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Chemical and Physio-Chemical Characterization of the Flours and Oils from Whole and Rejected Cashew Nuts Cultivated in Southwest Nigeria

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Abstract: Processed whole as well as rejected cashew nuts were obtained from a processing plant located at Owo, Ondo State, Nigeria. Each of them were divided into two, a part defatted while the other part were undefatted. They were thereafter characterized with respect to their proximate constituents, energy, mineral contents, anti-nutritional factors and functional properties. The physio-chemical properties of the oil from the cashew nuts were also determined. On the average, crude protein (CP) of the whole nut ranged from 200.0 ± 0.3 g kg^{-1} DM in undefatted to 304.0 ± 0.1 g kg^{-1} DM in the defatted sample while it ranged from 176.0 ± 0.6 g kg^{-1} DM to 323.0 ± 0.5 g kg^{-1} DM with 30% and 45.5% increments, respectively. The crude fat of the undefatted samples ranged: 436.0 – 452.0 g kg^{-1} DM while the gross energy content averaged 106 MJ kg^{-1} (range: 39 – 206 MJ kg^{-1}). Apart from Cu and Co, which was not detected, cashew nut meal (CNM) contained appreciable nutritionally needed mineral elements, which were higher in most cases in defatted than in the defatted samples. The phytic acid content averaged 24.6 mg g^{-1} and tannin as total phenols averaged 12.1g kg^{-1}. The water absorption capacity (WAC) was enhanced by 35% and 50%, respectively in the whole and rejected samples by defatting while oil absorption capacity (OAC) were enhanced by 18% and 42%, respectively by defatting. There were wide variations among the foaming capacity (FC) and foaming stability (FS) as evident in the high values of coefficient of variation (CV) of 127.7% and 115.5% respectively. The protein solubility curves generally had multiple maxima and minima peaks. The oil from the CNM had iodine value of 115.0 wijs in rejects and 136.9 wijs in whole nut and the peroxide value varied widely with a CV of 41.85% when compared with other properties of the oil analyzed. The analytical data indicate that the good and rejected cashew nut could be important alternative protein and energy contributors to compound non ruminant animal feed in this region.

Key words: Cashew nut oil, flours, ruminant animal feed

Introduction

The nutritional inadequacies that arise from high cost of animal proteins (milk, eggs, meat) in developing countries have given rise to various forms of malnutrition such as the kwashiorkor, maramus, infant blindness, mortality and morbidity (Tee, 1992; Aletor *et al*., 2002). This has necessitated the use of non-conventional protein food source, especially from plant origins and compelled the need to harness the potentials of the so-called 'wastes' as part replacement for the more expensive protein resource in monogastric feeding (Agbede and Aletor, 2004 and 2005).

The cashew plants are either trees or shrubs, monoecious or diecious and usually radially symmetrical. Cashew is chiefly tropical in distribution while some are strictly in temperate areas of the North hemisphere. There are two types viz: the principal representative in the North America called the Rhus and the mango (*Mangifera indica*) is cultivated in the South of America. The latter represents the most common type in West Africa especially Nigeria (Benson, 1972).

Cashew fruits (*Anacardiaceae*) are among the widely cultivated fruits in southwestern Nigeria. The fruit juice is squeezed and made into fruit juice and the seeds, which contain the nuts, are processed into cashew nuts, pistachio, resin and oils. Although, the nutritional values of cashew nuts have long been recognized (Fetuga *et al*., 1974), cashew nut meal has more recently assumed greater importance due to the fact that its use has been extended from human consumption to the feeding of poultry, especially in layers (Onifade, *et al*., 1998). The upsurge in the consumption of the cashew in this region has resulted in its large-scale production for local consumption and export during which, large quantities of the kennels are broken, bruised or burnt. Such grades of nuts, which do not meet local or export requirements are usually discarded as wastes in several industrial sites in southwest of Nigeria. Conceivably, rejects could be exploited as alternative protein food resources in monogastric feeding after a careful evaluation of the nutritional potentials.

While some of the nutritive values of cashew nuts of other regions have been well detailed, information on the nutritional and physico-chemical characterization of the nuts cultivated in southwest Nigeria remains scanty. This study was therefore designed to assess both whole and rejected cashew nuts produced in Nigeria with respect to the chemical composition and physico-chemical properties of the flour and oil with a view to increasing their utilization.

Materials and Methods

Good and 'wastes' or reject cashew nuts were collected from Ideal Family Farm in Owo, Nigeria. Ideal Family Farm is one of the major exporters of cashew nuts in Nigeria. At the farm the raw cashew nuts were usually washed manually with sand and water. Thereafter, they were soaked, steamed and dried in the sun for 4 to 5 days. The nuts were then roasted to facilitate the release of the kernels when shelling was done. The shelling was done manually with a locally fabricated Sheller. The whole nuts after shelling were normally dried in the sun. The whole nuts were roasted with sand in a locally constructed frying pan. Thereafter, the nuts were allowed to cool and the nuts separated manually from the sand. In the process of roasting some nuts were burnt and considered as wastes or rejects. The good ones were packed for export. The whole and rejects nuts were finely ground using a laboratory hammer mill (DIETZ, 7311 Dettingen-Teck, Germany). Half of either the whole or rejects were defatted and considered as defatted samples. In all, four samples viz: undefatted whole, defatted whole, undefatted reject and defatted reject were used for analysis. They were kept in airtight container and deep frozen (-18°C) prior to analysis.

Extraction of oil from cashew meal (deffated cashew meal): The ground cashew nut meals were extracted for 6 hours with diethyl ether in a soxhlet extractor. Thereafter, the solvent was evaporated under reduced pressure (AOAC, 1990).

Chemical analysis: The defatted and undefatted samples were analyzed for proximate composition. Crude protein was calculated by multiplying the nitrogen content of the samples with the factor of 6.25. The Na and K contents were determined by Flame photometry (Jenway Ltd, Dunmow, Essex, UK), and P by Vanado-molybdate method (AOAC, 1990). Ca, Mg, Fe, Zn, Cu and Mn were determined after wet digestion with a mixture of nitric, sulphuric and hydrochloric acids, using atomic absorption spectro-photometer (Buck Scientific, East Norwalk, CT06855, USA). The gross energy was determined against thermo-chemical-grade benzoic acid using a Gallenkamp Ballistic bomb calorimeter (Cam Metric Ltd, Cambridge, England).

Analysis of anti-nutrients

Tannin and phytin: For the determination of tannin, finely milled defatted and undefatted samples (200mg in 10ml of 70% aqueous acetone) were extracted for 2 h at 30°C in water-bath using Gallenkamp orbital shaker (Surrey, U.K) at 120 revolutions per minute. Pigments and fat were first removed from the samples by extracting with di-ethyl ether containing 1 % acetic acid. Thereafter, the total polyphenols (as tannic equivalent) was determined as described (Makkar and Goodchild, 1996). The amount of total polyphenols (as tannic equivalent) was calculated from the standard curve.

For the quantification of phytin, eight (8) grams of each finely ground defatted and undefatted samples was soaked in 200ml of 2% hydrochloric acid and allowed to stand for three hours. The extract was thereafter filtered through two layers of hardened filter paper. Thereafter, Phytin-Phosphorus was determined and phytin content was calculated by multiplying the value of phytin-Phosphorus by 3.55 (Young and Greaves, 1940).

Physico-chemical properties of cashew nut oil: The physico-chemical properties of the crude oils extracted viz: the specific gravity, acid value, saponification value, peroxide value, iodine value, free fatty acid (as oleic acid) were determined (AOAC, 1990). Refraction index at 29°C was determined using Abbe refractometer.

Determination of the functional properties of the cashew nut meal: The protein solubility (PS) of the cashew nut meal (whole and rejects) was determined as described (Oshodi and Aletor, 1993; Adeyeye *et al*., 1994) while the water absorption capacity (WAC) and fat emulsion stability were also determined (Beuchat, 1977). The fat absorption capacity (FAC) was determined as described (Solsulki, 1962) and the lowest gelation concentration (LGC), foaming capacity (FC) and foaming stability (FS) were determined using a standard technique described elsewhere (Coffman and Garcia, 1977).

Data analysis: Mean values for all parameters measured between the cashew nut (whole and rejects) were assigned a coefficient of variation (CV) as described (Snedecor and Cochran, 1973).

Results

Table 1 reveals that defatting enhanced the crude protein (CP) in both the whole and rejected samples by 34% and 45.5%, respectively. Ether extract varied from 436.0 to 452.0 g kg^{-1} DM in undefatted samples while 23.0 to 76.0 g kg^{-1} DM in the defatted samples. The ash contents of the defatted samples (51.0 – 54.0 g kg^{-1}DM) were higher than those of undefatted samples (13.0 g kg^{-1}DM). The gross energy (GE) of the undefatted whole sample (206.2 MJ kg^{-1}) was reduced by 68.8% in the defatted whole sample while that of the undefatted rejected sample was reduced by 66.7 % in the defatted rejected sample.

The mineral elements (P, Ca, Mg, K, Na, Zn and Fe) were more abundant in whole and rejected defatted

Table 1: Proximate Composition (g kg^{-1}DM) and gross energy (MJ kg^{-1}) of Cashew nut meal

	Dry Matter	Crude Protein	Ether Extract	ASH	Gross Energy
Whole undefatted	961.0±0.0	200.0±0.3	452.0±0.0	13.0±0.1	206.2
Whole defatted	938.0±42	304.0±1.1	23.0±0.0	51.0±0.4	64.4
Reject undefatted	953.0±0.1	176.0±0.6	436.0±0.0	13.0±0.3	116.0
Rejected defatted	946.0±5.6	323.0±0.5	76.0±0.0	54.0±0.8	38.6
Coefficient of variation CV%	1.03	29.32	92.75	69.63	69.61

+Values are for triplicate determinations

Table 2: Mineral Composition (mg kg^{-1}) of Cashew Meal

Minerals	Whole undefatted	Whole defatted	Reject undefatted	Reject defatted	(CV%)
Macro minerals					
Phosphorus (P)	685.4	878.6	3610.3	5468.8	86.43
Calcium (Ca)	1887.8	2208.7	1326.8	2427.3	24.37
Magnesium (Mg)	1704.1	1805.8	1240.2	1956.7	18.42
Potassium (K)	1323.1	2504.9	1131.3	2331.7	38.17
Sodium (Na)	1976.2	2577.1	1354.7	1678.8	27.41
Micro minerals					
Iron (Fe)	132.7	170.0	67.0	139.4	34.01
Zinc (Zn)	17.0	534.0	36.3	25.1	165.97
Manganese (Mn)	10.2	9.7	8.4	11.2	12.12
Copper (Cu)	NDT	NDT	NDT	NDT	NDT
Cobalt (Co)	NDT	NDT	NDT	NDT	NDT

+Values are for triplicate determinations; NDT = Not detected

Table 3: Anti nutritional Constituents of Cashew nut meal

Samples	Phytin (mg g^{-1})	Phytin-Phos-phorus (mg g^{-1})	Tannin (g kg^{-1})
Whole undefatted	14.9.0±0.6	4.2±0.2	Nd
Whole defatted	33.7.0±4.1	9.5±1.5	11.4
Reject undefatted	16.7±0.3	4.7±0.1	Nd
Reject defatted	33.0±0.0	9.3±0.0	14.3
Mean	24.6	6.9	12.9
Standard deviation (sd)	10.2	2.9	2.1
Coefficient of variation (%)	41.5	42.0	16.3

+ Values are for triplicate determinations; nd = not determined

samples than the undefatted samples (Table 2). Mn was the least abundant in all while Cu and Co were not detected in the samples. The coefficient of variation (CV) with regard to minerals between the whole and rejected samples varied from 12.1 to 166.0 %.

Table 3 shows the phytin, phytin-P and Tannin constituents of the cashew nut meal. Phytic acid varied from 14.9±0.6 mg g^{-1} in whole undefatted sample to 33.7 ± 4.1 mg g^{-1} in whole defatted with CV of 41.5%. Phytin-P varies widely from 4.2±0.2 mg g^{-1} in whole undefatted to 9.5±1.5 mg g^{-1} in whole defatted while tannin in the defatted samples ranged between 11.4 mg kg^{-1} and 14.3 mg kg^{-1} (Table 3).

Table 4 presents the functional properties (%) of cashew nut meal. The defatted samples (whole and rejects) showed higher percentage of water absorption and oil absorption capacity while foaming capacity and foaming stability were 0% in the reject defatted and undefatted samples. All the samples showed varying solubility with changes in pH (Fig. 1).

Table 5 shows the physico-chemical properties of cashew nut oil. The oil from the whole sample had lower specific gravity (0.90); acid value (12.66) and free fatty acid (0.73), respectively while saponification and peroxide values were higher in the rejected sample. Both had similar refractive index.

Discussion

The present study showed that with respect to the crude protein, ether extract and ash, cashew nut meal could be used as source of good quality food for human and or monogastric animals in this region. For example the nutritive components of the defatted cashew nut samples compared favourably, with and in some instances, surpassed those reported for most legumes grown in West Africa (Ologhobo, 1980 and Aletor and Aladetimi, 1989). The removal of fat enhanced the crude protein in the products by 34-45.5 %, thus suggesting that defatting process could be used to enhance its use as a protein food resource. However, the high fat content of this nut suggests that it could be used as veritable source of energy in human and/ or monogastric animal diets.

This study further confirmed that, like most tropical legumes, cashew nut meal irrespective of whether it is whole or rejected samples contains both major and minor mineral elements. However, the values observed fall within the range reported for several cowpea varieties (Oke *et al*., 1995) and more recently for differently processed *Canavalia ensiformis* and *Mucuna pruriens* (Agbede and Aletor, 2005). The defatted cashew nut meal (CNM) had the higher values of the minerals evaluated than the undefatted samples.

Table 4: Functional properties (%) of cashew nut meal

	Whole undefatted	Whole defatted	Reject undefatted	Reject defatted	CV
Water absorption capacity	142.5±3.5	219.5±0.7	139.5±0.7	279.0±1.4	34.4
Oil absorption capacity	167.4±0.0	203.7±1.3	129.3±1.3	222.3±1.3	22.8
Foaming capacity	3.0±0.0	6.0±0.1	0	0	127.7
Foaming stability	2.0±0.1	2.0±0.1	0	0	115.5
Emulsion capacity	49.0±0.1	48.6±0.2	49.1±0.1	46.50±0.1	2.6
Least gelatin	8.0±0.0	10.0±0.0	12.0±0.0	10.0±0.0	16.3

+ Values are for triplicate determinations.

Table 5: Physico-chemical Properties of Cashew nut Oil

Parameters	Whole	Reject	CV
Specific gravity (at 20°C)	0.90	0.91	0.66
Acid value (mg/KOH/g)	12.66	22.72	40.19
Saponification value (mg/KOH/g)	17.60	10.01	38.88
Peroxide value (meg/kg)	2.94	1.60	41.85
Refractive index (at 29°C)	1.47	1.47	0.07
Iodine value (Wij's)	136.89	115.01	12.28
Free fatty acids (as oleic acid)	0.73	1.18	33.33

Conceivably, while the whole defatted and undefatted CNM could be used in human food formulations especially in low hypertension risk areas where quality food shortage is endemic, the rejected samples could be used to replace the more expensive conventional plant protein food resources such soy bean and groundnut cake, in monogastric animal diets to enhance animal protein production and consumption in this region.

In spite of the potential contribution of cashew nut meal to the amelioration of protein dearth in most under developed countries, their endowment with ability to synthesize anti-nutritional factors remains a major drawback to their direct use as food by man and livestock. For instance, the phytin and phytin-P of CNM varied from 14.9mg g^{-1} to 33.7mg g^{-1} and 4.2 mg g^{-1} to 9.5 mg g^{-1}, respectively while tannin-averaged 12.9g kg^{-1}. This further confirms the wide occurrence of these two anti-nutritional factors in most leguminous seeds.

The values of the functional properties of the cashew nut meal from this study suggest its potential for the development of different food products. The water absorption capacity (WAC) ranged: 139.5-279.0% for the rejects and the whole ranged: 142.5-279.0% and this compared favourably with those reported for some edible legume seeds (Oshodi and Ekperigin, 1989). The high WAC is considered important in viscous foods such as soups and gravies. The observed values for fat absorption capacity (FAC) were high especially in the defatted whole and rejected (219.5-279.0%) samples and this were higher than the one reported for pigeon pea flour (89.7%) (Oshodi and Ekperigin, 1989), thus indicating the nutritional potentials of CNM as flavour retainers. The foaming capacity and foaming stability (FS) for the rejects were 0% and the values for the whole were equally low (2.0%) at 30 minutes when compared with the values reported elsewhere (Oshodi and Adeladun, 1993) for dehulled varieties of lima bean flour whose FS ranged from 8.80 to 15.20%. This indicates that the cashew nut meal may not be a suitable whipping agent. The whole and rejected samples showed different solubility at different pH ranges in both the acidic and basic regions (Fig. 1), implying that they could be useful in industrial food applications in both acidic and basic regions.

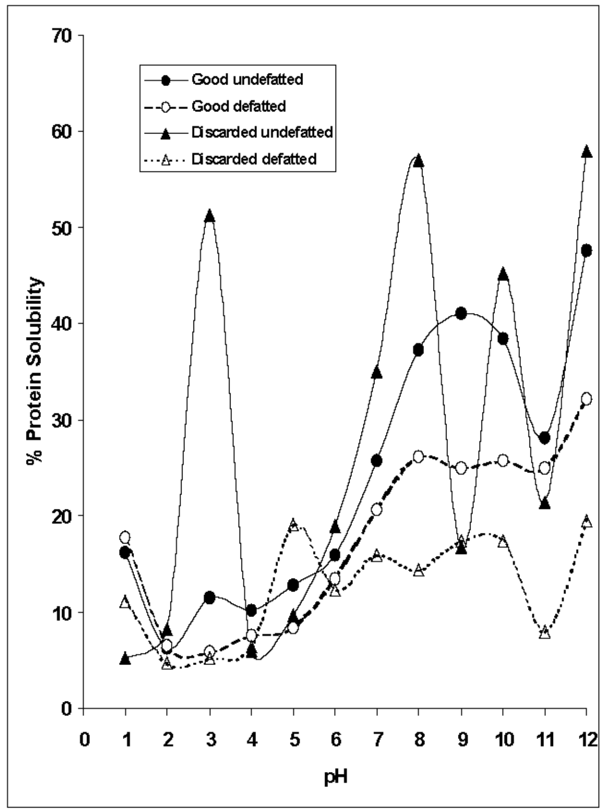

Fig. 1: Protein solubilities as a function of pH

The physico-chemical properties of the oil from the CNM showed that the whole nuts had a higher iodine value (IV), thus suggesting that it has higher proportion of unsaturated fatty acid than in the rejects. The study further showed that the oil is not a drying one as previously indicated (Pearson, 1947). However, the peroxide values obtained for the oils in whole and rejects were still below the recommended standards (Codex Alimentarius Commission, 1970) for all edible oils.

Conclusion: The study further confirmed the nutritive potentials of CNM. Defatting the nut enhanced the protein content but increased the level of phytic acid in the nut. Also the functional properties of the nut indicated their potential usefulness in various food preparations. The Iodine value of the oil suggests that the oil is not a drying one thus implying its edibility. While defatted and undefatted whole cashew nut meal are recommended for human consumption in this region, the rejected nuts could be used to replace the more expensive conventional pulses used in animal food formulations with a viewing to reducing the cost of finished foods which, often derives from the high cost of pulses in this region.

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