Biotica Research Today

Vol 3:1 035/037 2021

Foam Mat Drying of Fruits: Concept, Opportunities and Limitations

Thippeswamy B., Alka Joshi* and Shruti Sethi

Division of Food Science & PHT, ICAR- Indian Agricultural Research Institute, Pusa, New Delhi, Delhi (110 012), India

Open Access

Corresponding Author

Alka Joshi

e-mail: alka.foodtech@gmail.com

Keywords

Application, Drying, Foam, Foaming agent

Article History

Received in 15th January 2021

Received in revised form 18th January 2021

Accepted in final form 19th January 2021

E-mail: bioticapublications@gmail.com

How to cite this article?

Thippeswamy *et al*., 2021. Foam Mat Drying of Fruits: Concept, Opportunities and Limitations. Biotica Research Today 3(1): 035-037.

Abstract

Science of drying has evolved from traditional sun drying to ultra modern drying techniques such as freeze drying/ microwave drying/ infrared drying *etc*. Each drying method has its own opportunities and practical limitations. Foam mat drying has recently been explored as a method of processing and preservation of fruit powders. It is majorly used for viscous or high sugar matrices such as drying of bael, melon, beetroot, cherry, pineapple *etc*. which otherwise are difficult to dehydrate using other conventional drying procedures. Foam mat drying technology can be well adopted commercially due to its ease and ability to produce porous reconstituable dried fruit products. Therefore, foam mat drying can be considered as 'second generation drying technique' which provides benefits of both the drying methods; traditional and modern.

Introduction

Foam-mat drying (FMD) is a process of drying semisolid or liquid foods. The product is mixed with a foaming agent and/or stabilizer to produce stable foam followed by thin layer (1-5 mm) drying in a tray drier. The technology was patented in 1917 by Campbell for the drying of foamed evaporated milk. It is majorly used for viscous or high sugar matrices such drying as bael, melon, beetroot, cherry, pineapple etc. which otherwise are difficult to dehydrate using other conventional drying procedures. This may be due to physico-chemical nature of commodity and/or cost or feasibility constrains of the drying technology. Wide surface area provided by foam and enhanced moisture diffusivity of evaporation front accelerates rate of water removal during whole course of drying.

Steps Involved in Foam Mat Drying

- **Transforming** a liquid or a semi-liquid food material into stable foam by incorporating air into it.
- **Drying** of the thin layer of foam.
- **Compression** for size reduction.

Mechanism of Foam Formation

Foam is a type of colloidal mixture in which a continuous phase/ internal phase (liquid) entraps a dispersion phase/ external phase (air). Separating wall between two bubble surfaces is known as lamella. The particle size of colloidal particle is in between the size of a true solution and a suspension ranging between 0.001-1.00 µm. Foam density generally ranges from 0.4-0.6 g per cubic cm. The dispersed phase is present in larger proportion than the continuous phase. Foam may be classified as: (a) polyhedric, or (b) dilute bubbly; depending on the ratio of both the phases. Honey comb structure is the characteristics of polyhedric foam such as in egg white foam. In case of dilute bubbly foam due to less number of bubbles per unit area, enough space is available to form spherical shaped bubbles in the foam.

Foam Generation Methods

Foam can be generated by adopting any of the three methods,

(1) Whipping/ beating,

(2) Bubbling/ sparging, or

(3) Shaking

Unlike other drying mechanisms, the physical structure of moist matrix gets changed due to foaming. Porous capillaries are formed in the foam that facilitates faster water evaporation from the matrix and thus saving energy. Research suggested that approximately eighty percent energy is saved in case of foamed apple juice drying.

Foaming Agents and Foam Stabilizers

Foam can be stabilized by reducing the surface tension on the foam bubble surface. A protein molecule can reduce the surface tension while a fat molecule can increase it. Therefore, foam mat drying is not a good option for fat rich foods. Hydrophobicity and possible conformational rearrangements make proteins a good choice for use as a foaming agent and stabilizer. Protein molecules for example egg albumin, pea protein, soy protein, whey protein can act as good foaming agents @ 1-10 percent (w/w) level of addition. Albumin fraction of guar meal can be used as an alternative to egg albumin. To further stabilize this foam, carbohydrates especially gums such as carboxymethyl cellulose (CMC), xanthan gum, guar gum, propylene glycol alginate can be used, if required @ 0.5-2 % (w/w). Gums increase the viscosity of continuous phase and when proteins are used as stabilizer they form a 3-D network due to which movement of particles gets restricted and results in a more stable foam.

Applications of FMD

FMD Technology can be used for:

• Drying viscous fruit pulp such as bael, tamarind, figs etc.

• Drying high-sugar foods having sticky behaviour such as mango, pineapple, apple etc can be dried by this technology.

• Developing high quality reconstituable and flowable powders through formation of honey comb structure.

• Achieving open and porous texture of dried material resulting in easier grinding of dried material thus, reducing energy consumption.

• Development of reconstitutable beverage formulation (ready-to-reconstitute).

• Development of flavouring agent for incorporation in bakery products.

A Few of the Studies Conducted on FMD of Various Pulpy Fruits are Discussed hereunder

Kadam *et al.* (2012) studied the effect of different drying temperatures, foaming agents and stabilizing agents on biochemical quality attributes of foam-mat-dried pineapple juice/ pulp powder. Pineapple cv. Queen was used for this experiment in which tricalcium phosphate (0.25-1 %) and egg white (0.5-2 %) were used as foaming agents along with 0.25% of CMC as foaming stabilizer. The foamed pineapple flesh was dried at 65, 75 and 85 °C in a tray dryer. Changes in total and reducing sugars, and ascorbic acid retention were observed in drying at 65 °C with maximum retention of studied quality attributes. Egg white and tricalcium phosphate significantly altered the nutritional composition of FMD pineapple powder, yielding 10% and 25% higher total phosphorus and calcium content, respectively than the control counterparts.

Valenzuela and Aguilera (2013) developed low calorie aerated apple leathers (AAL) through foam mat drying using foaming agent gelatin (0-1.5 %) for whipping time between 3-9 min. With increasing level of gelatin and whipping time, gas hold-up time increased upto 42.3% with subsequent decrease in bubble size. Samples with 1.5% gelatin and 7 min whipping time presented the highest drying rate, taking 2.8 h of drying to reach a moisture content of 0.13 kg H_2O/kg dry basis while control sample took 5.67 h to reach similar moisture level.

de Carvalho *et al.* (2017) evaluated the quantitative and qualitative changes in phenolic compounds (anthocyanins, flavonols and hydrolysable tannins) in jambolan juice and in its dehydrated products prepared by foam mat drying at different temperatures (60, 70, and 80 °C), in comparison with lyophilized sample (control). Twenty percent maltodextrin helped in development and stabilization of foam. FMD jambolan juice performed well and was at par with lyophilized sample by exhibiting comparable values for anthocyanins (3,5-diglucosylated anthocyanins, 3-monoglucosylated anthocyanins - 2207.33 v/s 2297.90 mg/kg dwb, respectively) and flavanols (58.10 v/s 62.58 mg/kg dwb, respectively). However, for hydrolysable tannins the performance of FMD was quiet low when compared with lyophilized powder in terms of gallotannins and total elagitannin content (196.23 v/s 344.44 mg/kg dwb, respectively) and (105.12 v/s 164.30 mg/kg dwb, respectively).

Opportunities of the FMD Technology

• Low cost alternative of freeze, spray and drum drying.

• Drying at lower temperature.

• Reduction in drying time.

• Higher energy efficiency than conventional dryers.

• Reduced microbial damage of product.

• Better retention of heat and light sensitive nutrients and bioactives.

• Nutritional quality of product can be modified through foam mat drying.

Limitations of the Technology

• As the technology employs removal of moisture from a thin layer of the foamed material, the material spread per unit surface of drying area is very small.

• Foaming decreases the thermal conductivity of product thus; foam needs to be dried as thin layer of 0.1-0.5 cm.

• Some foaming agents and stabilizers can cause changes in foamed products by altering their experimental and economical properties.

• Foam should be mechanically and thermally stable to resist any collapse during handling and whole course of drying.

• Prolonged whipping may rupture the foam/ bubble wall.

Future Thrust

• Studies on gasses such as nitrogen or nitrous oxide as foaming agent can be tried for oxygen sensitive materials.

• Fruit powders can be developed with additional nutritional benefits.

• Interaction of foam mat drying on various flavor compounds can be studied since it affects the commercial success of the products.

• Combination of FMD with other drying techniques (hybrid techniques) will intensify the adoption of this renewed method in the food industry.

Conclusion

Drying and dehydration are considered as the most ancient art of food preservation. To remain competitive in the growing food processing sector, processors are faced with the challenges to create innovative products with unique shape, texture and flavours. Due to simplicity in the operation, foam mat drying can be established as a cost effective and feasible alternative of spray, drum and freeze dryer. This technology may cater the need of small and marginal food entrepreneurs who are interested in formulation of competitive products at comparative low cost inputs.

References

de Carvalho, T.I.M., Nogueira, T.Y.K., Mauro, M.A., Gómez-Alonso, S., Gomes, E., Da-Silva, R., Lago-Vanzela, E.S., 2017. Dehydration of jambolan [*Syzygium cumini* (L.)] juice during foam mat drying: Quantitative and qualitative changes of the phenolic compounds. *Food Research International* 102, 32-42.

Kadam, D.M., Wilson, R.A., Kaur, V., Chadha, S., Kaushik, P., Kaur, S., Rai, D.R., 2012. Physicochemical and microbial quality evaluation of foam-mat-dried pineapple powder. *International Journal of Food Science and Technology* 47(8), 1654-1659.

Valenzuela, C., Aguilera, J.M., 2013. Aerated apple leathers: effect of microstructure on drying and mechanical properties. *Drying Technology* 31(16), 1951-1959.