Chapter 23

Novel drying techniques in fish processing and preservation

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Drying

Drying is the most ancient and pre-eminent physical methods of food preservation. Normally the term 'drying' implies the removal of water by evaporation It is aimed at lowering the moisture content of foodstuff and predominately used for foods which are considered 'highly perishable'. Water is essential for the activity of all living organisms its removal will slow down, or stop, microbiological or autolytic activity thereby act as a preservation technique. Dried foods offer multiple benefits which include extended product shelf-life, reduced packaging requirements, lower storage space, lesser handling and transportation costs, throughout the year availability and finally diversified product for the consumers.

Fish drying

Drying has evolved as a traditional method of preserving fish, the action of the sun and wind is used to effect evaporative drying. In recent times, the controlled artificial dehydration of fish has been developed in some industrialised countries so that fish drying can be carried out regardless of weather conditions. In any process of drying, the removal of water requires an input of thermal energy. At normal temperatures, fish muscle can be considered to be a gel; it remains a gel until a considerable quantity of water has been removed. During drying, considerable shrinkage takes place, as well as other irreversible changes, and dried fish will not reconstitute to their original condition.

During air drying, water is removed from the surface of the fish and water moves from the deeper layers to the surface. Drying takes place in two distinct phases. In the first phase, whilst the surface of the fish is wet, the rate of drying depends on the condition (velocity, relative humidity etc.) of the air around the fish. If the surrounding air conditions remain constant, the rate of drying will remain constant; this phase is called the 'constant rate period'. Once all the surface moisture has been carried away, the second phase of drying begins and this depends on the rate at which moisture can be brought to the surface of the fish. As the concentration of moisture in the fish falls, the rate of movement of moisture to the surface is reduced and the drying rate becomes slower; this phase is called the 'falling rate period'.

Novel drying techniques

Conventional drying technologies have now been used on commercial scale for drying numerous food products. Conventional drying process relies on conductive and convective form of heat transfer but these methods end up in poor quality product and higher contamination. This leads to the development of dryers that have the capacity for more efficient and reliable drying process In recent years, there have been many advances in technology associated with the industrial drying of food including pre-treatments, techniques, equipment and quality. Recent research has revealed that novel drying approaches such as microwave- or ultrasound-assisted drying, high electric field drying, heat pump drying and refractance window drying can be now taken to improve the efficiency and efficacy of drying process with high quality product and minimum energy requirement.

Microwave-Assisted Drying

Microwave radiation is part of the electromagnetic spectrum with wavelengths ranging from 1 mm to 1 m. For food applications, the common frequencies used are 915 and 2450 MHz. Microwaves are non-ionizing in nature, and the concept of application of microwave energy is considered as a fourth-generation technology. There is an increase in interest in microwave-assisted dehydration. Unlike conventional drying techniques, in microwave heating energy is delivered directly to the material through molecular interactions with the electromagnetic field. This principle of dielectric heating involves two basic mechanisms: dipolar rotation and ionic interaction/ionic conduction, and relies heavily on the product's dielectric permittivity and loss factor. Major process parameters are time–power level combinations used. Among the crucial product parameters is the moisture content of the product and its dielectric properties. Microwave-assisted drying of various food materials has shown excellent results. For example, up to 25–90 % reduction in drying time, up to 400–800 % increase in drying rate and 32–71 % reduction in energy consumption as compared to conventional drying techniques, superior product quality, even better than freeze dried foods, lesser floor-space requirements and better overall process control (Wang *et al.*, 2014).

High Electric Field Drying

In high electric field (HEF) or electrohydrodynamic (EHD) drying, an alternating current (AC) or direct current (DC) at high intensity and normal frequency (around 60 Hz) is used for moisture removal during drying. Potential difference generated between the electrodes showed direct effects with sample drying rate. The exothermic interaction of the electric field within the dielectric food material results in rapid evaporation. The heating effect is caused as a result of the secondary flow induced by the electric field. This is termed as 'corona wind' or 'ionic wind'. In short, the method creates forced convection using ionic injection, followed by subsequent acceleration between electrodes. Parameters such as electrode size, electric field strength and inter-electrode spacing are major deciders of efficiency of the drying process. High electric field drying is a convective drying technique that can effectively remove product moisture whilst retaining heat-sensitive components including ascorbic acid. As a non-thermal drying technique, high electric field drying shows lower risk to browning. High electric field drying offers high energy efficiency, reduction in drying time and lower power requirements compared to conventional drying techniques. Superior dried product quality attributes of shrimps in comparison with oven drying (Bai and Sun, 2011) further support the hypothesis that high electric field is a promising method for drying of seafoods. Similar conclusions were drawn from studies conducted on scallop muscle (Bai *et al.*,2012) and Spanish mackerel (Bai *et al.*,2011).

Infrared Drying

Infrared radiation is part of the electromagnetic spectrum, ranging between 0.75 and 1,000 lm in wavelength. As a food processing technique, it offers several advantages including high heat transfer capacity, better process control and uniform heating. Infrared energy incident on the food material creates charges in electronic, vibrational and rotational states at atomic and molecular levels, without heating the surrounding air. The uniqueness of the process is that infrared drying results in uniform temperature distribution require less start-up time and less residence time.

Heat Pump Drying

Unlike other drying systems that require new technology and capital investments, heat pump dryers can be developed with little modification of existing refrigeration systems. Hence, most commonly used heat pump units are closed-loop systems that work on the thermodynamic principle of vapour compression cycle. Heat pump dryers have the capability to convert the latent heat of vapour condensation into sensible heat of an air stream passing through the condenser. The basic components of the heat pump drying system encompass an expansion valve, two heat exchangers (evaporator and condenser), and a compressor and a dryer attachment. The evaporator functions as dehumidifier and the condenser as heater. More recently, chemical and hybrid (microwave, infrared and radiofrequency) heat pump sources have been developed, to improve process efficiency. Drying temperature and air humidity in heat pump drying systems can be kept under control. This has allowed heat pump dryers to be employed for both agricultural, pharmaceutical products and also suitable for highly heat-sensitive commodities. Shi *et al.* (2008) suggested that heat pump drying is the best method to produce intermediate moisture foods, particularly for applications in fish processing. Fadhel *et al.* (2011) have reviewed the recent advances in technologies for solar-assisted CHP dryers for agricultural produce, highlighting the uniqueness of utilizing renewable energy sources for drying.

Ultrasonic Vacuum Drying

Ultrasound treatment is widely used as a pre-treatment technique to accelerate drying. Applying ultrasound interrupts the continuity of the membranes, and thus increases the mass transfer rate between the cell and its extracellular surroundings. Ultrasound treatment is connected to drying during the process and as a preliminary treatment positively affects the drying process in terms of improving the quality of the dried products and reducing the energy consumed during drying. Ultrasound can be applied to improve the convective heat transfer co-efficient or to increase mass transfer for different products and processes. Combining vacuum drying with ultrasound treatment can be considered as perfect drying techniques to increase drying efficiency and to reduce drying time. In this method, the advantages of both processes were used to shorten the drying period.

Conclusion

Novel drying techniques/methods listed above for fish processing and preservation can be considered as better option due to its lower drying time and higher quality product. However, the development of new dry food items using novel techniques introduces different challenges, namely the consumer perception, the approval of the novel technology and the retention of the physical, sensorial and nutritional quality of foods. The potential of novel technologies for drying and food preservation has gained increased industrial interest and has the potential to replace, at least partly, the traditional entrenched preservation methods, as the industry seeks to become more environmentally and economically sustainable.

Further reading

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