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A Review Paper on Different Drying Methods

Miss. Shilpa B. Mali[1] and Prof. M. C. Butale[2]
[1] Student of Department of Electrical Engineering
[2] Associate professor of Department of Electrical Engineering
Padmbhooshan Vasantraodada Patil Institute of Technology, Budhgaon

***Abstract*:- Drying is one of the oldest preservation processes available to the mankind, on that we can track since prehistoric times. In today food market dried foods play an important role in the food supply chain. As for fruits and vegetables it can be estimated that they constitute about 1% of the total drying in the food industry, by large being the grains the most important. The main feature of this process consists on lowering the water content in order to avoid or slow down food spoilage by microorganism. For understanding some common words found are "drying" or "dehydration", or even "dewatering". There are various aspects that must be considered when drying small fruits and vegetables, whether for the food and functional food industries. A system which minimizes exposure to light, oxidation and heat, (i.e. high heat 70ºC and shorter time duration) may help conserve critical bioactive compounds. Natural convection method is normally used to produce quality of agricultural products and related details are discussed in this review paper**

Keywords: Drying method; food; fruit; vegetable; sun drying; solar drying

1. INTRODUCTION :

The conventional drying system to preserve fruits, vegetables, grains, fish, meat, wood and other agricultural products is sun drying which is a free and renewable source of energy. But, for large-scale production, there are various known limitations of sun drying as damage to the crops by animals, birds and rodents, degradation in quality due to direct exposure to solar radiation, dew or rain, contamination by dirt, dust or debris. Also this system is labour- and time intensive, as crops have to be covered at night and during bad weather, and have to be protected from attack by domestic animals. There is also a chance of insect infestation and growth of microorganism due to non-uniform drying. The advancement of sun drying is solar drying systems in which products are dried in a closed system in which inside temperature is higher [1]. 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.

Solar energy

The sun is the primal energy producer of our solar system. Solar radiation causes all natural cycles and activities such as rain, wind, ocean currents, photosynthesis and several other phenomena which are crucial for life. The entire world energy need has been based from the very beginning on solar energy [7-9]. All fossil fuels (coal, gas, oil) are converted form of solar energy. The solar surface temperature of the sun is 6000°C which corresponds to 70,000 to 80,000 kW/m2 radiation intensity. Earth receives only a very small portion of this energy. In spite of this, the incoming solar radiation energy in a year is some 2×10^{17} kWh; this is more than 10,000 times the yearly energy demand of the whole world [10,11]. The solar radiation intensity outside the atmosphere is nearly 1,360 W/m2 (solar constant).

Drying

Drying is commonly described as the operation of thermally removing water content to yield a solid product. The drying rate can be governed by the rate at which the two processes proceed. Energy transfer as heat from the surrounding environment to the wet solid can occur as an outcome of convection, conduction, or radiation and in some cases as a result of a combination of these effects [14,17-21]. Various dryers differ in type and design, depending on the principal method of heat transfer applied. In most cases, heat is transferred to the surface of the wet solid and then to the interior. However, in dielectric heating, radio frequency (RF) or microwave drying, energy is supplied to generate heat within the solid and flows to the exterior surfaces.

2. DRYING METHODS

Fig. 1 shows the detailed classification of drying methods, which are of relevance to regions of world.

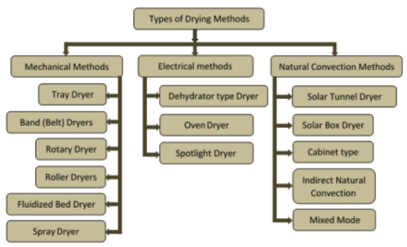

Fig. 1. Drying methods

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3. MECHANICAL METHODS

3.1 Tray Dryer

Tray dryers (Fig. 2) are classified as batch type and band dryer and can dry almost everything. However, owing to the labors needed for loading and unloading, they are expensive to operate. They notice most frequent application once valuable product like dyes and prescribed drugs ar concerned. This type of appliance is often used for drying of wood and varied agricultural product.

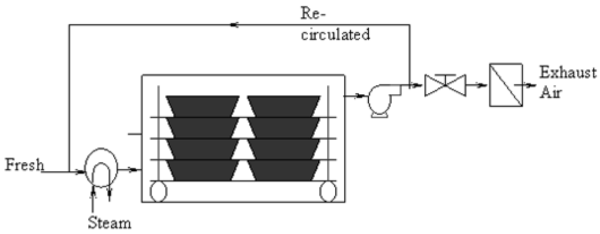

Fig. 2. Tray Dryer.

3.2 Band (Belt) Dryers

A band dryer (Fig. 3) is preferable if the particles to be dried are rather coarse (i.e. between 5 to 10 mm). The particles spread evenly into slowly moving, e.g. 5mm/s, perforated belt. The belt moves into a drying cupboard and heat gas passes downward through the layer. This type of appliance is chosen once it's unfeasible to suspend the particles within the drying gas. The dryer must offer a residence time, say 15min, because bound moisture must defuse through the pellet

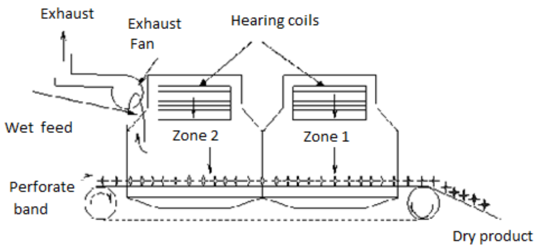

Fig. 3. Band dryers.

3.3 Rotary Dryer

The rotary dryer (Fig.4) consist of a cylindrical shell, horizontal or slightly inclined toward the outlet. They are heated by

a) Direct contact of air or gas with the solids,

b) By hot gasses passing through associate external jacket on the shell, or,

c) By steam condensation during a set of longitudinal tubes mounted on the inner surface of the shell.

The product is fed to the higher opening and transported throughout mixture through the cylinder. Regardless of the strategy of the heating, the water is removed with the air. The disadvantage of rotary dryers is that the massive power losses, which occur if the product is fine grained. The installation of the particle/ gas separation at the wet air outlet (e.g. cyclones) may reduce the product losses significantly.

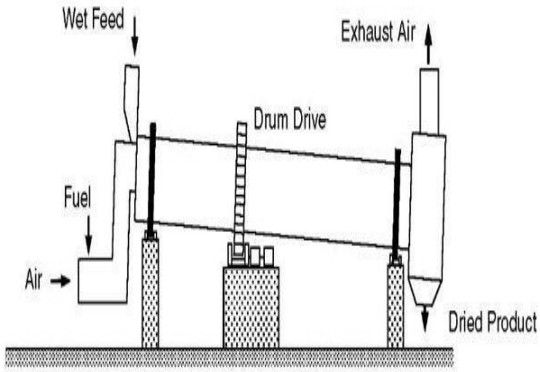

Fig. 4. Rotary dryers

3.4 Roller Dryer

A roller appliance carries with it a cylinder, heated from the within by stream. A thin film of the merchandise is sprayed on the skin of the cylinder and it's heated whereas the cylinder rotates.

The rate of drying and also the final water content within the product is laid low with the Rotational spread of the roller, Steam pressure, Thickness of the film, and Properties of the product. Owing to the type contact time in combination with high drying temperature, the roller appliance is well tailored to heat sensitive product. Typical applications square measure cloth drying in textile industries and paper band drying in paper mills. Hitesh N Panchal & Dr. P. K. Shah [3] explained on the glass thickness lower glass cover thickness increases distillate output from solar still, i.e. 4 mm glass cowl thickness produces a lot of liquid output compared with eight metric linear unit furthermore as twelve metric linear unit. Lower glass cowl thickness decreases inner glass cowl temperature within star still, i.e. 12 metric linear unit glass cowl thickness produces highest inner glass cowl temperature compared with four metric linear unit furthermore as eight metric linear unit thickness of glass cowl.

3.5 Fluidized Bed Dryer

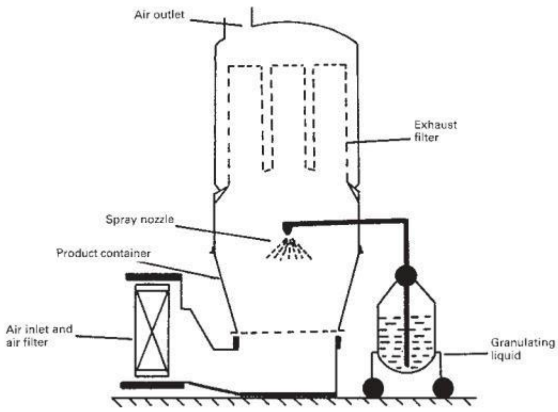

Fig. 5. Fluidized bed dryer

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In a fluidized –bed dryer (Fig. 5), the particles are fluidized by air or gas in a boiling bed unit. The average time a particle stays in an exceedingly bed is sometimes between 30and 60s. If fine particles are present, there may be considerable solids carried over with the exit gas, and cyclones nd bag filters are needed for their recovery.

3.6 Spray Dryers

The pneumatic or 'flash' dryer is used with products that dry rapidly owing to the easy removal
of free wetness or wherever any needed diffusion to the surface happens without delay. Drying takes place in a matter of seconds. Wet material is mixed with a stream of heated air (or other gas), which conveys it through a drying duct where high heat and mass transfer rates rapidly dry the product. Applications embrace the drying of filter cakes, crystals, granules, pastes, sludges and slurries; in truth virtually any material wherever a fine product is needed. Salient features are as follows.

1 Particulate matter can be dispersed, entrained and pneumatically conveyed in air. If this air is hot, material is dried. 2 Pre-forming or mixing with dried material may be needed feed the moist material.
3 The dried product is separated in a cyclone. This is followed by separation in more cyclones, fabric sleeve filters or wet scrubbers.
4 This is suitable for rapidly drying heat sensitive materials. Sticky, greasy material or that which can cause attrition (dust generation) isn't appropriate.

The type of spray dryer is normally Pneumatic / Flash dryer is shown in (Fig. 6).

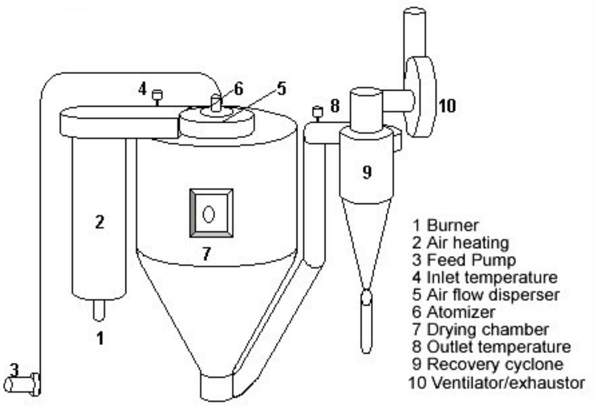

Fig. 6. Spray Dryer

4. ELECTRICALMETHODS

4.1 Dehydrator Dryer

A dehydrator dryer (Fig. 7) is dehydrating food is an ancient method of preserving food.

It is a delicate, process that removes wet from food. Using a controlled heat temperature, air is circulated from the top of the unit to each of the five trays and base. This method of drying seals in the flavor sand nutrients of the food, leaving a high food nutrient and vitamin content. Natural healthy snacks will simply be created exploitation your Food dehydrator. A variety of fruit rolls like pear, berry and apple rolls, to name a few. You can build tasty, breakfast food bars, exploitation all natural ingredients.

Fig. 7.Dehydrator dryer

4.2 Oven Dryer

Oven drying (Fig. 8) is the simplest way to dry food because you need almost no special equipment. It is additionally quicker than sun drying or employing a food drier. But kitchen appliance drying is used solely on atiny low scale. An ordinary room kitchen appliance will hold solely four to six pounds of food at just once. Set the kitchen appliance on the bottom attainable setting and heat up to a hundred and forty degrees F. (60 C.). Do not use the broiler unit of an electrical kitchen appliance as a result of the food on the highest receptacle can dry too quickly' take away the unit if it's no separate management. Some gas ovens have a pilot right, which may keep the oven warm enough to dry the food. It is vital to stay the kitchen appliance temperature at a hundred and forty to a hundred and sixty F. (60 to 70 C.). So put an oven thermometer on the top tray about half way back where you can see it easily. Check the temperature about every half hour.

Arrange one to two pounds of ready food in an exceedingly single layer on every receptacle. Put one tray on each oven rack. Allow 1-1/2 inches of area on the perimeters, front, and back of the trays so air will flow into all around them within the kitchen appliance. To stack more trays in the oven, use blocks of wood in the comers of the racks to hold the trays at least I inches apart. Dry no quite four trays of food at a time. A lighter load dries quicker than a full load. Keep the oven door open slightly during drying. A rolled newspaper, a block of wood, or a hot pad will keep the door ajar so that moist air can escape while the heat stays in the oven. Four to 6 inches for electrical ovens or one to two inches for gas ovens is typically enough area for ventilation, but use a thermometer to check the oven temperature to form certain it stays at a hundred and forty F. An electric fan placed before of the kitchen appliance door helps to stay the air current. Shifting the trays often is important for even drying because the temperature is not the same everywhere in the oven. Rotate the trays from high to bottom and from front to back each [*fr1] hour. It helps to range the trays thus you'll keep track of the order during which you rotate them.

Stirring fruit or vegetables each [*fr1] hour approximately additionally helps the food to dry equally.

Fig. 8. Oven Dryer

4.3 Spotlight Dryer

Manjula et al [4] proposed laboratory experiments contain the spotlight drying method shown in (Fig. 9). The study shows that there is an inverse relationship between air temperature and drying time. The air temperatureas radiation intensity is an influential external parameter which is not the case of air velocity. Drying curves do not clearly indicate the effect of air velocity on drying time, and there is an inverse relationship between radiation intensity and drying time. Taking into account the evaporation process of water, abetter understanding of drying phenomena was achieved by determining internal conductance C(X) and D(X). No expression of C(X) and respectively D(X) with air velocity can be seen. Future work can be done designing and measuring drying experiments on a higher scale to better validate the results. However, the laboratory model could satisfactorily represent the drying of red peppers in large ranges of air temperature, air velocity and incident radiation. The statistical analysis confirmed the suitability of the established model. The laboratory model does not roughly predict the drying data for open sun and greenhouse conditions because the drying operation presents inertia to variation of external parameters. To adjust predictions of the drying process under time varying conditions a correction factor in time was introduced in the formulation of the model. The corrected model could adequately describe the thin layer drying behavior of red peppers in open sun and greenhouse conditions. The methodology adopted in this particular drying process may be applied to different agricultural products as well. Models of this nature are applicable to the study and simulation of greenhouse type-solar dryers. more. There is also a possibility fungus formation of the products if they are kept as it is.

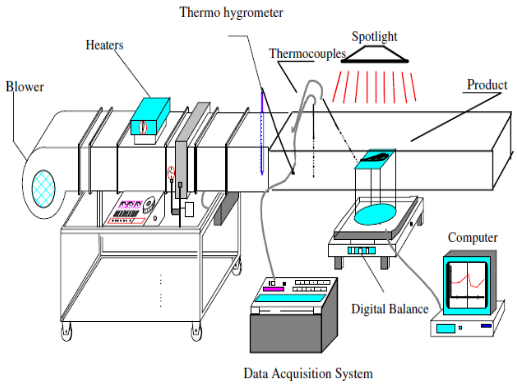

Fig. 9. Spotlight dryer

5.2 Solar Tunnel Dryer

n natural convection method different types of solar dryers are used based on the quantity and time. Solar drying may be a continuous method wherever wet content, air and product temperature change simultaneously along with the two basic inputs to the system i.e. the solar isolation and the ambient temperature

Fig. 10. Solar Tunnel Dryer

The solar tunnel dryer (Fig. 10) consists of dryer comprises a plastic sheet-covered flat plate collector and a drying tunnel. The drying rate is plagued by close weather conditions. This includes: temperature, relative humidity, sunshine hours, available solar isolation, wind velocity, frequency and duration of rain showers during the drying period [1]. Open sun drying of assorted industrial and agricultural merchandise is being practiced since age. Open sun drying is slow and exposes the produce to various losses and deterioration in quality. A number of industries have, therefore, accepted mechanical drying of the produce. Fuel wood, crude fuel, coal or electricity is used for air heating in the mechanical dryers. Solar air dryers have nice potential for replacement of business scale drying of business and agricultural merchandise. Besides, effecting saving of precious fossil fuel, fuel wood or electricity, the solar drying may also is cost effective. Joy c.m. and K.P. Jose [5] explained solar dryers in comparison with open sun drying gave better quality products with lesser drying time (Patil1989). Kamaruddin et al. (1994) have developed a method for the drying of pepper using solar energy. Pruthi (1989) had shown a drying time of 8 hours for 30-40 tones of pepper when dried in a mechanical dryer imported from Holland. To improve the overall quality of pepper, a solar dryer and some additional appropriate technologies were used to produce pepper of a high microbiological standard, deep black col› our and low humidity (Ahlert et at. 1997). The quality of black pepper is assessed by its aroma and pungency retained after drying. The pun› gency of pepper is due to the presence of piper› ine.

Fig. 11 Solar Tunnel Dryer

Oparaku, n.f [6] explained about solar tunnel dryer (Fig. 11) model performance at 10% residual error interval was 78.4 and 83.3%, respectively, for global solar radiation and plenum chamber temperature. Linear relations existed between the simulated and mean of satellite global solar radiat ion, and simulated and actual plenum chamber temperature. The correlation between the simulated and satellite solar radiation was strong since the coefficient of determination was high (R2 =0.788). S. A.S.M.Mohsin et al [7] explained about daily solar radiation varies between 4 and 6.5 kWh/m2.In this regard, solar dryer for domestic as well industrial usage could be an effective alternative of saving conventional energy. Utilization of solar thermal energy through solar dryer is relatively in a nascent state in Bangladesh

5.3 Mixed Mode Dryer

G. M. Kituu et al [8] discussed about mixed mode natural convection of solar dryer integrated with a simple biomass burner and bricks for storing heats. The drier was designed for small-scale industrial producers of agricultural product in non-electrified locations. From a series of analysis trials of the system, the capacity of the dryer was found to be 60–65 kg of unshelled fresh harvested groundnuts. The drying potency of the star element alone was found to be twenty third.While, the potency of the burner with heat storage in manufacturing helpful heat for drying was found to be four-hundredth.The key design features of the dryer contributed to produce an acceptable thermal potency, and uniformity of drying air temperature across the trays, were the jacket and gap enclosing the drying chamber and arranged bricks for storing heats. S. Janjai et al [9] described the solar radiation passing through the polycarbonate roof heats the air and the products in the dryer as well as the concrete floor. Ambient air is drawn in through a small opening at the bottom of the front side of the dryer and is heated by the absorber and the products exposed to solar radiation. The heated air, while passing through and over the products absorbs moisture from the products. Direct exposure to radiation of the product and therefore the heated drying air enhance the drying rate of the product. A. A. Zomorodian and M. Dadashzadeh [10] showed the moisture ratio decreases with a diminishing rate at totally different air flow rates and for 2 star drying systems. This means that every one drying amounts were performed within the falling rate period. These results square measure in sensible agreement with the results of alternative analysisers UN agency had some in depth research on the star drying of various product like pistachio, chilli, crapes etc. [11] The performance of the solar dryer depends on several factors, the solar radiation, inlet air temperature of solar dryer and the dryer design factors note that access to the highest temperature required for drying when tray 4 is from 61°C and is at the highest intensity of the radiation 700 W/m2 at 11. There were no significant differences in temperature at the trays (1, 2 and 3) with the differences ranging from (2 to 5°C). B. K Bala et al [12] proposed the solar tunnel drier was installed at the yard of the workshop of the Department of Farm Power and Machinery, Bangladesh Agricultural University, Mymensingh, Bangladesh. The drier was placed on raised platform. Mushrooms used for star drying were collected from the native markets of Mymensingh and Savar. Three tests on star drying of Mushrooms were disbursed at Asian country Agricultural University, Mymensingh
in the month of May in 2007 and in the month of March and May in 2008.
Mohod A.G et al [13] showed during winter season (Fig.3), the average temperature inside solar tunnel dryer was found to be 50.39°C with corresponding relative humidity 11.92 % which was the lowest value. The corresponding ambient temperature, relative humidity and solar intensity were found to be 33.97°C, 14.38 %, 445.58 w/m2 respectively. The maximum average temperature inside the solar tunnel dryer was found to be 52.41°C at center of solar tunnel dryer followed by north side (51.06°C) and south side (47.69°C). The minimum average relative humidity inside the solar tunnel dryer was found to be 11.40 % at the center of solar tunnel dryer
followed by side (12.19 %) and south side (12.27 %). The increased relative humidity at south side could be attributed to incoming fresh air through air inlets provided at south side of solar tunnel dryer. Ojike. O et al [14] samples of pawpaw fruit were dried in the open-air and with solar dryers. Vitamin A, B1, B2, C and E were analysed to see their concentrations before and when drying. In all cases there have been important changes within the concentration of vitamins when drying. The changes were abundant in outdoor drying than in star dryers used. Thus, the utilization of star dryers for drying of pawpaw is extremely suggested. Among the star driers used angular distance box dryer gave the most effective end in terms of nutriment retention.

CONCLUSION

Advances in dehydration techniques and development of novel drying methods have in recent years enabled the preparation of a wide range of dehydrated products and convenience foods from fruits and vegetables meeting the quality, stability and functional requirements coupled with economy. This review paper discussed various types of drying methodologies of present and past. We have discussed in detail about natural convection method of drying which is most suited for agricultural product and eatables to get quantity with expected quality with affordable cost. Solar Tunnel Dryer method is better than open yard sun drying method in all aspects. the solar dryer is beneficial than the sun drying techniques . Solar dryers do have shortcomings. They are of little use during cloudy weather. During fair weather they can work too well. Although 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.

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