

# Research of Functional and Technological Properties of Persimmon Fruits as an Object of Drying

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**Abstract:** Persimmon fruits should be initially quite hard, so that they can not only be easily peeled, but also fastened with a strong rope for the closely adjacent stems and dried for a month or two under a canopy. Despite the extensive nature of this process, farmers are used to this artisanal method and the small profit it can provide in those 3-4 post-harvest weeks, as long as the persimmon can remain firm. The aim of this work was to develop more efficient alternative drying methods that allow drying persimmons in an accelerated mode and at all stages of its post-harvest storage. The objects of the study were the fruits of the cultivars "Hachiya" and "Hiakume", grown in the experimental farm of the Research Institute of Horticulture and Tea Industry (Guba, Azerbaijan). The method of creating the final products was used, based on taking into account the physical and chemical changes that occur in the persimmon during its maturation. It was found that the natural balance between leucoanthocyanins (the most tart among polyphenols), protopectin, which refers to insoluble dietary fiber and easily digestible carbohydrates, does not provide the best color and taste of 100% dried persimmon from early solid raw materials. Slicing slices of hard fruit into slices 2-3 mm thick and holding the slices for 10-15 minutes in solutions of table salt and sugar allows you to improve their color and taste initially. Aged softened fruits are amazingly delicious and without additives. Taking into account these and other revealed facts, technologies were developed for obtaining natural chips from solid persimmons, and 100% dried persimmons from softened persimmons. Calculations have shown that the proposed technologies are cost-effective and promising for wide application.

**Keywords:** Persimmon Fruits, Drying, Post-harvest Storage, Biochemical Changes, Product Innovations, Prospects for Commercialization

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## 1. Introduction

In recent years, the production of persimmon (*Diospyros kaki* L.) in the Republic of Azerbaijan has been steadily increasing, where in 2017 and 2018 they were at the level of 200 thousand tons. A significant part of the crop grown here is exported to countries such as Russia, Moldova, Belarus, Ukraine, Kazakhstan, as well as some Arab countries. The total volume of persimmon exports from the republic was estimated at \$ 114 million in 2018, which is 17 percent more than in 2017. Part of the 2018 harvest in the amount of about 26 million dollars were put into cold storage and exported in January-February 2019. In the republic, persimmon is becoming increasingly important not only as a functional product, but also as the most important (after pomegranate) subtropical crop in terms of its opportunities to conquer

foreign markets for fresh fruit. Therefore, the local manufacturing sector faces the challenge of introducing new product options to reduce losses associated with persimmon fruit management and seasonality.

The global commercial production of persimmon fruit in 2013 was 4.6 million metric tons. [1] The list of persimmon-producing countries has traditionally been headed by China, the Republic of Korea and Japan. Now Spain claims the second place in this list, as it was expected that by 2020 the volume of the grown persimmon crop in this country will be brought to 600,000 tons mainly due to the astringent cultivar "Rojo Brillante" due to its high quality and adaptation to climatic conditions [2].

Based on their astringency at harvest and the state of

pollination, these cultivars can be divided into three categories: "strongly tolerant", "intolerant" and "varying". "Varying" cultivars are those that change their taste from year to year depending on the degree of pollination. All three categories of persimmons can be harvested for the first time from trees at commercial ripeness, that is, when the fruit becomes hard and the skin changes color from green to yellowish-green, yellow, orange or reddish-orange (depending on the cultivar) [3]. If the fruits are pollinated in the spring and, as a result, have seeds, they will be sweet and delicious immediately after harvest. Unpolished (astringent) cultivars of cultivated varieties must undergo an additional de-astringency process so that they are tasty and raw.

Persimmon ripens quickly after harvesting, which reduces its availability in some months of the year and increases the number of post-harvest losses, which can reach 20% of the total annual volume of its production [4, 5].

The drying process is a common and simple technique, the purpose of which is to preserve the persimmon fruit, extending the period during which they are available. Drying is finished at a humidity of about 50% (when receiving semi-dry persimmons) or it is conducted to a water content of 35% and below [6, 7].

The production and consumption of semi-dry persimmons is traditional in Asian countries such as South Korea, China and Japan, with various processing methods to produce a new high-quality and stable product with good sensory properties [8-9].

In Azerbaijan (and in neighboring Georgia), the simplest and, so far, the only way to process persimmons is to dry them in private farmsteads and farms. For drying, take only hard fruits. Carefully peel them from the skin, without affecting the stems, for which they are then tied with strong threads so that they do not touch each other. Ready-made "garlands" are hung for drying under a canopy. Some manufacturers periodically slightly crumple them with their fingers to give a better shape and accelerate the appearance of sugar coating. It takes about a month to dry the fruit, but sometimes they are left hanging on a string until March.

Bundles of dried persimmon tied with threads are sold in the markets of Georgia at a fairly low price—from 3.5 lari (\$1.1) per 1 kg. However, the prices for dried persimmon without seeds (which is made from the variety "Hachiya") - twice as high, they start from 7.5 lari (\$2.3) for 1 kg. For comparison, the price of prunes, also popular in Georgia, starts from 10 lari per 1 kg (\$3.03). The prices for dried persimmons and prunes in Azerbaijan are almost the same as in Georgia.

Here, the shelves with dried persimmons are much less suitable than the shelves with dried apricots, grapes, plums. And this is also partly due to the fact that, despite the fact that in most cases dried persimmons are in the form of whole flattened fruits without skin, their appearance is constantly changing in detail.

Farmers prefer to sell dried persimmons not immediately, but after they are covered with a white fluffy coating consisting of small sugar crystals that have appeared on its

surface. However, such a white environment can scare off a certain part of potential buyers, and not without reason – because this actually increases the risk of contamination of the product with microorganisms [10].

Despite the fact that this method is consolidated, studies have been conducted regarding changes in the quality characteristics of the target product depending on the persimmon variety used and the region where it is grown. In particular, this applies to the studies of Spanish authors, during which information was obtained about the physico-chemical and microstructural changes that occur during air drying of persimmons "Rojo Brillante", collected in two stages of maturity [11]. The fruits of the first stage of maturity weighed about 195.3 g, which was lower than the fruits that reached the second stage of maturity (252.0 g). The humidity level of 50%, at which the persimmon is considered semi-dry, was reached after 21 and 28 days for fruits weighing 195.3 g and 252.0 g, respectively. During drying, there was a slight darkening, which was reflected in the deterioration of the color. The removal of water led to a significant decrease in the content of soluble tannin - on the 28th day of drying, the fruits were no longer tart.

The main feature of the traditional drying method is that the persimmon is taken for drying only in the short period when it is still solid and is easily served for processing and drying. In addition, this method is extensive in its essence, so drying persimmons in the open air lasts for weeks. In these conditions, it is difficult to achieve high performance.

An important condition for its improvement may be the development of alternative drying methods that allow drying persimmons not only in the early stages of its post-harvest storage, but also in the future, when the fruits are fully ripe and soft, which would also provide greater product purity and higher productivity.

## 2. Materials and Methods

### 2.1. Research Objects

The work was carried out using persimmons "Hachiya" and "Hiakume" grown in the experimental farm of the Research Institute of Fruit and Tea Industry (Guba, Azerbaijan).

The natural and climatic conditions of this region are very favorable for the cultivation of this plant, although several facts have been noted when persimmon trees froze in an unusually cold winter.

### 2.2. Organization of the Work and Its Venue

The fruit was eaten from all sides of three to five mature trees during their mass harvest (in the last decade of October-the first decade of November), when they are in the commercial stage of maturity and are still very hard, but already completely colored in the color characteristic of this cultivar. The average sample in the amount of 20 kg was delivered to the laboratory of Processing and Storage Technologies. In the laboratory, their chemical composition

was studied the next morning after delivery and after being kept until softened in an uncooled utility room.

### 2.3. Chemical Analyses

The content of soluble solids was determined using a refractometer according to GOST P 51433-99, simple sugars-by the Bertrand method according to GOST (State standard of Russia) 8756.134-87, organic acids-by titration in the presence of a color indicator according to the interstate standard ISO 750-2013, ascorbic acid - by the iodometric method according to GOST 28556-89, carotenoids – by the optical density of acetone extracts according to GOST P 54058-2010. Humidity was determined by standard methods according to GOST 24027.2-80, the total amount of water-soluble polyphenols - according to GOST 24027.2-80 (the method is based on titration of 0.1 n. with a solution of potassium permanganate of the indigocarmine residue, not consumed for the oxidation of polyphenolic substances). Pectins were determined by the Ca-pectate method, which is based on the precipitation of pectin acids and accounting for their amount by weight [12]. The determination of leucoanthocyanins and catechins was carried out by photometric methods based on their ability to form colorless colored anthocyanins when heated in their solutions with mineral acid (leucoanthocyanins) and give colored solutions in the presence of a vanillin reagent (catechins) [13, 14].

### 2.4. Preparation of Persimmon Fruits for Drying

The hardness of the pulp was determined by a pycnometer FT-372 with a plunger diameter of 11 mm.

Pretreatment of hard fruits was carried out in three related variants:

1. Remove from the fruit only the cups together with the stalks, cut into 4-8 approximately equal slices and chop with an electric vegetable cutter (REDMOND RKA-FP1) into slices 0.2-0.3 mm thick; the slices immediately fall into a container for receiving sliced fruits with a stabilizing solution, which is used as a mixture prepared from 1 part citric acid, 2 parts table salt and 40 parts water;

2. Pretreatment is carried out according to option number 1, with the difference that a mixture prepared from 1 part of table salt, 10 parts of sugar and 20 parts of water is used as a stabilizing solution;

3. Pretreatment is carried out according to the variant with the number 1, with the difference that as a stabilizing solution, a mixture prepared from 1 part citric acid, parts table salt, 2 parts sugar and 80 parts water is used.

Preparation of aged softened persimmons for drying was carried out only in one version, which has already been reported [15]. The fruits are washed piece by piece under a tap or wiped from the surface with a wet cloth, then cut with a sharp knife by hand crosswise from their tip to the very base into 4-8 approximately equal lobules, leaving the lobules attached with their lower end to the base of the fruit,

where the calyx is located. The lobules are slightly pushed down until free spaces are formed between them. As a result of such cutting, the fruit becomes like an open flower with 4-8 "petals".

### 2.5. The Thickness of the Layer of Prepared Fruits and the Temperature Regime of Their Drying

Park and his colleagues dried wafer-shaped slices of persimmon by convective method at 60°C [16]. At such a low temperature, the duration of this basic operating cycle stretches to 12 hours. We felt that this was too much, considering not only the growing time and economic costs, but also the possible loss of flavonoids, carotenoids and ascorbic acid. Persimmon is a good source of these natural antioxidants, which are highly responsive to prolonged heat treatment [17, 18].

Thus, the drying of persimmon slices should be as fast as possible, and delaying this main operational process up to 12 hours is impractical, not only for purely economic reasons, but also based on the principle of ensuring the best preservation of labile components of raw materials.

In this study, an attempt was made to speed up the drying of persimmons, for which the process of dehydration was carried out at a temperature of 70-72°C. A higher temperature could lead to "boiling" of the cell juice, so it was not used (with the exception of one experiment, when they tried to find out how this would affect the astringency of persimmons).

Drying was carried out to the water content of 24% (critical humidity) and below. The drying depth was determined based on the initial humidity of the control sample and its changing mass as a result of moisture evaporation.

The prepared fruits were loaded onto extruded plastic nets with square-shaped cells measuring 4 x 4 mm, which were then fed to the dry-heat cabinet GP-80-400, Belarus.

Before that, the temperature in the cabinet rose to 100°C. Then the cabinet door was slightly opened so that the temperature inside it was set at the required level of 70-72°C. In the future, the door remained open all the time to maintain the set temperature. This also prevented waterlogging of the air inside the dryer.

The fruits, which after cutting them began to resemble one large open flower, were dried in one layer. Wafer-shaped slices with a thickness of 2-3 mm were dried in a layer with a thickness of 0.6-0.9 cm, respectively (with a larger layer thickness, the slices began to stick to each other).

Persimmon drying products were stored for 6-12 months in plastic bags with fasteners or in plastic boxes with hinged lids at a temperature not exceeding 10°C.

### 2.6. Processing and Evaluation of Primary Data

A statistical method for processing experimental data was used, based on the determination of the average value of the calculated value based on at least 5 repeated determinations [19].

## 2.7. Economic Calculations

Innovation managers who are determined to try to apply innovations in the real economy are primarily interested in the commercial attractiveness of innovative projects. Taking this into account, the calculated data were given, showing what benefits can be expected from the creation of a small site for the production of dry food products from persimmons with a prolonged processing season of up to 2-3 months. The calculations were carried out taking into account the current prices for raw materials, equipment and electricity, the cost of renting premises and labor in Azerbaijan for May 2021. At the same time, the output of target products was also taken into account as a fundamental element in influencing its cost price [20].

## 3. Results

### 3.1. Biochemical Changes Occurring in Persimmon Fruits During Their Post-harvest Ripening

The data in Table 1 relate to the physical and chemical changes that occur in persimmon fruits during their post-

harvest aging in a warehouse at ambient temperature. It shows that at the very beginning of aging, the hardness of the persimmon "Hachiya" (unpolished parthenocarpic fruits) was 5.0 kg/cm<sup>2</sup>, but after two weeks it became 2.5 times less. From the same table, it can be seen that the persimmon "Hiakume" (pollinated fruits with seeds) turned out to be more resistant to softening - it took about 3 weeks for it to transition from the original strongly solid state (5.7 kg/cm<sup>2</sup>) to a hard-soft state (2.7 kg/cm<sup>2</sup>). From other data placed in the same table, it can be seen that during the aging of fruits for 0.5-1 months before their weak softening, the content of protopectin in the persimmon pulp, which is involved in strengthening the cell walls, not only did not decrease, but even slightly increased. Apparently, at this stage, the softening of the fruit first occurs due to the hydrolysis of hemicellulose rather than protopectin, which is indirectly confirmed by an increase in the content of the mass fraction of monosaccharides in them during the transition from the solid state to the hard-soft and soft. But then, apparently, protopectin is also included in this process, since by the time the fruit is completely softened, its concentration in them drops sharply.

*Table 1. Biochemical changes in persimmon fruits that ensure their maturation in an uncooled storage.*

Date (day, month)	Solid, kg/sm <sup>2</sup>	Soluble solids, °Brix	Titrate acidity, g / 100 g of malic acid	Monosaccharides, g / 100 g	Sucrose, g / 100 g	Water-soluble polyphenols, mg / 100 g	Soluble pectin, g / 100 g	Proto-pectin, g / 100 g
Unpolished (without seeds) fruits of the Hachiya cultivar								
15.10	5.0	24.8	0.38	12.51	0.16	247.0	0.52	1.26
01.11	2.0	22.0	0.47	14.81	0.20	130.4	0.25	1.39
15.11	0.5	22.0	0.50	16.87	0.46	80.0	0.17	0.30
Pollinated (with 1-2 seeds) fruits of the Hiakume cultivar								
25.10	5.7	19.0	0.37	12.60	0.78	197.0	0.22	0.74
20.11	2.7	17.0	0.32	13.80	0.47	100.2	0.18	0.94
30.11	1.5	17.0	0.30	14.40	0.30	70.2	0.10	0.40

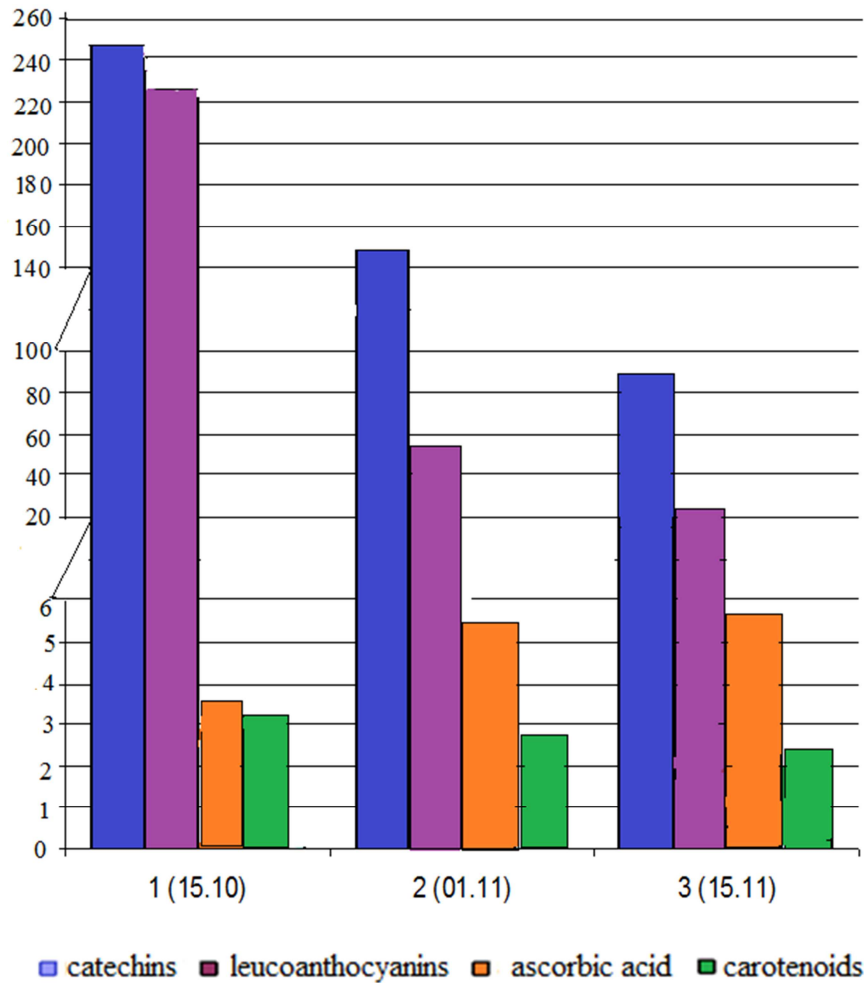
Average value of 5 repeated definitions

During the period covered by the analyses, the content of monosaccharides in the fruits, as already noted, increased. Therefore, it was quite reasonable to expect that all this time the content of soluble solids in their pulp would also increase. However, everything was somewhat different. By the time of weak softening of the fruit, the content of soluble solids in their pulp did not increase, but, on the contrary, decreased, after which it did not change for a long time (at least until the fruit pulp was completely softened). This may be due to the fact that the content of biocolloids in the cell juice of hard fruits is still high, which makes it cloudy; when kept, the concentration of biocolloids of a polyphenolic nature decreases and the cell juice becomes more transparent.

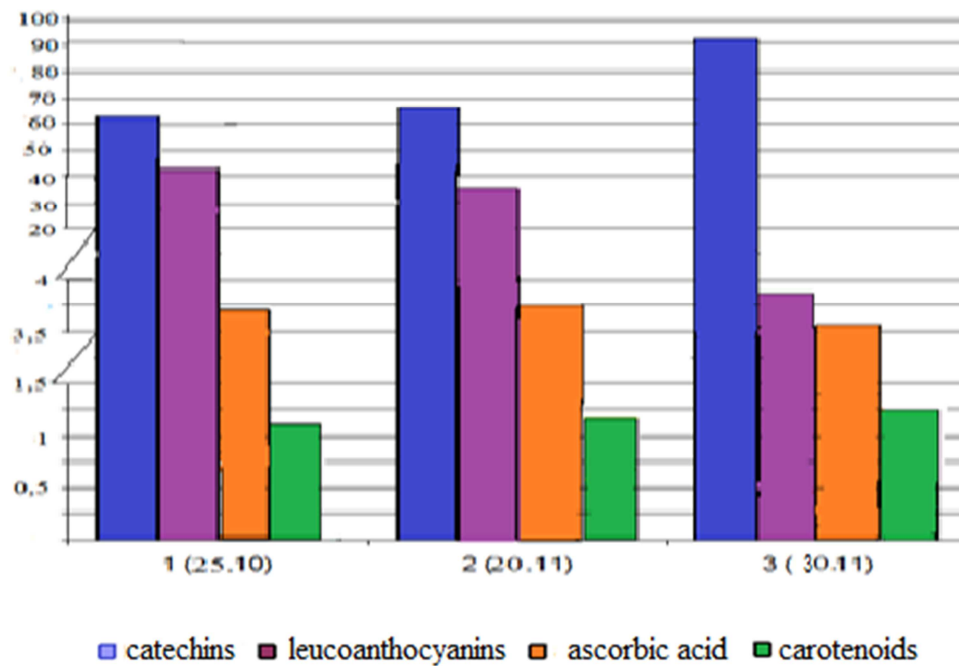
From the same table, it can be seen that in the period from 15.10 to 15.11, the content of protopectin, which is part of the complex called "insoluble dietary fiber", in the persimmon "Hachiya" decreased by more than 4 times; in the

persimmon "Hiakume" (in the period from 25.10 to 30.11) – almost 2 times. During the same periods, the concentration of water-soluble polyphenols (including the most tart oligomeric forms) in the persimmon "Hachiya" increased from 247.0 to 80.0 mg/100 g, and in the persimmon "Hiakume" - from 197.0 to 70.2 mg/100 g, that is, by 3.1 and 2.8 times.

As a characteristic feature of each of the above-mentioned varieties, it can be noted that on the first date of analysis, the pollinated persimmon "Hiakume" contained significantly more sucrose (0.78 g/100 g) than the unsullied seedless persimmon "Hachiya" (0.16 g/100 g). After post-harvest aging of the fruit, the sucrose content in the persimmon "Hachiya" increased almost 3 times, while in the persimmon "Hiakume" its concentration fell by more than 2 times. The same can be said for the dynamics of titrated acids.



**Figure 1.** Changes in the concentration of catechins, leucoanthocyanins, ascorbic acid and carotenoids in the persimmon "Hachiya" during its post-harvest aging under normal conditions: 1 (15.10) - hard fruits; 2 (01.11)-hard-soft fruits; 3 (15.11) -very soft fruits.



**Figure 2.** Changes in the concentration of catechins, leucoanthocyanins, ascorbic acid and carotenoids in the persimmon "Hiakume" during its post-harvest aging under normal conditions: 1 (25.10) - hard fruits; 2 (20.11)-hard-soft fruits; 3 (30.11) -slightly soft fruits.

These cultivars differ somewhat both in the initial content of leucoanthocyanins and catechins, and in the nature of their quantitative changes, as can be seen from Figures 2 and 3.

From these drawings, it can be seen that in the persimmon "Hachiya" in the period from 15.10 15.11 to the ascorbic acid content increased from 3.50 to 5.63 mg/100 g, and the content of carotenoids, on the contrary, decreased from 3.2 mg/100 g to 2.4 mg/100 g

In the persimmon "Hiakume" for the entire period from 25.10 30.11 ascorbic acid content remained above the level of 3.5 mg/100 g, and the content of carotenoids even increased from 1.12 mg/100 g to 1.25 mg/100 g

At the same time, it is necessary to take into account the natural loss in the mass, which occurs due to the evaporation of moisture. And this process is in the seedless persimmon "Hachiya" it was much slower than the persimmon "Hiakume" with 2-3 seeds.

A separate experiment was made, which showed that the persimmon "Hachiya" when it was aged from 05.11 to 0.5.01, that is, for 55 days, the weight loss was not as significant (6.25%) as in the persimmon "Hiakume" when it was aged from 14.11 to 14.01, that is, for 63 days (18.05%).

Aged fruits dry faster than freshly picked ones, since some of the moisture from them has already evaporated naturally, and the dry matter content, on the contrary, has increased.

When comparing the data in Figure 1 with the data in Figure 2, it becomes clear that these two varieties do not differ much from each other in terms of the rate of decrease in the content of leucoanthocyanins, which are most responsible for the tart taste of persimmons. In the persimmon "Hachiya" the content of leucoanthocyanins for the month decreased from 225.0 to 23.0 mg/100 g, in the persimmon "Hiakume" - from 42.3 to 3.85 mg/100 g, that is, approximately 10-11 times. And this is the strongest argument, emphasizing the vulnerability of the known approach based on the use of unripe hard fruits in drying. Moreover, the too high content of polyphenols in the

feedstock is associated not only with the deterioration of the taste of persimmons, but also with the rapid darkening of its pulp in contact with air oxygen.

Thus, the use of solid unripe persimmons in drying, although it promises certain advantages associated with the ease of its pre-processing, at the same time it does not contribute to obtaining 100% dried persimmons of the best taste. This is due to the fact that at this time, the best balance between the substances that cause the astringency of persimmon and other components of its chemical composition has not yet been formed. It is necessary to wait some time for the ratio between the above components to become optimal. You can also compensate for this lack in the taste of unripe hard fruits by using additives that can improve the color and taste of slices of hard persimmons before drying them.

### 3.2. The Essence of the Developed Technologies and the Expected Results from Their Commercialization

#### 3.2.1. Technology of Natural Chips

The main advantage of unripe and still quite hard ripe fruits is that they can be chopped using electric vegetable cutters.

In small persimmon fruits processing plants, an electric vegetable cutter "Robot couple cl 50 ultra" with a capacity of 5 kg of fruit/ /min can be used for this purpose; it is equipped with a volumetric hopper-receiver with an area of 139 cm<sup>2</sup>.

It is clear that it is easier to continue working with hard fruits. However, they are still very tart, and their flesh quickly darkens in contact with oxygen in the air due to the high content of leucoanthocyanins and catechins.

But it is necessary to involve them in drying in order to increase the duration of the drying season. With this in mind, a technology for producing natural chips from hard persimmon fruits has been developed, the essence of which can be understood from Figure 3.

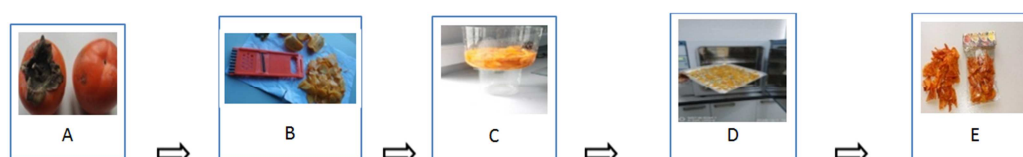


Figure 3. Block diagram of obtaining natural chips from solid persimmons.

It consists of the following.

The fruits (Figure 3, A) are first washed, then the peduncle and calyx are removed from each of them, after which they are cut into independent slices (depending on the size of the fruit, there may be 4 or 8 slices).

The amount of waste generated after such treatment is insignificant and does not exceed 20 g for each 1 kg of raw material.

The resulting slices are chopped into slices 2-3 mm thick, immediately dropping them into a pre-prepared mixture prepared from 1 part citric acid, 2 parts table salt and 40 parts water (Figure 3, B; Figure 3, C). When using an electric

vegetable cutter for this purpose, this mixture is poured into a container - receiver of sliced fruits.

With each repetition of this operation, a little new portion of it is added to the water mixture of citric acid and table salt. The mixture left over after processing four batches of slices is used to make other canned fruit.

The processed slices are carefully removed with a slotted spoon and laid out on the grates to drain the excess amount of syrup.

Slices treated with an acid-salt mixture are laid out on extruded grids with square cells measuring 5×5 mm (namely, on grids, and not on aluminum baking sheets, to which the



slices stick during their further drying) in one layer. One grid size of 35 cm x 35 cm can fit 600 g of processed slices.

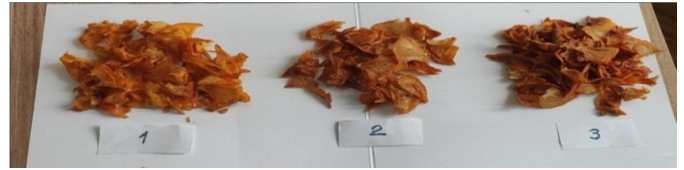
Nets with slices are placed on mobile racks and loaded into the drying chamber (Figure 3, D). Drying is carried out at a temperature of 70...72°C and finish after 3 hours, when the residual water content in the product is reduced to 11%.

The yield of dried slices from 1 kg of persimmon "Hiakume" (fruit weight 268 g; unused parts – the stalk together with the calyx 2.7 g and 3 seeds – 3.3 g) is  $216 \pm 0.4$  g.

Dried slices are packed in plastic bags with fasteners (Figure 3, E), in which they perfectly retain their original characteristics (including color) for 1 year or more.

This can also be seen from Figure 4, which shows the

appearance of three samples of chips after 6 months of storage at a temperature of no more than 10°C.



**Figure 4.** The appearance of three samples of natural chips obtained by persimmon "Hiakume" in the same way, with its shredding in a mixture of different composition: 1-a mixture of 1 part citric acid, 2 parts table salt and 40 parts water; 2-a mixture of 1 part table salt, 10 parts granulated sugar and 20 parts water; 3-a mixture of 1 part citric acid, 2 parts table salt and 80 parts water.

**Table 2.** The biochemical composition of three samples of natural chips obtained from the persimmon "Hiakume" in the same way, by chopping it in a mixture of different compositions: 1-a mixture of 1 part citric acid, 2 parts table salt and 40 parts water; 2-a mixture of 1 part table salt, 10 parts granulated sugar and 20 parts water; 3-a mixture of 1 part citric acid, 2 parts table salt and 80 parts water.

Samples	Water, g/100 g	Monosac -carides, g/100 g	Sucrose, g/100 g	Titratable acidity, g / 100 g of malic acid	Water-soluble polyphenols, g /100 g	Vitamin C, mg /100 g
1	8.0	50.49	1.28	3.62	0.16	13.33
2	8.0	50.80	1.33	1.67	0.38	8.00
3	8.0	53.00	0.18	2.48	0.20	10.55

Average value of 5 repeated definitions

They were obtained according to the proposed method from slices of the same persimmon "Hiakume", but with their aging before drying in mixtures with a slightly different composition.

It shows that all three samples with a well-preserved color of the raw material, but still chips from slices that were aged before drying in a mixture with number 1 (which consisted of 1 part citric acid, 2 parts table salt and 40 parts water) with a more attractive appearance.

Table 2 shows the chemical parameters of the chips of these three samples. It shows that the advantage is again in the sample with the number 1, since it retains more vitamin C than in the other two samples, and polyphenols, among which the tart forms predominate, are less.

### 3.2.2. Technology of 100% Dried Persimmon

Hard persimmons are easier to work with.



**Figure 5.** Block diagram of obtaining 100% dried persimmon.

Preparation of aged softened fruits for drying is as follows.

First, each such fruit is carefully washed separately under the tap and cut with a sharp knife crosswise from their tip to the very base into 4-8 approximately equal slices, leaving them attached with their lower end to the base of the fruit, where the calyx is located, and put on a lattice baking sheet. Then these not quite independent lobules are pushed apart until large spaces are formed between them and the fruit takes the form of an open flower with 4-8 "petals" (Figure 5, B).

But the slices from cutting the aged softened persimmon fruit (in this case, it is only possible by hand) almost do not change their original color, they become flexible, they can be pushed apart until the fruit takes the form of an open flower. While the slices obtained as a result of cutting hard fruits, with a significant shift, break off and become completely independent. But the most important thing is that the chemical composition of ripe fruits is more suitable for obtaining 100% dried persimmons, since they taste incomparably better than unripe hard persimmons.

Figure 5 is an illustration of the changes that occur with the raw material (Figure 5, A) during the implementation of the technology developed by us for the production of 100% dried persimmon.

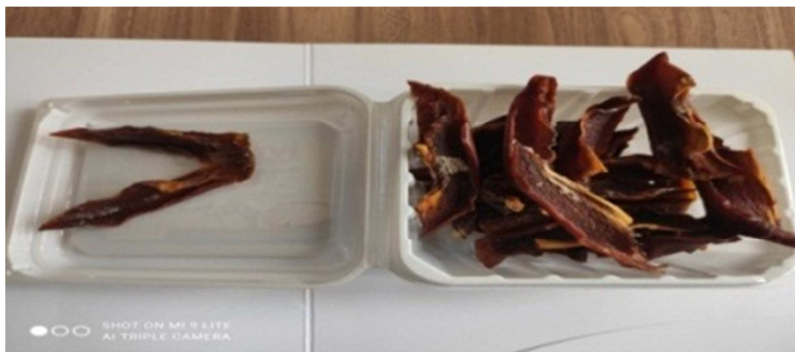
Drying of aged softened persimmons in this form is carried out in one layer at 70-72°C for 9.5-10.5 hours to a critical humidity of 24%.

Dried fruits (Figure 5, C) are divided by hand into parts, each of which may consist of two lobes connected to each other at the base (Figure 5, D), while the peduncles and calyxes are removed. The slices are packed in plastic bags with fasteners (Figure 5, E). For this purpose, plastic boxes with hinged lids can also be used.

The resulting 100% dried persimmon is stored at a

temperature no higher than 10°C in order to better preserve its initial color, which is almost the same as that of the raw material.

The shelf life of 100% dried persimmons is 6 months. This is the period after which a white coating consisting of sugar crystals appears on the slices (Figure 6).



**Figure 6.** Appearance of 100% dried persimmon "Hachiya" in 6 months after its production.

The yield of the finished product from 1 kg of aged unsoiled (seedless) persimmon "Hachiya" (fruit weight 205.5 g) was 284 g; waste from cleaning dried fruits (calyx, peduncle) was 15 g.

The yield of the finished product from 1 kg of poorly pollinated (1-2 seeds) aged persimmon "Hiakume" (fruit weight 290 g) was 280 g.

**Table 3.** Biochemical composition of 100% dried persimmon.

100% dried persimmon	Water, g/100 g	Monosac -carides, g/100 g	Sucrose, g/100 g	Titrateable acidity, g / 100 g of malic acid	Water-soluble polyphenols, g /100 g	Vitamin C, mg /100 g
"Hachiya"	24.0	49.45	8.70	1.18	0.28	7.79
"Hiakume"	24.0	45.28	3.08	0.94	0.18	7.44

Average value of 5 repeated definitions

Table 3, devoted to the results of the biochemical evaluation of the finished samples, shows that in 100% dried persimmon "Hachiya" the concentration of simple sugars and polyphenols is much higher than in 100% dried persimmon "Hiakume", which can serve as a reason to recommend them to different population groups.

## 4. Discussion

As can be seen, the effectiveness of the research is quite high both in terms of raising awareness about the physical and chemical characteristics of hard and softened persimmon fruits, and taking into account the effectiveness of the proposed solutions for drying them.

Two different states of the fruit in the post - harvest period

- hard and softened-led to the formation of two different approaches to their drying, which were then implemented in two different technologies for obtaining natural chips from hard persimmons, and 100% dried persimmons from softened persimmons. The first of these technologies is intended for use in the 1st month, while the persimmon is still quite hard, and the second - in the 2nd and 3rd post-harvest months.

Below are the estimated technical and economic indicators of a small production that can be created on the basis of the proposed technologies for the production of natural chips and 100% dried persimmons, calculated based on the current prices for raw materials, materials, energy, transportation costs, as well as the cost of labor in the territory of the Republic of Azerbaijan:

1)	Duration of the persimmon fruit processing season, in months	3
2)	Working hours	3 shifts per day (8 hours each), 24 working days per month
3)	Total time of one production cycle, hours. in the 1st month seasons - 4, in 2 and 3 months	11
4)	Maximum volume of raw materials loaded into the dryer at a time, kg	150
5)	Yield of finished products (on average), kg / 1 ton of fresh fruit	250
6)	Capacity of the drying area for finished products, kg / day; kg / for the entire season	75; 5400
7)	Daily and seasonal (3 months) demand for raw materials, kg	300; 21600
8)	Seasonal costs for the purchase of the annual volume of materials, raw materials and cold storage of its part in the amount of 14400 kg, AZN	20000
9)	The service life of the dryer cost 25000 AZN, years	10



10)	Payments for the refund of funds spent on the purchase of one dryer at a cost of 25,000 AZN, AZN /per 1 сезон	2500
11)	Cost of seasonal electricity consumption, AZN	3000
12)	Labor costs (per shift), person / hour	0.75
13)	The amount of salary expenses per day and for the entire season (3 months)	200; 18000
14)	The cost of a three-month lease of a production building, AZN	3000
15)	Costs for packaging and labeling of the seasonal volume of the finished product, AZN	1000
16)	Total production costs for the production of seasonal production volume, AZN	47500
17)	Cost of 1 ton of finished products, AZN	$47500 / 5.4 = 8796$
18)	Selling price of 50 g of prepackaged finished product, AZN	1.0
19)	Revenue from the sale of the total seasonal volume of the product (5400 kg), AZN	108000
20)	Profit from the sale of the total seasonal volume of the product (5400 kg), AZN	60502
21)	Product profitability - the ratio between the profit from the sale of 1 ton of products (11204 AZN) and its cost price (8796 AZN),%	127.4
22)	The ratio between the cost of 1 ton of products and the revenue from the sale of 1 ton of products (margin, profit ratio)	$11204 / 20000 = 0.56 \times 100 = 56\%$

This means that each 1 AZN spent in the first production season will bring a profit of 0.56 AZN (at the exchange rate of the State Bank of the Republic of Azerbaijan as of 01.01.2021, 1 AZN=0.59 \$ US).

As you can see, the total production costs for the production of the entire seasonal volume of 5.4 tons in monetary terms should be 47500 AZN, the revenue from its sale will be 108000 AZN, and the net profit-60502 AZN, which is 13000 AZN more than the amount required for the resumption of production.

The production of dried persimmons can extend the period of commercialization and export, as the moisture content and, consequently, the volume and weight are reduced. The shelf life increases due to low microbiological and biochemical damage, and the costs of packaging, storage and transportation are reduced [9]. Drying is also used as an option to control the astringency, as this process also has a positive effect on its reduction. In China, this is the main way to commercialize astringent persimmons, which are more suitable for drying than non-astringent varieties, because the latter turn brown and hard after drying [21, 22].

## 5. Conclusions

Although fresh persimmon has become popular as a functional product with high antioxidant activity, its involvement in industrial processing is slow, as there are many unresolved issues in this area.

In particular, this applies to the drying of persimmons, which is still carried out in an artisanal way in a fairly short post-harvest time, while it is still hard and it is fastened with a strong rope for the closely adjacent stems and dried for a month or two under a canopy.

This study allows you to extend the drying season of persimmons and increase its intensity, as well as change the form of presentation of drying products to the consumer, who would like them to be offered not in open form, but in a hygienic package, and most importantly-to get from this a benefit sufficient for reproduction.

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