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Potential for apricot farming and processing in Central Asia

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Abstract. Apricot (*Prunus armeniaca* L.) remains one of the key fruits of temperate zones, with Central Asia serving as a major centre of its origin and genetic diversity. The study aimed to evaluate the economic potential of fresh and dried apricot production and trade worldwide, with a special focus on Central Asian countries, and to assess the efficiency of various drying technologies. Data from FAOSTAT, WITS, Tridge and WTO for 2020-2025, along with a systematic review of scientific literature on drying technologies (Scopus, Web of Science, etc.), were used; return on investment (ROI) and gross profit were calculated for traditional sun drying, convective, infrared and freeze-drying methods assuming an annual output of 50 tonnes of dried apricots. It was established that global apricot production reached approximately 4.5 million tonnes in 2024; Turkey, Uzbekistan and Iran remain the leading producers, but in 2025 catastrophic spring frosts in Turkey (particularly in Malatya province) reduced output, causing a sharp rise in global prices for fresh and dried apricots. In Central Asia, Uzbekistan (~526-540 thousand tonnes in 2024), Tajikistan (~313-348 thousand tonnes in 2024-2025) and Kyrgyzstan (~57 thousand tonnes in 2023-2024) demonstrate substantial export potential; Turkey exported dried apricots worth USD 404.5 million in 2024, yet regional suppliers (especially Uzbekistan and Tajikistan) gain competitive advantages in 2025. ROI calculations showed: sun drying – 7.3%, convective – 23.4%, infrared – 28.5%, freeze-drying – 33.9%; infrared and freeze-drying provide the highest product quality. The findings can be applied by farmers, processors and investors in Central Asia (primarily Kyrgyzstan) to select appropriate drying technologies, reduce post-harvest losses and access premium export markets (EU, USA, Russia)

Keywords: harvested area; yield; drying technology; equipment; return on investment; operating costs

Introduction

Central Asia represents a pivotal centre of origin and genetic diversity for apricots (*Prunus armeniaca* L.), providing an abundance of germplasm resources vital to

global breeding and conservation initiatives. The region's agro-ecological zones support extensive apricot cultivation, making this fruit a cornerstone of rural

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livelihoods and agricultural income across Kyrgyzstan, Uzbekistan, and Tajikistan. However, the sector faces mounting challenges stemming from environmental degradation, climate variability, and institutional fragmentation following the collapse of collective farming systems in the early 1990s. F. Su *et al.* (2024) demonstrated that Central Asian countries, characterised by fragile ecosystems and less advanced agricultural infrastructure, are particularly vulnerable to climate change impacts on food security. A. Mirzabaev *et al.* (2023) identified land degradation as a critical barrier to poverty reduction across the region, threatening the sustainability of fruit production systems. These environmental pressures are compounded by socio-economic constraints; A. Azarov *et al.* (2019) documented how smallholder farmers continue to struggle with market access, technological gaps, and resource limitations inherited from post-Soviet transitions. Despite these challenges, Y. Zhang *et al.* (2025) argued that Central Asia's abundant per-capita land resources present significant opportunities for achieving food self-sufficiency and contributing to global food security through strategic agroforestry development.

Apricots hold particular economic and nutritional importance in this context. The fruit is cultivated predominantly in regions characterised by warm, dry summers and cold winters, with mature trees yielding 22.5-90 kg annually depending on climatic conditions and management practices. Apricots provide essential dietary components including fibre, minerals (potassium, calcium, iron, magnesium), vitamins A and C, and B-complex vitamins (U.S. Department of Agriculture, 2022). A. Ahmed *et al.* (2020) highlighted the fruit's rich phytochemical profile, including antioxidants, carotenoids, and xanthophylls, whilst M. Al-Soufi *et al.* (2022) emphasised regular apricot consumption's role in chronic disease prevention. Beyond fresh consumption, apricot processing generates significant value-added opportunities. N. Karataş & M. Şengül (2020) described diverse utilisation pathways including drying, canning, and juice production. Apricot kernels and shells represent promising by-products; M. Kiralan *et al.* (2019) documented their applications in oil extraction, cosmetics, and benzaldehyde production, whilst recent research has explored their potential in activated carbon manufacturing.

The short shelf life of fresh apricots necessitates effective preservation technologies. Drying remains the most widely adopted method for extending storage duration and enabling year-round market access. Traditional sun drying dominates in Central Asia due to favourable climatic conditions and minimal capital requirements; however, this approach suffers from quality inconsistencies, hygiene concerns, and weather dependency. S. Kayran & İ. Doymaz (2021) noted that sulphur dioxide (SO₂) pre-treatment is commonly employed to preserve colour and inhibit microbial growth,

yet M. Tynarbekova *et al.* (2025) emphasised growing consumer demand for organic, sulphur-free products, particularly in premium export markets.

This study aimed to analyse current global and Central Asian apricot production trends, evaluate the economic potential of fresh and dried apricot trade with particular attention to the 2025 Turkish frost crisis, and compare the techno-economic viability of traditional and modern drying technologies. The findings were intended to inform investment decisions and technology selection for processors and farmers in Central Asia, particularly Kyrgyzstan, to reduce post-harvest losses and access higher-value export markets.

Materials and Methods

This study employed a secondary data analysis approach combined with a comparative techno-economic evaluation of apricot drying technologies. All analyses focused on global and Central Asian apricot production and trade trends up to the most recent available years (primarily 2020-2025), with particular emphasis on the disruptive impact of the 2025 spring frost in Turkey. Production, yield, and harvested area data for fresh apricots worldwide and in selected Central Asian countries (Kyrgyzstan, Uzbekistan, Tajikistan) were retrieved from the FAOSTAT (n.d.) database. Export and import statistics for fresh and dried apricots in 2023-2024 were obtained from Tridge (n.d.), WTO (n.d.), and WITS (2024) reports. Data on the 2025 Turkish frost impact and resulting production collapse were compiled from industry reports and market analyses.

To review drying technologies and post-harvest loss reduction strategies, a systematic literature search was conducted in the following databases: Scopus, Web of Science, ScienceDirect, PubMed, Google Scholar, and Semantic Scholar. Keywords included "apricot drying", "dried apricot production", "infrared drying apricot", "freeze-drying fruit", "post-harvest losses apricot", "Central Asia", "Kyrgyzstan", "Uzbekistan", "Tajikistan", and "Turkey". Inclusion criteria limited publications to the period 2000-2025.

The economic comparison of drying methods was performed using a standardised scenario assuming an annual production target of 50 metric tonnes of dried apricots (equivalent to ~333 tonnes of fresh apricots at an average drying yield of 15%). Key assumptions included:

- purchase price of fresh apricots: USD 0.20 per kg (conservative regional average for smallholder supply in Central Asia);
- full capacity utilisation and 200 operating days per year;
- technology-specific selling prices for dried product reflecting quality differences (higher for infrared and freeze-dried apricots due to premium positioning);
- operating expenditures (OPEX) encompassing raw materials, energy/utilities, labour, packaging, logistics, and maintenance;

● capital expenditures (CAPEX) limited to drying equipment and basic processing infrastructure (sourced from 2025 equipment quotations and literature estimates).

Return on investment (ROI) was calculated using the formula (1):

$$ROI (\%) = (\text{Annual net profit} / \text{CAPEX}) \times 100, \quad (1)$$

where annual net profit = annual revenue – annual OPEX.

Gross profitability was defined as (Revenue – OPEX including depreciation)/Revenue.

All financial metrics exclude financing costs, taxes, land acquisition, detailed depreciation schedules, and inflation effects to ensure cross-technology comparability. Results represent indicative benchmarks and are sensitive to input price volatility, energy tariffs, and market access; project-specific feasibility studies are recommended prior to investment. Data processing and visualisation were carried out using Microsoft Excel. All monetary values are reported in United States dollars (USD) at the respective years' average exchange rates.

Results and Discussion

Key economic indicators for apricot production worldwide

Figure 1 shows an increasing tendency of apricot production worldwide from 2000 to 2024 according to the Food and Agriculture Organization (FAOSTAT, n.d.). Worldwide apricot production amounted to approximately 4.5 million t in 2024.

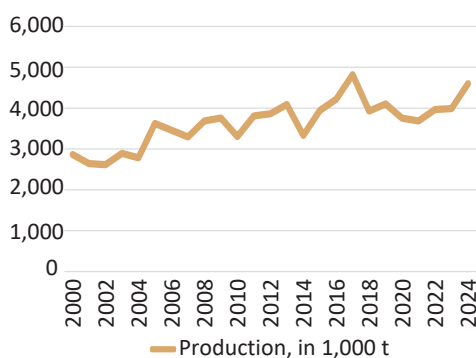


Figure 1. Production of apricots in world from 2000 to 2024

Source: compiled by the authors based on FAOSTAT (n.d.)

In 2022, apricot production remained relatively stable, with Turkey (639.67 thousand tonnes), Uzbekistan (347.47 thousand tonnes), and Iran (319.33 thousand tonnes) maintaining their positions as the world's leading producers (Fig. 2). Collectively, these countries dominated global output. By 2024, however, the production landscape had evolved, with Tajikistan and Greece gaining prominence among major apricot-producing nations.

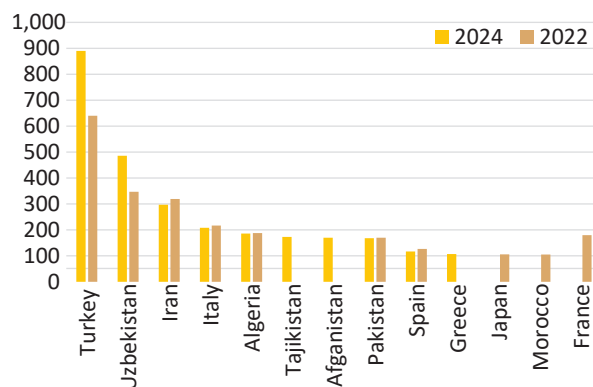


Figure 2. Top 10 countries in the world in terms of apricot production in the years 2022 and 2024
Source: compiled by the authors based on FAOSTAT (n.d.)

Turkey is the world's largest apricot producer, accounting for over half of global dried apricot output, with traditional production concentrated in Malatya and surrounding provinces. (Poyraz & Gül, 2022). According to A. Polat & O. Caliskan (2013), apricot cultivation is practised in almost all regions of Turkey, except the particularly humid areas surrounding the Black Sea and the high plateaus of the East Anatolian Region: Elazig, Kayseri, Kahramanmaras, Sivas, and Erzincan. In Turkey, the practice of farming regional cultivars, in conjunction with the introduction of foreign cultivars from Greece, France, Italy, Spain, and the USA, can extend the cropping season to May and June. However, apricot production in Turkey in 2025 has been highly unusual due to extreme weather conditions. Severe frosts in 2025 damaged Turkey's apricot harvest, leading to a sharp rise in prices for fresh, dried, and frozen apricots worldwide. Malatya Province, which accounts for 85% of Turkey's apricot production, was particularly hard hit. Nearly all 13 million trees were damaged during the flowering period. Projected apricot production fell from 750,000 tonnes in 2024 to just 10,000 tonnes in 2025 (Expana, 2025).

Global demand for dried apricots has increased notably in recent years, driven by consumer perception of their beneficial health properties. Key importing markets include the USA, Germany, France, Russia, and the United Kingdom, positioning dried apricots as a significant commodity in international trade (WTO, n.d.). In 2022, Turkey dominated global exports (Fig. 3). Export values demonstrated continued growth in 2023, reflecting sustained demand across major consumer markets and the premium positioning of dried apricots in the health food sector. According to WTO (n.d.), in 2022, Turkey was the leading exporter, with export values exceeding USD 400 million. On the demand side, the main importing countries were the United States (USD 64.2 million), Germany (USD 38.6 million), France (USD 36.2 million), Russia (USD 30.5 million), and the United Kingdom (USD 25.3 million),

indicating that demand was concentrated in large consumer and high-income markets. Kyrgyzstan was also ranked 12th in dried apricot exports, with USD 2.67 million in export value. Table 1 shows the global export performance of dried apricots in 2024 according to WITS (2024). The consistency between the major importing countries identified in 2022 and the export expansion observed in 2024 suggests stable

international demand. By 2024, Turkey further reinforced its dominant position, exporting USD 404.5 million worth of dried apricots with a volume of approximately 76,439 tonnes. This increase in export value and substantial shipment volume underscore Turkey's continued comparative advantage and scale efficiency. Other exporters remained comparatively minor participants (WITS, 2024).

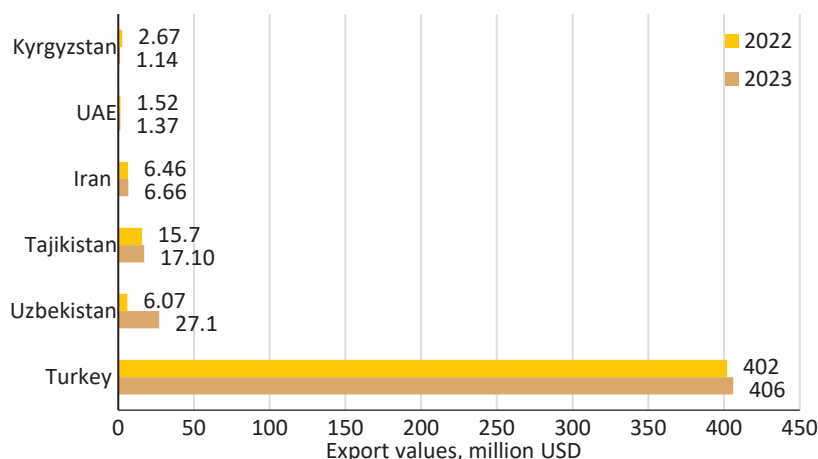


Figure 3. Dried apricot exports worldwide in 2022 and 2023, by leading countries

Source: compiled by the authors based on WTO (n.d.)

Table 1. Global trade in dried apricots: Leading exporters

Country/region	Export value (USD thousand)	Export volume (kg)	Unit price (USD/kg)
Turkey	404,491.37	76,439,100	5.30
Uzbekistan	17,514.57	11,264,500	1.55
France	15,678.09	2,137,120	7.33
Germany	12,357.97	1,826,590	6.77
European Union	12,218.93	1,538,160	7.94

Source: compiled by the authors based on WITS (2024)

Overall, the data show a market characterised by extreme supply-side concentration, with Turkey accounting for the vast majority of global exports in both value and volume terms with an average unit price of USD 5.30/kg. Uzbekistan follows as the second top exporter in 2024 with the lowest unit price. France, Germany, and the European Union stand out, with significantly smaller volumes but higher unit prices in some cases (France: USD 7.33/kg, EU: USD 7.94/kg). The data indicate that while Turkey leads in scale, European exporters capture higher per-unit value, reflecting product differentiation and access to premium markets.

Key economic indicators for apricot production in Central Asia

Figure 4 shows the production volume (a) and harvested area (b) of apricots in Central Asian countries compared to those in Turkey, according to the FAO in 2024 (FAOSTAT, n.d.).

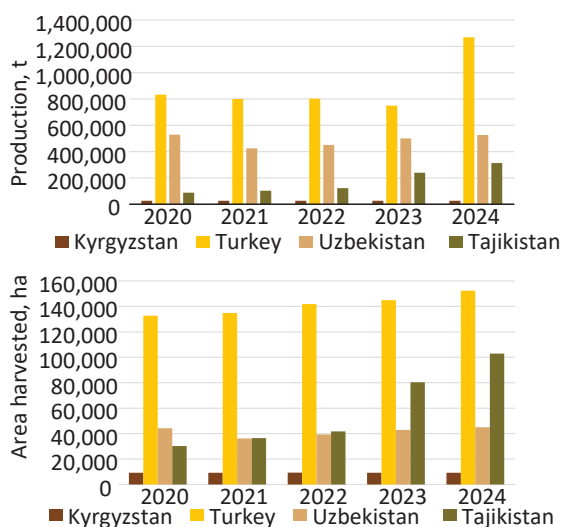


Figure 4. Production quantity (a), harvested area (b) of apricots in Central Asian countries

Source: compiled by the authors based on FAOSTAT (n.d.)

The apricot yield in Uzbekistan is substantially higher than in Kyrgyzstan, Tajikistan, and Turkey. This is probably due to regional cultivars and traditional experience as well as modern agricultural technology, such as effective water management, which is used in Uzbekistan. Climate factors disrupt flower bud dormancy, leading to floral anomalies (Polat & Caliskan, 2013). Thus, environmental conditions and cultivation practices remain critical factors in determining the stability of apricot yields across the region.

Uzbekistan. Uzbekistan is one of the most significant apricot-producing countries in Central Asia, with extensive apricot orchards in the Fergana and Zarafshan valleys. Apricot orchards constitute approximately 70-80% of orchard land in key producing regions. The combination of a longer summer, high temperatures, and low relative humidity creates optimal conditions for apricot drying (Mirzaeva & Makhmudova, 2020). The country's apricot production plays a pivotal role in its agricultural sector, providing both domestic consumption and export opportunities. Uzbekistan cultivates a diverse range of apricot cultivars for both fresh consumption and processing. According to FAOSTAT (n.d.), apricot production in Uzbekistan amounted to 529,109 t in 2020 and 526,693 t in 2024. The decline in production was attributed to adverse weather conditions in 2022. Thus, Uzbekistan ranked second globally in apricot exports, behind only Spain, which supplied 96,000 t of fresh apricots to foreign markets in 2020. In 2020, for the first time, Uzbekistan surpassed even Turkey in the export volume of fresh apricots (EastFruit, 2022a). In 2024 Uzbekistan ranked second among the largest exporters (Table 1). In Uzbekistan, farmers have recently begun implementing innovative technologies, such as drip irrigation and the cultivation of dwarf apricot varieties, which are now bearing fruit (Figs. 5, 6).



Figure 5. Farmers' practices in cultivating apricots in Uzbekistan

Note: water consumption unit for drip irrigation, underground water is extracted through a well from a depth of 180 meters, Pap district of Namangan region, Uzbekistan, April 2024

Source: photo by the authors

The yield of dwarf apricot orchards is 10 t of ripe apricots per ha. Harvesting begins on May 1 or 2, and fresh apricots are sold for USD 3 per kilogram. According

to EastFruit (2022b), the main importers of fruit and vegetables from Uzbekistan are Russia (42.5%), Kazakhstan (18.9%), China (9.1%), and Pakistan (8.8%).



Figure 6. Orchard featuring dwarf varieties of apricot trees

Note: Pap district of Namangan region, Uzbekistan, April 2024. The illustration shows new varieties of dwarf apricots and their cultivation practices; these apricot varieties were ready for harvest as early as May 1st, 2024

Source: photo by the authors

Kyrgyzstan. The fruit processing industry is a priority, export-oriented sector in Kyrgyzstan's agro-industrial economy. According to Programme for the Development... (2017), the industry's production capacity is based on 27 industrial enterprises and more than 300 mini-workshops. In 2022, up to 425,517 t and in 2025 of fruit and berries were produced in the country. Apricots are the second most important fruit after apples. The high export potential of this industry enables increases of up to 20% in fruit and vegetable exports annually (FAOSTAT, n.d.). According to Tridge (n.d.), fresh apricot production in Kyrgyzstan has fluctuated between 20,000 and 30,000 t over the past decade, ranking 29th globally. About 20% of apricots in Kyrgyzstan are consumed fresh, and about 55% are dried. Less than 1% of the total crop is processed into jams and nectar. From a young age, apricot trees yield 31-40 kg per tree (Ergashova, 2018). According to FAOSTAT (n.d.), fresh apricot production in Kyrgyzstan has remained relatively stable in recent years, amounting to approximately 26,067 tonnes in 2022 and 26,849 tonnes in 2023. Yield averaged around 4,000-5,000 kg per ha, depending on regional conditions and orchard management (with harvested area typically exceeding 8,000 ha). Apricot plantations in 2025 are estimated to cover more than 8,329 ha in Kyrgyzstan (FAOSTAT, n.d.). More than 80% of them is located in the country's southwest, in Batken (Kadyrov, 2023). The Batken region has a hot climate; therefore, it is renowned for its sweet apricots. In Kyrgyzstan, apricots are also grown in the Jalal-Abad, Osh, and Issyk-Kul regions. The Issyk-Kul region, in northern Kyrgyzstan, is a notable area for apricot cultivation. In this region, apricots mostly ripen in late summer and early autumn, extending the fresh apricot season.

Only a few manufacturers produce dried fruit and vegetables in Kyrgyzstan. Most dried fruit and vegetables are produced by individual entrepreneurs using sun drying. Kyrgyz companies have limited financial resources and therefore prefer to use solar energy. According to trade data for 2024, key export markets for Kyrgyz dried apricots include Russia (USD 991 thousand), the United States (USD 73.7 thousand), Kazakhstan (USD 24.8 thousand), Iraq (USD 18.2 thousand), China (USD 16.5 thousand), and Uzbekistan (USD 11.0 thousand) (OEC, n.d.). The share of fruit and vegetable processing in the republic remains low, not exceeding 13-14%. Generally, Kyrgyzstan exports more fresh fruit and vegetables than processed goods. Among Central Asian countries, Kyrgyzstan has the smallest harvested area of apricot orchards; nevertheless, Kyrgyz farmers have periodically ranked among the top exporters of dried apricots in the region.

The authors' assessment of Kyrgyzstan's fruit processing sector reveals substantial transformation over the past three decades. Historically, the main challenges included an outdated technical base and processing technologies, insufficient financial resources for enterprises, and underdeveloped storage, transportation, and logistics infrastructure. More recently, however, new large and small workshops equipped with modern machinery, as well as the first fruit logistics centres, have been established across the country. Enterprises in Kyrgyzstan have been increasingly investing in the processing of apricots into value-added products, such as apricot jam, apricot nectar, and apricot oil. These processed apricot products are not only sold domestically but are also exported to international markets. Nevertheless, limited human capacity and the seasonal nature of work continue to constrain production volume expansion. Although enterprises in the industry cannot compete with neighbouring countries in the volume of conventionally dried apricots, they possess competitive advantages in producing organic, sulphur-free, and freeze-dried apricots, which offer higher nutritional value and command higher prices.

Tajikistan. Apricots account for a significant share of Tajikistan fruit production, often alongside apples and grapes as leading crops by harvested tonnage (Qureshi, 2022; Murzakulova, 2024). This country has a strong tradition of apricot cultivation, and dried apricots are considered a form of alternative currency (East-Fruit, 2020). According to trade data for 2025, the country has established approximately 100,000 hectares of apricot orchards (FAOSTAT, n.d.). The main apricot orchards in Tajikistan are located in the Sughd, Zeravshan, Khatlon, and Gissar valleys, as well as in mountainous regions. The Ashat district of the Sughd region is a well-known fruit-producing region in Tajikistan. There are 16,018 ha of apricot orchards in this area, in which up to 3 t of apricots are harvested from each hectare (CentralAsia, 2017). However, in Tajikistan, prices in 2023

were USD 0.79-1.06 per kg, i.e., 3-5 times lower than in Uzbekistan. In addition to a good harvest, another factor affecting apricot prices in Tajikistan is the complete closure of the border with Kyrgyzstan, through which exports are usually conducted.

Apricots make up a significant portion of the total fruit production, with 63.5% contributed by farmers, 25.1% by the general population, and 11.4% by public enterprises. According to FAOSTAT (n.d.) data for 2025, apricot production in Tajikistan has shown strong growth: the total apricot production in 2020 was 87,671 tonnes, in 2024 – 313,052 tonnes, this is due to the significant growth of the apricot orchard areas from 30,238 ha to 102,928 ha. Estimates for 2025 suggest that total apricot output reached 348,000 tonnes, representing an increase of more than 24% compared to previous years (Asia-Plus, 2025). According to TAJSTAT (n.d.), 20 small- and medium-sized enterprises are engaged in dried fruit processing and packaging. In 2023, these enterprises produced 3,642 tonnes of products, including 293 tonnes of apricots, 29 tonnes of prunes, 104.6 tonnes of dried apples, 1,663.6 tonnes of assorted dried fruit, 160.9 tonnes of rosehips, and 1,219.5 tonnes of dried apricots. The fruit harvest in Tajikistan was higher in 2024 than in 2020, and prices have increased by 20-100%. Dried apricots continued to be the leading exported product; core enterprises comprised the majority of exports, totalling 20,854 tonnes in 2022, valued at USD 15.119 million, and increasing to USD 17.2 million in 2024 (OEC, n.d.). About 45% of fruit exports go to Russia, followed by Kazakhstan and Iraq (Qureshi, 2022). The main consumers of Tajik dried fruit in 2024 were Kazakhstan, Turkey, Azerbaijan, Ukraine, and Poland.

While production volumes have been rising, labour shortages – especially during peak harvest seasons – have become a concern in some apricot-growing districts due to out-migration and workforce constraints. Price fluctuations and market access can influence farmer profitability, as local markets sometimes absorb large harvests at low prices. Enhanced processing (e.g., dried fruit production), improved logistics, and export market diversification are key opportunities to strengthen the sector's economic performance (East-Fruit, 2023). In conclusion, Tajikistan is one of the leading apricot producers in Central Asia, benefiting from favourable agro-climatic conditions, extensive orchard areas, and a strong tradition of dried apricot production for export. Apricots play a strategic role in rural livelihoods and agro-exports, with growing opportunities in value-added processing despite challenges related to labour and market volatility.

Analysis of apricot drying technologies

Drying, or dehydration, is the process of removing excess moisture from food to reduce microbial activity and spoilage (Arslan & Alibaş, 2024). Drying is used

to extend the shelf life of fruit and vegetables; as a result, the moisture content is reduced to below 20%. Typically, dried foods have a water activity of less than 0.06, which prevents microbial growth (Karabulut *et al.*, 2007; Akter *et al.*, 2022). In the production of dried apricots and other fruits, traditional (solar) drying, convective drying (hot air drying), freeze-drying, and infrared drying are used (Gao *et al.*, 2024). Pre-treatment significantly influences drying efficiency and final product quality. C. Ertekin *et al.* (2023) showed that sulphur dioxide (SO_2) treatment increases heat and mass transfer rates during drying by disintegrating the cellular matrix, whilst preserving the characteristic orange colour. However, growing demand for organic certification has prompted research into SO_2 -free alternatives using natural acidulants and controlled atmosphere techniques.

Drying technologies play a pivotal role in realising the economic potential of apricot production in Central Asia, where fresh fruit has a very short shelf life and is highly susceptible to post-harvest losses (often exceeding 30-50% due to inadequate handling, weather exposure, and limited cold-chain infrastructure). Effective drying not only extends shelf life to 12-24 months, reduces moisture content below 20-25% to inhibit microbial growth, but also significantly enhances export competitiveness by enabling access to distant high-value markets (Russia, EU, USA, China) with stable demand for premium dried products. In Kyrgyzstan, Uzbekistan, and Tajikistan – countries with small to medium-scale orchards and seasonal surpluses – modernisation of drying practices

(from traditional sun drying to infrared or freeze-drying) can substantially increase farmer incomes, reduce sulphur dioxide dependency for organic certification, improve product quality (colour, nutritional retention, and safety), and help capitalise on the post-2025 global supply gap caused by the Turkish frost crisis. Thus, the choice of drying method directly influences ROI, gross margins, and the overall contribution of the apricot sector to rural livelihoods and national export revenues in the region.

Sun drying. Natural sun drying in the open air is widely used in Central Asia and other countries with hot, and tropical climates. Food is exposed to sunlight for several days to remove moisture (Adeyeye *et al.*, 2022). With sun drying, according to İ. Toğrul & D. Pehlivan (2003), significant savings are achieved since the energy source is free and renewable. However, sun drying is a relatively slow process that can take several days or even weeks, resulting in substantial losses (Toğrul, 2005). Also, as mentioned by S. Vijayavenkataraman *et al.* (2012), insect infestations, enzymatic reactions, microbial growth, and mycotoxin development decrease the product quality. Traditional drying techniques of apricot involve manually removing the pit and collecting the fruit flesh on the ground in the garden or near the drying area. Fruit is laid out in inaccessible places, on flat stones, large boulders, and grass. During the drying process, fruit accumulates dust and becomes black, particularly when it rains (Hussain *et al.*, 2012). Figure 7 describes the traditional sun drying technology used in dried apricot production in Kyrgyzstan.

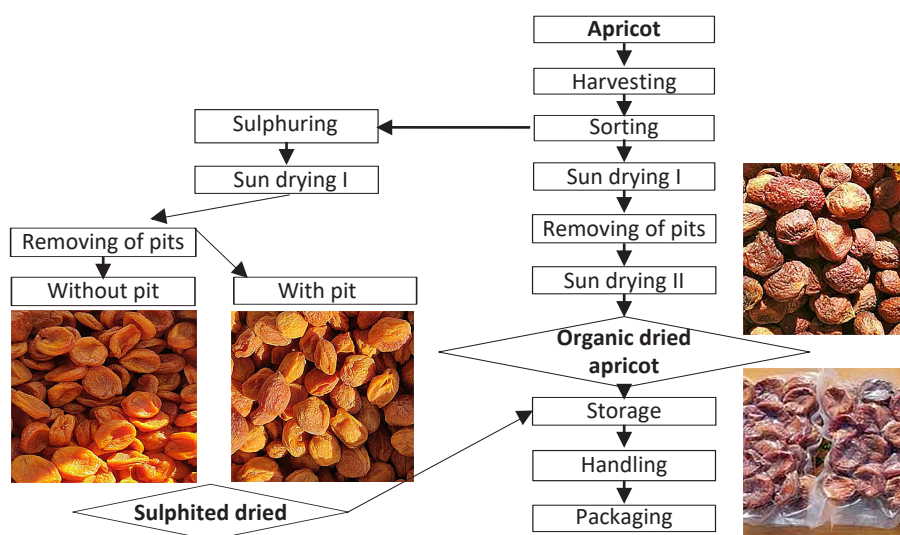


Figure 7. Home technology scheme for drying apricots

Source: created by the authors

According to farmers in Kyrgyzstan, there are two stages in the production of dried apricots. In the first stage, sulphur dioxide (SO_2) treatment of fresh apricots, which is known as sulphitation, preserves colour and prevents the growth of microbes that cause decay. As a result of sulphur dioxide treatment, apricots retain their

natural reddish-yellow or intense orange colour with good stickiness during drying, processing, and storage (Elmaci *et al.*, 2008; Igual *et al.*, 2012). SO_2 fumigation is carried out in rooms of approximately $2.4 \times 2.4 \times 2.2$ m dimensions; the duration of fumigation is about 8-12 h, and the average sulphur consumption in this process

is 1.6-1.8 kg/t of material. The second stage consists of two drying operations, in which the apricots are traditionally dried in the open air before and after pit removal. In addition to sun drying of apricots, shade drying and stem stacking methods are used in this region.

There are three terms used to describe dried apricots, depending on the presence of the pit. Kuraga is a dried, pitless half-apricot. Ashtak is a whole dried fruit from which the stone has been removed before drying and put back into the apricot. Kaisa is a whole dried apricot without a stone, which is removed through a recess at the stalk's point of attachment. The drying period varies with pit removal: 6-10 days for Kuraga, 13-17 days for Ashtak and 10-20 days for Kaisa. For export, apricot quality must meet specified standards and requirements. The United Nations Economic Commission for Europe (UNECE) developed the quality standards concerning the marketing and commercial quality control for fresh (FFV-02) and sun-dried

apricots (DDP-15) (UNECE, 2017). According to this standard, the moisture content of untreated dried apricots should not exceed 25.0%. For dried apricots treated with preservatives or otherwise preserved (e.g., pasteurised), the moisture content should be above 25.0% but not exceed 40.0%. Products with a moisture content between 32.0 and 40.0% should be labelled as high moisture or an equivalent designation.

Hot air drying. Hot air drying (HAD) has several advantages over sun drying, including reduced microbial contamination, more controlled drying parameters, less adverse effects of weather conditions, shorter drying times, and lower labour costs (Karabulut *et al.*, 2007). Convective drying relies on heat transfer from a heated drying agent (air or a vapour-gas mixture) to the product. Conductive drying relies on heat transfer from a hot surface to the product being dried. HAD is a common method for drying foods, although it often yields a medium-quality product (Fig. 8).



Figure 8. Hot air-dryer used for apricot drying in Batken region, Kyrgyzstan, and dried apricot in hot air-dryer (pre-treated with 1% citric acid solution)

Source: photo by the authors

The drying temperature and pre-treatment methods affect the colour and nutritional value of dried fruit. As stated by D. Nowak & E. Jakubczyk (2020), shrinkage is a notable example of such changes. The selection of chemicals, dipping temperature, time, and their concentrations has previously been described in the literature. Hot air flow is also recommended for desulphiting over-fumigated and dried apricots (Güçlü *et al.*, 2006). For apricots, a hot air circulating oven is recommended; however, depending on production capacity, manufacturer the cost of a hot air dryer for a daily input of 1,000 kg is USD 13,500-21,000 (Fruit and Vegetable Dryer, 2025).

Infrared drying. Infrared drying technology is used as an alternative drying method for many agricultural products. According to D. Zhang *et al.* (2023), during infrared drying, water molecules in wet materials directly absorb infrared radiation and convert it into thermal energy, thereby heating and drying the material. Infrared energy is transferred to the product surface from the heating element without heating the surrounding

air, resulting in a high-quality final product and a stable drying temperature (Adak *et al.*, 2017; Ye *et al.*, 2021). Advantages of infrared drying: the material is heated directly, drying is fast, and it consumes significantly less energy than hot air convective drying (El-Mesery *et al.*, 2023). Infrared drying with a daily input capacity of 1,000 kg is USD 10,110.

Freeze-drying. Freeze-drying is the process of removing moisture from a frozen product under high vacuum conditions. This method is regarded as one of the most effective drying techniques for preserving vitamins and other bioactive components of dried foods. Conversely, freeze-drying has been identified as the costliest dehydration process, with the sublimation stage accounting for approximately 50% of the total energy consumption (Ratti, 2001). Freeze-drying is used to produce high-quality food powders and solids (Bhatta *et al.*, 2020). It is essential to select appropriate conditions for the freeze-drying process to ensure that the water does not melt (Fig. 9).



Figure 9. Freeze-dryer used for apricot drying (Namangan region, Uzbekistan) and freeze-dried apricots

Source: photo by the authors

However, freeze dryers are more expensive than hot air dryers, for example, freeze-dryer with a daily input capacity of 1,000 kg is USD 134,614-2,880,000 (KEMOLO, n.d.).

Comparison of different drying methods. Table 2 presents the return-on-investment (ROI) and gross profitability calculation for different drying methods for apricots with a volume of 50 tonnes of dried apricots per year. Traditional sun drying is characterised by very low capital expenditure (CAPEX), enabling small-scale entry, exhibits the lowest margin and a high vulnerability to price fluctuations. Convective drying requires moderate CAPEX and allows for industrial-scale production, with economically viable returns achievable provided that minimum market selling prices are met. Infrared (IR) drying involves slightly lower CAPEX and yields superior product quality, making it suitable for premium market segments. The exceptionally high ROI for infrared drying is primarily driven by very low capital expenditure assumptions and should be interpreted as an indicative upper-bound estimate. Freeze-drying is associated with very high CAPEX and elevated OPEX. Infrared and freeze-drying provide more stable gross margins; however, their economic viability depends on access to premium markets. Table 3 shows comparison of apricot drying technologies.

Table 2. Return-on-investment (ROI) and gross profitability calculation for different drying methods

Indicator	Sun drying	Hot air	Infrared	Freeze-drying
Selling price (USD/kg)	4.5	6.5	7.5	10.3
Annual revenue (USD)	225,000	325,000	375,000	515,000
Raw material cost (USD)	67,000	67,000	67,000	67,000
Energy + labour + packaging (USD)	140,000	180,000	200,000	260,000
CAPEX (USD)	15,000	21,000	10,110	134,614
Amortisation (10%) (USD)	1,500	2,100	1,011	13,461
Total OPEX (USD)	208,500	249,100	268,011	340,461
Net profit/year (USD)	16,500	75,900	106,989	174,539
ROI (%/year)	110%	361%	1,059%	130%
Simple payback	<1 year	<1 year	<1 year	~0.8 year
Gross profitability	7.3%	23.4%	28.5%	33.9%

Source: calculated by the authors

Table 3. Comparison of apricot drying technologies

Parameter	Traditional (sun drying)	Convective (hot air drying)	Infrared (IR) drying	Freeze-drying (lyophilisation)
Drying principle	Natural moisture evaporation using sun and wind	Heated air circulation (50-75°C)	Infrared radiation heats the water molecules	Freezing → vacuum → sublimation of ice
Capital expenditure (CAPEX)	Very low	Low-medium	Medium-high	Very high
Operating costs (OPEX)	Minimal	Medium (electricity/gas)	Medium (electricity)	Very high (energy + maintenance)
Drying time	7-15 days	12-36 hours	4-12 hours	18-36 hours
Dependence on climate	Very high	Low	Low	None
Process control	Very limited	Good	Very good	Full, automated
Colour retention	Low-medium (browning possible)	Medium	High	Very high (near fresh appearance)
Nutrient retention	Medium	Medium	High	Maximum (90-95%)
Product texture	Dense, chewy	Classic dried fruit texture	Softer, more uniform	Light, porous, crispy
Quality uniformity	Low	Medium-high	High	Very high
Hygiene and food safety	Low-medium	High	High	High (if pretreated with hot water blanching)

Table 3. Continued

Parameter	Traditional (sun drying)	Convective (hot air drying)	Infrared (IR) drying	Freeze-drying (lyophilisation)
Compliance with export standards (EU, USA)	Limited	Yes	Yes	Premium
Typical export market segment	Low to mid-price	Mid-price	Mid-to-high	Premium/functional foods
Export price potential	Low	High	Medium	Low-medium
Production scalability	Low	High	Medium	Low-medium
Applicability in Central Asia – advantages	Low investment, traditional, suitable climate	Best price-quality balance	High value-added export potential	Niche markets, high margins
Applicability in Central Asia – limitations	Quality risks, difficult certification	Energy costs, competition	Higher entry barrier, market required	High CAPEX, limited demand

Source: compiled by the authors

Based on the comparison of apricot drying technologies, clear trade-offs emerge between investment cost, operating expenses, and market positioning. Traditional sun drying requires minimal capital investment but offers limited quality control and export potential, making it suitable mainly for local or small-scale markets. Convective drying represents a balanced option, with moderate CAPEX and scalable production, and can achieve positive returns if minimum selling prices are secured. Infrared drying provides improved product quality and access to premium markets at the cost of higher capital and operating requirements. Freeze-drying delivers the highest quality product but involves high CAPEX and OPEX, restricting its economic viability to niche, high-margin markets with stable long-term demand.

Conclusions

The growing global demand for healthy, natural fruit-based products underscores the promising prospects for apricot processing, particularly in Central Asia, where favourable agro-climatic conditions, genetic diversity, and proximity to major export markets (Russia, EU, Middle East, China) provide a strong competitive foundation. The analysis revealed that global apricot production reached approximately 4.5 million tonnes in 2024, with Turkey historically dominating both fresh and dried segments. However, the catastrophic spring frosts of 2025 in Turkey created a significant supply gap, offering Central Asian producers – especially Uzbekistan (~526-540 thousand tonnes), Tajikistan (~313-348 thousand tonnes), and Kyrgyzstan (~57 thousand tonnes in recent years) – a unique window to increase market share in dried apricots. ROI calculations for drying technologies at a scale of 50 tonnes of dried product per year demonstrated clear advantages of modern methods: sun drying yielded 7.3%, convective drying 23.4%, infrared drying 28.5%, and freeze-drying 33.9%. Infrared and freeze-drying not only delivered superior

product quality (better colour retention, nutritional value, and safety without sulphur dioxide), but also ensured higher and more stable gross margins, making them particularly suitable for small- and medium-scale operations in Kyrgyzstan and similar regions with limited harvest volumes.

To capitalise on these opportunities, farmers and processors in Central Asia should prioritise the adoption of infrared drying for mid-premium segments and freeze-drying for high-value organic and export-oriented markets, while governments and development agencies should support targeted investments in modern equipment, training in quality standards (UNECE, organic certification), and improved logistics infrastructure to minimise post-harvest losses and enhance export competitiveness. Further research should focus on conducting region-specific techno-economic feasibility studies that incorporate local energy tariffs, labour costs, and actual smallholder supply chain constraints; performing full-scale pilot trials of infrared and freeze-drying technologies under Kyrgyz and Tajik conditions; investigating the long-term sensory and nutritional stability of sulphur-free dried apricots during extended storage and transport; and assessing the impact of new early-ripening cultivars on extending the harvest window and reducing climate-related risks in the post-2025 market environment.

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Conflict of Interest

No potential conflict of interest was reported by the authors.

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Аннотация. Өрүк (*Prunus armeniaca* L.) мелүүн зоналардын негизги жемиштеринин бири бойдон калууда, Борбордук Азия анын келип чыгышынын жана генетикалык ар түрдүүлүгүнүн маанилүү борбору болуп саналат. Изилдөө дүйнө жүзү боюнча, өзгөчө Борбордук Азия өлкөлөрүндө жаңы жана кургатылган өрүктү өндүрүү менен соодалоонун экономикалык потенциалын баалоого, ошондой эле ар кандай кургатуу технологияларынын натыйжалуулугун талдоого багытталган. FAOSTAT, WITS, Tridge жана WTO маалыматтары (2020-2025-жылдар), илимий адабияттардын системалуу карап чыгуусу (Scopus, Web of Science ж.б.) колдонулду; жыл сайын 50 тонна кургатылган өрүк өндүрүү шартында салттуу күн кургатуу, конвективдүү, инфракызыл жана сублимациялык (freeze-drying) ыкмалар үчүн инвестициянын кайтарымдуулугу (ROI) жана дүң киреше эсептелди. Аныкталгандай, 2024-жылы дүйнөлүк өрүк өндүрүшү болжол менен 4,5 млн тоннага жеткен; Түркия, Өзбекстан жана Иран лидер болуп калууда, бирок 2025-жылы Түркияда (айрыкча Малатья облусунда) катуу жазгы үшүккө байланыштуу өндүрүш чейин кыскарган, бул жаңы жана кургатылган өрүктүн дүйнөлүк бааларынын кескин өсүшүнө алып келген. Борбордук Азияда Өзбекстан (~526-540 миң т 2024-ж.), Тажикстан (~313-348 миң т 2024-2025-жж.) жана Кыргызстан (~57 миң т 2023-2024-жж.) олуттуу экспорттук потенциалды көрсөтүүдө; Түркия 2024-жылы кургатылган өрүктү 404,5 млн АКШ долларына экспорттогон, бирок 2025-жылы регионалдык жеткирүүчүлөр (айрыкча Өзбекстан жана Тажикстан) атаандаштык артыкчылыкка ээ болууда. ROI эсептөөлөрү: күн кургатуу – 7,3 %, конвективдүү – 23,4 %, инфракызыл – 28,5 %, сублимациялык – 33,9 %; инфракызыл жана сублимациялык ыкмалар эң жогорку сапатты камсыз кылат. Жыйынтыктар Борбордук Азиянын (негизинен Кыргызстандын) фермерлери, кайра иштетүүчүлөрү жана инвесторлору тарабынан кургатуу технологияларын тандоодо, түшүм жыйналгандан кийинки жоготууларды азайтууда жана премиум-экспорттук рынокторго (ЕБ, АКШ, Россия) чыгууда колдонулушу мүмкүн

Негизги сөздөр: жыйноо аянты; түшүмдүүлүк; кургатуу технологиясы; жабдуу; инвестициянын кирешелүүлүгү; эксплуатациялык чыгымдар

Потенциал выращивания и переработки абрикосов в Центральной Азии

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Аннотация. Абрикос (*Prunus armeniaca* L.) остается одним из ключевых фруктов умеренных зон, а Центральная Азия является важным центром его происхождения и генетического разнообразия. Целью работы была оценка экономического потенциала производства и торговли свежими и сушеными абрикосами в мире с акцентом на страны Центральной Азии, а также анализ эффективности различных технологий сушки. Для анализа использовались данные FAOSTAT, WITS, Tridge и WTO за 2020-2025 гг., а также систематический обзор научной литературы по технологиям сушки (Scopus, Web of Science и др.); выполнен расчет рентабельности инвестиций (ROI) и валовой прибыли для традиционной солнечной, конвективной, инфракрасной и сублимационной (freeze-drying) сушки при производстве 50 т сушеных абрикосов в год. Было установлено, что мировое производство абрикосов в 2024 г. составило около 4,5 млн т; Турция, Узбекистан и Иран остаются лидерами, однако в 2025 г. из-за катастрофических заморозков в Турции (особенно в Малатье) производство там сократилось, что привело к резкому росту мировых цен на свежие и сушеные абрикосы. В Центральной Азии Узбекистан (~526-540 тыс. т в 2024 г.), Таджикистан (~313-348 тыс. т в 2024-2025 гг.) и Кыргызстан (~57 тыс. т в 2023-2024 гг.) демонстрируют значительный экспортный потенциал; Турция в 2024 г. экспортировала сушеные абрикосы на 404,5 млн долл., однако в 2025 г. региональные поставщики (особенно Узбекистан и Таджикистан) получили конкурентные преимущества. Расчет ROI показал: солнечная сушка – 7,3 %, конвективная – 23,4 %, инфракрасная – 28,5 %, сублимационная – 33,9 %; при этом инфракрасная и сублимационная сушка обеспечивают наивысшее качество продукта. Результаты могут быть использованы фермерами, переработчиками и инвесторами Центральной Азии (прежде всего Кыргызстана) для выбора технологий сушки, снижения послеуборочных потерь и выхода на премиум-сегменты экспортных рынков (ЕС, США, Россия)

Ключевые слова: площадь сбора урожая; урожайность; технология сушки; оборудование; окупаемость инвестиций; операционные расходы