Development of a Solar Dryer for Mushroom Preservation in Rainy Season

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Abstract: Using solar energy to dry agricultural products is a very cost-effective method, particularly for medium-to-small quantities of products. Drying crops, agricultural products, and foodstuffs including fruits, vegetables, wood, aromatic herbs, etc. is still done at home and on modest commercial scales, greatly boosting the economies of small farming communities and farms. The present work provides solutions to M/S Kamesh Mushroom world, Jabalpur, a mushroom producing unit having monthly production of 100000 KG. in rainy season since sale is not good and production is high, mushroom being a perishable product they were facing problem of storage. For this problem a mushroom dryer is developed, able to operate in rainy and cold season, exhaust fans operate able with PV panel, equipped with evacuated-tube collector. The outcomes are then experimentally tested for weight loss V/S total weight-time- temperature- moisture etc

Keywords: Drying mushroom, dryer efficiency, moisture content, solar energy, thermal analysis.

1 INTRODUCTION

The star that radiates our system's planets with a distance-dependent power is the Sun. The earth is positioned to receive the best possible radiation for the important activities of the creatures that inhabit it; this distance is estimated to be 1,495×1011 m on average, with annual changes of 1.7 percent because of the eccentricity of the Earth's orbit. The solar energy emitted by the Sun is fundamental to making the Earth a habitable planet, however the average temperature of our planet depends on the balance between the amount of energy that the Sun sends us in the unity of time with that which our ecosystem is capable of retaining. This balance, very delicate, determines the climate of the Earth. Energy production in the center of the Sun takes place by a fusion process in which two hydrogen nuclei fuse into a helium nucleus with mass defect. Energy is released and projected into space as electromagnetic waves because the mass of the two hydrogen nuclei is greater than that of a helium nucleus. The earth only receives a small portion of the energy because of its distance from the Sun.

Due to the rotation and orbital motion of the Earth around the Sun, the apparent position of the Sun in the skychanges over time. The study of the apparent motion of the Sun with respect to the Earth plays a role of fundamental importance to use solar energy efficiently. In this section, after a brief description of the motions of the Earth, the parameters used to determine, at any time of the day, the relative position of the Sun compared to our planet andtherefore incident radiation.

SOLAR RADIATION

Anybody in the universe with a temperature above absolute zero emits radiant energy through a specific wavelength range of the electromagnetic spectrum. The Sun emits energy in a wide range of wavelengths, extending from the ultraviolet section, visible, up to the infrared section of the electromagnetic spectrum. This energy is radiated into space uniformly in all directions, and its intensity decreases with the inverse of the square of the distance from the Sun. Considering the surface of an imaginary sphere centered in the Sun, of radius R equal to the average Earth-Sun distance,the average power for a unit of area of solar radiation falling on such surface takes the name, improper, of solar constant I_{CS} and assumes a value equal to 1367 W / m^2. It is helpful to know the spectrum distribution of extraterrestrial radiation, or the radiation that one would receive on Earth without the atmosphere, in addition to the overall energy released. The standard spectral irradiance curve was drawn up on the basis of measurements made in space and is shown in Figure (1.) compared to the typical blackbody spectrum with temperature of 5777 K.

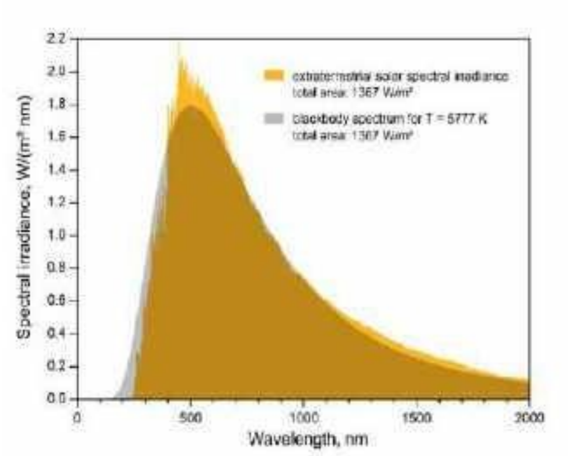

Figure 1: Comparison between the spectrum of theSun and that of a black body

Solar Radiation on the Ground

The "mass of air" that the sun's rays cross, or the distance that the sun's rays travel following their entry into the atmosphere to the Earth's surface, determines how much the extra-atmospheric radiation is attenuated as it passes through the atmosphere. As it passes through the atmosphere, which is full of dust, water vapor, and other gases, it actually experiences attenuation effects that absorb and reflect the radiation, which may be broken down into three parts:

- Direct radiation ($I_{d)}$: reaches the surface of the earth in thedirection of the sun's rays without having undergone reflections or absorption. This component arrives directly on the considered surface without being absorbed or dispersed by the atmosphere following a precise direction (Sun – object).
- *Reflected* radiation ($I_{R)}$: it reaches the Earth's soil (or the body in question) because it is reflected by the surrounding bodies. The reflection coefficient *(albedo)* of each material is defined, in its values, by the UNI 8477 standard. In many cases, especially if the albedo coefficient of the bodies surrounding the capturing surface is low or if the surface is slightly inclined with respect to the horizontal, this contribution is neglected.
- *Diffuse* radiation ($I_{D)}$: reaches the Earth's soil from all directions due to atmospheric processes of reflection and diffusion. Such radiation is always present at ground level, even on perfectly clear days precisely because such processes in the atmosphere occur in any case. On days when the sky is clear it represents about 10% of the direct radiation, while on very cloudy days it constitutes the totality of the radiant energy.

Technologies for the Use Of Solar Energy

In recent years, two different currents of thought have gradually taken hold with as many visions regarding the definition of solar energy and methods of exploitation and conversion of that energy. In a broader vision, among the conversion methods are often also included biomass energy and wind because they are consequences of the effect of solar activity on our planet. In the present study we will use a more restrictive definition, dealing only with methods *of direct exploitation* of solar energy, i.e. methods that can be directly reported. solar radiation. This appears to us, from the engineering point of view, the only possible classification especially to make a reliable comparison between the different technologies.

A first distinction between the methods of exploitation of solar energy is made between *passive* or *active* use of such energy. In *passive solar,* used for energy saving in buildings, heat and light produced by the Sun are not converted but only collected through various methods of design and construction. The simplest conceptualization of passive solar in building design is represented by the *greenhouse,* a construction that allows sunlight to penetrate inside it preventing it then the subsequent spill, thus contributing to a rise in temperatures inside the room. Trivially also the right orientation of the building and the correct arrangement ofthe glass surfaces, combined with a correct management ofthe shielding system, can be defined as one passive exploitation of solar energy. In general, passive solar systems are divided into three categories: *direct gain* systems, *indirect* (including solar *walls). Trombe-Michel*) and *isolated*. In the former, solar energy penetrates directly into the inhabited environment, while in indirect gain systems solar radiation is received by collectors (of standard transparent surfaces) and stored in the form of thermal energy in the storage masses that give it to the interior spaces gradually over time. Finally, in isolated gain systems, the collection takes place through components independentof the building, connected to the inhabited environments through a system of ducts that transfer stored heat. Ultimately, passive solar represents a virtuous way of exploiting the energy transmitted by the Sun but it must be absolutely an integral part of the original construction project, of a *contextual design,* due to the almost total impossibility of intervening on existing structures especially if poorly oriented.

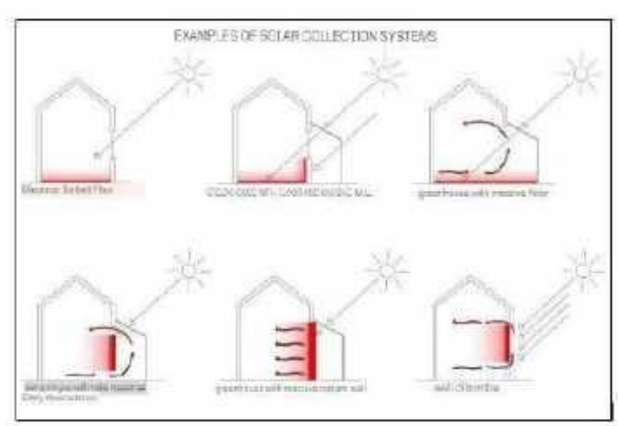

Figure.2: Passive exploitation of solar energy

Methods of *active* or *direct* exploitation of solar energy arethose systems used to store or convert solar energy for usein other applications such as heating of water for sanitary ordomestic uses, the production of heat for industrial uses orthe production of electricity, either directly or through theuse of steam turbines. These systems, which we will deepenin the following paragraphs, are further divided into*thermodynamic* or *photovoltaic systems* according to themethod used to convert or transfer energy. Two furtherclassifications are based instead on the presence or absenceof an incident solar ray *concentrator* and the use of a *solar tracking system.*

figure .3 solar energy usage classification

Drying And Drying Technologies

The oldest food preservation technique is drying. Historically, water was extracted from fruits, meats, cereals, and herbs using the sun, wind, and a smoky fire. Food dehydration is, by definition, the process of drawing water out of food by passing heated air across it, which stops germs and enzymes rom growing. Dried foods are delicious, wholesome, portable, simple to make, and convenient to use and store. There is less energy input than what is required for freezing or can, and there is less storage space required than for freeze containers and canning jars. Food's nutritional value is only slightly impacted by drying. Vitamin A is retained during drying.

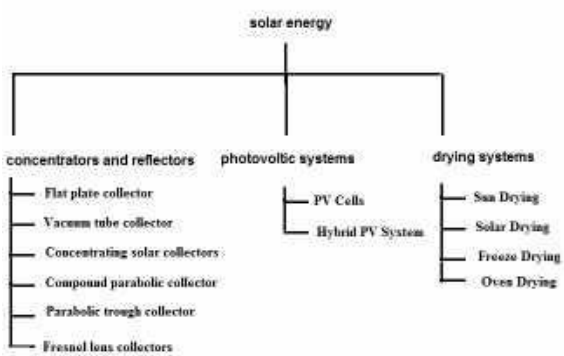

Figure 4 sun drying However, food containing vitamin A should be kept in dark areas due to its sensitivity to light. Vitamin A is abundant in yellow and dark green vegetables including sweet potatoes, winter squash, carrots, and peppers. Heat destroys vitamin C, but adding lemon, orange, or pineapple juice to meals beforehand boosts its vitamin C concentration. Dried fruits and veggies are a healthy food option because they are low in fat and high in fiber and carbs.

Drying TechnologiesSun Drying

Because fruits contain a lot of sugar and acid, they can be safely dried in the sun. Sun-drying vegetables or meats is not recommended. Vegetables are low in acidity and sugar. This makes food deterioration more likely. Meats' high protein content makes them ideal for microbial growth in environments with uncontrollable heat and humidity. Drying in the sun is best done on hot, dry, breezy days. While 86 o F is the minimum necessary, higher temperatures are preferred. Foods need to spend a few days drying outdoors. Because the weather is uncertain, sun drying could be risky. Another problem is the excessive humidity in the South. Less than 60% humidity is good for solar drying. These ideal conditions are often not accessible when fruit ripens. The sun-dried fruits are placed on screen trays or wooden dowels. Screens must not come into contact with food. The best screens are made of stainless steel, fiberglass, or plastic coated with Teflon. Avoid displays that are made of "hardware cloth." This is galvanized metal cloth covered with zinc or cadmium. It is possible for these compounds to oxidize and leave harmful residues on food. Avoid copper and aluminum screens as well. Copper breaks down vitamin C and speeds up oxidation. Aluminum is quickly corroded and discolored. Most timbers are suitable for making trays in an outdoor drying rack. Redwood, oak, pine, cedar, or green wood, however, should not be used. These woods cause food to become distorted, discolored, or to acquire unfavorable flavors. Place the trays atop blocks to increase the airflow around the food. Because the ground may be damp, it is best to place the racks or screens on a concrete driveway or, if possible, over a sheet of aluminum or tin. The sun's reflection off the metal raises the drying temperature. To help shield the fruit from insects or birds, cover the trays with cheesecloth. Fruits that have been exposed to the sun should be covered or stored indoors at night. The drying process may be slowed considerably if the cool air at night condenses and adds moisture to the food.

Solar Drying

Recent efforts to improve sun drying have led to the development of solar drying. For solar drying, the sun also acts as a heat source. The foil surface inside the dehydrator helps to increase the temperature. Ventilation speeds up the drying process. Shorter drying times reduce the possibility of food rotting or mold formation.

Figure 5 solar drying

Freeze Drying

Freeze-drying is a popular dehydration technique for keeping perishable items or making them more portable. The process of freeze-drying entails first freezing the material and then reducing the surrounding pressure to allow the frozen water to sublimate directly from its solid state to the gas phase.

Figure 6 freeze drying

Oven Drying

Every home with an oven has a dehydrator. When heat, low humidity, and air flow are combined, an oven can be used as a dehydrator. An oven can occasionally be used to dry surplus vegetables, such as celery or mushrooms, fruit leathers, and banana chips. The oven may not be sufficient to preserve an excess of garden food because it is required for everyday cooking. Oven drying is slower than dehydrators because it lacks an integrated fan for air movement. However, some convection ovens have fans. Drying food in an oven takes nearly twice as long as using a dehydrator. As a result, a dehydrator works better and uses less energy than an oven.

Figure 7 oven drying

THE PRESENT WORK

It is observed that radiation energy in sunlight is a vast source of thermal energy which is utilized to develop a solardryer for mushroom able to operate in rainy seasons.

2. LITERATURE REVIEW

Solar drying technology is one of the renewable energy sources, particularly for low temperature heating, which makes it a very appealing option for small firms with minimal funding. Studies undertaken so far have clearly indicated that while the initial cost of solar dryers are high, the life time cost of drying is only a third of dryers based on conventional fuels (Chavda and Kumar, 2009). Using a solardryer, the drying time can be shortened by about 65% compared to sun drying because, inside the dryer, it is warmer than outside; the quality of the dried products can beimproved in terms of hygiene, cleanliness, safe moisture content, colour and taste; the product is also completely protected from rain, dust, insects; and the payback period forsuch dryers ranges from 2 to 4 years depending on the rateof utilization (Sacilik et al., 2006).

The attractiveness of solar drying is further enhanced by its low capital and drying energy cost (Tunde-Akintunde, 2011). Many tropical countries receive on average 325 days per year of bright sun light (Yansane, 2007). In Tanzania, solar energy resource is abundantly available almost throughout the year (GTZ, 2007). Tanzania, which is located in a "solar belt," receives 2800–3500 hours of sunshine year and experiences 4–7 kWh/m2/day of global solar radiation. Based on a 24-hour period, the average solar flux can reach 300W/m2 or higher.

(Kimambo, 2007). With such a high level of solar energy resource, Tanzania is naturally suitable for application of solar energy as viable alternative sources of modern energy supply like mechanical dryer for drying agricultural produce especially in rural area (GTZ, 2007). Solar drying technology produces better quality products and is considered to be an alternative for drying agricultural products in developing countries (Gurlek et al., 2009). Its use of a specially designed structure that absorbs and intensifies solar radiation in order to gather radioactive energy for drying purposes is often what sets it apart from "sun drying". Some advantages of solar dryers over sun drying include labor and energy savings, environmental protection, and the creation of higher air temperatures and consequently lower relative humidities, which are advantageous for more effective drying rates and a lower final moisture content of the drying crops. Other advantages are less spoilage and less microbiological infestation, thus leads to improved and more consistent product quality (Tunde-Akitunde, 2011). However, one of the drawbacks of sun drying technology is its reliance on the weather to function. A lot of work has gone into creating and utilizing hybrid dryers that are more effective in inclement weather. The size of solar collector required for a certain size of dryer depends on the ambient temperature, amount of sun, and humidity (Green and Shwartz, 2001).

To increase overall efficiency, additional energy from heat can be added to the air by enlarging the collector. Larger collector areas are beneficial in humid areas, chilly or cold climates, and locations with limited solar energy. The size of solar collector required for a certain size of dryer depends on the ambient temperature, amount of sun, and humidity (Chavda and Kumar, 2009). Tilting the collectors is more effective than placing them horizontally for two reasons. First, more solar energy may be gathered if the collector surface is nearer perpendicular to the sun's beams. Second, when the collectors are tilted, the warmer, less dense air naturally rises into the drying chamber.

Research has been done to determine the best angle for harnessing solar energy. FAO (2008) states that the collector should be oriented at a 90° angle to the midday sun, facing north in the southern hemisphere and south in the northern, and that the angle should be more than 15 to allow rainwater to drain off. Additionally, the dryer should be placed far from buildings or trees that cast shadows. A 90 degree angle is the highest angle of incidence and represents the angle at which the most energy can be captured from the sun (Stadler, 2011). The sun penetrates equator at a 90 degree angle on average topographically, and it passes twice a year, makingit an area that receives the most amount of light energy from the sun (Stadler, 2011). Solar dryers employ one of two airflow systems: forced convection or natural convection. Convection dryers use fans to push air through the drying chamber, utilizing the natural concept that hot air rises. (Vargas and others, 1996)

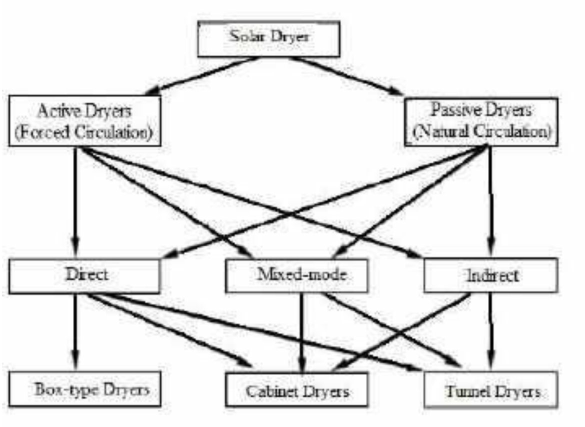

Figure 8 Classification of solar dryers and drying modes

Adding a chimney can increase the impact of natural convection by further heating the air that exits. Additionally, prevailing winds may be taken advantage of (Green and Shwartz, 2001).

Green and Schwartz (2001) claim that using forced convection can cut the necessary collector area by 50% and drying time by three times. Fig. 2.1 shows the condensed grouping of solar dryers and drying modes:

3. OBJECTIVE: -

The present work provides solutions to M/S Kamesh Mushroom world, Jabalpur, a mushroom producing unit having monthly production of 100000 KG. In rainy season since sale is not good and production is high, mushroom being a perishable product they were facing problem of storage. For this problem a mushroom dryer shall be developed, able to operate in rainy and cold season, exhaust fans operate able with PV panel. The outcomes shall be thenexperimentally tested for weight loss V/S total weight- time-temperature- moisture etc

4. Construction Of Model

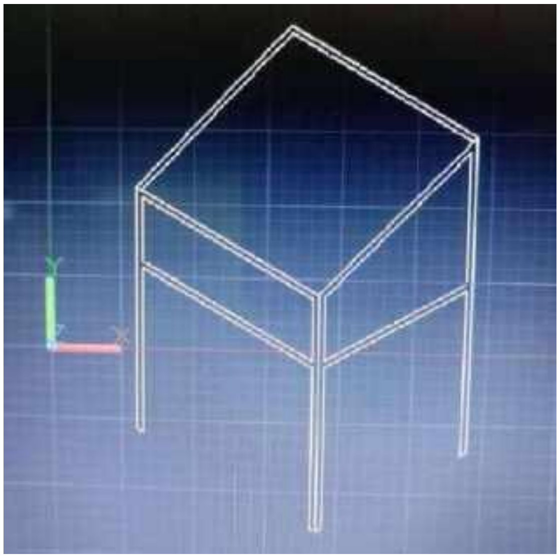

Fig 4. CAD image of modelMajor components of dryer are as follows:-

- Dryer structure
- Drying chamber
- Drying plate
- Exhaust blowers
- PV panel
- Insulation
- Thermo meter
- Weighing machine

Fig 5 fabricated structure of model

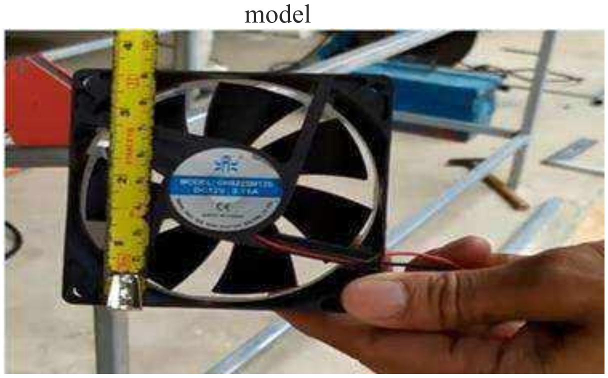

Fig 6 blower used for exhaust in model

Fig 7 Final assembled model

5. EXPERIMENTATION AND OBSERVATION

The experiment is done in moderate rainfall and moistureclimate.

Fig 8 Final setup during test

The bellow three images are temperature readings taken at different intervals as shown in table, it can be observed that the temperature inside dryer is more than ambient temperature

The bellow four images are weight readings taken at different intervals as shown in table, it can be observed that the weight is gradually decressing

Observation 2 Date 2.08. 22 place VIST Bhopal

As seen in above all pictures mushroom of 200 gm weight is reduced to 124 gm and temperature found is 20 degree above ambient also it is operated in modrate rain fall, in almost total mosturus atmosphere.

From the above observations following tables of temperature v/s time v/s weight is made Observation 1 Date 1.08. 22 place VIST Bhopal

S N	WEIGHT			TEMPRATUR		TIME		CLOUR	BLOWER	
	NET	DRY	REDUCTION	IN	Ambient	FROM	TO	P.W	ON	OFF
1	182g	151g	31g	37.5T	30.3T	11:30	13:10	White	ON	
2	151g	140g	11g	39T	30.6T	13:12	13:42	Creem	ON	
3	140g	124g	16g	36.8T	30.3T	14:38	14:38	Creem	ON	
4	124g	111g	13g	37.7T	32.8T	14:40	15:40	Pale yellow	ON	

S N	WEIGHT			TEMPRATUR		TIME		CLOUR	BLOWER	
	NET	DRY	REDUCTION	IN	Ambient	FROM	TO	P.W	ON	OFF
1	185	160	25	36.5	32.5	11:30	12:30	White	ON	
2	160	145	15	38	33	12:30	13:30	Creem	ON	
3	145	134	11	39	27	13:30	14:30	Creem	ON	
4	134	110	24	42	28	14:30	15:00	Pale yellow	ON	

6 CONCLUSION

Using solar energy to dry agricultural products is a very cost-effective method, particularly for medium-to-small quantities of products. Drying crops, agricultural products, and foodstuffs including fruits, vegetables, wood, aromatic herbs, etc. is still done at home and on modest commercial scales, greatly boosting the economies of small farming communities and farms.

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For this problem a mushroom dryer is developed, able to operate in rainy and cold season, exhaust fans operate able with PV panel, equipped with evacuated-tube collector. The outcomes are then experimentally tested for weight loss V/S total weight- time-temperature- moisture etc and found that the dryer when working in wet climate can produce upto degree centigrade temperature more than ambient also during experiment the weight of product is reduced by 50% in duration of 4 hours.

Conflict of Interest: The corresponding author, on behalf of second author, confirms that there are no conflicts of interest to disclose.

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