INFLUENCE OF THE PROCESSING STEPS ON CASHEW NUT QUALITY

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Cashew nuts have high nutritional value. This nut provides macronutrients, micronutrients and a large variety of antioxidants, such as phenolic compounds. There are losses in some compounds during the processing of fruits and there are very few studies on this aspect. Given the above, this research aimed to determine the effect of the processing steps on cashew nut characteristics with emphasis on total antioxidant activity. Significant differences were observed between the processing steps for all the chemical and physical-chemical characteristics studied. Cashew nuts contained high levels of lipids and energy, low content of moisture and water activity and medium content of phenolic compounds (51.33 GAE/100 g) and antioxidant activity by the $ABTS^{\bullet+}$ radical (6.49 µM Trolox/g) at the end of the process. Regarding the total antioxidant activity, it was observed that the $ABTS^{\bullet+}$ radical method can be considered appropriate to measure the antioxidant activity of cashew nuts, since the results presented lower coefficients of variation and express proportionate results to other methods.

KEYWORDS: NUTRITIONAL LOSSES; ANTIOXIDANTS; PROCESSING; FRUITS QUALITY.
ABBREVIATIONS: TEP - TOTAL EXTRACTABLE POLYPHENOLS; AW - WATER ACTIVITY; GAE - GALIC ACID EQUIVALENT; MOIST – MOISTURE; LIP – LIPIDS; PROT – PROTEINS; CHO – CARBO-

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1 INTRODUCTION

The cashew nut has high nutritional value. It is considered to be a source of high quality protein, it is rich in polyunsaturated fatty acids and high energy, and contains high levels of calcium, iron and phosphorus (PAIVA *et al*., 2000) as well as other bioactive molecules.

There are losses in some compounds during the processing of fruits and there have been few studies on this aspect. Studies emphasize the importance of evaluating the nutritional value of food in order to know its contribution to the supply of the recommended daily intake and to understand the influence of processing and preservation technologies in food chemical composition (TUDELA *et al*., 2002; ZHANG and HAMAUZU, 2004). Studies involving the monitoring of nutritional losses and chemical changes during the processing of nuts are even scarcer.

Bioactive compounds are substances which have important properties to the body, such as antioxidants. These compounds act by protecting the body against diseases such as cancer and cardiovascular diseases (BLOMHOFFI *et al*., 2006). Several groups of bioactive compounds were identified in cashew nut, including phenols, tocopherols and phytosterols (ALASALVAR and SHAHIDI, 2008).

Due to the importance of antioxidant sources in the diet, this research aimed to determine the effect of the processing steps on cashew nut chemical and physical-chemical characteristics with emphasis on the total antioxidant activity determined by two different methods.

2 MATERIAL AND METHODS

The study was performed with cashew nuts (*Anacardium ocidentale* L.), given by a large company in the Northeast ,state of Ceara (Brazil), obtained by mechanical processes according to the flow diagram shown in Figure 1. The nuts (type Special Large Whole) were collected at six stages of processing: after shelling, before peeling, after peeling, after classification, before the final drying and after the final drying.

Five lots of samples were collected during May to July 2009. Each lot consisted of 500 g individual packages of nuts for each step listed above. The samples were crushed in a domestic blender until a flour was obtained and then packed in flexible packaging covered with laminated film, vacuum sealed, identified and stored under ambient conditions until the time of analysis.

The pH was measured directly in the crushed cashew nut diluted in water (1 g cashew nut in 10 mL of water) (IAL, 2008). The water activity was determined by direct reading of the crushed samples, using the digital Higrotermo 95. The moisture was determined by the direct heating of 5 g of crushed cashew nut at 70°C in a vacuum oven, until the constant weight was obtained (AOAC, 1996). The ash was determined in a muffle furnace at 550°C, using 5 g of crushed cashew nut (AOAC, 1996). Therotein was measured by the micro-Kjeldahl method, consisting on the determination of total nitrogen. The conversion factor used to estimate the protein level was 6.25 (AOAC, 1996). The lipids were extracted in Soxhlet apparatus, using hexane as the solvent (AOAC, 1996). The total carbohydrates were estimated by the difference between the percentage of centesimal composition and the sum of the moisture, ash, lipids and proteins percentage (BRASIL, 2001). The energy value was determined as the sum of the carbohydrate, proteins and total lipids energy value, calculated using the following conversion factors: carbohydrates provide 4 kcal/g, protein provides 4 kcal/g and fat provides 9 kcal/g (BRASIL, 2001).

In order to obtain results with better repeatability and after preliminary tests, it was decided to determine the total extractable polyphenols and the total antioxidant activity using defatted nuts. The process to remove the fat consisted in using 10 g of crushed nuts and the addition of 20 mL of hexane followed by stirring of the solution for 20 minutes in a magnetic stirrer and subsequent centrifugation at 3000 rpm for 15 minutes. The supernatant was discarded and the residue was

placed in the fume hood to complete the evaporation of the hexane. The extract of defatted nuts was prepared according to Larrauri *et al*. (1997) using ethanol (50%) and acetone (70%) and the centrifugations were performed at 3000 rpm.

The total extractable polyphenols (TEP) determination was performed according to Obanda and Owuor (1997), using galic acid as standard. The reading was performed using a spectrophotometer (Shimadzu, UV – 1800 model) at 700 nm.

The antioxidant activity by $ABTS^{\bullet+}$ and $DPPH^{\bullet}$ methods, were performed using a spectrophotometer (Shimadzu, UV – 1800 model) and extracts ranging from 12500 to 200000 ppm. In the $ABTS^{\bullet+}$ test, the reading was performed exactly 6 minutes after the mixture of the $ABTS^{\bullet+}$ radical with the phenolic extract of cashew nut, at 734 nm (Re *et al*. 1999). In the $DPPH^{\bullet}$ test, the reading was performed thirty minutes after mixing the cashew nut extract with ethanolic solution of 0.06 mM $DPPH^{\bullet}$ at 515 nm (BRAND-WILLIAMS *et al*., 1995).

The experiment was conducted in a completely randomized design in a factorial scheme 6x5 (six treatments (collection steps) x five replicates (lots)). The analysis of variance (ANOVA) ($P \leq 0.05$) was performed to test the difference between the results. For the statistical analysis, the Tukey test ($P \leq 0.05$) was applied, using the statistical software SISVAR version 4.3 (Ferreira, 2000).

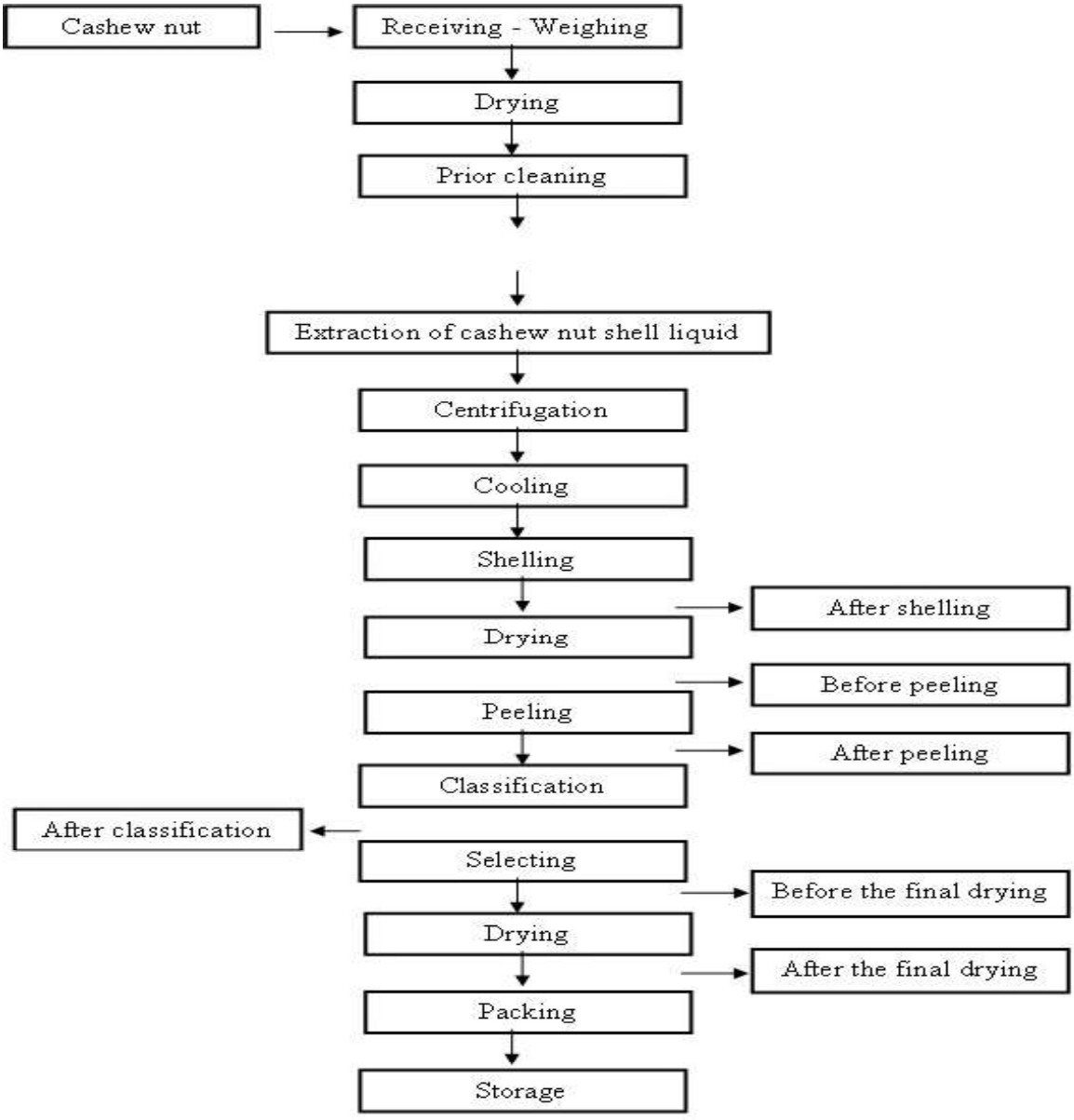

FIGURE 1 – FLOW CHART OF CASHEW NUTS BY MECHANIZED PROCESS.

3 RESULTS AND DISCUSSION

3.1 INFLUENCE OF THE PROCESSING STEPS IN CHEMICAL AND PHYSICOCHEMICAL CHARACTERISTICS OF CASHEW NUTS

The analysis of variance of chemical and physicochemical characteristics presented significant difference ($P \leq 0.05$) for all the characteristics during the steps of processing, since the water activity, moisture, lipids, proteins, carbohydrates and energy, differed significantly at 1% of probability by Tukey test.

The pH values found were of 6.53 ± 0.15 (after shelling), 6.54 ± 0.07 (after peeling) and 6.57 ± 0.02 (after the final drying) (Table 1). Similar results were reported by Melo *et al*. (1998) which characterize raw and toasted cashew nuts originating from the state of Ceara and found mean values of 6.20 and 6.14, respectively.

TABLE 1 – MEAN VALUES OF PH, WATER ACTIVITY (AW), MOISTURE (MOIST.), ASH, LIPIDS (LIP.), PROTEINS (PROT.), CARBOHYDRATES (CHO) AND ENERGY (ENG) OF CASHEW NUTS COLLECTED DURING THE PROCESSING.

Samples	pH	Aw	Moist. (g/100 g)	Ash (g/100 g)	Lip. (g/100 g)	Prot. (g/100 g)	CHO (g/100 g)	Eng (Kcal/100 g)
After shelling	6.53 ± 0.15^{ab}	0.75 ± 0.10^{a}	8.97 ± 0.76^{a}	2.42 ± 0.07^{a}	39.60 ± 1.71^{a}	11.66 ± 0.79^{a}	37.35 ± 2.09^{a}	552.43 ± 7.94^{a}
Before peeling	6.44 ± 0.06^{a}	0.54 ± 0.04^{b}	2.59 ± 0.33^{b}	2.50 ± 0.06^{ab}	42.31 ± 1.78^{ab}	15.84 ± 0.91^{b}	36.88 ± 2.16^{a}	591.22 ± 8.74^{b}
After peeling	6.54 ± 0.07^{ab}	0.55 ± 0.02^{b}	2.78 ± 0.56^{b}	2.53 ± 0.09^{ab}	43.68 ± 1.69^{bc}	16.00 ± 0.67^{b}	35.01 ± 1.90^{a}	597.18 ± 9.57^{b}
After classification	6.59 ± 0.03^{b}	0.62 ± 0.02^{b}	3.27 ± 0.59^{b}	2.57 ± 0.05^{b}	45.54 ± 1.09^{c}	22.47 ± 0.67^{c}	26.15 ± 1.20^{b}	604.30 ± 7.20^{b}
Before the final drying	6.61 ± 0.04^{b}	0.62 ± 0.03^{b}	3.04 ± 0.69^{b}	2.47 ± 0.04^{ab}	44.81 ± 0.88^{bc}	22.63 ± 0.92^{c}	27.06 ± 1.94^{b}	602.03 ± 3.33^{b}
After the final drying	6.57 ± 0.02^{ab}	0.59 ± 0.03^{b}	2.98 ± 0.47^{b}	2.48 ± 0.10^{ab}	44.14 ± 1.24^{bc}	22.87 ± 1.33^{c}	27.53 ± 1.16^{b}	598.85 ± 5.15^{b}

* Same letters within the same column are not statistically different by Tukey test ($P \leq 0.01$).

For the water activity (Aw) and moisture results, only the sample collected after the shelling significantly differed ($P \leq 0.05$) from the nuts collected in other processing steps, presenting values of 0.75 ± 0.10 and 8.97 ± 0.76 g/100 g, respectively (Table 1). The decrease in the Aw and moisture which occurred in nuts collected after shelling steps can be explained by the drying step that was performed at 80°C.

During the processing a gradual increase was observed in the water activity and moisture in nuts collected between the steps after the classification and before the final drying and although they did not differ significantly from the later steps after shelling, they presented values of 0.62 ± 0.02 and 0.62 ± 0.03 of water activity and 3.27 ± 0.59 and 3.04 ± 0.69 g/100 g of moisture, respectively (Table 1). The exposure to environmental conditions and handling of nuts throughout processing are the possible causes for this increase in water activity and moisture values and it explains the final drying step prior to packaging in final processing.

It is possible to verify, in Table 1, a gradual increase in the amount of ash, lipids and proteins during processing. It can be explained due to the decrease in moisture that occurs throughout the stages of processing. The sample collected after classification step presented the highest content of ash and lipids, with averages of 2.57 ± 0.05 g/100 g and 45.54 ± 1.09 g/100 g, respectively. Samples collected before and after the final drying presented lower levels of ash and lipids compared to the sample collected after the classification step. There is no evidence of factors that may cause the reduction of these levels in stages subsequent to classification.

Nuts collected after the final drying presented ash of 2.48 ± 0.10 g/100 g, lipid of 44.14 ± 1.24 g/100 g and protein of 22.87 ± 1.33 g/100 g (Table 1). The result for ash is similar to that observed by Lima and Borges (2004) and Venkatachalan and Sathe (2006), which are 2.5 g/100 g and 2.66 g/100 g, respectively. These authors also reported a protein content of 24.5 g/100 g, 18.81 g/100 g and 18.22 g/100 g, respectively, differing from the results observed in the present study.

The lipids content found in the present study is similar to that reported by Venkatachalan and Sathe (2006) (43.71 g/100 g).

The reduction in carbohydrate content during processing may be due to the indirect determination of this parameter, since changes in the levels of the other nutrients directly influence the carbohydrate content. At the end of the processing (nuts collected after the final drying) the nuts presented a carbohydrate content of 27.53 ± 1.16 g/100 g (Table 1).

Due to the high level of lipids which are responsible for about 66 g/100 g of nut calories, at the end of processing nuts showed 598.85 ± 5.15 kcal/100 g (Table 1), which is similar to the levels reported by Philippi (2003) who found 574 kcal/100 g

3.2 INFLUENCE OF THE PROCESSING STEPS ON THE ANTIOXIDANT ACTIVITY OF CASHEW NUTS

The analysis of variance of total extractable polyphenols (TEP) and antioxidant capacity by $ABTS^{\bullet+}$ and $DPPH^{\bullet}$ methods presented significant difference ($P \leq 0.01$) by the Tukey test.

For the TEP level, only cashew nuts collected after the shelling and before peeling differed significantly from the cashew nut collected during the other steps of processing, presenting values of 683.19 ± 120.81 mg galic acid equivalent (GAE)/100 g and 669.88 ± 168.91 mg GAE/100 g, respectively (Table 2). The decrease in TEP levels can be explained by the removal of film after the peeling step.

TABLE 2 – MEAN VALUES OF TOTAL EXTRACTABLE POLYPHENOLS (PET) ANTIOXIDANT ACTIVITY BY $ABTS^{\bullet+}$ AND $DPPH^{\bullet}$ METHODS OF CASHEW NUTS COLLECTED DURING THE PROCESSING

Samples	PET (mg GAE/100 g)	$ABTS^{\bullet+}$ (µM Trolox/g)	$DPPH^{\bullet}$ (g/g of DPPH)
After shelling	683.19 ± 120.81^{c}	75.46 ± 2.94^{c}	1342.60 ± 95.74^{a}
Before peeling	669.88 ± 168.91^{c}	13.55 ± 5.58^{b}	4252.59 ± 1452.08^{ab}
After peeling	115.31 ± 38.51^{b}	10.70 ± 4.47^{ab}	7512.06 ± 511.55^{b}
After classification	53.72 ± 6.07^{ab}	8.35 ± 0.73^{ab}	22091.05 ± 1110.43^{c}
Before the final drying	44.94 ± 7.84^{a}	6.26 ± 1.74^{a}	29098.05 ± 5252.94^{d}
After the final drying	51.33 ± 5.12^{a}	6.49 ± 0.29^{a}	29964.40 ± 2328.01^{d}

* Same letters within the same column are not statistically different by Tukey test ($P \leq 0.01$).

Several authors reported that the seed coatings (film) have high level of phenolic compounds (DUENAS *et al*., 2004; DUENAS *et al*., 2006). Studies have demonstrated that the extract of nut films (SANG *et al*., 2002; CHEN *et al*., 2005) have high antioxidant activity.

After peeling, classification and final drying, the cashew nuts ready to be packaged presented TEP of 51.33 ± 5.12 mg GAE/100 g (Table 2) differing from the results of Yang *et al*. (2009) who, evaluating total phenolic extracted with acetone and hexane, observed levels of 86.7 mg GAE/100 g and Kornsteiner *et al*. (2006), who, using the same conditions as Yang *et al*. (2009), found levels of TEP of 137 mg GAE/100 g.

The difference between the total phenolic reported in the literature and in the present work may be explained by the variation in the solvents employed in the extraction process. Naczk and Shahidi (2006) reported that the phenolic extract from plant material is influenced by the solubility of the solvent used in the extraction process. Therefore, it is difficult to develop a standard extraction suitable for the extraction of all plant phenols (ALOTHMAN *et al*., 2009).

Pieces of research which quantify the antioxidant activity in cashew nuts extracted with ethanol and acetone by $ABTS^{\bullet+}$ or $DPPH^{\bullet}$ methods have not been found. Therefore, the present work discussion was based on the results found by other authors using nuts commonly consumed in Brazil and abroad.

For the antioxidant activity by the $ABTS^{\bullet+}$ method, only the sample collected after shelling differed from all the other samples, presenting results of 75.46 ± 2.94 µM Trolox/g (Table 2). The high antioxidant activity is related to the polyphenols present in the film. Most of the antioxidant in nuts is located in the film and less than 10% is retained in the nut when the film is removed. In most cases nuts without film had less than 50% of the antioxidants in nuts with film (BLOMHOFF *et al*., 2006).

Cashew nuts collected before and after the final drying and ready to be packaged presented lower results of antioxidant activity than the nuts collected after the classification. There is no evidence of factors that may cause the reduction in antioxidant activity in steps subsequent to classification. This fact is possibly due to the long exposure time of nuts in the processing or to a lack of homogeneity in the batch.

After the peeling, classification and final drying, cashew nuts ready to be packaged presented values of 6.49 ± 0.29 µM Trolox/g (Table 2) which correspond to retention of 8.60% in antioxidant activity.

For the antioxidant activity by $DPPH^{\bullet}$ method, according to the method applied, the result corresponds to the amount of sample required to reduce by 50% the initial concentration of $DPPH^{\bullet}$ (EC_{50}), being expressed in g of nut/g of $DPPH^{\bullet}$. Thus, a high $DPPH^{\bullet}$ result means that the sample has a low antioxidant activity.

The samples collected after the shelling and before peeling did not differ significantly and presented values of 1342.60 ± 95.74 g/g of $DPPH^{\bullet}$ and 4252.59 ± 1452.08 g/g of $DPPH^{\bullet}$, respectively. Therefore these were the samples with higher total antioxidant capacity (Table 2).

After peeling, classification and final drying, cashew nuts ready to be packaged presented values of 29964.40 ± 2328.01 g/g de $DPPH^{\bullet}$ (Table 2), which is a high value, evidencing a low antioxidant capacity. This result was not expected since the TEP and the antioxidant activity by $ABTS^{\bullet+}$ results showed good antioxidant activity.

Reddy *et al*., (2010), studying cashew nuts commercialized in India, evaluated the antioxidant activity using methanol extract of $DPPH^{\bullet}$ and found values of 320.37 mg de Trolox/ 100 g, indicating a good antioxidant activity.

The results obtained in the present study by the $DPPH^{\bullet}$ showed low levels of antioxidant activity, possibly due to the solvent employed to extract. Sharma and Bhat (2009) reported that the most appropriate solvent for the $DPPH^{\bullet}$ is methanol or buffered methanol and that the high absorption in methanol solutions implies a better sensibility related to ethanol solutions of $DPPH^{\bullet}$.

The correlation analysis showed high correlation between the contents of TEP and antioxidant activity by the $ABTS^{\bullet+}$ ($r=0.70993$; $p<0.0001$) and $DPPH^{\bullet}$ ($r=0.79126$; $p<0.0001$), verifying the high correlation for the $DPPH^{\bullet}$ method (Table 3).

TABLE 3 – PEARSON CORRELATION COEFFICIENT BETWEEN THE TOTAL ANTIOXIDANT ACTIVITY BY $ABTS^{\bullet+}$ AND $DPPH^{\bullet}$ METHODS AND THE TOTAL EXTRACTABLE POLYPHENOLS OF CASHEW NUTS COLLECTED DURING THE PROCESSING.

Parameters	Correlation Coefficient (r)	
	$ABTS^{\bullet+}$	$DPPH^{\bullet}$
Total extractable polyplenols	0.70993*	0.79126*

* Significant at 0.1%

4 CONCLUSIONS

Cashew nuts showed significant variation in all chemical and physicochemical parameters evaluated during the processing steps, presenting at the end of processing, high lipid content and energy and a low moisture and water activity.

Regarding the antioxidant activity of cashew nuts, it was possible to observe that the film contribution on the phenolic content is high, contributing to a high antioxidant activity and that the loss is significant throughout the processing steps.

The $ABTS^{\bullet+}$ method can be considered appropriate to measure the antioxidant activity of cashew nuts, since the results presented lower coefficients of variation and expressed proportionate results to other methods.

RESUMO

INFLUÊNCIA DAS ETAPAS DE PROCESSAMENTO NA QUALIDADE DA CASTANHA DE CAJU

A castanha de caju possui elevado valor nutricional. Esta amêndoa fornece macronutrientes, micronutrientes e uma elevada variedade de antioxidantes como os compostos fenólicos. Ocorrem perda de alguns compostos durante o processamento do fruto e existem somente poucos trabalhos realizados sobre esse aspecto. Diante do exposto, esta pesquisa teve como objetivo determinar o efeito das etapas de processamento da amêndoa de castanha de caju com ênfase na atividade antioxidante. Diferenças significativas foram observadas entre as etapas de processamento para todas as características químicas e físico-químicas estudadas. A amêndoa de castanha de caju apresentou elevados teores de lipídios e energia, baixo conteúdo de umidade a atividade de água e teor médio de compostos fenólicos (51,33 GAE/100 g) e de atividade antioxidante pelo método $ABTS^{\bullet+}$ (6,49 μM Trolox/g) no final do processamento. No que diz respeito a atividade antioxidante, foi observado que o método com o radical $ABTS^{\bullet+}$ pode ser considerado apropriado para determinar a atividade antioxidante da amêndoa de castanha de caju, já que os resultados apresentaram baixos coeficientes de variação e expressam resultados proporcionais aos outros métodos.

PALAVRAS-CHAVE: PERDAS NUTRICIONAIS; ANTIOXIDANTES; PROCESSAMENTO; QUALIDADE DE FRUTAS.

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