A Review: Solar Dryers for Food Preservation

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Abstract- *Food, shelter, clothes: These are three basic needs of human being. Three of them can be produced naturally as well by using artificial methods. But as compared with shelter and clothes, food is having extremely less shelf life. Nowadays world's population index is so high. But in contradiction of this index, food production rate is really slow. Also whatever food is produced in farms is getting wasted due to various natural disasters as well as manmade activities. This causes improper supply of food to each and every human being. Majority wastage of food occurs due to its minimum shelf life. If we would increase its life then we can overcome this problem. It can be done by removal of moisture content in food product. As open sun drying method have its limitation like contamination by dust, human or by animal. Solar dryer is one of the best devices to increase shelf life of food items. Solar dryer removes moisture content of food and increases its life In this paper we have done a comprehensive study of various types of solar dryers and their advantages and disadvantages.*

Keywords- Solar thermal dryers, Advantages, Advancements, Evaluation

I. INTRODUCTION

Preservation of agricultural products is essential for keeping them for a long time without further deterioration in the quality of the product. Several process technologies have been employed on an industrial scale to preserve food products, among that. Drying is the efficient and reliable method. It offers a highly effective and practical means of preservation to reduce postharvest losses and offset the shortages in supply. Drying is a simple process of moisture removal from a product in order to reach the desired moisture content and is an energy intensive operation. The prime objective of drying apart from extended storage life can also be quality enhancement, ease of handling, further processing and sanitation and is probably the oldest method of food preservation practiced by humankind.[1]

The advancement of sun drying is solar drying systems in which products are dried in a closed system in which inside temperature is higher. Major advantage includes protection against flies, pests, rain or dust. Several significant attempts have been made in recent years to harness solar energy for drying mainly to preserve agricultural products and get the benefit from the energy provided by the sun. Sun drying of crops is the most widespread method of food preservation in most part of India and world because of solar irradiance being very high for the most of the year. As this technique needs no energy during day time, it is more beneficial to the small scale farmers who can't afford the electricity or other fuel for drying. If it is necessary to dry product in night or in bad weather, an additional bio-fuelled heater can be used for heat supply.[2]

II. DRYING

In drying phenomena the psychometric is of importance as it refers to the properties of air-vapor mixture that controls the rate of drying. When an adequate supply of heat is provided for drying, the temperature and rate at which liquid vaporization occurs will depend on the vapor concentration in the surrounding atmosphere.[3]

Drying is commonly described as the operation of thermally removing water content to yield a solid product. Moisture held in loose chemical combination, present in the product matrix or even trapped in the microstructure of the solid, which exerts a vapour pressure less than that of pure liquid is called bound moisture. Moisture in excess of bound moisture is called unbound moisture. When a solid is subjected to thermal drying, two processes occur simultaneously:

A. Transfer of energy from the surrounding environment to evaporate the moisture from the surface.

B. Transfer of internal moisture to the surface of the solid and its subsequent evaporation due to application of energy.

The removal of moisture as vapour from the material surface, depends on the external conditions such as temperature, air humidity and flow, area of exposed surface, and pressure Apart from weather conditions the drying behavior of agricultural crops during drying depends on the:

- Product type
- Size and shape
- Initial moisture content

- Final moisture content
- Thickness of the layer
- Temperature, humidity of air
- Mechanical or chemical pre-treatment

In a drying operation, any one of these processes may be the limiting factor regulating the rate of drying.[2]

III. CLASSIFICATION

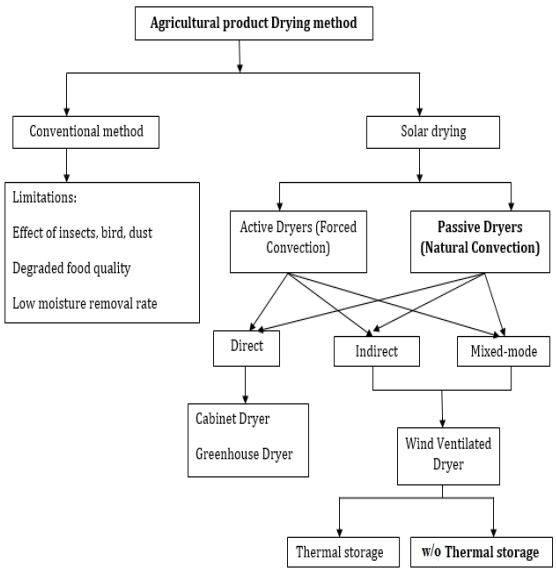

Fig.1: Classification of drying methods

3.1 ACTIVE SOLAR DRYER:

Active solar dryers are also termed as forced convection or hybrid solar dryers. Optimum air flow can be provided in the dryer across the drying process to control temperature and moisture in wide ranges independent of the weather conditions. Moreover, the bulk depth is less restricted and the air flow rate can be controlled.

Hence, the capacity and the reliability of the dryers are enhanced considerably compared to natural convection dryers. It is generally agreed that well designed forced-convection distributed solar dryers are more effective and more controllable than the natural- circulation types. The use of forced convection can reduce drying time by three times and decrease the required collector area by 50%. Consequently, dryer using fans may achieve the same throughput as a natural convection dryer with a collector six times as large. Fans may be powered with utility electricity if it is available, or with a solar photovoltaic panel. Almost all types of natural convection dryers can be operated by forced convection as well.[2]

3.2 PASSIVE SOLAR DRYER:

In a passive solar dryer, air is heated and circulated naturally by buoyancy force or as a result of wind pressure or in combination of both. Normal and reverse absorber cabinet dryer and greenhouse dryer operates in passive mode. Passive drying of crops is still in common practice in many Mediterranean, tropical and subtropical regions especially in Africa and Asia or in small agricultural communities. [1]

3.3 INTEGRATED TYPE SOLAR DRYER:

In Integral type dryers the moisture is removed from top; air enters into cabinet from below and leaves from top. This is open to the sun drying type of dryer only difference is food product is covered with the glass cover. When sun light fall on the surface of glass then three things happens, first is some light is absorbed, some light is reflected back from the glass, and some light is transmitted. As part of radiation absorbs by surface of crop which causes increase in temperature. The glass cover reduces direct convective losses to the ambient and which plays important role in increasing temperature of agricultural product and cabinet temperature. [1]

3.4 DISTRIBUTED DRYER:

This type of dryer differs from direct dryer by heat transfer and vapour removal. In this method atmospheric air heated in flat plate collector then this hot air from flat plate collector is flow in the cabin where products are placed. The moisture from this type of dryer is removed by convection as well as by diffusion.[1]

3.5 DIRECT SOLAR DRYER:

Direct solar drying is the conventional way of drying the products. In this method the products are directly exposed to the solar radiation and reduce the moisture content to atmospheric air. The air movement is due to density difference. It is broadly classified into two categories:

(1) The outdoor open air solar drying.
(2) Through a transparent cover which protects partly the foodstuff from rain and other natural phenomena i.e. a passive solar drying method.[4]

3.6 INDIRECT SOLAR DRYER:

Indirect solar drying or convective solar drying is the new technique of product drying. It is very efficient method than the direct type of solar drying. In this method the

atmospheric air is heated in flat plate collector or concentrated type solar collector. The heating process is either passive or active. This hot air then flow in the cabin where products are stored. Therefore moisture from the product may lost by convection and diffusion. This method of drying is used to avoid direct exposing to the solar radiation. This method mainly reduces the disadvantages of direct solar drying. [4]

3.7 MIXED MODE SOLAR DRYER:

It is combination of direct and indirect solar drying method. Product may dry with both direct exposure to solar radiation and hot air supplier on it. Air may heated in solar energy collector first then pass to the chamber where products are stored. In this process product may dry according to convective moisture loss. The same chamber is partially or totally covered with the transparent material to exposure the products to solar radiation. [4]

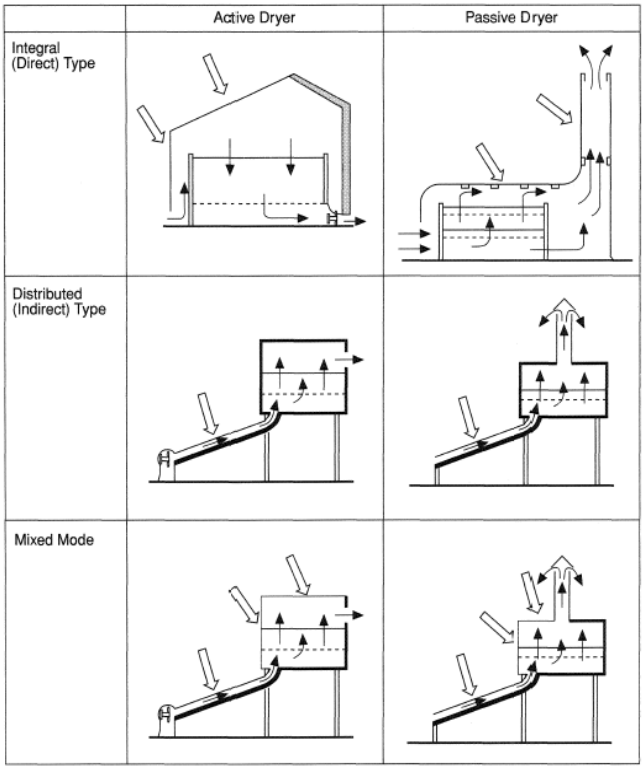

Fig.2: Solar dryer types according to mode of action [5]

IV. ADVANTAGES AND LIMITATIONS

3.2 Advantages:

1) Better Quality of Products are obtained
2) It Reduces Losses and Better market price to the products.
3) Products are protected against flies, rain and dust; Product can be left in the dryer over night during rain, since dryers are waterproof.
4) Prevent fuel dependence and Reduces the environmental impact
5) It is more efficient and cheap. [6]

3.2 Limitations:

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1) Adequate solar radiation is required.
2) It is more expensive.
3) Can be used in daytime only when adequate amount of energy is available [6]

V. DIFFERENT ADVANCEMENT IN DRYING

Solar drying system using phase changing material:

A phase-change material (PCM) is a substance with the properties like a high heat of fusion (Latent Heat), melting and solidifying at a certain temperature and capable of storing and releasing large amounts of heat energy during phase change. It is also known as “Latent Heat Storage (LHS) units”. Broadly, Heat energy are of two types:

A. Sensible Heat (changes Temperature).
B. Latent Heat (No change in Temperature)

PCMs changes its phase at a constant temperature, by storing a large amount of latent heat and again changes back its phase by releasing the stored heat, which is used for heating or drying purpose. Solid-Liquid PCMs are used generally used as handling of material in this stage is easier. The thermal energy transfer occurs when a material changes from solid to liquid, or liquid to solid. Initially, these solid–liquid PCMs perform like conventional storage materials; their temperature rises as they absorb heat. PCMs absorb and release heat at a nearly constant temperature. They store 5-14 times more heat per unit volume than sensible storage materials such as water.[2]

VI. SOLAR DRYER EVALUATION

In order to compare different types of dryers and their various enhancement models, it is necessary to evaluate the performance based on certain parameters. Certain parameters that are generally measured to evaluate the performance of the dryers can be categorized as:

1) Physical features of the dryer:
-Type, size, shape.
-Drying capacity/loading density.

-Tray area and number of trays.
-Loading/unloading convenience.

2) Thermal performance:
-Drying time/drying rate.
-Drying air temperature and relative humidity.
-Airflow rate.

3) Quality of dried product:
-Sensory quality (colour, flavour, taste, texture)
-Nutritional attributes.
-Rehydration capacity. [7]

Sr. No	**Author/Journal/ Year**	**Key findings**
1	Blaise Kamenan Koua/Journal of saudi Society of Agricultural Science/2017	The cocoa beans thermophysical properties were obtained & fitted to nonlinear correlations describing their behaviour as a function of moisture content.
2	Anupam Tiwari/ A Review on Solar Drying of Agricultural Produce by Journal of Food Processing And Technology/ 2016	Suggests various types of solar dryers for different agricultural products for best processing and good quality food.
3	Maundu Nicholas Musembia/International Conference on Power and Energy System Engineering/2016	To find mid-latitude applications, efficiency analyze air properties by use of phy-chometric chart and access the quality of dried product.
4	Karunesh Kant et Al. /Research Gate/2016	For a better thermal performance of solar dryers, a PCM with a high latent heat of fusion and with a large surface area for heat transfer is mandatory
5	Mingle Liu et Al/International Journal of Clinical Medicine/ 2015	Solar dryers can be used economically and more effectively for processing of herbal medicine
6	Mujau Numbing et Al. /IOSR Journal of Applied Physics /2015	The solar fish dryer has no smoke; soot or nauseating smell .Solar fish dryers function effectively via the use of solar energy
7	Ashish D. Chaudhari et Al. /International Journal of Research in Advent Technology/2014	In this paper, we studied the various modes of solar drying and classification of solar drying techniques
8	UmeshToshniwal/ International Journal of Engineering Research and Applications /2013	Solar dryers involve an initial expense, they produce better looking, better tasting, and more nutritious foods, enhancing both their food value -and their marketability. They also are faster, safer, and more efficient than traditional sun drying techniques.
9	Sunday Sobowale et Al./Journal of Engineering and Applied Science/2012	The solar dryer can raise the ambient air temperature to a considerable high value for increasing the drying rate of agricultural crops. The capital cost involved in the construction of a solar dryer is much lower to that of a mechanical dryer. The collector and dryer efficiencies are very reasonable.
10	Ahmed Abed Gatea/African Journal of Agricultural Research / 2011	Average thermal efficiency ofthe solar air collector-25.64%Maximum daily efficiency of drying-18.41 %Minimum daily efficiency of drying-16.27%

VII. CONCLUSION

The solar dryers are able to raise the ambient air temperature to a considerable high value for increasing the moisture removal rate of product. The product inside the dryer is comparatively safe from attack by rain or both human and animals, compared with those in the open sun drying.
There is ease in monitoring when compared to the natural sun drying technique. The variation of the temperatures inside the cabinet and air-heater are much higher than the ambient temperature during the most hours of the day-light. Advancement like use of PCM can give better utilization of system. The dryer exhibited sufficient ability to dry food items reasonably rapidly to a safe moisture level and it preserves the food quality for longer duration and hence becomes economical

REFERENCES

[1] A. Balasuadhakar Teklebirhan Fisseha, Amessalu Atenafu, Bariso Bino, A Review on Passive Solar Dryers for
Agricultural Products, –*International Journal for Innovative Research in Science & Technology*, Volume 3 Issue 01 June 2016
[2] [Anupam Tiwari, A Review on Solar Drying of Agricultural Produce, *Journal of Food Processing And Technology*, 2016
[3] Solar Drying: Fundamental Applications and Innovations, C.L. Hii, S.V. Jangam, S.P. Ong and A.S. Mujumdar, ISBN: 978-981-07- 3336-0, 2012
[4] Ashish D. Chaudhari et Al. /International Journal of Research in Advent Technology/2014
[5] Ekechukwu, O.V., 1999, Review of solar-energy drying systems I: an overview of drying principles and theory, Energy Conversion and Management, 40, pp. 593–613.
[6] UmeshToshniwal, International Journal of Engineering Research and Applications /2013
[7] M Augustus Leon, S Kumar, S.C.Bhattacharya, A Comprehensive procedure for performance evaluation of solar food dryers, Elsevier, Aug 2002
[8] Blaise Kamenan Koua/Journal of saudi Society of Agricultural Science, 2017
[9] Maundu Nicholas Musembia/International Conference on Power and Energy System Engineering, 2016
[10] Karunesh Kant et Al. Research Gate, 2016
[11] Mingle Liu et Al, *International Journal of Clinical Medicine*,2015
[12] Mujau Numbing et Al. IOSR Journal of Applied Physics, 2015
[13] Sunday Sobowale et Al.,Journal of Engineering and Applied Science,2012
[14] Ahmed Abed Gatea, African Journal of Agricultural Research, 2011