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# Effect of osmotic pretreatment on quality of mango chips by explosion puffing drying

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ABSTRACT

The effect of osmotic dehydration pretreatment duration (30, 60 and 120 min) on the glass transition, texture, color, expansion, rehydration and other properties of mango chips was investigated. Mango slices were immersed into 65 °Bx sucrose solution at 30 °C and then predried to a moisture content of 30 g water/100 g by hot-air-drying at 50 °C. The mango chips were then obtained by explosion puffing drying. The osmotic pretreatment improved the color of mango chips, whereas sucrose impregnation resulted in a hard and brittle texture. The non-pretreated samples had a higher glass transition temperature, expansion ratio and rehydration ratio and lower hardness and crispness values than the pretreated samples. With increasing immersion time, the glass transition temperature decreased and the water activity simultaneously increased for the chips. Sensory evaluation showed that the pretreated samples were of better overall quality than the non-pretreated samples, although this difference is slight.


## 1. Introduction

Mango (*Mangifera indica* L.) is one of the most important tropical fruits, treasured worldwide due to its bright color, characteristic flavor and high nutritional value (vitamins A, C and B complex, fibers and minerals) (Bernardi, Bodini, Marcatti, Petrus, & Favaro-Trindade, 2009; Torezan, Menezes, Katekawa, & Silva, 2007). China is one of the largest producers of mangoes in the world. However, a great loss of mangoes during the postharvest period occurs due to a lack of proper postharvest handling and processing. Therefore, it is necessary to develop novel products using new processing technology to increase the value of this fruit and satisfy the increasing demand for processed food.

Recently, fruit and vegetable chips have become very important in the diet of the modern consumer. Deep fat frying (Torezan, Favareto, Pallet, Menezes, & Reynes, 2004; Torezan et al., 2007) or vacuum frying (Ikoko & Kuri, 2007; Nunes & Moreira, 2009) have been the subjects of extensive studies. Fried chips are quite appealing to the consumer because of their crispy texture and attractive flavor. However, fried chips have high oil content, which is harmful for human health, and fried chips cannot be stored for an extended period of time due to possible lipid oxidation and rancidity (Nath & Chattopadhyay, 2008; Tabtiang, Prachayawarakon, & Soponronnarit, 2012). Freeze-drying produces the highest-quality dried foods, characterized by the retention of color, aroma and nutrients, a crispy texture, superior taste, high porosity and rapid rehydration. However, freeze-drying is also more expensive and slower than other drying processes (Cui, Li, Song, & Song, 2008; Hofsetz, Lopes, Hubinger, Mayor, & Sereno, 2007; Wang, Zhang, & Mujumdar, 2010). Another cheaper alternative for producing materials with similar qualities to those of freeze-dried products is called puffing. Puffing is performed at an intermediate stage in the drying process. A sudden increase in temperature or a sudden decrease in pressure causes the water within the cells of the material to vaporize and expand. A puffing process involves the release or expansion of vapor or gas within the product, either to create an internal structure or to expand and/or rupture an existing one (Antonio, Alves, Azoubel, Murr, & Park, 2008; Hofsetz et al., 2007). The puffing process can create a porous structure and save drying time and energy (Wang et al., 2010). Some puffing methods include explosion puffing (He, Liu, & Huang, 2011; Lai et al., 2011; Saca & Lozano, 1992), high-temperature and short-time air puffing (Antonio et al., 2008; Hofsetz et al., 2007; Nath & Chattopadhyay, 2008) and superheated steam puffing (Li, Seyed-Yagoobi, Moreira, & Yamsaengsung, 1999; Wang et al., 2010).

Osmotic dehydration has been widely used as a pretreatment for the partial removal of water from fresh fruits and vegetables before further processing because it can reduce energy consumption and improve product quality (e.g., color, texture, flavor and nutrients) (El-Aouar, Azoubel, Barbosa, & Murr, 2006; Wang et al., 2010). In osmotic dehydration, fruits and vegetables are immersed in hypertonic solutions (e.g., sugar, salt, sorbitol and glycerol). Three

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simultaneous mass transfers occur: water transfers from the product to the solution; the solute transfers from the solution to the product; and the product's own solutes (sugars, organic acids, minerals, vitamins, etc.) leach out. However, this third process is negligible compared with the first two transfers (Eren & Kaymak-Ertekin, 2007; Sablani & Rahman, 2003; Wang et al., 2010). Many researchers have worked on osmotic dehydration as a preliminary step for mango processing (Bernardi et al., 2009; Nunes & Moreira, 2009; Torezan et al., 2004, 2007).

Mango, due to its bright yellow color, characteristic flavor and nutritional values, is excellent for chip production. In this work, explosion puffing drying technology was of interest. The main objective of this work was to study the effects of osmotic dehydration on the quality of mango chips produced by explosion puffing drying and to evaluate the relevant quality attributes, such as the water activity, glass transition temperature, texture, color, expansion and rehydration of the mango chips.

## 2. Materials and methods

### 2.1. Sample preparation

Mango fruits (var. "Keit") of similar ripening degree were obtained from a local market (Wuliting Market, Nanning, China). The mangoes were washed thoroughly and peeled manually using a stainless steel peeler. Two slices parallel to the stone were cut from each fruit, which were then further sliced into 26 × 26 × 5 mm pieces using a sharp slicer. The mango samples were subjected to four different treatments: T0 (no osmotic treatment), T1 (30 min of osmotic dehydration pretreatment), T2 (60 min of osmotic dehydration pretreatment) and T3 (120 min of osmotic dehydration pretreatment).

### 2.2. Osmotic dehydration (OD)

Mango samples were immersed into a 65 °Bx sucrose solution at 30 °C with an osmotic solution to fruit ratio of 3:1 (w/w) to avoid excessive dilution of the solution (Deng & Zhao, 2008a). Agitation was manually performed every 10 min. After the specified immersion time (30, 60, or 120 min), the samples were removed from the osmotic medium, quickly rinsed with distilled water to remove the excess solution, and then gently blotted with tissue paper to remove excess water. The water loss (WL) and solids gain (SG) in osmotically treated mango were calculated by the following equations (Shi, Fito, & Chiralt, 1995):

$$\mathrm{WL} = \frac{M_0 \cdot X_{\mathrm{w0}} - M_{\mathrm{t}} \cdot X_{\mathrm{wt}}}{M_0}, \tag{1}$$

$$\mathrm{SG} = \frac{M_{\mathrm{t}} \cdot X_{\mathrm{st}} - M_0 \cdot X_{\mathrm{s0}}}{M_0}, \tag{2}$$

where $M_0$ and $M_{\mathrm{t}}$ are the initial and final sample mass (g), respectively; $X_{\mathrm{w0}}$ and $X_{\mathrm{wt}}$ are the initial and final sample moisture content (g water/100 g), respectively; and $X_{\mathrm{s0}}$ and $X_{\mathrm{st}}$ are the initial and final sample total soluble solids content (g solid/100 g), respectively. All experiments were conducted in triplicate, and the average values were reported.

### 2.3. Air-drying (AD)

The hot-air-drying experiments were carried out at a constant air velocity (2 m/s) and at an air temperature of 50 °C in a laboratory oven (Model DHG-9146A, Shanghai Jing Hong Laboratory Instrument Co. Ltd., Shanghai, China). After the moisture content was reduced to 30 g water/100 g, the dried samples were packed in polypropylene bags and placed into a chamber at 4 °C for 24 h to equilibrate the moisture content for further drying via puffing.

### 2.4. Explosion puffing drying (EPD)

The puffing experiments were conducted using the experimental explosion puffing drying equipment system (Fig. 1), which consists of a puffing chamber, vacuum chamber, vacuum pump, decompression valve, air compressor and steam generator (He et al., 2011; Lai et al., 2011). The puffing processes were as follows. First, in the puffing chamber, the samples were placed on a stainless steel grid and the decompression valve was closed. The samples were indirectly heated to 95 °C by the steam generator and maintained at this temperature for 5 min. During sample heating, the puffing chamber was inflated to an absolute pressure of 0.2 MPa by the air compressor, and the vacuum chamber was evacuated to approximately 100 Pa (absolute pressure) by the vacuum pump. In the depressurizing treatments, the absolute pressure was decreased from 0.2 MPa to 100 Pa in the puffing chamber by opening the decompression valve. The temperature of the puffing chamber decreased from 95 to 75 °C. The puffed samples were vacuum-dried for 180 min under these conditions, yielding puffed mango chips. All of the parameters were determined by preliminary studies.

### 2.5. Experimental analysis

#### 2.5.1. Physicochemical characterization

Moisture content was determined by convection air-drying at 105 °C to constant weight (GB50093, 2010). Total soluble solids (TSS, g solid/100 g) were measured with a refractometer (Model WZS-I, Shanghai Optical Instrument Co. Ltd., Shanghai, China) at 20 °C. Titrable acidity (TA, g citric acid/100 g) was calculated as the percentage of citric acid by titrating a sample with 0.1 mol/L NaOH (GB/T12456, 2008). Water activity ($A_{\mathrm{w}}$) was determined using a water activity meter (Model HD-4, Wuxi Hua Ke Instrument Co. Ltd., Wuxi, China) at 25 °C (GB/T23490, 2009). All analyses were carried out in triplicate.

#### 2.5.2. Glass transition temperature ($T_{\mathrm{g}}$) measurement

The $T_{\mathrm{g}}$ of fresh mango and mango chips was determined using differential scanning calorimetry (DSC200PC, Netzsch, Bavaria,

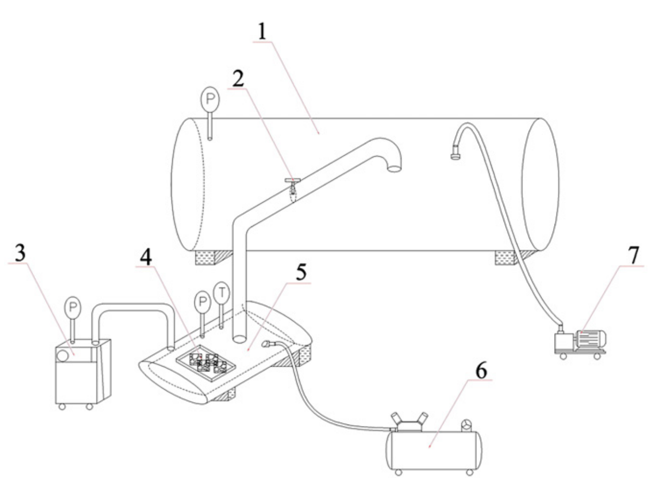


**Fig. 1.** Schematic diagram of explosion puffing drying dryer and associated units: 1, vacuum chamber; 2, decompression valve; 3, steam generator; 4, samples; 5, puffing chamber; 6, air compressor; 7, vacuum pump.