Original Article
Food Science and Technology

ISSN 0101-2061 (Print)
ISSN 1678-457X (Online)

DOI: https://doi.org/10.1590/fst.56122

Mechanical properties of *Bertholletia Excelsa* H. B. K. kernels stored in different packagings

Kênia Borges de OLIVEIRA[1]*, Osvaldo RESENDE[1], Lígia Campos de Moura SILVA[1], Juliana Aparecida CÉLIA[1], Weder Nunes FERREIRA JÚNIOR[1], Érika Gonçalves ANDRADE[1]

Abstract

Evaluate texture in relation to the hardness, fracturability, cohesiveness, elasticity and chewiness parameters of Brazil nut kernels stored in different packagings over time of 240 days. The experimental compression tests were conducted in 15 kernels for each treatment using a texturometer equipped with a load cell of 25 kg. The following parameters were used: pre-test speed: 2.0 mm s^{-1}; test speed: 0.50 mm s^{-1} and post-test speed: 0.50 mm s^{-1}; 10% compression and rest period of 2 s between the two cycles; initial load of 7 g; and data acquisition rate of 10 points per second. The data were subjected to analysis of variance (ANOVA), followed by the Scott-Knott test at 5% significance level, using R software. Storage time interfered in the moisture content, leading to the highest value initially, 4.03% w.b., and lowest value at 120 days, with an average of 2.705% w.b. The hardness values of the kernels stored in the polypropylene packaging remained the same throughout storage. The different packagings and storage times had no influence on the fracturability parameter. Polypropylene and vacuum packaging did not influence the elasticity of kernels throughout storage. Cohesiveness and chewiness showed differences between the packagings and between the storage periods.

Keywords: food; Brazil nut; quality; texture.

Practical Application: Storage of almonds in vacuum packaging, polypropylene and low-density polyethylene.

1 Introduction

IBGE data from 2019 show that Brazil produced 32,900 tons of nuts, which represented 11.1% of the economic profit generated by the exploitation of natural plant resources according to Instituto Brasileiro de Geografia e Estatística (IBGE) (Instituto Brasileiro de Geografia e Estatística, 2019). The consumption of Brazil nut kernel and its use in food production by the industry are due to its nutritional benefits, such as high selenium content, high concentration of protein, fibers and bioactive compounds, mainly phenolics, sterols and tocopherols, in addition to fatty acids (Cardoso et al., 2017).

Food packaging has the function of protecting it from damage that can occur during processing, maintaining the physical, chemical, microbiological and sensory characteristics of the products (Andrade et al., 2021).

In sensory terms, texture is one of the most important properties in solid foods and can change when food is stored. In the fresh and processed food industry, texture is used to assess product quality and acceptability, in addition to determining shelf life (Wang et al., 2022). Texture refers to the rheological and structural properties (geometric and surface) of the products, perceived by mechanical, tactile and, sometimes, visual and auditory receptors (Instituto Adolfo Lutz, 2008).

Universal texturometers are equipment used to evaluate the texture of various materials, with application of deforming forces, such as compression, shear, cutting and tension. Instrumental Texture Profile Analysis (TPA) is based on the parameters of hardness, cohesiveness, elasticity, chewiness, gumminess and resistance, obtained from the analysis of the representative curve of the product. This analysis reflects food chewing, with successive force applications, simulating the action of compression and cutting of teeth (Araújo et al., 2021).

Based on these aspects, the objective of this work was to evaluate the texture parameters in relation to the properties of hardness, fracturability, cohesiveness, elasticity and chewiness of Brazil nut kernels stored in different packagings (vacuum, polypropylene and low-density polyethylene) over time.

2 Material and methods

The experiment was carried out at the Laboratory of Post-Harvest of Plant Products of the Federal Institute of Education, Science and Technology of Goiás - IF Goiano, located in the municipality of Rio Verde, GO, Brazil.

2.1 Collection, selection and moisture content

The fruits were collected manually in a rural area, on the Itapiranema farm in the municipality of Tefé, Manaus - AM, at 28 meters of altitude relative to sea level with the geographical coordinates: Latitude 3° 19' 15" South, Longitude: 64° 43' 25' West.

Received 08 June, 2022
Accepted 15 July, 2022
[1] *Laboratório de Pós-Colheita de Produtos Vegetais, Instituto Federal Goiano, Rio Verde, GO, Brasil*
*Corresponding author: keniaborges_2008@hotmail.com

The fruits were opened to remove the nuts, which were selected by discarding the visibly damaged ones. Then, the nuts were homogenized and subjected to the determination of the initial moisture content according to the methodology of Silva et al. (2022), in an oven with forced air circulation at 105 °C for 31 h, until reaching constant mass. The initial average moisture content of the nuts was 11.02% on a wet basis (w.b.).

2.2 Drying

After determining the water content, the nuts were homogenized and placed in rectangular stainless-steel trays (20.5 x 30.5 x 4.0 cm) with layer thickness of approximately 2.0 cm in three replicates and subjected to drying in an oven with forced air circulation at 60 °C, until reaching a moisture content of 4.03% ± 0.53 (w.b.).

A guillotine-shaped blade was used to remove the woody integument and obtain the kernels. The kernels were packed in vacuum, polypropylene (PP) and low-density polyethylene (LDPE) packagings, containing 15 units in each packaging and stored.

2.3 Storage

Storage was carried out between July 2020 and February 2021 in a laboratory environment with an average temperature of 29.78 ± 1.13 °C and relative humidity of 48.69 ± 8.95%, monitored using a data logger (LOGBOX-RHT-LCD model), for a period of eight months (zero, 30, 60, 90, 120, 150, 180, 210 and 240 days), with analyses performed every 30 days.

2.4 Experimental trials

The experimental tests of kernel compression were conducted individually in a universal test machine (TA Hdi Texture Analyser) equipped with a load cell of 25.0 kg.

The probe used for compression was the 38.1-mm-diameter acrylic cylindrical probe TA 4/100 with pre-test speed of 2.0 mm s^{-1}, test speed of 0.50 mm s^{-1} and post-test speed of 0.50 mm s^{1}, 10% compression and rest period of 2 s between the two cycles, with initial load of 7 g and data acquisition rate of 10 points per second.

Measurements of height, length and thickness were made on the beans before compression using a digital caliper. Uniaxial compression between two parallel plates was performed using 15 kernels, in the natural resting position. To determine the texture profile, the properties of hardness, fracturability, elasticity, cohesiveness and chewiness were analyzed, indicated in force versus deformation curves. The typical curve of texture profile analysis can be observed in Figure 1.

After applying the cycle with two successive compressions performed by the texturometer, the values of the parameters were extracted from the curve: Hardness (Maximum force required to compress the sample, H), Fracturability (Recorded when two force peaks are identified in the first cycle of analysis, and the fracture corresponds to the first one), Elasticity (Ability of the sample to recover the original shape after the deformation force is removed), Cohesiveness (Extent in which the sample can be deformed before rupture, A2/A1), Chewiness (Work required to chew a solid sample to the steady state of swallowing, elasticity x gumminess) (Chen & Opara, 2013).

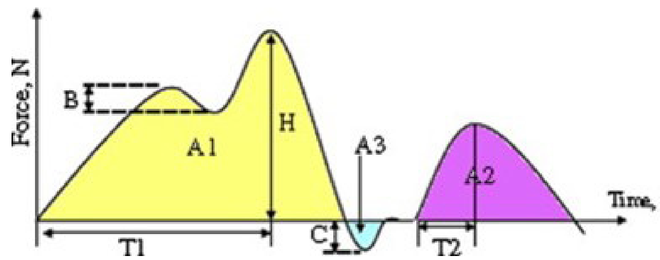

Figure 1. Characteristic curve of TPA. Hardness = H, Cohesiveness = A2/A1, Fracturability = B, Elasticity = T2/T1, Chewiness = H x A2/A1 x T2/T1. Source: Chen & Opara (2013).

2.5 Experimental design and statistical analysis

The experiment was conducted in a completely randomized design in a 3 x 9 factorial arrangement, corresponding to three packagings (PP, vacuum, LDPE) and nine storage times (zero, 30, 60, 90, 120, 150, 180, 210 and 240 days), with 15 replicates. The data obtained were subjected to analysis variance (ANOVA), followed by the Scott-Knott test at 5% significance level, using the statistical program R version 4.1.0.

3 Results and discussion

The means of temperature, 29.78 ± 1.13 °C, and relative humidity, 48.69 ± 8.95%, as a function of the storage time along which the Brazil nut kernels were stored.

The packagings had no effect on the moisture content of the kernels, which had average values of 3.42 ± 1.37% (w.b.) for polypropylene packaging (PP), 3.56 ± 1.19% (w.b.) for vacuum packaging and 3.41 ± 0.97% (w.b.) for low-density polyethylene (LDPE).

Sousa et al. (2012), when evaluating packaging technology and food conservation in terms of physical, chemical and microbiological aspects, stated that plastic packagings may vary in relation to the barrier to the passage of gases, including water vapor, depending on the thickness and type of polymer that constitutes the packaging. These factors may justify the fact that the analyzed packagings had lower permeability to water vapor and, consequently, maintain the kernel masses during storage.

The results of the present study for polypropylene packaging were similar to those reported by Lima & Bruno (2007), who evaluated the stability of cashew nut kernel paste and observed that the type of packaging used in the study had no influence on moisture content and, therefore, cashew nut kernel paste can be stored for 10 months, in glass or polypropylene packaging.

Reis et al. (2019) evaluated fresh baru kernels stored in different packagings of polypropylene (PP), polyvinyl chloride + expanded polystyrene (PVC + EPS), low-density polyethylene (LDPE), polyethylene terephthalate (PET) and control (expanded polystyrene tray without cover) and proved that the packagings reduced the water gain of kernels during storage, some of them more than others. These results differ from those obtained in the present study, in which there was no influence packaging on the moisture content.

Table 1 shows the moisture contents of Brazil nut kernels stored for eight months.

The nuts showed the highest moisture content (4.03% w.b.) at time zero, differing from the other times, while the lowest moisture content was observed at 120 days of storage, 2.71% of w.b., a period in which the greatest variation between temperature and relative humidity was recorded, justifying the water loss by the kernels, which are hygroscopic.

The same behavior was described by Goldfarb & Queiroga (2013), who studied seed storage and reported that the temperature and relative humidity of the storage environment directly influenced the moisture content of the seeds, due to their hygroscopic character.

Silva & Marsaioli (2006), when evaluating the texture profiles of vacuum-packed macadamia nut kernels, observed that the kernels showed no major changes in moisture content during storage for six months under ambient conditions ≈ 25 ± 3 °C. According to the present study, this is probably due to the way in which the samples were vacuum-packed in transparent packaging (nylon/low-density polyethylene (LDPE) compound).

Table 2 shows the hardness values of Brazil nut kernels stored in different packagings for eight months.

Hardness is the maximum force required to compress the sample (Chen & Opara, 2013). Among the packagings, it was verified that only kernels stored in the LDPE packaging had lower hardness, in the period of 210 days, with an average of 190.20 N. When observing the effect of storage time, the PP packaging led to no change in hardness, showing more efficient maintenance of this attribute; however, the vacuum and LDPE packagings led to variation from 174.08 to 246.74 N and from 174.08 to 243.78 N, respectively, over the storage time.

Guiné et al. (2014) emphasize that, in the case of dried fruits such as kernels, which already are characteristically hard, an increase in hardness can compromise and determine a high degree of product loss, making it essential that storage conditions do not produce significant changes in this attribute. The PP packaging maintained the storage condition and caused no change in hardness.

The results reported by Reis et al. (2019) were similar for PP packaging and different for LDPE packaging. These authors observed, in the evaluation of fresh baru kernels stored in different packagings of polypropylene (PP), polyvinyl chloride + expanded polystyrene (PVC + EPS), low-density polyethylene (LDPE), polyethylene terephthalate (PET) and control (expanded polystyrene tray without cover), that the hardness of the kernels did not vary for the evaluated treatments due to the adequate protection against environmental humidity provided by the packaging used.

Fracturability exists when two peaks are recorded during the first cycle and is given by the force recorded at the first peak (Chen & Opara, 2013). Regarding the fracturability parameter of Brazil nut kernels stored in different packagings for eight months, it was observed that there was no influence of the factors ($p > 0.05$).

Table 3 shows the fracturability values (Frac) of Brazil nut kernels stored for eight months in different packagings.

Unlike the present study, Guiné et al. (2014) observed variation in the fracturability parameter for kernels stored in linear low-density polyethylene (LLDPE) and low-density polyethylene (LDPE) packagings at 30 °C and 90% relative humidity.

For Gusmão et al. (2016), fracturability is the tendency of the product to show fracture, breakage or disintegration due to the application of an amount of force on it. Such characteristic is exhibited by a product of high degree of hardness and low degree of cohesion, commonly being the textural property observed

Table 1. Mean values of moisture content (WC) of Brazil nut kernels (% w.b.) stored for eight months.

Variable	Time (days)								
	0	30	60	90	120	150	180	210	240
WC	4.03 ± 2.88 a	3.71 ± 0.44 b	3.29 ± 0.56 c	3.12 ± 0.60 c	2.71 ± 0.54 d	3.63 ± 0.45 b	3.34 ± 0.72 c	3.50 ± 0.33 b	3.58 ± 0.82 b

Means followed by the same letter in the row do not differ from each other at 5% probability level.

Table 2. Mean values of hardness (N) of Brazil nut kernels stored in different packagings for eight months.

Time (days)	Packaging		
	PP	Vacuum	LDPE
0	174.08 ± 56.33 aA	174.08 ± 56.33 aB	174.08 ± 56.33 aB
30	225.68 ± 42.45 aA	196.69 ± 62.00 aB	243.78 ± 52.64 aA
60	214.84 ± 65.37 aA	246.74 ± 44.16 aA	237.88 ± 50.76 aA
90	234.15 ± 53.67 aA	241.40 ± 48.13 aA	235.65 ± 49.36 aA
120	205.71 ± 42.32 aA	189.06 ± 59.65 aB	183.90 ± 65.59 aB
150	222.67 ± 51.71 aA	216.85 ± 67.22 aA	212.45 ± 31.52 aA
180	216.19 ± 29.39 aA	227.72 ± 149.73 aA	229.10 ± 35.14 aA
210	251.17 ± 43.58 aA	234.21 ± 38.20 aA	190.20 ± 42.92 bB
240	237.03 ± 32.00 aA	217.81 ± 48.34 aA	179.37 ± 34.16 aB

Means followed by the same lowercase letter in the row and uppercase letter in the columns do not differ from each other at 5% probability level.

Table 3. Mean values of fracturability (N) of Brazil nut kernels stored in different packagings for 8 months.

Parameter	Packagings								
Frac (N)	PP			Vacuum			LDPE		
	147.74 ± 43.73 a			154.28 ± 47.96 a			148.83 ± 48.48 a		
	Time (days)								
	0	30	60	90	120	150	180	210	240
	150.49 ± 39.11 a	142.88 ± 56.36 a	159.53 ± 50.85 a	152.35 ± 38.06 a	130.37 ± 54.22 a	152.68 ± 42.62 a	149.60 ± 53.64 a	154.02 ± 41.39 a	159.36 ± 52.93 a

Means followed by the same letter in the row do not differ from each other at 5% probability level.

in "dry" products. This behavior was observed in the present study. Table 4 shows the elasticity values of Brazil nut kernels stored in different packagings for eight months.

Elasticity is the ability of a sample to recover its original shape after the deformation force is removed (Chen & Opara, 2013). In the present study, it was possible to verify the variation of this attribute at 30 days of storage between the different packagings and as a function of the effect of storage time, with the LDPE packaging having the highest elasticity (2.80 mm). On the other hand, the PP and vacuum packagings showed no changes in elasticity, both of which maintained this attribute during storage.

Hernandez-Chavez et al. (2019) when evaluating the effect of corn flour tortillas, reported that, a food with high elasticity has a rubbery texture, while a product with low elasticity is frangible, which shows that the nuts in the present study have low elasticity, being considered a frangible food. Cardoso et al. (2022) observed low values of elasticity and cohesion in moin-moin, thus confirming the brittle, brittle nature of the product.

Lima (2002), when evaluating the shelf life of cashew nut kernels in commercial packaging, reported the importance of the effect of the moisture content on their texture and stated that the kernel with high moisture content becomes elastic and little appreciated by the consumer. Table 5 shows the cohesiveness values of Brazil nut kernels stored in different packagings for eight months.

Cohesiveness is the extent to which the sample can be deformed before rupture (Chen & Opara, 2013). There was a difference between the different packagings in the cohesiveness of kernels at 60, 90,180 and 240 days. For the storage time, there was difference; the PP packaging showed a variation from 0.07 to 0.17, and the vacuum and LDPE packagings had the same variation, from 0.07 to 0.17, but at different times.

A lower cohesiveness indicates less force necessary to stretch a food until it is broken (Szczesniak, 2002). The variation of this parameter was the same for kernels packed in PP, vacuum and LDPE. Table 6 shows the chewiness values of Brazil nut kernels stored in different packagings for eight months.

Chewiness is the work required to chew a solid sample to a steady state swallowing (Chen & Opara, 2013). The kernels stored in different packagings showed difference, and it was possible to verify lower chewiness for kernels stored in LDPE packagings at 30 days and vacuum at 240 days.

Table 4. Mean values of elasticity (mm) of Brazil nut kernels stored in different packagings for eight months.

Time (days)	Packagings		
	PP	Vacuum	LDPE
0	1.24 ± 1.74 aA	1.24 ± 1.74 aA	1.24 ± 1.74 aB
30	1.55 ± 0.69 bA	1.35 ± 1.50 bA	2.80 ± 2.85 aA
60	1.09 ± 0.18 aA	1.22 ± 0.52 aA	1.13 ± 1.41 aB
90	0.73 ± 2.41 aA	1.16 ± 0.51 aA	1.13 ± 0.68 aB
120	1.11 ± 1.16 aA	1.07 ± 2.39 aA	1.21 ± 0.33 aB
150	1.19 ± 1.13 aA	1.15 ± 0.94 aA	1.21 ± 2.77 aB
180	1.22 ± 1.16 aA	1.07 ± 1.63 aA	1.32 ± 1.45 aB
210	1.25 ± 2.12 aA	1.29 ± 0.13 aA	1.37 ± 1.00 aB
240	1.30 ± 1.50 aA	1.27 ± 1.44 aA	1.15 ± 0.91 aB

Means followed by the same lowercase letter in the row and uppercase letter in the columns do not differ from each other at 5% probability level.

Table 5. Mean values of cohesiveness of Brazil nut kernels stored in different packagings for eight months.

Time (days)	Packagings		
	PP	Vacuum	LDPE
0	0.17 ± 0.05 aA	0.17 ± 0.05 aA	0.17 ± 0.05 aA
30	0.14 ± 0.07 aB	0.15 ± 0.05 aA	0.12 ± 0.02 aA
60	0.09 ± 0.06 bC	0.13 ± 0.06 aA	0.10 ± 0.06 bB
90	0.07 ± 0.06 bC	0.11 ± 0.05 aB	0.10 ± 0.04 aB
120	0.09 ± 0.03 aC	0.10 ± 0.03 aB	0.07 ± 0.03 aB
150	0.11 ± 0.03 aC	0.10 ± 0.02 aB	0.11 ± 0.04 aB
180	0.13 ± 0.04 aB	0.07 ± 0.06 bB	0.11 ± 0.05 aB
210	0.12 ± 0.03 aB	0.13 ± 0.03 aA	0.13 ± 0.06 aA
240	0.17 ± 0.06 aA	0.09 ± 0.03 bB	0.14 ± 0.04 aA

Means followed by the same lowercase letter in the row and uppercase letter in the columns do not differ from each other at 5% probability level.

Regarding the effect of storage time, the values varied from 57.37 to 15.24 mJ in the PP packaging, from 46.68 to 23.05 mJ in the vacuum packaging, and from 36.24 to 16.98 mJ in the LDPE packaging.

Similar behavior was reported by Silva & Marsaioli (2006), who evaluated the texture profiles of macadamia nut kernels in vacuum packaging and stored for six months and observed variation in chewiness because the kernels had high lipid content.

Freitas & Naves (2010) observed the chemical composition of nuts and seeds and verified lipid contents of 64.94 $g.100^{-1}$ and 66.16 $g.100^{-1}$ for Brazil nuts and macadamia nuts, respectively.

Table 6. Mean values of chewiness (mJ) of Brazil nut kernels stored in different packagings for eight months.

Time (days)	Packagings		
	PP	Vacuum	LDPE
0	36.24 ± 93.11 aB	36.24 ± 93.11 aA	36.24 ± 93.11 aA
30	48.26 ± 36.84 aA	46.68 ± 25.83 aA	28.95 ± 88.30 bA
60	23.40 ± 24.85 aC	36.55 ± 20.98 aA	23.80 ± 30.03 aB
90	15.24 ± 46.85 aC	23.05 ± 13.95 aB	23.02 ± 12.52 aB
120	23.73 ± 12.69 aC	27.25 ± 61.65 aB	16.98 ± 10.00 aB
150	30.15 ± 17.66 aC	31.85 ± 20.85 aA	36.17 ± 50.41 aA
180	30.17 ± 36.58 aC	23.34 ± 17.99 aB	34.65 ± 46.07 aA
210	38.77 ± 64.32 aB	36.18 ± 10.14 aA	37.38 ± 25.20 aA
240	57.37 ± 43.55 aA	23.94 ± 46.72 bB	34.40 ± 24.02 bA

Means followed by the same lowercase letter in the row and uppercase letter in the columns do not differ from each other at 5% probability level.

That is, the lipid content of Brazil nut kernel may have been the main factor for the variation in its chewiness.

4 Conclusion

PP and vacuum packagings are the most suitable for the storage of Brazil nut kernels, because they were the ones that maintained the parameters of hardness, fracturability and elasticity without major changes during eight months of storage. Thus, the packaging under study can be characterized as a potential product used by the food industry in the commercialization of nuts aiming at shelf life.

However, further studies can be conducted to complement the understanding of the parameters evaluated.

Acknowledgements

The authors extend thanks to IF Goiano, CAPES, FAPEG, FINEP and CNPq for their financial support, which was indispensable to the execution of this study.

References

Andrade, A. P., Souza, A. L. R., Souza, J. R. S. C., & Melo, N. R. (2021). Food contamination by migration of packaging components: cases of occurrence. *Research, Society and Development*, 10(2), e39710211411. http://dx.doi.org/10.33448/rsd-v10i2.11411.

Araújo, L. F., Navarro, L. A. O., Coelho, R. R. P., Silva, E. V., Silva, O. S., & Felix, R. A. A. R. (2021). *Análise físico-química de alimentos*. Nova Xavantina: Pantanal Editora. http://dx.doi.org/10.46420/9786588319512.

Cardoso, B. R., Duarte, G. B. S., Reis, B. Z., & Cozzolino, S. M. F. (2017). Brazil nuts: nutritional composition, health benefits and safety aspects. *Food Research International*, 100(Pt 2), 9-18. http://dx.doi.org/10.1016/j.foodres.2017.08.036. PMid:28888463.

Cardoso, L. A., Greiner, R., Silva, C. S., Maciel, L. F., Santos, L. F. P., & Almeida, D. T. (2022). Small scale market survey on the preparation and physico-chemical characterstics of moin-moin: a traditional ready-to-eat cowpea food from Brazil. *Food Science and Technology*, 42, e59920. http://dx.doi.org/10.1590/fst.59920.

Chen, L., & Opara, U. L. (2013). Approaches to analysis and modeling texture in fresh and processed foods – a review. *Journal of Food Engineering*, 119(3), 497-507. http://dx.doi.org/10.1016/j.jfoodeng.2013.06.028.

Freitas, J. B., & Naves, M. M. V. (2010). Composição química de nozes e sementes comestíveis e sua relação com a nutrição e saúde. *Revista de Nutrição*, 23(2), 269-279. http://dx.doi.org/10.1590/S1415-52732010000200010.

Goldfarb, M., & Queiroga, V. P. (2013). Considerações sobre o armazenamento de sementes. *Tecnologia e Ciência Agropecuária*, 7, 71-74.

Guiné, R. P. F., Almeida, C. F. F., & Correia, P. M. R. (2014). Efeito da embalagem nas propriedades físico-químicas de amêndoas durante o armazenamento. *Journal of Hygienic Engineering and Design*, 8, 82-87.

Gusmão, R. P., Cavalcanti-Mata, M. E. R. M., Duarte, M. E. M., & Gusmão, T. A. S. (2016). Particle size, morphological, rheological, physicochemical characterization and designation of minerals in mesquite flour (*Proposis julifrora*). *Journal of Cereal Science*, 69, 119-124. http://dx.doi.org/10.1016/j.jcs.2016.02.017.

Hernandez-Chavez, J. F., Guemes-Vera, N., Olguin-Pacheco, M., Osorio-Diaz, P., Bello-Perez, L. A., & Totosaus-Sanchez, A. (2019). Effect of lupin flour incorporation of mechanical properties of corn flour tortillas. *Food Science and Technology*, 39(3), 704-710. http://dx.doi.org/10.1590/fst.06518.

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

Instituto Brasileiro de Geografia e Estatística – IBGE. (2019). Produção da extração vegetal e da silvicultura 2019. *PEVS*, 34, 1-8.

Lima, J. R. (2002). *Vida de prateleira de amêndoas de castanha de caju em embalagens comerciais* (Comunicado Técnico, No. 76, pp. 1-3). Fortaleza: Embrapa Agroindústria Tropical.

Lima, J. R., & Bruno, L. M. (2007). Estabilidade de pasta de amêndoa de castanha de caju. *Food Science and Technology*, 27(4), 816-822. http://dx.doi.org/10.1590/S0101-20612007000400023.

Reis, V. B. S. X., Campos, S. J., Araujo, K. K. S., Melo, P. C., & Reis, J. L. (2019). Avaliação de amêndoas de baru in natura armazenadas em diferentes embalagens. *Revista de Ciências Agrárias*, 42(2), 539-546.

Silva, F. A., & Marsaioli, A. Jr. (2006). Perfil de textura de amêndoas de noz macadâmia (Macadamia integrifolia) secas com aplicação de energia de microondas e ar quente. *Revista Ciências Exatas e Naturais*, 8(2), 189-199.

Silva, P. C., Resende, O., Ferreira, W. N. Jr., Silva, L. C. M., Quequeto, W. D., & Silva, F. A. S. (2022). Drying kinetics of Brazil nuts. *Food Science and Technology*, 42, e64620. http://dx.doi.org/10.1590/fst.64620.

Sousa, L. C. F. S., Sousa, J. S., Borges, M. G. B., Machado, A. V., Silva, M. J. S., Ferreira, R. T. F. V., & Salgado, A. B. (2012). Tecnologia de embalagens e conservação de alimentos quanto aos aspectos físico, químico e microbiológico. *Agropecuária Científica no Semi-Árido*, 8(1), 19-27.

Szczesniak, A. S. (2002). Texture is a sensory property. *Food Quality and Preference*, 13(4), 215-225. http://dx.doi.org/10.1016/S0950-3293(01)00039-8.

Wang, S., Guo, L., Miao, Z., Ma, H., & Melnychuk, S. (2022). Effects of maternal vitamin D3 status on quality characteristics of pork batters in offspring pigs during cold storage. *Food Science and Technology*, 42, e102021. http://dx.doi.org/10.1590/fst.102021.