CIGR - International Conference of Agricultural Engineering
XXXVII Congresso Brasileiro de Engenharia Agrícola

Brazil, August 31 to September 4, 2008

ZINC LOSS DURING DEWATERING-IMPREGNATION SOAKING OF GUAVA

VALÉRIA APARECIDA VIEIRA QUEIROZ[1]; PEDRO AMORIM BERBERT[2]; MARÍLIA AMORIM BERBERT-MOLINA[2]; GERALDO DE AMARAL GRAVINA[2]; LUCIANO RODRIGUES QUEIROZ[3]

[1] Researcher, DS, EMBRAPA/Sete Lagoas – Brazil. e-mail: valeria@cnpms.embrapa.br
[2] Lecturer/Researcher, PhD, UENF/Campos dos Goytacazes – Brazil.
[3] DS, Crop Production, CCTA/UENF/Campos dos Goytacazes – Brazil.

Presented at
CIGR INTERNATIONAL CONFERENCE OF AGRICULTURAL ENGINEERING
XXXVII CONGRESSO BRASILEIRO DE ENGENHARIA AGRÍCOLA – CONBEA 2008
Brazil, August 31 to September 4, 2008

ABSTRACT: This work investigated the loss of zinc to the osmotic solution during the dewatering-impregnation soaking of guava slices. The dehydration was conducted at 50 °C, for 2 h, using a fruit to syrup ratio of 10:1 (w/w), and a single level of agitation of the solution, 60 min^{-1}. Guava slices were immersed into solutions of sucrose, sucrose + sucralose, and inverted sugar. Inverted sugar was responsible for a lesser degree of zinc retention in fruit tissue than sucrose. Reductions from 26 to 47% in zinc content were observed during the osmotic dehydration of guava slices in the hypertonic solutions.
KEYWORDS: *Psidium guajava*, osmotic dehydration, food conservation, minerals

INTRODUCTION: Zinc is essential for human health and plays a key role in human metabolism. According to MAFRA & COZZOLINO (2004) zinc is vital for the proper functioning of enzymes, participates in cell division, genetic expression, physiological processes like growth and development, genetic transcription, as well as programmed cell death. Furthermore, zinc affects the immune function and cognitive development. Symptoms of zinc deficiency include oxidative damage, reduced sense of taste and smell, skin disorders, reduced fertility, and neuropsychological impairment such as mental lethargy. TORREGGIANI (1993) stated that the dewatering and impregnation soaking processes (DIS), a food pre-treatment also known as osmotic dehydration, is capable of improving the nutritional and sensory characteristics of fruit which will be further submitted to convective air drying. The DIS consists of the immersion of fruit pieces in a hypertonic solution. During the DIS process, three types of mass transfer occur: water flows from the product to the solution; the solute is transferred from solution to the product and the product's own solutes, such as sugars, organic acids, minerals and vitamins, leach out to the solution (PEIRÓ-MENA et al., 2007). Few studies have been conducted to identify and quantify the losses of minerals during the DIS process. On this basis, the object of this work was to assess the loss of zinc during the osmotic dehydration of guava is sucrose- and inverted-sugar solutions.

METHODOLOGY: This work was carried out at the Agricultural Engineering Laboratory, Northern Rio de Janeiro State University (UENF), Campos dos Goytacazes, Brazil. Twenty guavas (*Psidium guajava* L.) of the Pedro Sato variety were harvested with a similar degree of ripening, i.e., skin hue angle between 113 and 116°, and care was taken to avoid selecting individual guavas with injuries, bruises, rots and apparent softening of the tissue. Upon arrival at the laboratory fruits were stored at 7 °C until reaching a ripening stage characterised by skin hue angles between 108 e 112°. At the end of the storage period, the selected fruits had a mean weight of 185.5±37.3 g, total soluble solids content of 8.6±1.3 °Brix, and water content of 86.7±1.1% w.b. The fruits were removed from storage and subsequently washed and immersed in a 10 ppm sodium hypochlorite solution for 15 min. Distilled and deionised water was used throughout. Fruits were manually peeled and cut in halves with a stainless steel knife, the central pulp was removed with a spoon, and the remaining flesh of each fruit was cut in eight slices of similar size (Figure 1). Blanching was performed by exposing the fruit slices to steam for 1 min at atmospheric pressure, and then cooled in ice bath for 1 min. Fruit slices were subsequently immersed in a 1% ascorbic acid solution. The DIS process was performed employing two types of solute: sucrose and inverted sugar. Food grade sucrose was produced and supplied by Usina Sapucaia, and the experiment was conducted using osmotic solutions prepared with distilled water to the following concentrations: 0.5 g $m.L^{-1}$ (T1), 0.4 g mL^{-1} (T2), 0.3 g mL^{-1} (T3). To this latter treatment, 0.2 g of sucralose was added per litre of solution. Inverted sugar, with a degree of inversion higher than 90%, was provided by Dulcini S.A. Treatments with this solute comprised a 41% (w/w) solution (T4), and undiluted syrup (T5). The experiment was carried out by immersing guava slices (each slice corresponding to $1/8^{th}$ of a whole fruit, as shown in Figure 1) in the hypertonic solutions contained in 1000 mL beakers mounted on temperature- and agitation-controlled shakers (B.Braun Biotech, model Certomat U / Certomat HK). In an attempt to assure uniform temperature (50 °C) and concentration of the solution around the fruit samples, and at the same time to reduce external resistance and increase overall mass transfer rate, osmotic dehydration was conducted using a single level of agitation of the solution, 60 min^{-1}. All beakers were closed to avoid evaporative losses and spilling of water. The syrup to fruit ratio was 10:1 (w/w). The samples were osmo-dehydrated for a period of 2 h; preliminary tests have shown that this period was enough to reach equilibrium conditions concerning water loss and solids gain. Besides, osmotic treatments with immersion periods larger then 2 h resulted in tissue collapse making it difficult to handle the guava slices. At the end of the immersion period in the hypertonic solutions, the fruit slices were quickly rinsed with distilled water to partially remove adhering solutes and excess solution and then were gently blotted dry with tissue paper.

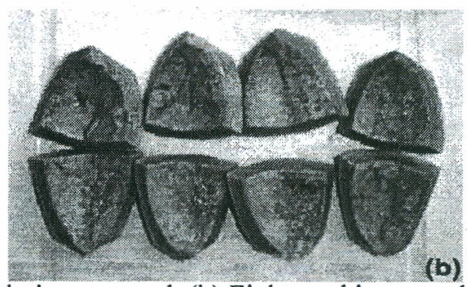

FIGURE 1. (a) Longitudinal cut of a fresh guava with tips removed; (b) Eight working samples obtained from a single fresh guava.

The zinc content of the guava slices was determined by atomic absorption spectrophotometry (AAS) after the samples were dry mineralised for 4 h, at 450°C. The obtained ash was dissolved in a 50% HCl solution, which was subsequently placed in a sand bath at 180 °C until complete evaporation of the acid. This latter operation was repeated, and after the crucible was cooled the residue was dissolved in deionised water to 20 mL. A calibration curve prepared with zinc standard solutions was used to determine zinc concentration in guava slices, which was determined directly from mineralisate on a Zeiss AA-S4 spectrophotometer (AOAC, 1990). Zinc content was expressed as mg.100 g^{1} on a dry basis. The content was determined for fresh guavas slices, guava slices after immersion in citric acid, and for osmo-dehydrated slices.

The experiment was set up according to a randomised complete-block design with factorial treatments (dehydration and process steps) in four replications. Data were analysed by ANOVA and differences between mean values of zinc content in each treatment were assessed by Tukey's test ($P < 0.05$). Group treatments were also compared through orthogonal contrasts which allows multiple pairwise or more complex comparisons among groups. Significance of the contrasts was evaluated by the F test ($P < 0.05$). The group of treatments contrasted were: sucrose *vs* inverted sugar (C1), 41% (w/w) inverted sugar solution *vs* undiluted inverted sugar (C2), sucrose 0.5 g mL^{-1} *vs* sucrose 0.4 g mL^{-1} (C3), sucrose 0.5 g mL^{-1} *vs* sucrose 0.3 g mL^{-1} + sucralose 0.2 g L^{-1} (C4).

RESULTS AND DISCUSSION: Table 1 shows the mean zinc content (mg.100 g^{1} d.b.) of slices of fresh guavas (FG), guava slices after immersion in citric acid (ICA), and for osmo-dehydrated slices (DIS) for all the treatments studied. A significant reduction of zinc content was observed in all treatments (but 0.5 g mL^{-1} sucrose solution) when values obtained for fresh fruit were compared with those obtained after the DIS process.

TABLE 1. Zinc content (mg.100 g^{1} d.b.) in samples of fresh guavas (FG), guava samples after immersion in citric acid (ICA), and in osmo-dehydrated samples (DIS) for all the treatments studied.

Process step	Treatment				
	Sucrose 0.5 g mL^{-1}	Sucrose 0.4 g mL^{-1}	Sucrose 0.3 g mL^{-1} + sucralose 0.2 g L^{-1}	Inverted sugar 41% (w/w)	Undiluted inverted sugar
FG	0.87 ^{aB}	1.23 ^{aAB}	1.31 ^{aAB}	1.35 ^{aA}	1.16 ^{aAB}
ICA	0.76 ^{aA}	0.99 ^{aA}	1.04 ^{abA}	1.04 ^{aA}	0.94 ^{aA}
DIS	0,56 ^{aA}	0.51 ^{bA}	0.7 ^{bA}	0.56 ^{bA}	0.53 ^{bA}

Means in the same column followed by the same lower-case letter, and in the same line followed by the same capital letter, are not significantly different according to the Tukey test ($P < 0.05$).

In order to compensate for the differences in initial moisture content and moisture content after immersion in ascorbic acid solution, the results were normalised making it possible to compare zinc losses among treatments on a percentage basis. Figure 2 shows the percentage reduction in zinc content for all treatments studied. Leaching of zinc from fruit tissues to the osmotic solutions during the DIS process was more pronounced (47%) in the following treatments: sucrose 0.4 g mL^{-1} (T2), 41% (w/w) inverted sugar solution (T4) and undiluted inverted sugar syrup (T5). The lowest zinc loss (26%) was recorded during dehydration in 0.5 g mL^{-1} sucrose solution. Table 2 shows the orthogonal contrasts under consideration and their estimates.

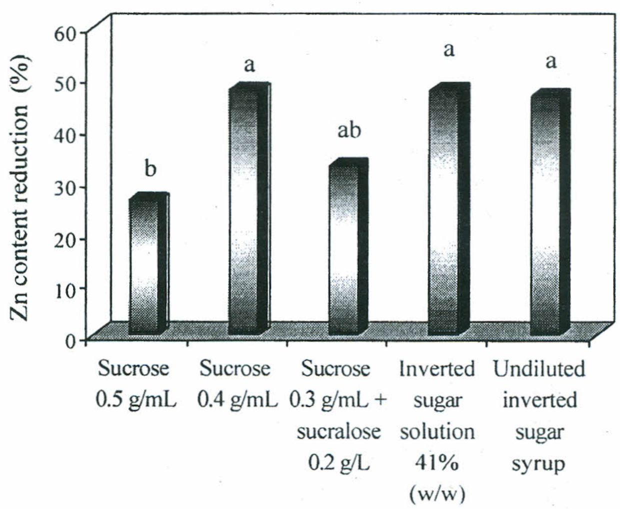

FIGURE 2. Zinc percentage reduction during the osmotic dehydration of guava slices. Means followed by the same letter are not significantly different according to the Tukey test ($P < 0.05$).

TABLE 2. Contrast comparison for the following treatments: sucrose 0.5 g mL^{-1} (m_1), sucrose 0.4 g mL^{-1} (m_2), sucrose 0.3 g mL^{-1} + sucralose 0.2 g L^{-1} (m_3), 41% (w/w) inverted sugar solution (m_4), and undiluted inverted sugar syrup (m_5). Contrasts were calculated with mean values of zinc percentage loss (m) during DIS.

Group contrast	C1	C2	C3	C4
	$y = 2(m_1+m_2+m_3) - 3(m_4+m_5)$	$y = m_5 - m_4$	$y = m_1 - m_2$	$y = m_1 - m_3$
Contrast estimates	-67,49*	$-1{,}21^{ns}$	-21,32*	$-6{,}72^{ns}$

^{ns} = not statistically significant at the 5% level, * = statistically significant at the 5% level.

Contrast C1 shows that inverted sugar is responsible for a lesser degree of zinc retention in fruit tissue than sucrose. This same behaviour was noticed by QUEIROZ (2006) for magnesium and potassium, using the same experimental conditions. One can infer that the higher the concentration of the solution, the higher the degree of water loss and mass reduction during osmotic dehydration of the fruit. This may have lead to a higher zinc loss (which is a water soluble mineral) to the hypertonic solution. Nonetheless, according to contrast C4, treatment T2 (sucrose 0.4 g mL^{-1}) prompted a higher loss of zinc than T1 (sucrose 0.5 g mL^{-1}).

PEIRÓ et al. (2006) observed losses of Na, K, Ca and Mg between 23 to 51%, 48 to 68%, 23 to 68% and 19 to 35%, respectively, after osmotic dehydration of grapefruit. They also analysed the content of these minerals in the osmotic medium, and proved that there was a flow of nutrients from the fruit tissues to the solution. RODRIGUEZ (1993) and BOGNAR (1998), quoted by KREŠIC et al. (2004), also described losses of minerals from 25 to 50% in candied celeriac. However, the zinc content was not evaluated by these authors nor was found in the literature any data concerning the reduction of this mineral in the osmotic dehydration of fruit.

CONCLUSIONS: Inverted sugar was responsible for a lesser degree of zinc retention in fruit tissue than sucrose Reductions from 26 to 47% in zinc content were observed during the osmotic dehydration of guava slices in sucrose and inverted sugar solutions.

ACKNOWLEDGEMENTS: Authors are indebted to the International Foundation for Science – IFS; Minas Gerais state Research Foundation – FAPEMIG; Rio de Janeiro state Research Foundation – FAPERJ, Brazilian Council for Scientific and Technological Development – CNPq, and Brazilian Research and Projects Financing – FINEP.

REFERENCES:

AOAC. Association of Official Analytical Chemists. **Official Methods of Analysis**. 15th Edition. Arlington: AOAC, 1990, 1298p.

BOGNAR, A. Comparative study of frying to other cooking techniques influence on the nutritive value. **Grasas y aceites**, 49(3-4):250-260, 1998.

KREŠIC, G.; LELAS, V.; ŠIMUNDIC, B. Effects of processing on nutritional composition and quality evaluation of candied celeriac. **Sadhana**, 29(1):1-12, 2004.

MAFRA, D.; COZZOLINO, S.M.F. Importância do zinco na nutrição humana. **Revista de Nutrição,** 17(1):79-87, 2004.

PEIRÓ, R.; DIAS, V.M.C.; CAMACHO, M.M.; MARTÍNEZ-NAVARRETE, N. Micronutrient flow to the osmotic solution during grapefruit osmotic dehydration. **Journal of Food Engineering**, 74(3): 299-307, 2006.

PEIRÓ-MENA, R.; CAMACHO, M.M.; MARTÍNEZ-NAVARRETE, N. Compositional and physicochemical changes associated to successive osmodehydration cycles of pineapple (*Ananas comosus*). **Journal of Food Engineering**, 79(3):842-849, 2007.

QUEIROZ, V.A.V. Nutritional quality of guava (*Psidium guajava* L.) as affected by the dewatering and impregnation soaking process followed by convective drying. Ph.D. thesis. Agricultural Engineering Laboratory. Northern Rio de Janeiro State University. 2006.

RODRIGUEZ, T. Mineral losses in hot water blanched and microwave blanched green dry white beans. **Journal of Agriculture of the University of Puerto Rico**, 77:129-135, 1993.
TORREGGIANI, D. Osmotic dehydration in fruit and vegetable processing. **Food Research International**, 26: 59-68, 1993.