Assessment of the nutritional value and prospects of using ziziphus fruit for a healthy human diet

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Abstract. In modern conditions of development of society, food products with antioxidant and immunostimulating properties are becoming increasingly important. This led to research to identify the natural sources of such compounds. Ziziphus fruits grown in the subtropical conditions of the Krasnodar territory of the Apsheron, Chinese 2A, Koktebel and Lakomy varieties were selected as objects of research. It was found that the highest content of pectin substances is allocated to the late-maturing variety Lakomy (7.23%), the lowest – mid-maturing variety Apsheron (4.72%). The fractional composition of pectin substances is represented by protopectin (PP) and soluble pectin (SP). At the same time, the highest content of both SP and PP was found in the ziziphus Lakomy variety (1.73 and 5.50%, respectively). By the highest content of flavonoids and the amount of phenolic compounds, the ziziphus Koktebel variety is distinguished, the lowest - the Chinese 2A variety. All varieties of unabi fruits had high values of total antioxidant activity. At the same time, the lowest antioxidant activity was observed in the Chinese 2A variety (381.9 mg/100 g), and the highest – in the Nikitsky Botanical garden selection variety Koktebel (503.2 mg/100 g). The antioxidant activity in the Apsheron variety (493.4 mg / 100 g) was 1.3 times higher than that in the Chinese variety 2A and slightly different from the Lakomy variety (488.3 mg/100 g). Experimental data confirmed the nutritional value of ziziphus fruits, which allows us to recommend them as a functional source of antioxidants and pectin substances.

1. Introduction

The rhythm of life and work of modern man requires large resources of the body in the form of biologically active substances to maintain all physiological systems. Plants are the natural source of such biologically active substances. One of them is a subtropical plant of jujube Zizyphus jujuba Mill. or the Chinese date (unabi, jojoba, chelon) (Ziziphus jujuba Mill), which is distinguished by valuable biological, medicinal and nutritional qualities [1]. Modern studies of ziziphus fruits have shown a high content of fruit sugars, starch, pectin substances, vegetable proteins, fats, minerals and trace elements. In terms of vitamin content, ziziphus fruits are superior to all known vitamin-bearing fruits [2].

This makes it widely used for the production of therapeutic and prophylactic food products, including drugs [3]. It is also proved that the components of unabi leaves are able to inhibit putrid
microflora, contribute to the creation of buffering in the system of minced fish, which can be used in the barrier technology of hydrolysates [4].

The composition of the main components of unabi fruit depends largely on the variety and climatic conditions of the growing area. The chemical composition of the main Chinese large unabi varieties zoned in the Western Caucasus of Russia, such as Ta Yan Zao, Gu Tao Zao, Du Bai Zao and Ucin Xun, has been well studied. These varieties can be preserved by various methods or consumed fresh [5, 6].

Employees of the University of southern Yandza studied the antioxidant properties of five varieties of unabi fruits grown in China [7, 8]. A team of scientists from the Chinese agricultural University conducted research to determine the total content of phenols and antioxidant activity in the skin and pulp of unabi fruits of Chinese selection. TEAC analysis revealed that 67-95 % of the antioxidant activity is in the skin and only 44-65 % in the flesh [9, 10].

Employees of the Chinese agricultural University under the leadership of Zhihui Zhao studied the composition and content of polysaccharides in the fruits of Chinese unabi. The predominance of highly branched pectin polysaccharides was found, which differed in the degree of branching and contained a large amount of uronic acid, arabinose, and galactose [11]. Phytochemical studies of unabi fruits have shown that they demonstrate pronounced medicinal properties associated with the presence of substances with antioxidant and immunostimulatory properties [12, 13].

In addition to triterpene glycosides, alkaloids, and vitamins, ziziphus fruits and leaves contain fairly high concentrations of phenolic compounds. They are mainly represented by derivatives of isospinosine, quercetin, apigenin, and kaempferol [14]. For humans, phenolic compounds are important as antioxidants [15, 16]. They are considered as p-group vitamins. They can directly belong to low-density lipoproteins (LDL) circulating in the blood and prevent their oxidation, as well as activate the synthesis of antioxidant enzymes in the human body, protect against epidemic, cardiovascular diseases, cancer, and senile dementia. Pectin substances with hypoglycemic, hypocholesterolemic, detoxifying and immunomodulatory properties are no less important component in a healthy diet [17-20].

In connection with the above, the study of phenolic and pectin compounds of ziziphus fruits grown in the South of Russia is of particular interest.

2. Materials and methods

We selected the southern region of Russia, in particular the Krasnodar region, as an experimental site.

On the black sea coast of the Krasnodar territory, the only subtropical zone in Russia is located, which occupies the coast from Tuapse to the Psou river. There are two areas of subtropical climate: dry Mediterranean from Anapa to Gelendzhik and humid subtropical.

We selected mid- and late ripening ziziphus fruits: Apsheron, Chinese 2A, Koktebel, and Lakomy (Figure 1 – 4).

![Figure 1. Fruit of Ziziphus jujuba Mill.](image1)

![Figure 2. Fruit of Ziziphus jujuba Mill. Chinese variety 2A (or 52)](image2)
Figure 3. Fruit of Ziziphus jujuba Mill.
Koktebel variety

Figure 4. Fruit of Ziziphus jujuba Mill.
Lakomy variety

Mid-ripe ziziphus fruits gain sweetness and reach technical maturity at the very end of September or in October. The ripening period of late-maturing varieties of ziziphus fruit is the end of October – the beginning of December.

For the quantitative determination of flavonoids, a technique was used based on their ability to form a colored complex with an alcoholic solution of aluminum chloride, which causes a batochromic shift of the long-wave absorption band and at the same time gives the main maximum of absorption with a wavelength of 400 nm.

The Apsheron variety (figure 1) was created by Krasnodar breeders. The average weight of the fruit is 6-8 g. They are chocolate-brown in color and resemble real dates. The flesh is tender, vanilla-colored, and the taste is bright, combining sweetness and a slight sourness. Full ripeness of the fruit is reached in the second half of October.

Chinese variety 2A is a variety of Chinese selection (figure 2). From China, it first came to America, and only then to Russia. Large (up to 25 g) fruits ripen by the end of October. Oval-elongated dates at the time of ripeness acquire a rich chestnut color. The light flesh is juicy and sweet. The sour taste is weak.

The Koktebel variety (figure 3) was created by Crimean breeders of the Nikitsky Botanical garden. The weight of the fruit is up to 50 g. Flesh is pistachio-white with a delicate sweet-sour taste. It ripens by the end of October.

The Lakomy variety (figure 4) is a variety of Tajik selection. The weight of the fruit is up to 35 g in weight. Flesh is cream-colored and has a sweet taste. It ripens in October-November.

For the quantitative determination of phenolic compounds, a method was used based on the oxidation of the Folin-Ciocalteu reagent containing sodium tungstate and sodium phosphomolybdate to form a blue complex with a maximum absorption at a wavelength of 730 nm, the color intensity of which is estimated by the photoelectrocolorimetric method. The ratio of raw materials and extractant is 1:10. Boiling 96% ethanol was added to the pre-dried prototype and left for a day. The ratio of the extract and the solution of the multiplexer is 1:1.

The total antioxidant activity was determined spectrophotometrically with aluminum chloride and Triton X100 using the FRAP method.

The method of quantitative determination of pectin substances in plant raw materials is based on extracting pectin from plant raw materials and converting it to a dissolved state. The basis of the study of the extracts of hydropectin and protopectin is the calcium-print method and precipitation with ethanol.
3. Discussion and results

One of the main valuable components of fruits is pectin substances. We conducted studies to determine the fractional composition and total content of pectin substances (figure 5).

In all the studied samples, the fractional composition of pectin substances (PS) is represented by protopectin (PP) and soluble pectin (SP). In this case, the content of protopectin prevails over the soluble fraction, which is natural for vegetable raw materials.

![Figure 5. Fractional composition of pectin substances in samples of ziziphus fruits of the studied varieties](image)

The results of experimental studies showed that the lowest content of hydratopectin (0.95%) was observed in the fruits of the Chinese 2A variety, the highest is in the Lakomy variety (1.73%). A high content of protopectin was also found in the fruits of the Lakomy variety (5.5%), and a low content was found in the Apsheron variety. The total content of pectin substances in the studied varieties of ziziphus fruit ranges from 4.72 – 7.23%.

The results of studying the content of phenolic compounds and flavonoids in ziziphus fruits of the studied varieties are presented in table 1.

| Varieties of ziziphus fruit | Flavonoids, mg / 100 g | Amount of phenolic compounds, mg / 100 g |
|-----------------------------|------------------------|----------------------------------------|
| Apsheron                    | 7.5                    | 430                                    |
| Chinese 2A                  | 7.1                    | 410                                    |
| Koktebel                    | 7.8                    | 451                                    |
| Lakomy                      | 7.6                    | 440                                    |

From the data shown, it can be seen that the highest content of flavonoids and the amount of phenolic compounds is allocated to the ziziphus Koktebel variety, the lowest-the Chinese 2A variety.

The results of determining the antioxidant activity (AO) in various varieties of unabi fruit are shown in Figure 6.

According to experimental data, all unabi fruit varieties had high values of total antioxidant activity. At the same time, the lowest antioxidant activity was in the Chinese 2A variety (381.9 mg/100 g), and the highest – in the Nikitsky Botanical garden selection variety Koktebel (503.2 mg/100 g). The antioxidant activity in the Apsheron variety (493.4 mg / 100 g) was 1.3 times higher than that in the Chinese variety 2A and slightly different from the Lakomy variety (488.3 mg/100 g).
4. Conclusion
The industrial varieties of ziziphus selected for study: Apsheron, Chinese 2A, Koktebel, and Lakomy showed high nutritional value as a source of pectin and phenolic compounds.

In ziziphus fruit, the highest content of hydratopectin was found in the Lakomy variety (1.73%), and the lowest content was found in the Chinese 2A variety (0.95%). The ziziphus Lakomy variety is also distinguished by the highest content of protopectin (5.50%), the lowest – the Apsheron variety (3.13%). In this case, the total content of pectin substances ranges from 4.72 to 7.23 %.

According to the content of flavonoids and the amount of phenolic compounds, the ziziphus Coctebel variety is distinguished.

Experimental data showed that ziziphus fruits had pronounced functional properties and had a high antioxidant activity in the range of 381.9 (Chinese variety 2A) – 503.2 mg/100 g (Koktebel variety).

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