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Chemical composition and fatty acid profile of kernels from different Brazilian cashew tree genotypes

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Kernels from nine cashew tree genotypes were characterized with respect to their chemical composition and fatty acids profile, peroxide value and free fatty acids content of the extracted oil. Their proximate composition ranged from 2.69 to 8.37% for moisture, 17.50 to 24.49% for proteins, 39.88 to 47.10% for lipids, 27.14 to 34.94% for total carbohydrate and 2.74 to 4.14% for ash. The amounts of free fatty acids in the oils were smaller than 0.55% for all genotypes tested and no peroxides were detected. Oleic acid was the most abundant fatty acid in kernel oils, ranging from 57.66 to 67.12%. The genotypes that showed higher lipid contents and smaller carbohydrate contents among all genotypes tested were CCP09, EMB51, BRS226 and CCP1001. Those genotypes can be regarded as potential sources of high quality vegetable oil.

Key words: *Anacardium occidentale* L., cashew nut, edible oil, lipids, proximate composition.

INTRODUCTION

Nuts in general are being regarded as healthy foodstuff because their regular consumption has been reported to decrease the risk of coronary heart disease. The health benefits of nuts are usually attributed to their chemical composition, mainly unsaturated fatty acids, and their relation with total and LDL-cholesterol decrease as well as with HDL-cholesterol increase (Mexis and Kontominas, 2009; Yang, 2009; Yang et al., 2009).

There is an increasing interest in trials for the cultivation of high-yielding cashew tree genotypes that are adapted to specific locations and highly resistant to plant diseases. Furthermore, cultivation with a single genotype is not advisable because the orchards without genetic variability can be exterminated by new diseases and pests. However, knowledge from new tree genotypes is limited to aspects such as plant height, nut yield, nut weight, kernel weight and weight of kernel/weight of nut ratio (Barros et al., 2000; Cavalcanti et al., 2000; Paiva et al., 2004). The chemical composition and nutritional aspects of kernels from new genotypes have been mostly disregarded. Furthermore, the nut's chemical composition has been found to vary significantly among different tree genotypes and environmental conditions (Barros et al., 2000; Cavalcanti et al., 2000).

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On the other hand, cashew nut processing involves a number of steps that yields about 40% of broken kernels with lower commercial value than that of the whole kernel. Broken kernels have lipid content ranging from 35.7 to 45.5% (Lima et al., 2012) that can be extracted and commercialized as high quality oil. Moreover, as the technology involved in the oil extraction is simple, it can be used by small producers in order to improve their income. Lafont et al. (2011) studied different methods for oil extraction from cashew kernel and their influence on oil quality. The authors reported that the oil obtained from pressing presented better characteristics than oils obtained from different solvent extractions. Extraction by pressing yield was 68%.

Therefore, the objective of this study was to determine the chemical composition and fatty acid profile of kernels from nine cashew tree genotypes cultivated in Northeast Brazil. There was a special focus on determining which genotypes are more suitable for oil extraction. The cashew kernels' composition should be taken into account for genotype selection along with the advantages and disadvantages for their cultivation.

MATERIALS AND METHODS

Cashew kernels

Nuts from nine cashew tree genotypes (CCP76, CCP09, Embrapa 51, BRS189, BRS226, BRS265, BRS274, BRS275 and CP1001) were obtained from production areas located at Embrapa Tropical Agroindustry's Experimental Station, in Pacajus, Ceará, Northeastern Brazil (4°11'26.2" S and 38°29'50.78" W). All tree genotypes were cultivated under the same conditions. Cashew nuts were processed to obtain the kernels according to the following processing steps:

i) Manual harvesting and apple (peduncle) detaching;
ii) Manual cleaning to eliminate strange materials, such as leaves, stones, sand and pieces of cashew apples;
iii) Sun drying for 2-3 days to reduce the moisture to 7-8%;
iv) Storing in gunny bags piled up on stands in airy cleaned dry place (nuts can be stored up to one year, but for our experiment, they were stored for one month);
v) Heating/steaming for 20 min at 2 Kgf/cm^2 by direct vapour injection;
vi) Cooling at room temperature (~28°C) for 10-12 h to bring the steamed nut to equilibrium with the atmospheric conditions;
vii) Shelling to remove kernels with the help of a hand cum pedal operated cutter (hand built);
viii) Drying of cashew kernels with hot air at 65-70°C for 6-8 h, until 5-8% moisture content;
ix) Manual peeling with knifes to remove the brown testa;
x) Packing in 50 pounds (22.68 kg) aluminium bags and a secondary card board packing, making up the total of 50 pounds net weight. In our experiment, 5 kg of kernels from every genotypes were packed in high density polyethylene bags and transported to the laboratory for analysis.

Proximate composition of kernels

Cashew kernels were ground and analysed for moisture (method 925.40), ash (method 950.49), lipid (method 948.22) and protein (method 950.48) contents (AOAC, 1997). Total carbohydrate content was estimated by the difference from other components using the modified formula from AOAC, since water and alcohol were not considered: 100 - (weight in grams [protein + lipids + ash] in 100 g of food). Results were reported in dry weight.

Chemical analysis of kernel oils

Oil was extracted from dried and triturated cashew kernels through cold press extraction with a home built hydraulic press and filtered in qualitative paper (ø = 12.5 cm). Oils were analysed for free fatty acids (method Ca 5a-40) and peroxide values by iodometric titration with 0.01 N sodium thiosulfate solution (method Cd8-53) (AOCS, 1988).

Fatty acid profile of kernel oils

Fatty acids obtained from the oils, as described below, were converted to their methyl esters (FAMEs) and following the method described by Hartmann and Lago (1973). FAMEs were determined by gas chromatography using a GC CP3380 (Varian) equipped with a flame ionization detector (FID), a split/splitless capillary inlet system and a SP2560 (100% bis-cyanopropyl polysiloxane; Supelco Bellefonte, USA) column with dimensions of 100 m x 0.25 mm id x 0.20 µm df. The carrier gas (hydrogen) flow rate was 1.5 mL/min. The temperatures of the injection port and detector were 220 and 230°C, respectively. The GC oven was programmed as follows: column initial temperature of 80°C, increasing at the rate of 11.0°C/min to 180°C, then at 5.0°C/min to 220°C and held for 9 min. FAMEs were identified by comparing the retention time of samples and the appropriate fatty acids methyl esters standards purchased from Supelco (Bellefonte, USA). Each fatty acid was expressed in percentages of relative area, obtained by area normalization (fatty acid peak area relative to the chromatogram's total area).

Statistical analysis

Results were submitted to analysis of variance (ANOVA) and Tukey test was applied (α=0.05) for the comparison of mean values. Proximate composition and chemical analysis in kernel oils were performed in three repetitions and fatty acids profile in four repetitions. Statistical analyses were performed using the SAS statistical program for Windows System (SAS, 2009).

RESULTS AND DISCUSSION

Chemical characteristics of kernels and oils

The chemical characteristics of kernels from different cashew tree genotypes and the free fatty acids values of the extracted oils are shown in Table 1. Peroxides are not reported since they were not detected for oils from all genotypes tested.

Kernel moisture varied from 2.69 to 8.37%, which are acceptable values for the commercialization of cashew kernels. Actually, drying to appropriate moisture content is an important factor to ensure good kernel quality. Moisture is not an intrinsic characteristic of the cashew genotype, although it can influence the kernel's characteristics. Low moisture (< 2%) renders kernels more

Table 1. Chemical composition (% dry weigh) of kernels from different cashew tree genotypes and acid values (g/100 g) of cold pressed oils (mean ± SD, n=3).

Genotype	Moisture	Ash	Lipid	Protein	Carbohydrate	Free fatty acids, as oleic
CCP76	7.04[cd] ± 0.46	2.98[b] ± 0.03	43.34[bcd] ± 0.41	21.83[c] ± 0.63	31.86[cd] ± 1.03	0.07[d] ± 0.01
CCP09	7.62[abc] ± 0.47	4.14[a] ± 0.31	45.40[ab] ± 0.14	23.29[b] ± 0.66	29.78[e] ± 1.01	0.31[c] ± 0.02
EMB 51	6.71[d] ± 0.16	2.74[b] ± 0.04	45.33[ab] ± 0.99	22.15[c] ± 0.25	29.78[e] ± 1.18	0.30[c] ± 0.04
BRS189	7.50[bc] ± 0.10	2.86[b] ± 0.26	42.43[d] ± 1.43	19.77[d] ± 0.10	34.94[a] ± 1.37	0.34[c] ± 0.01
BRS226	7.73[abc] ± 0.09	2.75[b] ± 0.04	45.21[ab] ± 0.94	17.50[e] ± 0.02	34.54[ab] ± 1.00	0.32[c] ± 0.02
BRS265	6.54[d] ± 0.17	2.85[b] ± 0.23	42.86[cd] ± 0.33	22.15[c] ± 0.16	32.14[bcd] ± 0.50	0.29[c] ± 0.01
BRS274	8.37[a] ± 0.17	2.87[b] ± 0.22	44.80[bc] ± 1.08	21.64[c] ± 0.13	30.69[cd] ± 1.19	1.34[a] ± 0.05
BRS275	7.94[ab] ± 0.16	2.86[b] ± 0.06	39.88[e] ± 0.57	24.49[a] ± 0.30	32.77[abc] ± 0.32	0.55[b] ± 0.02
CP1001	2.69[e] ± 0.21	3.14 [b] ± 0.05	47.10[a] ± 0.48	22.61[bc] ± 0.38	27.14[e] ± 0.87	0.29[c] ± 0.00
Mean	6.91 ± 1.63	3.02 ± 0.44	44.04 ± 2.16	21.71 ± 1.97	31.23 ± 2.84	0.42 ± 035

In each row, means with the same letter are not significantly different (Tukey, α=0.05).

breakable, whereas an excess of moisture (> 10%) can be a problem for storage, making kernels elastic and not sensory acceptable (Lima et al., 2000; Cárcel et al., 2012).

Minor differences (α=0.05) were observed in ash content among kernels from different cashew tree genotypes, ranging from 2.74 to 4.14%. Kernels showed lipid content ranging from 39.88 to 47.10%, protein content ranging from 17.50 to 24.49%, and total carbohydrate content ranging from 27.14 to 34.94%. Results are in good agreement with those of USDA National Nutrient Database for Standard Reference (2010), regarding cashew kernel proximate composition. Many reports were found on cashew kernel proximate composition, but authors usually report only the geographic production area. Kosoko et al. (2009) reported lipid content ranging from 44.58 to 47.01% in cashew kernels from Nigeria, Oladimeji and Kolapo (2008) reported lipid content of 42.1%, protein of 19.5% and carbohydrate of 23.8%, also for kernels from Nigeria.

Considering that oil extraction from kernels is one of the goals of this project, high oil content is an important kernel characteristic. The cashew tree genotypes that produced the highest lipids levels were CCP09, EMB51, BRS226 and CCP1001.

High total carbohydrate content can be a technological problem for oil extraction, since during extraction by mechanical pressing the material's temperature is raised significantly, which can lead to starch gelatinization. During continuous pressing starch gelatinization promotes the formation of a film which impairs the oil flow. Even if the oil is cold pressed, cooking before pressing generally improves oil yield and can also result in starch gelatinization (Singh et al., 2002; Venter et al., 2007). The cashew tree genotypes that produced the smallest total carbohydrate content were CCP09, EMB51 and CP1001. Yang (2009) reported that cashew nuts possess the maximum total carbohydrate content (>20%) among various nuts tested (almonds, brazil nuts, hazelnuts, macadamia, peanuts, pecans, pine nuts, pistachios and walnuts).

Free fatty acid amounts found in the extracted oils were smaller than 0.55% for all cashew kernels studied and peroxides were not detected. Those results are within the Codex General Standard for Fats and Oils that state the cold pressed oil maximum values of 4.0 mg KOH/g oil for acid value (2.01% free fatty acids, as oleic) and 15meq/kg oil for peroxide values (FAO/WHO, 2001).

Adeigbe et al. (2015) on a review of cashew production in Nigeria, reported existence of narrow genetic base within Nigeria cashew germplasm and within geographic cashew variety groups in Tanzania and India. The existence and exploration of different genetic materials from Brazil can broaden the genetic base in those countries.

Fatty acid profile of kernel oils

Fatty acid compositions of the extracted oils are shown in Table 2. The fatty acids profile was constituted by 12 fatty acids, and significant (α=0.05) differences among the kernel oils from different cashew tree genotypes were observed for palmitic, stearic, oleic and linoleic acids. Oleic acid was the most abundant one in all kernel oils ranging from 57.66 to 67.12%. Linoleic acid was the second in order of importance, ranging from 17.57 to 21.95%. As to the remaining fatty acids, only palmitic, ranging from 7.31 to 9.70%, and stearic acids, ranging from 6.33 to 9.32 %, showed considerable amounts.

Considering the importance of essential fatty acids in the human diet, the CCP76, CCP09, BRS226, BRS265, BRS274, BRS275 and BRS189 cashew tree genotypes showed higher linoleic acid content in kernel oil than the other genotypes. Linoleic acid is known as a dietary essential fatty acid because it cannot be synthesized by humans.

Unsaturated fatty acids, due to the high content of oleic

Table 2. Fatty acid composition (expressed as percentage of total fatty acid) of the oil extracted from kernels of different cashew tree genotypes (means ± SD, n=4).

Fatty acid	CCP09	EMB51	CCP76	BRS189	BRS226	BRS265	BRS274	BRS275	CP1001	Mean
Myristic (C14:0)	0.01^{a} ± 0.01	0.01^{a} ± 0.01	0.02^{a} ± 0.01	ND	0.01^{a} ± 0.01	0.01^{a} ± 0.01	0.37^{a} ± 0.04	-	0.02^{a} ± 0.00	0.05 ± 0.01
Palmitic (C16:0)	8.38^{ab} ± 0.94	7.31^{b} ± 0.11	8.28^{ab} ± 0.16	9.70^{a} ± 0.57	7.93^{b} ± 0.23	8.23^{ab} ± 0.11	8.75^{ab} ± 0.10	8.20^{ab} ± 0.11	8.58^{ab} ± 0.05	8.37 ± 0.65
Palmitoleic (C16:1)	0.26^{a} ± 0.08	0.28^{a} ± 0.02	0.27^{a} ± 0.01	0.43^{a} ± 0.24	0.25^{a} ± 0.01	0.28^{a} ± 0.02	0.26^{a} ± 0.03	0.24^{a} ± 0.00	0.30^{a} ± 0.02	0.28 ± 0.06
Margaric (C17:0)	0.13^{a} ± 0.02	0.12^{a} ± 0.01	0.12^{a} ± 0.02	0.26^{a} ± 0.02	0.08^{a} ± 0.05	0.08^{a} ± 0.05	0.13^{a} ± 0.01	0.12^{a} ± 0.01	0.17^{a} ± 0.01	0.13 ± 0.05
Stearic (C18:0)	8.67^{a} ± 0.80	6.33^{b} ± 0.28	9.32^{a} ± 0.20	8.50^{a} ± 1.47	7.85^{ab} ± 0.41	8.53^{a} ± 1.16	8.62^{a} ± 0.84	8.68^{a} ± 0.05	7.47^{ab} ± 0.01	8.22 ± 0.88
Oleic (C18:1)	60.63^{bc} ± 2.02	67.12^{a} ± 0.21	58.81^{c} ± 0.10	57.66^{c} ± 5.02	62.03^{abc} ± 0.20	61.96^{abc} ± 0.04	60.90^{bc} ± 1.26	62.13^{abc} ± 0.03	64.73^{ab} ± 0.00	61.77 ± 2.86
Linoleic (C18:2)	20.83^{ab} ± 1.99	17.57^{b} ± 0.76	21.95^{a} ± 0.20	18.61^{ab} ± 1.52	20.62^{ab} ± 0.71	19.73^{ab} ± 1.66	19.44^{ab} ± 1.83	19.43^{ab} ± 0.08	17.79^{b} ± 0.03	19.55 ± 1.44
Linolenic (C18:3)	0.20^{a} ± 0.06	0.19^{a} ± 0.01	0.17^{a} ± 0.04	0.87^{a} ± 0.02	0.19^{a} ± 0.02	0.11^{a} ± 0.04	0.22a ± 0.02	0.20^{a} ± 0.00	0.11^{a} ± 0.00	0.71 ± 0.54
Arachidic (C20:0)	0.53^{a} ± 0.02	0.64^{a} ± 0.02	0.52^{a} ± 0.01	2.15^{a} ± 0.06	0.50^{a} ± 0.04	0.54^{a} ± 0.08	0.58^{a} ± 0.02	0.53^{a} ± 0.01	0.43^{a} ± 0.00	0.34 ± 0.26
Gondoic (C20:1)	0.18^{a} ± 0.08	0.26^{a} ± 0.04	0.35^{a} ± 0.03	1.02^{a} ± 0.01	0.33^{a} ± 0.09	0.33^{a} ± 0.06	0.20^{a} ± 0.01	0.21^{a} ± 0.01	0.20^{a} ± 0.01	0.25 ± 0.24
Behenic (C22:00)	0.10^{a} ± 0.01	0.11^{a} ± 0.02	0.09^{a} ± 0.01	0.51^{a} ± 0.02	0.17^{a} ±0.01	0.10^{a} ± 0.02	0.46^{a} ± 0.06	0.15^{a} ± 0.05	0.08^{a} ± 0.00	0.20 ± 0.17
Lignoceric (24:00)	0.09^{a} ± 0.01	0.07^{a} ± 0.01	0.10^{a} ± 0.01	0.30^{a} ± 0.03	0.06^{a} ± 0.01	0.10^{a} ± 0.02	0.08^{a} ± 0.01	0.14^{a} ± 0.04	-	0.10 ± 0.08
SFA	17.90^{ab} ± 0.19	14.58^{a} ± 0.72	18.44^{ab} ± 0.23	21.43^{b} ± 0.46	16.59^{ab} ± 0.72	17.59^{ab} ± 1.50	18.99^{ab} ± 0.29	17.80^{ab} ± 0.06	16.74^{ab} ± 0.04	17.78 ± 1.87
USFA	82.09^{ab} ± 0.19	85.41^{a} ± 0.73	81.56^{ab} ± 0.23	78.58^{b} ± 0.46	83.42^{ab} ± 0.72	82.40^{ab} ± 1.50	81.01^{ab} ± 0.29	82.21^{ab} ± 0.07	83.12^{ab} ± 0.04	82.20 ± 1.86

SFA = Saturated fatty acids, USFA = unsaturated fatty acids. In each row, means with the same letter are not significantly different (Tukey, α=0.05).

and linoleic acid, were the main component of the total oil that was extracted from the genotypes studied, representing values around 82% of total oil. Unsaturated fatty acids have been associated with beneficial effects on health promotion and disease prevention (Mexis and Kontominas, 2009; Yang, 2009; Yang et al., 2009).

Conclusions

Results show that most kernels' characteristics measured were significantly affected by cashew tree genotypes, but regardless the differences, kernels can be considered good sources of proteins (21.71%), lipid (44.04%) and total carbohydrate (31.23%) for the human diet. The CCP09, EMB51 and CP1001 genotypes showed higher lipid content and smaller total carbohydrate content than the other genotypes tested which are desirable characteristics for oil production.

Conflict of interests

The authors did not declare any conflict of interest.

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