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# FARMER FRIENDLY BASED LOW COST SOLAR DRYER FOR FRUITS AND VEGETABLES

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**ABSTRACT:**
India is one of the **world's major producing** countries and has the **second largest share of** agricultural **income, account ing for** 61% of the **country's total income.** The most valuable **groups will plan** this **progress correctly, making** their **en tire country** one of the **world's major producing regions. For** a long time, **many developing countries** and **the youth h ave been facing shortages of special crops** and vegetables due to **disasters such as earthquakes, heavy rains** and othe r unforeseen events. **The main problem at present in this article is ensuring** the **safety** of **food** to the **consumer after harvest,** which **accounts for** 60% of **the situation** due to the **method** of **isolating additional goods.** This **article focuses** on **traditional techniques for drying special crops and vegetables using solar dryers. One of** the **problems they face is the change in exposure price. Tomatoes can be sold at Rs** 80 per **kilo in** one month and **Rs** 20 per **kilo the next mo nth. However, farmers cannot guarantee food** for more than 1 to 2 weeks **due to transportation** costs, **financial diffic ulties** and **the need for capital** to **build capacity** in **existing facilities.** When **prices** are **too high,** farmers **often** have to **stop producing, causing great suffering.** The **next promise will cause some farmers** to commit suicide. **I found an aff ordable dryer to solve** this **problem. Made entirely** from bamboo, **the machine is very cost-effective and can produce** bamboo in **the field, allowing farmers to dry their rustic products** and **bring** them **back aft er** a **minimum** of six **months of finishing, coloring** and **testing.**

## INTRODUCTION:

Drying has long been utilized as a method to extend the shelf life of food products, dating back to ancient times. Harnessing the sun's heat and wind, this age-old technique remains a cornerstone of food preservation. However, its energy-intensive nature, coupled with the increasing scarcity and cost of fossil fuels, has spurred a shift towards renewable energy sources. Among these, solar energy stands out for its environmental friendliness and minimal ecological footprint. Various types of solar dryers have been developed and tested across different regions, primarily falling into two categories: natural convection and forced convection. Natural convection dryers rely on buoyancy-induced airflow, while forced convection dryers employ fans, typically powered by electricity, solar modules, or even fossil fuels.

Solar thermal technology, rapidly gaining traction in agricultural applications, offers distinct advantages over other alternatives like wind or shale. Abundant, inexhaustible, and clean, solar energy presents a sustainable solution for food preservation needs. Addressing the pressing issue of agricultural produce preservation, particularly in developing countries, holds significant importance. Inadequate infrastructure, limited processing capacities, and market challenges contribute to substantial post-harvest losses, exacerbating food security concerns. Drying emerges as a viable solution, not only curbing spoilage but also bolstering income opportunities and supply stability.[1]

At the farm level, drying immediately post-harvest, especially during peak harvest periods, helps manage surpluses and extends storage capabilities. Thermal energy-based drying facilitates longer shelf lives and easier transportation by reducing moisture content. Moreover, when executed correctly, drying preserves nutritional quality and inhibits the proliferation of harmful pathogens. While energy-intensive, drying efficiency hinges on several factors such as produce type, size, arrangement on drying racks, and frequency of rotation. Optimal drying necessitates avoiding overcrowding and ensuring regular turning to achieve uniform drying.

## Literature Review:

Crop drying is a vital process in agriculture, aimed at reducing moisture content to ensure safe processing and prolonged storage of produce. It is estimated that a significant portion of global vegetable production—about 20%—is lost post-harvest due to inadequate handling and suboptimal postharvest technology implementation. Typically, vegetables and

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seeds are harvested with moisture levels ranging from 18% to 40%, requiring drying to levels between 7% and 11%, depending on specific applications and market demands. Storage of harvested vegetables is often necessary before marketing or utilization as feed.[2] The duration of safe storage depends on factors like initial harvest condition and storage facility type. Low temperature and moisture content storage conditions facilitate extended shelf lives for vegetables such as maize, rice, and beans. Solar drying methods can be categorized as direct, indirect, or mixed-mode dryers. Direct solar dryers utilize solar energy absorbed by the vegetables within an air heater, facilitating drying through radiation and subsequent conduction. Indirect dryers collect solar energy in a separate air heater, with heated air circulated through the vegetable bed. Mixed-mode dryers employ both direct and indirect solar energy absorption methods simultaneously. Energy plays a pivotal role in human development, with solar energy emerging as a promising renewable resource. However, challenges like lower energy density and geographic variability hinder its widespread adoption. Efficient solar energy concentration technologies are thus essential for maximizing its utility.

## PLAN APPROACH AND METHODOLOGY:

Solar drying alludes to a procedure that utilizes occurrence sun-based radiation to change over it into warm vitality required for drying purposes. Most sun-oriented dryers utilize sun based discuss radiators and the warmed discuss is at that point passed through the drying chamber (containing fabric) to be dried. The discuss exchanges its vitality to the fabric causing dissipation of dampness of the material.

**Design Methods** In numerous parts of the world there is a developing mindfulness that renewable vitality have an critical part to play in expanding innovation to the agriculturist in creating nations to increment their efficiency. Sun powered warm innovation is a innovation that is quickly picking up acknowledgment as an vitality sparing degree in agribusiness application. It is favored to other elective sources of vitality such as wind and shale, since it is plenteous, limitless, and non-polluting. Sun based discuss radiators are basic gadgets to warm discuss by utilizing sun-based vitality and utilized in numerous applications requiring moo to direct temperature underneath 80 C, such as trim drying and space warming. Drying forms play an imperative part in the conservation of agrarian items. They are characterized as a handle of dampness expulsion due to concurrent warm and mass exchange. [3] According to two sorts of water are display in nourishment things; the chemically bound water and the physically held water. In drying, it is as it were the physically held water that is expelled. The most critical reasons for the ubiquity of dried items are longer shelf-life, item differences as well as significant volume decrease. This may be extended advance with advancements in item quality and handle applications. The application of dryers in creating nations can decrease post gather misfortunes and essentially contribute to the accessibility of nourishment in these nations. Estimations of these misfortunes are by and large cited to be of the arrange of 40% but they can, beneath exceptionally unfavorable conditions, be about as tall as 80%. A noteworthy rate of these misfortunes are related to dishonorable and/or inopportune drying of foodstuffs such as cereal grains, beats, tubers, meat, angle, etc

**Design Execution** Surrounding temperature was recorded amid the course of tests with the offer assistance of advanced sensor. This extend presents the plan, development and execution of a mixed-mode sun powered dryer for nourishment conservation. The dryer displayed adequate capacity to dry nourishment things sensibly quickly to a secure dampness level and at the same time it guarantees a prevalent quality of the dried product **History:**

**How the extend fabricated Plan and arranging**: Start by planning the sun powered vegetable dryer, considering variables such as estimate, shape, capacity, and usefulness. Decide the number and measure of drying racks or plate required to suit the wanted vegetable volume. Arrange the situating of the sun-oriented boards, fan or blower, and other components. Bamboo determination and planning: Select bamboo posts that are solid, straight, and of reasonable breadth. Evacuate any branches or clears out from the posts. Cut the bamboo to the required lengths for the different components of the dryer, such as the primary outline, supporting structures, and drying racks. Treatment and conservation: Treat the bamboo to improve its solidness and resistance to rot. This can be done through different strategies such as oven drying, warm treatment, or chemical medications. Take after the particular treatment rules based on the sort of bamboo and craved conservation comes about. Component creation: Cut, shape, and plan the bamboo shafts agreeing to the plan details. This may include strategies such as sawing, boring, or carving. Make the primary outline structure, supporting pillars, drying racks, and any extra components required for the dryer. Joinery and gathering: Collect the distinctive bamboo components utilizing fitting joinery strategies. This may incorporate lashing, weaving, or utilizing cements particularly planned for bamboo. Guarantee solid and secure joints to give basic astuteness to the sun powered vegetable dryer. Integration of sun-based components: Introduce the sun-oriented boards on the dryer structure, guaranteeing legitimate arrangement and situating to maximize sun-oriented vitality retention. Interface the boards to a charge controller or battery 46 framework. Introduce a fan or blower to encourage wind stream inside the drying chamber. Quality control and testing: Conduct careful assessments to guarantee the quality and usefulness of the sun-oriented vegetable dryer. Check for any auxiliary shortcomings, guarantee appropriate arrangement of components, and test the

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sun-based board and fan operations. Make any fundamental alterations or repairs. Wrapping up touches: Apply a defensive coating or wrap up to the bamboo surfaces to upgrade their life span and aesthetics. This may include utilizing characteristic oils, varnishes, or eco-friendly coatings. Bundling and shipping: Get ready the sun-oriented vegetable dryers for bundling, guaranteeing satisfactory assurance amid transportation. Consider eco-friendly bundling choices to adjust with the maintainable nature of the item. We are at long last made a ordinary sun based vegetable dryer which is completely made a of bamboo. this demonstrate is valuable for all small-scale agriculturists, house spouse & vegetable cellars. This demonstrate is exceptionally light weight, ecofriendly & convenient. Real Waight of the venture is around 15-20 kg. And this show is effectively mobile.

## Theoretical Background

### Design Specifications and Assumptions

Solar drying systems can be classified into direct and indirect solar dryers. In direct solar dryers, the vegetables are placed inside the air heater, where solar energy passes through a transparent cover and is directly absorbed by the vegetables.[4] The heat needed for drying is primarily provided through radiation to the upper layers of the vegetable bed, followed by conduction throughout the bed. In contrast, indirect solar dryers use a separate solar collector (air heater) to gather solar energy, which then heats the air that flows through the vegetable bed. A mixed-mode solar dryer combines both methods: it uses heated air from a solar collector and also allows the drying cabinet to absorb solar energy directly through transparent walls or a roof. This study aims to design a mixed-mode solar dryer where vegetables are dried simultaneously by direct radiation through transparent sections of the cabinet and by heated air from a solar collector. The construction materials for the mixed-mode solar dryer are inexpensive and readily available in the local market. [5]

### Solar Dryer Components

The solar dryer is composed of the following parts:

1. **Collector (Air Heater):** The inner box of the solar air heater, which serves as the heat absorber, is constructed from well-seasoned wood and painted black. The solar collector assembly features an air flow channel enclosed by a transparent cover (glazing).

2. **Drying Cabinet:** The drying cabinet, along with the structural frame of the dryer, is built from well-seasoned wood that can resist termites and weathering. An outlet vent located near the upper end at the back of the cabinet helps control the convection flow of air through the

3. **Drying Trays:** Inside the drying chamber, the drying trays are made from a double layer of fine chicken wire mesh with an open structure to allow drying air to pass through the food items.

4. **Solar Panel:** A 12-volt, 5-watt solar panel is used to charge the battery.

5. **Solar Charge Controller:** This device charges the battery and operates the fan simultaneously.

6. **Battery:** The battery stores energy for future use.

7. **Exhaust Fan:** The fan provides forced air circulation inside the structure.

**Fig. 3D Cad Model of solar vegetable dryer**

**The Experimental Set-Up:**

**Fig. Actual 3D Model**

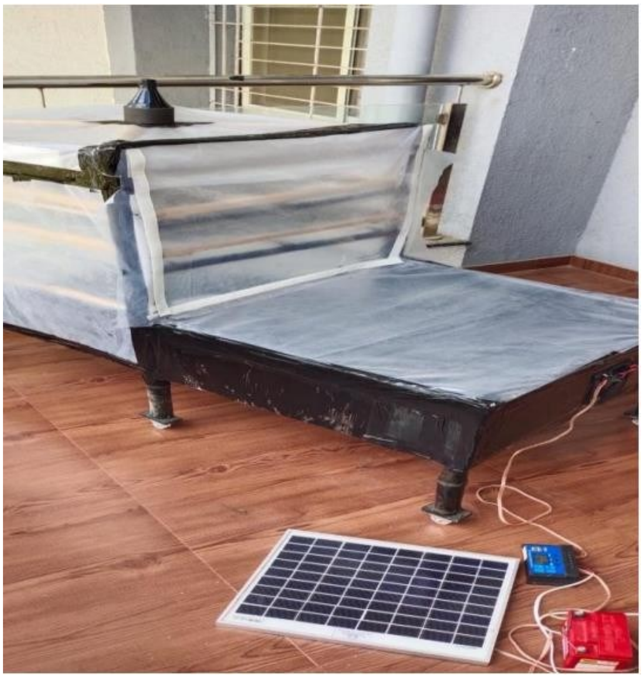

**Fig. Actual Prototype**

## Numerical Models and Formulations

### Operation of the Dryer

The dryer operates as a passive system, meaning it contains no moving parts and relies on solar energy. Sunlight enters through the collector's glazing, and the inside surfaces of the collector, painted black, enhance the absorption of solar rays.[7] This trapped energy heats the air within the collector. The greenhouse effect within the collector facilitates the movement of air through the drying chamber. When the vents are open, hot air rises and exits through the upper vent of the drying chamber, while cooler ambient air enters through the lower vent of the collector.[8]

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**Drying Mechanism**

Drying Component Drying includes two fundamental forms: warm application to vanish dampness from the fabric and wind stream to to expel the dissipated dampness.

The drying prepare incorporates two crucial mechanisms:

1. Moisture movement from the insides of the fabric to its surface.

2. Evaporation of dampness from the surface to the encompassing air.

The drying prepare is a complex interaction of warm and mass exchange, impacted by outside factors such as discuss temperature, stickiness, and speed, as well as inner factors like surface characteristics (e.g., unpleasantness or smoothness), chemical composition (e.g., sugars and starches), physical structure (e.g., porosity and thickness), and the measure and shape of the product.[9]

**Basic Hypothesis (Formulations)**

Some critical formulae utilized are given as follows:

Dryer productivity (η d):

Dryer effectiveness is the ratio of collection productivity (ηc) and the Framework efficiency (ηs).

$(\eta c) = Qu / AcIs$ .......... (1)

Where,

$Qu = mCp\Delta t$

Ac = collector surface area

Is = Separator on tilted surface

Efficiency$(\eta s) = WL / AcIs$

Where,

W= Mass of dampness Evapourated

L= ideal warm of evaporation in the dryer temperature

Determination of dampness substance:

$Mwb = (Mi - Md) / Mi \times 100$

Where,

Mwb = Dampness on damp basis

Mi= introductory mass of the sample

Md= last mass of the sample

## CALCULAION OF SUN-POWERED DRYER EFFICIENCY

1 Dryer effectiveness

➢ One day Dryer effectiveness (η d) for green chilli = 13.6%

➢ One day Dryer effectiveness (η d) for grapes = 14.19 %

➢ One day Dryer effectiveness (η d) for apples = 13.78%

The dryer productivity is found out to be 13% for one day.[10]

2 Moisture content

➢ Moisture content for green chilli = 64%

➢ Moisture content for grapes = 58%

➢ Moisture content for apple = 60%

## Future Scope and Market Need:

Establishing a market for dried products presents a significant opportunity for farmers to increase their income and secure returns on investment. This enables farmers to access loans from various organizations or financial institutions to acquire drying machines within a relatively short timeframe, typically 1 to 2 years. With the flexibility to adapt to market fluctuations, farmers can dry their produce during periods of low prices and wait for better market conditions, thereby maximizing their profits. Throughout the development of the drying machine, emphasis was placed on affordability and accessibility of materials. By harnessing solar energy, farmers incur no additional electricity costs, and installation can be done without the need for specialized technicians. The ultimate goal is to combat food waste and uplift the livelihoods of farmers, particularly in regions like India where farmer suicides are prevalent. Over the next decade, the aim is to proliferate solar dryers globally, thereby reducing wasted produce and addressing socio-economic challenges in agricultural communities.

## Conclusion:

In conclusion, solar drying offers a low-cost solution for enhancing food processing by adding value to fruits and vegetables. By reducing spoilage and improving product quality and hygiene, these technologies can significantly boost agricultural returns for farmers. Solar tunnel drying emerges as a cost-effective method for preserving fruit quality and nutritional retention while promoting renewable energy adoption amidst increasing non-renewable energy shortages. Key findings indicate that solar dryers effectively increase ambient air temperature, accelerating agricultural crop drying rates while minimizing risks associated with natural sun exposure. The simplicity, low capital cost, and ease of monitoring make solar dryers a viable option for drying various crops. Experimental results demonstrate substantial moisture removal, validating solar dryers as an efficient alternative for food preservation, particularly in resource-constrained regions. This research underscores the potential for widespread adoption of solar drying technologies, offering sustainable solutions for food security and energy challenges worldwide.

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