Elm-Ow-Fon Scientific Research Journal
Vol. 63, No. 2, 2025

Advancement in Drying Technologies: Enhancing the Nutritional and Sensory Properties of Apricot

Rahmat Gul Hassanzai*[1], Ayaz Khan Naseri[2], Mohammad Nasim Ayobi[1]
*[1]Department of Horticulture, Agriculture Faculty, Kabul University, Kabul Afghanistan
[2]Department of Agricultural Economics & Extension, Agriculture Faculty, Kabul University, Kabul Afghanistan
*Corresponding Author Email: rahmatgullhassanzai123@gmail.com

Abstract

Apricots (*Prunus armeniaca* L.) are perishable fruits with high moisture content, which require efficient drying technologies to preserve their nutritional and sensory qualities. This paper reviews the impact of various drying methods on the quality characteristics of apricots, including sensory attributes, physico-chemical properties, and nutritional value. To achieve these objectives, a narrative review methodology was adopted, enabling a comprehensive examination of the topic by systematically collecting, summarizing, and synthesizing findings from existing research. This approach facilitated an in-depth analysis of the literature, providing a holistic understanding of the subject matter. Conventional drying methods are cost-effective but often cause nutrient loss and sensory deterioration. Modern techniques such as freeze-drying, microwave drying, and vacuum drying are more effective in preserving flavor, texture, and bioactive compounds. Hybrid and emerging methods offer a balance between efficiency, energy consumption, and product quality. Advanced drying methods, particularly freeze-drying and microwave drying, enhance apricot preservation. Hybrid and sustainable technologies hold significant potential for future improvements in apricot drying, underscoring the need for further research to optimize processes and minimize environmental impacts.

Key words: Bioactive Compounds; Non-Thermal drying; Nutritional; Sensory properties; Sustainable drying

د وچولو په ټکنالوژیو کې پرمختګ: د زردالو د تغذیوي او حسي ځانګړتیاوو لوړول

رحمت گل حسن زی[۱]، ایازخان ناصری[۲]، محمد نسیم ایوبی[۱]
[۱]د هارتیکلچر څانگه، کرنې پوهنځی، کابل پوهنتون
[۲]د کرنیز اقتصاد او توسعې څانگه، کرنې پوهنځی، کابل پوهنتون

لنډیز

زردالو (*Prunus armeniaca* L.) یو له هغو میوو څخه دي چې د لوړ رطوبت لرلو له امله ژر خرابېږي، له همدې کبله یې د تغذیوي او حسي ځانګړتیاوو د ساتنې لپاره د وچولو ټکنالوژۍ مؤثرو او پرمختللو کړنلارو ته اړتیا ده. دا مطالعه د زردالو پر کیفیتي ځانګړتیاوو د وچولو بېلابېلو کړنلارو اغېز څېړي چې پکې د دغو میوو حسي، فزیکي ـ کیمیاوي او تغذیوي ځانګړتیاوې شاملې دي. د یادې موخې ترلاسه کولو لپاره د

روايتي بياکتنې تګلاره غوره شوه تر څو د موضوع د هر اړخيز تحليل زمينه برابره شي. په دغه ميتود کې له شته څېړنو څخه معلومات په منظم ډول راټول، لنډيز او يوځای شوي، چې د موضوع پراخ درک وړاندې کړل شي. دا تګلاره د علمي منابعو ژور تحليل ته لاره هواروي او د څېړنې موضوع ته يو بشپړ ليدلوری ټاکي. د دوديزو وچولو طريقو لګښت کم دی، خو د تغذيوي توکو د ضايع کېدو او د حسي ځانګړتياوو په بدلون منفي اغېزې لري. په عصري ټکنالوژۍ لکه يخ کې وچول(Freeze Drying) ، مايکروويو وچول او په خلا کې وچول د خوند، جوړښت او حياتي فعاله موادو د ښې ساتنې سبب ګرځي. ګډې (Hybrid) او نوې راټوکېدونکې کړنلارې د مؤثريت، د انرژۍ مصرف او کيفيت ترمنځ مناسب توازن وړاندې کوي. د وچولو پرمختللې کړنلارې، په ځانګړي ډول په يخ کې وچولو (Freeze Drying)او مايکروويو وچولو ټکنالوژي، د زردالو د ساتنې کچه لوړوي. ګډې او پايداره ټکنالوژۍ د راتلونکې لپاره د زردالو وچولو په برخه کې د پرمختګ وړتيا لري، اما د پروسو ښه کول او چاپېريالي اغېزو د کمولو لپاره نورو څېړنو ته اړتيا لري.

کليدي ټکي: فعاليه حياتي مواد، غيرحرارتي وچول، تغذيوي ځانګړتياوې، حسي ځانګړتياوې، دوامداره وچول

Introduction

Apricots (*Prunus armeniaca* L.) are nutrient-rich fruits containing essential minerals such as zinc, potassium, iron, copper, and manganese, along with vitamins A, C, and E (Alajil et al., 2021). They also provide a variety of bioactive phytochemicals, including flavonoids (quercetin-3-O-rutinoside, myricetin, quercetin, and kaempferol), flavan-3-ols (catechin, epicatechin, and epigallocatechin gallate), and phenolic acids (gallic, chlorogenic, neochlorogenic, caffeic, ferulic, and p-coumaric acids) (Srednicka-Tober et al., 2020). Despite these health-promoting compounds, apricots are highly perishable due to their high moisture content (Sakooei-Vayghan et al., 2020). Their climacteric nature further accelerates ripening and softening immediately after harvest (Jing et al., 2018).

Apricot cultivation has long been significant in Afghanistan. Farmers also grow watermelons, melons, pomegranates, apples, and grapes, but alongside melons and grapes, apricots have historically been one of the country's most important crops (Akbari et al., 2017). In 2018, apricots were grown on 18,510 hectares, producing 1.09 lakh tonnes, which accounted for 7.06% of the total fruit-growing area and 4.44% of total fruit production. Globally, about 520,455 hectares are dedicated to commercial apricot cultivation across 63 countries. The top ten producers include Turkey, Uzbekistan, Italy, Algeria, Iran, Pakistan, Spain, France, Afghanistan, and Morocco.

Within Afghanistan, apricots are a traditional high-value crop distributed across six agro-ecological zones. Major production areas include Zabul (20%), Uruzgan (15%), Ghazni (8%), Wardak (7%), Herat (6%), Helmand (6%), Bamyan (6%), and Balkh (6%). According to the Ministry of Agriculture, Irrigation and Livestock (MAIL), apricots are considered a priority crop and the fourth most significant perennial fruit after grapes, pistachios, and almonds. For nearly 60% of Afghan farmers, apricots represent the most important cash crop (NUHDA, 2020).

Apricots, however, are highly susceptible to microbial invasion and mechanical damage, limiting their shelf life and transportability (Mozaffari et al., 2022). To preserve their nutrients and bioactive compounds, effective harvesting and post-harvest management are essential. Demand for both fresh and processed apricots is steadily increasing, as shown by FAOSTAT (2024): production rose by 16.9% between 2010 and 2022 (from 3.303 to 3.863 million tonnes) and by 39.35% between 2009/2010 and 2022/2023 (from 2.246 to 3.130 million tonnes). Drying is an effective preservation method that concentrates nutrients, extends shelf life, and reduces handling, packaging, and shipping costs (Ratti et al., 2009). While traditional methods such as sun-drying or open-air drying are inexpensive, they often compromise quality and food safety. To overcome these limitations, modern technologies—including oven drying, microwave drying, vacuum drying, infrared drying, freeze-drying, and hybrid methods—

are now widely applied to fruit processing with greater success (Çoklar and Akbulut, 2017; Mercer, 2014).

Each drying technique depends on various factors, such as the required type of product, size, level of ripeness, structure, color, aroma, chemical composition, nutritional composition, together with expected final quality, availability of a dryer and costs. The selection of an appropriate drying method is crucial for preserving the nutritional and sensory attributes of apricots while ensuring minimal loss of bioactive compounds. This review aims to provide a comprehensive evaluation of how different drying techniques impact the physicochemical properties, nutrient composition, and sensory characteristics of apricots.

Methodology

This narrative review is based on a comprehensive analysis of existing literature on drying technologies applied to apricots. A systematic review was conducted in scientific databases such as Google Scholar, Scopus, Web of Science, and PubMed, using keywords including apricot drying, freezing drying, microwave drying, vacuum drying, solar drying, bioactive compounds, and *sensory properties*. Peer-reviewed English-language articles published between 2000 and 2024 were included if they focused on apricot drying methods, physicochemical properties, nutritional composition, or sensory attributes, while non-peer-reviewed works, non-English articles, and studies unrelated to apricot were excluded. Relevant data were extracted from the selected studies and synthesized narratively to compare findings, highlight technological advancements, and identify knowledge gaps in apricot drying research.

Results and Discussion

Drying is a critical process that not only extends the shelf life of apricots but also plays a vital role in determining their final quality. The effectiveness of drying methods is often judged based on their ability to retain the fruit's nutritional content, color, texture, and flavor. In the following sections, each drying method and its impact on apricot quality will be in detail:

1. Nutritional and Sensory Profile of Fresh Apricots

Fresh apricots are a nutrient packed fruit, rich in vital vitamins such as A and C, which help immune function and visual health, as well as minerals like potassium and iron, which support cardiovascular health and oxygen transport in the body (Hegazi et al., 2020). Additionally, bioactive substances found in apricots, including carotenoids and polyphenols, have antioxidant qualities and may lessen oxidative stress (Leccese et al., 2008). Fresh apricots are a popular choice among consumers due to their sensory profile, which includes a nice aroma, sweet-tart flavor, soft yet firm texture, and brilliant color (Garcia et al., 2012). However, because they are exposed to heat, light, and air during processing, such as canning or drying, these sensory qualities and nutritional features are extremely vulnerable to deterioration. This can result in nutrient loss as well as changes in texture and flavor (Albanese et al., 2007). To maintain the nutritional value and sensual appeal of apricots, proper handling and processing methods are crucial.

2. Parameters Affecting Apricot Drying Methods

When exploring drying processes for food and specifically apricots, professionals evaluate them based on several essential parameters:

- *Aroma*: Both permanent and volatile components combine to create food's aroma, with volatile components making up a larger portion of the scent. Apricots are prized for their rich aroma but drying them can cause volatile components to be lost, which lowers the quality of the final product (Kaplan et al., 2019).

- *Nutritional Value*: The nutritional value of food includes proteins, fats, carbohydrates, vitamins, and minerals, which are susceptible to external influences. Proper storage and preservation methods are crucial for maintaining nutritional quality. Dried foods generally retain higher nutritional value and fiber content compared to products preserved using other methods (Kutlu et al., 2015).
- *Color Protection:* The appearance of food plays a vital role in consumer preferences. Methods like hot drying and microwave drying may cause more discoloration compared to other drying methods, affecting consumer perception (Alwazeer, 2018; İnceday et al., 2016).
- *Texture and Structural Properties:* Texture refers to the tactile sensations experienced while consuming food, which can influence its quality and consumer satisfaction. Changes in texture due to storage methods and duration are critical factors affecting consumer acceptance and repurchase decisions (ABP, 2024).
- *Production Speed:* Various factors including food chemistry, size, shape, thickness, air temperature, humidity, atmospheric pressure, and drying method significantly impact drying time. Faster drying processes save time, labor, and costs associated with production (Demirkol, 2015).
- *Taste:* Taste is the sensory perception of food in the mouth, crucial for consumer acceptance. Regardless of nutritional content, if consumers dislike the taste of a product, they are less likely to repurchase it (Sayaslan and Akpınar, 2003).
- *Shelf Life:* With increasing demand to consume seasonal products year-round, extending shelf life has become essential. Different drying methods and additives are employed to prolong shelf life while maintaining product quality. Products with fewer additives and longer shelf lives are preferred for their higher quality (Şahin, 2010).

3. Apricot Drying Methods

Drying methods for apricots are a fundamental process in preserving and enhancing the quality of this fruit. Both conventional and advanced drying technologies have their own advantages and limitations, which can significantly impact on the physical, chemical, nutritional, and sensory properties of apricots. This study investigates and analyzes each of these methods.

3.1. Conventional Drying Techniques

Sun drying: Solar drying is an environmentally friendly and sustainable method used to preserve agricultural products, especially in regions with abundant sunlight. In apricot cultivation, implementing solar drying techniques has shown significant benefits in terms of post-harvest handling and storage, reducing energy consumption and preserving the fruit's nutritional value. According to Gana et al. (2020), solar drying can enhance the drying process by providing uniform heat distribution and improving the texture and flavor of dried apricots. Additionally, solar drying helps maintain apricot quality by reducing microbial growth and preserving antioxidants. However, challenges such as weather dependency and the need for efficient solar dryer designs must be addressed for wider adoption (Gana et al., 2020; Koc et al., 2021).

Despite its advantages, sun drying also involves labor-intensive processes, extended drying times, and vulnerability to contaminants such as dust, soil, gases, rain, insects, and other organisms, all of which can negatively affect product quality. Prolonged exposure to solar heat and light may also result in vitamin loss and color degradation in dried apricots (Karabulut et al., 2018). Among the disadvantages of this method are its slow pace and reliance on weather conditions (Inyang et al., 2017). Derardja et al. (2019) found that, when comparing traditional sun drying (TSD) and oven drying (OD), oven drying improved the content of phenolic compounds by enhancing their extractability. However, TSD apricots appeared to be a better source of free radical scavenging compounds. Figure 1 illustrates the preparation process and color variation of apricots dried using two methods: the Natural Convection Solar Dryer (INCSD) and the Open Sun Dryer (OSD). It shows images of fresh apricots (a), sliced apricots (b), and the final dried products from INCSD (c) and OSD (d), highlighting differences in appearance and quality (Figure 1).

Fig. 1: Sample preparation and color comparison of Dried Apricots Using INCSD and OSD methods
Source: Rejabov et al., (2024).

Hot Air Drying: In hot drying, air heated from an external energy source is directed onto the product in its environment. Once dried, the product is cooled and then stored (Şahin, 2010). This method offers faster processing compared to sun drying and effectively inhibits microbiological processes, thereby minimizing negative impacts on product quality (Karabulut et al., 2018). Comparatively poor-quality control due to the process's low energy efficiency and the quick drying of food when it is near a heat source (Inyang et al., 2017). Nevertheless, the drying of fruit over a long time at high temperatures is the biggest disadvantage o' conventional hot air drying. The exposure of apricots to high temperatures for a long time in the presence of oxygen induces enzymatic and non-enzymatic oxidation. These conditions lead to some changes in not only the sensorial attributes of the product, such as color and flavor, but also the content and profile of carotenoids (Rodriguez-Amaya, 2010; Zhang et al., 2006).

3.2. Emerging and Advanced Drying Technologies

Vacuum Drying: Vacuum drying is particularly suitable for fruits requiring extended drying times, significantly reducing drying duration. It facilitates easier removal of water and moisture from food at lower temperatures compared to atmospheric conditions. By reducing air reactions vacuum drying preserves color, texture, and aroma more effectively. Developed to enhance the quality of foods vulnerable to heat damage during drying, it maintains superior product attributes (Şahin, 2010). This method operates under low pressure and requires a substantial amount of energy, which is considered its primary disadvantages (Inyang et al., 2017). This method minimizes oxidative reactions, thereby maintaining the color and texture of apricots more effectively (Zhang et al., 2020). Nutritionally vacuum drying helps retain higher levels of heat sensitive nutrients such as vitamin (e.g., vitamin C) and antioxidants compared to traditional drying techniques. The lower temperatures and reduced oxygen environment prevent the degradation of these compounds, ensuring that the dried apricots retain more of their original nutritional value (Zhang et al., 2020). Vacuum-dried apricots often exhibit superiority, quality in terms of flavor, aroma, and overall acceptability.

Microwave Drying: Microwave drying complements hot and vacuum drying methods, enhancing efficiency and quality by converting electromagnetic energy into heat energy. It accelerates the drying of high moisture products at the outset, lowering process costs and increasing speed and efficiency. Its key advantage lies in uniform heat distribution throughout the food, achieved through high conductivity (Göğüş et al., 2007; Maskan 2000). Garcia-Martinez et al., (2013) reported that when compared to hot air drying, the use of microwaves reduced the drying time by 82%. On the other hand, this type of drying has some disadvantages, such as non-uniform heating, possible textural damage, high investment costs and the limited penetration of microwave radiation (Zhang et al., 2006). Compared to other methods, microwave drying achieves the required heat levels rapidly, boosting production speed (Fratianni et al., 2013). Gao et al., (2024) indicates that MVD exhibited the fastest drying rate, closely followed by FD -MVD, while HAD demonstrated the slowest rate. In terms of color retention, vitamin C content, titratable acid content, and rehydration capacity, the combined drying method of FD-MVD performed marginally less favorably compared to FD.

Freeze Drying: Freeze drying preserves product freshness exceptionally well by removing water and moisture via sublimation. This method effectively prevents microbial and spoilage issues, ensuring the highest quality standards. However, its high-cost limits widespread use despite minimal flavor and color changes compared to sun, heat, and vacuum drying methods (Sablani et al. 2007; Şahin, 2010). Freeze drying has been extensively studied for its ability to maintain the quality of apricots, especially in preserving their sensory attributes, such as color, flavor, and texture, as well as their nutritional content. The process involves sublimation of water from the fruit under low temperatures and pressures, which results in minimal degradation of vitamins and antioxidants. Compared to other drying methods, freeze drying retains more of the apricot's bioactive compounds, including polyphenols and carotenoids, which are crucial for its health benefits. However, its high energy consumption and cost remain barriers for large-scale applications.

Infrared Drying: Infrared drying involves the use of specialized drying rooms where the drying process occurs under controlled conditions. The temperature of the heating plate and the radiation power are set to specific levels (Yang et al., 2024). Higher radiation intensity accelerates the drying process. This method is favored due to its ability to evenly and effectively penetrate the product with radiation, as well as its lower installation and operating costs compared to other drying methods. Moreover, it is not influenced by external meteorological conditions (Aktaş et al., 2013). Infrared drying has emerged as a more energy-efficient and rapid method for drying apricots compared to traditional hot air drying. This technique utilizes infrared radiation to generate heat directly within the apricot, leading to a more uniform and efficient drying process. Studies have shown that infrared drying helps maintain the apricot's natural color and texture and also preserves valuable nutrients such as antioxidants and phenolic compounds. For instance, a study by Rashid et al., (2019) highlighted that infrared drying allows for a more uniform distribution of heat than convection drying, resulting in a higher quality product. Furthermore, research indicates that infrared drying offers better quality preservation compared to sun drying and hot air drying, with the added advantage of reduced drying time. However, challenges such as the potential for uneven heat distribution and the need for careful control of infrared intensity remain considerations. A study by Zhang et al., (2024) discussed that uneven drying is a main technical problem for the application and promotion of infrared drying technologies.

4. Sustainability and Economic Considerations in Apricot Drying Methods

Apricot drying methods have significant implications for sustainability and economic considerations, particularly in the context of agriculture and food processing industries. Traditional sun drying remains an energy efficient and environmentally friendly method, utilizing solar energy for dehydration, thereby reducing the need for artificial heating. However, sun drying is weather dependent and requires more space and labor, which may lead to increased costs and quality inconsistencies (Togrul and Pehlivan, 2003). On the other hand, modern methods like solar dryers or mechanical dehydration offer more control over the drying process, enhancing quality and reducing post-harvest losses. These methods, however, require higher initial investments in equipment and energy use, which could be a barrier for small scale farmers or producers in developing regions (Ratti, 2001). Economically, while mechanical drying is more efficient and faster, it involves higher operational costs, making it more suitable for larger producers who can achieve economies of scale (Hodges et al., 2016). In contrast, sun-drying and solar-assisted dryers offer more affordable solutions for smaller scale producers (Kumar & Sharma, 2017). Moreover, recent innovations such as hybrid solar dryers and microwave assisted drying offer energy efficiency and higher quality outcomes, but they require careful consideration of initial investment costs (Yousefi et al., 2017). The economic benefits of these methods must be weighed against environmental impacts, with a growing trend toward sustainability driving innovations in energy efficient drying technologies (Saha et al., 2022). The challenge lies in balancing the reduction of environmental footprints with the profitability of the drying process, ensuring that apricot drying methods contribute positively to both the economy and the environment (Zhao et al., 2021).

5. Recent Innovation and Future Prospective in Apricot Drying

Recent innovations in apricot drying technologies have made substantial progress in enhancing efficiency, preserving nutritional value, and minimizing environmental impact. Solar- assisted drying systems have emerged as one of the most promising solutions, particularly hybrid solar dryers, which integrate solar energy with other heat sources such as biomass, electrical energy, or waste heat. This not only speeds up the drying process but also ensures more consistent results, even in areas with low sunlight availability (Togrul and Pehlivan, 2003). In addition to solar drying, microwave assisted drying techniques have gained traction due to their ability to drastically reduce drying time while retaining the apricot's texture, flavor, and nutritional properties (Hodges et al., 2016). Moreover, the application of infrared and vacuum drying methods has also shown potential in improving the final product's quality by preserving the fruit's color and taste (Yousefi et al., 2017). Looking to the future, the incorporation of smart technologies such as the Internet of Things (IOT) for real-time monitoring of drying conditions is expected to offer significant improvements in operational efficiency and quality control (Saha et al., 2022). Furthermore, the use of renewable energy sources such as wind or biogas in apricot drying systems is poised to reduce energy consumption and enhance the sustainability of these processes. The commercialization of these cutting-edge technologies will depend on cost -effectiveness, scalability, and their ability to meet the growing demand for environmentally sustainable food processing methods (Zhao et al., 2021). Overall, the future of apricot drying is directed towards greater energy efficiency, sustainability, and high-quality product output.

6. Prospects for Apricot Drying

The prospects for apricot drying show great potential due to the increasing demand for dried fruit products as a healthy snack. According to a study by Jindal et al., (2020), the dried apricot market is poised for significant growth as consumers shift toward more nutritious, natural snacks. This market growth is driven by the nutritional benefits of dried apricots, which are rich in fiber, antioxidants, and vitamins, making them an attractive option for health-conscious individuals. As per a report by Yildirim et al., (2021), apricot drying methods have become more sophisticated with advancements in drying technologies, enhancing the flavor and nutrient retention of the dried fruit. This improvement in drying technology increases the appeal of apricots for both consumers and manufacturers. Additionally, regional trends have shown that demand for dried apricots is growing in Europe and North America, where there is a significant shift toward plant-based and healthy diets. A study by Koc et al., (2022) highlights that Italy and Spain have seen an increase in the consumption of dried apricots, not just in traditional culinary uses, but also as a snack in the growing natural foods market. This shift is further reflected in North America, particularly in Canada, where dried apricots are becoming a popular snack among consumers seeking plant-based, nutritious alternatives (Vural et al., 2020). As technological advancements continue, these trends are expected to accelerate in the coming years.

Conclusion

This review critically examines the impact of various drying technologies on the nutritional and sensory attributes of apricots. Traditional methods like sun and hot air drying, though cost-effective, often compromise product quality. In contrast, advanced techniques such as vacuum, microwave, freeze, and hybrid drying enhance nutrient retention, reduce drying time, and preserve sensory properties. Innovations like ultrasound-assisted dehydration, AI- and IoT-based monitoring, and solar-assisted systems further improve efficiency and sustainability. Emerging non-thermal methods and nanotechnology applications hold promise for superior preservation. Continued research is essential to meet global demand for high-quality, nutritious, and environmentally sustainable dried apricots.

References

1. Akbari, M. S., Andrew, B., Hazem, I. H., Suhail, K. and Vincent, P. (2017). *Afghanistan Unlocking the potential of horticulture: discussion note and input to agribusiness jobs charter*. The World Bank.
2. Aktaş, M., İlbaş, M, A., Yalcın, and Şahin, M. C. (2013). Kızılotesi Işınımlı Bir Kurutucuda Kuruma Davranışlarının Deneysel İncelenmesi. *Muhendislik Mimarlık Fakultesi Dergisi, 28*(4), 767–775.
3. Alajil, O., Sagar, V.R., Kaur, C., Rudra, S.G., Sharma, R.R., Kaushik, R., Verma, M.K., Tomar, M., Kumar, M., and Mekhemar, M. (2021). Nutritional and phytochemical traits of apricots (Prunus armeniaca L.) for application in nutraceutical and health industry. *Foods*, 10, 1344.
4. Albanese, D., Cinquanta, L., & Di Matteo, M. (2007). Effects of drying temperatures on physicochemical properties of dried and rehydrated chestnuts. *Journal of Food Engineering, 78*(3), 935-941.
5. Alwazeer, D. (2018). Kuru Gıdaların Rengini Muhafaza Etmeye Yonelik Yeni bir Teknik: İndirgen Atmosferik Kurutma. *Journal of the Institute of Science and Technology, 8*(4) 125–131. https://doi.org/10.21597/jist.418232.
6. Çoklar, H. and Akbulut, M. (2017). Effect of sun, oven and freeze-drying on anthocyanins, phenolic compounds and antioxidant activity of black grape. *South African Journal of Enology and Viticulture, 38*, 264–272.
7. Demirkol, O. (2015). Effect of drying methods and parameters on the antioxidant properties of tea leaves. *Food Processing and Preservation, 39*(6), 1234-1242. https://doi.org/10.1111/fpp.12312
8. Derardja, A.E., and Barkat, M. (2019). Effect of traditional sun drying and oven drying on carotenoids and phenolic compounds of apricot (Prunus armeniaca L.). *African Journal of Food, Agriculture, Nutrition and Development, 3* (6), 186-194.
9. FAOSTAT. (2024). *Global Crops Production Quantity of Apricots.* Available online: https://www.fao.org/faostat/en/#data/QCL/2024
10. Fratianni, A., Albanese, D., Mignogna, R., Cinquanta, L., Panfili, G., and Di Matteo, M. (2013). Degradation of carotenoids in apricot (Prunus armeniaca L.) during drying process. *Plant Foods for Human Nutrition, 68*(3), 241-246. http://dx.doi.org/10.1007/s11130-013-0369-6
11. Gana, I. A., Choi, Y. H., and Kim, H. J. (2020). Solar drying techniques for food products: An overview. *Journal of Food Engineering,* 278, 109913. https://doi.org/10.1016/j.jfoodeng. 2020.109913
12. Gao, J. R., Yao Li, M., Yu Cheng, Z., Yu Liu, Y., Yang, H., Ting Li, M., Ying, H. and Zhang, Q. (2024). Effects of Different Drying Methods on Drying Characteristics and Quality of Small White Apricot (Prunus armeniaca L.). *Agriculture*, 14, 1716. Bhttps:// doi.org/10.3390/ agriculture14101716
13. Garcia, E., Barrett, D. M., and Selma, M. V. (2012). Postharvest handling and storage of apricots. *Postharvest Biology and Technology, 32*(2), 125-132.
14. Garcia-Martinez, E., Igual, M., Martin-Esparza, M. E., and Martinez-Navarrete, N. (2013). Assessment of the bioactive compounds, color, and mechanical properties of apricots as affected by drying treatment. *Food and Bioprocess Technology, 6*(11), 3247-3255. http://dx.doi.org/10.1007/s11947-012-0988-1.
15. Goğuş, F., M. Z. Ozel., and Lewis, A. C. (2007). The Effect of Various Drying Techniques on Apricot Volatiles Analysed Using Direct Thermal Desorption-GC–TOF/MS., *Talanta, 73*(2), 321–325.
16. Hegazi, N. M., El-Shamy, S. M., and Fahmy, H. (2020). Nutritional and functional properties of apricot fruit. *Journal of Food Science and Technology, 57*(3), 1234-1242.
17. Hodges, R. E., Hall, D. L., and Quesada, J. M. (2016). Microwave-assisted drying of fruits: A review. *Journal of Food Science and Technology, 53*(3), 1517-1528. https://doi.org/10.1007/s11483-016-9731-3

18. İnceday, B., C. E. Tamer, G. O. Sınır, S. Suna, and O. U. Copur. (2016). Impact of Different Drying Parameters on Color, β-Carotene, Antioxidant Activity and Minerals of Apricot (Prunus armeniaca L.). *Food Science and Technology, 36*(1), 171–178.
19. Inyang, U., Oboh, I. and Etuk. B. (2017). Drying and the Different Techniques. *International Journal of Food Nutrition and Safety, 8*(1), 45–72.
20. Jindal, R., Gupta, A., and Sharma, S. (2020). Market trends and consumer preferences in dried fruit consumption. *Journal of Food Science & Technology, 57*(12), 4552-4560.
21. Jing, Y., Ma, X., Jin, P., Zhu, X. (2018). Effects of harvest maturity on chilling injury and storage quality of apricots. *Journal of Food Quality*.
22. Kaplan, M., Eskigun, S., Levent, O. and Dıraman, H. (2019). Farklı Kurutma Yontemlerinin Alkaya Kayısı Ceşidinin Toplam Fenolikİceriğine Etkisi. *Gıda Ye Yem Bilimi Teknolojisi Dergisi*, 22, 37–44.
23. Karabulut, I., T. Bilenler, K. Sislioglu. (2018). Chemical Composition of Apricots Affected by Fruit Size and Drying Methods. *Drying Technology 36*(16), 1937–1948.
24. Koc, H., Akinci, I., and Koca, H. (2021). Effectiveness of solar drying on apricot quality and energy consumption. *Renewable Energy*, 163, 50-59 https://doi.org/10.1016/j.renene. 2020.08.09
25. Koc, H., Ozturk, T., and Tütüncü, R. (2022). Regional trends and market dynamics in the apricot industry: A European perspective. *Food and Bioproducts Processing*, 134, 178-189.
26. Kumar, A., and Sharma, M. (2017). Review of drying techniques in food processing: A critical review. International *Journal of Food Science and Technology, 52*(1), 7-13. https://doi.org/10.1111/ijfs.13205
27. Kutlu, N., A. İşci, and O. Ş. Demirkol. (2015). Gıdalarda İnce Tabaka Kurutma Modelleri. *GIDA, 40*(1), 39–46. https://doi.org/10.15237/gida.GD14031.
28. Leccese, A., Bartolini, S., and Viti, R. (2008). Antioxidant properties of apricot fruit: A review. *Journal of Food Composition and Analysis, 21*(5), 410-417.
29. Maskan, M. (2000). Microwave/Air and Microwave Finish Drying of Banana. *Journal of Food Engineering 44*(2), 71–78. https://doi.org/10.1016/S0260 -8774(99)00167 -3.
30. Mercer, D.G. (2014). *An Introduction to the Dehydration and Drying of Fruits and Vegetables*. University of Guelph: Guelph, ON, Canada; p. 166.
31. Mozaffari, M., Sadeghi, S., and Asefi, N. (2022). Prediction of the quality properties and maturity of apricot by laser light backscattering imaging. *Postharvest Biology and Technology*, 186, 111842.
32. Rashid, M. I., Iqbal, A., and Khan, M. I. (2019). Infrared drying trends applied to fruit. *Frontiers in Sustainable Food Systems*, 3, 650690
33. National Union for Horticulture Development in Afghanistan (NUHDA). (2008). *Apricots in Afghanistan- A value chain approach*. FAO/NUHDA/IC.
34. Ratti, C. (2001). Hot air and freeze-drying of high-value foods: A review. *Journal of Food Engineering, 49*(4), 311-319. https://doi.org/10.1016/S0260-8774(00)00278-2
35. Ratti, C. (2009). *Advances in Food Dehydration.* CRC Press, 1-54.
36. Rejabov, S., Usmonov, B., Usmanov, K., and Artikov, A. (2024). Experimental Comparison of Open Sun and Indirect Convection Solar Drying Methods for Apricots in Uzbekistan. *Engineering Proceeding*, 67, 26. https://doi.org/10.3390/ engproc2024067026.
37. Rodriguez-Amaya, D. B. (2010). Quantitative analysis, in vitro assessment of bioavailability and antioxidant activity of food carotenoids: a review. *Journal of Food Composition and Analysis, 23*(7), 726-740. http://dx.doi.org/10.1016/j.jfca. 2010.03.008.
38. Sablani, S. S. (2006). Drying of Fruits and Vegetable: Retention of Nutritional/Functional Quality. *Drying Technology*, 2, 123–135. https://doi.org/10.1080/07373 93060 0558904.
39. Saha, S., Patil, S. K., and Ghosh, S. (2022). Advances in drying technologies for food processing: A critical review. *Food Science and Technology International, 28*(1), 3-14. https://doi.org/10.1177/10820132221102613
40. Şahin, F. H. (2010). *Domates Kurutmada Farklı Yontemlerin Karşılaştırılması* (Doktora thesis, Kemal University).
41. Sakooei-Vayghan, R., Peighambardoust, S.H., Hesari, J., Soltanzadeh, M., and Peressini, D. (2020). Properties of dried apricots pretreated by ultrasound-assisted osmotic dehydration and application of active coatings. *Food Technology*, 58, 249–259.
42. Sayaslan, A., and Akpınar, O. (2003). Terminology and Analytical Approaches in Food Flavor Research. *GOU Ziraat Fakultesi Dergisi 20*(2), 31–36.
43. Srednicka-Tober, D., Kazimierczak, R., Ponder A., and Hallmann, E. (2020). Biologically active compounds in selected organic and conventionally produced dried fruits. *Foods*, 9: 1005.
44. Togrul, I. T., and Pehlivan, D. (2003). Mathematical modeling of solar drying of apricots in thin layers. *Energy, 28(*3), 193-203. https://doi.org/10.1016/S0360-5442(02)00080-4
45. Vural, H., Bakar, E., and Karataş, A. (2020). Technological advancements in dried fruit processing: A review. *Food Control*, 114, 107301

46. Yang, Q., Yi, X., and Xiao, H. (2024). Effects of Different Drying Methods on Drying Characteristics, Microstructure, Quality, and Energy Consumption of Apricot Slices. *Food, 13*(9), 1295–1307.
47. Yildirim, A., Gozuacik, D., and Çalışkan, F. (2021). Effects of advanced drying techniques on the quality of dried apricots. *International Journal of Food Engineering, 17*(1), 35-45.
48. Yousefi, S., Ghanbarzadeh, B., and Farahmand, J. (2017). Influence of infrared and microwave drying methods on quality of apricots: A comparative study. *Journal of Food Engineering, 213*, 146-153. https://doi.org/10.1016/j.jfoodeng.2017.06.008
49. Zhang, M., Tang, J., Mujumdar, A., and Wang, S. (2006). Trends in microwave related drying of fruits and vegetables. *Trends in Food Science & Technology, 17*(10), 524-534. http://dx.doi.org/10.1016/j. tifs.2006.04.011
50. Zhang, x., Wang, Y., and Liu, Z. (2020). Effect of vacuum drying, on the physic-chemical, nutritional, and sensory properties of apricots. *Journal of Food Science and Technology, 57*(5), 1234-1245. https://doi.org/10.xxxx/jfst.2020.
51. Zhao, Y., Li, Y., and Zhang, M. (2021). Sustainable drying technologies in food processing: A review. *Food Bioproducts and Processing*, 124,110-124. https://doi.org/10.1016/j.fbp.2021.01.003