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ORIGINAL ARTICLE

Effect of sucrose and binary solution on osmotic dehydration of bell pepper (chilli) (*Capsicum* spp.) varieties

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Abstract Pepper (chilli) (*Capsicum annum*) varieties, 'Tatase' and 'Rodo', *(Capsicum frutescens)* 'Sombo' and 'Bawa' were osmotically dehydrated in sucrose solutions of 40, 50 and 60º Brix and binary solutions of 50° sucrose with 5, 10 and 15% salt at 20, 30 and 40°C for 9 h. Samples osmosed at higher sugar concentrations (50° and 60°Brix) gave better results while improved solute gain were obtained using binary mixture with lower processing time, energy and cost. Effects of varietal differences on solid gain and water loss showed a descending in the order 'Sombo', 'Rodo', 'Bawa' and 'Tatase'. The colours were retained and stabilized after osmotic dehydration. Therefore, the solid gain and colour retention are indications of value addition.

Keywords Bell pepper · Chilli · Capsicum · Osmotic dehydration · Pretreatment · Quality retention

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Introduction

Pepper (chilli) (*Capsicum* spp) is widely consumed as spice, vegetable and fruit in many ethnic diets including African, Asian, Hungarian and Mexican. The world production is put at over 19 million tons fresh fruits from 1.5 million hectares (FAOSTAT 2004) with Nigeria being the highest producer in Africa. Pepper comes in varieties of shapes, sizes and colours, ranging from green, yellow to red. They are green when immature turning red at maturity and having pungency level depending on the varieties and growth conditions. Most of the cultivated bell pepper belongs to *Capsicum annum* but the small, very pungent varieties belong to *Capsicum frutescens*. Some of the local varieties of red peppers are hot pepper 'Atarodo' (*Capsicum annum*), bell pepper 'Tatase' (*Capsicum annum*), Cayenne pepper 'Sombo' (*Capsicum frutescens*) and long red pepper 'Bawa' (*Capsicum frutescens*).

The pungent characteristic is known to help to fight inflammation and Sombo (*Capsicum frutescens*) help to reduce blood cholesterol while increasing the body's ability to dissolve blood clots thus reducing the risk of heart attack and stroke (GMF 2004). Two teaspoons of red pepper provide 5% of the daily value for vitamin C coupled with more than 13% of the daily value for vitamin A (GMF 2004).

Bell peppers have very high moisture content with typical storage life of 3 to 5 weeks (AFIF 2004) and hence to preserve and reduce losses they are dried. Traditional sun-drying and hot air drying are the major drying methods (Govindarajan 1985). Sun drying however changes the colour and shrinks considerably leading to an unattractive final product. The main problem in drying is the outer layer (skin) which impedes water transport from the interior or core to its surface, slowing the drying process. There are several pre-treatments used to reduce the effect of skin resistance and promote water transport from the core of the material during drying. Mechanical pretreatments of cutting to slices and chips, skin abrasion and puncturing exposes the inner part of the product other than the skin alone (Sunjka and Raghavan 2004). Thermal treatments such as boiling and blanching soften the skin tissue but they add to the moisture content hence may change the colour and increase dehydration energy. Chemical pretreatment involves immersion of the product in alkaline or acidic solutions prior to drying or dehydration to form cracks on skin surface or skin dissociation thereby helping for the removal of water.

One of the most useful pre-processing steps prior to drying of foods, which retains the food quality is osmotic dehydration (Collignan and Raoult-Wack 1994). Osmotic dehydration is a water removal process, which involves soaking food material such as fruits or vegetables in a concentrated solution (Raoult-Wack et al. 1992). During the process, a two-way counter flow of mass exchange takes place (Lenart 1996) leading to water diffusion from the sample to be dehydrated to the surrounding hypertonic solution and an opposite stream of osmotic substances that enters the sample. Osmotic dehydration does not reduce only air drying time but also extends the shelf-life (Dhingra et al. 2008), improves the quality of the material due to limited heat damage, helps in vitamin retention, flavour enhancement and colour stabilization (Karathanos et al. 1995, Barbosa-Canovas and Vega-Mercado 1996, Sunjka and Raghavan 2004).

Most of the research work reported on osmotic dehydration involved the use of diced, sliced and cubed fruit pieces (Collingnan and Raoult-Wack 1994, Ozen et al. 2002, Ramaswamy and Van-Nieuwenhuijzen 2002, Ade-Omowaye et al. 2003a, Tiwari and Pandey 2007, Singh et al. 2008, Suresh Kumar and Sagar 2009), sliced and deskinned (Ade-Omowaye et al. 2003b, Simal et al. 2005), punched and perforated samples (Azoubel and Murr 2000). Ade-Omowaye et al. (2002) worked on the kinetics of osmotic dehydration of red bell peppers as influenced by pulsed electric field pre-treatment.

In the sub-saharan Africa however, peppers are dried whole and are preferred by consumers as whole (fresh or dry) to be ground dry for storage or immediate use, rehydrated before grinding or hydrated during grinding. It is therefore, important to adopt a pre-treatment method which will stabilise the quality and retain the wholeness. The knowledge of the kinetics of moisture loss and solid gain with respect to concentration and temperature is also necessary in the design of processing machines for pepper varieties. Currently, limited information exists on effects of osmotic dehydration on whole pepper, thus the need for this study. The study therefore explored the potentials of osmotic dehydration as a pre-treatment itself. This work was limited to the use of sucrose and salt, which are being readily available cheap materials as solutes in osmotic concentration.

Materials and methods

Mature pepper (chilli) varieties of 'Rodo' (hot pepper, *Capsicum annum*), 'Tatase' (bell pepper, *Capsicum annum*), 'Sombo*'* (cayenne pepper, *Capsicum frutescens*) and '*Bawa'* (long red cayenne pepper, *Capsicum frutescens*), sugar and table salt were purchased from Bodija Market, Ibadan, Nigeria. Stalks of the peppers were cut with a knife to ensure that the fruits were not damaged and then washed sparingly in water to remove extraneous materials. A set of fresh samples punched with sharp objects to create perforations were oven dried at 100°C for 24 h in an air oven (Blue-M SW-17TA, Blue-M Electric, Illinois) before the commencement of the osmotic dehydration process to determine the initial dry matter and moisture contents on dry basis (g/g dry solid (ds)). Five whole pepper samples of each variety each weighing not less than 100 g (depending on variety) were cleaned, dried and put into separate labelled perforated mesh baskets. This was done in triplicates.

Osmotic solutions with 40°, 50° and 60° Brix of sugar (sucrose) concentrations were prepared by blending 666.7, 1000 and 1500 g of sugar in 1000 ml distilled water and maintained at 20, 30 and 40°C in a water bath. The Brix (solute) content of the solutions were confirmed with an Abbe refractometer. The samples in the perforated mesh baskets were fully immersed in the sugar solutions. An excess of osmotic solution (fruit to solution ratio 1:10) was used to limit concentration changes due to uptake of water from pepper samples and loss of solute to the pepper. The second set of tests with sugar/salt solutions prepared by blending 5, 10 and 15% salt, respectively in 3 prepared 50 Brix sucrose solutions were also conducted at 20, 30 and 40°C, respectively.

Samples weighed prior to immersion were withdrawn from osmotic solutions, clean-dried to remove adhering solutions and weighed after 9 h in the solution. It should be noted that this study aimed to explore the possibilities of osmotically dehydrating whole pepper hence the usual practice of weighing every interval of 30 min to 1 h was not part of the exercise. It is expected that when appropriate solution and temperatures are established for the whole peppers, kinetics of water movement will then be studied for these conditions at intervals. Fresh and osmosed samples were oven dried at 100°C in an air draught oven and weights noted at interval until constant weights were obtained to determine the initial and final moisture contents.

Data obtained were used to compute the water loss (WL), solid gain (SG) using the method of Panagiotou et al. (1999) and moisture content. The osmotic dehydration process was evaluated using the following calculated parameters: WL, SG and moisture content (dry basis) as follows:

$$WL = \frac{\left(M_0 - m_0\right) - \left(M - m\right)}{M_0} \quad (1)$$

$$SG = \frac{m - m_0}{M_0} \quad (2)$$

$$\text{Moisture content (db)} = \frac{M - m}{m} \quad (3)$$

where M_0 is the initial mass of fresh pepper prior to osmotic dehydration, M the mass of pepper after time (t) of osmotic dehydration, m the dry mass of pepper after time (t) of osmotic dehydration and m_0 the dry mass of fresh pepper.

Results and discussion

Moisture content: Moisture contents of pepper varieties decreased with time as a result of the movement of moisture from pepper into surrounding hypertonic solution during osmotic dehydration (Table 1). 'Rodo' indicated slightly higher initial moisture content than 'Bawa' but lower moisture contents after osmotic dehydration. The percentage WL was therefore the highest in 'Rodo'. This could probably be due to 'Rodo' having large area of contact with the osmotic solution due to its size and a skin texture that favours water loss at high temperature. 'Tatase' indicated higher initial and final moisture contents prior to and after osmotic treatment due to its very high moisture content. Although it has large surface area similar to 'Rodo', the excessive moisture and the slightly tougher skin resulted in lower percentage loss. 'Sombo', however, showed the least initial and final moisture contents and the least percentage WL. This variety has a more glossy appearance/surface and low moisture content, hence the lowest rate of WL. The WL of a maximum of 16% in osmotic dehydration of cherry tomatoes in NaCl solutions (Azoubel and Murr 2000) and a maximum of 15% by Medaa et al. (2005) on osmotic dehydration of prairie fruit are reported.

Effect of Brix concentration and temperature: The results of the dehydration processes are presented in Fig. 1. Both SG and WL after 9 h were low at 20 and 30°C for all the Brix for 'Rodo' samples. However at the highest temperature used, there were improvement in both the WL and SG, though the SG was still low for all Brix. This can be attributed to the structure and texture of 'Rodo' which only softens at higher temperature. The thick and hard skin impede exchange of molecules at lower temperature while higher temperature softens the skin, opening up spaces for particles and moisture transfer.

'Tatase' samples showed poor WL and SG at 20 and 30°C with negative SG at higher temperature. This implies that the solutes within the pepper were diffusing into the solution at higher temperature with associated higher WL. This is as a result of the nature of 'Tatase' sample. Generally when pressed it releases coloured water which means the solute within the pepper adhere to water molecules and are therefore escaping from samples together. Also 'Tatase' has a very high moisture content, which diffuses into the hypertonic solution. It is interesting to note that the dissolved solute in 'Tatase' samples also moves with the water into the hypertonic solution. This is an experimental confirmation of the observation of Famurewa et al. (2006) who obtained lower protein content after further drying of osmosed pepper as compared to non-osmosed. They concluded that there was leaching of some solute into the solution from pepper samples during osmosis leading to loss of nutritional content. However, at higher temperature the adhesion forces between the combined moisture and moisture within the pepper breaks down and an increase in SG was obtained.

The 'Sombo' sample showed a better performance at 30 and 40°C but very poor for 40° and 50° Brix at 20°C. This proved that the concentration of the dissolved solute within 'Sombo' sample was high hence it required higher osmotic solution for effective osmosis. In addition, the nature of 'Sombo' with a very tough and strong skin did not allow easy exchange of molecules at lower Brix and temperature. The best results (WL and SG) were obtained at 60° Brix at all temperatures. The trend was similar for 'Bawa' (with similar texture and shape as 'Sombo') except that the performance was better at 20°C. This performance may also be due to the smaller size with less area of contact with the osmotic solutions.

With these results having no definite trend further studies were carried out to investigate the effect of a combined salt and sugar solution at 50°Brix sugar with 5, 10 and 15% salt at 20, 30, and 40°C. From the results (Fig. 1) considerable improvement was noticed in all except 'Sombo' which showed a good performance only at 40°C. This implies that there may be a need to first determine the sugar content of the samples before selecting the quantity of sugar to be used in the solution.

The scope of this work was limited to a maximum temperature of 40°C because of the observation of Pointing et al. (1966) that the rate of biochemical reaction increases with temperature up to about 45°C above which denaturation becomes predominant and enzymatic browning and flavour deterioration begin to take place. Therefore, this study was aimed at working below this temperature to ensure the retention of the taste and colour. All 4 pepper varieties prior to osmotic dehydration in 40, 50 and 60°Brix sucrose solutions indicated winish-red colour as also after immersion and dehydration.

Prior to and after osmotic dehydration showed that osmotic dehydration helps to retain and stabilize pepper colour. This is in agreement with the report by Karathanos

Table 1 Moisture content of pepper varieties during osmotic dehydration in 40º Brix sucrose solution at 40ºC

Pepper variety	Moisture g/g ds		Loss, %
	0 h	9 h	
'Rodo'	4.4	3.6	17.8
'Tatase'	8.0	7.3	8.5
'Sombo'	3.0	2.9	4.7
'Bawa'	4.3	3.9	8.9

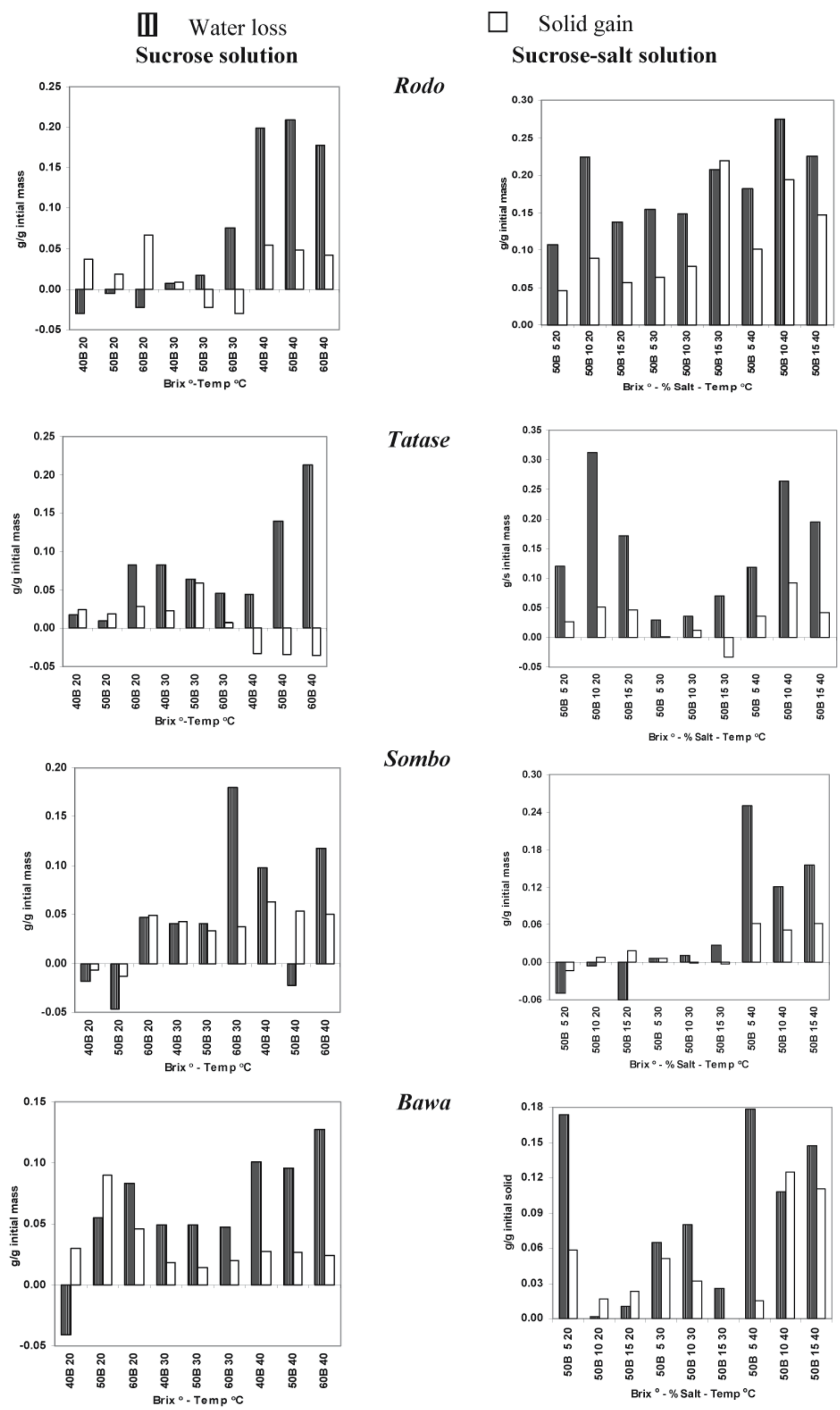

Fig. 1 Water loss (WL) and solid gain (SG) in 'Rodo', 'Tatase', 'Sombo' and 'Bawa' varieties of pepper in sucrose solution and sucrose-salt binary solution (n=3)

et al. (1995) that osmotic dehydration improves textural quality and colour stabilization in fruits and vegetables.

Conclusion

Skin and the contact area of the product greatly influences the osmotic dehydration process. The possibility of value addition through osmotic dehydration of whole pepper is also indicated unlike the decolouration of pepper samples in the sun drying method which is the most commonly used in the developing countries. Decolouration accounts for the lack of interest and patronage of the dried products. This raises the hope of supply of quality whole pepper, fresh or dried in most sub-Saharan countries in Africa which is on high demand. However, there is a lot to be studied on the determination of the appropriate Brix and temperature for osmotic dehydration of each of the whole pepper samples. Therefore, further works will be reported on this and the kinetics of moisture and particle transfers.

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