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Economic and Nutritional Values of Walnut: The Main Reason for Development of Walnut in Uzbekistan

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A R T I C L E I N F O

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A B S T R A C T

This work systematically addresses the chemical composition, use, production and consumption of walnuts. The protein amino acid composition, fatty acid composition and vitamin contents of walnut kernel was analyzed. It was shown that walnut oils may be used to treat inflammatory processes and ulcers of the stomach and intestines and its therapeutic effect is associated with the presence of linoleic acid. The kernel cake remaining after the extraction of the oil contains a great deal of protein with high levels of essential amino acids. A delicious, useful and nutritious halva can be prepared from kernel cake. The kernel can also be used in the confectionery industry for the production of fillings for sweets, cakes, and chocolate. The review also describes the dynamics of walnut production, in the USA, Ukraine, Turkey, Iran, China, India, Brazil, Chile and the countries of the European Union as the largest producers. It also discusses that in Uzbekistan, walnuts were historically collected on farm plots as natural walnut forests, small plantations and household plots, but now there is an increased interest in improving walnut crops using the achievements of science and technology, as well as agrotechnical methods of cultivation. Using the work of scientists at the Uzbek Research Institute of Horticulture, Viticulture and Wine making the volume of production of this valuable product will increase in near future.

Introduction

Nutritional elements provides requisites for supporting human life, growth, development and performance. Plant-based products play a major role in providing nutrition. Moreover, information about the use of plants for their medicinal properties can be found in the most ancient written records of human culture (Chatrabnous *et al.*, 2018b; Pakrah *et al.*, 2021).

Among the products of plant origin, fruits occupy a special place in the human diet. Both fresh and canned fruits are widely used. The nutritional value of fruits lies in the fact that, along with vegetables, fruits are the main suppliers of vitamins, pectin substances, fiber, alkaline mineral elements (magnesium, sodium, potassium, and calcium), organic acids and carbohydrates. Due to their aroma, pleasant appearance, and delicate taste, fruits are powerful appetite stimulants. They enhance the secretory functions of all digestive glands. Under the influence of the organic acids and aromatic substances in fruits, the secretion of digestive juices increases. Therefore, regular consumption of fruits contributes to normal digestion and increases the absorption of proteins, fats, and mineral elements (Petrovsky and Samsonova, 1981).

Nut fruits, including walnuts, are significantly different in chemical composition from other fruits, due to the high content of fat and protein substances (Jahanbani *et al.*, 2018; Sarikhani *et al.*, 2021).

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It should be noted that in terms of useful properties, walnuts have no equal amount of raw materials as vegetables. Today, on a global scale, the largest walnut producers are China, the USA, Iran, Turkey, Ukraine, Chile, and some of the EU countries (Vahdati *et al.*, 2018).

Walnut grows quickly, lives a long time, adapts to a variety of conditions, bears fruit abundantly for several hundred years, and wide aisles of walnut plantations can be occupied by valuable fruit bushes, such as edible honeysuckle, which grows well and bears fruit in shade (Dorofeev, 1953; Strela, 1990; Petrova, 2000; Aslamarz, 2010).

Analysis of the structure of fruit crops cultivation areas in Uzbekistan shows that until now the areas under walnuts were insignificant. There is also very little scientific research on the study of commercial qualities, nutritional value, processing and rational use of walnut crops (Avanzato *et al.*, 2014).

In this regard, by the decree of the President of the Republic of Uzbekistan dated July 1, 2017, the Association of Walnut Producers and Exporters was formed (Mirziyoyev, 2017). The decision was aimed at stimulating the efficient use of rain-fed lands, increasing the walnut production, creating modern plantations and introducing science-based methods and intensive technologies for growing walnuts, with the support of foreign investment.

In this regard, the following tasks of this research have been identified:

To characterize walnuts as a source of complete protein, fats and other biologically active substances, as well as to track changes in the production of walnuts in the world and in Uzbekistan in recent years.

In recent years, significant research has been carried out on studying the genetic resources, phenology, biochemical properties, selection and propagation of walnuts (Ebrahimi and Vahdati, 2006; Hassankhah, 2017; Vahdati, 2019; Akça, 2020; Sarikhani, 2021), which increase the yield and prevalence of the walnut.

Objectives and research methods: Literature review was done using books, articles, reports, and notes describing the nutritional value, use, production, and consumption of walnuts, as well as global statistical and economic information on agriculture identifying the main producers of walnuts. The main research method is a comparative analysis of the works of scientists and researchers devoted to the chemical composition, nutritional and biological value, use, production and consumption of walnuts.

Since ancient times, walnuts have been considered as the most famous and valuable of all species of their kind, and this still remains true today. The walnut is a natural wonder, and in terms of the totality of its useful properties, it is almost unmatched with many of the world plants (Gomilevsky, 1885; Tuychiev, 1959; Egorov *et al.*, 2004; Ibragimov, 2007).

Productivity of walnut is distinguished from other plants. It is not without reason that it is also called a “wood-combine” (Zhilin, 1980). Almost all the components of the walnut tree, including the leaves, bark of the trunk, roots, and wood, green fruits, ripe fruits, and their shells, are used in various spheres of human activity (Avanzato *et al.*, 2014).

Its products are primarily used in food, followed by medicine, wood, furniture, building materials, fuel, animal feed, fertilizers, leather tanners, fabric dyes, cosmetics, emery, linoleum, decorative ornaments, tools, special oils, paints, varnishes, printing ink, as well as coolness, "orderly" air and much more (Strela, 1990; Zhilin, 1980). In short, this plant gives a person beauty, abundance and wealth. “Whoever said a kind word to you about a walnut, no matter what he praised him for, the one who praises him will be right” (Noskov, 1971).

The walnut kernel contains many nutrients that are of nutritional value for humans: fats (40-80 to 90%), proteins and carbohydrates (Table 1, Fig. 1),

Table 1. The chemical composition of a walnut (per 100 g of kernels).

Protein	16.2 g
Fats	60.8 g
Carbohydrates	11.1 g
Alimentary fibre	6.1 g
Water	3.8 g
Starch	7.2 g
Ash	2 g
Saturated fatty acids	6.2 g
Mono- and disaccharides	3.6 g

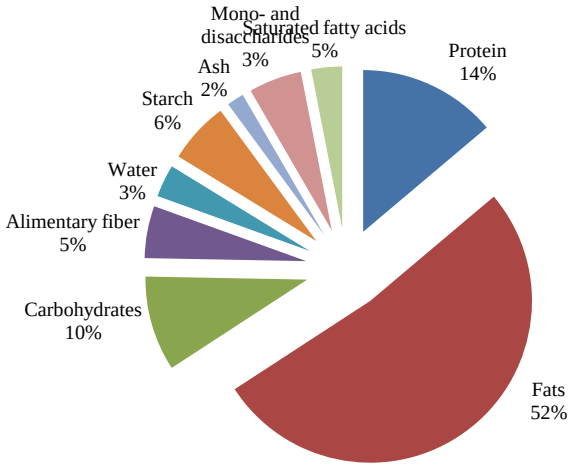


Fig.1.The share of the main components in the composition of the walnut.

Walnut also contains minerals: magnesium, nitrogen, phosphorus, calcium, iron, sulfur, cobalt, iodine, zinc, tannins, vitamins A, B1, B2, C, E, K, P, PP, and F (Table 2) and other biologically active compounds (Stepanova, 1972).

Table 2.The content of vitamins in walnuts (mg per 100 g of walnut kernels)

Vitamins	
Vitamin PP	1.2 mg
Beta carotene	0.05 mg
Vitamin A (RE)	8 µg
Vitamin B1 (thiamin)	0.39 mg
Vitamin B2 (riboflavin)	0.12 mg
Vitamin B5 (pantothenic acid)	0.8 mg
Vitamin B6 (pyridoxine)	0.8 mg
Vitamin B9 (folic acid)	77 mcg
Vitamin C	5.8 mg
Vitamin E (TE)	2.6 mg
Vitamin PP (niacin Equivalent)	4.8 mg
Vitamin K (phylloquinone)	2.7 mg

In total, the dry matter content reaches 95-97.5% of the total mass of the fruit kernel. The walnut kernel has a rich set of amino acids (Dementyev, 1966), with 16 free amino acids identified in the kernel of the nut and a total amount of 125.6-263.2 mg air-dried mass. Moreover, it is of particular value because almost half (35.5-47.5%) of these are essential amino acids — leucine, phenylalanine, valine, tryptophan, threonine, and lysine. The human body does not synthesize essential amino acids, which are necessary for proteins

synthesis. Therefore, they must be consumed as food proteins. The nutritional and medicinal value of proteins are determined precisely by the essential amino acid content. Walnut kernel fat is a complex mixture of various triglycerides, free fatty acids and a variety of non-fatty substances. Triglycerides also include fatty acids, which range from low molecular weight to high molecular weight. Walnut kernel fat contains palmitic, stearic, oleic, linoleic, linolenic and other acids. Linoleic and linolenic are polyunsaturated fatty acids (Rohi Vishekaii et al., 2021). Moreover, 73.4% of the fat content is composed of polyunsaturated fatty acids. According to the Soviet medical scientist (Gazaryan, 1999), polyunsaturated fatty acids of plants normalize the liver metabolism in the human body, as well as the ratio between prostacyclin and thromboxane, which reduces the risk of vasospasm and blood clots. Unsaturated fatty acids, which are also abundant in the walnut kernel, are important in the treatment and prevention of atherosclerosis and diabetes, cardiovascular diseases, some liver diseases, metabolic disorders, and others (Stepanchikova, 2001; Preobrazhensky, 2004; Pokrovsky, 2005). This is why nuts are widely consumed. The walnut kernel has useful fat and amino acid composition, that are easily digested and is a particularly valuable product in general, and it is irreplaceable in medical nutrition, especially for older individuals and children (Jahanbani *et al.*, 2016).

According to researchers, walnut oil contains a large amount of unsaturated fatty acids, mainly linoleic (6.84–69.2%) and linolenic (7–17.9%) acids (Aisenberg, 1956). These acids are indispensable for nutrition, necessary for vital activities of the human body, and in small doses are provisionally referred to as vitamins of group F. Unsaturated fatty acids, similar to essential amino acids, are not synthesized in the animal body and cannot be replaced by fatty acids that are part of animal fats. Unsaturated fatty acids are easily oxidized. Aviles, Garbuzov, Yuldasheva suggested that linoleic and linolenic acids protect the body against the action of carcinogenic substances. They have an antitumor effect, protecting healthy tissue from possible metastases. These acids are capable of increasing the body's resistance to radiation exposure (Garbuzov, 2005; Roozban *et al.*, 2015, Yuldasheva *et al.*, 2017).

The use of walnuts in medicine and other fields

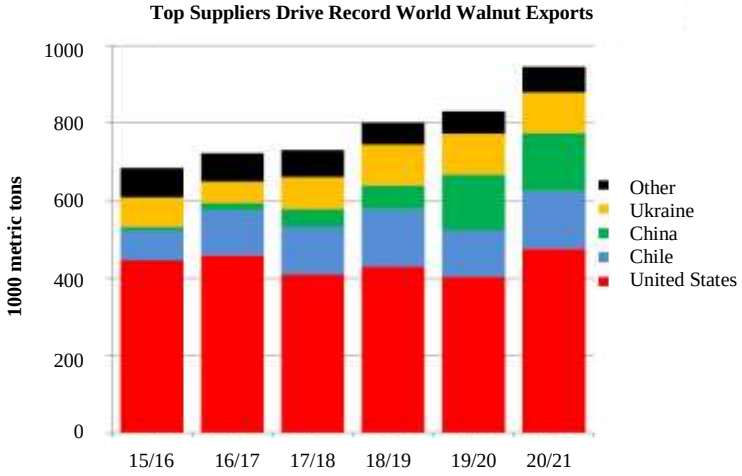
There are many studies on the successful use of kernels and walnut oil for the treatment of inflammatory and ulcerative diseases of the stomach, intestines, and the therapeutic effect is associated with the presence of linoleic acid (Boychinov, 1970; Eyyubova-Kasumova, 1975; Abdallah *et al.*, 2015; Chatrabnous *et al.*, 2018a). Walnut oil is used as an excellent food and dietary product for treatment of many diseases, and is also used for special technical purposes. Liquid walnut oil dries quickly and polymerizes, make it a strong elastic film (linoxin) forms on the surface of an object covered with oil. Walnut liquid oil is also widely used in the perfumery industry as a solvent for obtaining rose, violet and other essential oils, as well as for making the best varieties of soaps, mascara etc. Importantly, the oil keeps well, remaining edible for up to two years without loss of quality (Aisenberg, 1956).

The kernel cake remaining after the extraction of oil contains approximately 50% protein, including many essential amino acids (6.2 g per 100 g), 10% walnut oil, contains a large amount of mineral salts and other substances. Delicious, very healthy and nutritious nut halva is prepared from the kernel cake in Uzbekistan. In addition, cake is used in the confectionery industry in the production of fillings for sweets, cakes, chocolate and gingerbread (Pardaev and Normakhmatov, 2020).

Also, unripe walnut fruits are used in the food industry (Chatrabnous *et al.*, 2018a; Habibie *et al.*, 2019). It is known that the content of vitamin C in green walnuts is quite large. It has been established that green fruits contains up to 3-5 thousand mg of vitamin C, which is 3-4 times more than in wild rose, 5-6 times more than in black currant berries, 100 times more than lemons and oranges. Green fruits are also rich in vitamin P, organic acids, mineral salts, tannins, tonic substances, an alkaloid called juglone. In addition, they contain a lot of iodine, and therefore are used in

traditional medicine for the treatment of certain thyroid diseases. Jams, compotes, marinades, fortified infusions, liqueurs, wines and others used by humans for food are prepared from the green fruits of walnuts (Pardaev and Normakhmatov, 2020).

The use of walnuts in medicine is highly valuable because they are a treasure trove of substances that are useful for treating ailments and injuries and for strengthening the body (Korobkina, 1968) or necessary in the daily diet of adults and children. Scientists believe that walnuts stimulate the brain, fight depression and neuroses. The first results are noticeable within a month. Four nuts, eaten in one meal daily, protect against increased environmental radiation. Walnuts are also able to remove toxins from the body and stimulate and strengthen important organs, such as the heart, kidneys, liver, spleen, and gastrointestinal tract (Ladynina and Morozova, 1987). Nuts go well with all foods in Uzbekistan. It is especially useful to combine them with herbs, an excellent dietary product. Walnut oil has the highest content of PUFAs among all plant oils. It also protects body from the effects of carcinogenic substances, increases the body's resistance to radiation, removes radionuclides, and has an anti-tumor effect. Any part of a walnut can be used as a cancer prevention agent. These drugs have bactericidal, restorative, anti-sclerotic, moderately hypoglycemic, hemostatic, anti-inflammatory, astringent, laxative, anthelminthic, and epithelial wound-healing effects (Jahanbani *et al.*, 2016).



Production and consumption of walnuts in the world

Recorded global walnut production and trade are forecasted. Production continues to expand to 2.3 million tons in-shell basis, with China and the United States accounting for over 75 percent of total product. World's walnut export, dominated by the United States, are expected to rise 14 percent to 946,000 tons. World ending stocks are forecasted 20 percent higher to a record 140,000 tons on a sharp buildup in the United States (USDA, 2020).

U.S. production is forecasted up nearly 20 percent to a record 708,000 tons on both area and yield gains. A warm and dry January and February force growers to start irrigating earlier. The 2020 chilling hours were low. Leaf-out was prolonged, which resulted in uneven canopy and nut development. April rains increased infection to blight disease risk in walnut orchards. Nut sets looked good, with reports of tree limbs full of nuts. Exports are forecasted 18 percent higher to a record of 475,000 tons because of higher shipments to the European Union, Turkey, and the United Arab Emirates. Despite consumption continuing to expand, recorded production is expected to increase.

China production is forecasted up just 2 percent to 1.0 million tons on favorable growing conditions. Although domestic consumption is expected to nearly 90 percent of output, exports to Kyrgyzstan and Kazakhstan have risen sharply in the recent years and this trend is expected to be continued. Imports are

expected to remain almost unchanged at just 20,000 tons as consumers continue to rely on domestic products. China's SCTC launched a tariff exclusion process on March 2, 2020 where importers can apply for tariff exclusions on specific consignments from the United States (USDA, 2020). If an exclusion application is successfully approved, the section 301 tariffs imposed on U.S. products would be exempted for a year from the date of approval.

Chile production is forecasted to raise 20% equal to 150,000 tons as output rebounds from last year's damaging drought and cultivated area continues to expand. Exports are expected up similarly to Chile's top market, the EU.

Ukraine production is forecasted to remain unchanged at 126,000 tons on normal growing conditions. Exports to top markets, the European Union and Turkey, are expected unchanged.

Chile demand is driven by snack foods and cooking ingredients on the retail side and pastries on the industrial side.

World exports and consumption of nuts will grow compared to previous years. We can see this in the Table 3.

Table 3. A summary of walnut production and domestic consumption (Metric tons, in-shell basis)

	2015/16	2016/17	2017/18	2018/19	2019/20	Oct 2020/21
Production						
China	1, 000, 000	1, 060, 000	1, 000, 000	850, 000	1, 000, 000	1, 020, 000
United States	549, 754	625 , 000	571, 527	613, 257	592, 392	707, 604
Chile	80, 000	119, 000	126, 000	150, 000	125, 000	150, 000
Europen Union	117, 928	116, 670	121, 000	130, 000	133, 000	127, 000
Ukraine	115, 080	108, 000	108, 660	127, 190	125, 900	126, 000
Turkey	60, 000	63, 000	58, 000	63, 000	65, 000	67, 000
India	33, 000	32, 000	32, 500	34, 000	35, 000	35, 000
Other	41, 900	51, 900	53, 600	42, 800	49, 300	51, 300
Total	**1, 997, 622**	**2, 175, 620**	**2, 071, 287**	**2, 010, 247**	**2, 152, 925**	**2, 283, 904**
Domestic consumption						
China	1, 075, 500	1, 088, 400	980, 00	809, 900	875, 300	890, 000
Europen Union	310, 228	355, 170	387, 100	390, 100	420, 100	452, 000
United States	134, 576	194, 435	171, 611	184, 732	194, 112	210, 000
Turkey	117, 600	119, 400	127, 100	139, 800	145, 100	149, 000
India	43, 400	45, 500	45, 100	44, 900	61, 800	66, 400
Kyrgyzstan	0	1, 700	7, 600	34, 900	54, 800	60, 000
United Arab Emirates	15, 100	32, 700	28, 100	58, 700	44, 500	55, 000
Japan	40, 400	45,800	49, 700	43, 400	42, 000	50, 000
Canada	18, 300	20, 800	26, 500	28, 800	28, 900	30, 800
Korea, South	31, 400	32, 100	28, 800	30, 800	27, 000	30, 000
Other	174, 230	166, 454	174, 349	185, 714	165, 000	200, 200
Total	**1, 960, 734**	**2, 102, 459**	**2, 025, 960**	**1, 951, 746**	**2, 058, 612**	**2, 193, 400**

The largest producers of walnuts, as we can see from the diagram, are China and the United States of America (USDA, 2020).

Whereas walnuts were previously generally used as ingredients in the production of confectionery, the consumption of walnuts as a snack has been on the rise recently due to an increase in healthy eating among Turkish consumers. In Uzbekistan, historically, the collection of nuts has been carried out on farm plots of natural walnut forests and small plantations, where the average yield is 100-150 kg per tree (Ozolin, 1990). At present, the Republic has seen increased interest in applying the achievements of science and technology, as well as agro-technical

methods of cultivation, to nut crops. Recently, considerable progresses have been made in improving walnut production (Thapa et al., 202; Farsi et al., 2018; Rahemi *et al*., 2016). All this will contribute to uninterrupted supply of nut products to the population. Using the work of scientists of the Uzbek Research Institute of Horticulture, Viticulture and Winemaking, [Research Institute of Horticulture] as well as its branches in the regions, the volume of production of this valuable product will increase soon. In 2018, specialists from the agro-industrial complex of the Samarkand region, scientists, entrepreneurs and growers made a technical tour to Turkey. In this tour, they took particular care to study the experience of local growers in growing walnuts in mountainous and foothill conditions. During the visit, they chose the Chandler variety, which is capable of adapting to their local climate, water, and soil (Nikitinsky, 1970). It is also important that the fruits of this variety are large, the shell is thin, and the kernel of the nut is white. All these components meet the market requirements, noted the director of the Samarkand branch of the M. Mirzaev Research Institute of Horticulture, Viticulture and Winemaking. The workers of the branch have already prepared two hectares of land for growing walnut. In 2019, walnut plantations were laid out in the Urgut region in an area of 4.5 thousand hectares. In the future, they will appear in the Dzhambay region.

The rapid growth of production in the agricultural sector is one of the main factors in the overall recovery of the state's economy. With the aim of reforming agricultural and economic relations in the countryside, President Sh. Mirziyoyev instructed to develop a program to increase the production of walnuts (Mirziyoyev, 2017). The Association of Walnut Producers and Exporters has been established in Uzbekistan. The new organization will form a Walnut Research Center, a Walnut Logistics Center, MTP Sag agro, as well as Yongokagro territorial organizations in Jizzakh, Kashkadarya, Surkhandarya, Namangan and Tashkent regions. Among the main tasks of the association being created is the implementation of programs for the creation of modern plantations of high-yielding varieties of walnut adapted to local natural and climatic conditions, as well as the widespread introduction of scientifically based cultivation methods and modern resource-saving technologies.

Conclusions

All of the above results indicate that walnuts are superior to other types of fruit products in terms of their chemical composition, and especially in terms of proteins and fats. Due to the high biological value of the protein amino acid and fatty acid composition, they can be successfully used in confectionery, baking and other industrial enterprises as food fortifiers. Additionally, walnut fruits are widely used in pharmacology. The study of the current state of world production shows that at the time, the main producers are the USA, China, Iran, Ukraine, Turkey and EU countries.

In Uzbekistan, after gaining independence, conditions for the development of horticulture and vegetable growth were created by reducing the area of cotton as a monoculture and using the vacated areas for new species. It is obvious that the key to the successful development of walnut production in Uzbekistan must be based on the use of scientific achievements and advanced cultivation technologies in the agricultural sector.

Conflict of interest

We have no conflict of interest to declare.

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