Acta Scientiarum

http://www.uem.br/acta
ISSN printed: 1806-2563
ISSN on-line: 1807-8664
Doi: 10.4025/actascitechnol.v35i1.10551

Physicochemical quality of eggplant dehydrated with varied pretreatments

Rafael Chaves Osidacz and Miriam Carla Bonicontro Ambrosio-Ugri*

*Departamento de Engenharia de Alimentos, Universidade Estadual de Maringá, Av. Colombo, 5790, 87020-900, Maringá, Paraná, Brazil. *Author for correspondence. E-mail: miriamugri@uol.com.br*

ABSTRACT. Among the main advantages of dehydrated fruit and vegetables are the great reduction of weight and volume, the ease of transport and storage, not requiring refrigeration, and a longer shelf-life compared with fresh products. This study analyzed the effect of bleaching and osmotic dehydration on the drying of eggplant slices, considering the quality parameters pH, titratable acidity, soluble solids, and shrinkage by image analysis. The pretreatments consisted of: (I) osmotic dehydration in 10% NaCl aqueous solution for 20 minutes at 35ºC; (II) bleaching of eggplant slices for 5 minutes followed by osmotic dehydration above cited. The pretreated eggplants were subjected to drying (70ºC), along with fresh eggplants, for further comparison. The results showed that the pretreated eggplants (bleached and osmotically dehydrated or osmotically dehydrated) have dried more rapidly than the control sample.

Keywords: *Solanum melongena* L., bleaching, osmotic dehydration, drying.

Análise da qualidade físico-química de berinjela desidratada com variações no pré-tratamento

RESUMO. Entre as principais vantagens de frutas e hortaliças desidratadas estão: a imensa redução de massa e volume dos mesmos, a facilidade de transporte e armazenamento, pois não necessitam ser refrigerados, e grande aumento da vida de prateleira (*shelf-life*) em comparação ao produto “in natura”. Neste trabalho foi estudado o efeito do branqueamento e da desidratação osmótica na secagem de fatias de berinjela nos parâmetros de qualidade pH, acidez titulável, sólidos solúveis e encolhimento por análise de imagem. Os pré-tratamentos utilizados foram: (I) desidratação osmótica em solução aquosa de NaCl a 10%, por 20 min., a 35ºC; (II) branqueamento das fatias de berinjela durante 5 min. seguido de desidratação osmótica nas condições citadas. As berinjelas pré-tratadas foram submetidas à secagem (70ºC), juntamente com a berinjela “in natura”, para efeito de comparação. Os resultados obtidos demonstraram que as berinjelas pré-tratadas (branqueadas e desidratadas osmoticamente ou desidratadas osmoticamente) e, então, secas apresentaram menor tempo de secagem em relação à amostra seca sem pré-tratamento.

Palavras-chave: *Solanum melongena* L., branqueamento, desidratação osmótica, secagem.

Introduction

In Brazil, eggplants are mainly sold fresh and used after a heat treatment (cooked in water, sautéed in oil, fried, and baked). In this country, the industrialization of eggplants primarily occurs in small companies that process dry eggplant, fermented pickles, canned with other vegetables, and pates (EMBRAPA, 2007).

The eggplant fruit is a good source of vitamins and minerals and its total nutritional value is similar to that of tomato. The fresh weight of the fruit has the following composition: 96.3% water, 1.9% fiber and 19% calories. In 100 g of raw eggplant are found the following minerals: 1.1 mg copper, 100 mg sulfur, 90 mg magnesium, 3.8 mg manganese, 2.7 mg zinc, 112.7 mg potassium, 38.2 mg sodium, 17 mg calcium, 0.4 mg iron and 29 mg phosphorus. Vitamins are found in the following proportions: 5 μg vitamin A (retinol), 60 μg vitamin B1 (thiamine), 45 μg vitamin B2 (riboflavin), 0.6 μg de vitamin B3 (niacin) and 1.2 mg vitamin C (ascorbic acid) (EMBRAPA, 2007).

In the early twentieth century it was proved the effectiveness of eggplant for treating hypercholesterolemia, being an Argentine researcher, Roffo in 1943 to show for the first time the efficacy of this plant in animals and humans. Since then, the eggplant came to be indicated to treat hypercholesterolemic patients by presenting a considerable content of total dietary fiber (about 40% d.b.) (PEREZ; GERMANI, 2007).

Guimarães et al. (2000) evaluated the reduction of blood cholesterol levels after ingestion of a infusion prepared with eggplant powder. The authors observed a significant reduction in LDL cholesterol and apoliprotein B in the blood, indicating a trend of reduction in blood cholesterol.

The dehydration of fruit and vegetables has been examined for a long time, seeking drying methods that provide, besides low cost, products that keep their sensory and nutritional characteristics. Conventional drying processes usually employed can remove most of the free water of foodstuffs. However, the combination temperature/drying time should be evaluated to avoid a great darkening of the product, affecting an important sensory attribute (REIS et al., 2006).

Therefore, different drying processes combined with osmotic dehydration processes have gained great attention in recent years. Corrêa et al. (2010) evaluated the effects of pulsed vacuum osmotic dehydration (PVOD) in the drying of guava slices. Fante et al. (2011) studied the pulsed vacuum osmotic dehydration (PVOD) combined with convective drying of plum, and obtained a final product with good appearance and satisfactory shrinkage.

Osmotic dehydration is frequently used as pretreatment in the drying of foods. This because it accounts for a reduced expenditure of energy, by shortening the time of the product in the dryer, and by improving the sensory quality of the final product (AZEREDO, 2004; DIONELLO et al., 2009; SOUZA et al., 2009).

Few studies have been developed on eggplant drying. Al-Hakim, in 1974 was one of the first investigating the influence of different drying conditions on the quality of the dried eggplant. Ertekin and Yaldiz (2004) studied the eggplant drying in thin layer, and evaluated some conditions of the process and pretreatments. Doymaz and Göl (2011) evaluated the effects of air temperature and sample thickness on the drying kinetics of blanched/unblanched eggplant slices. They verified that blanched samples had shorter drying times than unblanched samples and drying air temperature and slice thickness were important factors in the drying of eggplant slices (high drying temperature and thinly sliced products resulted in a shorter drying time).

In this way, this study aimed to analyze the influence of a process combining bleaching, osmotic dehydration, and drying on the physicochemical quality of eggplant slices, regarding the following parameter: pH, titratable acidity, soluble solids, and shrinkage by image analysis.

Material and methods

The experiments were conducted at the Laboratories of Food Technology and Analysis of the Department of Food Engineering of the State University of Maringá (UEM), Maringá, Paraná State, Brazil.

Raw material

The eggplants were purchased in the local commerce of the city of Maringá (Paraná State). They were supposed to be firm, with uniform color and size.

The raw material was prepared as follow: the eggplants were washed successively in running water, immersed in an aqueous chlorine solution (0.01 mL chlorine for each 1 L water), washed again with running water and dried with paper towel. Then, the eggplants were cut into 1 cm-thick slices.

Methods

Characterizing the samples

The samples were evaluated by the following analyses: pH, total titratable acidity, moisture content and soluble solids, all performed in triplicate. The fresh product as well as the pretreated samples were analyzed based on the Analytical Standards of the Adolfo Lutz Institute (IAL, 2008).

The moisture content was determined by the mass difference, before and after oven-dried, and calculated by the equation 1.

$$X = \frac{m_i - m_f}{m_f} \text{ (dry basis)} \qquad (1)$$

where:

m_i – initial mass of the moist solid (kg);

m_f – final mass of the dry solid (kg);

X – moisture content of the solid in dry basis (kg kg^{-1}).

Pretreatments

The eggplants (*Solanum melongena* L.) were washed, cut into 10mm-thick slices (EMBRAPA, 2007) and subjected to two pretreatments, being: osmotic dehydration in dehydrating solution, and bleaching followed by osmotic dehydration. The pretreatments were performed in duplicate.

The bleaching consisted of immersing eggplant slices in water at 60°C for approximately 5 minutes (EMBRAPA, 2007). After bleaching, the slices were rapidly immersed in water at room temperature to avoid the excessive softening.

After prior studies, we determined the following conditions for osmotic dehydration: 10% NaCl aqueous solution for 20 minutes at 35°C, at a ratio fruit/brine of 1:10. The samples after being withdrawn from the dehydrating solution, were washed with distilled water, and with dry surface, were weighed and submitted to drying process.

Drying

Slices of fresh and previously treated eggplants were dried at 70°C in oven without air circulation. At each time interval, the samples were weighed and put back in the oven. This procedure lasted until constant weight. It was obtained the curves of drying kinetics and drying rate. This rate (R) was estimated by the equation 2.

$$R = -\frac{1}{A}\frac{dX}{dt} \quad (2)$$

where:

A – drying area (m^2);

R – drying rate (kg kg^{-1} m^2 min.).

Results and discussion

The Table 1 lists the results of acidity, pH, soluble solids, and moisture of slices of fresh eggplant, before and after drying, and pretreated eggplant, after drying.

Comparing the results between the samples of fresh dried and pretreated samples before drying process, it was observed similar results for pH and titratable acidity, but a slight reduction in the soluble solids and final moisture content for the sample that was fresh dried.

The Figure 1 illustrates the dried slices after the drying process.

The eggplant slices bleached before undergoing osmotic dehydration (Figure 1c) presented a greater shrinkage than fresh eggplants (Figure 1a), as well as the sample that only underwent osmotic dehydration (Figure 1b). This result is confirmed by the study of Demirel and Turhan (2003), which verified a strong relationship between fruit shrinkage and moisture removal.

The Figure 2 presents the drying kinetics curves of eggplant slices, with moisture content expressed in dry basis, obtained for the three samples.

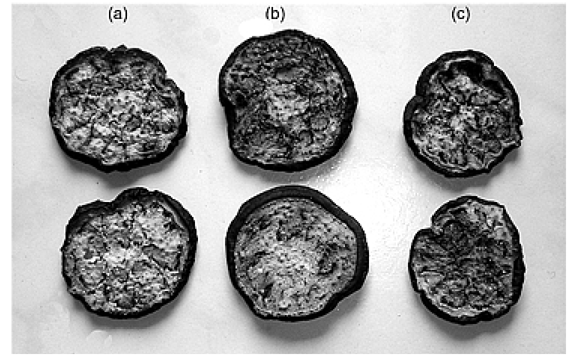

Figure 1. (a) fresh eggplant dried; (b) eggplant submitted to osmotic dehydration before drying; (c) eggplant submitted to bleaching followed by osmotic dehydration before drying

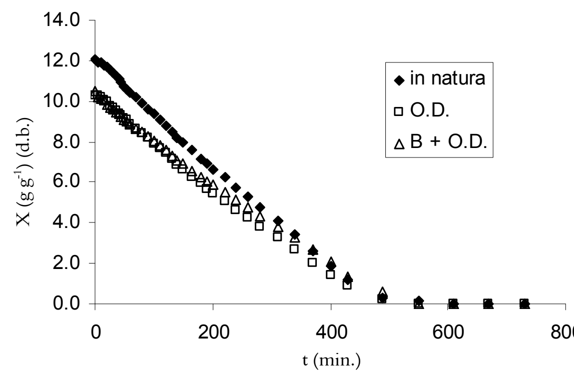

Figure 2. Kinetics of drying at 70°C for eggplant slices, considering the different processes.

According to Embrapa (2007), the final moisture content of dried eggplant should be around 5% w.b. For the experiments performed, this moisture content in wet basis refers to moisture content in dry basis equal to 0.0526 g g^{-1}.

By analyzing the Figure 2, relative to the drying curves, the value of final moisture content desired (lower than 5% w.b.) was obtained in the following times: for the fresh sample, the drying time was 600.4 min.; for the sample osmotically dehydrated the drying time was 542.6 min., and for the eggplant bleached and osmotically dehydrated, the drying time was 548.2 min. Therefore, both studied pretreatments shortened the drying time around 10% at a fixed temperature of 70°C. This result agrees with Ertekin and Yaldiz (2004).

Table 1. Physicochemical characterization in samples of fresh eggplant, after osmotic dehydration, and after bleaching plus osmotic dehydration.

Analyses	Eggplant samples			
	Fresh	Fresh dried	Osmotic dehydration and drying	Bleaching, osmotic dehydration and drying
pH	5.47	4.66	4.62	4.75
Titratable acidity (%)	1.98	2.19	2.38	2.11
Soluble solids (°Brix)	4.0	3.6	3.8	3.8
Moisture content (%)	93.72	1.47	2.18	2.25

Ertekin and Yaldiz (2004) argue the importance of pretreating the eggplant before drying, once it affects the drying time and reduces the resistance to humidity transport. These same authors observed that the drying process took 366.6 min. without pretreatment, while the drying after pretreatment resulted in a drying time of 209.40 min. for reducing the moisture content to 6%. Hence, the pretreatment may shorten the drying time about 43.24%, at a drying air temperature of 60°C, velocity of 2 m s^{-1}, and eggplant slice with 0.635 cm thick. In their study, the drying time was shorter likely due to the air circulation in the oven, besides the smaller thickness of the slices, which facilitated the drying process.

The drying rates of the three processes studied are shown in Figure 3.

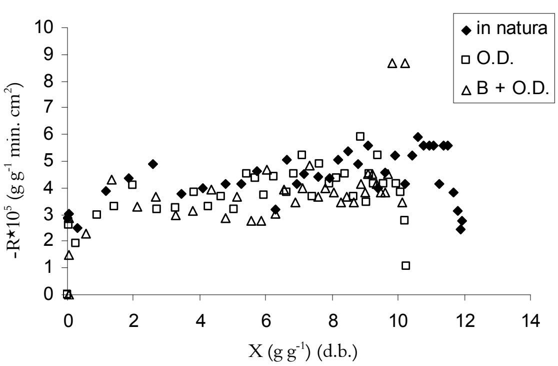

Figure 3. Drying rate of the eggplant slices, considering the different processes.

The drying rate ranged from 3 to 6 $g_{water}\ g_{dry\ solid}^{-1}$ min. cm^2, and its behavior (Figure 3), prevailing the constant drying rate, is in line with the curves presented in the Figure 2. However, the results of the present study evidenced an atypical behavior, differing from literature data (DOYMAZ; GÖL, 2011; AKPINAR; BICER, 2005; REIS et al., 2006).

Conclusion

The values of titratable acidity, soluble solids and pH had almost no changes after the drying of the pretreated eggplants, as well as the fresh fruit dried, reflecting thus the importance of drying in fruit, vegetable, and legume.

Regarding the moisture results, when pretreated, the samples presented a product with similar quality with a shorter drying time in relation to the eggplant dried without pretreatments, around 535 min. for the pretreated samples, and for the fresh sample, the drying time was of 600.4 min.

The eggplant in its dehydrated form, as well as all dehydrated foods, has a reduced cost for transport, due to the reduced mass, and possibility of transporting at room temperature, besides extending its shelf life.

References

AKPINAR, E. K.; BICER, Y. Modelling of the drying of eggplants in thin-layers. **International Journal of Food Science and Technology**, v. 40, n. 3, p. 273-281, 2005.

AZEREDO, H. M. C. **Fundamentos de estabilidade de alimentos**. Fortaleza: Embrapa Agroindústria Tropical, 2004.

CORRÊA, J. L. G.; PEREIRA, L. M.; VIEIRA, G. S.; HUBINGER, M. D. Mass transfer kinetics of pulsed vacuum osmotic dehydration of guavas. **Journal of Food Engineering**, v. 96, n. 4, p. 498-504, 2010.

DEMIREL, D.; TURHAN, M. Air-drying behavior of Dwarf Cavendish and Gros Michel banana slices. **Journal of Food Engineering**, v. 59, n. 1, p. 1-11, 2003.

DIONELLO, R. G.; BERBERT, P. A.; MOLINA, M. A. B.; PEREIRA, R. C.; VIANA, A. P.; CARLESSO, V. O. Secagem de fatias de abacaxi *in natura* e pré-desidratadas por imersão-impregnação: cinética e avaliação de modelos. **Ciência e Tecnologia de Alimentos**, v. 29, n. 1, p. 232-240, 2009.

DOYMAZ, I.; GÖL, E. Convective drying Characteristics of eggplant slices. **Journal of Food Process Engineering**, v. 34, p. 1234-1252, 2011.

EMBRAPA-Empresa Brasileira de Pesquisa Agropecuária. **Hortaliças**: sistemas de produção. 2007.

ERTEKIN, C.; YALDIZ, O. Drying of eggplant and selection of a suitable thin layer drying model. **Journal of Food Engineering**, v. 63, n. 3, p. 349-359, 2004.

FANTE, C.; CORRÊA, J. L. G.; NATIVIDADE, M.; LIMA, J.; LIMA, L. Drying of plums (Prunus sp, c.v Gulfblaze) treated with KCl in the field and subjected to pulsed vacuum osmotic dehydration. **International Journal of Food Science and Technology**, v. 46, n. 5, p. 1080-1085, 2011.

GUIMARÃES, P. R.; GALVÃO, A. M.; BATISTA, C. M.; AZEVEDO, G. S.; OLIVEIRA, R. D.; LANOUNIER, R. P.; FREIRE, N.; BARROS, A. M.; SAKURAI, E.; OLIVEIRA, J. P.; VIEIRA, E. C.; ALVAREZ-LEITE, J. I. Eggplant (*Solanum melongena*) infusion has a modest and transitory effect on hypercholesterolemic subjects. **Brazilian Journal of Medical and Biological Research**, v. 33, n. 9, p. 1027-1036, 2000.

IAL-Instituto Adolfo Lutz. **Métodos físico-químicos para análise de alimentos**. São Paulo: Instituto Adolfo Lutz, 2008.

PEREZ, P. M. P.; GERMANI, R. Elaboração de biscoitos tipo salgado, com alto teor de fibra alimentar, utilizando farinha de berinjela (*Solanum melongena* L.) **Ciência e Tecnologia de Alimentos**, v. 27, n. 1, p. 186-192, 2007.

REIS, F. R.; MASSON, M. L.; WASZCZYNSKYJ, N. Efeitos da secagem convectiva e a vácuo sobre parâmetros de qualidade de fatias de berinjela. **Revista Brasileira de Produtos Agroindustriais**, v. 8, n. 2, p. 163-169, 2006.

SOUZA, T. S.; CHAVES, M. A.; BONOMO, R. C. F.; SOARES, R. D.; PINTO, E. G.; COTA, I. R. Desidratação osmótica de frutículos de jaca (*Artocarpus integrifolia* L.): aplicação de modelos matemáticos. **Acta Scientiarum. Technology**, v. 31, n. 2, p. 225-230, 2009.

Received on June 29, 2010.
Accepted on May 2, 2012.