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Antioxidant Properties of Red and Yellow Varieties of Cashew Apple, Nut and Husk (*Anacardium Occidentale* L.) Harvested in Mexico

Figueroa-Valencia **M**[1], Rosales-Martinez P[1], Santoyo-Tepole F[2], Ramos-Monroy O.A[1], García-Ochoa F[1], **Hernández-Botello M.T**[1], López-Cortez **M.S**[1,*]

[1]Escuela Nacional de Ciencias Biológicas-Instituto Politecnico Nacional. Department of Biophysics

[2]Escuela Nacional de Ciencias Biológicas-Instituto Politecnico Nacional Department of Biochemical Engineering.

Abstract

Numerous studies have reported the health benefits of consuming fruits and vegetables that contain antioxidant properties. Within the group of fruits considered exotic, some are accessible and only consumed in their place of origin, such as soursop, noni, kiwi, pitahaya, and others. *Anacardium occidentale*, cashew, is a crop native to the Brazilian northeast that has excellent medicinal and nutritional properties. Because few studies have characterized cashew produced in Mexico, in the present work, the physicochemical properties and antioxidant capacity of cashew apple (red and yellow varieties) and its nut were studied. The content of total phenolic compounds and the antioxidant capacity were higher in the nut (174.19±20.98 GAE mg/100 g db) while cashew red pulp showed a superior value of the phenol content (159.75±12.91 GAE mg/100 g db) to that of yellow cashew pulp (151.9±5.23 GAE mg/100 g db). A high value was obtained for the TPC of the husk of cashew nut (74.30 mg GAE/g) compared with those of the kernel and false fruit. Red cashew presented a higher antioxidant capacity at 77.65 µmol Trolox/g and was superior to that of the kernel (38.52±2.9 µmol Trolox/g). Because cashew apple is usually discarded, a marmalade based on the pulp is proposed as an alternative for its conservation because it has a high content of phenolic compounds that is conserved for six weeks of shelf life.

Corresponding author: López-Cortez, Escuela Nacional de Ciencias Biológicas-Instituto Politecnico Nacional. Department of Biophysics, Prol. Carpio y Plan de Ayala, s/n. Col. Casco de Santo Tomás, Apartado Postal 42-186 México, D.F. C.P. 11340, México. Tel: +52 5557296000 ext. 62314

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Introduction

In recent years, the natural antioxidants present in fruits and vegetables have been the objectives of several pharmaceutical studies and the relationship between the natural product consumption and reduction of the risk of oxidative-stress-induced diseases was established[1]. It has been reported that phenolic compounds have excellent antioxidant activity, acting as hydrogen donors, reducers and eliminator agents of free radicals[2]. They also have an adequate chemical structure for their antioxidant action, attracting free radicals and neutralizing dangerous reactive species of oxygen and metallic and chelator ions[3]. Because of their high reactivity, they are found in almost all cases combined with an organic acid, a sugar or even a polymer[4]. Thus, the United Nations Organization for Food, Agriculture/ World Health Organization (FAO/OMS) recommends adequate balanced feeding, including fruits and vegetables, in general[5], because they contain vitamins, essential micronutrients, fiber, vegetable proteins, and chemical compounds, as well as bioactive content that helps human metabolism to prevent diseases[6].

Antioxidant compounds play a very important role in the control of numerous types of diseases related to oxidative stress. The use of some plant extracts with antioxidant properties has been reported, for example *Zataria multiflora* ethanolic extracts protects lung tissues from Cyclophosphamide-Induced (CP-induced) toxicity and suggest a role for oxidative stress in the pathogenesis of lung toxicity produced by CP in mice[7]. Another study also showed that *Zataria* produces a potent hepatoprotective role and could be a potent candidate to use concomitantly as a supplement agent against hepatotoxicity of CP for the patients undergoing chemotherapy[8]. *Origanum vulgare* ethanolic extract exerts a potent genoprotective effect against CP-induced genotoxicity in mice bone marrow, which might be possibly due to the scavenging of free radicals during oxidative stress conditions[9]. Hesperidin is a flavonone glycoside, belonging to the flavonoid family, which is widely found in Citrus species and acts as a potent antioxidant and anticancer agent because of the protection roles against oxidative stress[10].

The cashew apple and their diverse biological activities have been described, as their potent antibacterial activity against Gram-positive bacteria[11], moderate cytotoxic activity against several tumor cell lines[12], and tyrosinase[13], lipoxygenase[14] and others inhibitory activities. These studies have evidence that antioxidants play an important role in reducing the risk of cancer[15].

Other study reports the evaluation of antibacterial activity in vitro of different parts of two varieties of *Anacardium occidentale* L. on human pathogens. This study showed that there were variations in the capacities of extracts of the various plant parts to inhibit bacterial growth of the six experimental human pathogens (SEHP)[16]. This is due to the type and amount of bioactive compounds present in the extracts of the different parts of the fruit.

Regarding the fruit group, some are not of general consumption, they are common only in their origin region, and they also have significant antioxidant properties, including exotic fruits or superfruits, such as noni, lychee, pitaya, mangosteen and cashew, among others[17,18]. Peculiar characteristics of these fruits include their appearance, with a specific and different flavor from that of ordinary and universal fruits; most of them are consumed to quench thirst because of the high content of water; others have medicinal properties or high levels of fiber, indicating they are laxative and have good digestive properties[19].

Tropical fruits are consumed naturally or in juices; the exotic varieties of fruits have unique textures and a mixture of sweet and sour taste and are beneficial to health because they contain vitamins (A, B and C) and minerals, such as calcium, iron, potassium, and magnesium[20].

Cashew (*Anacardium occidentale* L.) is known commonly as anacardo, castaña of cajú, cashew or merey and is found in the Brazilian Northeast with excellent medicinal and nutritional properties. Currently, all of its components, false fruit or cashew apple and seed (Figure 1), are used in different areas, such as in elaborate candies, cosmetics, and even medications for different diseases[21,22,23].The nut (known as Nut of India) of the fruit is valued because of its high content of proteins and essential oils[24]. The nutshell contains oil used in the manufacture of insecticides, waterproofing, and varnishes[25]. Cashew apple can also be consumed

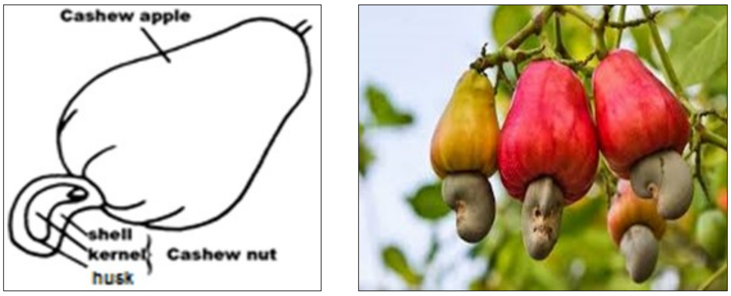

Figure 1. Parts of Cashew (*Anacardium occidentale* L.)[12,13]

fresh or processed with various final products such as jam, juices, and wines. The vitamins, minerals, organic acids and carbohydrates in cashew apple are essential sources of nutrients. Nevertheless, these components of cashew apple are highly perishable; therefore, they require special care during storage, transportation and processing[26].

In Mexico, cashew is produced in some states of the country such as Campeche, Chiapas, Guerrero, and Veracruz[27], where the consumption is mainly natural and the pulp is used to prepare beverages and artisan desserts. However, cashew fruit is overlooked and wasted to obtain only the nut, which has the maximum commercial value[28].

Considering the few investigations about the characterization of cashew produced in Mexico, the objective of the present work was to study the physical, chemical and antioxidant properties of the apple or false fruit (cashew apple) and walnut of the red and yellow varieties. These were harvested in Guerrero, one of the states with the highest production. To obtain an alternative to conservation and avoid wasting of the false fruit, we proposed to make a commercial product such as a marmalade, exploiting its antioxidant properties.

Materials and Methods

Raw Material

Cashew (*Anacardium occidentale*) used was from the Costa Grande region located in the state of Guerrero. The cultivation area is at the south, southwest, and west of the country, as well as at the north in the Tierra Caliente region and part of Michoacán state. Cashew fruit must be harvested at an optimum state of maturation to have the nut in the best condition. The March-June 2015 harvest was transported under refrigeration conditions (4°C) to avoid fast over-mature or deterioration and was stored in the laboratory at -18° C until analysis. The sample preparation was as follows:

a. Pulp: cashew apple was cut into small slices and macerated. The flesh was obtained on a Whatman No. 40 filter paper and was used to obtain the juice, which determined the total phenol and antioxidant properties.

b. Nut peel (coarse): the thick skin of the nut was subjected to thermal treatment at 100°C for 1 hour in an electric oven to extract the kernel (the thick shell was not studied because it is inedible). The nut peel was considered an untreated sample.

c. Husk: the thin crust covering the kernel was separated manually using tip tweezers and then was macerated to obtain a fine powder that was also packaged and stored at 4°C for analysis.

d. *Nut:* the nut without the thin shell was macerated until a powder was obtained that was packaged in a flask and stored in refrigeration at 4°C to determine phenolic compounds and antioxidant activity.

e. Toasted Nut: the toasting process employed an electric oven, in which the whole nut was placed in a tray and exposed at 133°C for two hours, followed by storage until subsequent analysis.

Physicochemical parameters: the pH measurement of the pulp of cashew apple was performed according to standard procedures[29]. The acidity percentage was determined using the flesh of cashew apple according to standard procedures expressing the results as % of citric acid for being the one of greater proportion in the samples[30]. Soluble solids

(°Brix) were determined using the juice of the pseudofruit[31]. The density (g/ml) of cashew apple juice was determined according to standard procedures[32]. The humidity (%) of cashew apple was assessed by applying the technique of Bidwell Sterling[33] using standard procedures [34].

Methanol Extract

Samples of cashew apple, nut, commercial nut and husk were previously milled and macerated. Next, 2 g of cashew apple, 2 g of nut, 2 g of commercial nut and 0.5 g of husk were taken and placed into flasks separately. The samples were then subjected to extraction in 100 % methanol (10 ml) for 24 h in the dark and room temperature, followed by filtration to obtain the extract.

Phenolic Compounds

The method used was described previously[35]: 200 µL of the extract was mixed with 0.1 ml of Folin-Ciocalteu reagent for 3 minutes at room temperature, followed by the addition of 2 mL of sodium carbonate (7.5 %) and 2.8 mL of water. The sample was incubated for 1 h in the dark, followed by measurement in a Spectrophotometer at a wavelength of 725 nm. A curve of gallic acid was used, and the results were expressed as milligram equivalents of gallic acid (GAE) per 100 grams of sample fresh and dry.

Antioxidant Capacity by DPPH

A modified previously reported method[36] was used to determine the antioxidant properties. The reducing power of the samples was determined by the method described by Brand-Williams *et al.* (1995),[37] for the inhibition of the stable radical 2,2-diphenyl-1-picrylhydrazyl (DPPH). The assay was performed by mixing 0.1 mL of methanolic extract from the samples with 3.9 ml of a methanol solution of DPPH (0.005 g DPPH/10 ml of methanol). After 30 minutes in the dark, the absorbance at 515 nm was measured using 100% methanol as a blank and methanol 80% as a control treated with DPPH. The percentage of inhibition with respect to the initial absorbance obtained for the methanolic solution of DPPH is expressed as micromoles of TEAC (antioxidant activity equivalent of TROLOX) per 100 g of fresh sample, based on the TEAC type curve.

Processing of Marmalade

The raw material fruit was washed at the select maturation stage of both varieties. The fruit was divided into quarters and 500 g of fresh fruit, 400 g of sugar and 600 g of water were mixed, using citric acid as a preservative, and the marmalade was obtained using an artisanal method as follows: 3 g of the white skin of a lemon was added to 50 mL of water, followed by heating in a microwave oven for one minute (0.17 % citric acid). This hot citric acid mixture was used in the marmalade.

The previous preparation of water, citric acid and fruit was heated at 50 °C until 65 °Bx was obtained. After cooling 50 g samples in jars, each underwent pasteurization (100°C for 30 min) to obtain a shelf life of 45 days stored under refrigeration conditions[38].

Sensory Evaluation

The sensory evaluation was carried out using 50 untrained judges performing discriminative and affective tests. A sample comprised 30 ml at 25°C. Discriminative analysis was performed using a comparison by pairs: two samples, (1) marmalade of cashew and (2) mango marmalade of a commercial brand, were evaluated for their characteristics—flavor, acidity, color intensity, aroma and like or dislike perception. A descriptive test applied using a scale of attributes, in which two samples were used: (1) marmalade of cashew and (2) marmalade of mango of a commercial brand[39].

Statistical analysis of the results was carried out with the MINITAB 17.0 Software to obtain the mean ± standard deviation of the data (n = 3), and the multiple comparisons of Tukey test to determine significant difference between the samples.

Results and Discussion

Physicochemical Tests

Table 1 shows the results obtained for the physicochemical parameters of the red and yellow cashew varieties.

A significant difference in pH values was observed between red and yellow cashew apple, while ° Brix, density and acidity did not show it. Studies[40] showed pH values of 4.14 and 4.15 for the red and yellow cashew varieties, respectively, similar to that obtained in this study. Some studies reported the pH of

Parameter	Red	Yellow
Ph	4.05±0.18[a]	4.602±0.115[b]
(°Brix)	11.55±1.1[a]	11.54±1.238 [a]
Density (g/ml)	1.301±0.009 [a]	1.290±0.01 [a]
Acidity* (citric acid %)	0.433±0.065 [a]	0.40±0.04 [a]
Humidity (%)	80	70

Table 1. Physicochemical parameters of cashew pulp (cashew apple)

Means value ± σ (standard deviation) of n = 3. Means that do not share a letter are significantly different (α = 0.05) according to multiple comparisons of Tukey test

the false fruit, varying from 4 to 5.5. Guerrero *et al.* (2008)[25], performed the physicochemical characterization, of the nut and false fruit of *Anacardium occidentale* L. (merey) under dry conditions and obtained for the harvested product pH values 6.47±0.02 and 3.57±0.07 for the nut and false fruit, respectively. The soluble solids obtained from both varieties (11.55 ° Bx) were in the range reported for samples of *Anacardium occidentale* L. of Brazil and oscillated between 6 and 13 ºBx[41,42]. However, Chávez (2009)[40] obtained pH values of fruits from El Salvador of 8.5 and 10 °Bx for the red and yellow cashew varieties, respectively. Guerrero *et al.* (2008)[25] reported a higher value (17°Bx) for false fruit. An increased concentration of total soluble solids (monosaccharide) exists because of polysaccharide hydrolysis (homopolysaccharide) during maturation[41,43]. Significant differences (with a level of confidence of 95%) were not observed in the density values between both varieties. Cashew red presented a higher percentage of acidity than that reported by Chavez (2009)[40] at 0.36 % total acidity, but the variety of cashew used was not specified. Guerrero *et al.* (2008)[25] reported a higher value of acidity in fruits of *A. occidentale* L. under dry conditions (1.42 %) than that observed under conditions of irrigation (0.32 %)[44]. False fruit pulp presented a lower acidity than that reported for samples harvested in Tanzania, Costa Rica, India and Brazil[41,42]. Rodríguez (2011)[44] expressed values of acidity of 0.185 ±0.01% for malic acid of the juice of cashew fruit.

The values of humidity for cashew red and yellow were similar to those reported by Chávez (2009)[40] who attributed the differences to the conditions of cashew harvest, mature stage, and origin. The physicochemical characteristics of the fruits vary depending on their maturity, handling, and origin (climatic conditions and soil, among others). Water supply is an essential influence of the physiological development of the fruit (preservation of nutrients) and determines the quality and quantity of the harvested product[45]. For the nut sample, only the humidity generated a value of 12.84 %. This value has not been reported.

Total Phenolic Compounds

The results of the total phenolic compounds obtained from extracts of different samples of cashew apple and nut are presented in Table 2.

Cashew Apple

Cashew red pulp showed a superior value of the phenol content to that of yellow cashew pulp. Rufino (2010)[46] determined the content of phenols in non-traditional fruits from Brazil, reporting a value of 118±3.7 mg GAE/100 g wb for cashew (Cajú). Fruits such as Bacuri, Carnaúba, Gurguri, Jaboticaba have a wide range of values of 23.8±0.7 to 549±22.2 mg AG/100 g. A high variability in the content of phenolic compounds of cashew is shown in the literature because of their origin, soil difference cyclic conditions, seasonal growth, postharvest, storage and extraction methods of polyphenols[47]. Plants can activate polyphenol synthesis as a response to stress conditions such as injuries, pathogens, and low nutrient compounds[48].

On the other hand, when comparing the content of total phenols obtained for the red cashew with that for other fruits, the fruit of cashew had a value close to red fruits, such as strawberry (205.4±2.1 mg GAE/100 g wb), pomegranate (328.7±2.5 mg GAE/100 g wb[51], and was higher than that reported for saladette tomato (92.31 mg GAE/100 g wb)[52].

Cashew Nut

The untreated nut sample showed a higher content of phenolic compounds. However, in the nut toasted at 133°C for two hours, the TPC was decreased. Ogunlade et al. (2014)[49] and Chandrasekara[50] reported values of 204.95±1.4 and 114±0.47 (defatted meal) mg GAE/100 g db, respectively, for the nut of *Anacardum occidentale*. The value of 528±1.0 was published for the nut treated at 130°C for 33 min[50]. This difference could be because, in the toasted process used in the present work, the samples were exposed to higher temperatures and more extended periods (133°C; 2 hrs), causing structural changes, such as isomerization and a reduced content of phenolic compounds[53,54]. Other causes of these differences could be because, in the present study, defatted samples were used that could modify the general composition[53]. However, Chandrasekara and Shahidi[50] reported that, during heat treatment, the reaction between reducing sugars and amino acids, known as the Maillard reaction, can occur, leading to the formation of various byproducts, intermediate and brown pigments (melanoidins), which may contribute to the TPC, flavor, antioxidant activity and color of food. The value of the TPC of nut obtained in the present work (174.19±20.98 mg GAE/100 g db) was higher than that reported for almond, hazelnut and Macadamia nut at 114, 111 and 87 mg GAE/100 g (wb), respectively, but inferior to that reported for cashew nut (nut of India), 381 mg GAE/100 g (wb)[55] (Figure 2).

A high value was obtained for the TPC of the husk of cashew nut (74.30 mg GAE/g) compared with those of the kernel and false fruit. Other authors have reported a value of 269.05±9.77 GAE mg/g in a defatted meal[50]. The samples of cashew nut and skin had proteins and sugar, and the formation of MRPs during roasting is possible. Thus, the roasting condition, as well as the type of nut, affects the TPC values of the extracts of cashew skins[50]. Studies have reported high amounts of husk or cuticle of different nuts. Rosales *et al*. (2014)[54] declared a value of 132.9 mg GAE/g for the peanut cuticle Virginia variety. The high amounts of TPC obtained in the husk sample of cashew compared with the fruit are because the husk is the external part of the nut and protects against stress conditions, synthesizing the highest amount of phenols in this structure[56]. Francisco & Resurrección (2009)[57] reported that phenolic compounds in the outer layer of plants as shell, cuticle, and sheath are present in a high concentration to protect all internal materials as cotyledons. Some phenolic acids, although they are united with a covalent bond of polymers, are not soluble in water and other components of the cellular wall as arabinoxylanes[58]. Thermal treatment could set free antioxidants of low molecular weight that could be sub-units of polymers of high molecular weight[59]. Studying the skin or husk of nuts is important because several studies have reported that the husk has healing properties such as hypoglycemic, hypoglycemic, antihypertensive, astringent, antihelminthic, and anti-inflammatory properties[56].

Antioxidant Capacity

Table 2 shows the results of the antioxidant activity of the extracts of false cashew fruit and treated and untreated nut. Red cashew presented a higher antioxidant capacity at 77.65 µmol Trolox/g and was superior to that of the kernel. Additionally, red cashew had a higher content of TPC. The differences between red and yellow cashew can be attributed to the type and amounts of phenolic compounds present in each because they contain tannins, polyphenols, and carotenes[55]. Some studies have reported that cashew has different characteristics and amounts of phenolic acids, such as ferulic, gallic, ellagic, p-coumaric and syringic acids, as well as flavonoids, such as myricetin, catechin, epicatechin, and epigalocatequine[59,60]. Ogunlade *et al*. (2014)[49] reported a value between 50 to 53.21 µmol Trolox/100 g for *Anacardium occidentale* nut but they used a FRAP method.

Comparing values of the antioxidant capacity obtained for cashew with that of a common fruit, such

Table 2. TPC and AA of pulp, nut and husk of cashew

Sample	TPC (GAE mg/100 g db)	AA (μmols Trolox/g db)
red cashew (pulp)	159.75±12.91	77.65±1
yellow cashew (pulp)	151.9±5.23	56.53±1.2
nut	174.19±20.98	38.52±2.9
toasted nut (133°C, 2 h)	96.80±9.48	ND
Husk	7430±730	1549.55±170
commercial nut	ND	2.48±0.2
	Reported values (comparative purposes)	
nut (Ogunlade *et al.*[49])	204.95±1.4 (raw)	50-53.21 (FRAP)
toasted nut (130°C, 33 min) (Chandreskara and Shahidi,[50])	528±1.0	58.14±2.84 (defatted meal)
husk (testa) (130°C, 33 min) (Chandreskara and Shahidi[50])	26905 ±977 (raw) 34799±688 (defatted meal)	--------

Mean ± standard deviation (n = 9). TPC: total phenolic compounds; AA: antioxidant activity; wb = wet base; db = dried base; ND = not determined.

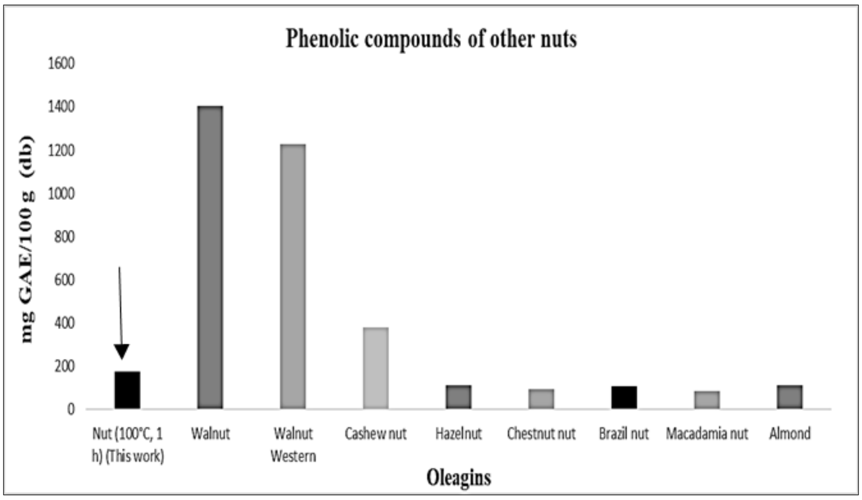

Figure 2. Content of the total phenols of other oilseeds, expressed as mg equivalents of gallic acid (GAE) / 100 g[55].

as red apple (*Malus sylvestris*), which contains 0.259 µmol TE/g[59], or with an exotic fruit of a higher consumption, such as soursop, which contains 2.88 µmol TE/g[61], cashew presented a higher antioxidant capacity than these fruits. It is essential to exploit the benefits of cashew apple and use it as a raw material in functional food processing.

Table 2 presents the values of the nut extracts. The nut studied had 38.52±2.9 µmol TE/g sample, and the commercial nut value was lower at 2.48 µmol TE/g sample. These results could be due to processes such as toasting and salting that are used commercially; high-temperature processes and high salt content can produce structural changes in phenolic compounds and generate structures with a lower antioxidant capacity and storage time[54,62]. Chandrasekara[50] reported a higher value of 58.14±2.84 (µmols Trolox/g db, defatted meal) for the toasted nut (130°C, 33 min) of *Anacardum occidentale* than the one obtained in the present study and may be the difference was because of the treatment time. The husk possesses a higher antioxidant capacity than other samples and is because it is the structure that protects the seed and is where the antioxidant compounds are synthesized in a greater proportion[54].

Antioxidants isolated from foods and beverages, such as the cashew apple and its processedproducts, may be superior to non-natural products[15, 51].

By relating the phenolic compounds against the antioxidant capacity of the fruit, nut and husk by means of a linear regression. The coefficient of determination provides a value of 0.9725 for red cashew, 0.9383 for yellow cashew, 0.9857 for nut and 0.9241 for husk; these values indicate a good fit of the data towards the linear, which represents that there is a directly proportional relationship between the phenolic compounds and the antioxidant capacity.

Marmalade Shelf Life

Fig. 3 shows the pH and acidity of marmalade for 6 weeks. The pH value decreased at the end of the period, showing a value of 3.68; this value is a warranty of a good shelf life of the final product. This value is in the range reported for the pH of marmalades (3.25-3.75) to ensure microbiological safety[38]. The final acidity level was 0.35% (presenting 22.2 % of reduction), and, according to standards, is acceptable until a value of 1%. Those values have been reported in other marmalades such as mango-flavored marmalade with an acidity value of 0.5% or orange-flavored marmalade with a final acidity value of 1%; the acidity value of cashew marmalade is in the range of that for jams of other more common fruits[38]. This low reduction might be due to the process because of the addition of sugar and water, and the general change in composition. The thermal process could cause structural changes that caused the difference in the acidity[63].

Cashew is considered an acid fruit, giving the

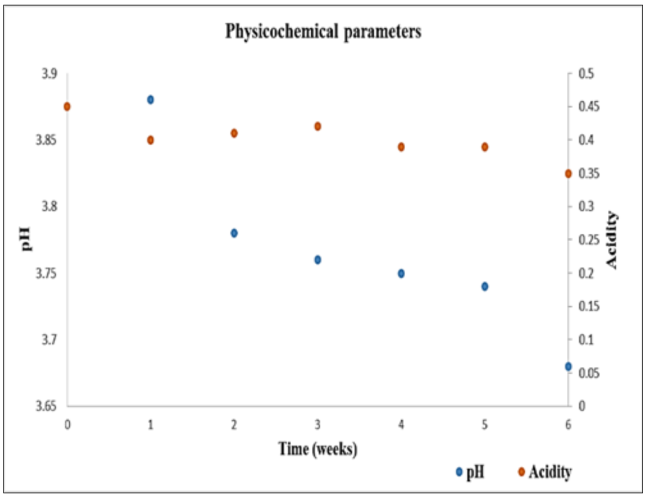

Figure 3. pH and acidity of marmalade during 6 weeks.

confidence of a final product with good quality[38]. The acidity of prepared marmalades (0.35 %) presented a significant difference in the acidity of fresh fruit (0.43 g citric acid/100 ml). In jams prepared with fruits, a lower value of acidity and low pH values give the advantage of the best shelf life; it must be considered that the addition of citric acid forms a gel, avoiding sugar crystallization and acting as a preservative agent[64].

Rodríguez (2011)[44] prepared a juice of cashew pulp and presented a pH value of 4.4, which was similar to that reported by other authors[65,66]. The acidity value, determined as the malic acid percentage, was 0.177 %. This value is outside the range of established norms in Brazil[67] for the juice of false fruit of cashew, which sets values between 0.22 and 0.52 %.

Fig. 4 shows the °Bx and phenol variation for six weeks. The °Bx data follow a linear trend and a slope almost at 0, obtaining a final value of 63.41°Bx, and an acceptable amount of marmalades according to the norms[31]. The behavior observed of phenolic compounds showed a slight increase in the initial value of 106.25 mg GAE/mL to 114 mg GAE/mL (6.8 % of growth). The cause may be the slight changes in temperature and light during the storage time[64,67]. The °Brix value did not change during this period. Vera (2012)[68] formulated marmalades of other fruits, such as the apricot, and evaluated the physicochemical properties during storage (6 weeks) to guarantee the shelf life of the product by 12 months under storage conditions at room temperature (37°C). De Oliveira et al. (2015)[69] also prepared strawberry marmalade, and evaluating the content of phenolic compounds during 60 days of storage showed a decreased of 235.84±10.15 mg EAG/100 g to 226.57±12.42 mg EAG/100 g, similar behavior to that in the present work.

Those results could suggest that some structural changes in the phenolic compounds can occur after 30 days. Klopotek et al. (2005)[70] argued that the processing and storage conditions caused co-pigmentation and auto-association of molecules, reducing the number of hydroxyl groups available to react in the Folin-Ciocalteu colorimetric assay, apparently decreasing the concentration of total phenols. The release of monomers of polymeric polyphenols also showed the highest values of the content of total phenols using the Folin-Ciocalteu assay[71]. Thus, it could explain the apparent increase in the phenolic compounds during the last week of storage of marmalade elaborated in this work. Thus, marmalade processing is an alternative to preserve the properties of bioactive compounds present in cashew fruit[72].

Diverse products derived from cashew have been developed as beverages. Rodríguez (2011)[44] developed a juice with cashew apple and reported a total phenolic concentration of 2321 mg GAE/L, lower than the value reported by Melo *et al.* (2006)[73] in cashew juice of 2952.5 mg EAG/L, but higher that the

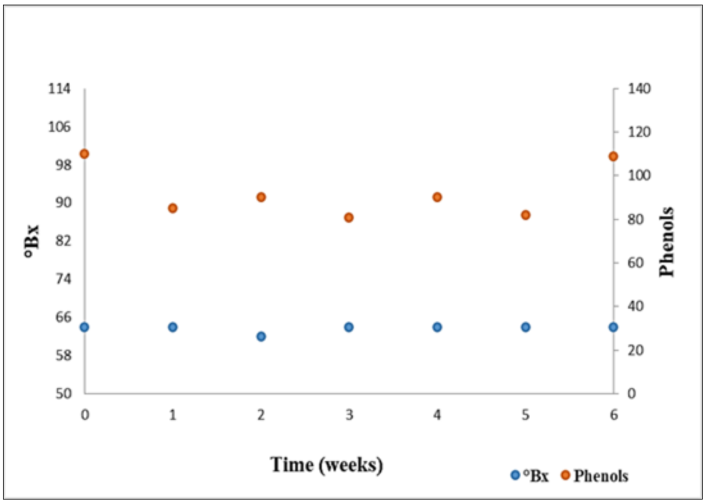

Figure 4. Behavior of phenols (mg AG/mL) and °Bx of cashew marmalade during 6 weeks.

value reported in the juice of common fruits, such as orange, which contain values of 620.7 to 630.5 mEq GAE/L[74]. For the above, the false fruit of cashew represents a good source of antioxidants (106.25 mg GAE/mL) compared with fruits of regular consumption.

Sensory Evaluation

A discriminative and descriptive test was applied using 20 untrained judges. The first test used comparison pairs to find differences between marmalade formulated for this work and a commercial brand. According to panelist perception, cashew marmalade presented a less acidic flavor than the mango marmalade of the retail brand. The results matched the physicochemical parameters, and no significant differences were found in the acidity content during the period of storage.

The panelists observed a similar color of marmalade of cashew (color characteristic) and mango. Regarding flavor, cashew marmalade was a slightly astringent; this result also matched those obtained for the physicochemical parameters (pH and acidity). According to the panelists, mango marmalade was more astringent than cashew marmalade. The cause may be that commercial jams used the highest amount of citric acid as a preservative; in cashew marmalade, the citric acid was obtained from a natural source and was at a lower concentration.

Attribute Scale

The second test consisted of describing attributes of flavor using a graphic scale; the objective was to evaluate the characteristics of cashew marmalade compared with mango marmalade of a commercial brand. The chart scale of taste used grading extremes: low astringent to extremely astringent. Cashew marmalade was evaluated as having a low astringent flavor, while mango marmalade had a high astringent flavor; the difference might be due to the high amount of preservative (citric acid). On the other hand, fruits such as cashew and mango have a content of different polyphenols, such as phenolic acids, which tend to contribute to the astringency and acidity in foods[75,76].

Cashew marmalade presented a higher °Bx value (63.41) than that of mango marmalade (30.67 ° Bx)[38]. According to sensorial analysis, cashew marmalade belongs to the group of jams, jellies, and marmalades, according to the values of Brix degrees established in the norm of CODEX[75,76]. The final product presented a good appearance at 45 days of storage and refrigeration.

Conclusions

Cashew harvested in Mexico has good functional properties, and the differences reported in the literature are due to its origin, weather conditions, and harvesting soil. As shown in this investigation, the content of total phenolic compounds was higher in the red variety of cashew apple than in the treated nut at 133°C. The antioxidant capacity of the false fruit cashew of the red variety was superior to that of the yellow one. In the elaborated marmalade, °Bx did not change and the pH and acidity slightly decreased, while the phenolic compounds showed a reduction of 6.8 % during six weeks of storage. According to sensory evaluation, cashew marmalade is a product with the correct color and flavor and a good odor. Thermic treatment modifies the antioxidant capacity and content of phenolic compounds of nut. Toasted nut, with its high content of antioxidant compounds, is a functional food that requires minimal processing and can be directly consumed.

The present work proposes focusing on the use of cashew apple, considering that only the nut is commercialized and the rest of the fruit is usually discarded.

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