



## Development and characterization of cereal bars made with flour of jabuticaba peel and okara

Patrícia Appelt<sup>1</sup>, Mário Antônio Alves da Cunha<sup>2\*</sup>, Ana Paula Guerra<sup>2</sup>, Cristiane Kalinke<sup>2</sup> and Vanderlei Aparecido de Lima<sup>2</sup>

<sup>1</sup>Programa de Pós-graduação em Química, Universidade Federal do Paraná, Curitiba, Paraná, Brazil. <sup>2</sup>Departamento de Química, Universidade Tecnológica Federal do Paraná, Via do Conhecimento, Km 1, 85503-390, Pato Branco, Paraná, Brazil. \*Author for correspondence. E-mail: [mcunha@utfpr.edu.br](mailto:mcunha@utfpr.edu.br)

**ABSTRACT.** Cereal bars are foods that stand out for practicality in consumption and nutritional quality and new formulations have been developed and introduced to the market by large corporations. In the present work, flours obtained from jabuticaba peel and okara were employed as ingredients in the development of three cereal bars formulations. The products obtained were characterized for physico-chemical parameters, microbiological quality and sensory acceptance. The bars showed high protein content (8.9 to 9.2 g 100<sup>-1</sup> g) and fiber (7.25 to 9.05 g 100<sup>-1</sup> g), microbiological parameters according to Brazilian legislation and high sensory acceptance. The average scores assigned by the judges in acceptance testing by hedonic scale were higher than 7 in all attributes (color, taste, texture, flavor and overall impression). The obtained results showed that cereal bar production can be a viable alternative for the technological use of jabuticaba peel and okara. The use of these ingredients can contribute to obtaining products with high nutritional quality and to the valuation of biomasses that are often regarded as agro-industrial waste.

**Keywords:** food bar, practical food, agro-industrial byproducts, soybean.

## Desenvolvimento e caracterização de barras de cereais produzidas com farinhas de casca de jabuticaba e okara

**RESUMO.** Barras de cereais são alimentos que se destacam pela praticidade no consumo e qualidade nutricional, e novas formulações têm sido desenvolvidas e lançadas no mercado por grandes companhias. No presente trabalho, farinhas obtidas de casca de jabuticaba e de okara foram empregadas como ingredientes no desenvolvimento de três formulações de barras de cereais. Os produtos obtidos foram caracterizados quanto a parâmetros físico-químicos, qualidade microbiológica e aceitação sensorial. As barras de cereais apresentaram elevado conteúdo de proteínas (8,9 a 9,2 g 100<sup>-1</sup> g) e de fibras (7,25 a 9,05 g 100<sup>-1</sup> g), parâmetros microbiológicos de qualidade adequados à legislação brasileira e à elevada aceitação sensorial. As notas médias atribuídas pelos provadores no teste de aceitação por escala hedônica foram superiores a 7 em todos os atributos avaliados (cor, sabor, textura, aroma e impressão global). Os resultados obtidos demonstraram que a produção de barras de cereais pode ser uma alternativa viável para o aproveitamento tecnológico de cascas de jabuticaba e do okara. O uso de tais ingredientes pode contribuir para a obtenção de produto com elevada qualidade nutricional e para a valorização de biomassas, muitas vezes consideradas como resíduos agroindustriais.

**Palavras-chave:** barra alimentícia, alimento prático, subproduto agroindustrial, soja.

### Introduction

The jabuticaba tree (*Myrciaria cauliflora* Berg.) is a fruit tree that has drawn interest from growers in different parts of Brazil, due to its high yield, rusticity and different possibilities of use for its fruits (ASQUIERI et al., 2009; BRUNINI et al., 2004). Jabuticaba processing adds value to the fruit and prolongs shelf life, given that the species has a relatively short post-harvest shelf life. It is a fruit rich in bioactive compounds with antioxidant activity,

especially in the peel and seeds (LIMA et al., 2011). Byproducts such as bagasse and peel, resulting from fermented jabuticaba and juice production, are used as animal feed or in organic fertilization, although they have important nutritional properties. In addition to fair amounts of niacin and iron, jabuticaba has high levels of anthocyanins (SATO; CUNHA, 2007), mineral salts, and a substantial amount of fibers, meaning it can be used as a food ingredient, especially in the form of flour.

*Okara* is another byproduct of agri-food chains noteworthy for its nutritional characteristics and which can be turned into flour. It is a byproduct created during the process of producing aqueous extract from soybeans and tofu (O'TOOLE, 1999). This byproduct has low commercial value and is commonly used as animal feed. Nevertheless, it has excellent nutritional quality because it contains high protein, high levels of fibers, minerals and phytochemicals such as flavonoids (MATEOS-APARICIO et al., 2010; VILLANUEVA et al., 2011).

Food industries routinely develop new products as a strategy to conquer new markets; in this context, cereal bars stand out with a market that grows in volume 20% annually (FONSECA et al., 2011). The formulation of food items with nutritional properties that help maintain health can be an important industrial strategy. A food bar containing biomass from soybeans and jabuticaba peel can add different substances with relevant nutritional value, giving functional appeal to the product. In that sense, the objective of the present work was to research a new alternative for the use of jabuticaba peel (*Myrciaria jabuticaba*) and byproduct *okara* in the formulation of food bars with high nutritional quality.

## Material and methods

The soybeans used to obtain *okara* were acquired in the local retail market. The jabuticaba peels were obtained from fruits produced in southwestern Paraná state, Brazil.

### Obtaining the flours made from jabuticaba peel and *okara*

The fruits were cleansed by immersion in sodium hypochlorite solution (20 ppm, 15 min.) and the peels were separated from the pulp by crushing in a hand-operated press. The peels were dehydrated in a forced-air oven at 55°C, until reaching moisture content around 10%. Following dehydration, the peels were ground in a blender for 5 minutes to obtain the flour.

To obtain *okara* flour, a water-soluble soy extract was first produced in laboratory. The soy extract was obtained from soybean *in natura*. The process consisted of cooking, maceration, grinding and filtering, resulting in two phases: liquid phase, corresponding to the water-soluble soy extract; and solid phase, which is the fresh *okara* mass. The moist biomass was dehydrated in a forced-air oven (55°C), ground in a blender, and the obtained flour was kept in polyethylene flasks at 5°C until the cereal bars were made.

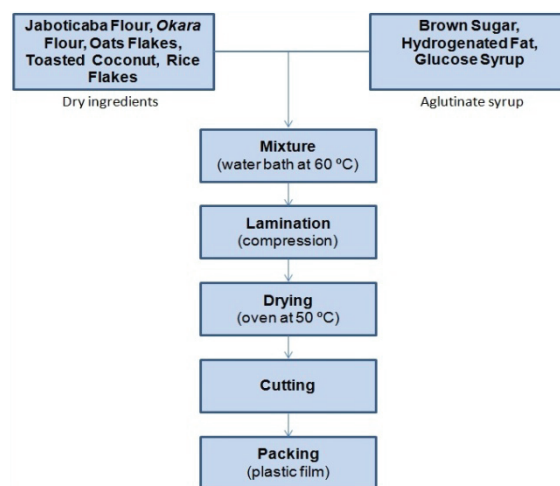
## Cereal bar formulations

Three cereal bar formulations were developed, named F1, F2 and F3, and the amounts of jabuticaba peel flour varied among the formulations, as shown in Table 1.

**Table 1.** Formulation of cereal bars.

Ingredients	Formulations		
	F1	F2	F3
<i>Okara</i> flour	20 g	20 g	20 g
Jabuticaba peel flour	5 g	10 g	15 g
Oat flakes	20 g	20 g	20 g
Brown sugar	20 g	20 g	20 g
Roasted coconut	15 g	15 g	15 g
Hydrogenated fat (80% lipids)	5 g	5 g	5 g
Glucose syrup	40 g	40 g	40 g
Rice flakes	10 g	10 g	10 g

The preparation of cereal bars followed the steps described in the flowchart below (Figure 1):



**Figure 1.** Flowchart of cereal bars production process.

### Physical-chemical characterization of jabuticaba peel, cereal bars and flours made from *okara* and jabuticaba peel

The followed parameters were assessed: moisture (dried at 105°C), lipids (Soxhlet extraction), total protein (Kjeldahl method, N x 6.25), ash and crude fiber, in accordance with the Official Methods of Analysis (AOAC, 2000).

To estimate the total energy value of each bar formula, the Atwater conversion was used – 4 kcal g<sup>-1</sup> protein, 4 kcal g<sup>-1</sup> carbohydrate and 9 kcal g<sup>-1</sup> lipid (DESSIMONI-PINTO et al., 2011).

Flour particle size was determined using a vibrating sifter and a set of screens with 14, 28, 60, 115 and 259 mesh size.

### Microbiology analysis

The microbiological quality of the produced bars was evaluated by surveying for coliforms at 45°C, *Salmonella* sp. and *Bacillus cereus*, according to the

protocols described in the Food and Water Microbiology Analysis Methods Manual (SILVA et al., 2007).

### Sensory analysis of the cereal bars

Sensory evaluation was carried out through affective acceptance testing using a nine-point structured Hedonic Scale, with acceptance scale ranging from 'I extremely disliked it' (1) to 'I extremely liked it' (9). A total of 50 tasters were recruited, aged 15 to 35 years, all of whom were potential consumers of cereal bars. The evaluated sensory attributes were: color, taste, aroma, texture and overall impression.

### Statistical analysis

The data set including the dependent variables concerning the nutritional (physical chemical) and sensory analysis was standardized to justify the parametric test. The standardized values were determined by subtracting each observation from the sample mean of each variable and dividing this difference by the sample standard deviation (GOTELLI; ELLISON, 2004). The homogeneity of variance was checked by Levene's test (GRANATO; ELLENDERSEN, 2009). Analysis of variance (ANOVA) and Tukey's test were performed on both data sets, at 5% significance. All statistical analyses were carried out in R environment (R DEVELOPMENT CORE TEAM, 2012).

## Results and discussion

### Characterization of jabuticaba peel and flours

Data on the physical-chemical characterization of the peels and flours made from jabuticaba peel and *okara* are described in Table 2.

**Table 2.** Chemical composition of jabuticaba peel *in natura* and flours made from jabuticaba peel and *okara*.

Physical-chemical parameters	Jabuticaba peel <i>in natura</i>	Jabuticaba peel flour	<i>Okara</i> flour
Moisture (%)	74.20 ± 0.43	10.20 ± 0.23	5.05 ± 0.17
Ash (%)	1.03 ± 0.07	3.10 ± 0.09	4.40 ± 0.13
Lipids (%)	0.35 ± 0.007	3.50 ± 0.07	16.3 ± 0.53
Crude protein (%)	0.95 ± 0.008	6.40 ± 0.30	34.6 ± 0.99
Crude fiber (%)	1.85 ± 0.09	2.84 ± 0.08	30.7 ± 0.97

Jabuticaba peel *in natura* showed high levels of moisture ( $74.2 \pm 0.43\%$ ), which was quite similar to those reported by Lima et al. (2008) in *Myrciaria cauliflora* Berg variety Paulista ( $75.85\%$ ). Dessimoni-Pinto et al. (2011) observed values of  $75.80 \pm 0.37\%$  in jabuticaba peel from the city of Diamantina in the Jequitinhonha Valley. The total protein content found in the peels used in the present work ( $0.95$

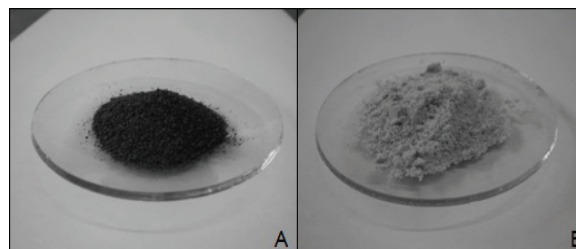
$\pm 0.008\%$ ) was similar to that described ( $1.10\%$ ) by Lima et al. (2008) and slightly lower to the values ( $1.38 \pm 0.13$ ) reported by Dessimoni-Pinto et al. (2011).

With regard to ash and lipids, Lima et al. (2008) reported slightly higher content in both varieties. In variety Paulista, they found  $2.88\%$  of ash, and  $4.4\%$  in the Sabará variety. With regard to lipid levels, those authors describe values of  $0.68\%$  in variety Paulista and  $0.57\%$  in variety Sabará.

The crude fiber content found in jabuticaba peel was  $1.85 \pm 0.09\%$  and in flour made from peels was  $2.84 \pm 0.08\%$ . The crude fiber level was determined after acidic and alkaline hydrolysis of the sample. The alimentary fiber content determined through the enzymatic-gravimetric method would likely be higher. In that regard, Lima et al. (2008) describe soluble alimentary fiber values around  $6.8\%$  in jabuticaba peel.

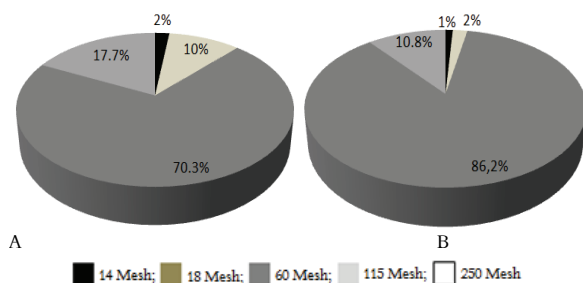
The protein content found in flour (Figure 2A) was relatively high ( $6.4 \pm 0.30\%$ ), considering it is a plant-based material. Ferreira et al. (2012) describe similar values ( $5.23\%$ ) of protein content in flour of jabuticaba peel produced from fruits grown in Diamantina city.

*Okara* flour (Figure 2B) showed high protein ( $34.6 \pm 0.99\%$ ) and fiber ( $30.7 \pm 0.97\%$ ) contents, characteristics that make biomass a potential ingredient in food bars, which are rich in protein and fiber. Pinto and Castro (2008) observed similar values of protein ( $38.51\%$ ) in dehydrated *okara* flour obtained from *okara* produced in industrial scale, and higher values *okara* flour produced in laboratory scale ( $45.71\%$ ). The same authors described slightly higher lipid content values -  $22.25\%$  in flour made from *okara* obtained in laboratory, and  $24.8\%$  in flour from biomass obtained in industrial scale. Those authors highlight that aspects such as soybean variety and quality; moisture level at the time the *okara* biomass enters the drying oven, among other factors, contribute to differences in physical-chemical characterization parameters of the final product.



**Figure 2.** Flour of jabuticaba peel (A). Flour of *okara* (B).

The Figure 3 features graphs of the particle size of the flours used as ingredients in the cereal bars.



**Figure 3.** Grain size of jabuticaba peel (A) and okara (B) flours.

The flours featured relatively large average particle size, with most of the flour passing through the 14 Mesh (1.19 mm) and 18 Mesh (1.00 mm) screens, and retained in the 60 Mesh (0.250 mm) screen. The flour content retained in the 18- and 60-Mesh screens was greater for *okara* flour (97%) compared to jabuticaba peel flour (88%) – that is, *okara* flour had slightly larger average grain size. Similar particle size values for *okara* flour (88% retained in the 60 Mesh screen) are described by Cunha et al. (2010). Silva et al. (2009b) report higher average particle size values for *okara* flour (90.6% at sizes between 14 and 35 Mesh) than those obtained in the present work. The size of *okara* flour particles is directly related to parameters such as: type of grinder used, grinding time, soybean variety, as well as crushed biomass moisture. Likewise, Ascheri et al. (2006) describe larger particle sizes (36% of particles larger than 0.5 mm) in flour made from jabuticaba bagasse.

### Chemical characterization of the cereal bars

The results of the proximate composition for the produced cereal bars are shown in Table 3.

**Table 3.** Nutritional composition of the cereal bars.

Chemical composition	Formulations		
	F1	F2	F3
Energy (kcal 100 <sup>-1</sup> g)	363.68	363.60	363.26
Moisture (g 100 <sup>-1</sup> g)	10.9 <sup>a</sup> ± 0.97	8.9 <sup>b</sup> ± 0.73	8.8 <sup>b</sup> ± 0.73
Ash (g 100 <sup>-1</sup> g)	1.68 <sup>a</sup> ± 0.09	1.68 <sup>a</sup> ± 0.07	1.71 <sup>a</sup> ± 0.09
Lipids (g 100 <sup>-1</sup> g)	8.6 <sup>a</sup> ± 0.77	8.2 <sup>a</sup> ± 0.77	8.3 <sup>a</sup> ± 0.71
Proteins (g 100 <sup>-1</sup> g)	9.2 <sup>a</sup> ± 0.37	8.9 <sup>a</sup> ± 0.97	8.9 <sup>a</sup> ± 0.86
Crude fiber (g 100 <sup>-1</sup> g)	7.25 <sup>a</sup> ± 0.98	8.77 <sup>b</sup> ± 0.94	9.05 <sup>b</sup> ± 0.68
Carbohydrates* (g 100 <sup>-1</sup> g)	62.37	63.55	63.24

\* Calculated by difference. \*\* means with the same letter, in the same line, do not differ statistically from one another ( $p \leq 0.05$ ).

The estimated total energy value in the bars was 363.68 Kcal 100<sup>-1</sup> g, 363.60 Kcal 100<sup>-1</sup> g and 363.26 Kcal 100<sup>-1</sup> g, respectively for formulations F1, F2 and F3. There were no significant differences among the formulations with regard to total caloric value, indicating that the increase in jabuticaba peel

flour concentration in the sample did not contribute to an energy increase in the product. Both formulations showed low moisture content (8.8 to 10.9%), which contributes to greater chemical and microbiological stability and is in accordance with Brazilian legislation determining that product moisture should stay below 15% (BRASIL, 2005).

There were no significant statistical differences ( $p > 0.05$ ) in the protein content of the samples at a 95% confidence interval. The observed protein values (8.9 and 9.2%) are satisfactory and higher than those usually found in cereal bars available in the market, which range between 3 and 4% (SANTOS et al., 2011). Lipid content varied between 8.2 and 8.6%, but there were no statistically significant differences among the samples. According to Sampaio et al. (2010), products currently for sale have values ranging between 4 and 12%. The levels of fiber found in the bars varied between 7.25 and 9.05%, thus qualifying the formulations as fiber-rich products. According to Ordinance no. 27, of January 13, 1998 (BRASIL, 1998), in order for a solid food item to be classified as such, it should have at least six grams of fiber per 100 grams of ready-to-eat product. The carbohydrate content was estimated by the difference from nutrient levels analyzed, as is commonly done in scientific studies. The study found carbohydrate values between 62.37% (F1) and 63.55% (F2). Freitas and Moretti (2006) developed cereal bars with high protein and vitamin levels, and described carbohydrate contents of 60.97%. Grden et al. (2008) describe carbohydrate values of 62% in cereal bars for sportspersons and athletes. Carbohydrate contents between 64.2 and 66.7% are described by Silva et al. (2009a) in cereal bars formulated with industrial byproducts from passion fruit processing. According to Sampaio et al. (2010), mean carbohydrate content values found in cereal bars in the market is 74%.

### Microbiological characterization of the cereal bars

In addition to nutritional quality, the microbiological quality of food items is essential in terms of consumer health and safety. The cereal bars developed were evaluated according to microbiological quality parameters before the sensory tests were carried out. The microbiological quality of the bars was satisfactory, in accordance with the requirements of RDC 12, of January 12, 2001 (BRASIL, 2001), which describes the microbiological parameters that must be verified in compacted cereals, with or without additions, as can be seen in Table 4.

**Table 4.** Microbiological quality parameters of cereal bars.

Microbiological parameters	Results	Brazilian legislation* (tolerance for the representative sample)			
		n	c	m	M
<i>Bacillus cereus</i>	< 10 <sup>2</sup>	5	2	10 <sup>2</sup>	5 x 10 <sup>2</sup>
<i>Coliformes a 45°C g<sup>-1</sup></i>	< 3	5	2	10	5 x 10
<i>Salmonella</i> sp.	Absent	5	0	Abs. 25 <sup>-1</sup> g	-

\*RDC 12, of January 12, 2001 (BRASIL, 2001).

### Sensory analysis

The average scores obtained by the three cereal bar formulations in the sensory analysis are demonstrated in table 5. All formulations had good sensory acceptability in attributes color, taste, texture, aroma and overall impression. The mean scores attributed by tasters were higher than 7 in all evaluated sensory attributes.

**Table 5.** Mean scores attributed by tasters to sensory attributes evaluated in the formulations of cereal bars made from jabuticaba peel flour.

Formulation	Color	Taste	Texture	Aroma	Overall impression
F1	7.98 <sup>a</sup>	8.20 <sup>a</sup>	8.18 <sup>a</sup>	7.70 <sup>a</sup>	8.30 <sup>a</sup>
F2	7.75 <sup>a</sup>	7.75 <sup>a,b</sup>	7.88 <sup>a</sup>	7.15 <sup>a</sup>	7.70 <sup>b</sup>
F3	7.73 <sup>a</sup>	7.55 <sup>b</sup>	7.83 <sup>a</sup>	7.40 <sup>a</sup>	7.65 <sup>b</sup>

\*means with the same letter, in the same column, do not differ statistically from one another (p &lt; 0.05)

With regard to the attribute color, there were no statistically significant differences (p > 0.05) among the formulations developed or prepared in this work. This result indicates that the higher concentration of jabuticaba peel flour in the formulations did not contribute to noticeable differences in product color. Likewise, the attributes texture and aroma did not show statistically significant differences, either, at a 95% confidence interval. On the other hand, analysis of variance (ANOVA) of the data indicated significant differences (p < 0.05) among the samples in attributes taste and overall impression (Table 5), with formulation F1 obtaining the highest scores in those attributes. Comparing samples F2 and F3, it is seen that there were no statistically significant differences among the formulations with regard to all evaluated sensory parameters, at a 95% confidence interval. The sensory analysis results suggest that the increased concentration of jabuticaba peel flour in the cereal bar formulations contributed to the slight reduction in taste acceptance, but does not influence texture and aroma of this type of food.

In the attribute overall impression, formulation F1 has the best acceptance compared to the other formulations, and the tasters did not see overall differences between formulations F2 and F3. In fact, overall, there was greater acceptance of the product by tasters when lower concentrations of jabuticaba peel flour were used in the formulation. Jabuticaba peel

flour has a rather sour taste, and that characteristic may have adversely influenced the overall acceptance of the cereal bars.

### Conclusion

Flour made from Jabuticaba peel and *okara* showed potential for use as ingredients in the formulation of cereal bars. The formulations containing these ingredients showed good nutritional quality, with higher protein contents than usually found in commercial cereal bars. All three formulations containing different amounts of jabuticaba peel flour showed good sensory acceptability. The use of jabuticaba peel and soy byproduct *okara* in the bar production can be a viable alternative to enjoy the nutritional value of those biomasses.

### Acknowledgements

The authors would like to thank the CNPq (National Council for Scientific and Technological Development) for the financial Support.

### References

- AOAC-Associations of Official Analytical Chemists. **Official methods of analysis**. 17th ed. Gaithersburg: AOAC, 2000.
- ASCHERI, D. P. R.; ASCHERI, J. L. R.; CARVALHO, C. W. P. Caracterização da farinha de bagaço de jabuticaba e propriedades funcionais dos extrusados. **Ciência e Tecnologia de Alimentos**, v. 26, n. 4, p. 897-905, 2006.
- ASQUIERI, E. R.; SILVA, A. G. M.; CÂNDIDO, M. A. Aguardente de jabuticaba obtida da casca e borra da fabricação de fermentado de jabuticaba. **Ciência e Tecnologia de Alimentos**, v. 29, n. 4, p. 896-904, 2009.
- BRASIL. Ministério da Saúde. Agência Nacional de Vigilância Sanitária. Regulamento técnico para produtos de cereais, amidos, farinhas e farelos. Resolução RDC n.º 263, de 22 de setembro de 2005. **Diário Oficial da União**, 23 de setembro de 2005. Seção 1, p. 368.
- BRASIL. Ministério da Saúde. Agência Nacional de Vigilância Sanitária. Regulamento técnico sobre os padrões microbiológicos para alimentos. Resolução RDC n.º 12, de 2 de janeiro de 2001. **Diário Oficial da União**, 10 de janeiro de 2001. Seção 1, p. 378.
- BRASIL. Ministério da Saúde. Agência Nacional de Vigilância Sanitária. Regulamento técnico referente à informação nutricional complementar. Portaria n.º 27, de 13 de janeiro de 1998. **Diário Oficial da União**, 16 de janeiro de 1998. Seção 1, p. 368.
- BRUNINI, M. A.; OLIVEIRA, A. L.; SALANDINI, C. A. R.; BAZZO, F. R. Influência de embalagens e temperatura no armazenamento de jabuticabas (*Myrciaria jabuticaba* (Vell) Berg) cv 'Sabará'. **Ciência e Tecnologia de Alimentos**, v. 24, n. 3, p. 378-383, 2004.

- CUNHA, M. A. A.; ANDRADE, A. C. W.; FERMIANI, E. A.; APPELT, P.; BURATTO, A. P. Food bars formulated with soy residue. **Revista Brasileira de Pesquisa em Alimentos**, v. 1, n. 2, p. 89-96, 2010.
- DESSIMONI-PINTO, N. A. V.; MOREIRA, W. A.; CARDOSO, L. M.; PANTOJA, L. A. Jaboticaba peel for jelly preparation: an alternative technology. **Ciência e Tecnologia de Alimentos**, v. 31, n. 4, p. 864-869, 2011.
- FERREIRA, A. E.; FERREIRA, B. S.; LAGES, M. M. B.; RODRIGUES, V. A. F.; THÉ, P. M. P.; PINTO, N. A. V. D. Produção, caracterização e utilização da farinha de casca de jaboticaba em biscoitos tipo cookie. **Alimentos e Nutrição**, v. 23, n. 4, p. 603-610, 2012.
- FONSECA, R. S.; DEL SANTO, V. G.; SOUZA, G. B.; PEREIRA, C. A. M. Elaboração de barra de cereais com casca de abacaxi. **Archivos Latinoamericanos de Nutrición**, v. 61, n. 2, p. 216-223, 2011.
- FREITAS, D. G. C.; MORETTI, R. H. Caracterização e avaliação sensorial de barra de cereais funcional de alto teor protéico e vitamínico. **Ciência e Tecnologia de Alimentos**, v. 26, n. 2, p. 318-324, 2006.
- GOTELLI, N. J.; ELLISON, A. M. **A primer of ecological statistics**. New York: Sinauer Associates, 2004.
- GRDEN, L.; OLIVEIRA, C. S.; BORTOLOZO, E. A. F. Q. Elaboração de uma barra de cereais como alimento compensador para praticantes de atividade física e atletas. **Revista Brasileira de Tecnologia Agroindustrial**, v. 2, n. 1, p. 87-94, 2008.
- GRANATO, D.; ELLENDERSEN, L. S. N. Almond and peanut flours supplemented with iron as potential ingredients to develop gluten-free cookies. **Ciência e Tecnologia de Alimentos**, v. 29, n. 2, p. 395-400, 2009.
- LIMA, A. J. B.; CORRÊA, A. D.; ALVES, A. P. C.; ABREU, C. M. P.; DANTAS-BARROS, A. M. Caracterização química do fruto jaboticaba (*Myrciaria cauliflora* Berg) e de suas frações. **Archivos Latinoamericanos de Nutrición**, v. 58, n. 4, p. 416-421, 2008.
- LIMA, A. J. B.; CORRÊA, A. D.; SACZK, A. P.; MARTINS, M. P.; CASTILHO, R. O. Anthocyanins, pigment stability and antioxidant activity in jaboticaba [*Myrciaria cauliflora* (Mart.) O. Berg]. **Revista Brasileira de Fruticultura**, v. 33, n. 3, p. 877-887, 2011.
- MATEOS-APARICIO, I.; MATEOS-PEINADO, C.; JIMENEZ-ESCRIG, A.; RUPÉREZ, P. Multifunctional antioxidant activity of polysaccharide fractions from the soybean byproduct okara. **Carbohydrate Polymers**, v. 82, n. 1, p. 245-250, 2010.
- O'TOOLE, D. K. Characteristics and use of okara, the soybean residue from soy milk production-a review. **Journal of Agriculture and Chemistry**, v. 47, n. 2, p. 363-371, 1999.
- PINTO, D. D. J.; CASTRO, P. S. Estudo preliminar da secagem do okara (resíduo do extrato aquoso de soja) para inativação dos fatores antinutricionais e conservação. **Brazilian Journal of Food Technology**, v. 12, n. 18, p. 125-131, 2008.
- R DEVELOPMENT CORE TEAM. **R: A language and environment for statistical computing**. Vienna: R Foundation for Statistical Computing, 2012. Available from: <<http://www.R-project.org/>>. Access on: Oct. 2, 2012.
- SAMPAIO, C. R. P.; FERREIRA, S. M. R.; CANNIATTI-BRAZACA, S. G. Caracterização físico-química e composição de barras de cereais fortificadas com ferro. **Alimentos e Nutrição**, v. 21, n. 4, p. 607-616, 2010.
- SANTOS, C. T.; BONOMO, R. F.; FONTAN, R. C. I.; BONOMO, C.; VELOSO, C. M.; FONTAN, G. C. R. Characterization and sensorial evaluation of cereal bars with jackfruit. **Acta Scientiarum. Technology**, v. 33, n. 1, p. 81-85, 2011.
- SATO, A. C. K.; CUNHA, R. L. Influência da temperatura no comportamento reológico da polpa de jaboticaba. **Ciência e Tecnologia de Alimentos**, v. 27, n. 4, p. 890-896, 2007.
- SILVA, I. Q.; OLIVEIRA, B. C. F.; LOPES, A. S.; PENA, R. S. Obtenção de barra de cereais adicionada do resíduo industrial de maracujá. **Alimentos e Nutrição**, v. 20, n. 2, p. 321-329, 2009a.
- SILVA, L. H.; PAUCAR-MENACHO, L. M.; VICENTE, C. A.; SALLES, A. S.; STEEL, C. J.; CHANG, Y. K. Desenvolvimento de pão de fôrma com a adição de farinha de 'okara'. **Brazilian Journal of Food Technology**, v. 12, n. 4, p. 315-322, 2009b.
- SILVA, N.; JUNQUIRA, V. C. A.; SILVEIRA, N. F. A.; TANIWAKI, M. H.; SANTOS, R. F. S.; GOMES, R. A. R. **Manual de métodos de análise microbiológica de alimentos**. 3. ed. São Paulo: Varela, 2007.
- VILLANUEVA, M. J.; YOKOYAMA, W. H.; HONG, Y. J.; BARTTLEY, J. E.; RUPÉREZ, P. Effect of high-fat diets supplemented with okara soybean by-product on lipid profiles of plasma, liver and faeces in Syrian hamsters. **Food Chemistry**, v. 124, n. 1, p. 72-79, 2011.

Received on June 3, 2013.

Accepted on August 21, 2013.

License information: This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.