ISSN 0101-2061

Food Science and Technology

DOI: 10.1590/1678-457X.0074

Effect of adding flours from marolo fruit (*Annona crassiflora* Mart) and jerivá fruit (*Syagrus romanzoffiana* Cham Glassm) on the physicals and sensory characteristics of food bars

Edson Pablo da SILVA[1*], Heloisa Helena SIQUEIRA[2], Clarissa DAMIANI[2], Eduardo Valério de Barros VILAS BOAS[2]

Abstract

The marolo (*Annona crassiflora* Mart.) and jerivá (*Syagrus romanzoffiana* Cham Glassm) fruits grow in the Cerrado biome, and have important sensory and nutritional characteristics. These fruits are eaten fresh or processed and embedded in ice cream, candy, juices, and liquors. However, their use is very limited and is localized exclusively to their native region. The aim of this study was to evaluate the use of these fruits in food consumer products to improve the nutritional patterns of consumers and extend knowledge thereof. To do this, different levels (0%, 5%, 10%, 15%, and 20%) of flour derived from the marolo and jerivá fruits were incorporated into food bars, which were then characterized in terms of their physical of the texture (TPA), porosity, color and sensorial properties. The food bars enriched with marolo and jerivá flours had an intense yellow color and increased hardness relative to the control bars; the porosity of the bars progressively decreased as the amount of flour added increased. The sensorial analysis in the snack bars developed added with the fruits flour no was influence by incorporation this component, showed good averages for the scores evaluated.

Keywords: flour; savannah fruits; porosity; physical properties.

Practical Application: Combine instrumental evaluation, with sensory analysis is increasingly important as we increase the reliability of data on the product developed. In this case we combine the TPA texture and sensory analysis of images in formulations added with foodstuffs bars with different concentrations of fruit flour.

1 Introduction

The savannah is an important Brazilian biome with many successful species. Many fruits from this ecosystem are edible and have been used locally for generations (Damiani et al., 2011). Marolo (*Annona crassiflora* Mart.) and jerivá (S*yagrus romanzoffiana* Cham Glassm) are native's fruit to the Brazilian savannah and have acceptable sensory characteristics as well as significant nutritional and functional potential. Silva et al. (2014), with the development of snack bars added with flour this fruits detected a percentual significance in the characterization of flours. The marolo flour showed values of proximate composition was 14.16 g.100 g^{-1} moisture, 2.92 g/100 g protein, 4.83 g.100 g^{-1} of lipid, 17.43 g.100 g^{-1} dietary fiber, 3.77 g.100 g^{-1} ash and 56.89 glycides, besides 183.06 mg.100 g^{-1} vitamin C, pH 4.96, AT 0.29%, 34.33 mg/kg Fe and 170 mg.100 g^{-1} Ca and 48.76° Brix. And the jerivá flour present the following composition: 116.35 mg.100 g^{-1} of vitamin C; 15.35 g.100 g^{-1} of total food fiber; 0.29% titratable acidity; 4.96 pH; 1.06% of lipid; 48.76º Brix; 83.69 ppm Fe and 0.17% Ca. Values showed by Coimbra & Jorge (2011) in the studies of proximate composition the palm fruits, reveal that the jerivá pulp a fruit rich in nutritional source, with 7.75% moisture, 5.41% of protein, 3.21 of ash, 7.48 for lipids and 26.98 of total fibers. These fruits are either consumed fresh or processed and incorporated in ice cream, sweets, juices, and liquors. Their use is rudimentary and limited to their area of growth, hence, they are not widely known. Recent changes in lifestyle have altered dietary habits, resulting in nutritional deficiencies that require the development of fortified foods (Rosell, 2007). Additionally, nutritious, high quality, appealing food products are in demand. In this context, the incorporation of fruits into products, such as food bars, considerably increases the vitamin and mineral content of these foods (Silva et al., 2014). There is consumer demand for food products that provide a healthy, balanced diet (Sociedade Brasileira de Alimentos Funcionais, 2013).

Cereal bars are convenience foods that are often proposed as alternatives to meet the demand for low-calorie or protein-enriched products aimed at athletes. These products are easy to manufacture and are generally obtained by compacting cereal flakes such as rice, maize, oats, and barley, glucose syrup, sugar and/or natural or artificial sweetener, and dried fruits (Sampaio et al., 2010). The cereal bars are multicomponent and can be very complex in its formulation. The ingredients must be combined to adequate to ensure that complement each other the taste characteristics, texture and physical properties, particularly in water activity breakeven point (Murphy, 1995). Barboza et al.

Received 16 Nov., 2015
Accepted 07 Feb., 2016

[1] Instituto de Agroquímica y Tecnologia de Alimentos – IATA, Paterna, Valencia, Espanha
[2] Departamento de Ciência dos Alimentos, Universidade Federal de Lavras – UFLA, Lavras, MG, Brasil
*Corresponding author: edsonpablos@hotmail.com

(2003) claimed that it is essential to optimize presentation and quality characteristics, such as color, appearance, smell, taste, texture, consistency, and interactions among components, in the development of new products to achieve a comprehensive balance between ingredients. The three major factors that influence food sensory acceptability are appearance, flavor, and texture, and the latter is essential for crispy food products such as bars (Kim et al., 2009). Savannah fruits have acceptable sensory and functional qualities and accordingly could be useful in the development of food bars. The aim of this study was to determine the effect of incorporating fruit-derived flour into bars on quality parameters. The objective of this study was to determine the effect of acceptance and quality physical parameters of cereal bars added jerivá and marolo swell and flour in five different proportions.

2 Materials and methods

2.1 Preparing marolo and jerivá flours

The fruits of marolo (*A. crassiflora* Mart) and jeriva (*S. romanzoffiana* Cham Glassm) harvest 2012/2013, were harvested in a savannah area in southern Minas Gerais, Brazil. The fruits were washed to remove dirt and impurities from the field and disinfected with sodium hypochlorite solution (1.216 μM). Marolo and jerivá pulps were extracted using a Hauber Macanuda (model JEM-05, 074-09 series Joinville, Brazil) and were subsequently dried at 65 °C for 48 hours and crushed with an industrial mixer. Flour was sifted in a nylon mesh sieve 3 to remove large particles.

2.2 Food bar processing

The process of preparing food bars was performed as described by Silva et al. (2014). The standard formulation was 400 g of cornstarch cake, 60 g of oatmeal, 60 g of skim milk powder, 40 g of flaked rice, and 450 g of glucose syrup from corn. The fruit flour was incorporated into the cornstarch cake using various amounts of marolo or jerivá flour (i.e., 5%, 10%, 15%, or 20% was replaced resulting in cake + fruit flour amounts of 380 g + 20 g, 360 g + 40 g, 340 g + 60 g, and 320 g + 80 g). The dry ingredients (corn starch cake, skimmed milk powder, and rice flakes) were manually mixed in a tray. In parallel, the syrup binder was prepared as a mixture of high-fructose corn syrup and honey, without heating. The syrup was added to the mixture until a product of uniform consistency was obtained, which was subjected to rolling (1 cm), allowed to stand for 8 hours, cut (10 cm × 2 cm, approximately 25 g each), packed in aluminum-coated cellophane, and maintained at 20 °C, until the completion of the analysis.

2.3 Physical analysis

Coloration was determined at three different positions on the food bars using the Minolta CR-400 (Tokyo, Japan) and the CIE L^*, a^*, b^* scale. The L^* coordinate represents the brightness of the sample, with values ranging from 0 (totally black) to 100 (completely white); the a^* coordinate range from −80 to +100 indicating green and red at the endpoints, respectively; the b^* coordinate represents the intensity of blue to yellow and varies from −50 (totally blue) to +70 (completely yellow).

For the hardness test, the texture meter Stable Micro System TA-XT2 was used to measure cutting forces or shear and compression forces. To measure the cutting force of food bars, a probe-type knife (10 cm in length, 1-mm thick) was used. Samples were placed on the texture analyzer base plate and cut to 80% of their original thickness. The conditions used for cutting measurements were as follows: pretest speed of 2 mm/s, test speed of 2 mm/s, post-test speed of 15 mm/s, and a distance of 8 mm.

The compression force used was the TPA (was estimated using a texture profile analysis) comprising a double compression cycle that simulates mouth chewing (Larmond, 1997). The parameters recorded were hardness, which represents the deformation necessary for a certain strength, and cohesiveness, representing the amount of energy needed to break the internal interactions of the samples. Furthermore, the elasticity was estimated as the speed at which a deformed material regains its original structure when the compression force is removed. The conditions used for this analysis were in accordance with those used by Kim et al. (2009), i.e., a pretest speed of 60 mm/s, test speed of 100 mm/s, post-test speed of 60 mm/s, and 80% strain with a cylindrical probe that is 20 cm in diameter.

The internal structure of the cross section of the bars was determined by image analysis. The bars were cut transversely and placed in the scanner. Scanning was performed at a resolution of 300 megapixels, resulting in high image definition. The analysis of scanned images was performed using the HP PrecisionScan Pro 3.1 software. RGB images (red, green, and blue) were converted to gray scale, and an area of 150.84 mm was defined. Subsequently, the scaling of 8-bit pixels, which varies from 0-256 pixels was performed, and category 0 was optimal for counting pores, which were defined as black spaces. To count the pores, 6 replicates were used for each bar formula.

For the sensorial analysis used a hedonic sensory evaluation of snack bars was conducted with 100 usual consumer volunteers of those products. Consumer test was carried out in the Sensory Analysis Laboratory of the Department of Food Science of University Federal of Lavras (Brasil) in individual booths. Snack bars were evaluated for appearance, aroma, taste, texture and overall acceptability on a nine-point hedonic scale, according to Meilgaard et al. (1991). Attributes were scored on a scale varying from "9 = like extremely" to "1 = dislike extremely". Samples were presented in white plastic dishes coded with three-digit random numbers and served in a randomized order, in according with registration number on the ethics committee 20489913.0.0000.5148.

2.4 Statistical analysis

All results were analyzed using the Statgraphics V5.1 program. The results were analyzed by multifactor analysis of variance (MANOVA) and significant factors for certain parameters were assessed using multiple samples and Tukey's tests ($P \leq 0.05$). A randomized design was used in a 5 × 2 factorial scheme corresponding to the five concentrations (0%, 5%, 10%, 15%, and 20%) and two kinds of flour (jerivá and marolo flour).

3 Results and discussion

The color of food bars was significantly influenced ($P < 0.05$) by the amount of marolo and jerivá flour added (Table 1). However, the coloration of bars did not differ between the marolo and jerivá flours. A reduction in the L^* value was observed as the concentration of flour increased, suggesting darker bars. Except for bars containing 5% fruit flour, the bars containing 20% flour had lower L^* value than that of the others, indicating a darker color. The addition of fruit flour increased a^* value at concentrations up to 15%, suggesting a slight reddening of the bars by the addition of flour. The values of L^* and a^* observed in this study are similar to those reported by Silva et al. (2009) for cereal bars made with passion fruit waste, which had L^* values ranging from 65.41 to 46.40 and a^* values from 4.70 to 7.91. Different values have been reported by Aramouni & Abu-Ghoush (2011) ($L^* = 80.25$ and $a^* = 4.51$) for cereal bars with soy or wheat. The variable b^* was not significantly affected by the type of flour or flour concentration. The average b^* was 23.78, indicating a yellow color.

The textural variables cutting, two estimates of hardness, and elasticity were significantly influenced by the addition of flour, but not by the amount of flour added ($P < 0.05$; Table 2; Figure 1). For cutting or shearing ($P < 0.05$), bars with added jerivá and marolo flour showed significantly lower values than that of the control, requiring a greater application of force for shearing. This difference may be explained by the high levels of dietary fiber observed in marolo and jerivá flour (17.43 and 15.35 $g.100\ g^{-1}$ total dietary fiber, respectively; data presented in the characterization of the flour). Higher cutoff values were reported by Silva et al. (2009), ranging from 27.34 to 40.21 N for cereal bars developed with passion residues. According to with Jensen et al. (2010), the textural properties are strongly influenced by the size or the structure of cells and are strongly determined by the quantity and quality of gluten or other substances in bulk. In addition, the texture attributes undoubtedly contribute greatly in product freshness of perception by consumers.

For the two indicators of hardness ($P < 0.05$), which represent the force needed to produce distortion in food during chewing in the first (hardness 1) and second (hardness 2) molar teeth, bars developed with jerivá flour had higher values (hardness 1, 168.93 N and hardness 2, 77.53 N) than those of the control bars (hardness 1, 115.19 N and hardness 2, 71.93 N) and bars with marolo flour (hardness 1, 136.93 N and hardness 2, 73.53 N). Control bars and those with marolo flour did not differ with respect to hardness. However, the addition of jerivá flour made food bars more resistant to chewing. There is high variation in the hardness values of food bars in general due to the difficulty in achieving repeatability and the large variety of formulations and ingredients. However, the hardness observed for the control bars and those containing jerivá and marolo flour are higher than those reported in the literature, i.e., 7.30 and 30.27 N for bars developed with soy and wheat (Aramouni & Abu-Ghoush, 2011), 16.38 N for cereal bars based on rice and agro-industrial waste (Paiva, 2008), 11.60 N for cereal bars containing textured soy protein and toasted wheat germ, and 16.69 N for cereal bars based on passion fruit waste (Oliveira et al., 2002)., There are no studies on the ideal or optimal hardness for food bars.

Although food bars do not exhibit elasticity like that observed for bakery products (e.g., breads and bowling), the bars that were

Table 1. Effect of the addition marolo and jerivá flour on the color of food bars.

Nivel (%)	L* value	a* value
0	63.47^c	5.80^a
5	63.26^c	6.46^b
10	59.06^b	6.95^c
15	58.92^b	7.91^d
20	57.85^a	7.99^d
Average	**60.51**	**7.02**
St. Deviation	**2.36**	**0.84**

Average followed by same letter in the column do not differ at the 5% significance ($p < 0.05$).

Table 2. Effect of the addition of marolo and jerivá flour on the texture of food bars.

	Cutting	Hardness (1) (N)	Hardness(2) (N)	Elasticity (N.seg)
Control	10.43^a	115.19^a	71.93^a	0.12^a
Marolo	17.87^b	136.93^a	73.53^a	0.82^b
Jerivá	15.86^b	168.36^b	77.53^b	0.71^b
Average	**14.72**	**140.16**	**77.66**	**0.83**
St.Deviation	**3.84**	**26.73**	**4.20**	**0.86**

Average followed by same letter in the column do not differ at the 5% significance ($p <0.05$).

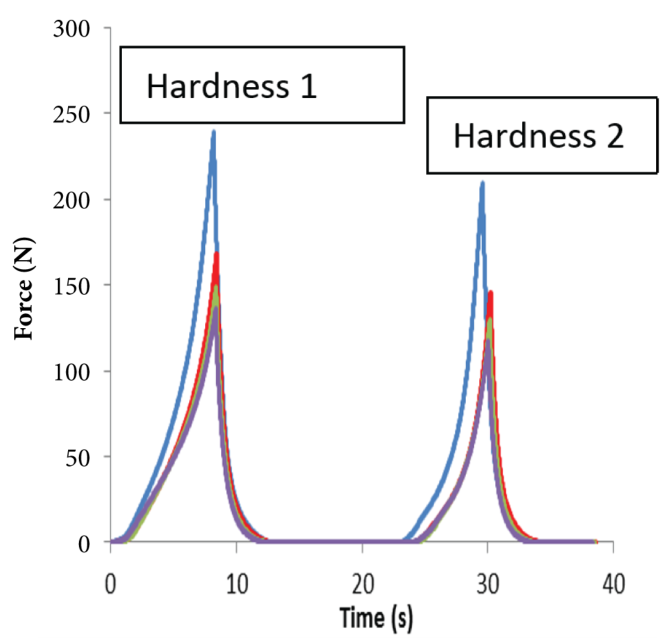

Figure 1. Demonstration of the curve relating force and time required for TPA (texture profile analysis) in the samples of snack bars developed.

made with jerivá and marolo flour exhibited a greater degree of feedback (0.82 N/sec and 0.71 N/sec, respectively) compared to that of control bars (0.12 N/sec) (Table 2). Güemes-Vera et al. (2009) reported values between 0.99 and 1.01 N/sec for fresh breads fortified with protein from whey higher than those observed for control bars and those for the bars containing flours.

For cohesion, which is related to the degree to which a substance can be compressed between the teeth before it breaks, and porosity, estimated as the number of spaces between each ingredient added to the formulations, the amount of flour added significantly influenced the physical structure of the bars. As the amount of flour used to replace the cornstarch cake increased, the cohesion increased and the numbers of pores decreased, indicating increased compaction by the addition of flour (Table 3; Figure 2). Table 2 shows the results for the cutting and hardness variables, and demonstrates that the bars are harder and more compact than the control product. Gerrard et al. (1996) showed that a digital image analysis can be used to evaluate porosity; this new non-destructive technique can be used to control and evaluate food and agricultural products, particularly with respect to hardness. The cohesion and porosity parameters showed a more compact and harder product as the percentage of fruit flour increased in each formulation.

For the sensorial analysis, no was observed significance difference between the concentration of marolo and jeriva flour, incorporated in the formulations development. The cereal bars were subjected to sensory analysis using a consumers' panel not

Table 3. Effect of the addition of marolo and jerivá flour on cohesion and porosity.

Nivel (%)	Cohesion (N)	Porosity Number of spaces
0	0.11[a]	56.66[d]
5	0.16[b]	42.83[c]
10	0.18[bc]	29.33[b]
15	0.19[cd]	21.66[a]
20	0.20[d]	18.83[a]
Average	**0.17**	**33.86**
St.Deviation	**0.03**	**15.77**

Average followed by same letter in the column do not differ at the 5% significance ($p < 0.05$).

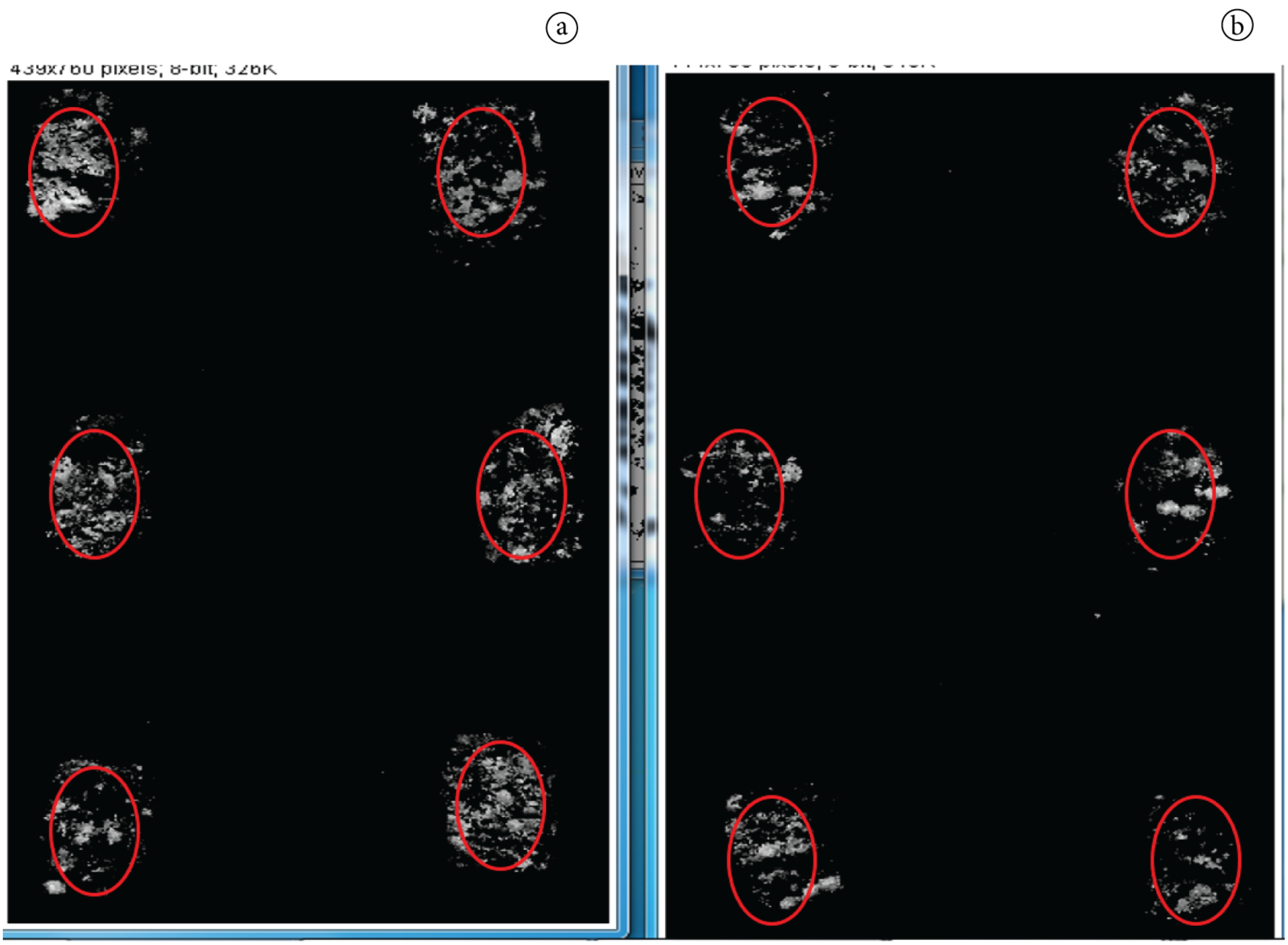

Figure 2. Images of porosity of the food bars with jerivá (a) and marolo (b) flour added at 20%.

trained. The scores given by the panelists to cereal bar formulations, as a sensorial preference are shown average values between 7.02 and 7.11 for the total scores evaluated. Supplemented bars with jeriva flour 10% CCO15% and CCO20% and marolo flour MMO 15% and MMO 20% received the highest averages in relation to appearance, flavor and texture attributes. Therefore, the replacement of part of corn starch biscuit for marolo and jerivá flour improved the sensory acceptability of the food bars. The scores obtained in the jerivá flour supplemented bars were higher than those reported for other nutritious bars (Bower & Whitten, 2000; Freitas & Moretti, 2006).

4 Conclusion

The flours that were added to the prepared food bars significantly influenced the color and texture profiles analyzed; specifically, they conferred a yellow hue and increased hardness to the products.

Acknowledgements

The authors acknowledge the financial support of CAPES; FAPEMIG, CNPq, the Spanish Council for Scientific Research (CSIC), and the Generalitat Valenciana (Prometheus Project 2012/064). EP da Silva wishes to thank the Federal University of Lavras (Lavras, Minas Gerais, Brazil) for a predoctoral fellowship.

References

Aramouni, F. M., & Abu-Ghoush, M. H. (2011). Physicochemical and sensory characteristics of no-bake wheat–soy snack bars. *Journal of the Science of Food and Agriculture*, 91(1), 44-51. http://dx.doi.org/10.1002/jsfa.4134. PMid:20737416.

Barboza, L. M. V., Freitas, R. J. S., & Waszczynskyj, N. (2003). Desenvolvimento de produtos e análise sensorial. *Brasil Alimentos*, 18, 34-35.

Bower, J. A., & Whitten, R. (2000). Sensory characteristics and consumer linking for cereal bar snack foods. *Journal of Sensory Studies*, 15(3), 327-345. http://dx.doi.org/10.1111/j.1745-459X.2000.tb00274.x.

Coimbra, M. C., & Jorge, N. (2011). Proximate composition of guariroba (Syagrus oleracea), jerivá (Syagrus romanzoffiana) and macaúba (Acrocomia aculeata) palm fruits. *Food Research International*, 44(7), 2139-2142. http://dx.doi.org/10.1016/j.foodres.2011.03.032.

Damiani, C., Vilas Boas, E. V. B., Asquieri, E. R., Lage, M. E., Oliveira, R. A., Silva, F. A., Pinto, D. M., Rodrigues, L. J., Silva, E. P., & Paula, N. R. F. (2011). Characterization of fruits from the savanna: Araça (*Psidium guinnensis* Sw.) and Marolo (*Annona crassiflora* Mart.). *Food Science and Technology (Campinas.)*, 31(3), 723-729. http://dx.doi.org/10.1590/S0101-20612011000300026.

Freitas, D. G. C., & Moretti, R. H. (2006). Caracterização e avaliação sensorial de barra de cereais funcional de alto teor protéico e vitamínico. *Ciência e Tecnologia de Alimentos*, 26(2), 318-324. http://dx.doi.org/10.1590/S0101-20612006000200014.

Gerrard, D. E., Gao, X., & Tan, J. (1996). Beet marbling and color score determination by image processing. *Journal of Food Science*, 61(1), 145-148. http://dx.doi.org/10.1111/j.1365-2621.1996.tb14745.x.

Güemes-Vera, N., Totosaus, A., Hernandez, J. F., Soto, S., & Bolaños, E. N. A. (2009). Propriedades de textura de massa e de pão doce tipo concha fortificados com proteínas do soro de leite. *Ciência & Tecnologia de Alimentos*, 29(1), 70-75. http://dx.doi.org/10.1590/S0101-20612009000100011.

Jensen, S., Oestdal, H., & Thybo, A. K. (2010). Sensory profiling of changes in wheat and whole wheat bread during a prolonged period of storage. *Journal of Sensory Studies*, 25(2), 231-245. http://dx.doi.org/10.1111/j.1745-459X.2009.00254.x.

Kim, E. H.-J., Corrigan, V. K., Hedderley, D. I., Motoi, L., Wilson, A. J., & Morgenstern, M. P. (2009). Predicting the sensory texture of cereal snack bars using instrumental measurements. *Journal of Texture Studies*, 40(4), 457-481. http://dx.doi.org/10.1111/j.1745-4603.2009.00192.x.

Larmond, E. (1997). *Laboratory methods for sensory evaluation of food* (73 p.). Ottawa: Agriculture Canada.

Meilgaard, M., Civille, G. V., & Carr, B. T. (1991). *Sensory evaluation techniques* (2nd ed., 354 p.). Florida: CRC Press.

Murphy, P. (1995). Countlines and cereal bars. In E. B. Jackson, *Sugar confectionery manufacture* (Chap. 13, pp. 287-297). Cambridge: Chapman & Hall.

Oliveira, L. F., Nascimento, M. R. F., Borges, S. V., Ribeiro, P. C. N., & Ruback, V. R. (2002). Aproveitamento alternativo da casca do maracujá - amarelo (Passiflora edulis F. lavicarpa) para produção de doce em calda. *Food Science and Technology*, 22(3), 1-60.

Paiva, A. P. (2008). *Estudos tecnológico, químico, físico-químico e sensorial de barras alimentícias elaboradas com subprodutos e resíduos agroindustriais* (Dissertação de mestrado). Lavras: Universidade Federal de Lavras.

Rosell, C. M. (2007). Vitamin and mineral fortification of bread. In B. Hamaker (Ed.), *Technology of functional cereal products* (pp. 336-361). Cambridge: Woodhead Publishing Ltd.

Sampaio, C. R. P., Ferreira, S. M. R., & Canniatti-brazzaca, S. G. (2010). Physico-chemical and nutritional characterization of cereal bars fortified with iron. *Alimentos e Nutrição*, 21, 607-616.

Silva, E. P., Siqueira, H. H., Lago, R. C., Rosell, C. M., & Vilas Boas, E. V. (2014). Developing fruit-based nutritious snack bars. *Journal of the Science of Food and Agriculture*, 94(1), 52-56. http://dx.doi.org/10.1002/jsfa.6282. PMid:23794383.

Silva, I.Q; Oliveira, B.C.F; Lopes, A.S; Pena, S.R. (2009). Obtenção de barra de cereais adicionada do resíduo industrial de maracujá. *Alimentos e Nutrição*, 20, 321-329.

Sociedade Brasileira de Alimentos Funcionais – SBAF. (2013). *Alimentos funcionais*. Retrieved from: http://www.sbaf.org.br/