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Eureka Journal of Agricultural Science & Bio-Innovation (EJASB)

ISSN 2760-4969 (Online) Volume 2, Issue 5, May 2026

https://eurekaoa.com/index.php/7

AGROTECHNOLOGY OF CULTIVATION, BIOCHEMICAL COMPOSITION, AND POTENTIAL APPLICATIONS OF BALKHI AND SHOTUT FRUITS IN THE FOOD INDUSTRY

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ABSTRACT

This article analyzes the agrotechnology of cultivation, biochemical composition, and prospects for the industrial processing of medicinal and nutritionally valuable Balkhi (white mulberry) and Shotut (black mulberry) fruits grown under the climatic conditions of Uzbekistan during seasonal vegetation periods. In addition, based on the data presented in the article, a comparative study was conducted on the chemical composition of the fruits, particularly focusing on the content of dry and soluble substances, natural sugars, organic acids, and mineral elements. Furthermore, relying on the scientific heritage of the great physician Abu Ali ibn Sina (Avicenna), the medicinal properties of these fruits and their potential use in food technology for producing dietary and traditional natural products such as mulberry syrup, juice, vinegar, raisins, and talqon were highlighted. The study also scientifically substantiates the high polyploid characteristics of Shotut and its practical significance in the confectionery, juice, and winemaking industries, especially as a source of natural food coloring agents and antioxidants.

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Keywords: Balkhi mulberry, Shotut, agriculture, sericulture, cultivation agrotechnology, vegetation period, mulberry fruit, biochemical composition, medicinal properties, food industry, processing, medicinal plants, natural products, mulberry syrup, juice, vinegar, raisins, talqon, natural dyes, processing technology.

Introduction

The mulberry tree (Morus L.) has long held significant strategic importance in the agricultural sector of Uzbekistan. Traditionally, this branch of agriculture has mainly been focused on providing a nutritional base for sericulture. However, in recent years, ensuring food security, supplying the population with natural products possessing high medicinal value, and diversifying the raw material base have become urgent priorities in the country.

Particularly within the agro-industrial complex, extensive attention has been given to the deep processing of fruit-bearing mulberry species — Balkhi mulberry (white mulberry variety) and Shotut (black mulberry variety) — as well as to the opportunities for obtaining high value-added products for the food industry from these fruits.

One of the major trends and requirements of modern food technology is the production of medicinal and dietary food products with enhanced therapeutic properties. Balkhi and Shotut fruits fully satisfy these requirements due to their rich biochemical composition, including natural sugars, vitamins, organic acids, anthocyanins, and mineral substances.

At present, products such as mulberry syrup, juice, vinegar, raisins, talqon, and halva are produced from these fruits using traditional methods by small-scale entrepreneurial entities. Nevertheless, the level of industrial-scale processing, shelf-life extension, and export-oriented production of finished products remains insufficient. One of the main reasons for this is the high perishability and seasonal

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nature of Balkhi and Shotut fruits, as well as the lack of properly established technological enterprises capable of ensuring their efficient utilization.

Research Methodology and Materials

Since this article is analytical and comparative in nature, the research methodology is based on the systematic use, selection, analysis, and generalization of existing scientific literature, laboratory research findings, and international experience related to the propagation methods of Balkhi and Shotut mulberries, cultivation agrotechnology, biochemical composition, medicinal properties, and food processing technologies.

The process of evaluating and analyzing the research results was carried out through a comparative assessment of information published in scientific journals and publications related to agriculture and food technologies. In order to identify relevant scientific literature on the topic, both international and national electronic scientific databases were utilized. The generalization and analysis of the conducted research findings were based on resources from **Google Scholar, Scopus, Web of Science, CyberLeninka**, and the electronic resources of the National Library of Uzbekistan named after Alisher Navoi.

In systematizing the selected scientific sources and analyzing the obtained research results, particular attention was focused on the following three main directions:

- **Cultivation, biochemical composition, and nutritional evaluation of Balkhi and Shotut fruits:** A comparative analysis was conducted on the percentage composition of water, soluble substances, sugars, acids, and mineral elements contained in Balkhi and Shotut fruits.
- **Technological and industrial opportunities for fruit processing:** Technologies for processing the fruits under household and industrial conditions, including sterilization duration, drying methods, and concentration parameters for syrup production, were analyzed. In addition, the potential use of the high

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polyploid characteristics of Shotut in the winemaking and natural dye industries was evaluated.

- **Therapeutic and medicinal significance:** Based on the descriptions of Abu Ali ibn Sina (Avicenna) and data from modern medicine, the scientific basis for using these fruits as components of dietary food products was summarized.

Results and Discussion

A systematic analysis of existing scientific literature, conducted laboratory studies, and historical-medical sources demonstrates that Balkhi mulberry and Shotut fruits are strategically valuable raw materials for the food industry due to their biochemical composition and technological characteristics. The findings obtained from the literature review were analyzed across several fundamental directions.

In particular, the cultivation agrotechnology, biochemical composition, and medicinal properties of Balkhi and Shotut fruits were examined based on the scientific studies conducted by R.S. Wang, P.H. Dong, X.-X. Shuai, Chen, S. Ercisli, E. Orhan, J. Chen, J. Kan, J. Tang, C.J. Wang, E.M. Sanchez-Salcedo, P. Mena, C. Garcia-Viguera, J. Jose Martinez, F. Hernandez, M. Obanda, P.O. Owuor, S.J. Taylor, D.P. Makris, G. Boskou, N.K. Andrikopoulos, L. Butkhup, W. Samappito, S. Samappito, M.M. Radojkovic, Z.P. Zekovic, S.S. Vidovic, D.D. Kocar, P.Z. Maskovic, M. Ozgen, S. Serce, C. Kaya, K. Ogursov, M.I. Grebinskaya, O‘. Qo‘chqorov, U. Bakirov, and A. Po‘latov.

At the same time, in food technology, the chemical composition of Balkhi and Shotut fruits serves as a primary indicator in determining their nutritional value and identifying suitable processing directions.

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Balkhi mulberry fruit (Morus alba) **Shotut fruit (Morus nigra)**

Figure 1. Fruits and morphological appearance of the main mulberry species cultivated in the Republic of Uzbekistan.

Based on laboratory analyses presented in the selected scientific sources, the principal components of Balkhi mulberry, Shotut, and reddish mulberry fruits were comparatively evaluated (Table 1).

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Table 1 Chemical composition of mulberry fruits

Chemical Indicators	Balkhi mulberry (White mulberry)	Shotut (Black mulberry)	Reddish mulberry
Water	81.84	83.95	81.56
Insoluble substances	4.28	5.97	3.17
Soluble substances	16.27	10.28	15.07
Total sugars	10.91	5.52	14.08
Inverted sugars	10.32	5.09	13.25
Sucrose	0.59	0.42	0.83
Acidity (in terms of malic acid)	0.62	0.83	0.94
Tannins	0.082	0.157	0.106
Fiber	1.67	2.68	1.08
Nitrogenous substances	1.46	1.39	1.29
Ash	0.90	0.86	0.89
Phosphoric acid	0.120	0.116	0.098

The analysis of the research results demonstrates that Balkhi mulberry is distinguished by its high content of soluble substances (16.27%) and total sugars (10.91%). These indicators confirm its suitability as a natural sweetening raw material for the production of confectionery products and concentrated mulberry syrup (shinni) without the need for additional sugar. In contrast, although the sugar content of Shotut fruit is relatively lower (5.52%), it was found to possess higher acidity (0.83%) and tannin content (0.157%).

According to biological studies, Shotut is characterized by a high level of polyploidy. The number of chromosomes in Shotut is approximately eleven times greater than that of white mulberry. This genetic characteristic contributes to the stable and concentrated accumulation of pectin substances, vitamin C, carotene, essential oils, and organic acids in the fruit.

In this regard, the great scholar and physician Abu Ali ibn Sina (Avicenna), in his work The Canon of Medicine, provided a detailed analysis of the medicinal

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properties of white and black mulberries. Avicenna referred to Shotut as "sour mulberry" or "Syrian mulberry" and described it as follows: "White mulberry possesses warming properties, whereas Shotut has cooling characteristics. The juice of white mulberry and Shotut was considered an effective remedy for treating patients with high blood pressure, sore throat, and inflammatory conditions of the oral cavity such as angina and gum inflammation. Its raisins, freshly squeezed juice, and syrup were also used for treating cracks of the lips and tongue, as well as oral ulcers."

Modern medical and biochemical literature also confirms these findings. In traditional medicine, white mulberry fruit has been studied as a blood-purifying and hematopoietic (anti-anemic) remedy used in cases of fever and intestinal disorders. Meanwhile, decoctions prepared from the dried leaves of Shotut, due to their tannin, vitamin C, and vitamin B_2 content, are recommended for the treatment of hypertension.

Scientific sources substantiate several technological approaches for extending the shelf life of Balkhi and Shotut fruits and for their deep industrial processing. These fruits possess significant potential for application in the canning and confectionery industries. However, the extremely soft texture of the fruits and their rapid deterioration after falling to the ground — especially in the case of Balkhi mulberry, which ripens during May–June — limit their long-term storage capacity. The literature describes a preservation technology for Shotut fruits involving mixing them with sugar (300–350 g of sugar and 650–700 g of fruit per 1-liter jar) followed by steam sterilization for 10–15 minutes. This method ensures the preservation of the product for up to 1–2 years without spoilage.

Due to the relatively high sucrose content (0.59%) and total sugar concentration in Balkhi mulberry, additional sugar is not required in the production of mulberry syrup (concentrated extract) and juice derived from this fruit.

Furthermore, raisins can be produced by sun-drying Balkhi mulberry fruits, while grinding the dried fruits in a mortar makes it possible to obtain talqon and sweet

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masses that can subsequently be processed into halva. These products represent completely natural raw materials for the confectionery industry.

Balkhi and Shotut fruits can also serve as primary raw materials for the production of various natural products with high beneficial properties, as well as for the winemaking industry. The extended ripening season of Shotut fruits, lasting from June to September, enables their use as a stable raw material source. Moreover, the organic acids (0.83%) and pectin substances contained in Shotut facilitate juice extraction and pressing technologies.

Figure 2. Types of canned products produced from Balkhi and Shotut mulberry fruits

According to studies conducted by researchers, the technology of producing wine from second- and third-grade (industrial-grade) Shotut fruits provides high economic efficiency. Wine produced from Shotut is characterized by a deep ruby-red color, a distinctive pleasant aroma, and a sweet-sour taste. Experts have evaluated this wine significantly higher than traditional wines made from apples

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and plums in terms of biological activity and organoleptic properties. This indicates that Shotut can serve as a strong local alternative and import-substituting source for synthetic colorants and flavoring agents used in the non-alcoholic beverage and winemaking industries.

CONCLUSION AND PRACTICAL RECOMMENDATIONS

The literature review and systematic analyses conducted on the biochemical composition, medicinal properties, and processing technologies of Balkhi and Shotut fruits make it possible to draw the following fundamental conclusions:

- Balkhi mulberry fruits, due to their high sweetness level (total sugars – 10.91%), represent a ready natural source for producing natural sweetening products such as sugar-free mulberry syrup, juice, raisins, and talqon. Shotut, owing to its genetic polyploidy (with a chromosome number 11 times greater than that of white mulberry), is rich in organic acids, pectin, and anthocyanins, making it a strategically important import-substituting raw material for the food industry, particularly in the production of natural colorants and high-quality premium wines.
- The integration of modern biochemical studies confirms that these fruits and their processed products possess therapeutic effects against hypertension, anemia, diabetes mellitus, and respiratory diseases. This allows them to be classified as functional and dietary food products.
- In order to solve the problems associated with the seasonal nature and rapid perishability of these fruits, it is necessary to introduce household-tested technologies such as steam sterilization (10–15 minutes) and sugar-based preservation into industrial-scale production through the implementation of modern aseptic packaging lines.

Based on the above conclusions and the obtained research findings, the following recommendations are proposed:

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- In order to ensure a continuous supply of high-quality raw materials for food industry enterprises, it is necessary to establish specialized nurseries for the propagation of varietal seedlings through vegetative methods, as well as specialized Balkhi and Shotut orchards in various regions of the republic.
- In the cultivation of fruit-bearing varietal mulberry seedlings, the most effective propagation methods — including budding, root grafting, and bark grafting — are recommended. During the vegetation period, irrigation should be carried out 7–8 times, while mineral fertilizers should be applied at the rate of 120 kg of nitrogen, 60 kg of phosphorus, and 30 kg of potassium per hectare in pure nutrient form. These agrotechnical measures ensure the maximum accumulation of essential soluble solids and vitamins in the fruits.
- It is advisable to expand the production of various natural local products derived from Shotut, including mulberry syrup, juice, vinegar, and raisins. In addition, the use of Shotut extract as a natural coloring agent in the confectionery and soft beverage industries instead of synthetic additives is highly promising. Furthermore, the development of export-oriented brands of talqon and halva products produced from Balkhi mulberry is considered economically and technologically beneficial.

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