Artigo

CHEMICAL COMPOSITION OF UMBU (*Spondias tuberosa* Arr. Cam) SEEDS

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The umbu tree (*Spondias tuberosa* Arr. Cam) is an important fruit tree the economy of the semi-arid northeastern region of Brazil. With the objective of finding use for the seeds, physical and chemical characterizations of the seeds from 2 cultivars in 2 maturation stages were carried out and their fatty acid and mineral profiles determined. The results showed no differences between the seeds analyzed. The yield was about 10% and the dimensions as follows: length from 1.48 to 2.11 cm and width from 0.76 to 1.16 cm. The average lipid content was 55% of which 69% was unsaturated and the average protein content was 24%. The seeds were a good source of the following minerals: P, K, Mg, Fe and Cu. The overall results indicated that the oil or the seeds could be used for food stuffs if no toxic agents were found.

Keywords: umbu (*Spondias tuberosa* Arr. Cam.); chemical composition; seeds.

INTRODUCTION

The semi-arid northeastern region of Brazil possesses an enormous potential in xerophyllic plants, completely ignored by the competent authorities with respect to their domestication and rational use by man. Amongst these is the umbu tree (*Spondias tuberosa* Arr. Cam). This tree can be found throughout the backwoods of the States of Pernambuco, Sergipe, Bahia, the south of Piaui and the north of Minas Gerais[1].

The harvest of umbu fruit reached approx. 9919 tons in 2001, with the harvesting areas spread throughout the Northeast of Brazil with the exception of the States of Maranhão and Alagoas[2]. During the harvesting season, the picking and selling of umbu fruits is the main source of jobs and income for the majority of smallholders in the semi-arid northeastern region of Brazil. One umbu tree can produce from 28 to 32 thousand fruits of weight varying from 8 to 23 g. On average each tree produces up to 350 kg in fruit[3]. The umbu fruit is constituted of roughly 22% skin, 68% pulp and 10% seed, representing a considerable amount of residue as a result of pulp processing. This residue has been chemically characterized [4] and various forms of industrial use investigated[5-8].

However, little is known about the composition of the seed which contains oil, protein and some minerals[9] and should be better investigated with the aim of making use of this raw material for enriching foods or as a source of edible oil, thus providing an alternative income for the smallholders and contributing to the agro-industrial development of the northeastern region, as well as reducing environmental pollution.

Thus the objective of this research was the physical and chemical characterization of the umbu seeds obtained from fruits in different stages of maturation and from different varieties.

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EXPERIMENTAL

The seeds from two different varieties were used – the tuberous variety of Moraes Pires, in the unripe and ripe stages and the hairy variety of Moraes Pires in the ripe stage, all from the municipality of Petrolina. In order to extract the seeds, the stones were cracked with a hammer.

The yield in seeds was based on the weights of the stone and the seeds and the measurements were made with a pachymeter.

The pH, titratable acidity, moisture, ash, lipid and protein contents were all determined[10]. The carbohydrate content was obtained by difference.

The fatty acid composition of the lipids was determined from the ether extract [10], the methyl esters being prepared[11] and analyzed by High Performance Gas Chromatography (HP 5890 gas chromatograph with a FID detector) using a silica column fused with ciano propyl siloxane (60 m x 0.2 μm x 0.32 mm); column temperature from 150-200 °C programmed to rise 1.3°C/min; injector temperature of 250 °C; detector temperature of 280 °C and hydrogen flow rate of 2.5 mL/min. The fatty acid methyl esters were identified by comparison with the retention times of NU CHECK Inc. standards (Elysian, 1L) and quantified by internal normalization.

The minerals were determined by plasma emission spectrometry. 40mL of 65% nitric acid and 10 mL $HClO_4$ were added to 10 g of defatted sample weighed in a 250 mL beaker, and covered with a watch glass. The sample was heated to boiling to promote oxidation of all the organic material and transferred to a 50 mL volumetric flask. After completing the volume with de-ionized water, the reading was made in a spectrophotometer with the wavelength being automatically determined by the equipment for each element.

This design was repeated three times and the means compared by Tukey's test at the 5% level of probability.

RESULTS AND DISCUSSION

On average the umbu seeds weighed 1.4 g each. Table 1 shows the results of the physical aspects (length and width) for each of the cultivars and also the yield with respect to the internal part of the seed (nut), which was the objective of this study. It can be seen that the greatest yield for the nut was obtained from the immature stage of the tuberous Moraes Pires cultivar, whilst the mature stage of the hairy Moraes Pires cultivar gave higher values for length and width.

Table 1. Yield and physical aspects of the umbu seeds

Cultivar	Yield (%)	Length (cm)	Width (cm)
Moraes Pires, tuberous, immature	11.00 ± 0.95[a]	1.48 ± 0.31[a]	0.76 ± 0.20[a]
Moraes Pires, hairy, mature	9.30 ± 0.95[b]	2.11 ± 0.31[b]	1.16 ± 0.20[b]
Moraes Pires, tuberous, mature	9.40 ± 0.95[b]	1.78 ± 0.31[a]	0.94 ± 0.20[a]

Means followed by the same small letters between columns do not differ according to Tukey ($p<0.05$).

Table 2 shows the results for the proximate composition of the seeds of each umbu cultivar. The seeds from the immature stage of the tuberous cultivar of Moraes Pires showed the highest carbohydrate content, whereas the seeds from the mature stage of the hairy cultivar of Moraes Pires showed the greatest amounts of ash. The highest levels of protein were found in the seeds of the mature stage of the tuberous cultivar of Moraes Pires. With respect to the moisture and lipid contents there was no significant difference between the seeds examined.

Table 2. Proximate composition (%) of the umbu seeds of two cultivars in two stages of maturity

Component (%)	Moraes Pires tuberous, immature	Moraes Pires hairy, mature	Moraes Pires tuberous, mature
Moisture	5.10 ± 0.25[a]	5.60 ± 0.25[a]	5.30 ± 0.25 [a]
Lipids	55.00 ± 2.33[a]	56.00 ± 2.33[a]	58.00 ± 2.33[a]
Ash	4.20 ± 0.31[b]	4.60 ± 0.31[a]	4.00 ± 0.31[b]
Protein	24.20 ± 0.22[a]	24.40 ± 0.22[a]	25.10 ± 0.22[b]
Total carbohydrate	11.50 ± 3.11[b]	9.40 ± 3.1[ab]	7.60 ± 3.11[a]

Means followed by the same small letters between columns do not differ according to Tukey ($p<0.05$).

The chemical composition of the seeds from any genotype can vary widely according to the production location, climate, fertilizers and even the position of the seed.

The moisture content of seeds is considered to be an important factor with respect to their conservation at room temperature and there is a limiting value for seed survival (no deterioration), which varies according to the seed. For peach seeds this value is 31%. Some seeds are subject to microbial growth leading to deterioration when the moisture content is above 15%, as in the case of peppercorns and quinoa[12]. However in the case of umbu the limiting moisture content has not yet been determined, although it can be seen from the above results, that the moisture content of its seeds is below that of the seeds of some fruits, some oily seeds and of the cereal grains traditionally used for human consumption, including those of papaya[13] (71.89%), sapodilla[14] (8.66%), jaca[15] (12.88%), cotton[16](10.91%), sesame[17] (5.40%), quinoa[18] (9.50%), wheat[12] (12.84%), corn and rice[19] (13.80, 12.00%, respectively).Thus it could be said that its conservation is aided by its low water activity.

Proteins are considered as a predominantly plastic nutrient, that is, their main function is in the formation of tissue in the tissue renovation process[20]. For growth purposes they provide the amino acids necessary for such synthesis as also for the synthesis of many other tissue constituents. Thus the requirement for protein signifies a requirement for amino acids. The average value of 24.6 ± 0.22 obtained for the protein content of umbu seeds is higher than the value found in the literature for some well known fruit seeds such as cashew nut[21] (22.11%), papaya[13] (8.40%), melon[22] (15.22%) and baru[20] (23.9%). It is also higher than that for some cereal grains and oil seeds such as quinoa[23] (15.50%), wheat[12] (11.57%), corn[17] (8.90%) and sesame[17] (18.60%), with the exception of pumpkin[24] (31.60%).

Cereals such as wheat, corn, rice and oats, commonly consumed in Brazil, are a cheap source of energy, their nutritive value being provided mainly by the carbohydrates arising from the starch fraction responsible for more than 60% of the cereal[19]. In the case of the umbu seed, the carbohydrate content is very low and cannot therefore be considered as a good energy source when compared to cereals and oil seeds.

Due to the high caloric potential (9 kcal/g) released during their metabolic oxidation, the lipids are considered as important energy sources for the organism due to its capacity to store these compounds, especially the triglycerides, in the adipose tissues, serving as an energy reserve and also for heat insulation. Some lipids have an essential role in the structure of the cells, tissues and the organism in general, as is the case of the phospholipids, which are indispensable constituents of the cell membrane structure[20].

The lipid content of umbu seeds can be considered economically attractive for oil extraction due to the high lipid content as compared to the seeds of some fruits such as the cashew nut[21] (46.28%), papaya[13] (9.50%), melon[22] (25.74%), sapoti[14] (11.50%), pumpkin[24] (36.27%) and baru[23] (38.2%). It is also high when compared to some cereals and oil seeds such as corn[19] (3.90%), rice[19] (0.40%) and cotton[16] (21.21%). The lipid content of umbu oil is close to that of sesame oil[17] (49.10%), an oil seed widely used as a seasoning and in the preparation of biscuits, bread, sweetbreads and animal feed amongst other uses. In the chemical industry, sesame oil can be used to manufacture margarines, cosmetics, perfumes, medicines, lubricants, soap, paints and insecticides[17].

The quality and digestibility of edible oils is determined by the amount and quality of their constituent unsaturated fatty acids. The presence of linoleic acid in adequate amounts is fundamental, since the human body is unable to synthesize it. The higher the linoleic acid content in relation to the oleic acid content in a vegetable oil, the better its quality with respect to avoiding the formation of bad cholesterol[25,26].

The fatty acid profile of the umbu seeds under study is presented in Table 3.

In general it can be seen that the seeds were rich in oleic and linoleic acids and that only slight differences in fatty acid profiles existed between the three varieties. The mature tuberous Moraes Pires seeds showed a higher oleic acid content and the mature hairy Moraes Pires seeds higher stearic acid contents. Comparing this fatty acid profile with that of other studied seeds, the umbu oil showed higher levels of palmitic and oleic acids than baru seed oil (7.6 and 28.0%, respectively)[23]. The palmitic, stearic and oleic acid contents were also higher than those of apple seeds, whose values were 10.49, 4.33 and 4.12% respectively[27]. Melon and pumpkin seeds showed greater amounts of linoleic acid (50.6 and 55.6% respectively) and lower amounts of oleic acid (18.1 and 20.4% respectively)[26]. In other studies on the influence of location on pumpkin seeds[28], it was found oleic acid contents similar to those of

Table 3. Fatty acid profile of umbu seeds

Fatty acid (%)	Moraes Pires tuberous, immature	Moraes Pires hairy, mature	Moraes Pires tuberous, mature
Palmitic acid (C 16:0)	19.00 ± 0.3[b]	19.98 ± 0.3[a]	19.21 ± 0.2[b]
Stearic acid (C 18:0)	10.57 ± 0.4[b]	12.08 ± 0.5[a]	11.31 ± 0.5[b]
Oleic acid (C 18:1)	33.60 ± 0.6[b]	33.61 ± 0.5[b]	35.89 ± 0.6[a]
Linoleic acid (C 18:2)	35.52 ± 0.2[b]	33.04 ± 0.6[a]	32.44 ± 0.4[a]
Arachidic acid (C 20:0)	0.55 ± 0.01[a]	0.56 ± 0.02[a]	0.56 ± 0.02[a]

Means followed by the same small letters between columns do not differ according to Tukey ($p<0.05$).

Table 4. Percent fatty acid composition of umbu seed oils at different stages of maturation

Fatty acid (%)	Moraes Pires tuberous, immature	Moraes Pires hairy, mature	Moraes Pires tuberous, mature
Saturated	30.12	32.62	31.08
Mono-unsaturated	33.60	33.61	35.89
Poly-unsaturated	35.52	33.04	32.44
Ratio. sat./unsat.	1/2.30	1/2.04	1/2.20
Ratio oleic/linoleic	1/1.05	1/0.98	1/0.9

Table 5. Percent fatty acid composition of the main edible vegetable oils and of some seeds

Fatty acids (%)	Baru[23]	Pumpkin[26]	Melon[26]	Peanut[25]	Corn[25]	Soy[25]
Saturated	18.8	23.5	21.7	18.0	13.0	15.0
Mono-unsaturated	53.1	20.8	18.4	48.0	25.0	24.0
Poly-unsaturated	28.1	55.6	60.0	3.0	61.0	54.0
Sat./unsat.	1/4.3	1/3.26	1/3.6	1/2.8	1/6.7	1/5.7
Oleic/linoleic	1/0.6	1/2.7	1/3.3	1/0.5	1/2.44	1/2.35

umbu seed oil (30.6 to 35.5%) and attributed the differences to genetic diversity.

Table 4 shows the percent fatty acid composition of umbu seed oil at different stages of maturation. As compared to the oil of various oil seeds traditionally used in the food industry (Table 5), the ratio between the saturated and unsaturated acid contents suggests the use of this oil in frying, since oil instability and oxidative rancidity are related to the unsaturated fatty acid content. Despite containing the essential linoleic acid, the oleic/linoleic acid ratio was close to that of baru and peanut and lower than that of the other edible nutritious oils.

The minerals essential to the organism are usually divided into two groups, the macroelements with organic requirements above 100 mg/day and the microelements or oligoelements with organic requirements below 100 mg/day. Calcium, phosphorous, potassium, sodium, magnesium, sulfur and chlorine are classified as macroelements. Iron, copper, manganese, cobalt, zinc, iodine, fluorine, molybdenum, selenium, chromium, silicon and boron are classified as oligoelements[20]. The umbu seed can be considered as a relevant source of minerals, with an ash concentration oscillating between 4.0 and 4.6%, the average value being 4.30 ± 0.31% as can be seen in Table 2. Table 6 shows the individual mineral contents in the umbu seeds of the three cultivars analyzed. The umbu seeds show considerable amounts of the macroelements, a fact considered to be positive due to their essentiality in organic functions, there being no notable differences between the varieties and stage of maturation. The calcium concentrations oscillated between 114.48 and 191.02 mg/100 g, the individual daily need of an adult being 800 mg, according to the National Academy of Sciences of the United States of America[20]. The phosphorus concentrations varied from 772.38 to 825.03 mg/100 g, the daily requirements for an individual adult being 750 mg. For magnesium the concentrations varied between 462.56 and 477.59 mg/100 g, the recommended daily intake being 350mg. For potassium the concentrations varied between 679.09 and 699.14 mg/100 g.

As compared to baru seeds[23], the umbu seeds were richer in Ca, Cu, Fe, P and Mg and poorer in Mn and K. Pumpkin and melon

Table 6. Mineral profile (mg/100g) of the seeds of three umbu cultivars

Mineral (mg/100g)	Moraes Pires tuberous, immature	Moraes Pires hairy, mature	Moraes Pires tuberous, mature
Phosphorus	825.03 ± 50.0[b]	779.61 ± 47.0[ab]	772.38 ± 43.0[a]
Potassium	679.09 ± 22.0[a]	699.14 ± 15.0[a]	684.01 ± 16.0[a]
Calcium	191.02 ± 3.0[a]	114.48 ± 5.0[c]	143.12 ± 6.0[b]
Magnesium	462.56 ± 10.0[a]	477.59 ± 15.0[a]	476.64 ± 12.0[a]
Iron	9.59 ± 1.0[a]	7.50 ± 0.5[b]	10.10 ± 1.0[a]
Copper	2.33 ± 0.3[a]	2.60 ± 0.2[a]	2.62 ± 0.2[a]
Manganese	2.38 ± 0.3[a]	1.85 ± 0.1[b]	2.16 ± 0.5[a]
Sodium	0.16 ± 0.02[a]	0.14 ± 0.2[a]	0.16 ± 0.02[a]
Aluminum	0.55 ± 0.1[a]	0.46 ± 0.2[a]	0.53 ± 0.3[a]

Means followed by the same small letters between columns do not differ according to Tukey ($p<0.05$).

seeds were richer than the umbu seeds in the following minerals: P, K, Na, Mg and Fe, which presented average values of 1184.5; 1079; 35.5; 512 and 11.5 mg%[26].

CONCLUSIONS

The significant amount of lipids found in the umbu seeds together with the fatty acid composition of its oil and its high mineral content, suggest its use as an edible oil or for food enrichment or even as a frying oil, if the absence of toxic and allergenic factors were subsequently proven.

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