Revista Ciência Agronômica, v. 49, n. 4, p. 708-714, out-dez, 2018
Centro de Ciências Agrárias - Universidade Federal do Ceará, Fortaleza, CE
www.ccarevista.ufc.br

Technical Article
ISSN 1806-6690

Vegetal burgers of cashew fiber and cowpea: formulation, characterization and stability during frozen storage[1]

Hambúrgueres vegetais de fibra de caju e feijão-caupi: formulação, caracterização e estabilidade durante armazenamento congelado

Janice Ribeiro Lima[2]*, Deborah dos Santos Garruti[3], Terezinha Feitosa Machado[3] and Ídila Maria da Silva Araújo[3]

ABSCTRACT - This work aimed to obtain a vegetable burger from the cashew juice production residue (fiber) and cowpea that are two abundant materials in Northeast Brazil. Fiber was washed and pressed in an expeller for five times. Cowpea was soaked in water and, after skin removal, ground to obtain a paste. Hamburgers were made by mixing the cashew fiber, the cowpea paste, and the ingredients used in traditional burger recipes, then shaped and frozen. Four sensory tests were performed to define: (1) the need of cooking the cowpea paste with the other ingredients; (2) the fiber/paste proportion; (3) ingredients to enhance the sensory characteristics; (4) burger acceptance. The resultant formulation had 29.3% of cashew fiber, 29.3% of cowpea paste, 25.1% of tomato, 6.8% of onion, 5.3% of sweet pepper, 1.3% of garlic, 0.1% of black pepper, 0.2% of dehydrated parsley, 1.2% of salt and 1.4% of corn oil. The sensory acceptance was 7.8 in a 9-point hedonic scale. Proximate composition was 71.08% moisture, 2.07% ashes, 4.86% proteins, 1.19% lipids and 20.79% total carbohydrates. Stability was evaluated during frozen storage (-18 ºC) for 180 days. In this period, acidity increased and pH and ascorbic acid decreased. As to color, a* and b* values increased, indicating that the burgers became more orange/brown. The burger was considered microbiologically safe and shelf-stable for at least 6 months.

Key words: *Anacardium occidentale* L.. *Vigna unguiculata* L.. By-products. Shelf life.

RESUMO - Esse trabalho teve como objetivo obter hambúrguer vegetal a partir do resíduo da extração do suco de caju (fibra) e de feijão caupi, que são materiais abundantes na região Nordeste do Brasil. A fibra foi lavada e prensada em *expeller* por cinco vezes. O caupi foi macerado em água e após remoção da casca, moído para obtenção de pasta. Os hambúrgueres foram obtidos pela mistura da fibra, da pasta de caupi e de outros ingredientes usados em receitas tradicionais, moldados e congelados. Quatro testes sensoriais foram usados para definir: (1) necessidade de cozimento da pasta de caupi com os outros ingredientes; (2) a proporção fibra/pasta de caupi; (3) ingredientes para melhorar as características sensoriais; (4) aceitação do hambúrguer. A formulação obtida continha 29,3% de fibra de caju, 29,3% de pasta de caupi, 25,1% de tomate, 6,8% de cebola, 5,3% de pimentão, 1,3% de alho, 0,1% de pimenta do reino, 0,2% de salsinha desidratada, 1,2% de sal e 1,4% de óleo de milho. A aceitação sensorial foi 7,8 em escala hedônica de nove pontos. A composição centesimal foi 71,08% de umidade, 2,07% de cinzas, 4,86% de proteínas, 1,19% de lipídeos e 20,79% de carboidratos totais. A estabilidade foi avaliada durante armazenamento congelado (-18 ºC) por 180 dias. Nesse período, a acidez aumentou e o pH e o ácido ascórbico diminuíram. Com relação à cor, os valores de a* e b* aumentaram, indicando que os hambúrgueres ficaram mais laranjas/marrons. O hambúrguer foi considerado seguro microbiologicamente e estável por pelo menos seis meses.

Palavras-chave: *Anacardium occidentale* L.. *Vigna unguiculata* L.. Subprodutos. Vida-de-prateleira.

DOI: 10.5935/1806-6690.20180080
* Corresponding author
Received for publication on 11/03/2016; approved on 16/01/2017
[1]Pesquisa financiada pela Embrapa Agroindústria Tropical, parte do projeto SEG 03.11.01.016.00.00
[2]Embrapa Agroindústria de Alimentos, Av. das Américas, 29501, Guaratiba, Rio de Janeiro-RJ, Brasil, 23.020-470, janice.lima@embrapa.br
[3]Embrapa Agroindústria Tropical, Rua Doutora Sara Mesquita, 2270, *Campus* do Pici, Fortaleza-CE, Brasil, 60.511-110, deborah.garruti@embrapa.br, terezinha.feitosa@embrapa.br, idila.araujo@embrapa.br

INTRODUCTION

The juice is the most important product obtained from the cashew apple (*Anacardium occidentale* L.) and its extraction generates a residue called cashew fiber, which represents 20 to 40% of the apple weight (ABREU *et al*., 2013; KUILA *et al*., 2011). The cashew apple fiber is usually used as animal feed (DANTAS FILHO *et al*., 2007; RAMOS *et al*., 2006) or even in ethanol production (CORREIA *et al*., 2013; LIMA *et al*., 2012; ROCHA *et al*., 2014), however, some authors have reported its use for human consumption, mainly because it is 12% dietary fibers (PINHO *et al*., 2011a). Good sensory results were obtained by adding 8 to 15% of dry cashew fiber in cookies (MATIAS *et al*., 2005). It was also reported the replacement of up to 10% of meat by dried cashew fiber in burgers without any sensory changes (PINHO *et al*., 2011b). Previous studies revealed that burgers made exclusively from cashew fiber had medium sensory acceptance (5.9 in a 9-point hedonic scale) and low protein value (5%) (LIMA, 2008).

On the other hand, cowpea is abundant in Brazil and could be used to enhance palatability and protein value of burgers made from cashew apple fiber. Cowpea (*Vigna unguiculata* L. Walp) is an annual legume that is commonly known as southern pea, black-eyed pea, alubia, caupi, tape or frijole (AVANZA *et al*., 2013). In Brazil, cowpea is frequently produced by small and medium size farmers for either personal consumption or trade. Cowpea protein content ranges from 20 to 30% (ADEGUNWA *et al*., 2012; AVANZA *et al*., 2013; CARVALHO *et al*., 2012; GIAMI, 2005; VASCONCELOS *et al*., 2010).

Therefore, the objective of this work was to obtain a vegetable burger from the cashew juice production residue (fiber) mixed with cowpea (protein source) and evaluate its composition, sensory acceptance, and stability during 180 days of frozen storage (-18 ºC).

MATERIAL AND METHODS

Ingredients

The residue from the cashew apple juice production (cashew apple fiber) was obtained at a factory located in Fortaleza city, Northeastern region of Brazil. The cashew fiber was washed and pressed in an expeller (Incomap 300, Fortaleza, Brazil) for five times in order to reduce size and acidity. At each time, water was added in the proportion of 1:1 (w:w). Cowpea was obtained from local suppliers (Fortaleza, CE, Brazil), soaked in water for 2 hours and, after skin removal, crushed to obtain a paste. The other ingredients were purchased at the local market.

Defining the vegetal burgers formulation

Four consecutive sensory tests were performed to define the burger formulation. Preliminary tests indicated that the mixture of cashew apple fiber and cowpea paste should constitute 55.2% of the burger formulation. The other ingredients were tomato (21.2%), onion (6.4%), sweet pepper (7.4%), garlic (1.3%), salt (0.9%), corn oil (1.3%), and water (6.3%). The ingredients were cooked all together, shaped (80 g per unit), packed in polyethylene bags and frozen.

Sensory judges were non-smokers and used to consuming burgers occasionally. Before the analysis, burgers were pan fried with 10 mL of corn oil for 5 minutes, alternating cooking sides. Burgers were cut in three pieces, each piece was placed in small plastic containers coded with random three-digit numbers and presented in a balanced order. Judges were instructed to consume the sample and rinse the mouth with water (room temperature) between sample evaluations. Tests were performed in individual acclimatized booths (24 ºC) (MEILGAARD; CIVILLE; CARR, 1999).

At first, a paired preference test applied to 40 judges was used to verify the need of cooking the cowpea paste together with the other ingredients. Burgers were prepared using cashew fiber and cowpea paste in the proportion of 3:1. Judges were asked to choose between burgers made with cooked and uncooked cowpea paste. Choice was compulsory, with a “no preference” option not being allowed. The results were analyzed using the critical number of correct responses in a two-sided directional difference test table (α=0.05) (MEILGAARD; CIVILLE; CARR, 1999).

Next, a ranking test applied to 48 judges was used to verify the preference among three formulations made with different cashew apple fiber/cowpea paste proportions (60/40, 50/50, 40/60). Judges were asked to rank the samples from the least (n° 1) to the most preferred (n° 3), and the results were analyzed by Friedman test, using Newell and MacFarlane (1987) tables.

Thirdly, a focus group meeting, involving eight professionals from the gastronomy course, was held to gather opinions on what ingredients could be changed in order to enhance the burgers’ sensory characteristics.

Finally, an acceptance test was applied to 50 judges to verify the overall acceptability of burgers using a structured 9-point hedonic scale ranging from 1 (extremely dislike) to 9 (extremely like). Judges were also asked about their purchase intent using a structured 5-point scale ranging from 1 (I would certainly not buy it) to 5 (I would certainly buy it). Results were presented as frequency histograms.

Physicochemical analysis of burgers

Burgers formulated according to the results obtained previously were analyzed for moisture, ash, lipid and protein contents (ASSOCIATION OF OFFICIAL ANALYTICAL CHEMISTS, 1997). Total carbohydrate content was estimated by the difference from other components: 100 - [weight in grams (water + proteins + lipids + ashes) in 100 g of food]. Analyses were performed with three repetitions and results were presented as means and standard deviations. The energy value was calculated using 4 kcal g^{-1} for carbohydrates and proteins and 9 kcal g^{-1} for lipids (BRASIL, 2003).

Stability of burgers

Burgers were prepared, packed in polyethylene bags (80 g), sealed and frozen (-18 ºC). The stability test (acidity, pH, ascorbic acid content, color, sensory acceptance and microbiological quality) was carried out under freezing temperature (-18 ºC), at about 40 day intervals, up to 180 days.

Total titratable acidity, pH and ascorbic acid (2,6-dichloroindophenol titrimetric method) were determined according to the ASSOCIATION OF OFFICIAL ANALYTICAL CHEMISTS guidelines (1997). The color was assessed using a colorimeter (Chroma Meter CR-400, Konica Minolta Sensing Inc., Osaka, Japan) to determine the L*a*b* values. Analyses were performed in triplicates.

Sensory acceptability tests were carried out with the burger samples by an untrained 48-member panel consisting of employees and students who worked at Embrapa Tropical Agroindustry. Judges were not necessarily the same at the time of each evaluation; they were non-smokers and consumed burgers occasionally. Burgers were pan fried, as described above, and approximately 20 g of burger were placed in small plastic containers coded with random three-digit numbers. Judges used a 9-point hedonic structured scale, where 9 was extremely like and 1 was extremely dislike for the overall acceptability of samples (MEILGAARD; CIVILLE; CARR, 1999). The tests were performed in individual acclimatized booths (24 °C) with daylight like illumination.

Results from acidity, pH, ascorbic acid content, color and sensory acceptance were submitted to regression analysis using the SAS statistical program for Windows system (STATISTICAL ANALISYS SYSTEM, 2009) and presented as graphics.

The microbiological quality of samples was analyzed by the determination of fecal coliforms, *Staphylococcus aureus* and *Salmonella* sp., according to the American Public Health Association guidelines (DOWNES; ITO, 2001). Analyses were performed in triplicates.

RESULTS AND DISCUSSION

Vegetal burger formulation

For the preference test used to choose between cooked and uncooked cowpea paste, the minimum number of agreeing judgments to establish significance (n=40, α=0.05) is 27. The number of judges that preferred the cooked sample was 23 and the number that preferred the uncooked was 17 (difference = 6), indicating that no preference was observed between the samples. Consequently, cooking the cowpea paste with the other ingredients was the procedure chosen for the next step, given that such procedure made burgers easier to mold. Furthermore, heating can improve the nutritive value of legumes by decreasing the levels of anti-nutrients and increasing protein digestibility (ADEGUNWA *et al*., 2012; AVANZA *et al.*, 2013; CARVALHO *et al.*, 2012; GIAMI, 2005; VASCONCELOS *et al.*, 2010).

The ranking scores for the formulations with different cashew apple fiber and cowpea paste proportions are presented in Table 1. No preference was observed among the burgers, so the cashew fiber/cowpea paste proportion of 50/50 was chosen for the next test because it made molding burgers easier than the proportion of 60/40 and the former (50/50) used a higher amount of fiber than the latter (40/60).

Table 1 - Ranking scores for burgers formulated with different cashew fiber and cowpea paste proportions (n=48)

Cashew fiber/cowpea proportion	60/40	50/50	40/60
Ranking scores	85 a	105 a	101 a

Means with the same letters are not statistically different (Friedman, α=0.05, critical value=23)

As to the focus group, when presented to the whole fried burger and asked “What do you think about the burger’s appearance, texture and smell?”, it answered that the appearance was good, similar to those on the market; the texture was good, when cutting with a knife; and the smell was fine. The other question, when a piece of the burger was presented for tasting, was “What is your general opinion about the burger´s taste and your suggestions for its improvement?”, and the answers were to increase the amounts of salt, onion, parsley and black pepper; and to decrease the amount of sweet pepper. As a result, the final formulation was: cashew fiber (29.3%), cowpea paste

(29.3%), tomato (25.1%), onion (6.8%), sweet pepper (5.3%), garlic (1.3%), black pepper (0.1%), dehydrated parsley (0.2%), salt (1.2%) and corn oil (1.4%).

The mean of hedonic values for the sensory acceptance test was 7.8 in a 9-point scale. Ninety-two percent of the hedonic sensory scores (Figure 1) were within the acceptance range of the scale, which comprises categories from 6 (like slightly) to 9 (extremely like). Moreover, when asked about their purchase intent (Figure 2), 86% of judges answered that they would buy it or certainly would buy it. Therefore, we can conclude that the burger was accepted by the consumers. Pinho *et al.* (2011b), using a 9-point hedonic scale, found lower averages (~ 5.0) for overall acceptance of burgers with 7 to 14% replacement of meat by cashew fiber. These authors suggested that the presence of tannins in the fiber could be responsible for the low acceptance of the burgers, an effect that was reduced in the burgers made in our study by the pressing step, which promoted fiber washing with the inclusion of water in each pressing cycle.

Physicochemical analysis of burgers

The proximate composition of burgers made from cashew fiber and cowpea was 71.08% (± 0.07) moisture, 2.07% (± 0.09) ashes, 4.86% (± 0.05) proteins, 1.19% (± 0.12) lipids and 20.79 % (± 0.26) total carbohydrates. The moisture value obtained in this study is higher than that obtained in a previous study (LIMA, 2008) where burgers were made by using only cashew fibers (49.50%). This difference is probably due to the soaking cowpea step. In order to compare our results with this previous work, the values of both studies were converted to dry weight. The inclusion of cowpea in the formulation has promoted an increase in ashes (from 6% to 7%), proteins (from 11% to 17%) and carbohydrates (from 66% to 72%), and a decrease in lipids (from 16% to 4%).

The lipids (1.19%) and energy values (113 Kcal $(100g)^{-1}$) obtained for the cashew fiber and cowpea burger were considerably lower than the values for the traditional meat burgers (10% lipids, 260 Kcal $(100g)^{-1}$) (UNITED STATES DEPARTMENT OF AGRICULTURE, 2015). Hence, the burgers obtained in this study can be considered as a low-fat and low-calorie product.

Stability of burgers

Regression analysis for the stability data was significant ($p<0.05$) for acidity (Figure 3) and pH (Figure 4). Acidity increased from 0.29 to 0.34% and pH decreased from 5.77 to 5.30. Changes in pH and acidity are usually associated with microbial growth; however, this was not the case, considering the microbiological analyses. Throughout the 180 days of storage, all coliforms, including *Escherichia coli*, were lower than 3 MPN g^{-1}. *Salmonella* spp. was absent in 25 g and *Staphylococcus aureus* was lower than 10 CFU g^{-1}. Therefore, the burger was considered microbiologically safe for at least 6 months of frozen storage.

Ascorbic acid content was lower than 94 mg $(100\ g)^{-1}$, value reported by Lima *et al.* (2013) for the cashew fiber, decreasing ($p<0.05$) from 34.03 to 18.11 mg $(100\ g)^{-1}$ (Figure 5). Ascorbic acid reduction in foods can occur either chemically (non-enzymatic oxidation) or through enzymatic processes, as there are enzymes that can resist the processing stages (thermo-resistant) (PHILLIPS *et al.*, 2016). Moreover, freezing is not enough to block all enzymatic reactions

Figure 1 - Frequency histograms of sensory acceptance of burgers made from cashew fiber and cowpea (1=extremely dislike, 2=dislike very much, 3=dislike moderately, 4=dislike slightly, 5=neither like nor dislike, 6=like slightly, 7=like moderately, 8=like very much, 9=extremely like)

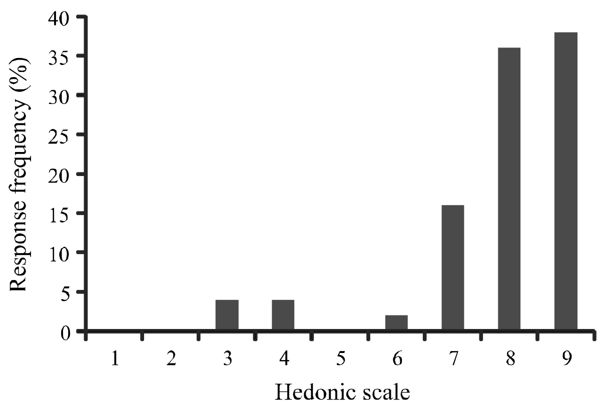
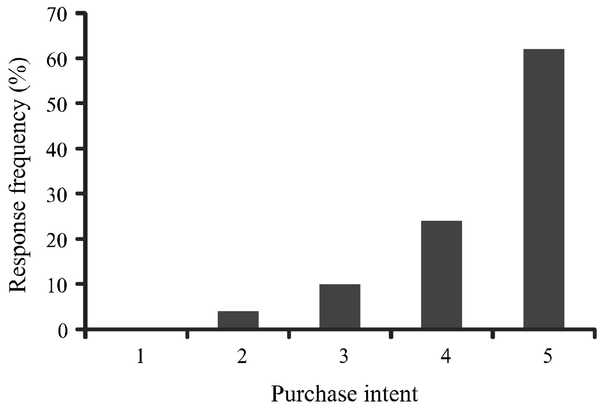


Figure 2 - Frequency histograms of purchase intent of burgers made from cashew fiber and cowpea (1=I would certainly not buy it, 2=I would probably not buy it, 3= I'm not sure whether or not I would buy it, 4=I would probably buy it, 5=I would certainly buy it)



(MAZZEO *et al.*, 2015). However, at the end of 180 days of storage, approximately 53% of the initial ascorbic acid content remained in the burger.

Figure 3 - Acidity of burgers made from cashew fiber and cowpea during 180 days of frozen storage

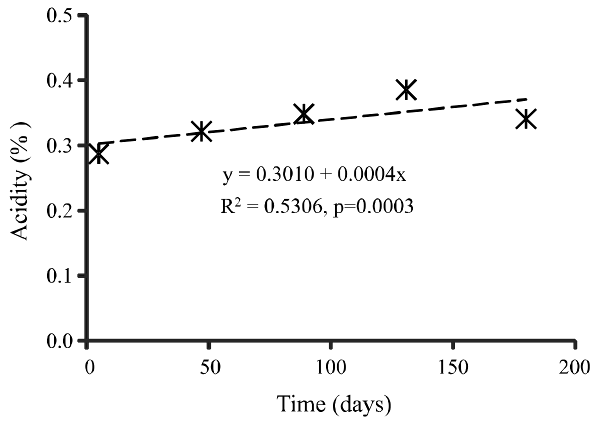


Figure 4 - Hydrogen potential (pH) of burgers made from cashew fiber and cowpea during 180 days of frozen storage

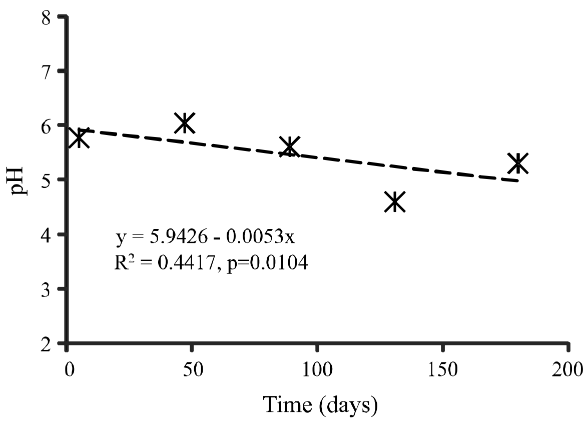
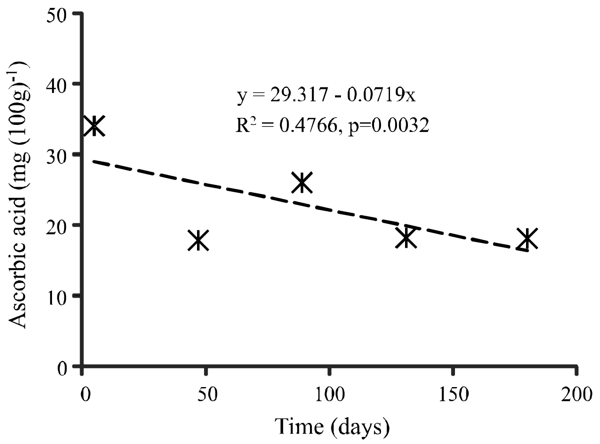


Figure 5 - Ascorbic acid content of burgers made from cashew fiber and cowpea during 180 days of frozen storage



Regression analysis was not significant ($p>0.05$) for lightness (L*), with a mean value of 54.7 during the storage time, but was significant ($p<0.05$) for the other chromaticity coordinates, a* (green to red) and b* (blue to yellow) (Figure 6). An increase in a* (from 2.8 to 4.9) and b* values (from 15.6 to 23.9) was observed, indicating that the burgers became more orange/brown, probably due to the ascorbic acid degradation (DAMASCENO *et al.*, 2008). Moreover, industrial freezing and storage processes partially deprive vegetables of the initial antioxidant capacity (PACIULLI *et al.*, 2015), meaning that the oxidation process may occur and that could account for the change in color (SHAHIDI; AMBIGAIPALAN, 2015).

Regression analysis was not significant ($p>0.05$) for sensory acceptance, so that the slight changes observed in the physicochemical characteristics during storage did not affect the sensory acceptance of burgers, which remained the same throughout the 180 days of storage (Figure 7), with a hedonic mean of 6.7, a value very close to 7.0, corresponding to "like moderately" in the hedonic scale.

Figure 6 - Color of burgers made from cashew fiber and cowpea during 180 days of frozen storage

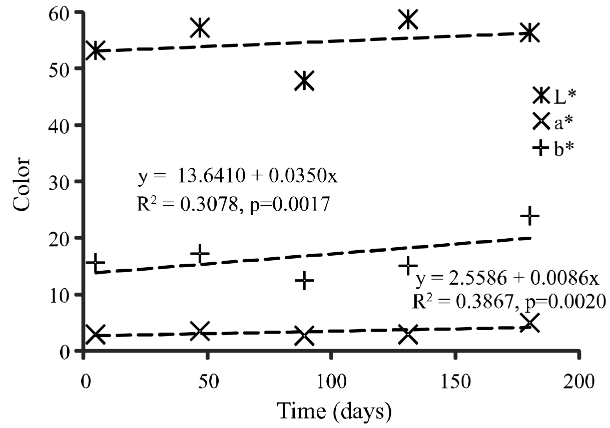
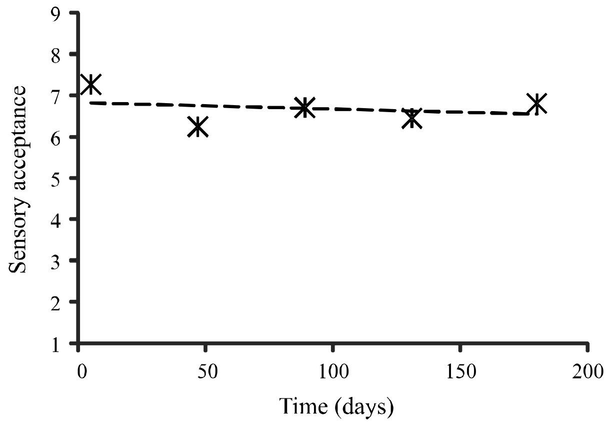


Figure 7 - Sensory acceptance of burgers made from cashew fiber and cowpea during 180 days of frozen storage



CONCLUSION

The final formulation for the vegetable burger is: cashew fiber (29.3%), cowpea paste (29.3%), tomato (25.1%), onion (6.8%), sweet pepper (5.3%), garlic (1.3%), black pepper (0.1%), dehydrated parsley (0.2%), salt (1.2%) and corn oil (1.4%). The vegetable burger thus developed is considered a low-fat and low-energy product and shows good sensory acceptance. Despite the slight physicochemical changes during storage, it is considered microbiologically safe and sensory acceptable for consumption throughout the 180 days of frozen storage.

REFERENCES

ABREU, F. P. *et al.* Cashew apple (*Anacardium occidentale* L.) extract from by-product of juice processing: a focus on carotenoids. **Food Chemistry**, v. 138, n. 1, p. 25-31, 2013.

ADEGUNWA, M. O. *et al*. Processing effects on chemical, functional and pasting properties of cowpea flour from different varieties. **Nigerian Food Journal**, v. 30, n. 1, p. 67-73, 2012.

ASSOCIATION OF OFFICIAL ANALYTICAL CHEMISTS. **Official methods of analysis of the Association of Analytical Chemists**. 16th ed. Gaithersburg, M.D., 1997.

AVANZA, M. *et al.* Nutritional and anti-nutritional components of four cowpea varieties under thermal treatments: principal component analysis. **LWT - Food Science and Technology**, v. 51, n. 1, p.148-157, 2013.

BRASIL. Ministério da Saúde. Agência Nacional de Vigilância Sanitária. Resolução RDC nº 360, de 23 de dezembro de 2003. Aprova regulamento técnico sobre rotulagem nutricional de alimentos embalados. **Diário Oficial da União**, Poder Executivo, Brasília, 26 de dezembro de 2003.

CARVALHO, A. F. U. *et al.* Nutritional ranking of 30 Brazilian genotypes of cowpeas including determination of antioxidant capacity and vitamins. **Journal of Food Composition and Analysis**, v. 26, n. 1/2, p. 81-88, 2012.

CORREIA, J. A. C. *et al.* Alkaline hydrogen peroxide pretreatment of cashew apple bagasse for ethanol production: study of parameters. **Bioresource Technology**, v. 139, n. 1, p. 249-256, 2013.

DAMASCENO, L. R. *et al*. Non-enzymatic browning in clarified cashew apple juice during thermal treatment: kinetics and process control. **Food Chemistry**, v. 106, n. 1, p. 172-179, 2008.

DANTAS FILHO, L. A. *et al.* Inclusão de polpa de caju desidratada na alimentação de ovinos: desempenho, digestibilidade e balanço de nitrogênio. **Revista Brasileira de Zootecnia**, v. 36, n. 1, p. 147-154, 2007.

DOWNES, F. P.; ITO, H. **Compendium of methods for the microbiological examination of food**. 4. ed. Washington: American Public Health Association, 2001.

GIAMI, S. Y. Compositional and nutritional properties of selected newly developed lines of Cowpea (*Vigna unguiculata* L. Walp). **Journal of Food Composition and Analysis**, v. 18, n. 5, p. 665-673, 2005.

KUILA, A. *et al.* Process optimization for aqueous extraction of reducing sugar from cashew apple bagasse: a potential, low cost substrate. **LWT - Food Science and Technology**, v. 44, n. 1, p. 62-66, 2011.

LIMA, F. C. S. *et al.* Chemical composition of the cashew apple bagasse and potential use for ethanol production. **Advances in Chemical Engineering and Science**, v. 2, n. 4, p. 519-523, 2012.

LIMA, J. R. Caracterização físico-química e sensorial de hambúrguer vegetal elaborado a base de caju. **Ciência e Agrotecnologia**, v. 32, n. 1, p. 191-195, 2008.

LIMA, W. A. *et al.* Caracterização e armazenamento de farinhas obtidas a partir do resíduo de caju. **Revista Geintec**, v. 3, n. 4, p. 109-120, 2013.

MATIAS, M. F. O. *et al.* Use of fibres obtained from cashew (*Anacardium ocidentale*, L) and guava (*Psidium guaiava*) fruits for enrichment of food products. **Brazilian Archives of Biology and Technology**, v. 48, p. 143-150, 2005. Número especial.

MAZZEO, T. *et al.* Impact of the industrial freezing process on selected vegetables. Part II: Colour and bioactive compounds. **Food Research International**, v. 75, p. 89-97, 2015.

MEILGAARD, M.; CIVILLE, G. V.; CARR, B. T. **Sensory evaluation techniques**. 3. ed. New York, USA: CRC Press, 1999. 390 p.

NEWELL, G. J.; MACFARLANE, J. D. Expanded tables for multiple comparison procedures in the analysis of ranked data. **Journal of Food Science**, v. 52, n. 6, p. 1721-1725, 1987.

PACIULLI, M. *et al.* Impact of the industrial freezing process on selected vegetables. Part I: Structure, texture and antioxidant capacity. **Food Research International**, v. 74, p. 329-337, 2015.

PHILLIPS, K. M. *et al.* Stability of vitamin C in fruit and vegetable homogenates stored at different temperatures. **Journal of Food Composition and Analysis**, v. 45, p. 147-162, 2016.

PINHO, L. X. *et al.* Desidratação e aproveitamento de resíduo de pedúnculo de caju como adição de fibra na elaboração de hambúrguer. **Alimentos e Nutrição**, v. 22, n. 4, p. 571-576, 2011a.

PINHO, L. X. *et al.* The use of cashew apple residue as source of fiber in low fat hamburgers. **Ciência e Tecnologia de Alimentos**, v. 31, n. 4, p. 941-945, 2011b.

RAMOS, L. S. N. *et al.* Polpa de caju em rações para frangos na fase final: desempenho e características e carcaça. **Revista Brasileira de Zootecnia**, v. 35, n. 3, p. 804-810, 2006.

ROCHA, M. V. P. *et al.* Evaluation of dilute acid pretreatment on cashew apple bagasse for ethanol and xylitol production. **Chemical Engineering Journal**, v. 243, n. 1, p. 234-243, 2014.

SHAHIDI, F.; AMBIGAIPALAN, P. Phenolics and polyphenolics in foods, beverages and spices: antioxidant activity and health effects: a review. **Journal of Functional Foods**, v. 18, p. 820-897, 2015.

STATISTICAL ANALISYS SYSTEM. **Statistical analysis system user's guide**. Version 9.2. Cary, N.C.: SAS Institute, 2009.

UNITED STATES DEPARTMENT OF AGRICULTURE. **National nutrient database for standard reference**. Disponível em: <http://ndb. nal.usda.gov/ndb/searchUSDA>. Acesso em: 16 jan. 2015.

VASCONCELOS, I. M. *et al.* Protein fractions, amino acid composition and antinutritional constituents of high-yielding cowpea cultivars. **Journal of Food Composition and Analysis**, v. 23, n. 1, p. 54-60, 2010.