones dry faster, but the moisture may not be distributed evenly. Therefore, it is important to sort fruits by size on an industrial scale.

Dry matter content — The dry matter content (sugar, acid, and pectin) of apples directly affects their taste and nutritional value when dried. Fruits with a high dry matter content can produce high-quality and colorful dried products [9].

As shown in Table 1, the technological characteristics of apple fruits differed depending on the variety. Since the amount of dry matter in apple fruits is considered one of the main quality indicators, based on the results of the analysis in the experiments conducted, it is possible to conduct a more extensive analysis of the technological characteristics of apple varieties during the drying process and their quality in the dried state, based on the data shown in the Table. The technological characteristics of fruits during the drying process directly affect the efficiency of their drying process and the quality of the product. In this process, varieties adapted to drying, drying time, various aspects of fruits, as well as their nutritional value during the drying process are of great importance [10].

One of the main characteristics of apples during the drying process is the dry matter content, i.e. the amount of sugar, acid and pectin substances. Apple varieties with a high dry matter content are useful for obtaining high-quality and colorful products during drying. According to the table, the Saratoni variety (14.0%) has the highest dry matter content, and it is expected that dried products from this variety will have high quality, traditional taste and color.

The high dry matter content of the **Saratan** variety helps to achieve high efficiency in the drying process. The high sugar and acid content of this variety serves to increase the taste and nutritional value of the fruit. Thus, **Saratan** is not only balanced in nutritional value and texture, but also has high quality in terms of color, texture, and egg storage properties [11].

During the drying process, the variety **Guzal** (10.9%) has the lowest dry matter content. This, according to the table, can lead to its lower quality in the dried state, poor color, and also lower nutritional value. Another important factor affecting the final product during drying is the substances that directly affect the degree of enrichment. Therefore, varieties with the highest dry matter content help to turn into a high-quality product during drying [12].

The degree of hardness of apple tissues has a significant impact on the preservation of shape and structure during drying. Fruits with a high degree of hardness are less deformed during drying and retain their shape well. Based on the table, the varieties **Rozmarin** belyy (7.7 kg/cm2) and Saratoni (7.5 kg/cm2) have the highest degree of hardness, and their dried products have such qualities that their shape and structure are preserved correctly and without damage (Table 1).

Table 1. Indicators of fruit technicalization of apple varieties, 2024

No	Varieties	Dry matter content, %	Hardness, kg/cm2	Fruit diameter, mm
1	Borovinka Tashkent	12,8	7,3±0,15	78,2±1,15
2	Golden Delicious	13,3	6,9±0,14	72,0±1,06
3	Jonathan	12,7	7,2±0,15	77,0±1,13
4	Kamola	12,3	7,5±0,15	67,0±0,99
5	Red apple	11,4	7,2±0,15	69,0±1,02
6	Guzal	10,9	7,2±0,15	68,0±1,0
7	Mantet	12,1	7,2±0,15	67,0±0,99
8	Aydin	11,5	7,6±0,16	78,0±1,15
9	The Firstborn of Samarkand	12,7	7,2±0,15	76,0±1,12
10	Renet Simirenko	11,2	7,4±0,15	73,0±1,07
11	White rosemary	13,0	7,7±0,16	79,0±1,61
12	Saratani	14,0	7,5±0,15	82,0±1,67
13	Farangiz	12,9	7,4±0,15	70,0±1,43
14	Feruza	12,5	7,5±0,15	71,0±1,45
	EKF_{05}	–	0,3	2,5
	$Xs_{\%}$	–	4,0	3,4

The drying process and technological characteristics of apple varieties, including factors affecting drying efficiency, are presented in the table, which allow for their specific analysis [13]. One of the important factors in increasing the efficiency of apple varieties in the drying process is the textural characteristics of the fruits, in particular, their degree of firmness, that is, how hard they are. The degree of firmness plays an important role in any technological process, including drying, as it affects the shape and structure of the fruits and helps to determine information about fruit deformation or problems [14].

The degree of hardness indicates the technological maturity of apple fruits and their storage properties. Apples with a high degree of hardness retain their shape and structure better during drying, which helps to improve the quality of the dried product. During the research, a penetrometer FT 516 was used in the nozzle, which is used to determine the average hardness of apple fruits. In field conditions, apple samples taken from different contours determined their average hardness, which helped to determine the effectiveness of drying fruits.

According to the results of the analysis, among the varieties with a high level of hardness of apples, the following varieties were distinguished: Rozmarin belyy (7.7 kg/cm2), Aydin (7.6 kg/cm2), Kamola (7.5 kg/cm2), Saratoni (7.5 kg/cm2), Feruza (7.5 kg/cm2). These varieties should have high efficiency in the drying process and allow to obtain a quality product [15].

In addition, although the hardness of the Golden Delicious, Farangiz and Renet Simirenko varieties was somewhat lower (6.9-7.2 kg/cm2), the drying results showed that they were distinguished by the high quality of the dried product obtained from them. This fact, i.e. the good organoleptic properties of the dried product (taste, color, nutritional value, etc.), indicates that the lower hardness of the fruits directly affected their commercial quality.

According to the data in the table, the hardness level of Borovinka Tashkentskaya and Jonathan varieties is 7.2-7.4 kg/cm2. At the same time, low organoleptic properties and marketability indicators of fruits were observed during the drying process. This may lead to the conclusion that the efficiency of drying depends not only on the hardness level of fruits, but also on their transformation characteristics. Low organoleptic indicators in dried products of Borovinka Tashkentskaya and Jonathan varieties indicate that they encountered very serious problems during the drying process.

When choosing apple varieties for drying, not only their hardness level, but also the diameter of the fruit, the dry matter content and organoleptic characteristics are of great importance. Varieties with a high hardness level, such as Rozmarin belyy, Aydin, Saratoni, can be successful in drying, but their drying efficiency may be somewhat lower, since their large diameter and high dry matter content increase the drying time.

To effectively organize the drying process, it is necessary to take into account the technological characteristics of apple varieties, in particular, their hardness. To reduce the deformation of varieties with low hardness during drying, they can be stabilized using various techniques or processes. For example, for apple varieties with low hardness, efficiency can be increased by extending the drying time or lowering the temperature.

In addition, for high-quality drying of apples, it is necessary to pay attention to increasing the dry matter content. Varieties with high dry matter content are designed to give high-quality drying results. Therefore, choosing apple varieties that meet the requirements and have high efficiency is an important factor in improving the quality of the product.

In conclusion, in the process of drying apples, technological characteristics such as the degree of hardness, dry matter content and diameter of the varieties play an important role. Based on the data in the table, although varieties such as Rozmarin belyy, Aydin, Saratoni have a high degree of hardness, their efficiency in the drying process may be lower. On the contrary, varieties with a low degree of hardness but high organoleptic qualities, such as Golden Delicious and Renet Simirenko, are successful. Therefore, the most important factors in the drying process are not only choosing the right variety, but also fully taking into account their technological characteristics.

4. Conclusion

The results indicate that no single technological characteristic is responsible for the efficiency and quality of the dried apples; instead, it is a combined interaction of several technological characteristics. High dry matter content and firmness breakdowns were observed in Saratoni and Rozmarin belyy that resulted in strong structure, high color and high nutritional status in dried products, while dry matter or organoleptic properties that were lower yet still obtained an adequate hardness had less quality. The results are also inconsistent, as some varieties having a relatively lower hardness achieved high-quality dried outputs, showing that many assumptions on linear relationships of firmness and drying efficiency through physical modelling, are only rarely proved in practice. This points to a limitation in current evaluation practices, where criteria for integrated variety selection are still underdeveloped (Klaeger et al. The practical implication is that there is a variety-specific and drying parameter specific approach that needs to be adopted to improve the quality of the product, reduce postharvest losses and improve the economic returns via value added processing and export potential. Future studies should aim towards standardized and multi-factor assessment models that simultaneously integrate physicochemical and structural as well as sensory characteristics and develop adaptive drying technologies according to specific varietal features.

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