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RESEARCH PAPER

Drying technology as an application in post-harvest processing

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SUMMARY : Preservation of fruits and vegetables through drying based on sun and solar drying techniques is one of the oldest forms of food preservation technique known to man. Fruits and vegetables are dried to enhance storage stability, minimize packaging requirement and reduce transport weight. The residual moisture in the vegetables should not be more than 6-8 per cent and in fruits 10-20 per cent. There are two types of drying processes: sun and solar drying and atmospheric dehydration which include stationary or batch processes and continuous processes. The novel methods of drying are Osmotic Dehydration (OD), vacuum drying, Pulse Electric Field (PEF) drying, high hydrostatic pressure drying, superheated steam drying, heat pump drying, spray drying and freeze drying. Sulphuring or sulphiting are generally used as pretreatments in case of fruits and blanching in case of vegetables for better safety, quality control and retention of nutritive value of the final product.

KEY WORDS : Osmotic Dehydration (OD), Vacuum drying, Pulse Electric Field (PEF) drying, Fluidized bed drier, Blanching and sulphuring

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Many of the third world countries produce large quantities of fruits and vegetables for local consumption and export. According to the Food and Agricultural Organization, the estimates of world total production for 2011 were approximately 599300 thousand metric tons of fruits and 1012524 thousand metric tons of vegetables (FAO Database, 2012). In Asia, India produced 74878 thousand metric tons of fruits and 146554 thousand metric tons of vegetables or 12.5 per cent and 14 per cent, respectively of the total world production (Indian Horticulture Database, 2011). Many of these fruits and vegetables contain a large quantity of initial moisture content and are, therefore, highly susceptible to rapid quality degradation, even to the extent of spoilage, if not kept under controlled storage facilities. Therefore, it is imperative that, besides employing reliable storage systems, post-harvest methods such as drying can be implemented hand-in-hand to convert these perishable products into more stabilized products that can be kept under a minimal controlled environment for an extended period of time.

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Drying (dehydration) of fruits and vegetables is one of the oldest forms of food preservation technique known to man and consists primarily of establishments engaged in sun drying or artificially dehydrating fruits and vegetables. Although dehydration is the primary reason for food preservation, it also lowers the cost of packaging, storing and transportation when compared with fresh ones (Okos *et al*., 1992) by reducing both weight and volume of the final product. In the process of drying or dehydration sufficient moisture is removed to protect the product from spoilage. The residual moisture in the vegetables should not be more than 6-8 per cent and in fruits 10-20 per cent (Rather and Parveen, 2010). Dried fruits can be used as such or after soaking while dried vegetables are usually soaked in water overnight and the cooked.

Recent advances in drying of fruits and vegetables :

Drying of fruits and vegetables has been principally accomplished by convective drying (Nijhuis *et al.*, 1998). There are number of studies that have addressed the problems associated with the convectional convective drying. Some important physical properties of the product have changed such as loss of colour (Chua *et al.*, 2000), change of texture, chemical changes affecting flavour and nutrients and shrinkage (Mayor and Sereno, 2004). Besides convective drying give little scope for prior rehydration to further processing after drying for a minimal quality (Khraisheh *et al*., 2004). The high temperature of the drying process is an important cause for the loss of quality. Lowering the process temperature has great potential for improving the quality of dried products (Nindo *et al*., 2003; Beaudry *et al*., 2004). However, in such conditions, the operating time and the associated cost become unacceptable. To reduce the operational cost, different pretreatments and new method of low temperature and low energy drying methods are evolved. A brief review of recent development (past 15 years) will be discussed in the following section.

Osmotic dehydration (OD) :

Osmosis is known as partial dehydration process. Although it does not remove enough moisture to be considered as dried product, the process has the advantage of requiring little energy. It works well as a pretreatment prior to drying in order to reduce energy consumption or heat damage (Jayaraman and Gupta, 1995). The advantage of OD is its lower energy use and lower product thermal damage since lower temperatures used allow the retention of nutrients (Shi *et al.* 1997). Lenart (1996) described the main advantages of using OD as the reduction of process temperature, sweeter taste of dehydrated product, reduction of 30-40 per cent energy consumption and shorter drying time.

Vacuum drying :

The reduction in pressure causes the expansion and escape of gas occluded into the pores. When the pressure is restored, the pores can be occupied by the osmotic solution, increasing the available mass transfer surface area. The effect of vacuum application during OD is explained on the basis of osmotic transport parameter, the mass transfer coefficient and the interfacial area (Rastogi and Raghavrao, 2004). Vacuum pressure (50-100 mbr) is applied to the system for shorter time to achieve the desired result.

EXPERIMENTAL METHODS

Drying mechanism :

The factors that control the rate of drying are air temperature, humidity and air velocity. When hot air is blown over a wet food, water vapour diffuses through a boundary film of air surrounding the food and is carried away by the moving air. A water vapour pressure gradient is established from the moist interior of the food to the dry air. This gradient provides the driving force for water removal from the food. The boundary film acts as a barrier to both heat transfer and water vapour removal during drying. The thickness of the film is determined primarily by air velocity, if the velocity is low, the boundary film is thicker and this reduces both the heat transfer coefficient and the rate of removal of water vapour. Water vapour leaves the surface of the food and increases the humidity of the surrounding air, to cause a reduction in the water vapour pressure gradient and hence the rate of drying. Therefore, faster the air, thinner the boundary film and hence faster the rate of drying.

Methods of drying/dehydration :

Dried fruits and vegetables can be produced by a variety of processes. These processes differ primarily by the type of drying method used, which depends on the type of food and the type of characteristics of the final product (Mujumdar, 1987; Nijhuis *et al*., 1998). There are two types of drying processes: sun and solar drying and atmospheric dehydration which include stationary or batch processes (kiln and cabinet driers) and continuous processes (tunnel, continuous belt, belt trough, fluidized bed, air lift and drum driers).

Common driers used for drying :

Solar drier :

This type of drier comprises of a drying chamber that is covered by a transparent cover made of glass or plastic. The drying chamber is usually a shallow, insulated box with air-holes in it to allow air to enter and exit the box. The food samples are placed on a perforated tray that allows the air to flow through it and the food.

Kiln drier :

It is one of the simplest kinds of air convection drier which is a two storey construction. A furnace or a burner on the lower floor generates heat, and warm air would rise through a slotted floor to the upper storey. This type of drier is generally used to dehydrate relatively large pieces of food material.

Cabinet (tray) drier :

The food may be loaded on trays or pans in a thin layer up to a few centimeters. Fresh air enters the cabinet, is drawn by the fan through the heater coils and is then blown across the food trays to exhaust. The screens filter out any dust that may be present in air.

Tunnel and continuous belt drier :

It is most commonly used for drying of fruits and vegetables. For larger operations, tunnel drier with elongated cabinets, through which trays on cart pass is used. When a dry cart emerges, it makes room to load another wet cart into the opposite end of the tunnel. The drying air moves across the trays from left to right. This is a counter flow pattern in which the hottest and driest air contacts the nearly dry product, whereas the initial drying of entering carts get cooler moist air that has cooled and picked up moisture going through the tunnel.

In a continuous belt drier, a continuously moving belt may be drawn through a tunnel.

Belt trough drier :

It is a special kind of air convection of belt drier in which the belt forms a trough. The belt is usually of metal mesh and heated air is blown up through the mesh. The belt moves continuously, keeping the food pieces in the trough in constant motion to continuously expose new surface.

Air lift drier :

It is generally used to dry the food materials that have been partially dried by other methods. This might be used to finish-dry semi-moist granules (of about 25 % moisture) coming from drum drier.

Fluidized-bed drier :

Heated air is blown up through the food particles with just enough force to suspend the particles in gentle boiling motion. The semi dried food particles enter at the left and gradually migrate to the right, where they are discharged dry. Heated air is introduced through a porous plate that supports the bed of granules.

Drum (roller) drier :

In this type of drier, liquid foods, purees, pastes and mashes are applied in a thin layer on to the surface of a revolving heated drum. The drum is generally heated from within by steam. The food may be applied continuously between the nip where two drums come together and a scraper blade is positioned to peel the thin dried layer of food from the drum.

High hydrostatic pressure :

It is observed that high hydrostatic pressure application damages the cell wall structure which leads to significant changes into the tissue architecture, leaving the cells more permeable, resulting in increased mass transfer rates during OD (Rastogi and Niranjan, 2008).

Pulse Electric Field (PEF) :

PEF processing is a method by means of brief pulses of a strong electric field. The substance to be dried is placed between two electrodes, and then the pulsed electric field is applied. The PEF treatment has been reported to increase the permeability of plant cells by enlarging the pores of cell membrane. PEF treatment induced cell damage, resulted in tissue softening, which in turn resulted in a loss of turgor pressure leading to a reduction in compressive strength. The increase in permeability of carrot tissues by PEF treatment resulted in improved mass transfer during OD (Rastogi *et al*., 1999).

Superheated steam drying :

It is an energy saving drying technology, uses superheated steam instead of hot air or combustion/ flue gases in a direct (convection) dryer. There is no free oxygen in superheated steam, so the decomposition of easily oxidized nutrients such as vitamin C is greatly reduced. This is a key advantage over food drying with hot air, which exposes the food to oxygen.

Heat pump drying :

The heat pump drying system has been designed to use recoverable energy *i.e.* latent heat is converted to sensible heat, thus, handles the product gently. It is a high-energy efficiency convective type of drying. It enables drying under low temperature conditions. In a heat pump dryer, the air velocity, temperature, relative humidity can be controlled independently. A heat pump collected heat from the condenser or outside the unit and discharges it inside the air handler which further will be discharged to the drying chamber.

Spray drying :

Spray drying involves pumping a concentrated liquid food through a device, which forms small droplets that are sprayed into hot air to force rapid drying and produce fine powdered product. It is limited to foods that can be atomized, such as liquids and low viscosity pastes and purees. The liquid food is introduced as a fine spray or mist into a tower or chamber along with heated air. As the small droplets make intimate contact with the heated air, they flash off their moisture, become small particles and drop to the bottom of the tower from where they are removed.

Freeze drying :

In this type of drying, the food material dries directly by sublimation of ice without passing through the intermediate liquid stage. The material such as fruit juice concentrate is first frozen on trays in the lower chamber of a freeze drier and the frozen material dried in the upper chamber under high vacuum.

EXPERIMENTAL FINDINGS AND ANALYSIS

The experimental findings of the present study have been presented in the followingz heads:

Schedule for drying of fruits and vegetables :

Pretreatment :

Sulphuring is done by making sulphur fumes. Sulphur dioxide fumes act as a disinfectant and prevent the oxidation and darkening of fruits on exposure and thus improves their colour. Sulphur fumes also act as a preservative, check the growth of moulds, etc. and prevent cut fruit pieces from fermenting while drying in the sun. Vegetables are generally not sulphured. Sulphiting is done by immersing the pieces in KMS solution for a specific duration. Pretreating vegetables by blanching in boiling water or steam is recommended to enhance the quality and safety of the dried vegetables. Blanching helps clean the material and reduce the amount of microorganisms present on the surface. It also preserves the natural colour of dried products. Blanching also relaxes tissues so pieces dry faster and shortens the soaking and/or cooking time during reconstitution.

Table 1 : Schedule for drying of fruits

Fruits	Preparation and pretreatment	Sulphuring time	Dryness test
Apple	Wash, peel, core, trim and cut into 5 mm thick slices	30 minutes or immerse in 1-2 % KMS solution for 30 minutes and drain	Pliable, springy feel, creamy white. No moist area when cut.
Apricot	Wash, halve and destone	30 minutes	Pliable and leathery.
Banana	Wash, peel, halve lengthwise or slice crosswise 12 mm thick	30 minutes	Sticky, chewy, and a caramel-like color.
Mango	Wash, peel, cut into 12 mm thick slices	2 hours	Sticky and chewy
Papaya	Wash, peel, remove seeds and cut into 6 mm thick slices	2 hours	Sticky and chewy
Grape	Dip in boiling 0.5 % caustic soda solution then rinse	1 hour	Pliable, dark brown
Pear	Wash, peel, cut into halves, remove core, keep in 1-2 % salt solution	30 minutes or immerse for 20-30 minutes in 1-2 % KMS solution and drain	Leathery, springy feel.
Peach	Wash, remove pits, cut into halves	30 minutes	Pliable and leathery.
Plum	Wash, halve and remove pits	30 minutes	Pliable and leathery

Table 2 : Schedule for drying of vegetables

Vegetable	Preparation	Treatment before drying	Dryness test
Cabbage	Wash, remove outer leaves and core, cut into fine shreds	Blanch for 5-6 minutes and immerse for 10 minutes in 0.5 % KMS solution and drain	Crispy, pale yellow to green.
Cauliflower	Wash, remove stalks, covering leaves and stems , break flowers apart into pieces of suitable size	Blanch for 4-5 minutes and immerse for 1 hour in 1 % KMS solution and drain	Tough to brittle
Chillies (red)	String mature dark red pods and hang in sun	No treatment	Brittle and crispy
Green peas	Wash, remove shell and collect the grains	Blanch or steam for 3-4 minutes, immerse in 0.5 % KMS solution and drain	Shatter when hit with a hammer.
Onion	Remove outer dry scales, cut into 5 mm thick slices	Dip for 10 minutes in 5 % salt solution and drain	Very crispy
Green leafy vegetables	Sort, wash, trim off rough stems and stalks and shred	Blanch for 2 minutes in boiling water or steam	Crispy, very dark green
Potato	Wash, peel and cut into 10 mm thick slices	Blanch in boiling water or steam for 3-4 minutes and immerse in 0.5 % KMS solution followed by draining	Brittle
Tomato	Wash	Blanch for 30-60 seconds, peel and slice 10 mm thick	Leathery, dull red
Broccoli	Trim, slice lengthwise in 5 mm strips.	Steam for 10 minutes or until tender but firm.	Tough to brittle
Turnip	Wash, remove stalks, peel and cut into 5 mm thick slices	Blanch for 2-4 minutes in boiling water and then immerse for 1-2 hours in 1 % KMS solution followed by draining	Brittle
Brinjal	Wash and cut lengthwise into 10 mm thick slices	Blanch for 4-5 minutes and then immerse for 1 hour in 1 % KMS solution followed by draining	Leathery to brittle
Carrot	Wash, scrape stalks and tips, and cut into 10 mm thick slices	Blanch for 2-5	Very brittle, deep orange.

Source: Doris and Lydia, 2009 Srivastava and Kumar, 2002

Packing and storage :

After foods are dried, cool them completely. Then package them in clean moisture-vapor-resistant containers. Glass jars, metal cans or freezer containers are good storage containers, if they have tight-fitting lids. Plastic bags are acceptable, but they are not insect and rodent proof. Fruit that has been sulphured or sulphited should not touch metal. Place the fruit in a plastic bag before storing it in a metal can. Dried food should be stored in a cool, dry and dark place. Most dried fruits can be stored for 1 year at 15° C and 6 months at 27° C. Dried vegetables have about half the shelf-life of fruits.

Nutritional benefits of dried food :

Dried foods are tasty, nutritious, lightweight, easy-to-

Fig. 1: Dried fruits and vegetables

prepare, and easy-to-store and use. The nutritional value of food is only minimally affected by drying. There is no change in calorie and fiber contents and Vitamin A is fairly well retained under controlled heat methods. Vitamin C is mostly destroyed during blanching and drying of vegetables. Some loss of thiamin, riboflavin and niacin during blanching but fairly good retention if the water used to rehydrate also is consumed. Some minerals may be lost during rehydration if soaking water is not used. Iron is not destroyed by drying.

Conclusion :

Dehydration is although, a long term food preservation process, it also lowers the cost of packaging, storing and transportation when compared with fresh ones. It is the cheapest among all the other preservation methods and also retains the nutritional quality of the food when proper packaging and storage is maintained.

LITERATURE CITED

Beaudry, C., Raghavan, G.S.V., Ratti, C. and Rennie, T.J. (2004). Effect of four drying methods on the quality of osmotically dehydrated cranberries. *Drying Technol.,* **22**: 521-539.

Chua, K.J., Ho, J.C., Mujumdar, A.S., Hawlader, M.N.A. and Chou, S.K. (2000). Convective drying of agricultural products-effect of continuous and stepwise change in drying air temperature. Paper No.29. **In**: Kerkhof, P.J.A.M., Coumans, W.J. and Mooiweer, G.D. Proceedings of the 12th International Drying Symposium. Amsterdam: Elsevier Science.

Jayaraman, K.S. and Das and Gupta, D.K. (1995). Drying of fruits and vegetables. In: *Handbook of Industrial Drying* (2nd Ed.) Marcel Dekker Inc. NEW YORK, USA. pp. 661-662.

Khraisheh, M.A.M., Cooper, T.J.R. and Magee, T.R.A. (2004). Shrinkage characteristics of potatoes dehydrated under combined microwave and convective air conditions. *Drying Technol.,* **15**: 1003-1022.

Lenart, A. (1996). Osmo-convective drying of fruits and vegetables: Technology and application. *Drying Technol.,* **14**(2): 391-413.

Mayor, L. and Sereno, A.M. (2004). Modelling shrinkage during convective drying of food materials: A review. *J. Food Engg*., **61**: 373-386.

Mujumdar, A. S. (1987). *Handbook of industrial drying*, Marcel Dekker Inc., NEW YORK, USA.

Nijhuis, H.H., Torringa, H.M., Muresan, S., Yuksel, D., Leguijt, C. and Kloek, W. (1998). Approaches to improving the quality of dried fruit and vegetables. *Trends Food Sci. & Technol.,* 13-20.

Nindo, C., Ting, S., Wang, S.W., Tang, J. and Powers, J.R. (2003). Evaluation of drying technologies for retention of physical and chemical quality of green asparagus (*Asparagus officinalis* L.). *LWT-Food Sci. & Technol.*, **36**(5): 507-516.

Okos, M.R., Narsimham, G., Singh, R.K. and Witnauer, A.C. (1992). Food dehydration. In: *Handbook of food engineering* by D.R. Heldman and D.B. Lund, Marcel Dekker Inc., NEW YORK, USA.

Rather, A.H. and Parveen, S. (2010). Dehydration techniques of fruits and vegetables. **In**: *Advanced technologies for post-harvest management of food crops (Training compendium)*, SKUAST-K. pp.38-43.

Rastogi, N.K., Eshtiagi, M.N. and Knorr, D. (1999). Accelerated mass transfer during osmotic dehydration of high intensity electrical field pulse pretreated carrots. *J.Food Sci.,* **64**: 1020-1023.

Rastogi, N.K. and Niranjan, K. (2008). Enhanced mass transfer during osmotic dehydration of high pressure treated pineapple. *J. Food Sci.*, **63** (3): 508-511.

Rastogi, N.K. and Raghavrao, K.S.M.S. (2004). Mass transfer during osmotic dehydration of pineapple: considering Fickian diffusion in configuration. *Lebensmittel-Wissenschaft und-Technologie,* **37**: 43-47.

Shi, J.X., Le Maguer, M., Wang, S.L. and Liptay, A. (1997). Application of osmotic treatment in tomato processing-effect of skin treatments on mass transfer in osmotic dehydration of tomatoes. *Food Res. Internat.,* **30**: 669–674.

Srivastava, R.P. and Kumar, S. (2002). Fruits and vegetables drying/dehydration and concentration. In: *Fruit and vegetable preservation*. (3rd Ed.) International Book Distributing Co. U.P., India. pp. 127-157.

■ WEBLIOGRAPHY

Doris, H. and Lydia, M. (2009). Drying of fruits and vegetables. Family and consumer sciences, The Ohio State University. *http://ohioline.osu.edu/hyg-fact/5000/pdf/5347.*

FAO Database (2012). Food and Agriculture Organization, Rome, Italy. *www.fao.org.*

Indian Horticulture Database (2011). National Horticulture Board, Gurgaon, India. *www.nhb.gov.in.*

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