A NEW DESIGN FOR A SOLAR DRYER: PART I

S D Suryawanshi

INTRODUCTION

Agricultural produce is perishable by nature. In India, nearly 10 % of agricultural produce, nearly 15 million tons of food grains per year, is damaged after harvesting. Preserving such agricultural produce by drying reduces wastage and allows storage of food needed. Drying makes produce lighter and smaller with value addition. Drying is the most established and oldest method of improving shelf life [1]. The drying process reduces the moisture content of food to a lower level, which prevents the deterioration of food caused by molds, yeasts, bacteria, and enzymes [2,3].

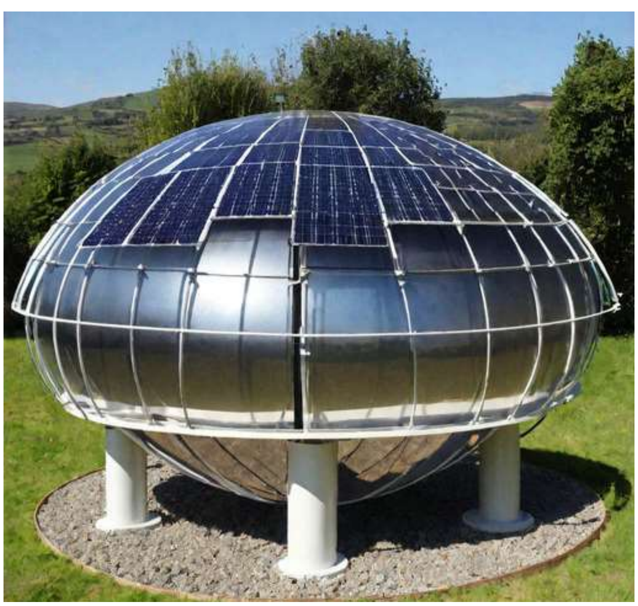
Agricultural produce is perishable by nature. In India, nearly 10 % of agricultural produce, nearly 15 million tons of food grains per year, is damaged after harvesting. Preserving such agricultural produce by drying reduces wastage and allows storage of food needed. Drying makes produce lighter and smaller with value addition. Drying is the most established and oldest method of improving shelf life [1]. The drying process reduces the moisture content of food to a lower level, which prevents the deterioration of food caused by molds, yeasts, bacteria, and enzymes [2,3].

The process also requires a large area of land, takes time, and is highly labour-intensive, as it is an attentive process [2]. With agricultural and industrial development, mechanical drying using heat sources from fossil fuels came into practice. However, these mechanical drying systems are highly energy-intensive and expensive, increasing the production cost [2]. Open sun drying is less costly and straightforward but requires two to three weeks. Due to long-time exposure to solar radiation, its nutritional values decrease [1,2]. Open-air drying has now shifted to solar drying as good options are available due to technological development. The solar drying system utilizes solar energy to heat air and dry agricultural produce.

Solar dryers available in the market are approximately cuboid (Cabinet) in shape with a transparent top face that slopes in a due south direction for installation in the northern hemisphere. Such a design demands proper insulation on five sides except the top transparent. The cuboid shape prevents the use of solar radiation in the morning and evening. It also exposes the produce, to be dried, to Ultraviolet rays. In this design, the air change differs across the drying area. Air is removed from various spots along the top edge. This action makes it hard to control air exchange, temperature, and humidity. The inside drying area in cuboid dryers is smaller than in hemispherical dryers for the same outside surface area.

These limitations of cuboid-shaped solar dryers have raised a demand for modular hemispherical solar dryers that can be used for drying, heating, and pest control by physical disinfection. The advantages of a modular hemispherical solar dryer:

1. It maintains proper air change and monitors temperature and relative humidity for effective drying.
2. It preserves nutritive content, aroma, flavour, and aesthetics (colour) of food without exposure to ultraviolet rays.
3. It utilizes morning and evening solar radiation.
4. It can be operated by handheld devices like smartphones using the Internet of Things (IoT).



Major production hub and related stakeholders of the agricultural produce/industry in India:

Grapes - Maharashtra, Karnataka
Banana – Maharashtra, Andhra Pradesh, Bihar, Tamilnadu, Gujrat, Karnataka
Spices – Northeast part of India
Onion - Maharashtra, Madhya Pradesh, Karnataka, Gujrat
Potato - Uttar Pradesh, West Bengal, Bihar, Gujarat
Mangoes - Uttar Pradesh, Andhra Pradesh, Bihar, Tamilnadu, Gujrat

A short note on the proposed design

A new design for a modular solar dryer is suggested. It allows drying without losing nutrients, aroma, flavour, or appearance. The outer transparent glazing surface and inner absorber are hemispherical, so this design gives maximum internal drying chamber volume. Insulation requirements are low compared with dryers commercially available on the market. The hemispherical shape effectively accepts morning and evening solar radiations and converts them into heat energy. The proposed design can be used in two modes as follows:

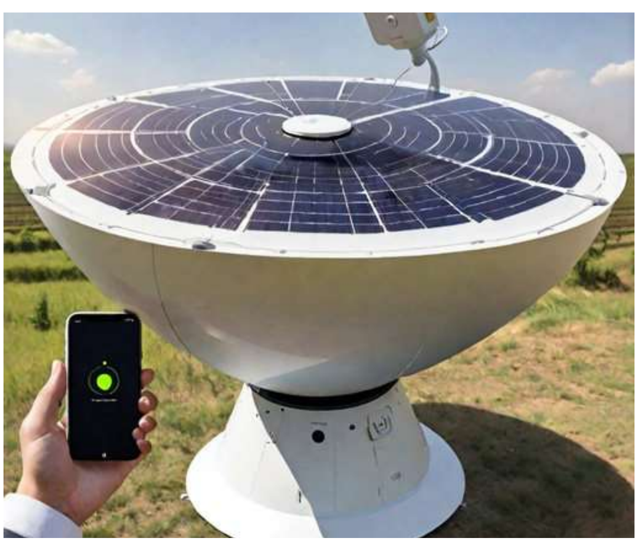
1. For drying and physical disinfection of ingredients having less moisture content after post-harvest, like pulses, dry fruits, and cereals.
2. For drying agricultural produce of more water content like fresh fruits and vegetables like grapes and onion.

In the first mode of operation of the dryer, if the air change rate is minimal, the temperature achieved in the drying chamber is 70 to 80 degrees Celsius. Farmers can use such conditions to make value-added products like mango and mix pickles, gulkand, and hair oil enriched with ayurvedic medicinal plant ingredients.

Salted ground nuts, almonds, and cashews can be dried and physically disinfected after harvest. This process works well for ingredients with low moisture. It involves optimizing air flow to reach a temperature between 50 to 60 degrees Celsius. This method is suitable for pulses, dry fruits, and cereals.

In the second mode of drying agricultural produce with more water content, like fresh fruits and vegetables like grapes, onions, etc., air change upon heating and dying the produce in the drying chamber is a vital parameter. The temperature and humidity in the drying chamber are regulated. This regulation involves sensors. These sensors track temperature and humidity. Additionally, there is proper air change. This air change is achieved by a blower installed at the top point of the hemispherical dryer.

The controller records time, temperature, and humidity inside the dryer and maps such parameters to the user device. The user device is configured to receive real-time updates from the controller regarding drying process notifications related to temperature, humidity, and drying duration. Air change is a vital controlling parameter, which is possible with this innovative design of the hemispherical shape. Hot and humid air ascends and accumulates at the top end of the dryer. From this area, it is easy to remove with intermittent operation of the blower. The controller regulates the operation of the blower motor of the air change mechanism using a humidity sensor and temperature sensor.



Location-specific importance

Typically, solar radiation varies between 4 -7 kWh/m2 /day in India during sunny days. The present invention utilizes both direct and diffused radiations effectively. India is the world's foremost producer and supplier of agricultural produce; therefore, almost all parts of India are favourable sites for the installation of the proposed project. Excess seasonal production of mangos, onions, bananas, grapes, tomatoes, and vegetables prompts solar drying. These products are perishable and need to be processed for preservation and export; solar drying is a techno-commercially perfect match.

In the next issue, I will explain the detailed design of a hemispherical solar dryer.

References:

1. Prakash, O., Kumar, A., & Sharaf-Eldeen, Y. I. (2016). Review on Indian solar drying status. Current Sustainable/Renewable Energy Reports, 3(3–4), 113–120. https://doi.org/10.1007/s40518-016-0058-9

2. Ali, Javed & Rani, Poonam. (2015). Overview of grain drying and storage problems in India, Int J Eng Res Gen Sci. 2015;3(5):674–78.

3. Wang, J., Mujumdar, A. S., Mu, W., Feng, J., Zhang, X., Qian, Z., Fang, X., Gao, Z., & Xiao, H. (2016). Grape drying: current status and future trends. In InTech eBooks. https://doi.org/10.5772/64662

4. Esmaiili M, Sotudeh-Gharebagh R, Cronin K, Mousavi MAE, Rezazadeh G. (2007). Grape drying: a review. Food Reviews International, 23(3), 257–280.

Dr. Sanjeev Damodhar Suryawanshi is currently working as Professor & Head at SSVPS BSD College of Engineering, Dhule
sanjeevsuryawanshi1@gmail.com