Acta Scientiarum

http://www.uem.br/acta
ISSN printed: 1806-2563
ISSN on-line: 1807-8664
Doi: 10.4025/actascitechnol.v36i4.19798

Physicochemical characteristics of guava "Paluma" submitted to osmotic dehydration

Roselene Ferreira Oliveira[1*], Lia Mara Moterle dos Santos[2] and Edmar Clemente[3]

*[1]Programa de Pós-graduação em Agronomia, Universidade Estadual de Maringá, Rua São João, 8, 87030-200, Maringá, Paraná, Brazil. [2]Departamento de Agronomia, Faculdade Integrado, Campo Mourão, Paraná, Brazil. [3]Departamento de Química, Universidade Estadual de Maringá, Maringá, Paraná, Brazil. *Author for correspondence. E-mail: oliveiraroselene@hotmail.com*

ABSTRACT. The aim of this work was to evaluate the conservation post process osmotic of guava stored temperature at 5ºC. Guava (Psidium guajava L.), red variety "Paluma" minimally processed by mild osmotic dehydration, were packaged in polyethylene terephthalate (PET) and stored temperature at 5ºC. Non-treated guava, packed in PET trays, was used as control. The treatment used was osmotic dehydration in sucrose syrup at 60ºBrix and physicochemical determinations were pH, total soluble solids (TSS), total titratable acidity (TTA), reducing sugars (RS), total sugars (TS) and parameters related to colour read (a★), chroma (c★), yellow (b★), luminosity (L★) of the fresh and osmotically dehydrated guava slices. The dehydrated fruits lost about 34.45% of water, concentrating contents of soluble solids, total and reducing sugars, when compared to control samples. The pH value remained around 3.76 for the OD fruits and 3.87 for the fresh fruits. The colour of the dehydrated fruits was more intense than the control samples'. The guava slices osmotic dehydration had 21 days of shelf life, showed physicochemical characteristics significantly superior to the control samples', having a stable and high quality product as a result.

Keywords: conservation, osmotic treatment, physicochemical parameters.

Caracteristicas fisico-quimicas de goiaba "Paluma" submetida à desidratação osmótica

RESUMO. O objetivo deste trabalho foi avaliar a conservação pós-processamento osmótico da goiaba "Paluma" armazenada à temperatura de 5ºC. Goiaba (*Psidium guajava L.*), variedade vermelha "Paluma" minimamente processada submetida à desidratação osmótica branda, foi acondicionada em embalagens de polietileno tereftalato (PET) e armazenada em temperatura de 5ºC. Foi utilizada goiaba não tratada acondicionada em bandejas PET, como controle. O tratamento usado foi a desidratação osmótica em xarope de sacarose a 60ºBrix e as determinações físico-químicas foram pH, sólidos solúveis totais (SST), acidez total titulável (ATT), açúcares redutores (AR), açúcares totais (AT) e parâmetros relacionados com a cor vermelho (a★), croma (c★), amarelo (b★) e luminosidade (L★) das frutas frescas e osmoticamente desidratadas. Os frutos desidratados perderam 34,45% de água, concentrando o conteúdo de sólidos solúveis, açúcares totais e redutores, em relação às amostras controle. O pH permaneceu em torno de 3,76 para os frutos osmoticamente desidratados e 3,87 para os frutos frescos. A cor dos frutos desidratados foi mais intensa que as amostras controle. As fatias de goiabas osmoticamente desidratadas tiveram uma vida de prateleira de 21 dias, apresentando características físico-químicas superiores às amostras controle, as quais foram armazenadas nas mesmas condições e tiveram uma vida de prateleira de 21 dias. Isto proporcionou um produto estável e de elevada qualidade.

Palavras-chave: conservação, tratamento osmótico, parâmetros físico-químicos.

Introduction

Among all Brazilian tropical fruit, guava production places Brazil as the largest producer in the world, especially of red guavas, with an export rate around 223.593 kg of guava for the market of fresh fruit (AGRINUAL 2008; FRANCISCO et al., 2010).

In Brazil, the minimal processing of fruit and vegetable is presented as a growing and strengthening market niche to determine the consumer's specific profile. It also provides a product with higher added value, when compared to other fresh fruit and vegetable, and lower after-harvest loss rate (EMATER, 2007).

Guava *(Psidium guajava* L.) is a highly perishable fruit with intense metabolic activity after harvest, and so, new preservation methods are needed. However, like any fresh product, the presence of enzymes, microorganisms, and other agents make the "Paluma" guava consumption restricted to a short period of time and susceptible to degradation. Thus, dehydration, or drying, is an alternative for its preservation.

Osmotic dehydration process (OD) has been considered an important tool for preservation of tropical fruit and development of new fruit products. The OD process has been used as a pretreatment to the traditional processes of drying and freezing (FALADE et al., 2007; LOMBARD et al., 2008) and also to produce minimally processed products (CASTELLO et al., 2009; TORRES et al., 2008).

Osmotic dehydration occurs because complex structures of cell walls act as a semi-permeable membrane, which is not completely selective, resulting in two mass transference flows in counter-current: water diffusion from food to solution and solute diffusion from solution to food (PANADÉS et al., 2008), water loss and solid gain are mainly controlled by the raw material characteristics.

This technique is also interesting because aims to increase the availability of the product for consumption, adding value and increasing its lifetime. It provides partial water removal from a food product, with low energy consumption and mild heat treatment.

Besides those requirements, the temperature and time of storage in which the product is conditioned can also influence its shelf life, for example, alterations in the physicochemical quality the product, alterations sensory characteristics, cost, and availability needs, among others.

Most studies on osmotic dehydration of fruit have been related only to kinetics and the effect of dehydration on physical, chemical and nutritional properties during dehydration process (MANGARAJ et al., 2009; PANADÉS et al., 2008; PINO et al., 2008).

Thus this study aimed to evaluate the period of maximum preservation of the physicochemical quality of red guavas (cultivar 'Paluma'), subjected to minimal processing, osmotic dehydration in sucrose at 60 °Brix, storage at 5°C refrigeration and packed in PET trays.

Material and methods

Fresh mature red guavas (*Psidium guajava* L.) cultivar 'Paluma', from commercial orchards in the municipality of Mandaguaçú, Paraná State, Brazil, were manually harvested early in the morning for use in this study. They were packed in polyethylene boxes and transported to the Laboratory of Food Biochemistry, at Universidade Estadual de Maringá - UEM. Fruit were selected according to their commercial ripening stage - defined by the yellow peel, color angle (°h) between 109 and 114, size uniformity and absence of injury.

Fruit were washed in running water, immersed in a solution of sodium hypochlorite at 1% for three minutes, for disinfection. Peeling was carried out by leaching (immersion of fruit in a solution of sodium hydroxide (NaOH) at 1% (p v^{-1}) and temperature at 85°C 2 $minutes^{-1}$). After leaching, they were washed in running water and neutralized with citric acid at 1%. Peeled fruit were transversally cut, removed the seeds, and underwent a whitening process (immersion of the fruits in water at 100°C 3 $minutes^{-1}$, followed by an ice bath/3 minutes), in order to inactivate enzymes and maintain the color and flavor of fruit.

The minimally processed guavas were divided into two portions of 100 fruit in each pack. In each package were placed three slices of fresh fruit (Portion 1), stored in polyethylene terephthalate (PET) packages and named 'control'; the other fruit (Portion 2) were conditioned in flasks of 3 L containing a dehydrating solution of commercial sucrose (prepared at 60 °Brix, therefore tested the dehydration of guavas in syrup, sucrose concentration of 50, 55, 60, and 65 °Brix. The concentration of 60 °Brix favored the rate of water loss during the process due to an increase in the osmotic pressure outside the fruit increasing the amount of moisture extracted. But in the 65 °Brix supersaturated solution the osmotic process was hampered. 300 ppm of ascorbic acid as preservative and citric acid to obtain pH 3 were added to the sucrose solution. The solution was previously heated at 40°C, in the proportion fruit:syrup 1:4 and taken to a thermostatic bath (Tecnal, TE-420), for 2 hours, in order to carry out the dehydration process. After the dehydration, guava slices were washed in a sanitizing solution at 0.20% (p v^{-1}) and placed upon absorbing paper to remove the excess of solution (QUEIROZ et al., 2010). Afterwards, the osmotically dehydrated fruit were conditioned, three slices in each PET.

Portions 1 and 2 were stored at 5°C and analyzed as to their physicochemical quality during 21 days of storage.

To develop laboratorial analyses, fruit mass was measured and next, they were homogenized in a blender in order to determine pH and Total Soluble Solids (TSS - expressed in °Brix) – according to AOAC (1995), Total Titratable Acidity (TTA - expressed in g of citric acid 100 g^{-1}), Reducing Sugars and Total Sugars (RS and TS - expressed in percentage%) - according to IAL (2005).

The parameters related to color a*, c*, b*, L* were determined by using a Minolta colorimeter (CR 300, Japan), with the Cielab scale (L*, a*, b*) at five distinct points of the samples of fresh and OD guavas, during the storage period.

The experiment was conducted in a completely randomized design, with four repetitions, and the physicochemical analyses were carried out in triplicates every three days, corresponding to days 0, 3, 6, 9, 12, 15, 18, 21, and 24 (9 days of analysis). The analyzed parameters were calculated and regression analyses were conducted to establish the relationship between the independent (pH, TTA, TSS, moisture, RA, AS and color a*, c*, b*, L*) and dependent variables (storage days), using the statistical software SISVAR 5.3 (FERREIRA, 2007).

Results and discussion

The results of the physicochemical analyses carried out during the storage period of fresh (control treatment) and osmotically dehydrated (OD treatment) guava slices are listed in Table 1 and Figures 1 to 5.

Table 1. Regression analysis with the mean values for variables pH, Total Titratable Acidity (TTA), Total Soluble Solids (TSS), Reducing Sugars (RA), Total Sugars (SA), Moisture and Color a*, c*, b*, L* of the slices of guava 'Paluma' from control and osmotically dehydrated treatments.

Regression Analysis			
Variables	Fresh	Variables	Osmotically Dehydrated
pH	$\hat{Y} = \bar{Y} = 3.87$	pH	$\hat{Y} = \bar{Y} = 3.76$
TTA	$\hat{Y} = \bar{Y} = 0.74$	TSS	$\hat{Y} = \bar{Y} = 13.73$
TSS	$\hat{Y} = \bar{Y} = 8.11$	Moisture	$\hat{Y} = \bar{Y} = 57.10$
Moisture	$\hat{Y} = \bar{Y} = 87.12$	RA	$\hat{Y} = \bar{Y} = 4.87$
RA	$\hat{Y} = \bar{Y} = 2.57$	SA	$\hat{Y} = \bar{Y} = 15.82$
SA	$\hat{Y} = \bar{Y} = 9.02$	Color b*	$\hat{Y} = \bar{Y} = 17.51$
Color a*	$\hat{Y} = \bar{Y} = 19.28$	Color L*	$\hat{Y} = \bar{Y} = 38.01$
Color c*	$\hat{Y} = \bar{Y} = 19.48$	pH	$\hat{Y} = \bar{Y} = 3.76$

For the variable pH, there was no significant difference as to the storage period, both for control treatment and osmotically dehydrated treatment (Table 1).

Mean pH values of guava slices from the control and osmotically dehydrated treatments were 3.87 and 3.76, respectively. The pH results obtained in this study are close to those reported by Guimarães and Silva (2008) studying osmotically dehydrated nuances. This oscillation in pH represents the increase or decrease of free hydrogen ions (H^+) in processed fruit, which can be confirmed through analysis of total titratable acidity (QUEIROZ et al., 2010).

The results obtained for TTA content in osmotically dehydrated guava slices is illustrated in Figure 1.

Total titratable acidity showed a cubic behavior in relation to the storage days. Initially, there was a reduction in citric acid content until the sixth day and, after, the concentration of citric acid increased up to the 18th day, when it reached 0.76% of citric acid. The samples of the control treatment (Table 1) showed 0.74% of citric acid during the storage period, which was similar to the concentration of total titratable acidity in the osmotically dehydrated guava slices, after the 18th storage day.

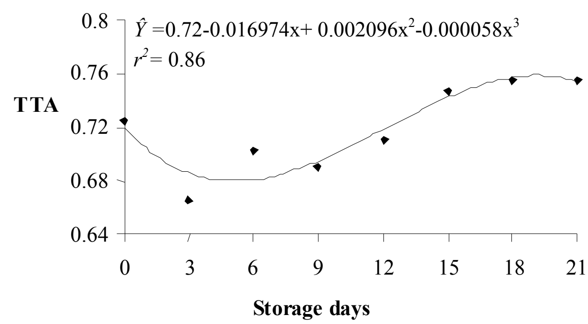

Figure 1. Total titratable acidity (% citric acid) of osmotically dehydrated guava fruits, according to the storage period.

The mean value for total soluble solids (TSS) (Table 1) of guava slices from control and OD treatments was 8.11 and 13.73 °Brix, respectively. As there were no significant differences related to the storage time, it was not possible to make a regression fit in both treatments. The highest value observed for OD treatment, that is, 13.73 °Brix, indicates that there was an addition of intracellular sucrose, resulting in increased soluble solids content. The effect of soluble solids content was also observed by CAMPOS et al. (2012), during the osmotic dehydration of star fruit slices.

Thus the lowest moisture value observed in OD fruit is a consequence of the dehydration treatment itself. These results are close to those obtained by Campos et al. (2012), who reported the addition of soluble solids to the reduction in the concentration of free water inside the fruit, due to the osmotic processing. Similar results were also verified in osmotic dehydration of melon with a sucrose and maltose solution, where there was loss of moisture around 30% (FERRARI et al., 2005).

The results related to reducing sugars and total sugars content, according to the regression analyses shown in Table 1, were 2.57 and 9.02% for the guava slices from the control treatment and 4.87 and 15.07% for the samples of the OD treatment. These results show that the highest percentages of sugars are observed in dehydration treatments. However, there was no significant variation in both treatments due to storage for these parameters. These results differ from those obtained by Pereira et al. (2006), who studied osmotically dehydrated fruit and reported a positive correlation between sugar contents and storage time.

Besides these parameters, the color change of guava slices must be pointed out in the preservation process, because this is the most important process that occurs during the fruit maturation and that suffers external influence during the storage period. The red color of guava represented by the color parameter a* has been positively influenced by the osmotic treatment and by the storage. For each variation unity in the storage days, that is, for each day added to the period of preservation, there is an increase of 0.109325 (angular coefficient) in color a* for the OD treatment (Figure 2).

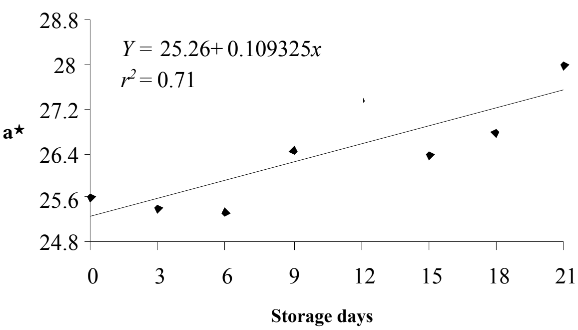

Figure 2. Parameter a*, representative of red color of guava (cultivar 'Paluma') slices from the OD treatment, according to the storage days.

Through Figure 2, it is possible to observe that the raising values obtained for parameter a* during storage justifies the evident red shade of the guava slices during this period. The intense red color of guava is related to an increase in sugars and a reduction in moisture in the samples, making the fruit more attractive to the consumer.

The color characteristics of the guava (cultivar 'Paluma') slices (Figure 3), from the control treatment demonstrate that, initially, the yellow pigment was lower and, at the end of the storage time, there was an increase of yellowish pigments. This characteristic is used as an indicator of degradation in guava slices.

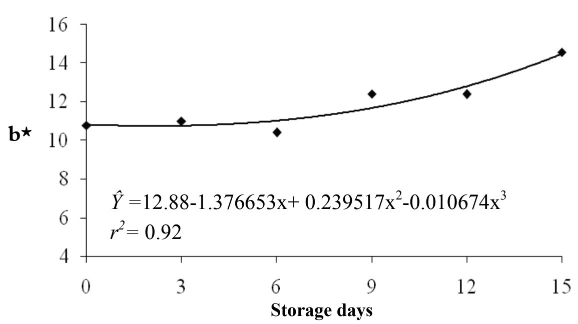

Figure 3. Parameter b*, representative of the yellow color of guava slices from the control treatment, according to the storage days.

Figure 4 depicts the behavior of variable L*, according to the storage time, which refers to luminosity in the samples from the control treatment.

The parameter L* ranges from 0 (totally dark) to 100 (clear). After observing Figure 4, it is made evident that the value of L* reached around 35 at the ninth day, revealing a tendency of the guava samples towards darkening (increase of L*) around this period.

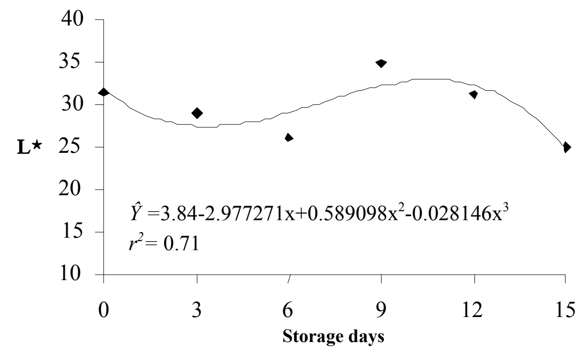

Figure 4. Parameter L*, representative of luminosity in guava slices (cultivar 'Paluma') from the control treatment, according to the storage time.

Chroma values reached an average of 19.48 for fruit of the control treatment, and showed no significant differences until the end of the storage time. On the other hand, the fruit of the OD treatment showed a cubic behavior for the variable Chroma according to the storage period (Figure 5).

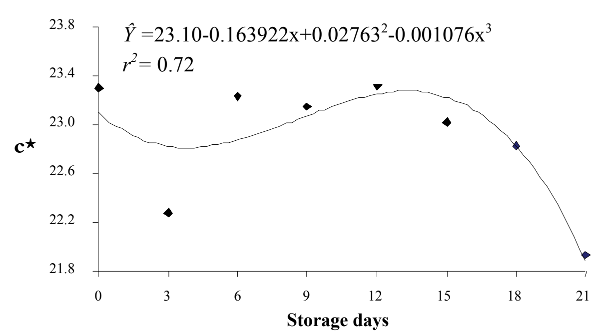

Figure 5. Parameter c*, representative of Chroma of guava slices (cultivar 'Paluma') of the OD treatment, according to the storage days.

It was possible to verify that the Chroma of OD fruit (Figure 5) has been positively affected by osmotic dehydration, reaching a maximum value around 23, between the 12 and the 15th day of storage, proving, therefore, the red color tendency towards darkening, due to osmotic treatment. These results are similar to those reported by Pereira et al. (2006), who evaluated the color of papaya dehydrated in sucrose solutions, and they are also similar to those obtained by Ito et al. (2007), who studied the effect of osmotic dehydration upon mango color parameters.

The process of osmotic dehydration utilized to preserve minimally processed guavas, associated to package and refrigeration, suggests effectiveness, since it slows the process of senescence and inhibits the respiratory metabolism of the product, thus providing maintenance of the physicochemical quality and increasing shelf life of the product.

Conclusion

Apart from color parameters b* and L*, the physicochemical characteristics of fresh guava slices remained unaltered until the 15th day of storage. The guava slices osmotically dehydrated had a period of maximum preservation at the of 21 days under refrigeration.

It is reasonable to suggest the process of osmotic dehydration as a profitable alternative, being considered an improvement in the definition of fruit preservation, with effective low cost standardization and better conservation of raw-material, such as the guava available in the region, aiming to industrial production and research.

References

AOAC-Association of Official Analytical Chemists. **Official Methods of Analysis of the Association of Official Analytical Chemists**. Arlington: AOAC, 1995. AGRINUAL. **Anuário Estatístico de Agricultura Brasileira**. 1. ed. São Paulo: FNP Consultoria e Comércio, 2008.

CASTELLO, M. L.; IGUAL, M.; FITO, P. J.; CHIRALT, A. Influence of osmotic dehydration on texture, respiration and microbial stability of apple slices (Var. Granny Smith). **Journal of Food Engineering**, v. 91, n. 1, p. 1-9, 2009.

CAMPOS, C. D. M.; SATO, A. C. K.; TONON, R. V.; HUBINGER, M. D.; CUNHA, R. L. Effect of process variables on the osmotic dehydration of star-fruit slices. **Ciência e Tecnolologia de Alimentos**, v. 32, n. 2, p. 357-365, 2012.

EMATER-Empresa de Assistência Técnica e Extensão Rural. **Pesquisa de mercado**: hortaliças minimamente processadas. Agroinforme. Distrito Federal, 2007. Available from: <http://www.emater.df.gov.br/sites/200/229/00001397.pdf> Access on: Nov. 22, 2011.

FALADE, K. O.; IGBEKA, J. C.; AYANWUYI, F. A. Kinetics of mass transfer and colour changes during osmotic dehydration of watermelon. **Journal of Food Engineering**, v. 80, n. 3, p. 979-985, 2007.

FERRARI, C. C.; RODRIGUES, L. K.; TONON, R. V.; HUBINGER, M. D. Cinética de transferência de massa de melão desidratado osmoticamente em soluções de sacarose e maltose. **Ciências e Tecnologia de Alimentos**, v. 25 n. 3 p. 564-570, 2005.

FERREIRA, D. F. **Sisvar**: Sistema de análise de variância para dados balanceados, versão 5.3. Lavras: DEX/UFLA, 2007. (CD-ROM).

FRANCISCO, V. L. F. S.; FAGUNDES, P. R. S.; BAPTISTELLA, C. S. L.; AMAROS, A. A. Cultura de goiaba no estado de São Paulo. Projeto Lupa. **Informações Econômicas**, v. 40, n. 9, p. 68-76, 2010.

GUIMARÃES, M. G.; SILVA, M. S. Valor nutricional e características químicas e físicas de frutos de murici-passa (Byrsonima verbascifolia). **Ciência e Tecnologia de Alimentos**, v. 28, n. 4, p. 817-821, 2008.

IAL-Instituto Adolfo Lutz. **Métodos físico-químicos para análise de alimentos**. Brasília: Editora MS, 2005.

ITO, A. P.; CAVENAGHI, M.; BERTOLDO, C.; PARK, K. J.; HUBINGER, M. D. Efeito do processo de desidratação osmótica a pulso de vácuo na transferência de massa e nas propriedades reológicas e de cor de fatias de manga. **Ciência e Tecnologia Alimentos**, v. 27, suppl. 1, 54-63, 2007.

LOMBARD, G. E.; OLIVEIRA, J. C.; FITO, P.; ANDRES, A. Osmotic dehydration of pineapple as a pre-treatment for further drying. **Journal of Food Engineering**, v. 85, n. 2, p. 277-284, 2008.

MANGARAJ, S.; GOSWAMI, T. K.; MAHAJAN, P. V. Applications of plastic films for modified atmosphere packaging of fruits and vegetables: A review. **Food Engineering Reviews**, v. 1, n. 2, p. 133-158, 2009.

PANADÉS, G.; CASTRO, D.; CHIRALT, A.; FITO, P.; NUÑEZ, M.; JIMENEZ, R. Mass transfer mechanisms occurring in osmotic dehydration of guava. **Journal of Food Engineering**, v. 87 n. 3 p. 386-390, 2008.

PEREIRA, M. E. C.; SILVA, A. S.; BISPO, A. S. R.; SANTOS, D. B.; SANTOS, S. B.; SANTOS, V. J. Amadurecimento de mamão ‘Formosa’ com revestimento comestível à base de fécula de mandioca. **Ciência e Agrotecnologia**, v. 30, n. 6, p. 1116-1119, 2006.

PINO, J. A.; PANADÉS, G.; FITO, P.; CHIRALT, A.; ORTEGA, A. Influence of osmotic dehydration on the volatile profile of guava fruits. **Journal of Food Quality**, v. 31, n. 3, p. 281-294, 2008.

QUEIROZ, V. A. V.; BERBET, P. A.; MOLINA, M. A. B.; GRAVINA, G. A.; QUEIROZ, L. R. Mecanismos de transferência de massa na desidratação osmótica de goiaba em soluções de sacarose, sucralose e açúcar invertido. **Engenharia Agrícola**, v. 30, n. 4, p. 715-725, 2010.

TORRES, J. D.; CASTELLO, M. L.; ESCRICHE, I.; CHIRALT, A. Quality characteristics, respiration rates, and microbial stability of osmotically treated mango tissue (Mangifera indica L.) with or without calcium lactate. **Food Science and Technology International**, v. 14, n. 4, p. 355-365, 2008.

Received on February 12, 2013.
Accepted on August 20, 2013.