Anacardium Plants

Subjects: Plant Sciences

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Anacardium plants are native to the American tropical regions, and Anacardium occidentale L. (cashew tree) is the most recognized species of the genus. These species contain a rich content of secondary metabolites in their leaf and shoot powder, fruits and other plant parts, with a plethora of biological applications.

Keywords: Anacardium ; cashew nut ; antioxidant ; antimicrobial ; industrial applications ; food preservative

1. Introduction

The Anacardiaceae family has about 77 genera and 700 species, mainly distributed in tropical, subtropical, and temperate areas [1][2]. Among them, the genus *Anacardium* has 20 species, widely distributed in tropical areas [3][4]. *Anacardium occidentale,* also known as cashew nut, is the most widely cultivated and used species. At which, *Anacardium microcarpum*, commonly known as Caju, and *A. occidentale* are widely used for medicinal and nutraceutical purposes [5]. Therefore, a summary of the current research outputs on this genus is crucial in order to promote its proper use and identify the current scientific gaps to drive future research.

2. Habitat and Cultivation of *Anacardium* Species

Anacardium grows in stony, sandy, loamy and heavy soils at elevation around 600 m. It prefers well drained soil and cannot grow in nutritionally poor soils. These species show poor growth in heavy, waterlogged clay or saline soils [6]. *Anacardium* genus grows in pH ranging from 4.5 to 6.5. Trees are fast growing with a life span of 30–40 years; in their third or fourth year they begin to bear fruit. The root system of a mature tree consists of a tap-root and a well-developed, extensive network of lateral and sinker roots, after grown from seed [7]. Production usually takes three years after planting, and eight years before economic yield can begin. However, some breeds, like the dwarf cashew tree, starts production in only one year and attains economic harvest in three years [8]. The pollination of flowers is done by flies, bees, ants, and wind. The plant is self-fertile, prefers moist soil, can tolerate drought, strong wind, but not maritime exposure [9].

Plants are not frost tolerant, and prefer a pronounced dry season of 3–4 months [10]. Plants produce their best crops when grown in their favorable climatic conditions. In semi-arid tropical areas of Africa, India, Sri Lanka, and southeastern Asia cashew nuts are cultivated commercially. In 2010, total world production of cashew nuts was 3.6 million tons, harvested from 4.4 million hectares. The leading producer of commercially sold cashew apples is Brazil [11].

The wild cashew (*Anacardium excelsum*), generally considered indigenous to the northern part of South America, is actually cultivated in the coastal region of India, mainly in states like Maharashtra, Goa, Karnataka, Kerala, Tamil Nadu, Andhra Pradesh, Orissa, Madhya Pradesh, West Bengal, northeastern states, Andaman and Nicobar Islands [12]. *A. occidentale* is a tough drought-resistant tropical and subtropical tree. It is an evergreen tree growing 10–15 m high with a short, irregular shaped trunk [13]. It is being planted on 1200 hectares of land in Pahang. A survey concluded that 120,000 hectares of land in Peninsular Malaysia are appropriate for its planting. This tree is irregularly a shrub with resin canals. The very young cashew apple is green or purple, and later turns green. When ripe, the apple becomes red or yellow, or a mixture of both. The cashew tree has a rigorous lateral root system and a tap-root which penetrates deeply into the soil [14]. *A. othonianum* is a tree native from the tropical savanna region of Brazil. Its fruit is similar (but smaller than) to the common cashew tree (*A. occidentale*) of the Brazilian Northeast. In the wild, the adult tree ranges from 2 to 6 m (3 m on average), and produces from 200 to 600 fruits every season.

3. Nutritional Composition

Studying the proximate, mineral and functional attributes of defatted and undefatted cashew kernel flours, it was found that in defatted cashew, the kernel flour proximate content of protein, crude fibre and carbohydrate (34.0, 6.2 and 32.2%, respectively) is significantly higher than that of undefatted cashew kernel flour [15]. The proximate, mineral, and energy

profiles were also studied in dried cashew nut testa [16]. The crude protein (190 g/kg), fibre (103 g/kg), fat (20.1 g/kg) and ash contents (20.2 g/kg) of dry matter were detected along with metabolizable energy of 7.12 MJ/kg dry matter. The moisture content, ether extracts (crude fat) and total ash (4.4, 1.6 and 1.8%, respectively) were found to be decreased in defatted flour. Likewise, noticeable variations were recorded in all the studied mineral elements between the defatted and undefatted flours, besides manganese, which showed significantly higher contents in undefatted samples compared to defatted ones. However, no significant variations were detected in bulk density, foam capacity/stability, emulsion capacity and nitrogen solubility (pH 8) between defatted and undefatted flours samples. Other parameters, like water/fat absorption capacity, emulsion stability and nitrogen solubility of these two samples at pH 8.0 also displayed significant variations [15].

Eleven samples of raw cashew kernel (*A. occidentale*) collected from India, Brazil, Ivory Coast, Kenya, Mozambique, and Vietnam were investigated for the total dietary fibre, sugar, protein, lipid profile, sodium, and energy contents [17]. Total fat comprises the major component corresponding to 48.3% of the total weight, of which 79.7% were unsaturated fatty acids, 20.1% saturated fatty acids, and 0.2% *trans* fatty acids. Proteins (21.3 g/100 g) were the second major constituents followed by carbohydrates (20.5 g/100 g). The mean value of sodium content was 144 mg/kg. The mean energy content was 2525 kJ/100 g.

The alterations in physicochemical properties of the juice of yellow and red cashew apples varieties from Yamoussoukro (Ivory Coast) were evaluated by Adou, et al. [18]. The protein content ranged from 0.51 to 0.53 g/100 g and major amino acids in order of size were leucine, cysteine and asparagine. Glucose, fructose and sucrose concentrations (g/L) between the varieties ranged from 47.2 to 65.8, 100.7 to 110.3 and 2.5 to 5.3, respectively. Among the organic acids, citric acid was found in the majority (290.7 and 1092.1 µg/mL), followed by tartaric acid (497.5 to 693.3 µg/mL), acetic acid (48.2 to 266.5 µg/mL), oxalic acid (197.8 to 204.3 µg/mL) and fumaric acid. The pH of the juice ranged from 4.37 to 4.5 while titratable acidity was 0.5 to 0.85%. Similarly, the total soluble solids (10.2 to 10.9%), dry matter (7.8 to 10%) and ash (1.3 to 1.9%) contents also varied among the samples. The vitamin C content varied between 370.9 and 480.3 mg/100 g while total sugars were found between 162.7 to 168.1 g/L in two studied varieties [18].

3.1. Amino Acids

Ion-exchange chromatography was used to evaluate the amino acids composition of *A. occidentale* (**Table 1**), in order to enhance the quality of cereal protein through food complementation [19]. *A. occidentale* possessed a total amino acids of 659.17 mg/g protein, and glutamic acid was present in the highest concentrations. Total essential amino acid percent was 51.0% in the species, and total acidic amino acids were 30.4%. The calculated isoelectric points for *A. occidentale* were 3.9, displaying they can all be precipitated at acidic pH. Threonine was detected as the limiting amino acid in *A. occidentale.* Likewise, the percentage of cystine concentration in total sulphur amino acid was 50.5%. In the Rico, Bullo and Salas-Salvado [17] study, based on *A. occidentale,* the amino acid with highest presence was glutamic acid with 4.60 g/100 g, whereas the one with lower presence was tryptophan with 0.32 g/100 g. In accordance with the study performed by Fagbemi [20], the major dominant amino acid was glutamic acid (183.5–214.0 mg/g crude protein) while tryptophan (3.9–9.2 mg/g crude protein) and leucine (34.8–38.2 mg/g crude protein) were the limiting amino acids.

Table 1. Amino acids present in *Anacardium occidentale*.

Country/Area	Amino Acid	Plant Part/Culture/Extract	References
Nigeria, India, Spain	**arginine alanine aspartic acid cysteine/cystine glutamic acid glycine histidine isoleucine leucine lysine methionine phenylalanine proline serine threonine tryptophan tyrosin evaline**	**Good grade and discarded cashew nut meal, cashew nuts, whole and defatted cashew nut flours, Vietnamese, Indian (Kerala origin) Brazilian, and Ivory Coast cashew kernels**	**[17][20][21][22]**

3.2. Vitamins and Minerals

Looking at the nutritional composition, few vitamins (B, C, and E; **Table 2**) and minerals (Na, K, Ca, Mg, P, Fe, Cu and Se; **Table 3**) have been identified in *Anacardium* plants [23]. The concentrations of four hydrophilic vitamins in the fruit of red fruited species of *A. occidentale* were found as: ascorbic acid 34.2 mg/100 g, thiamine 15.5 mg/100 g, riboflavin 2.90 mg/100 g, and niacin 0.23 mg/100 g [24]. In the Rico, Bullo and Salas-Salvado [17] study, based on *A. occidentale*, vitamin E was the most abundant vitamin with an average contribution of 5.80 mg/100 g. In a study by Tamuno and Onyedikachi [15], cashew apple juice pasteurized at 80 °C for 15 min was packaged in diverse packaging materials like green, brown, white bottles and polyethylene sachet in 200 mL batches and kept at room (30 °C) and refrigeration (4 °C) temperatures for four months to study the effect of packaging materials on both the vitamin C content and pH of cashew-apple juice. Juice stored at 30 °C exhibited significant differences in vitamin C content (48–159 mg/100 mL) and pH (5.0–6.2) from the juice stored at 4 °C. Maximum loss of vitamin C was recorded for samples in polyethylene sachet (83–48) from the first to fourth month, respectively. However, no significant impact of bottle color on vitamin C loss was recorded as the values ranged between 169–128 mg/100 g (white), 187–130 mg/100 g (green) and 188–132 mg/100 g (brown) from the first to the fourth month of refrigeration.

Table 2. Vitamins and functional biofactors present in *Anacardium occidentale*.

Variety/Cultivar	Country/Area	Vitamins/Functional Biofactors	Plant Part/Culture/Extract	References
-	Brazil Spain	vitamin C + dehydroascorbic acid)	fresh and processed apple juice, Vietnamese, Indian (Kerala origin) Brazilian, & Ivory Coast cashew kernels	[17][25]
M 6/1, Bla 256-1, M 10/4 and M 44/3, Red & Yellow fruited species	Nigeria	vitamin C	cashew apples and kernels, fruit, leaves, stem bark and roots	[24][26]
-	Spain	vitamins B1, B5 (pantothenic acid, microbiological) vitamin B6, B8 (biotin, microbiological), B9 (total folate, microbiological), and B12	Vietnamese, Indian (Kerala origin) Brazilian, and Ivory Coast cashew kernels	[17]
Red & Yellow fruited species	Nigeria Spain	vitamins B2 and B3	fruit, leaves, stem bark and roots, Vietnamese, Indian (Kerala origin) Brazilian, and Ivory Coast cashew kernels	[17][24]
-	Indonesia, Spain	vitamin E (tocopherol/α-tocopherol/y-tocopherol/δ-tocopherol)	kernels, kernels of cashew nut, Vietnamese, Indian (Kerala origin) Brazilian, and Ivory Coast cashew kernels	[4][17][27]
-	Spain	vitamin K1	Vietnamese, Indian (Kerala origin) Brazilian, and Ivory Coast cashew kernels	[17]
-	India	m-digallic acid	flowers	[28]
-	India	ethylgullute methyl gallute leucocyanidin leucodelphinidin	leaves	[28]
-	Indonesia	lutein zeaxanthin	kernels	[4][27]
Red & Yellow fruited species	Indonesia, Nigeria	thiamine	kernels, fruit, leaves, stem bark and roots	[4][24][27]

Table 3. Mineral composition in *Anacardium occidentale.*

Country/Area	Mineral	Plant Part/Culture/Extract	Reference
Spain	calcium iron magnesium potassium phosphorus sodium zinc	Vietnamese, Indian (Kerala origin) Brazilian, and Ivory Coast cashew kernels	[17]

3.3. Lipids and Fatty Acid Profile

High-yielding varieties of cashew were evaluated for lipids in cashew kernel (**Table 4**). It was found that neutral lipid from kernel contributed 96% of the total lipids while the remaining 4% was contributed by glycolipid and phospholipid. Unsaturated fatty acids like oleic and linoleic acid were found in a higher majority in triglycerides, while saturated fatty acids like lauric and myristic were the dominant glycolipids. Varietal difference was noticed with respect to the composition of neutral and glycolipids. However, no variations were detected in the composition of phospholipid among high-yielding varieties [29]. *A. occidentale* nut samples were processed by drying, boiling, fermentation, germination and roasting. The oils extracted from nuts were studied for fatty acid composition. The study revealed that the proximate composition of the nuts was significantly influenced by the processing techniques. Oleic acid (57.9–66.8%) and linoleic acid (10.4–17.7%) were found to be the major unsaturated fatty acids. Palmitic acid (8.9–11.7%) and stearic acid (6.9–8.4%) were identified as the saturated fatty acids [20]. In the Rico, Bullo and Salas-Salvado [17] study, based on *A. occidentale,* 14 fatty acids were detected, and oleic acid was dominant, contributing to 60.7% of the total fat, followed by linoleic (17.77%), palmitic (10.2%), and stearic (8.93%) acids.

Table 4. Fatty acids and esters present in *Anacardium occidentale.*

Country/Area	Fatty Acids and Esters	Plant Part/Culture/Extract	References
Spain, Indonesia	C18:0 stearic acid	whole and defatted cashew nut flours, kernels, Vietnamese, Indian (Kerala origin) Brazilian, and Ivory Coast cashew kernels	[4][17][20][27]
Spain	saturated fatty acid C17:0 heptadecanoic acid C20:0 arachidic acid C22:0 behenic acid C24:0 lignoceric acid monounsaturated fatty acid C20:1 gadoleic acid polyunsaturated fatty acid C18:3n3 linolenic acid trans fatty acid C18:1n9t elaidic acid C18:1n7t vaccenic acid	Vietnamese, Indian (Kerala origin) Brazilian, and Ivory Coast cashew kernels	[17]
China	C18:1t *trans*-oleic acid	cashew nut shell liquid	[30]
India	β-sitosterol	leaves and shoot powder, tender leaves	[28][31]
India	stigmasterol	leaves and shoot powder	[31]
Nigeria	1-cyclohexylnonene 2-trifluoroacetoxydodecane 3-[(trimethylsilyl)oxy]-17-[o-(phenyl methyl)oxime]-(3α,5α)-androstan -11,17-dione 5-methylbut-2-en-1-yl 3-hydroxy-5-methoxy cyclohexane carboxylate *cis*-oleic acid cyclohexane carboxylic acid cyclohexanecarboxylic acid, decyl ester decyl ester	cracked bark	[32]

3.4. Polysaccharides

A. occidentale gums from Brazilian plants were found to have higher galactose and lower arabinose and rhamnose concentrations when compared to cashew gums from India and Papua [33]. However, the distribution of other compounds, like glucose, mannose and glucuronic acid was similar (**Table 5**). Gel permeation chromatography detected the presence of 6% polysaccharide-protein complex, 42% polysaccharide of M_{pk} 1.6×10^4 in cashew gum.

Table 5. Polysaccharides present in *Anacardium occidentale.*

Country/Area	Polysaccharides	Plant Part/Culture/Extract	Reference
Brazil	arabinose galactose glucose glucuronic acid mannose rhamnose	crude gum	[33]

3.5. Antinutrients and Heavy Metals

Methanol (80%) extract of the inner stem bark of *A. occidentale* was quantitatively evaluated for antinutrients and few heavy metals [34]. Several compounds like tannins (5.75%), oxalates (2.50%), saponins (2%), phytate (0.25%) and cyanide (0.03%) were also recorded. Iron from dried crude (8.92 mg/100 g) was recorded from the extract whereas lead and cadmium were absent in the extract.

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