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Sustainable preservation: Exploring modern solar drying technologies for fruits and vegetables

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Abstract
The preservation of fruits and vegetables is a critical aspect of food security, ensuring access to nutritious produce beyond the harvest season. In this context, solar drying has emerged as an eco-friendly and energy-efficient method with significant potential for reducing post-harvest losses and enhancing the availability of nutritious foods. This review paper provides a comprehensive exploration of modern solar drying technologies used for fruits and vegetables. We delve into the principles, advantages, challenges, and innovations that characterize this sustainable approach. The drying process plays a pivotal role in determining the quality and cost of the final product. Innovations in drying procedures hold the potential to yield a plethora of benefits, such as heightened energy efficiency, superior product quality, reduced operational costs, and a diminished environmental footprint. As the dehydration of agricultural products is a critical step in their processing, it warrants meticulous consideration and ongoing improvement to meet the evolving needs of both consumers and the industry. The paper also assesses the impact of solar drying on food quality, nutritional content, and the environment. With a focus on the latest advancements and their potential applications, we shed light on the crucial role of modern solar drying in achieving sustainable food preservation, while addressing global food security and promoting environmentally responsible practices.

Keywords: Solar drying, food preservation, food security, energy efficiency, and nutritional content etc.

Introduction
In a world facing increasing population growth and climate uncertainty, the preservation of fruits and vegetables has emerged as a vital cornerstone of global food security. As the demand for fresh, nutritious produce extends beyond the harvest season, innovative and sustainable preservation methods have taken center stage in the quest to ensure a stable and ample food supply. Among these methods, solar drying stands out as an eco-friendly and energy-efficient solution that not only aligns with the principles of sustainability but also holds immense potential for reducing post-harvest losses and enhancing the availability of nutritious foods. The purpose of this review paper is to embark on a comprehensive exploration of modern solar drying technologies specifically tailored for fruits and vegetables. By bridging the gap between traditional preservation methods and cutting-edge innovations, we aim to shed light on the critical role that solar drying plays in achieving sustainable food preservation and food security. Through a lens that encompasses the economic, environmental, and social dimensions of food preservation, this review will navigate the principles, advantages, challenges, and advancements within the realm of solar drying, revealing its multifaceted significance in addressing one of the world's most pressing issues. Fruits and vegetables, often recognized as super or functional foods due to their nutritional benefits (Rwubatse *et al*., 2014) [3], present a unique challenge in preservation. Their high moisture content, typically exceeding 80%, renders them susceptible to spoilage caused by bacteria (Maisnam *et al*., 2017; Valarmathi *et al*., 2017) [21, 39]. While maintaining freshness is the ideal way to preserve their nutritional value, conventional storage methods rely on low temperatures, which pose logistical challenges across the distribution chain. In contrast, drying emerges as an effective post-harvest management strategy, particularly in regions like Nigeria and other Sub-Saharan African countries.

Here, issues such as frequent power outages and soaring fuel prices make the establishment of low-temperature storage, handling, and distribution facilities a rare luxury (Dereje and Abera, 2020) [12]. Approximately one-fifth of the world's fresh produce undergoes drying processes, contributing to an extended shelf life and enhanced food security (Pragati and Preeti, 2014; Betoret *et al*., 2016; Feng *et al*., 2021) [31, 5, 15]. Dried fruits and vegetables play a significant role in making healthy eating more practical and bridging the gap between recommended and actual fruit consumption. Dehydration, by reducing water activity, not only enhances the shelf life of these foods but also contributes to their safety and preservation. It impacts enzymatic activity, sensory characteristics, and microbial growth, making it a crucial process in the journey of preserving the nutritional integrity of fruits and vegetables (Özbek *et al*., 2007; Dereje and Abera, 2020) [29, 12].

The history of fruit and vegetable preservation through drying is deeply rooted in sun and solar drying techniques (Sagar and Kumar, 2010) [34]. In the early stages, the process was as straightforward as laying the produce out on mats, rooftops, or open drying floors, taking advantage of solar radiation and natural convection (Ahmed *et al*., 2013) [1]. Alternative methods involved sheltering the harvest under covers, on treetops, or even on makeshift field shelves (Rwubatse *et al*., 2014) [3]. During sun drying, heat was transferred to the raw materials through convection from the surrounding air and radiation from the sun's surface. However, this open-air approach had significant drawbacks, as it left the food exposed to environmental factors and climatic changes, resulting in sanitation issues and a lack of stability. To overcome challenges such as damage, dust, pest infestation, and the unpredictability of rainfall, mechanized solar dryers, including tray, cabinet, and tunnel dryers, were developed (Pragati and Preeti, 2014; Rwubatse *et al*., 2014; Karam *et al*., 2016; Ajuebor *et al*., 2017) [31, 3, 18, 2]. This shift towards mechanized drying methods aimed to conserve agricultural produce more effectively, thereby reducing the amount of fuel consumed during the drying process. Notably, the primary objective of drying agricultural products has evolved over time. While the initial goal was to extend the shelf life of dried fruits and vegetables, the contemporary focus is on producing high-quality dried produce (Rwubatse *et al*., 2014; Babu *et al*., 2018) [3, 4]. This change reflects an increased emphasis on product quality and nutritional preservation in modern drying practices. Currently, a diverse range of drying methods are employed, often utilizing equipment powered by combustible fuels and/or electricity (Maisnam *et al*., 2017; Feng *et al*., 2021; Radojin, *et al*., 2021) [21, 15, 32]. Convective drying methods within enclosed structures find application in cabinet, tray, and tunnel dryers (Mercer, 2014; Misha *et al*., 2013) [24, 25], with notable progress observed in fluidized bed drying (Law and Mujumdar, 2006) [20]. Conductive drying on a heated surface is employed in drum dryers (Kerr, 2013). Additionally, the drying and concentration of fruit and vegetable juices are achieved through atomization techniques (Cal and Solohub, 2009; Mercer, 2014) [6, 24]. Furthermore, innovative approaches such as lyophilization, involving the direct sublimation of ice to vapor, and the utilization of lower pressure in fruit and vegetable drying, result in products characterized by improved rehydration properties, sensory attributes, and reduced drying times (Falade and Igbeka, 2007; Cenkowski *et al*., 2008) [13, 9]. In methods like explosion puff drying and low-pressure super-heated steam drying, the concept of drying with steam and lowered vapor pressure is harnessed. These techniques not only reduce drying time but also enhance thermal efficiency (Calín-Sánchez *et al*., 2020) [8]. To address the imperative of reducing energy losses associated with traditional hot air drying, heat pump drying systems have been developed, substantially improving energy efficiency and curbing fossil fuel consumption (Fayose and Huan, 2016) [14]. Preceding the drying process, osmotic pretreatment of fruits and vegetables has gained widespread use to decrease processing time and enhance the overall consistency of the final dried food product (Mehta *et al*., 2013) [23]. Furthermore, the application of electromagnetic waves in fruit and vegetable drying is rapidly gaining momentum. This approach involves indirect electro-heating (Marra *et al*., 2009) [22], resulting in shorter drying times and lower drying temperatures (Kahyaoglu *et al*., 2012; Nindo and Tang, 2007; Calín-Sánchez *et al*., 2020) [17, 26, 8]. Despite these remarkable technological advancements in fruit and vegetable drying, this paper will critically assess the existing limitations of these processes and explore potential avenues for further improvement.

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Principles of Solar Drying

Solar drying operates on principles of heat and mass transfer. Solar radiation heats the product, causing water to evaporate, and airflow removes the moisture. Understanding these principles is essential for efficient solar drying system design and operation, making it a sustainable method for food preservation. Fig. 1 illustrates the fundamental operation of open sun drying, which relies solely on solar energy. Agricultural crops are typically spread out on surfaces like the ground, mats, or cement floors, exposed to short-wavelength solar energy for a substantial portion of the day, accompanied by natural air circulation. A portion of the solar energy is reflected, while the rest is absorbed, contingent on the crops' color. The absorbed radiation is converted into thermal energy, raising the material's temperature. However, this process incurs losses, including long-wavelength radiation loss as heat radiates from the crop's surface into the surrounding moist air, as well as convective heat loss due to wind blowing over the moist air above the crop. Open sun drying relies solely on sunlight and is cost-effective, but it has limitations. In many cases, open sun drying doesn't meet the required quality standards, making it difficult to market products internationally. Recognizing these limitations, a more scientifically advanced method, known as solar drying, has been developed to harness solar energy more efficiently for crop drying (Sharma *et al*. 2009) [35].

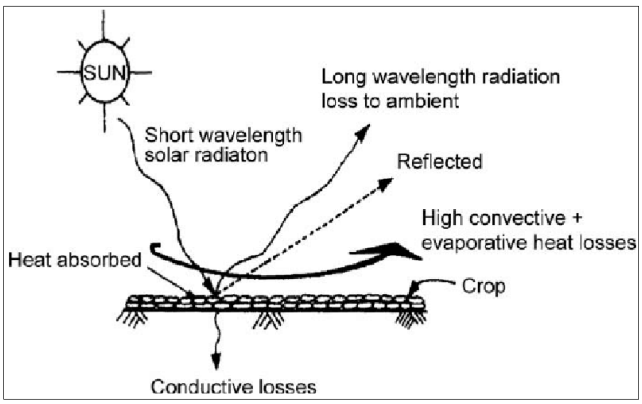

Fig 1: Working principle of open sun drying

Evolution of Fruit and Vegetable Drying Techniques

Drying fruits and vegetables, a practice with historical roots, has traditionally relied on sun and solar drying techniques

(Sontakke and Salve, 2015) [37]. The pursuit of enhanced product quality and reduced contamination risks has driven the development of advanced drying technologies. Commonly employed drying methods encompass freeze-drying, vacuum drying, osmotic dehydration, cabinet or tray drying, fluidized bed drying, spouted bed drying, Ohmic drying, microwave drying, and combined methods (Pragati and Preeti, 2014; Maisnam *et al*., 2017; Tontul and Topuz, 2017; Sakif *et al*., 2018) [31, 21, 38, 36]. With the exception of freeze-drying and osmotic dehydration, the fundamental mechanisms driving water evaporation during drying involve conduction, convection, and radiation. Forced air is often employed to facilitate vapor removal (Sagar and Kumar, 2010; Pragati and Preeti, 2014) [34, 31]. Drying techniques can be broadly categorized into three groups: traditional, mechanized, and advanced drying methods (Pragati and Preeti, 2014; Maisnam *et al*., 2017; Hasan *et al*., 2019) [31, 21].

Traditional methods of drying of fruits and vegetables

Sun drying, a traditional method of preserving fruits and vegetables, relies on the abundant energy of the sun to remove moisture from produce. The process involves spreading the harvested fruits and vegetables on open surfaces like mats, rooftops, or drying floors, allowing them to be exposed to direct sunlight for a significant part of the day. As the sun's energy is absorbed by the produce, it initiates the evaporation of water within. While this approach is cost-effective and environmentally friendly, it is subject to variations in weather and can result in quality issues due to exposure to environmental elements. Nevertheless, sun drying remains a widely practiced method in regions with ample sunlight and limited access to modern drying technologies. Sun drying, recognized as the oldest method of preserving fruits and vegetables (Misha *et al*., 2013) [25], has a rich historical backdrop in which solar energy, air, and even smoky flames were employed to extract moisture from a variety of foods, including fruits, meats, cereals, and plants (Ahmed *et al*., 2013) [1]. This approach is particularly suitable for fruits with high sugar and acid content, making them naturally resistant to spoilage during sun drying. The process typically involves laying out fruits on trays placed on elevated slabs, subjecting them to open-air exposure until the desired level of dryness is achieved. To facilitate this process, materials like stainless steel, Teflon-coated fiberglass, or plastic screens are commonly used. Optimal sun drying conditions entail a minimum temperature of 86°F and a relative humidity of less than 60% (Ahmed *et al*., 2013) [1]. Sun drying offers advantages like low capital and operating costs and minimal skill requirements. However, it is not without its limitations, such as challenges related to insect infestation, contaminants from dust and debris, extended drying times, quality degradation, and limited heat transmission due to moisture condensation. Despite these concerns, sun drying remains a viable method for preserving specific fruits like raisins and plums.

Modern Techniques for Drying Fruits and Vegetables

Artificial drying relies on mechanical or electrical equipment to efficiently remove substantial moisture from products (Babu *et al*., 2018) [4]. This method allows for precise control of essential parameters like temperature, drying air flow, and drying time (Okoro and Madueme, 2004; Babu *et al*., 2018; Xiao *et al*., 2018) [24, 4, 41], enabling a more controlled and consistent drying process.

Solar drying

Drying fruits and vegetables using solar dryers is an eco-friendly and energy-efficient method that has gained prominence in recent years. These specialized drying systems harness the power of the sun to remove moisture from produce, preserving their quality and extending shelf life. Solar dryers come in various designs, including cabinet, tray, and tunnel dryers, each tailored to specific needs and climatic conditions. Solar drying involves exposing the harvested fruits and vegetables to the sun's radiant energy, which is absorbed by the material, causing water to evaporate. The warm, dry air within the dryer facilitates this process. Solar dryers are particularly advantageous in regions with abundant sunlight, as they significantly reduce energy costs and reliance on fossil fuels. This sustainable method not only promotes food preservation but also helps address food security issues by reducing post-harvest losses and promoting the availability of nutritious foods throughout the year. Solar drying is employed to dehydrate food, utilizing specialized solar dryers like tray, cabinet, tunnel, spray, and fluidized dryers, which fall under the category of convectional dryers. In this method, food is subjected to heated air generated through the absorption of solar and radiant energy, often facilitated by a refractive medium like glass or polyethylene (Alamu *et al*., 2010) [3]. Compared to open-air drying, solar drying yields improved product quality, although it typically accommodates smaller capacities. Challenges encountered in this process encompass moisture condensation within the dryer and elevated humidity levels. There are two primary types of solar drying, direct and indirect and a range of food products, including berries, bananas, mangoes, and rosemary, can be effectively dried using solar dryers (Abhay *et al*., 2017) [42].

Advantages of Solar Drying for Fruits and Vegetables

- **Energy Efficiency:** Solar drying is a highly energy-efficient method of food preservation. It utilizes the sun's free and abundant energy, reducing the dependence on fossil fuels and electricity. This not only lowers operating costs but also decreases the environmental impact associated with energy consumption.
- **Nutrient Preservation:** Solar drying allows for gentle and gradual moisture removal from fruits and vegetables. This process helps to retain a higher percentage of the original nutrients, including vitamins and minerals. Compared to other drying methods, solar drying is known for its ability to preserve the nutritional content of the produce.
- **Enhanced Flavor:** The slow and controlled drying process in solar dryers can lead to concentrated flavors in fruits and vegetables. As moisture is removed, the natural sugars and flavors become more pronounced, resulting in a more intense and desirable taste in the dried products.
- **Extended Shelf Life:** Dried fruits and vegetables have a significantly longer shelf life compared to their fresh counterparts. Solar drying reduces the water activity in the produce, making it less susceptible to spoilage and microbial growth. This extended shelf life ensures that the food remains available and nutritious beyond the harvest season, contributing to food security.
- **Minimal Environmental Impact:** Solar drying is an environmentally friendly method. It does not produce greenhouse gas emissions or air pollutants, making it a sustainable and green approach to food preservation. It aligns with the principles of eco-friendly and sustainable agriculture.

- **Cost-Effective:** Solar drying systems have relatively low initial investment and operational costs. They are particularly advantageous in regions with abundant sunlight, where they can significantly reduce the expenses associated with energy-intensive drying methods.
- **Local Food Production:** Solar drying can be employed at the local or community level, supporting small-scale agriculture and local food production. This not only enhances food security but also stimulates local economies by creating opportunities for farmers to process and sell their produce.
- **Accessibility:** Solar drying is a versatile technique that can be adopted in a variety of settings, from small-scale household drying to large commercial operations. Its adaptability makes it accessible to a wide range of users.
- **Reduced Food Waste:** By extending the shelf life of fruits and vegetables, solar drying helps reduce food waste. It allows for the preservation of excess produce that might otherwise go to waste, contributing to a more sustainable and responsible food system.

Solar drying is a sustainable and efficient method of preserving fruits and vegetables, offering multiple advantages, from improved nutrient retention and flavor enhancement to cost savings and reduced environmental impact. It plays a vital role in addressing food security, promoting sustainable agriculture, and reducing food waste.

Quality Parameters of Solar-Dried Products

- **Moisture Content:** One of the most critical quality parameters in solar-dried fruits and vegetables is moisture content. The drying process aims to reduce moisture to a level where it inhibits microbial growth and enzymatic activity while maintaining the product's desirable characteristics. Solar drying should achieve the optimal moisture content for long-term storage and consumption.
- **Color Retention:** The color of fruits and vegetables is a vital aspect of their overall quality. Solar drying should preserve the natural color of the produce as much as possible. Exposure to excessive heat and sunlight can lead to color deterioration, impacting the product's visual appeal and perceived quality.
- **Texture:** The texture of solar-dried products plays a significant role in consumer acceptability. Overdrying or underdrying can lead to undesirable changes in texture. Proper solar drying should result in fruits and vegetables with an appealing texture, whether soft, leathery, or crisp, depending on the specific product.
- **Nutritional Value**: Solar drying should aim to retain the nutritional value of the dried produce. Vitamins, minerals, and other essential nutrients are sensitive to heat and light. Prolonged exposure to high temperatures during solar drying can lead to nutrient degradation. To maintain nutritional quality, the drying process must be carefully controlled.
- **Sensory Properties:** The sensory properties of solar-dried fruits and vegetables, including flavor and aroma, are vital factors that influence consumer preference. Solar drying should enhance the concentration of natural sugars and flavors, resulting in a product with an appealing taste and aroma. It should be free from off-flavors and odors that may result from improper drying.
- **Rehydration Capacity:** Solar-dried products should have the ability to rehydrate effectively when exposed to moisture. This is especially important for fruits and vegetables that may be reconstituted for use in cooking or recipes. Properly dried produce should rehydrate without becoming mushy or losing its texture.
- **Shelf Life:** The shelf life of solar-dried products is a crucial quality parameter. Dried fruits and vegetables should have an extended shelf life, allowing for long-term storage without spoilage or loss of quality. Packaging and storage conditions also impact the product's shelf life.
- **Microbiological Safety:** The absence of pathogens and harmful microorganisms is a critical quality parameter. Solar drying should ensure that the dried products are safe for consumption, free from microbial contamination, and meet established food safety standards.
- **Foreign Material Contamination:** Solar-dried products should be free from foreign material contaminants, such as insects, dust, and debris. Proper handling and storage are essential to prevent contamination during the drying process.
- **Size and Shape:** The size and shape of the dried products should be consistent and uniform, which is important for both visual appeal and ease of handling in culinary applications.

Optimizing these quality parameters is essential to produce high-quality solar-dried fruits and vegetables that meet consumer expectations for taste, texture, appearance, and nutritional value while ensuring safety and extended shelf life. Careful monitoring and control of the solar drying process are key to achieving these quality objectives.

Solar Drying Applications in the Food Industry

Solar drying finds diverse applications in the food industry, particularly in the enhancement of food products and processing. Solar-dried fruits and vegetables play essential roles in sauces and soups, enriching flavors and offering natural sweetness. They are integral to the snack industry, serving as nutritious components in chips and crisps. Ready-to-eat meals benefit from their extended shelf life and rehydration capabilities, contributing to convenience and quality. Dried fruits feature in baking and pastry, adding a chewy texture and natural sweetness to bread and pastries. In the cereal and granola industry, they enhance both taste and nutrition. Beverages such as fruit-infused teas rely on dried fruits for flavor, while nutritional supplements harness their vitamins and minerals. Solar-dried ingredients are also vital in creating ingredient blends for various applications in the food industry, offering both flavor enhancement and nutritional value, while promoting sustainability and improved food quality.

Sustainability and Climate Change: The Role of Solar Drying in Food Preservation

In the context of addressing climate change and fostering sustainability, solar drying emerges as a vital contributor to sustainable food preservation. By relying on renewable solar energy, this eco-friendly method significantly reduces carbon emissions linked to energy-intensive drying techniques, aligning with global efforts to combat climate change. Solar drying is inherently energy-efficient, utilizing the sun's abundant and free resource, thereby lowering operational costs and promoting sustainable food preservation practices. Furthermore, it reduces the need for non-renewable resources, such as electricity and fuel, conserving valuable energy supplies. By extending the shelf life of fruits and vegetables, solar drying curbs post-harvest losses, an essential step in food security, reducing food waste and its associated environmental impact. Its capacity to support local agriculture, adapt to climate variability, and minimize emissions and pollutants aligns with eco-friendly principles, promoting sustainability throughout the food industry. In essence, solar drying exemplifies an environmentally responsible approach to food preservation, contributing to a more sustainable world as it addresses the challenges of climate change and enhances food security.

Cabinet dryer

Fruits and vegetables designated for drying are arranged on shelves or racks within the cabinet's drying chamber, where they are exposed to a stream of hot, dry air (Mercer, 2014) [24]. While the equipment itself is cost-effective, the process operates in batches and tends to incur high labor costs, yielding relatively low performance. Various models have been developed for specific produce like potato chips, grapes, apricots, and beans. Ajuebor *et al*. (2017) [2] fabricated a cabinet dryer tailored for processing okra, chili peppers, and plantains and conducted a performance evaluation. Optimal drying conditions were achieved at 70 °C, a relative humidity of 60%, and an airspeed of 3.0 m/s. Under these specific process parameters, drying time was significantly reduced, and the results of the analyses conducted demonstrated superior performance at these settings.

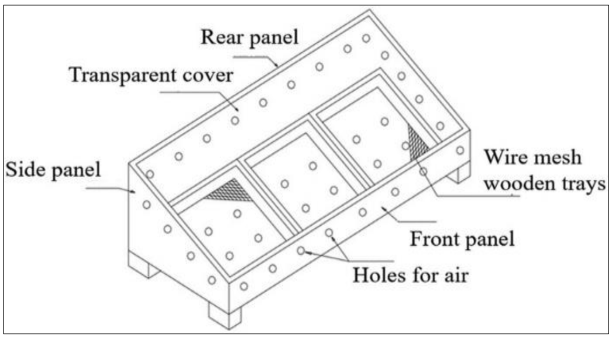

Fig 2: Solar cabinet dryer

Tray drying

The tray dryer, functioning as a batch dryer similar to a cabinet dryer, is designed to optimize airflow by employing large wire mesh trays for the arrangement of dried fruits and vegetables. Once the trays are loaded with produce, they are positioned on supports within a drying cabinet or compartment. The drying chamber is then sealed, and air is propelled into it to initiate the drying process (Mercer, 2014) [24]. Ensuring uniform airflow distribution over the trays is critical for the tray dryer's efficiency (Misha *et al*., 2013) [25]. One of the primary challenges associated with tray dryers is the potential for uneven drying, stemming from inadequate airflow circulation within the drying chamber. In many of the dryer systems built, solar energy is harnessed to reduce operating costs (Misha *et al*., 2013) [25]. Colak and Hepbasli (2007) [11] developed a model for drying green olives, and this method finds application in drying apple, banana, and apricot slices as well. Due to its capacity to achieve enhanced drying rates, improved product quality, and appearance, the tray dryer has been determined to outperform oven dryers (Norhadi *et al*., 2020) [27].

Tunnel dryers

A development beyond traditional tray and cabinet dryers, tunnel dryers were specifically engineered to replace sun drying methods for prunes, incorporating heated forced air drying techniques. Tunnel dryers consist of elongated tunnels through which trucks transporting trays filled with produce move, either with or against the flow of drying air, offering options for co-current, counter-current, or mixed current airflow. A truck laden with moist food enters one end of the tunnel, while another truck carrying dehydrated products emerges from the opposite end. The trucks are maneuvered either manually or mechanically, often using chains, depending on the truck's size and the tunnel's scale. Although tunnel dryers provide a flexible drying approach, they require a notable amount of labor compared to continuous belt dryers, which limits their widespread adoption (Mercer, 2014) [24]. This method has been employed for drying a variety of fruits and vegetables, including apricots, peaches, pears, apples, figs, dates, often in the form of fragments, purees, or liquids.

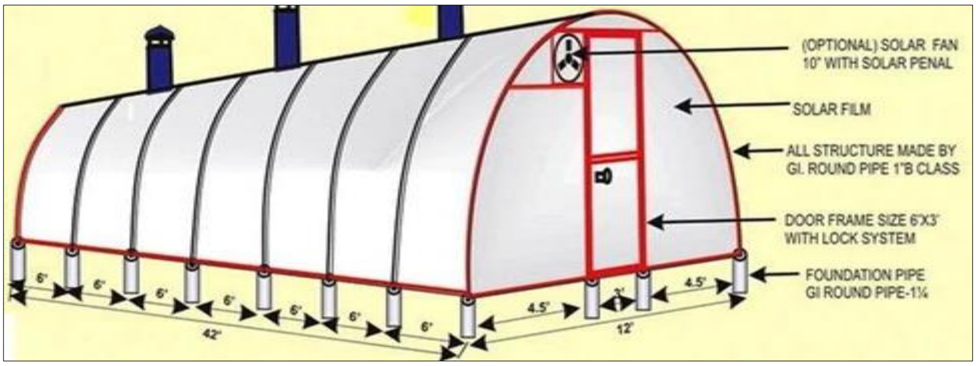

Fig 3: Solar tunnel dryer

Spray drying

According to Cal and Solohub (2009) [6], this apparatus was devised to enhance the drying and concentration of liquid substances through atomization. In this process, fruit or vegetable juice is propelled through an atomizing valve, breaking it into fine droplets evenly dispersed within a spacious drying chamber, where they descend into an upward-flowing stream of hot air (Mercer, 2014; Tontul and Topuz, 2017) [24, 38]. Controlling parameters such as particle diameter, air temperature, and airflow velocity allows for the attainment of the desired degree of drying, ultimately transforming the droplets into fine powder particles by the time they reach the bottom of the dryer (Mercer, 2014) [24]. It's worth noting that this method may not be suitable for foods vulnerable to mechanical damage due to the vigorous shear action during atomization. Drawbacks include the potential loss of bioactive compounds in the food and the tendency of sugar-rich foods to adhere to drying equipment. Moreover, the equipment's size and installation costs are substantial. Tomato juice has been successfully dried into powder utilizing this approach (Phisut, 2012; Verma and Singh, 2015) [30, 40].

Fluidized bed dryers: Fluidized bed dryers, as highlighted by Mercer (2014) [24], distinguish themselves by ensuring that the drying medium, typically warm air, makes contact with all surfaces of the product being dried. This method minimizes the risk of soluble materials migrating within the food particles by lifting them and conveying them outward using heated air blown from beneath the bed. Heated air is introduced into the drying chamber through openings in the bottom, establishing a linear velocity through a sufficient volumetric airflow to suspend and dry the wet fruit or vegetable (Mercer, 2014) [24]. Fluidized bed drying finds widespread application in drying various wet, granular, and particulate food products that can be fluidized within beds composed of inert solids, including slurries, pastes, and suspensions (Law and Mujumdar, 2006) [20]. Nevertheless, limitations of this method include constraints on particle size and suboptimal thermal efficiency. Commonly dried vegetables, such as peas, green beans, carrots, and onion slices, are often processed using this technique.

Conclusion

In conclusion, modern solar drying technologies represent a vital and sustainable solution for preserving fruits and vegetables in an era marked by climate change and growing food demands. These technologies enhance energy efficiency, product quality, and environmental responsibility, addressing the imperatives of sustainability. Their adaptability to diverse climates, support for local agriculture, and role in reducing food waste underscore their significance. Solar drying is a crucial ally in mitigating climate change and achieving sustainable food preservation.

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