European Journal of Medicinal Plants

32(12): 64-77, 2021; Article no.EJMP.77992
ISSN: 2231-0894, NLM ID: 101583475

Effect of Two Drying Methods on the Bioactive Cashew Apple Varieties Consumed in the City of Garoua (Northern Cameroon)

Kouogueu Seuyim Ghislain [a,b*], Nguedjo Wandji Maxwell [b,c], Dibacto Kemadjou Ruth Edwige [b,c], Nseme Mboma Yves Didier [b,d], Djouka Nembot Pelagie Marcel [a,e] and Takuissu Nguemto Guy Roussel [b,c]

[a] Institute of Agricultural Research for Development (IRAD), P.O. BOX 415 Garoua, Cameroon.
[b] Department of Biochemistry, Faculty of Sciences, University of Yaoundé 1, P.O.Box 812, Yaoundé, Cameroon.
[c] Centre for Food and Nutrition Research, Institute of Medical Research and Medicinal Plants Studies, P.O.Box 13 033, Yaoundé, Cameroon.
[d] Institute of Agricultural Research for Development (IRAD), P.O. BOX 13 Njombe, Cameroon.
[e] Department of Agricultural Sciences, National Polytechnic School of Maroua, University of maroua, P.O.Box 46, maroua, Cameroon.

Authors' contributions

This work was carried out in collaboration among all authors. All members contributed to designing the study. Authors KSG, NWM, and DKRE wrote the protocol and managed the analyses of the study. Author KSG and NWM performed the statistical analysis together with authors KSG, NMYDand DNPM who wrote the first draft of the manuscript. Authors TNGR. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/EJMP/2021/v32i1230436
Editor(s):
(1) Dr. Patrizia Diana, University of Palermo, Italy.
(2) Prof. Marcello Iriti, Milan State University, Italy.
Reviewers:
(1) Mahmoud Abbas Ali, South valley university, Egypt.
(2) Conxita Mestres, University Ramon Llull, Spain.
Complete Peer review History, details of the editor(s), Reviewers and additional Reviewers are available here: https://www.sdiarticle5.com/review-history/77992

Original Research Article

Received 05 October 2021
Accepted 10 December 2021
Published 16 December 2021

ABSTRACT

Aims: The cashew tree (family Anacardiaceae) grows widely in many parts of African countries, including Cameroon. Its fruit and nut are used for food and several studies have shown their beneficial effects on health. This work aimed to evaluate the impact of two drying methods on the content of bioactive compounds and antioxidant activity.

**Corresponding author: E-mail: seuyimghislain@yahoo.fr, seuyimghislain@gmail.com;*

Methodology: Four varieties (VAR 1, VAR 2, VAR 3, VAR 4) of cashew apple samples were collected and drying using sun-dried and oven-dried to a constant weight, and then ground in a blender to a powder, the fresh one was cut up and crushed in a blender. All sample were reconstituted with distilled water and polyphenols, flavonoids, alkaloids contents, and antioxidant activity through different mechanisms (DPPH radical, FRAP and TAC assays) were assessed.
Results: Alkaloids ranged from 1.50 mg EQui/g MF to 5.69 mg EQui/g DM for fresh and oven-dried VAR 1 respectively, polyphenols ranged from 786.15 mg EAG/g MF to 2836.92 mg EAG/g DM for fresh and oven-dried VAR 1 respectively, flavonoids ranged from 8.18 mg EAG/g MF to 295.45 mg EAG/g DM for fresh and oven-dried VAR 2 respectively. TAC values ranged from 13.09 mg EAA/g MF to 67.06 mg EAA/g for fresh and oven-dried VAR3 and VAR2 respectively. The highest DPPH radical scavenging value (86.25%) was obtained with fresh VAR 4 and the lowest (25.67%) with fresh VAR 1. The highest ferric reducing antioxidant power (FRAP) was obtained with fresh VAR 1 and VAR 3 (0.27 mg AAE/g MF) and the lowest with VAR 3 and VAR 4 oven-dried (0.23 mg AAE/g MF).
Conclusion: In conclusion, the different cashew varieties studied in this work are a good source of antioxidants. The drying method significantly affects bioactive compounds and antioxidant activities. A weak but not significant correlation was obtained between the number of bioactive compounds and antioxidant activities.

Keywords: Drying methods; cashew tree; bioactive compounds; antioxidant activity.

1. INTRODUCTION

Cashew fruit (*Anacardium Occidentale L.*) belongs to the Anacardiaceae family. It originates from tropical America and is widely grown in several countries in Africa, Asia and Central America as an agricultural crop of agricultural importance [1]. In Cameroon, cashew fruit (Anacardium occidentale L.) contributes to socio-economic development, its cultivation is only favourable in three regions namely Adamaoua, North and the Far North. Currently, due to the increasing demand, its cultivation is spreading to other regions such as the East and the Centre of the country [2]. Global cashew production was 2,971,046 tonnes in 2017 [3]. West Africa contributed almost a third (36%) while Latin America and East Africa contributed about 11 and 8% respectively. In all producing countries, nuts are harvested as the main crop, while cashew apples are discarded as waste [4,5]. Cashew apple loss is estimated at 90% worldwide [6]. In contrast to cashew nuts, cashew apples are a little known product in the consumer market [7].

According to Bahare et *al.* [8,9], ripe cashew apples are a good source of health-promoting nutrients such as organic acids, phenolic compounds, ascorbic acid, minerals and carbohydrates. In addition, several compounds with antioxidant capacities, such as carotenoids [10], flavonoids [11], phenolic acids, tannins and anacardic acids [12] have already been identified. Cashew apples also contain thiamine, niacin and riboflavin, as well as interesting amounts of minerals, such as copper, zinc, sodium, potassium, calcium, iron, phosphorus and magnesium [13]. Cashew apple is reported to have antitumour, antimicrobial, urease inhibitory, lipoxygenase activity, healing capacity and antiobesity activity [14,15].

Despite their promising economic potential, their interesting biochemical composition and the biological activities attributed to them, cashew apples are highly perishable fruits and subject to rapid microbial deterioration, so most of them rot in the growing areas. On the other hand, there is no adequate information on processing and storage technologies that allow for the proper utilisation of cashew apples [16]. Post-harvest losses of cashew apples could be avoided by transforming them into a stable intermediate product. With this in mind, several processes have already been developed to transform cashew apples into value-added products such as juice, jam, powder, candy and distilled products [17]. Dehydration is the process generally used to limit post-harvest losses. Dried cashew apple powder can be used in the formulation and development of value-added products such as biscuits, bread, infant porridges in riches. However, the drying process can also lead to significant changes in physical, chemical and organoleptic properties depending on the process used [18,19,20] Indeed, the drying process inhibits the microbial growth of the plants, influences the change of physicochemical properties (appearance and aroma) and at the

same time increases other changes that affect the quality of cashew powder. The loss of volatile compounds or the formation of new volatile compounds through multiple reactions such as oxidation or esterification, decomposition of antioxidant compounds, can occur [21]. This process can also lead to the loss of bioactive compounds that may have antioxidant potential and multiple health properties [22]. The aim of this work was therefore to evaluate the impact of two drying methods namely solar drying (traditional drying generally used) and oven drying on the content of bioactive compounds and antioxidant activity of four cashew apple varieties grown and consumed in the city of Garoua in northern Cameroon.

2. MATERIALS AND METHODS

2.1 Harvesting of Different Cashew Varieties and Technological Treatments

Cashew apple samples were collected in April 2021 in the experimental orchard of Kismatari located about 6 km from the Garoua multipurpose research station. The geographical coordinates are Latitude: 9° 19'N, Longitude: 13° 28'E, Altitude: 180 meters. These cashew apple varieties came from four cashew trees (VAR 1, VAR 2, VAR 3, VAR 4) with phenotypically different fruits. After cleaning, the pits were separated from the fruits and the fruits of each variety were divided into three batches. The first and second batches were air-dried (sun-dried at an average temperature of 40°C) and oven-dried (70°C) to a constant weight, and then ground in a blender to a powder. The resulting powders were stored in smoked jars. The third fresh batch was cut up and crushed in a blender to a homogeneous leg and stored in a cool place at -80°C for further analysis.

2.2 Preparation of Extracts

The extracts were obtained by weighing 10 g of powder and fresh material of the three batches of each variety and then adding 200 ml of distilled water. The resulting mixtures were macerated for 24 hours at room temperature with intermittent stirring. The mixtures obtained were centrifuged and the supernatants were collected and filtered through Whatman No. 2 paper. The filtrates obtained were used for further work. All the analyses were conducted in the laboratory of the Centre de Recherche en Alimentation et Nutrition (CRAN) de l'Institut de recherches Médicales et d'études des Plantes Médicinales (IMPM).

Fig. 1. Differents varieties of cashew apples

2.3 Determination of the Content of Bioactive Compounds

2.3.1 Assessment of total polyphenol content

The total phenolic content was determined according to the slightly modified method of Singleton and Rossi [23]. The Folin-Ciocalteu reagent was used with gallic acid as the standard phenolic compound. Approximately 0.5 ml of extract was introduced into test tubes, followed by 1.5 ml of Folin-Ciocalteu reagent (10%) and 1.5 ml of sodium carbonate solution (NaCO3, 7.5%). The tubes were homogenised with a shaker and the mixture was allowed to stand for 30 minutes at room temperature. Absorbances were read at 760 nm against the blank. Values were expressed as milligrams of gallic acid equivalent (GAE) per gram of dry matter extract (mg GAE/g DM) and per gram of fresh matter extract (mg GAE/g DM).

2.3.2 Assessment of total flavonoid content

The colourimetric method described by Aiyegoro and Okoh [24] with aluminium chloride was used to assess the total flavonoid content. 0.2 ml of an extract aliquot was added to 0.2 ml of aluminium chloride (AlCl3, 10%), followed by the successive addition of 0.2 ml of potassium acetate (CH3COOK, 1 M) and 1.12 ml of distilled water. After 30 minutes of incubation at room temperature, the absorbance was read at 420 nm against the blank. Quercetin was used as a standard at different concentrations (0-1000 µg/mL) to establish the calibration range. The results were expressed as mg EQ/g DM and mg EQ/g MF.

2.3.3 Evaluation of alkaloid content

The method of Singh et al. [25] with some modifications was used to assess the alkaloid content. To 500 µl of the extract was added 30 mL of 95% ethanol. The mixture was homogenised using a stirrer and left to stand for 10 minutes. From the resulting supernatant, 1 mL was taken to which 1 ml of the mixture [FeCl3 (0.025M) + HCl (0.5M)]and 1 mL of 1,10 phenanthroline (0.05M) prepared in ethanol was added. The resulting mixture was incubated in a water bath for 30 minutes with the temperature maintained at 70 ± 2°C. The absorbance of the red colouration of the complex formed was read at 510 nm against the blank. Quinine was used as standard and the results were expressed as mg QEi/g DM and mg Qei/g MF.

2.2 *In vitro* Evaluation of Antioxidant Potential

The antioxidant activity was evaluated according to 2 mechanisms: antiradical by scavenging the DPPH radical and reductive by reduction of ferric iron (FRAP) and molybdenum (CAT) ions.

2.2.1 Scavenging of the DPPH radical (2,2-Diphenyl-1-picrylhydrazyl)

The free radical scavenging capacity of the extract against DPPH (1,1-diphenyl-2-picrylhydrazyl) was performed according to the slightly modified method of Katalinie et al. [26]. To 50 µL of the extract was added 2.5 mL of DPPH solution prepared in ethanol (55 µM). The resulting mixture was incubated at 25°C in the dark for 30 min. The same procedure was repeated using a control sample (DPPH + ethanol instead of extract) and ascorbic acid was used as standard. The absorbances of the different mixtures were read at 517 nm. The capacity of the extracts to trap the DPPH radical was expressed as the percentage of DPPH radical trapping according to the formula :

$$\text{DPPH (\%)} = \frac{\boldsymbol{Abs}\mathbf{control}-\mathbf{Absessai}}{\boldsymbol{Abscontrol}} \times 100$$

2.2.2 Reduction of molybdenum ions

The reduction of molybdenum ions was evaluated by the total antioxidant capacity [27]. To this end, a 200 µl solution of extract was added to 2 ml of working solution (sulphuric acid (0.6 M), sodium phosphate (28 mM) and ammonium molybdate (4 mM)). The mixture was incubated at 90°C for 60 minutes in a water bath. After cooling, the absorbance of the solutions was measured at 695 nm against the blank which contained 2 mL of the reagent solution, 200 µL of distilled water and incubated under the same conditions as the sample. Ascorbic acid was used as the standard, and the total antioxidant capacity was expressed as milligrams of ascorbic acid equivalent (EAE) per gram of dry matter extract (mg EAE/g DM) and per gram of fresh matter extract (mg EAE/g MF).

2.2.3 Assessment of ferric reducing antioxidant power (FRAP)

The method of Oyaizu (1986) was used to assess the reducing power of cashew apple extracts. A volume of 1 mL of fruit extract was mixed with 2.5 mL of sodium phosphate buffer

(0.2 M, pH 6.6) and 2.5 mL of potassium ferrocyanide (1%) and incubated in a water bath at 50°C for 20 min. Next, 2.5 mL of (10%) trichloroacetic acid was added to the mixture which was centrifuged at 650g for 10 min. 2.5 mL of the supernatant was then mixed with 2.5 mL of distilled water and 0.5 mL of (0.1%) ferric chloride solution. The intensity of the blue-green colour was measured at 700 nm. Ascorbic acid was used as standard. The results were expressed as mg EAA/g DM and mg EAA/g MF.

2.3 Statistical Analysis of the Data

The data were entered into Excel 2016 and then transferred to SPSS (Statistical Package for Social Sciences) version 25.0 for Windows for statistical analyses. One-way analysis of variance (ANOVA) was used to detect differences in means between 3 groups in the presence of a continuous dependent variable. Multiple comparisons of group mean after the ANOVA test was performed using the LSD posthoc test. Results were expressed as mean ± standard deviation. Pearson's correlation was used to determine the strength of the association between two continuous variables of normal distribution. The significant effect was set at 5% ($P<0.05$) and the graphs were plotted in Excel.

3. RESULTS AND DISCUSSION

3.1 Results

3.1.1 Effect of drying methods on total phenolic, flavonoid and alkaloids contents of cashew apple

Table 1 shows the total phenolic content of fresh and dried cashew apples obtained by two drying methods. In each of the four varieties, the content of total polyphenols and flavonoids increased significantly with the drying method. The total polyphenol and flavonoid content were highest in oven-dried cashew apples followed by sun-dried cashew apples while fresh cashew apples had the lowest polyphenol and flavonoid content ($p<0.05$). However, when comparing the phenolic compound content according to the four varieties, the total polyphenol contents varied between 786.15 (VAR 1) and 1176.15 (VAR 4) mg EAG/g MF for fresh cashew apples, between 1922.30 (VAR 1) and 2413.07 (VAR 4) mg EAG /g DM for sun-dried cashew apples, and between 2478.46 (VAR 3) and 2836.92 (VAR 2) mg EAG /g DM for oven-dried cashew apples. Flavonoid content ranged from 8.18 (VAR 2) to 15.68 (VAR 4) mg EQ/g DM for fresh cashew apples, from 48.25 (VAR 1) to 136.28 (VAR 2) mg EQ /g DM for sun-dried cashew apples, and from 131.40 (VAR 1) to 295.42 (VAR 2) mg EQ /g DM for oven-dried cashew apples. However, statistical analysis revealed no significant difference in total polyphenol content between VAR 2 and VAR 4 in fresh cashew apples, between VAR 3 and VAR 4 in sun-dried cashew apples, and between VAR 1 and VAR 3; VAR 2 and VAR 4 in oven-dried cashew apples. For flavonoid content no difference was observed between VAR 1 and VAR 4; VAR 2 and VAR 3 in fresh cashew apples, between VAR 3 and VAR 4 in sun-dried cashew apples, and between VAR 3 and VAR 4 in oven-dried cashew apples.

Table 2 shows that alkaloid content was higher in oven-dried cashew apples followed by sun-dried cashew apples and fresh cashew apples for VAR 1, VAR 3 and VAR 4 ($p<0.05$); while for VAR 2 alkaloid content was higher in sun-dried cashew apples followed by oven-dried cashew apples and fresh extracts ($p<0.05$). However, alkaloid levels ranged from 1.50 (VAR 1) to 2.61 (VAR 4) mg EQui/g DM for fresh cashew apples, from 4.16 (VAR 1) to 5.02 (VAR 2 and VAR 3) mg EQui/g DM for sun-dried cashew apples, and from 4.63 (VAR 2) to 5.69 (VAR 1) mg EQui/g DM for oven-dried cashew apples. However, no significant difference was observed between VAR 1 and VAR 3; VAR 2 and VAR 4 in fresh cashew apples, between VAR 2 and VAR 3 in sun-dried cashew apples, and between VAR 3 and VAR 4 in oven-dried cashew apples.

Table 1. Alkaloids content of aqueous extracts of four cashew varieties

Extracts	Alkaloids			
	VAR 1	VAR 2	VAR 3	VAR 4
Fresh (mg EQui/g MF)	$^{\varphi}1.50\pm0\ .01^{a}$	$^{\varphi}2.51\pm0.11^{b}$	$^{\varphi}1.64\pm0.02^{a}$	$^{\varphi}2.61\pm0.11^{cb}$
Solar (mg EQui/g DM)	$^{\beta}4.16\pm0.11^{a}$	$^{\beta}5.02\pm0.03^{b}$	$^{\beta}5.02\pm0.05^{cb}$	$^{\beta}4.67\pm0.07^{d}$
Oven (mg EQui/g DM)	$^{\alpha}5.69\pm0.03^{a}$	$^{\alpha}4.63\pm0.02^{b}$	$^{\alpha}5.32\pm0.03^{c}$	$^{\alpha}5.36\pm0.17^{dc}$

Values with different lower case letters are significantly different within a row at p<0.05. The same applies to the columns.

3.1.2 Antioxidant Potential of Cashew Apples Varieties

Table 2 presents data on the iron-reducing capacity and total antioxidant capacity of different varieties of fresh and dried cashew apples. The FRAP results of fresh, oven-dried and sun-dried cashew apples ranged from 0.25 (VAR 2) to 0.27 (VAR 1 and VAR 3) mg AAE/g DM, from 0.24 (VAR 1, VAR 2 and VAR 4) to 0.25 (VAR 3) mg AAE/g DM, and from 0.23 (VAR 3 and VAR 4) to 0.24 (VAR 1 and VAR 2) mg AAE/g DM, respectively. Statistical analysis revealed no statistical difference in iron-reducing power between VAR 1, VAR 3 and VAR 4; between VAR 2 and VAR 4 in fresh cashews. In addition, regardless of variety, no significant differences were observed in oven-dried and sun-dried cashews. However, the FARP values for the varieties VAR 1, VAR 3 and VAR 4 were higher in fresh cashew apples compared to the sun and oven-dried cashew apples (p<0.05). However, no significant difference in FRAP was observed between fresh and sun- and oven-dried cashew apples.

Regarding the total antioxidant capacity of fresh and dried cashew apples. The total antioxidant capacity values of fresh cashew apples ranged from 13.09 (VAR 3) to 17.09 (VAR 1) mg EAE/g DM, while those of sun-dried cashew apples ranged from 47.04 (VAR 2) to 51.17 (VAR 3) mg EAE/g DM, and those of oven-dried cashew apples ranged from 54.62 (VAR 3) to 67.06 (VAR 2) mg EAE /g DM. Statistical analysis revealed no significant difference between VAR 2 and VAR 3, VAR 2 and VAR 4 for fresh cashew apples; between VAR 3 and VAR 4 for oven-dried cashew apples while no significant difference in TAC irrespective of variety was observed for sun-dried cashew apples. However, the TAC was significantly higher in the oven-dried cashew apples compared to the TAC of fresh and oven-dried cashew apples (p<0.05) for the varieties VAR 1, VAR 2 and VAR 4. However, in VAR 2, the TAC was higher in dried cashew apples compared to fresh cashew apples (p<0.05).

Figures 1a and 1b show the free radical scavenging capacity of fresh and dried cashew apples in the different varieties. From Figure 1a, it can be seen that the DPPH scavenging activity of fresh, oven-dried and sun-dried cashew apples varied from 25.67% (VAR 1) to 86.27% (VAR 4), from 66.98% (VAR 1) to 77.41% (VAR 4) and from 74.74% (VAR 1) to 80.46% (VAR 3), respectively. However, statistical analysis revealed no significant difference in DPPH scavenging activity in oven-dried cashew apples between VAR 3 and VAR 4, between VAR 1 and VAR 4, VAR 2 and VAR 3 in sun-dried cashew apples. While the radical scavenging capacity of fresh cashew apples was significantly higher in VAR 4 compared to the other varieties (p<0.05).

Concerning the free radical scavenging capacity of fresh and dried cashew apples within each variety (Figure 1b), the free radical scavenging capacity of sun-dried cashew apples was significantly higher compared to that of fresh and oven-dried cashew apples (p<0.05) for the varieties VAR 1 and VAR 3. However, the free radical scavenging capacity of fresh cashew apples and sun-dried cashew apples was significantly higher compared to the free radical scavenging capacity of oven-dried cashew apples (p<0.05) for VAR 2, while for VAR 4, only the free radical scavenging capacity of fresh cashew apples was higher (p<0.05).

3.1.3 Correlation between the tested bioactive compounds content and antioxidant activities of different cashew apples

Table 4 summarizes the correlation coefficients of the bioactive compounds of fresh cashews, oven-dried cashews, and sun-dried cashews with the antioxidant activities performed. overall, the correlations were positive or negative. in var 1, significant and positive correlations were observed between tac and total polyphenols from oven-dried cashews (r=0.998 ; p<0.05) and between tac and total polyphenols from sun-dried cashew apples (r=0.999; p<0.05); while a significant and negative correlation was observed between tac and alkaloids from oven-dried cashew apples (r=-1.000; p<0.01). for var 2, a significantly positive correlation was observed between dpph and flavonoids in fresh cashew apples (r = 0.999; p<0.05) and between tac and alkaloids in oven-dried cashew apples (r = 1.000; p<0.01). for variety 3, a positive correlation was observed between tac and flavonoids in fresh cashew apples (r = 1.000; p<0.05), while a negative and significant correlation was observed between frap and total polyphenols in oven-dried cashew apples (r = -0.999; p<0.05) and between tac and total polyphenols in sun-dried cashew apples (r = -1.000; p<0.01) for variety 4 we

Table 2. Phenolic content of aqueous extracts of four cashew apples varieties

Extracts	VAR	Polyphenols	Flavonoids
Fresh (mg EAG/g MF)	VAR 1	$^{\varphi}786.15\pm9.32^{a}$	$^{\varphi}14.01\pm1.49^{a}$
	VAR 2	$^{\varphi}1126.15\pm24.96^{b}$	$^{\varphi}8.18\pm0.91^{b}$
	VAR 3	$^{\varphi}861.92\pm12.69^{c}$	$^{\varphi}9.46\pm0.60^{cb}$
	VAR 4	$^{\varphi}1176.15\pm55.40^{db}$	$^{\varphi}15.68\pm1.36^{a}$
Solar (mg GAE/g DM)	VAR 1	$^{\beta}1922.30\pm86.12^{a}$	$^{\beta}48.25\pm12.26^{a}$
	VAR 2	$^{\beta}2223.84\pm17.62^{b}$	$^{\beta}136.28\pm24.83^{b}$
	VAR 3	$^{\beta}2381.53\pm12.21^{c}$	$^{\beta}122.50\pm9.55^{c}$
	VAR 4	$^{\beta}2413.07\pm9.60^{dc}$	$^{\beta}82.12\pm3.73^{dc}$
Oven (mg EAG/g DM)	VAR 1	$^{\alpha}2485.38\pm28.91^{a}$	$^{\alpha}131.40\pm8.92^{a}$
	VAR 2	$^{\alpha}2836.92\pm29.22^{b}$	$^{\alpha}295.45\pm2.53^{b}$
	VAR 3	$^{\alpha}2478.46\pm55.95^{a}$	$^{\alpha}212.87\pm8.44^{c}$
	VAR 4	$^{\alpha}2767.69\pm36.21^{cb}$	$^{\alpha}217.87\pm12.27^{dc}$

Table 3. Ferric reducing antioxidant capacity and total antioxidant capacity of aqueous extracts of four cashew apples varieties

	FRAP				TAC			
	VAR 1	VAR 2	VAR 3	VAR 4	VAR 1	VAR 2	VAR 3	VAR 4
Fresh (mg EFA/g MF)	$^{\beta}0.27\pm0.00^{a}$	$^{\alpha}0.25\pm0.00^{b}$	$^{\varphi}0.27\pm0.00^{a}$	$^{\beta}0.26\pm0.00^{ab}$	$^{\varphi}17.09\pm0.48^{a}$	$^{\varphi}13.95\pm0.62^{be}$	$^{\beta}13.09\pm0.24^{cb}$	$^{\varphi}14.19\pm0.74^{de}$
Oven (mg EAA/g DM)	$^{\alpha}0.24\pm0.00^{a}$	$^{\alpha}0.24\pm0.00^{a}$	$^{\alpha}0.23\pm0.00^{a}$	$^{\alpha}0.23\pm0.00^{a}$	$^{\alpha}59.53\pm0.03^{a}$	$^{\alpha}67.06\pm1.48^{b}$	$^{\alpha}54.62\pm1.38^{c}$	$^{\alpha}56.08\pm1.10d^{c}$
Solar (mg EFA/g DM)	$^{\alpha}0.24\pm0.00^{a}$	$^{\alpha}0.24\pm0.01^{a}$	$^{\beta}0.25\pm0.00^{a}$	$^{\alpha}0.24\pm0.00^{a}$	$^{\beta}49.41\pm3.69^{a}$	$^{\beta}47.04\pm2.38^{a}$	$^{\alpha}51.17\pm1.89^{a}$	$^{\beta}49.90\pm2.26^{a}$

obtained two significant correlations, one was significantly negative (r = -1.000; p<0.05) between frap and total polyphenols in fresh cashew apples and the other was significantly positive (r = 0.999; p<0.05) between dpph and total polyphenols in oven-dried cashew apples.

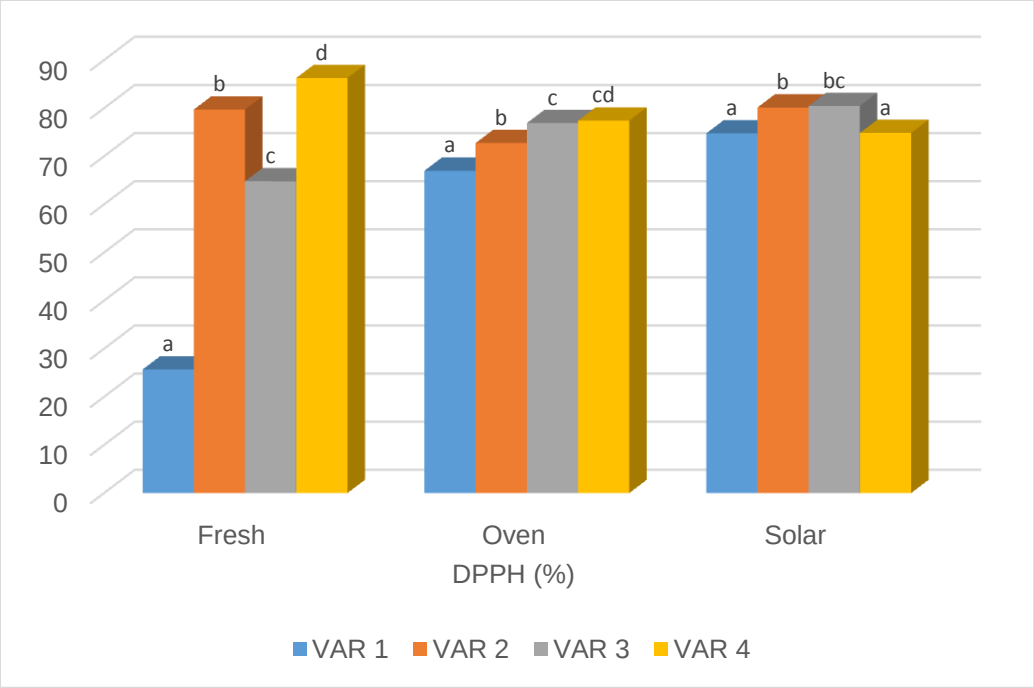

Fig. 2a. Free radical scavenging capacity of fresh and dried cashew apples depending on the variety

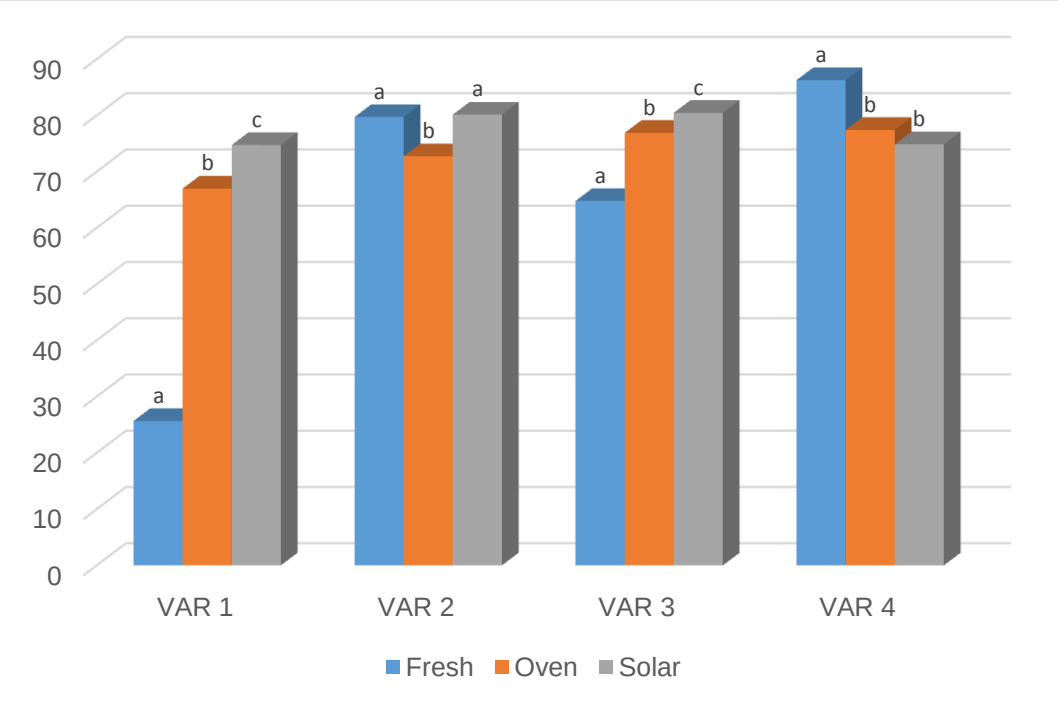

Fig. 2b. Free radical scavenging capacity of cashew varieties in fresh and dried cashew apples

Table 4. Correlation between the contents of bioactive compounds and antioxidant activities of fresh and dried cashew apples of different varieties

Extracts	anti oxidant activities	VAR 1			VAR 2			VAR 3			VAR 4		
		polyphenols	flavonoids	alkaloids	polyphenols	flavonoids	alkaloids	polyphenols	flavonoids	alkaloids	polyphenols	flavonoids	alkaloids
	FRAP	-0.033	-0.022	0.880	-0.911	-0.197	0.335	-0.703	-0.066	-0.350	**-1.000***	0.199	-0.682
Fresh	TAC	-0.985	-0.987	-0.594	-0.319	0.956	0.904	0.741	**1.000***	0.951	0.136	0.936	0.829
	DPPH	-0.995	-0.994	0.355	-0.555	**0.999***	0.984	-0.174	0.513	0.245	0.284	0.873	0.904
	FRAP	-0.033	0.996	-0.036	-0.584	0.997	0.260	**-0.999***	0.504	0.495	0.403	-0.503	0.883
Oven	TAC	**0.998***	0.127	**-1.000****	0.632	0.179	**1.000****	-0.990	0.579	0.569	0.956	0.324	0.223
	DPPH	-0.069	0.992	0.000	0.906	-0.267	0.900	-0.459	-0.581	-0.590	**0.999***	0.616	-0.109
	FRAP	0.898	0.380	-0.500	-0.826	-0.448	0.114	-0.189	0.297	-0.500	0.130	0.828	0.994
Solar	TAC	**0.999***	-0.774	0.028	0.899	0.313	-0.257	**-1.000****	0.994	0.757	0.973	-0.641	0.011
	DPPH	0.963	-0.899	-0.203	0.371	-0.970	-0.945	0.866	-0.805	-0.982	-0.974	0.234	-0.454

** Correlation is significant at p<0.05; ** Correlation is significant at p<0.01*

3.2 Discussion

This work allowed us to determine the contents of bioactive compounds and to evaluate the antioxidant capacity of different cashew varieties according to the type of drying. As observed in this work, cashew apples contain bioactive compounds that are involved in the protection against oxidative stress, the crossroads of many metabolic diseases. This antioxidant capacity of bioactive compounds has been demonstrated in several studies [28,29].

Several factors, such as environment, genetics, variety and technological treatments among others influence the physicochemical composition of foods [30]. This was the case when comparing the content of total phenolics, total flavonoids and alkaloids in different cashew apples that underwent different technological treatments. Overall the data were significantly different, these results are similar to those obtained by [31] in Tanzania, who found a significant difference ($P \leq 0.05$) in total phenolics and total flavonoids between five cashew apple varieties in the same site and between the same variety in different sites. Other works such as [32] showed that total phenolic and flavonoid content was significantly influenced by cashew colour and growing environment. Regarding alkaloids, to our knowledge no study has evaluated their contents in different cashew varieties, however, Zhong et al., [33] observed a difference between alkaloid contents in nine samples of one fruit (boluhui) and attributed this variation to the growing environment.

One of the methods used for the preservation of fruits is drying, which is a technique that consists of dehydrating the fruits for a long period of preservation. The temperature and duration of the treatment are the determining factors for the selection of the most effective drying method to preserve phenolic and alkaloidal compounds in plant materials [34,35]. Indeed, specific temperature variations in the different drying methods can prevent the degradation of these components, thus preserving or increasing the quality of the studied plant product [36]. Overall, oven-dried cashew apples had a higher content of total phenolic compounds, flavonoids and alkaloids followed by sun-dried and finally fresh cashew apples. To the best of our knowledge, no study has yet evaluated the influence of oven and sun drying on the bioactive compounds of cashew apples grown in Cameroon. However, several studies have reported through separate works that there is a variation in phenolic and alkaloid content depending on the drying method used [37,38,39]. Serratosa et al*,* [37] observed an increase in phenolic compounds in raisins compared to fresh grapes, this observation is confirmed by this study. They attributed this increase to the fact that during the drying process the evaporation of water causes an increase in dry matter concentration. On the other hand, the drying process alters the membrane and facilitates the extraction of phenolic compounds. On the other hand, Çoklar and Akbulut [38] observed a decrease in phenolic compound content between fresh and oven- or sun-dried grapes. This decrease was attributed to the fact that during the drying process the temperature causes degradation and/or oxidation, the small decrease in the phenolic compound in oven-dried grapes compared to sun-dried grapes would be due to the fact that oven-drying exposes the fruitless to oxidative degradation.

The antioxidant capacity of the samples was assessed in this work using 3 methods (DPPH, TAC and FRAP) to test different mechanisms of antioxidant reaction. The TAC and DPPH values varied significantly ($P \leq 0.05$) from one variety to another, this difference would be due to the variation in the content of bioactive compounds and the nature of the bioactive compounds. Environmental conditions, genotype, nature of the soil, maturity stage etc... are factors that influence the physicochemical composition of fruits [40,30]. In general, the highest antioxidant activities (DPPH, TAC and FRAP) were observed in oven-dried cashew apples or sun-dried apples confirming the clear correlation between antioxidant capacity and the amount of total phenolic compounds, flavonoids or total alkaloids. However, this was not the case when considering the percentage of DPPH inhibition in variety 4 fresh cashew apples, which was significantly higher than that in the oven- or sun-dried cashew apples. This suggests that the different drying methods (oven, sun) resulted in a difference like total phenolics, flavonoids and alkaloids. As reported by Brito et al., [14], the main phenolic compounds in cashew are flavonoids, especially glycosidic flavonols, including 3-O-galactoside, 3-O-glucoside, 3-O-rhamnoside, 3-O-xylopyranoside, 3-O-arabinopyranoside and 3-O-arabinofuranoside, derived from myricetin and quercetin.

The correlation results indicate that for these varieties, the results of one test cannot be

predicted from the results of the other test. The low correlation between antioxidant activities and phenolic content is in contrast to various studies that generally link the two parameters [41], which calls into question the nature of the phenolic compounds present in the extract. Other authors have noted a correlation between phenolic compound content and free radical scavenging in many spices, vegetables, fruits and beverages, and fruit skins [42,43]. These positive correlations suggest a contribution of phenolics and alkaloids to free radical scavenging activity. Phenolic compounds are important antioxidant molecules that are responsible for deactivating free radicals due to their ability to donate hydrogen atoms to free radicals [44]. However, while the correlation between antioxidant activities and phenolic and alkaloid contents has often been observed in many studies, the magnitude of these correlations can vary from variety to variety since two extracts from the same plant may have antioxidant compounds of different structures and compositions that react differently with either method [33,41]. It is well established that antioxidant activity is positively correlated with the structure of phenolics and alkaloids, not just their quantity. Thus, the antioxidant effect is not only dose-dependent but also structure-dependent [45,33]. The types of phenolic compounds and alkaloids contained in these different cashew varieties are probably responsible for the antioxidant activity.

4. CONCLUSION

This study has shown that the different cashew varieties contain a significant amount of bioactive compounds (alkaloids, flavonoids and polyphenols) which vary from one variety to another. The use of drying increases the extraction of alkaloids, flavonoids and polyphenols. Antioxidant activities varied depending on the type (fresh, oven-dried or sun-dried) and variety. Cashew apples are potential sources of antioxidant molecules that can be used to combat oxidative stress. However, in this study, there was no real correlation between the amount of bioactive molecule and antioxidant activities.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/77992