Caderno de Ciências Agrárias
Agrarian Sciences Journal

CADERNO DE CIÊNCIAS AGRÁRIAS
Agrarian Sciences Journal

ICA
INSTITUTO DE CIÊNCIAS AGRÁRIAS

UFMG

Acceptability and study of shelf life of gluten free cereal bar with popped and extruded sorghum based on a consumer acceptability

Caroline Liboreiro Paiva[1]*, Valéria Aparecida Vieira Queiroz[2], Maria Aparecida Vieira Teixeira Garcia[3], Carlos Wanderlei Piler Carvalho[4]

Abstract

Cereal bars have been an excellent vehicle for delivering functional ingredients to food market. Researches has showed that sorghum is a great source of phenolic compounds. Besides, it is a gluten free cereal, therefore a potential ingredient to celiac diets. Thus, a cereal bar with popped sorghum, sorghum extrudates, cashew fiber and dehydrated banana was formulated. Sensory acceptability of this product was determined by two panels: one panel composed of celiac individuals and another by non-celiac subjects. The product shelf life was estimated by the acceptability limit methodology. After remained stored for 120 days under 25°C, the shelf life was estimated at 163 ± 52 days. The sensorial study has not found significant differences in relation to overall acceptability between celiac and non-celiac individuals. This study suggest that sorghum co-products could be used successfully as a food ingredient to develop new formulations of the gluten free cereal bars.

Keywords: *Sorghum bicolor* L.; shelf life; hedonic test; chemical composition; product development.

Resumo

Barras de cereais têm sido uma excelente alternativa para oferecer ingredientes funcionais ao mercado de alimentos. Pesquisas têm mostrado que o sorgo é uma grande fonte de compostos fenólicos. Além disso, é um cereal sem glúten, portanto, um ingrediente potencial para dietas celíacas. Assim, uma barra de cereal com pipoca de sorgo, sorgo extrusado, fibra de caju e banana desidratada foi formulada. A aceitabilidade sensorial deste produto foi determinada por dois painéis: um painel composto por indivíduos celíacos e outro por indivíduos não celíacos. O prazo de validade do produto foi estimado utilizando-se a metodologia do limite de aceitabilidade. Após permanecer armazenado por 120 dias a 25°C, o tempo de vida útil foi estimado em 163 ± 52 dias. O estudo sensorial não encontrou diferença significativa em relação à aceitabilidade geral entre indivíduos celíacos e não celíacos. Este estudo sugere que coprodutos de sorgo podem ser usados com sucesso como ingredientes alimentares para desenvolver novas formulações de barras de cereais sem glúten.

Palavras-chave: *Sorghum bicolor* L.; vida de prateleira; teste hedônico; composição química; desenvolvimento de produto.

Introduction

Cereal bars are indicated to consumers interested in healthy diets, which have been incorporated by whole grains, other sources of fiber, functional and natural ingredients. The cereal bar market cluster has expanded and the consumer demands for convenient and healthy food shows no signs of slowing down (Agbaje *et al*., 2016).

Sorghum is one of the possible raw grains that can be incorporated in cereal bars. This due to its value as a potential source of fiber (Queiroz *et al.*, 2015), resistant starch (Teixeira *et al*., 2016), minerals (Paiva *et al*., 2017) and some bioactive compounds, such as polyphenols (Awika; Rooney, 2004). Moreover, there is an

[1]Universidade Federal de Minas Gerais, Instituto de Ciências Agrárias, Montes Claros, Minas Gerais, Brasil.
[2]Empresa Brasileira de Pesquisa Agropecuária, Embrapa Milho e Sorgo, Sete Lagoas, Minas Gerais, Brasil.
[3]Universidade Federal de Minas Gerais, Faculdade de Farmácia, Belo Horizonte, Minas Gerais, Brasil.
[4]Empresa Brasileira de Pesquisa Agropecuária, Embrapa Tecnologia de Alimentos, Rio de Janeiro, Rio de Janeiro, Brasil.
*Autora para correspondência: carolinepaiva7@gmail.com

Recebido para publicação em 10 de abril de 2018. Aceito para publicação em 7 de junho de 2018.
ISSN: 2447-6218 /

increased interest in using sorghum in foods worldwide due to its gluten-free and other health promoting properties, such as, slow digestibility, cholesterol-lowering, anti-inflammatory, and anti-cancer properties (Rooney; Awika, 2005; Chung *et al*., 2011; Moraes *et al*., 2012; Prasad *et al*., 2015; De Morais Cardoso *et al*., 2017).

In Brazil, the consumption of sorghum for human food is still insipient, although recently, many researchers have been developing new products with this cereal (Vargas-Solórzano *et al*., 2014; De Morais Cardoso *et al*., 2017; Anunciação *et al*., 2017; Queiroz *et al*., 2018). However, the shelf life of these products should be established in order to assess their viability. Besides, it is important to check the acceptability of consumers with celiac disease and non-celiac consumers since in this sense; few studies has been published.

Usually, in shelf life determinations of a food product, samples stored during pre-defined periods are submitted to physiochemical, sensory and microbiological tests for identification of quality loss (Man; Jones, 1994). However, if sanitary and nutritional characteristics are guaranteed, the most important aspect that must be certified is sensory quality (Hough, 2010).

In this context, trained panel is one of the sensory methodologies that can be applied, but it does not take into account the product acceptability (Hough; Garitta, 2012). Sensorial methodologies would be the most appropriate tool to determine the end of shelf life, because they show the interaction of the food with the consumer. The acceptability limitis one possible sensory methodology that can be applied to shelf life estimation, which is based on consumer panel answers (Hough, 2010).

Thus, the objective of this study was first to characterize the gluten free cereal bar with popped and extruded sorghum. Also, it had as purpose to compare the sensory acceptability between celiac and non-celiac consumer groups and to estimate the shelf life of the cereal bar by using the acceptability limit methodology. Besides, it was aimed at verifying if there was correlation between the overall acceptability and changes in sugar levels during storage.

Material and methods

Formulation of cereal bar is shown in Table 1. Glucose syrup (Mix, São Bernardo do Campo, SP, Brazil), maltodextrin (New Millen, Cajamar, SP, Brazil), soy lecithin (Solae, Esteio, RS, Brazil), maltitol (Wenda Ingredients, Dalian, China) and citric acid (Mix, São Bernardo do Campo, SP, Brazil) were used. In addition, cinnamon powder, dehydrated banana and brown sugar from a local market were used. The grains used to prepare the popped sorghum were originated from the BR 309, a white pericarp cultivar, and the grains used to prepare the extruded were from the BRS310, a red pericarp cultivar, both of them developed and grown in the experimental fields of the *Empresa Brasileira de Pesquisa Agropecuária, Embrapa* Maize and Sorghum (Sete Lagoas, MG, Brazil).

The cashew fiber was obtained from Embrapa's Tropical Agroindustry (Fortaleza, CE, Brazil). The extruded sorghum was developed by Embrapa Food Technology (Rio de Janeiro, RJ, Brazil), and was obtained according the methodology described by Vargas-Solórzano *et al.* (2014) with modification in the holder-inserts plate, which had four holes, each of 2.0 mm in diameter and 14 mm in length. The popped sorghum was prepared after thermal treatment of the grains in an electric popper (Proctor Silex, model H7340, Ciudad de México, Mexico).

Table 1 – Formulation of cereal bar

	Ingredients	%		Ingredients	%
Dry ingredients	Dehydrated banana	20	Agglutination syrup	Glucose syrup	18
	Cashew fiber	5		Brown sugar	20
	Cinnamon powder	1		Maltitol	8
	Popped sorghum	10		Soy lecithin	1
	Sorghum extrudates	10		Citric acid	0.04
				Maltodextrin	8

To cereal bar production, the binding agents were heated to 95°C with stirring until 82 °Brix, when the dry ingredients were added. Then, the bars were laminated and cut to form individual bars (7 x 3.5 x 2 cm) and wrapped in flexible film packaging of PET/LDPE/AL/LDPE (ethylene polyterephthalate, low density polyethylene, a layer of aluminum foil and low-density polyethylene) provided by Shellmar Modern Packaging Ltda. (São Bernardo do Campo, SP, Brazil).

Then, the product was subjected to physicochemical, microbiological and sensorial test to estimate the shelf life.

The moisture, protein, lipid, ash, fiber, carbohydrate and energy of cereal bar were determined according to the methodologies described below. Samples were ground for 2 minutes in a Marconi (TE 020) mill prior to analysis and were maintained in closed glass containers, under refrigeration (10 ± 2°C) until use. Neutral Detergent Fiber (NDF) was analyzed using a 0.5 g of sample with a Tecnal EQ LCC 08 fiber analyzer using the Ankon system with filter bags (Ankon, 2006). The lipids were determined in a 1 g of sample using an XT10 Ankon Fat extractor, following the AOCS protocol (AOCS, 2004). The protein content was determined by the Dumas method (Wiles *et al.*, 1998) in 0.25 g of sample using an FP-528 Leco Nitrogen Analyzer and the results were multiplied by the factor 6.25. The ash content was determined in 2 g sample, according to the AOAC (Horowitz, 2016) with calcination of the organic matter in a Q 318 D 24 Quimis muffle at 600°C for 2 hours. Moisture was determined by the gravimetric method in a 2 g sample, using a forced-air oven at 105°C for 6 hours. The carbohydrate content was calculated by difference. The caloric value (energy) was calculated using the Atwater conversion factors: 9 kcal per gram of lipid, 4 kcal per gram of carbohydrate and 4 calories per gram of protein. All results were expressed on a dry matter basis. Each analysis was performed in triplicate.

In the sensorial test, the samples of cereal bar were served to sixty three testers (36 females and 27 male, ranging between 19 and 52 years old), among graduate students and employees of the Federal University of Minas Gerais (Belo Horizonte, MG, Brazil). Also, thirty three celiac individuals (25 females and 8 males, ranging between 25 and 55 years old) members associated with ACELBRA (Brazilian Association of Celiac Individuals). These panelists had the habit of eating cereal bar.

Four cereal bars samples (0, 60, 90 and 120 days, stored under 25°C) were presented monadically in random order. Tasting was done in a sensory testing room with individual booths and controlled lighting (white). Samples (15 g) were presented to panelists in clear plastic boxes coded with three-digit random numbers. The samples were served accompanied by a glass of mineral water. The testers were invited to take part in a hedonic evaluation of the acceptability of cereal bar using a hedonichybrid scale (0 = extremely dislike; 10 = extremely like) (Villanueva *et al.*, 2005). This study was approved by the Human Ethics Research Committee at Federal University of Minas Gerais, Brazil (Nº 03591312.0.0000.5149).

Reducing and non-reducing sugars were determined according to Lane and Eynon (1934). The presence and amount of yeasts, moulds, *Bacillus cereus, Staphylococcus aureus*, Salmonella sp. and coliforms (determined at 45°C) were determined according to the Brazilian Legislation (Brasil, 2001).

The data of consumer acceptability were submitted to analysis of variance (ANOVA) and the celiac and non-celiac means scores were compared by the Tukey test at 5% probability, by using SISVAR Software, version 5.3 (Federal University of Lavras, Lavras, MG, Brazil).

Linear regression was performed considering consumers overall acceptability as a dependent variable and storage time as an explanatory variable. The end of shelf life was determined as the storage time required for the overall acceptability scores of the product to reach a predetermined value, i.g., 6.0 in a 10-point hybrid hedonic scale (Gámbaro *et al.*, 2006).

Results and discussion

The chemical composition of cereal bar is described in Table 2. The results showed high percentages of insoluble fiber and low fats, indicating that the bar has potential health benefits. The total caloric value of the cereal bar was 335.6 kcal/100 g or 100.7 kcal/30 g (one individual portion). This value was lower than the values determinate in industrialized cereal bars (360 to 440 Kcal/100g) (De Brito *et al.,* 2004).

Table 2 – Chemical composition of the cereal bar per serving size of 30g*

Component	**% (standard deviation)**	**% daily value****
Carbohydrate	77.14 ± 0.42	7.70
Insoluble fiber	6.80 ± 0.10	--
Fat	0.96 ± 0.01	0.50
Protein	4.60 ± 0.20	1.84
Ash	1.28 ± 0.03	--
Water	9.22 ± 0.17	--

n = 3.
* Serving size based on Brazilian Legislation (Brasil, 2003a).
** Percent daily values are based on a 2000-calorie diet (Brasil, 2003b).

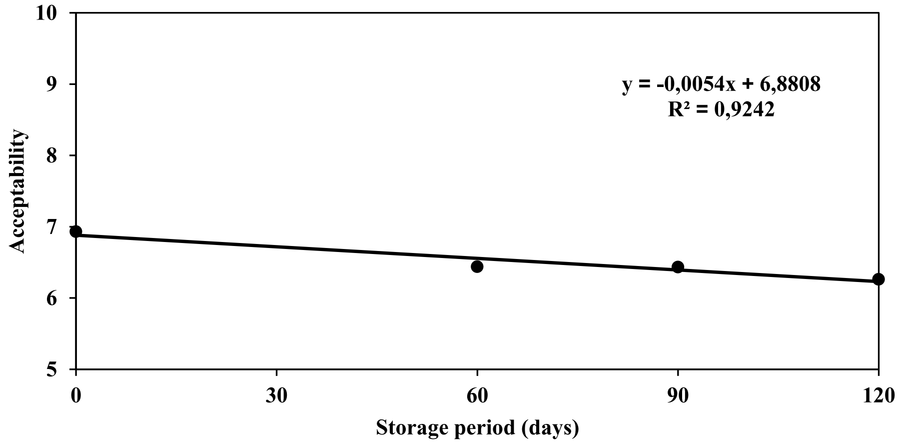
Usually, in formulations of cereal bars there are high carbohydrate contents due to the addition of honey and glucose syrup as binding agents (Agbaje *et al*., 2016). The carbohydrate contents in this study was 77.14%. In Agbaje *et al.* (2016) study with cereal bars formulated with puffed glutinous rice and selected dried foods, the carbohydrate contents obtained was lower, ranged from 58.31 to 74.59%. Probably this is due to the use of higher amount of binding agents in the cereal bar with popped and extruded sorghum. This formulation contained ingredients of different granulometry and therefore, required a greater number of binding agents, which contributed to higher carbohydrate content. However, the fat content was much lower than that found in cereal bars developed by Agbaje *et al.* (2016) (7.31 to 10.72%). Still, these researchers have found protein contents lower than this present work (3.38 to 4.04%).

According to Phimolsiripol *et al.* (2012), gluten-free products are generally of poorer quality when compared to conventional products. In general, they have low sensory quality and are poor in protein and dietary fiber. Therefore, the use of sorghum as ingredient may contribute to the improvement of the nutritional and sensorial quality of products intended for this public.

Graphic 1 shows the regression analysis of the overall acceptability and the storage period. Linear correlation was found between overall acceptability and storage period ($R^2 = 0.9242$). This linear regression was used to estimate sensory shelf life of cereal bar using 6.0 as a quality limit of the product. Thus, the shelf life was estimated in 163± 52 days.

Grizotto *et al.* (2006) and Paiva *et al.* (2012) also have found linear correlation between overall acceptability and storage time in the shelf life study of structured fruit of concentrated papaya pulp and sorghum cereal bar, respectively. In Paiva *et al.* (2012) research, the shelf life study used trained sensory panel, and the shelf life was somewhat lower: 144 days, probably because the tasters had greater sensory acuity in relation to untrained panel applied this study.

Graphic 1 – Overall acceptabilityof cereal bar stored for increasing time

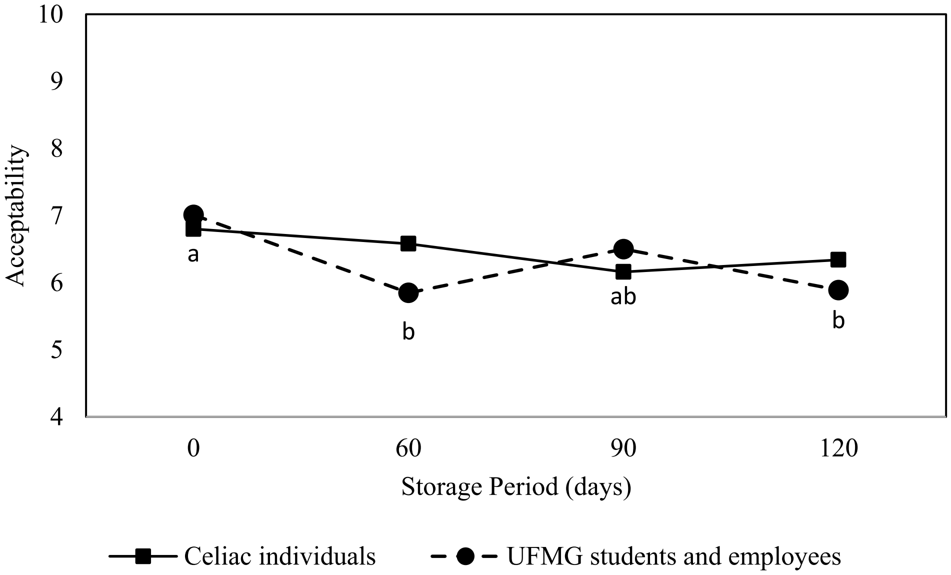


The overall acceptability scores of cereal bar stored in increasing time at 25°C are shown in Graphic 2. Data have indicated that in 120 days had a significant decrease of acceptability only to the public from the university ($p < 0.05$), what could not be verified in relation to individuals with celiac disease, although, within the same day of storage, no significant difference in acceptability of the product was noticed between celiac and non-celiac individuals.

There are few previous studies on literature comparing sensory and hedonic perception between celiac and non-celiac individuals. In the same way of this study, Laureati *et al.* (2012) also had not found significant difference between the opinion of celiac and non-celiac individuals in relation to sensory and hedonic perception of gluten free bread quality, applying the same methodology of this study. However, Giménez *et al.* (2015) found different acceptability between celiac and non-celiac individuals when they tasted Andean corn spaghetti. It shows the importance to research all the market clusters for the product.

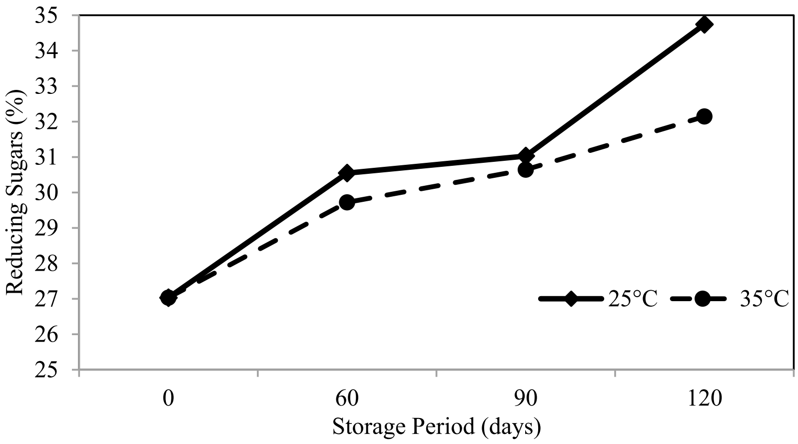
In cereal bars, reducing sugars were present in much higher concentration than non-reducing sugars, because the product was sweetened mainly with glucose syrup (Graphic 3 and 4). However, during the storage period the content of sugars changed. Reducing sugars content increased in cereal bars stored at 25°C more than in those stored at 35°C, from 27.03% to 34.74% and from 27.03% to 32.14% respectively (Graphic 3). On the other hand, the content of non-reducing sugars decreased over the storage time, from 5.65% to 3.93% at 25°C and from 5.65% to 4.03% at 35°C (Graphic 4). Probably it can be explained by a possible fermentation process that hydrolyzed saccharose into reducing sugars.

Graphic 2 – Means of acceptability scores of cereal bar stored for increasing time according celiac anduniversity public

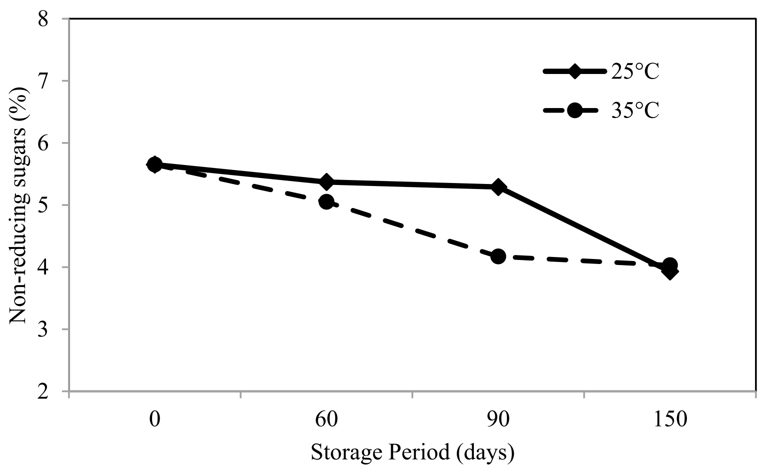


Means with different letters inthe same public are significantly different (Tukey test, $p < 0.05$).

Graphic 3 – Percentage of reducing sugars in cereal bar stored at 25° and 35°C



Graphic 4 – Percentage of non-reducing sugars in cereal bar stored at 25° and 35°C



In order to find possible indicators of consumer acceptability, a correlation analysis was performed between the percentage of overall acceptability and the content of different types of sugars (Table 3). Overall acceptability was not correlated with the increase in reducing sugars concentration nor with the decrease of non-reducing sugars, suggesting that these variables are not indicators of sensory acceptability. Su-Ah *et al.* (2018) pointed the water activity as a crucial factor for the acceptability of cereal bars during and after storage.

Table 3 – Pearson correlation coefficients between consumer acceptability and sugars content

Sugars	Consumer acceptability
Reducing sugar	0.89 ns
Non-reducing sugar	0.67 ns

ns: not significant.

In addition, the product was microbiologically stable during 120 days of storage, indicating adequate microbiological quality for consumption

Conclusions

In this study, a gluten free cereal bar made with co-products of sorghum was produced. The reducing and no-reducing sugars and the overall acceptability and was observed during 120 days of storage. The cereal bar had a good sensorial acceptability according to the public of celiac and non-celiac individuals. The product's shelf life was estimated in 163 days as sensorial acceptability limit. However, no significant correlations were observed in terms of overall acceptability and content of reducing and non-reducing sugars. Besides, sorghum co-products might be used as good alternative to manufacture gluten free cereal bars.

Acknowledgements

To Embrapa and the National Council of Technological and Scientific Development – CNPq for the financial support.

References

Agbaje, R.; Hassan, C. Z.; Norlelawati, A.; Abdul Rahman, A.; Huda-Faujan, N. 2016. Development and physico-chemical analysis of granola formulated with puffed glutinous rice and selected dried Sunnah foods. International Food Research Journal 23: 498-506.

American Oil Chemists' Society [AOCS]. 2004. Official methods and recommended practices of the American Oil Chemists' Society. Method Am 5-04: Rapid determination of oil/fat utilizing high temperature solvent extraction. 5th Ed. AOCS, Urbana, IL, US.

Ankon. Neutral Detergent Fiber in Feeds. Method 6. 2006. Available at: <https://www.ankom.com/embed-only/document/neutral-detergent-fiber-method-a2000>.

Anunciação, P.C.; De Cardoso, L. M.; Gomes, J.V.P.; Della Lucia, C. M.; Carvalho, C. W. P. De, Galdeano, M. C.; Queiroz, V.A.V.; Alfenas, R. C.G.; Martino, H. S. D.; Pinheiro Sant'Ana, H.M. 2017. Comparing sorghum and wheat whole grain breakfast cereals: sensorial acceptance and bioactive compound content. Food Chemistry 221: 984-989. Doi: https://doi.org/10.1016/j.foodchem.2016.11.065.

Awika J. M.; Rooney, L. W. 2004. Sorghum phytochemicals and their potential impact on human health. Phytochemistry 65: 1199-1221. Doi: https://doi.org/10.1016/j.phytochem.2004.04.001.

Brasil. Ministério da Saúde. Secretária de Vigilância Sanitária. Resolução RDC Nº 12 de 2 de janeiro de 2001. Diário Oficial da União, Brasília, DF, 10 jan. 2001. Available at: http://portal.anvisa.gov.br/documents/10181/2718376/%281%29RDC_12_2001_COMP.pdf/b3cb6241-6d1b-49fc-8a88-b0781a147980.

Brasil. Ministério da Saúde. Secretaria de Vigilância Sanitária. Resolução RDC Nº 359 de 23 de dezembro de 2003. Diário Oficial da União, Brasília, DF, 26 dez. 2003. Available at: http://portal.anvisa.gov.br/documents/33880/2568070/res0359_23_12_2003.pdf/76676765-a107-40d9-bb34-5f05ae897bf3.

Brasil. Ministério da Saúde. Secretaria de Vigilância Sanitária. Resolução RDC Nº 360 de 23 de dezembro de 2003. Diário Oficial da União, Brasília, DF, 26 dez. 2003. Available at: http://portal.anvisa.gov.br/documents/33880/2568070/res0360_23_12_2003.pdf/5d4fc713-9c66-4512-b3c1-afee57e7d9bc.

Chung, I. M.; Kim, M. J.; Park, D. S.; Moon, H. I.2011. Inhibition effects of the classical pathway complement of three Sorghum bicolor from South Korea. Immunopharmacologyand Immunotoxicology 33: 447-449. Doi: https://doi.org/10.3109/08923973.2010.532804.

De Brito, I. P.; Campos, J. M.; De Souza, T. F. L.; Wakiyama, C.; De Azeredo, G. A. 2004. Elaboração e avaliação global de barra de cereais caseira. Boletim do Centro de Pesquisa de Processamento de Alimentos 22: 35-50.

De Morais Cardoso, L.; Pinheiro, S. S.; Martino, H. S. D.; Pinheiro-Sant'Ana, H. M. 2017. Sorghum (Sorghum bicolor L.): Nutrients, bioactive compounds, and potential impact on human health. Critical Reviews in Food Science and Nutrition 57: 372-390. Doi: https://doi.org/10.1080/10408398.2014.887057.

Gámbaro, A.; Ares, G.; Giménez, A. 2006. Shelf-life estimation of apple-baby food. Journal of Sensory Studies 21: 101-111. Doi: https://doi-org.ez27.periodicos.capes.gov.br/10.1111/j.1745-459X.2006.00053.x.

Giménez, M.; Gámbaro, A.; Miraballes, M.; Roascio, A.; Amarillo, M.; Sammána, N.; Lobo, M. 2015. Sensory evaluation and acceptability of gluten-free Andean corn spaghetti. Journal of the Science of Food and Agriculture 95: 186-192. Doi: https://doi-org.ez27.periodicos.capes.gov.br/10.1002/jsfa.6704.

Grizotto, R. K.; Berbari, S. A. G.; Moura, S. C. S. R.; Claus, M. L. 2006. Estudo da vida-de-prateleira de fruta estruturada desidratada obtida de polpa congelada de mamão. Ciência e Tecnologia de Alimentos 26: 709-714.

Horowitz, W.2016. Official methods of analysis of the Association of Official Analytical Chemists. 20th ed. AOAC, Gaithersburg, MD, USA.

Hough, G. 2010. Sensory shelf life estimation of food products. Taylor & Francis Group, Boca Ratón, FL, USA.

Hough G.; Garitta, L. 2012. Methodology for sensory shelf-life estimation: a review. Journal of Sensory Studies 27: 137-147. Doi: https://doi-org.ez27.periodicos.capes.gov.br/10.1111/j.1745-459X.2012.00383.x.

Lane, J. H.; Eynon, L. 1934. Determination of reducing sugars by Fehling´s solution with methylene blue indicator. NormamRodge, London, United Kingdom.

Laureati, M.; Giussani, B.; Pagliarini, E. 2012. Sensory and hedonic perception of gluten-free bread: Comparison between celiac and non-celiac subjects. Food Research International 46: 326-333. Doi: https://doi.org/10.1016/j.foodres.2011.12.020.

Man, C. M. D.; Jones, A. A. 1994. Shelf life evaluation of foods. Blackie Academic & Professional, Glasgow, Scotland.

Moraes, E. A.; Natal, D. I. G.; Queiroz, V. A. V.; Shaffert, R. E.; Cecon, P. R.; Paula, S. O.; Benjamim, L. A.; Ribeiro, S. M. R.; Martino, H. S. D. 2012. Sorghum genotype may reduce low-grade inflammatory response and oxidative stress and maintains jejunum morphology of rats fed a hyperlipidic diet. FoodResearchInternational 49: 553-559. Doi: https://doi.org/10.1016/j.foodres.2012.07.029.

Paiva, C. L.; Queiroz, V. A. V.; Rodrigues, J. A. S. 2012. Estudos sensoriais para determinação da vida de prateleira de barra de cereais com pipoca de sorgo. Revista Brasileira de Milho e Sorgo 11: 302-311. Doi:http://dx.doi.org/10.18512/1980-6477/rbms.v11n3p302-311.

Paiva, C. L.; Queiroz, V. A. V.; Simeone, M. L. F.; Schaffert, R. E.; Oliveira, A. C.; Da Silva, C. S. 2017. Mineral contents in sorghum genotypes: influence of water stress. Food Chemistry 214: 400–405. Doi: https://doi.org/10.1016/j.foodchem.2016.07.067.

Phimolsiripol, Y.; Mukprasirt, A.; Schoenlechner, R. 2012. Quality improvement of rice-based gluten free bread using different dietary fibre fractions of rice bran. Journal of Cereal Science 56: 389-395. Doi: https://doi.org/10.1016/j.jcs.2012.06.001.

Prasad, M. P. R.; Rao, B. D.; Kalpana, K.; Rao, M. V.;Patil, J. V. 2015. Glycaemic index and glycaemic load of sorghum products. Journal of the Science of Food and Agriculture 95: 1626–1630. Doi: https://doi-org.ez27.periodicos.capes.gov.br/10.1002/jsfa.6861.

Queiroz, V. A. V.; Silva, C. S.; Menezes, C. B.; Schaffert, R. E.; Guimarães, F. F. M.; Guimarães, L. J. M.; Guimarães, P. E. O.; Tardin, F. D. 2015. Nutritional composition of [Sorghum bicolor (L.) Moench] genotypes cultivated without and with water stress. Journal of Cereal Science 65: 103-111. Doi: https://doi.org/10.1016/j.jcs.2015.06.018.

Queiroz, V. A. V.; da Silva Aguiar, A.; de Menezes, C. B.; de Carvalho, C. W. P.; Paiva, C. L.; Fonseca, P. C.; da Conceição, R. R. P. 2018. A low calorie and nutritive sorghum powdered drink mix: Influence of tannin on the sensorial and functional properties. Journal of Cereal Science 79: 43-49. Doi: https://doi.org/10.1016/j.jcs.2017.10.001.

Rooney, L. W.; Awika, J. M. 2005. Overview of products and health benefits of specialty sorghums. Cereal Foods World 50: 109-115.

Su-Ah, J.; Ahmed, M.; Eun, J. B. 2018. Physicochemical characteristics, textural properties, and sensory attributes of low-calorie cereal bar enhanced with different levels of saccharin during storage. Journal of Food Processing and Preservation 42: 1-7. Doi: https://doi-org.ez27.periodicos.capes.gov.br/10.1111/jfpp.13486.

Teixeira, N. C.; Queiroz, V. A. V.; Rocha, M. A.; Amorim, A. C. P.; Soares, T. O.; Monteiro, M. A. M.; Menezes, C. B.; Schaffert, R. E.; Garcia, M. A. V. T.; Junqueira, R. G. 2016. Resistant starch content among several sorghum (Sorghum bicolor) genotypes and the effect of heat treatment on resistant starch retention in two genotypes. Food Chemistry 197: 291-296. Doi: https://doi.org/10.1016/j.foodchem.2015.10.099.

Vargas-Solórzano, J. W.; Carvalho, C. W. P.; Takeiti, C. Y.; Ascheri, J. L. R.; Queiroz, V. A,V. 2014. Physicochemical properties of expanded extrudates from colored sorghum genotypes. Food Research International 55: 37-47. Doi: https://doi.org/10.1016/j.foodres.2013.10.023.

Villanueva, N. D. M.; Petenate, A. J.; Da Silva, M. A. A. P. 2005. Performance of the hybrid hedonic scale as compared to the traditional hedonic, self-adjusting and ranking scales. Food Quality and Preference 16: 691-703. Doi: https://doi.org/10.1016/j.foodqual.2005.03.013.

Wiles, P. G.; Gray, I. K.; Kissling, R. C. 1998. Routine analysis of protein by Kjeldahl and Dumas methods: review and interlaboratory study using dairy products. Journal of AOAC International 81: 620-632.