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Indirect drying food preservation technique on agricultural products

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ABSTRACT

In developing countries, using traditional energy sources to dry agricultural products are an expensive process. Food preservation is achieved primarily by decreasing the moisture content of the food product to the desired level. Since ancient times, solar drying has been one of the popular methodologies of food drying. However, it has a number of drawbacks. The aim of the work is to dry the agricultural product (ginger) through an indirect drying process for extending the lifespan of the food product without affecting its quality. In order to achieve that, a solar simulator along with waste materials (cool drinks, empty can) has been used as an absorber plate for producing hot air. The drying chamber inlet has connected with the outlet of the absorber plate along with a different layer of mesh arrangements. The parameters considered are the weight of the product, solar radiation, air temperature, humidity ratio, absorber plate Inlet and outlet area. The results show that the loss of moisture content in the ginger is about 85%, at the same time the change in the texture is insignificant.

KEYWORDS: *food preservation, indirect drying, solar simulator, waste material, hot air, moisture content.*

1. INTRODUCTION

Open sun drying is one of the ancient food preserving techniques. Most developing and underdeveloped countries use this as one of the most cost-effective options, especially in areas with enough of sunshine throughout the year [1]. However, every preserving technique has its own disadvantages since this technique is to dry the food products in direct sunlight, in this case food product spoils due to direct radiation emitted by the sun, loss due to over-drying, nearby vegetation (birds, insects), rain, dust, etc. So, some of these problems can be solved using indirect drying which is often referred to as absorbing heat radiation by any form of equipment, in our case a solar simulator along with waste tin materials has been used as an absorber plate for producing hot air. The inlet of the drying chamber has connected with the outlet of the absorber plate along with different layers of mesh arrangements [2].This eliminates the mentioned issues while also improving the quality and texture of the dish. In the human diet, fruits and vegetables are key sources of micronutrients, vitamins, and minerals. Most fruits and vegetables have a high-water activity and moisture content. As a result of metabolic activities such as enzyme production, breathing, and senescence, they are sensitive to microbial and other degradation [3,4]. Water content is reduced by precautions. Drying or dehydration is one of these procedures. Drying is the process of removing water from food to inhibit metabolic reactions and microbiological growth. Drying the product extends its shelf life, allowing it to be marketed during the off-season. The shelf life of a product refers to how long it can be kept before it becomes unfit for use or consumption. High temperatures (heated air drying or dielectric heaters), low temperatures (freeze drying), or room temperature are all options for drying (desiccant drying) [5]. However, it is a high-energy procedure. Renewable energy sources for drying are becoming more important because to the depletion of non - renewable resources and the rise in fuel prices[6].

The removal of heat and mass transfer from the surface and within the drying material is known as drying. It allows you to cut storage and transportation expenses by reducing interior moisture, preventing internal microbial growth, fungus, and biochemical reactions. Water transport from the interior to the surface of materials via pore spaces, and water propagation from the surface of the material to the environment via evaporation, are the two main characteristics of the drying process [7-9].It has been shown to be safe and clean to use, having no negative effects on the environment or community. Earth receives over than 7500 times the globe's total annual primary energy consumption of 450 EJ in solar radiation. Solar energy's copious availability, particularly in tropical countries, presents a significant potential for home and commercial applications. Humans have traditionally used solar energy for everyday purposes including starting a fire, cooking, food drying and clothing, and boiling water. Since then, much research and development in solar energy has been done to adapt it to today's reality. As a result, solar energy is now used for drying, steam generation, electricity generation, water distillation and desalination, and heating.Drying in sun is still frequently utilized in many subtropical and tropical nations. Sun drying is the cheapest technique; however, the dried items quality falls well short of international standards [10]. The introduction of appropriate drying technologies is the only way to improve product quality and reduce losses. Increasing farmers' buying power and reflecting quality in the price of quality dried products, on the other hand, are essential criteria for farmer acceptance and use of better drying methods. Farmers will reject innovative drying technology as long as there is no or just a tiny price difference between good and low-grade produce. However, field demonstrations of improved technology and advertising of high-quality dried products are required for widespread adoption. Microcredit may also be required, and an extension model based on Grameen Bank's microcredit approach could be implemented. Furthermore, marketing channels must be established to ensure the long-term viability of the improved drying technology. Many other techniques have been developed since the late nineteenth century in order to improve drying efficiency without compromising product quality [11-13]. Drying in vacuum, fluidized bed drying and freeze drying are among examples. Drying settings are kept as moderate as possible to prevent organoleptic alterations, and many microorganisms may withstand the dehydration process. Even if microbial development is prevented or minimized in dry objects, the consumer may be put at risk if a considerable number of hazardous germs remain after drying. Microbial development is inhibited by desiccation, yet green cells and spores can persist for months [14]. Furthermore, the multiplication of surviving organisms may be boosted when dehydrated materials are used to form meals with a significant final water content. This can lead to quicker deterioration and an increased risk of illness among customers. When semi-dried foods are prepared without pretreatment and/or posttreatment, the number of microbial survival and the risk of human illness are potentially increased due to the softer drying conditions. More than 80% of the world's food is produced by small farmers in developing countries. Natural sun drying is how these farmers dry their produce in the sun [15]. Aside from the fact that solar energy is free, the natural sun drying technique has some disadvantages. Aflatoxin contamination of wheat grains can also occur as a result of prolonged drying. To put it another way, the final result is of poor quality. Aside from that, the grade is outstanding. In some exceptional circumstances, such as cardamom, natural sun drying is not possible. such as cardamom, which cannot be dried in sun because the green color will erase.More moisture content is a major cause of food spoilage. Moisture content refers to the number of water molecules integrated into a food product. As a result, they are prone to microbial and other forms of deterioration. Moisture content can enter into a product through a various channel, including the manufacturing procedure, ambient moisture in the food production location, packing method, or food storage method [16]. The amount of moisture in a food product can have a big impact on its quality. It can affect a product's taste, texture, and appearance. The growth of microbes on food products will be reduced if the moisture content is reduced. As previously stated, the moisture of food products must be removed to preserve them. Fresh fruits and vegetables have a moisture content of more than 80%. Furthermore, the moisture we are attempting to remove should be a specific percentage, as if we fall below the maximum permissible water loss, the product will be damaged regardless of moisture removal [17-18]. To preserve food products, the moisture content should be as low as possible. The table below shows the moisture content and maximum permissible water loss of some common fruits and vegetables. The agricultural sector is one of the most important sectors where drying is widely used to preserve fruits, cereals, vegetables and greens [19]. The majority of the time, traditional energy sources like fossil fuels and electricity were used to dry the crops.The main objective of the work is to remove moisture content in ginger slices by sending hot air generated from solar air heater.

2. Methodology

Energy is collected from the heat emitted by the halogen lamps, which are mounted on a stand and are parallel to the absorber plate at a distance of 16 inches from the plate's top surface. The plate collector is angled at 30 degrees from horizontal to receive the most energy (Ground Surface). Following absorption, some of the energy is lost to the surrounding air after reflecting through a glass cover, while the remainder is transferred inside the collector. Heat is trapped inside the collector after passing through the glass, heating the air. Because hot air has a low mass, it rises, leaving a void that is filled by cold air, which has a higher mass, and the cycle continues indefinitely. The elevated hot air is directed to the chamber as the cold air pushes the hot air. The hot air circulates through the food product in the chamber for drying. After the air vents through a hole provided at the above of the drying chamber, the product is heated and moisture is removed. Following the drying process, the dried product is removed and weighed to determine the amount of moisture removed. The product is then stored in a specific chamber for later use. The product we are experimenting with is ginger because it has a low moisture content. The parameters considered are weight of the product, solar radiation, air temperature, humidity ratio, absorber plate Inlet and outlet area. To reduce discoloration and cracking on the product's surface, it is not directly exposed to solar radiation. The drying chamber keeps the product safe and free of dust and debris. Under the glass cover, black-coated cans (waste tins) are placed to receive the heat energy. A total of seven thermocouples were placed all over the setup to measure thetemperatures. Two were placed at the outlet and inlet of the absorber plate to read the air in and exit temperatures. And another three were placed in the chamber, one just below the bottom mesh and another goes just above top mesh and third one goes to the vent. And an extra one for the indoor room temperature. A dry bulb wet bulb thermometer is placed both indoor and outdoor for two days to measure the relative humidity of indoor and outdoor air [20]. The amount of water vapor in a water-air mixture compared to the maximum amount possible is measured by relative humidity.

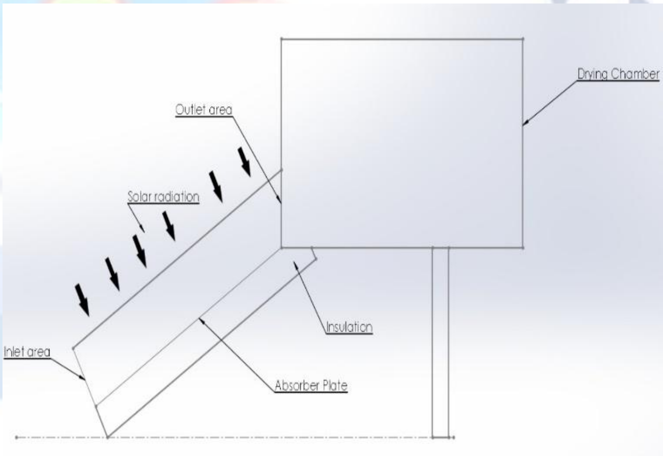

Fig 1. Experimental Setup

3. Results and Discussion

The results show that loss of moisture content in the food product is about 85%, at the same time the change in texture of the food product is insignificant.

DAY 1:DRY BULB AND WET BULB TEMPERATURE

The graph below depicts the Day-1 wet bulb dry bulb temperatures as they relate to time of day indoors. And it is clear that neither the wet nor the dry bulb temperatures have changed significantly

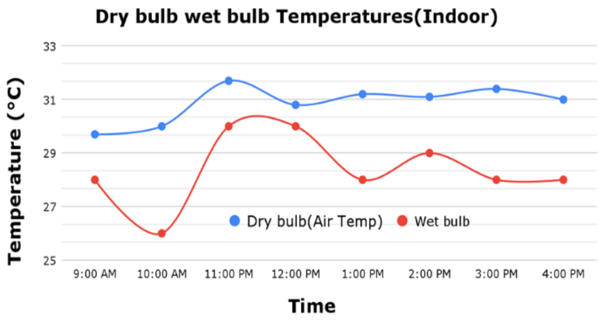

Fig2. Dry bulb and Wet bulb temperature(inlet)

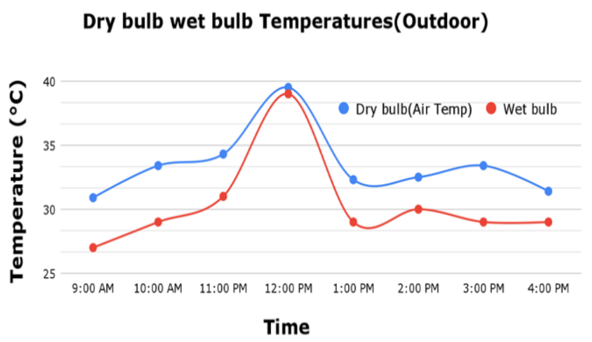

Fig3. Dry bulb and Wet bulb temperature (outlet)

The graph outside, on the other hand, rises at noon, as seen by the spike at 12:00 PM due to the maximum temperature at that time, and gradually decreases to the evening time. Both dry and wet bulb temperatures are around 40° around that time

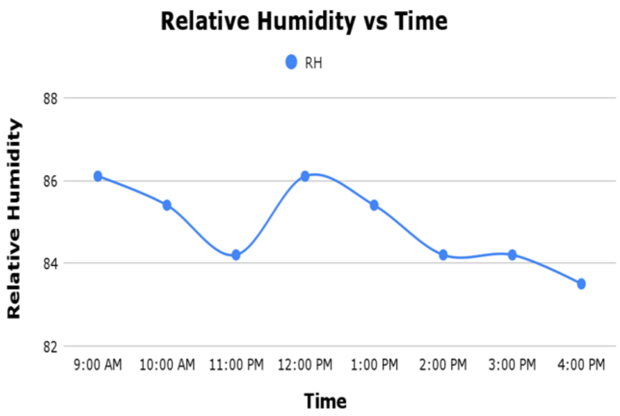

Fig4. Relative humidity vs time

The relative humidity of air measures its water vapor concentration (RH). It is the content of water vapor in the air shown as a percentage (percent RH) of what is needed to attain saturation at the same temperature. The graph above shows how much water vapor is present in the atmosphere during the day. It calculates how much water the air absorbs from the ginger slices.

The graph (fig 5) shows how weight of the sliced ginger pieces decreases with time under shadow (no fan) and how the trend gradually decreases. The sharp decrease after 4 p.m. is due to the mesh being left on all night without taking readings, and the trend gradually retains.

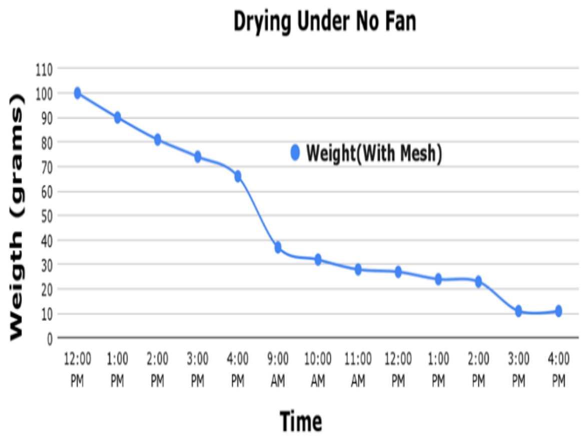

Fig5. Drying under (no fan)

DAY 2:DRYING UNDER FAN

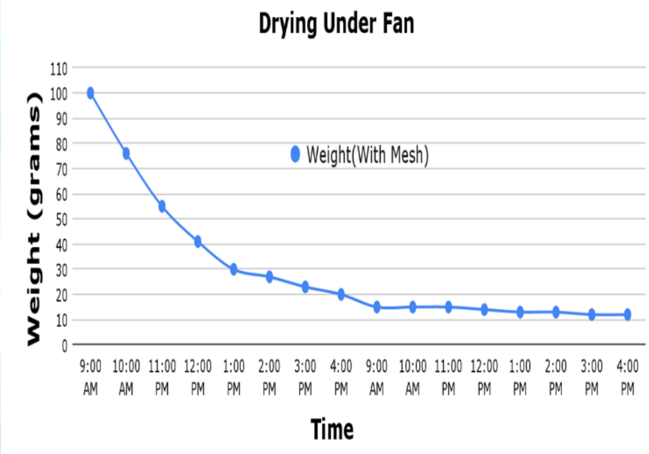

Fig6. Drying under fan

The graph above depicts the drying of 100 grams of ginger in the presence of a fan. When compared to day 1, there is a significant decrease in the weight of the ginger in the first five hours, followed by a slow descent.

DAY 2:DRYING UNDER AIR (NO FAN)

Drying without a fan is a slower process than drying with a fan, which we call free convection. The graph below is similar to day-1 drying without a fan, whereas when drying with a fan (forced convection), the trend gradually decreases with no sharp turns. The sharp decrease after 4 p.m. as mentioned in one of the above graphs is due to the mesh being left on all night without taking readings, and the trend gradually returns the next day

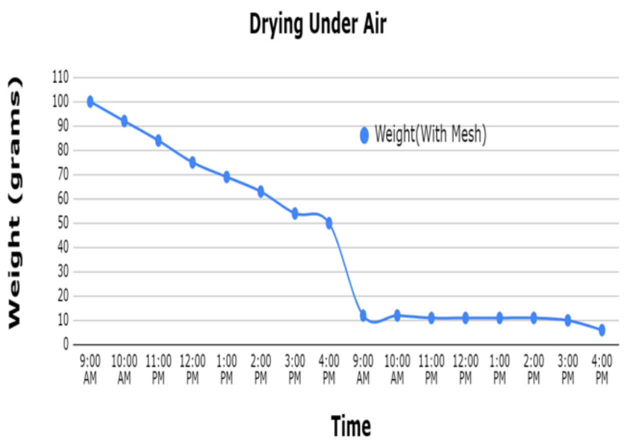

Fig7. Drying under air

TIME VS CHAMBER TEMPERATURE

These temperature graphs show the temperatures measured from the absorber plate outlet to the chimney. They are the absorber plate's outlet temperature, the chamber's inlet temperature, and finally the chimney temperature

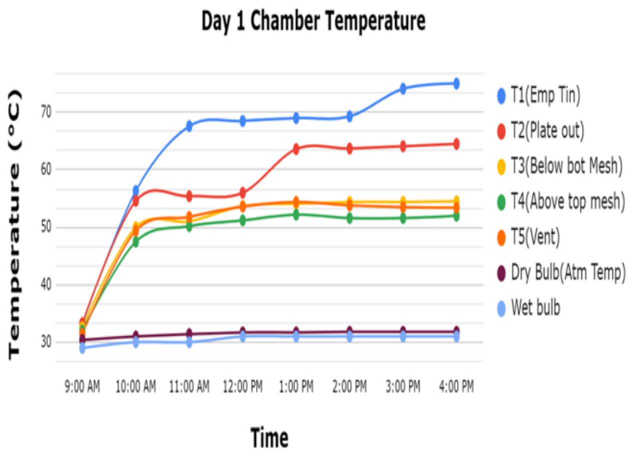

Fig8. Chamber temperature

DAY 1: CHAMBER OBSERVATION TIME VS WEIGHT

On day-1, 200 grams of ginger is placed on the bottom mesh and measured while the light setup is turned on, and the results are shown above. The moisture removal rate during the early hours is nearly 33%, while it is negligible during the later hours.

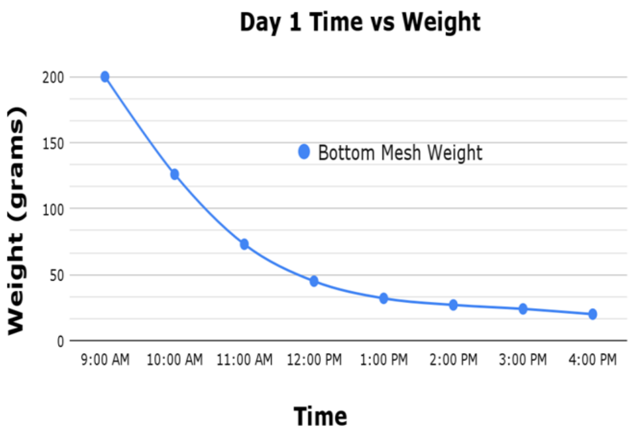

Fig9. Time vs Weight

4. CONCLUSION

There have been several solar drying techniques used in this field, and indirect drying techniques have shown to improve quality, save energy, and reduce drying time. A type of indirect air heater has been tested and designed. The absorber, which can be prepared from waste substances such as plastics and metals, was able to achieve the required temperature for dehydration of food. Natural convection carried heat from the collector to chamber where drying takes place. The dryer efficiently dried slices of fresh ginger while maintaining a relatively high texture quality. The results show that the food product's moisture content has been reduced by approximately 90%, while the texture has changed insignificantly. Use of halogen lamps aided in meeting the drying heat energy requirement. As a result, dehydrated ginger could be preserved for consumption during scarcity. This paper also discusses some easily usable dryers that can be used in small factories or farming communities. Such as low-cost drying of food methods may be easily applied in rural regions to minimize spoiling, increase quality, and improve overall processing cleanliness. The purpose of using these suitable drying methods is to greatly increase farmers' agricultural yields as a reward for their crop production efforts.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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