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Could the production region influence the quality and antioxidant activity of cashew apple?

¿Podría la región de producción influir en la calidad y la actividad antioxidante de la manzana de marañón?

Cashews from different clones in the two regions of Ceará, Brazil.

Photo: M.L.B. Almeida.

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ABSTRACT

Given the scarcity of research related to the interference of the climatic elements under the qualitative characteristics of the cashew apples, this work had the objective of evaluating the quality and total antioxidant activity of cashew apple of dwarf cashew in different climatic conditions. The experimental design was completely randomized, in a factorial scheme with repeated measurement in time, with three clones (CCP 09, BRS 265 and PRO 555-1) in two regions, cearense semiarid, sertão (Alto Santo – CE) and a coast (Beberibe – CE), with four replications and evaluated in different years. In the laboratory, the fruits were processed to obtain the pulp and evaluated for: soluble solids (SS, °Brix), titratable acidity (TA, % malic acid), SS/TA, soluble sugars (AS, % glucose), vitamin C (mg/100 g), total extractable polyphenols (TEP, mg L^{-1}), cinnamic acid (CA, mg L^{-1}), transcinnamoyl glycoside (TG, mg L^{-1}) and total antioxidant activity (TAA, μmol Trolox/g). It was observed highest values of SS, TA, AS, vitamin C, TG, TEP and TAA obtained in cashew apple in the sertão. The 'CCP 09' showed higher quality to the others, responding in a positive way to the variations of environments conditions. The quality and antioxidant activity of cashew apple are influenced by the climatic elements of each region, as well as the year of production and the genotype. The antioxidant activity attributed to the cashew apple showed to be more strongly related to TEP and transcinnamoyl glycoside content.

Additional key words: *Anacardium occidentale* L.; post-harvest; bioactive compounds; climatic elements.

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RESUMEN

Dada la escasez de investigaciones relacionada con la interferencia de elementos climáticos en los caracteres cualitativos de los pedúnculos de marañón, el presente trabajo tuvo como objetivo evaluar la calidad y actividad antioxidante de pedúnculos de diferentes clones de marañón enano en diferentes condiciones climáticas. El diseño experimental fue completamente al azar, en arreglo factorial con repeticiones en el tiempo, con tres clones (CCP 09, BRS 265 y PRO 555-1) en dos regiones, una ubicada en la región semiárida de Ceará, sertão (Alto Santo – CE) y en la costa (Beberibe – CE), con cuatro repeticiones y evaluados en diferentes años. En laboratorio, los frutos fueron procesados para obtener la pulpa y evaluados para: sólidos solubles (SS, °Brix), acidez titulable (AT, % ácido málico), SS/AT, azúcares solubles (AS, % glucosa), vitamina C (mg/100 g), polifenoles extraíbles totales (PET, mg 100 g^{-1}), ácido cinámico (AC, mg L^{-1}), transcinamoil glucósido (TG, mg L^{-1}) y actividad antioxidante total (AAT, μmol Trolox/g). Los valores medios más altos de SS, AT, AS, vitamina C, TG, PET y AAT se observaron en los pedúnculos producidos en la sertão. 'CCP 09' mostró una calidad superior a los demás clones, respondiendo positivamente a las variaciones de las condiciones ambientales. La calidad y la actividad antioxidante del marañón están influenciadas por los elementos climáticos de cada región, así como por el año de producción y el genotipo. La actividad antioxidante atribuida a los pedúnculos analizados se relacionó más fuertemente con el contenido de PET y TG.

Palabras clave adicionales: *Anacardium occidentale* L.; poscosecha; compuestos bioactivos; elementos climáticos.

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INTRODUCTION

The cashew tree (*Anacardium occidentale* L.) is an important native culture of Brazil, cultivated in several parts of the world, as in the tropical regions of Asia, Africa and South, Central and North Americas (Figueirêdo *et al*., 2016). This species is considered highly rustic, finding ideal conditions for its development in the Brazilian Northeast region, such as temperature, luminosity, altitudes, deep soils and rainfall, which varies from 600 to 1,200 mm per year. In this region, its production is concentrated in the dry season, from August to December (Souza *et al*., 2018).

The environmental factors that most influence fruit quality are temperature, rainfall, relative humidity, solar radiation and soil conditions, as well as the association of these with some cultural practices. Thus, it is possible that the environmental and cultural differences between the production regions may affect the production of photoassimilates in the plant, influencing its quality (Almeida *et al*., 2018).

Annual rainfall is of great importance for cashew cultivation, as it has a predominance of rainfed cultivation. There is a difference in rainfall between the regions of the sertão and coast, as well as between the years. Despite the ideal conditions for cashew cultivation, the accumulation of water needed during the year is, in most cases, below the historical average for the sertão. On the coast, sometimes, rainfall is also below the historical average, but within the range suitable for its cultivation. The rainfall below the average required by the crop causes water deficiency, which may affect the productive performance of the plants through the reduction of the photosynthetic process.

Brazil produces cashews apple with physical characteristics within commercialization standards, reaching weights of up to 107 g for the peduncle and 122 g for total fresh mass (Almeida *et al*., 2018). In addition to the adequate physical parameters, it also produces cashews apple with considerable concentrations of antioxidant activity and bioactive compounds due to favorable climatic conditions for the culture, a fact observed by Souza *et al*. (2019).

In recent years, studies indicate that fruits are among the main sources of antioxidant compounds, which are important for the maintenance of human health. Therefore, greater attention has been given to these compounds found in fruits and, consequently, people are more interested in obtaining a rich diet of these compounds (Almeida *et al*., 2016). However, several studies have shown the influence of the cultivation

region on the quality of the fruits of different species, such as wild bilberry (Mikulic-Petkovsek *et al*., 2015), camu-camu (Ribeiro *et al*., 2016) and blue honeysuckle (Senica *et al*., 2018). This is due to different factors, such as the genetic potential of plants, environmental conditions of the production region, which exert a strong influence on appearance, composition and conservation.

The cashew apples are considered a functional food because it is rich in dietary fibers, bioactive compounds, vitamins, amino acids, minerals and sugars (Das and Arora, 2017). However, given the scarcity of research related to the interference of the production region under quality of the fruit, this work had the objective of evaluating the influence of the region and the genotype on the quality and total antioxidant activity of the cashew 'CCp 09', 'BRS 265' and 'PRO 555-1' in different years.

MATERIALS AND METHODS

The cashews (cashew apples and cashew nuts) of dwarf cashew clones came from demonstration units of Embrapa Agroindústria Tropical, located in two regions of the state of Ceará, Brazil, one in the semiarid region, sertão (municipality of Alto Santo) and the other on the coast (municipality of Beberibe). Alto Santo with average temperature of 28°C and BSh semiarid climate. The soil type was classified as red-yellow latosol and sandy texture. The municipality of Beberibe with average temperature of 26.6°C and tropical atlantic and sub-humid climate (As). The soil type was classified as quartzarenic neosol of sandy texture. Annual rainfall data for the experiment period are shown in table 1.

The experimental design was completely randomized, in the factorial scheme with repeated measure in time, applying the confounding technique, with 4 replications, totaling 48 samples, each sample consisting of approximately 250 g of apples. The treatments consisted of three clones of dwarf cashew, CCP 09, BRS 265 and PRO 555-1, from the two regions and two years of production, 2013 and 2014. The total number of plants was represented by 30 plants of each clone in each region.

About 30 ripe cashews of each clone were harvested in the early hours of the day in each region. They were then packed in plastic boxes with the bottom of the box coated with 1 cm of polystyrene foam, arranged in a single layer to avoid physical damage to them. The cashews were transported under refrigeration to the post-harvest laboratory, where they underwent a selection process. After the selection, they were processed in a Walita® domestic centrifuge for pulp retrieval and stored in plastic containers and then stored in a freezer at -20°C for further evaluation.

The variables evaluated were: soluble solids (SS, °Brix), the content measured in an Atago® PR-101 Pallete digital refractometer (AOAC, 2005); titratable acidity (TA, % of malic acid) obtained from titration with 0.1 M NaOH solution (AOAC, 2005); SS/TA ratio was obtained by the dividing the two determinations; soluble sugars (AS, % glucose) was quantified by the anthrone method, according to the methodology of Yemn and Willis (1954). Vitamin C (mg of ascorbic acid/100 g pulp) was quantified immediately after processing of the apples (Strohecker and Henning, 1967).

The extraction procedure to quantify the content of total extractable polyphenols and the antioxidant activity was developed by Larrauri *et al*. (1997), where methanol/water (50:50, v/v) and acetone/water (70:30, v/v) were used to obtain the extract.

The total extractable polyphenols (TEP) were quantified by the Folin-Ciocalteu method (Obanda *et al*., 1997). Absorbance was measured at 700 nm and results were expressed as gallic acid equivalents (GAE, for 100 g pulp). The antioxidant activity was obtained by the free radical capture method ABTS$^{\bullet+}$ (2.2-Azino bis-3-ethylbenzothiazoline-6-sulphonic acid), with modifications (Re *et al*., 1999). As the standard solution, the synthetic antioxidant Trolox was used at concentrations of 100 to 2,000 μM

Table 1. Annual rainfall (mm) occurred from January to December 2013 and 2014 in the regions of Alto Santo and Beberibe-CE.

Month	Alto Santo/2013	Beberibe/2013	Alto Santo/2014	Beberibe/2014
Total	584.5	703	485.3	825
Historical mean	834.8	914.1	834.8	914.1

Source: Fundação Cearense de Meteorologia e Recursos Hídricos (Funceme, 2015).

in ethanol. The antioxidant activity was expressed as trolox equivalent (TEAC) and expressed in μmol Trolox/g.

The content of cinnamic acid and *trans* cinnamoyl glycoside (mg L^{-1}) were quantified by LC-DAD-ESI/MS (Brito *et al*., 2007), which consists of a HPLC 250 Varian (Varian, CA) coupled with a diode array detector (DAD) and a 500-MS IT (Varian) mass spectrometer. The two compounds were based on the retention time of the trans-cinnamic acid standard and quantified using the calibration curve of the standard solution.

The results were submitted to the analysis of variance (ANOVA) and performed using SISVAR software v. 5.1. Tukey test at $P<0.01$ statistical significance was used to compare the averages. In order to analyze if the bioactive compounds contributed to the antioxidant activity of the fruit, the Pearson correlation coefficients were calculated at $P<0.01$ and $P>0.05$ of significance, using the BioEstat *v.* 5.0 software program.

RESULTS AND DISCUSSION

Analyzing the data in general, we observed at least a double interaction between the factors studied, region of production, clone and year for all variables, except for the transcinamoyl glycoside, which presented an effect isolated from the factors.

For the soluble solids (SS), the highest levels were observed in the clones of the sertão region (Tab. 2). This is probably due to the smaller size of the cashew apples observed in this region (54.42 and 81 cm in the coastal region), since the soluble solids reflect the dry matter content and is inversely proportional to the size of the fruit (Beckles, 2012). 'CCP 09' showed higher values than the other clones in both regions. In the sertão, the highest values were obtained in

Table 2. Soluble solids content (SS), titratable acidity (TA), SS/TA and soluble sugars of apples of dwarf cashew clones as a function of environmental conditions.

Clone	Soluble solids (°Brix)		Titratable acidity (% malic acid)	
	Sertão	Coastal	2013	2014
CCP 09	17.92±0.51 aA	15.40±0.38 bA	0.42±0.07 aA	0.32±0.01 bA
BRS 265	14.80±0.22 aC	13.62±0.43 bB	0.32±0.04 aB	0.31±0.01 aA
PRO 555.1	15.99±0.20 aB	12.97±0.21 bB	0.32±0.04 aB	0.26±0.01 bB
Year	Sertão	Coastal	Sertão	Coastal
2013	16.79±0.50 aA	13.19±0.29 bB	0.48±0.03 aA	0.23±0.01 bB
2014	15.68±0.37 aB	14.80±0.39 bA	0.32±0.01 aB	0.28±0.01 bA
CV1 (%)	5.55		10.15	
CV2 (%)	3.70		12.95	
Clone	SS/TA		Soluble sugars (AS) (% glucose)	
			Sertão	Coastal
CCP 09	-	-	13.89±0.60 aA	12.44±0.29 bA
BRS 265	-	-	11.21±0.96 aB	11.60±0.24 aAB
PRO 555.1	-	-	12.94±0.44 aA	10.85±0.16 bB
Year	Sertão	Coastal	Sertão	Coastal
2013	35.72±0.89 bB	57.91±1.31 aA	14.28±0.30 aA	11.74±0.31 bA
2014	50.08±1.85 aA	53.46±1.47 aB	11.08±0.55 aB	11.52±0.23 aA
CV1 (%)	8.85		7.09	
CV2 (%)	9.12		7.23	

Means followed by the same lowercase letters on the lines and capital letters in columns do not differ by the Tukey test ($P<0.05$). CV = coefficient of variation.

the year 2013, while on the coast, the cashew apples from the year 2014 were the ones with the highest SS values. The values obtained were superiors to the report by Abdullah *et al*. (2021) and Luengo-Fereira and Hernández-Varela (2021).

The titratable acidity had similar performance to that of the SS, in which the highest TA values were for cashew apples from the sertão, with emphasis on the year 2013; in the coastal region, cashew apples produced in 2014 showed higher TA. For clone and year interaction, the highest values were observed in the year 2013, except for BRS 265, which did not differ between years. In 2013, 'CCP 09' stood out in relation to the others; already in 2014 the highest values were represented by 'CCP 09' and 'BRS 265', which did not differ among themselves (Tab. 2).

The TA had an average of 0.39 and 0.25% of malic acid for the sertão and coastal regions, respectively. Higher values of acidity in cashew apples produced in regions of higher temperatures were also observed by Emelike and Obinna-Echem (2020). Similar values in cashews, for different clones, were verified by Souza *et al.* (2019) when they studied cashew produced in the Ceará coastal region, found acidity of 0.24% of malic acid.

In the SS/TA ratio, there was a difference between the regions only in the year 2013, with the highest values obtained in cashew apples coming from the coast (Tab. 2). In the sertão, the highest values of SS/TA were observed in the year 2014. This higher SS/TA, in these years for each region, is due to the lower titratable acidity identified in them.

Regarding soluble sugars, the highest values were found in the cashew apples produced in the sertão, with the exception of the clone BRS 265 and the year 2014, which did not differ between the production regions (Tab. 2). In the coastal conditions, a difference was observed only between 'CCP 09' and 'PRO 555-1', with no difference between the years of production. The values obtained were similar to the report by Emelike and Obinna-Echem (2020).

The factors that may have interfered in the smaller size of the cashew apples produced in the semiarid and, consequently, in the quantity of the constituents of the same, is probably due to the nutritional state of the plants (Lado *et al*., 2014), together with low water supply, high average temperature and solar radiation. Since the cashew trees in both production regions were irrigated with only rainwater, with the region of the sertão having a low rainfall index, and also below the historical average of the region (Tab. 1).

Thus, the cashew apples did not have favorable moisture retention conditions for their growth, causing higher concentration of the compounds, SS, TA and soluble sugars for the sertão. These results corroborate with those obtained by Silva *et al*. (2008), in which studying guava fruits as a function of irrigation slides, observed that SS undergoes changes due to the amount of water applied, reducing as the slide increased. In this way, the high acidity of the fruits is explained, because the organic acids are compounds that tend to diminish according to the maturation of the fruits, in which it happens at the same time its size increases, due to the water retention. Another

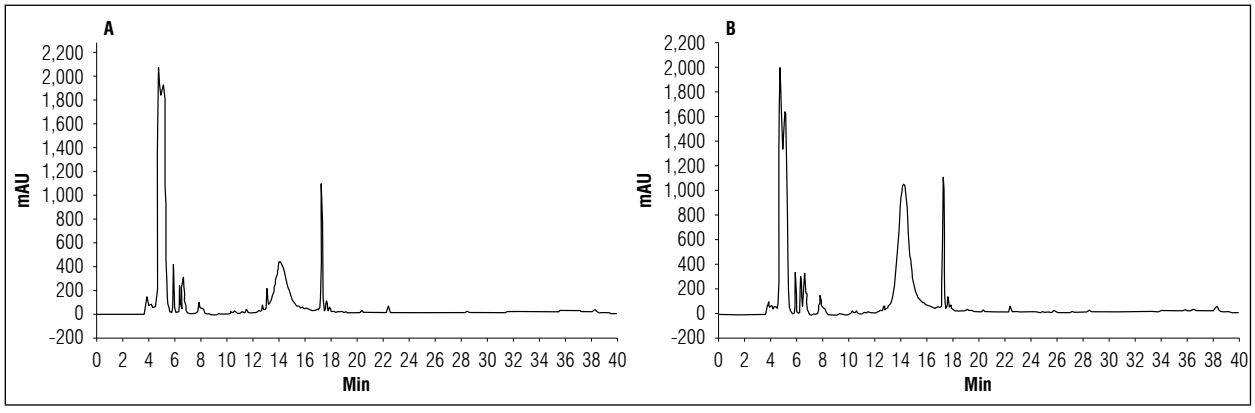

Figure 1. MS chromatograms at 254 nm of cashew apples. Peaks in retention time of 22.43 min for the cinnamic acid and 17.29 min for the transcinnamoyl glycoside. A – Alto Santo; B – Beberibe.

explanation for the higher amounts of SS, TA and AS in the sertão apples would be a possible stress caused by soil-climate conditions, which lead the plants to a greater conversion of carbohydrates to soluble sugars, which usually make up 65-85% of the SS (Lado *et al*., 2014), organic acids and defense compounds, rather than being used for fruit growth.

Despite the influence of the environmental conditions of the regions and years on quality of the cashew apples, there is a clone, such as BRS 265, that did not change in the TA and AS variables, indicating that these variables may be more associated with genetic control than the environment.

For the transcinnamoyl glycoside, glycosylated cinnamic acid, it was observed that there was no interaction between the studied factors, differing by itself. The overall average observed was 444.4 mg L^{-1}. It was verified the greater synthesis of this compound in cashew apples of 'CCP 09' (519,76 mg L^{-1}) and 'PRO 555-1' (460,91 mg L^{-1}), produced in the sertão conditions. In relation to the production years, there was no difference between them.

Transcinnamoyl glycoside and cinnamic acid were determined when peaks were detected (Fig. 1). The peaks of the mass spectrum corresponding to the transcinnamoyl glycoside and cinnamic acid were observed at 17.29 and 22.43 min, respectively.

In the present study, it was observed for cinnamic acid general average of 32.56 mg L^{-1}. For the clones in different years, the highest values were observed in year 2013, with the exception of 'CCP 09', which had the highest average value of cinnamic acid in 2014 (Tab. 3). In the year and region interaction, a greater synthesis of this compound was observed in

Table 3. Cinnamic acid, total extractable polyphenols (TEP), vitamin C and antioxidant activity of apples of dwarf cashew clones as a function of environmental conditions.

Clone	Cinnamic acid (mg L^{-1})		Total extractable polyphenols (mg/100 g)	
	2013	2014	2013	2014
CCP 09	33.53±2.97 bAB	49.66±3.14 aA	471.85±49.21 aA	265.51±16.49 bA
BRS 265	27.53±2.22 aB	20.07±1.23 bB	208.90±22.60 aB	143.46±11.09 bB
PRO 555.1	38.55±2.44 aA	26.02±2.37 bB	198.95±27.41 aB	132.16±8.0 bB
Year	Sertão	Coastal	Sertão	Coastal
2013	28.42±1.74 bB	37.99±2.20 aA	377.86±47.33 aA	208.60±30.40 bA
2014	35.08±4.25 aA	28.76±4.13 bB	192.40±14.80 aB	168.34±24.74 aB
CV1 (%)	15.68		12.09	
CV2 (%)	18.15		17.48	
Clone	**Vitamin C (mg/100 g)**		**Antioxidant activity (μmol Trolox/g)**	
	Sertão	**Coastal**	**2013**	**2014**
CCP 09	341.62±2.67 aB	192.53±12.04 bB	43.76±6.48 aA	35.00±0.58 bA
BRS 265	369.92±12.89 aA	196.74± 2.85 bB	19.90±2.49 aB	21.18±1.56 aB
PRO 555.1	380.01±9.10 aA	226.34±10.67 bA	17.12±2.71 aB	18.29±1.40 aB
Year			**Sertão**	**Coastal**
2013	-	-	35.79±5.23 aA	18.07±2.82 bA
2014	-	-	26.90±1.77 aB	22.75±2.78 aA
CV1 (%)	3.37		22.97	
CV2 (%)	6.33		23.37	

Means followed by the same lowercase letters in lines and capital letters on the columns do not differ by the Tukey test at 5% probability. CV = coefficient of variation.

cashew apples from the coastal region obtained in the year 2013; the sertão was represented by the year 2014. This may be due to the lower rainfall indexes, the high temperatures, the low relative air humidity, the high insolation, among other factors, occurred in each year of greater synthesis, since cinnamic acid belongs to the phenolic compounds that are produced by the secondary metabolism of the plants in reaction to the adversities of the environment.

Cinnamic acid is a naturally occurring organic acid in vegetables (Adisakwattana *et al*., 2012). It is also known as (E)-3-phenyl-2-propenoic acid and belongs to the phenolic compounds, within the group of hydroxycinnamic acids. It has low toxicity and a wide effect of biological activities (Hu *et al*., 2015), as a result of its high antioxidant activity, due to a variety of derivatives (caffeic, ferulic, sinapic, o-coumaric, p-coumaric, m-coumaric, cinnamic and 3,4-dimethoxycinnamic acid), in which it differs only in the number and location of hydroxyl and methoxy groups in the phenyl ring (Szeleszczuk *et al*., 2016).

Polyphenols presented a general average of 236.80 mg/100 g. It was observed for the clones in different years the greatest contents in the cashew apples produced in the year 2013, with the best performance presented by 'CCP 09', in both years. The values obtained were superiors to the reported by Abdullah *et al.* (2021). Analyzing the regions in these years, differences were observed only in the year 2013, with a higher synthesis of these compounds in cashew apples from the sertão (Tab. 3).

The chemical composition of the fruits can be affected by several factors, with environmental conditions being the most important in this process (Maro *et al*., 2014). According to Machado *et al*. (2013), the variation in polyphenol content in fruits is related to the availability of water to the plant during the fruit ripening period. In which they observed, under rainfed conditions, a higher polyphenol content than when irrigated. In addition to stress from environmental conditions, which lead to increased production and variability in polyphenol values among clones, they are also associated with the fact that plants can activate the synthesis of polyphenols in response to other types of stress, such as lesions, attacks of pathogens, low amounts of nutrientes, among others.

Regarding the vitamin C content, interaction between clone and region was observed (Tab. 3), with an overall average of 284.52 mg/100 g. There was a difference of all the clones between the regions, with an increase of 43.6% of the vitamin C content for the cashew apples produced in the sertão, especially for the clones BRS 265 and PRO 555-1. In the coastal region, clone PRO 555-1 showed the highest average value. The analyzed years differed in isolation, with 264.52 and 304.53 mg/100 g for the year 2013 and 2014, respectively.

The expressive difference in vitamin C content among the production regions may be directly associated with the quantity of soluble sugars produced by the cashew apples of the sertão. The changes caused by the different types of soil and climatic conditions such as luminosity, possibly, may have influenced directly the photosynthesis and, therefore, the production of the sugars necessary for its biosynthesis. Thus, the lower content of vitamin C in the cashew apple of the coastal region is probably due to the reduction of the luminosity in the plants during the fruiting period. The influence of this factor on the production of ascorbic acid was also cited by Ribeiro *et al*. (2016).

The vitamin C content of cashew apples produced in the sertão and TEP in both regions was higher than those reported by Ndiaye *et al*. (2022) in South of Senegal, and Lopes *et al*. (2012) for cashew apples produced in Pacajus, Ceará, which observed 226.11 and 279.37 mg/100 g ('CCP 09' and 'BRS 265'), 70.91 and 69.51 mg/100 g ('CCP 09' and 'BRS 265') for vitamin C and TEP, respectively. These variations observed in the composition of the apple show that they may be related to the different climate characteristics of each of these regions and periods of production. This fact was also affirmed by Ribeiro *et al*. (2016), who observed variations among the camu-camu fruits produced in different environments, in two states of the Brazilian Amazon.

Cashew tree plants are exposed to several adverse environmental conditions, such as water deficit, high temperatures and solar radiation, nutritional limitation of the soil, occurrence of pathogens and insects, among others. These factors can lead to the increase of the production of reactive oxygen species (ROS), and the antioxidant defense system of the plants may have been triggered, which they act in the neutralization of ROS, avoiding a possible oxidative stress (Gao *et al*., 2016).

The total antioxidant activity presented interaction between clone and year and between year and region

(Tab. 3). It was observed for the clones in the different years of production difference only the 'CCP 09', with the highest average value for the year 2013. The same clone stood out among the others in both years of production. Analyzing the regions in the years, it was verified that the TAA differed between regions only in 2013, with the highest values for cashew apples coming from the sertão. In the coastal region there was no difference between the years.

The results, in general, indicate that despite the different environmental conditions of the production regions, 'CCP 09' showed less influence of the environment, which responded positively to variations in the soil-climate conditions, that is, it can express satisfactory quality in different environmental conditions. The 'CCP 09' produced cashew apples of superior or similar quality to the other clones in both regions and years for SS, TA, AS, TG, CA, TEP and TAA. This fact can be observed in the antioxidant activity, in which the values were higher (43.76 and 35.00 μmol Trolox/g for the sertão and coastal regions, respectively) to the other clones and also to that observed by Ndiaye *et al*. (2022) to cashew apple red and orange.

Table 4 shows the Pearson correlation coefficients of vitamin C, TEP, CA and TG, with TAA. Significant and positive correlation coefficients were observed between antioxidant activity and total extractable polyphenols, vitamin C and transcinnamoyl glycoside. The cinnamic acid presented a positive coefficient, but not significant ($P>0.05$).

Table 4. Pearson's correlation coefficient (*r*) between bioactive compounds and the total antioxidant activity of apples of dwarf cashew clones as a function of environmental conditions.

Variable	Antioxidant activity
Vitamin C	0.2937 *
Total extractable polyphenols	0.9017 **
Cinnamic acid	0.1067 ^{ns}
Transcinnamoyl glycoside	0.5009 **

* and ** significant correlation coefficient at 0.05 and 0.01 significance level, respectively. ^{ns} not significant.

In view of the results, phenolic compounds (r = 0.90; $P<0.01$) and transcinamoyl glycoside (r = 0.50; $P<0.01$) were the main constituents for the antioxidant activity of cashew apples of the clones analyzed. This fact was also placed by Lopes *et al*. (2012) and Souza *et al*. (2016); and contrary to that observed by Gordon *et al*. (2012), which points out vitamin C as the main constitunt of antioxidant activity.

CONCLUSION

The production region interferes in the physicochemical variables, bioactive compounds and antioxidant activity of dwarf cashew apples, as well as the year of production and the genotype. The highest values of vitamin C, TG, SS, TA, AS, TEP and TAA were obtained in the apples of the clones coming from the sertão. 'CCP 09' presented a superior quality to the other clones, responding in a positive way to the variations of environmental conditions, that is, it can express satisfactory quality in different regions. The TAA attributed to the cashew apples of the clones analyzed was more strongly related to the content of TEP and TG.

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