Amino Acid and Mineral Compositions and Functional Properties of Some Oilseeds

O. Olaofe*

Chemistry Department, Ondo State University, P.M.B. 5363, Ado-Ekiti, Nigeria

F. O. Adeyemi and G. O. Adediran

Chemistry Department, University of Ilorin, P.M.B. 1515, Ilorin, Nigeria

The amino acid and mineral compositions and functional properties of some oilseeds, melon seed (*Citrullus vulgaris*), pumpkin seed *Telfairia occidentalis*), and gourd seed (*Legenaria vulgaris*), have been analyzed. Results show that oilseeds contained high amounts of crude protein (23.7-30.68) and fat (50.6-55.41%). Aspartic and glutamic acids (24.4-29.5%) were the most abundant amino acids present. The amino acid composition showed that oilseeds contained nutritional useful quantities of essential amino acids. However, pumpkin oilseed is highly deficient in some of the essential amino acids. The predominant mineral was potassium (965-1140 mg/100 g of sample). They also contained moderately high amounts of other minerals (calcium, magnesium, sodium, manganese, iron, and copper) which made them potentials for future food supplements. It was found that the melon, pumpkin, and gourd seed proteins have minimum solubility at pH 4.0, 5.5, and 5.5, respectively. The occurrence of the minimum solubility at these pH values has been related to their amino acid distribution. Other functional properties (water and oil absorption capacities, foaming and least gelation capacities) and the industrial application of the oilseed proteins have been fully discussed.

INTRODUCTION

Oilseeds [melon seed (*Citrullus vulgaris*), pumpkin seed (*Telfairia occidentalis*), and gourd seed (*Legenaria vulgaris*)] are widely cultivated in the tropical countries, particularly West Africa. Melon seed is widely eaten as soup thickener; the others are rarely used as soup thickener but are eaten as nuts after cooking or roasting. The industrial utilization of these oilseeds as sources of oil protein or protein food supplements is nonexistent in Nigeria due to lack of information on the chemical composition and functional properties of these oilseeds.

The chemical composition and functional properties of some of these oilseeds—pumpkin seed (Aisegbu, 1987; Fagbemi and Oshodi, 1991), casophor seed and three varieties of melon seeds (Ige *et al.*, 1984), and eguis (*Colocynthis citrullus*) seed protein products (Akobundu *et. al.*, 1982)—have been reported in the literature. However, the chemical compositions (amino acid and mineral) and functional properties of gourd oilseed have not been reported.

Second, some of the results in the literature do not include amino acid and/or mineral analyses. Hence, the protein solubility and other functional properties could not be related to amino acid distribution. This work was undertaken to determine the amino acid and mineral composition and functional properties of some selected oilseeds to supplement, contradict, and/or add to existing data in the literature. Such data will be of considerable value to dieticians, food scientists and manufacturers, medical personnel, and nutritionists and also in the preparation of a much needed food composition table for Nigeria.

MATERIALS AND METHODS

Oilseed samples [melon oil seed (*C. vulgaris*), fluted pumpkin oil seed (*T. occidentalis*), gourd oil (*L. vulgaris*)] were purchased from farmers in villages close to the University of Ilorin main campus, Nigeria. The seeds were removed from the pods, washed, dried, and screened to remove the bad seeds. The remaining good seeds were dehulled and blended into fine flour.

The moisture and ash contents were determined using the air oven and dry ashing methods of Pearson (1976). The ash was digested with 3 M HCl, and mineral contents were determined by atomic absorption spectrophotometry (Vogel, 1962). Samples were analyzed for fat and crude protein according to the methods of the Association of Official Analytical Chemists (AOAC, 1975). The percentage nitrogen was converted to percentage crude protein by multiplying by 6.25. The samples were hydrolyzed at 150 °C for 1.5 h, and the resulting solutions were analyzed for amino acids using a modification of the Waters Picotag system (Bidlingmeyer *et al.*, 1984). The detailed procedure for amino acid analysis is described by Gardener *et al.* (1991). The values reported are averages of two or more determinations. The method described by Oshodi and Ekperigin (1989) was used for the determination of protein solubility at room temperature (20 °C). The water absorption capacity, fat absorption capacity, foaming capacity, and least gelation concentration of the oilseed flour samples were determined according to the methods of Sathe *et al.* (1982) and Lin *et al.* (1975). All values recorded are averages of at least two determinations, and the difference between two analyses varied between 0 and 0.5 for all analyses.

RESULTS AND DISCUSSION

Table 1 presents the proximate compositions of the oilseed samples. Moisture, ash, fat, crude protein, and carbohydrate contents were recorded in grams per 100 g of wet sample or percentage of the wet sample. All oilseed samples have a low quantity of moisture, which makes them not highly susceptible to microorganism attack. The moisture contents are in close agreement with those reported by Ige *et al.* (1984) for *C. vulgaris* (8.23%), Aisegbu (1987) for fluted pumpkin seed (5.0%), and Fagbemi and Oshodi (1991) for fluted pumpkin seed (5.50%).

The oilseeds have high fat content which ranged between 50.6 and 55.4%. These values are in close agreement with those reported for *C. vulgaris* [47.9-51.1% (Ige *et al.*, 1984),

* Author to whom correspondence should be addressed.

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Table 1. Proximate Chemical Composition of the Oilseeds

composition	sample (g/100 g of fresh sample)		
	C. vulgaris (melon seed)	*T. occidentalis* (pumpkin seed)	*L. vulgaris* (gourd seed)
moisture content	8.32	6.93	3.48
dry matter	91.7	93.1	96.5
ash	4.14	4.95	5.25
crude protein	23.7	33.0	30.8
fat	55.4	51.4	50.6
carbohydrate by diff	8.47	3.77	9.83

Table 2. Amino Acid Composition of Oilseeds

amino acid	oilseed sample (g of amino acid/100 g of protein)					
	melon seed	egg score	pumpkin seed	egg score	gourd seed	egg score
Asp	11.4		9.9		10.0	
Glu	18.1		14.5		15.2	
Ser	3.4		6.8		3.1	
Gly	6.7		6.7		5.5	
His[a]	2.6	86.7	0.0	0	2.7	90.0
Arg[a]	16.0	192.2	0.0	0	17.4	209.6
Thr[a]	1.6	31.1	2.6	50.5	1.9	36.9
Ala	5.2		8.3		4.6	
Pro	4.3		9.4		4.1	
Tyr	3.5		6.0		3.5	
Val[a]	5.0	73.4	0.0	0	5.3	77.8
Met[a]	1.9	57.1	14.5	435.4	3.4	102.1
Cys	0.0		0.0		0.0	
Ile[a]	4.2	66.1	0.0	0	4.5	70.9
Leu[a]	6.7	76.5	0.0	0	7.5	85.6
Phe[a]	5.5	94.8	5.3	91.4	6.3	108.6
Lys[a]	3.7	53.7	15.8	229.9	4.6	66.8
EAA (%)	53.44		38.3		53.6	

[a] Essential amino acid (EAA). Tryptophan was not determined.

Table 3. Mineral Content of Oilseeds

mineral	sample (mg/100 g of wet sample)		
	melon seed	pumpkin seed	gourd seed
calcium	130.7	72.3	54.9
magnesium	657.7	778.3	719.7
potassium	1140.0	1127.0	965.0
sodium	118.0	214.7	174.4
manganese	3.3	3.6	2.1
iron	5.8	27.1	21.1
copper	2.8	3.4	6.4
zinc	9.6	16.7	15.7
phosphorus	466.0	578.8	380.7

pumpkin seed [49.2 and 47.0% (Fagbemi and Oshodi, 1991; Aisegbu, 1987)], and *Cucumeroplis edulis* [43.7% (Ige *et al.*, 1984(]. These values are high compared with 23.5% reported for soybean seed (Paul and Southgate, 1985). This indicates that these oilseeds are better sources of oil than soybean seed. The quantity of crude protein (23.07–33.0%) in these oil seeds is high compared with crude proteins in protein-rich foods such as soybeans, cowpeas, and pigeon peas (Olaofe *et al.*, 1993a). The oilseeds have moderate content of ash (4.14–5.25%) and carbohydrate (3.77–9.83%); these values are similar to compositions of some Nigeria grains (Olaofe and Sanni, 1988).

Table 2 shows the amino acid composition of the oilseed samples in grams of amino acid per 16 g of N protein and the egg score for the essential amino acids. The present results indicate that aspartic (Asp) and glutamic (Glu) acids were the major abundant amino acids in the oilseeds. This observation was in close agreement with the observation of Olaofe *et al.* (1992). The sum of the Asp and Glu amino acids ranged between 24.4 and 29.5%. The total essential amino acids in oilseeds ranged between 38.3 and 53.6%, which suggests that oilseeds will contribute significantly to the supply of essential amino acids in the diet. The total essential amino acids in melon and gourd oilseeds is much higher than that in soybean [44.4% (Kuri *et al.*, 1991)], cowpea [42.6% (Olaofe *et al.*, 1993a)], pigeon pea (*Cajanus cajan*) [43.60% (Oshodi *et al.*, 1992)], pigeon pea [45.2% (Nwokolo, 1987)], and pumpkin seed [39.6% (Aisegbu, 1987)]. However, the total essential amino acid in pumpkin seed (38.3%) is comparable to those reported for cowpea, pigeon pea, pumpkin seed, and soybean seed in the literature. This indicates that the protein in oilseeds (melon and gourd seeds) is of higher quality compared with those in cowpea, soybean, and pigeon pea. The present analysis indicated that the soilseeds are good sources of essential amino acids with the exception of histidine (His), arginine (Arg), valine (Val), isoleucine (Ile), and leucine (Leu) in pumpkin seed. It is worth nothing that pumpkin seed is highly rich in methionine (Met) and lysine (Lys). These observations are confirmed by the egg scores for the essential amino acids. The Ile, Leu, Lys, phenylalanine (Phe), Val, and Met values in melon and gourd seeds are higher than or comparable to the Food Agriculture Organization (FAO, 1970) reference values of 4.2, 4.2, 4.2, 2.8, 4.2, and 2.2 of amino acid/16 g of N protein, respectively. However, threonine (Thr) values for melon and gourd oilseeds are much lower than the Thr FAO reference value of 2.8 g of amino acid/16 g of N protein This suggests that oilseeds are deficient in Thr. Only Met and Lys contents in pumpkin seeds are comparable to or higher than those of the FAO reference values. The present results indicate that pumpkin seed is highly deficient in the remaining essential amino acids. It also indicates that melon and gourd oilseeds contained balanced essential amino acids when compared with pumpkin oilseed. The oilseed protein may be highly suitable for the fortification of maize food products which are widely used as weaning foods for children in most African countries (Akinrele and Edward, 1971).

Table 3 presents the mineral content of oilseeds. The most abundant mineral was potassium, which varied between 965 and 1140 mg/100 g of wet sample. This observation is in close agreement with the observations of Olaofe and Sanni (1988), Aletor and Aladetimi (1989), and Olaofe *et al.* (1993a). The present values are comparable with those reported by Aletor and Aladetimi (1989) for pigeon pea (1700 mg/100 g of sample) and by Olaofe and Sanni (1988) for some selected agricultural grain products [soybean, cowpea, maize, and sorghum (644–4510 mg/100 of g wet sample)] but lower than those reported for some selected Nigerian chilies [2031–3006 mg/100 g of dry sample) (Olaofe *et al.*, 1993b)]. This observation further stressed that potassium-rich chemical fertilizer would be required for planting in Nigeria to replace the large uptake of potassium by plants and maintain the fertility of the soil.

Magnesium is the next highest mineral component in all oilseeds followed by phosphorus. Deficiencies in these minerals (Mg and P) and calcium can led to abnormal bone development (Roberts, 1981). The magnesium content in oilseeds is higher compared to those in pigeon pea [240 mg/100 g of sample (Aletor and Aladetimi, 1989), 100 mg/100 g of sample (Holland *et al.*, 1991), 110 mg/100 g of sample (Oshodi *et al.*, 1992)] and soybean seed [250 mg/100 g of sample (Olaofe and Sanni, 1988)]. The differences in mineral content of plant products may be due to the soil's composition and the rate of uptake of minerals by each plant (Olaofe *et al.*, 1987; Nelson, 1980).

Table 3 further shows that values for other minerals (iron, calcium, manganese, copper, and zinc) are in good agreement with or comparable to values reported for some Nigerian agricultural crops (Oyenuga, 1968; Olaofe and

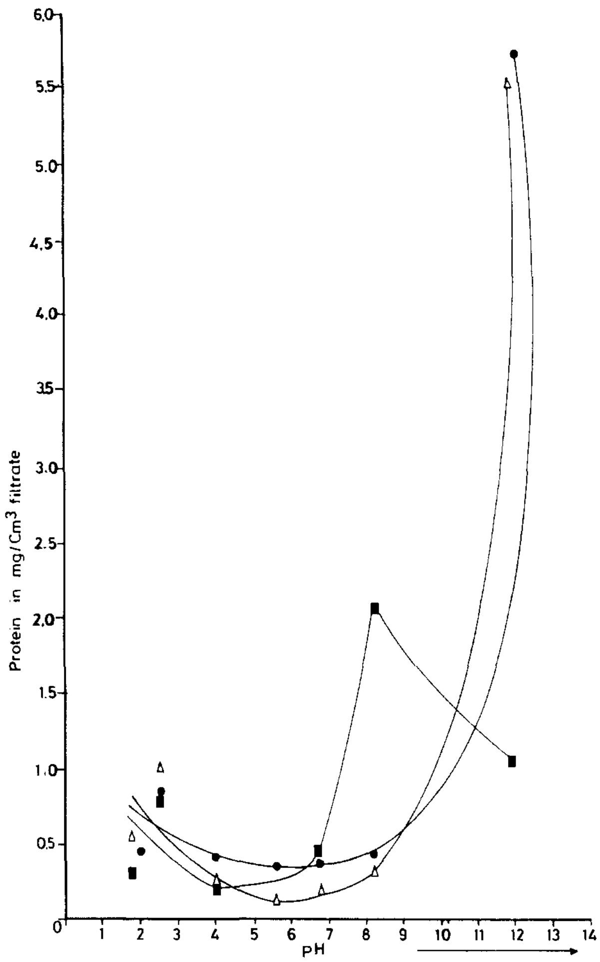

Figure 1. Effect of pH on protein solubility (mg/cm^3 of filtrate): (△) *L. vulgaris*; (●) *T. occidentalis*; (■) *C. vulgaris*.

Sanni, 1988). The moderate availability of essential minerals (calcium, iron, magnesium, phosphorus, and potassium) compared with conventional agricultural foods (Olaofe and Sanni, 1988; Aletor and Aladetimi, 1989; Oyenuga, 1968) indicates that oilseed flours are potential choices for future feed supplements and/or formulation of baby foods (Olaofe, 1988).

Figure 1 shows the oilseed protein solubiliity as a function of pH. This provides a good index of the potential or limitation of a protein as a functional ingredient. The minimum solubilities for melon, pumpkin, and gourd oilseed proteins occurred at pH 4.0, 5.5, and 5.5, respectively. Asp and Glu have their isoelectric points at pH 3.0 and 3.1, respectively. The remaining amino acids have their isoelectric points at pH greater than 4.5. The melon oilseed contained more Asp and Glu (29.5%) compared to pumpkin and gourd seeds. This probably explained the occurrence of minimum solubility of melon seed protein at a lower pH value. The observed minimum solubilities at pH 4.0, 5.5, and 5.5 are in close agreement with the results of Ige *et al.* (1984), who found that melon oilseed protein showed minimum solubility at pH 4.5. Fagbemi and Oshodi (1991) also reported that defatted fluted pumpkin has minimum solubility at pH 4.0. The present results also showed that oilseed protein is more soluble in the basic region than in the acidic region. This suggests that the protein of these oilseeds can be used in basic food formulation such as biscuit and meat products. Another interesting observation is that the solubiliity profile for melon seed showed a decrease in protein solubility as from pH 8 and above. This is similar to the observations of Ige *et al.* (1984) and Fagbemi and Oshodi (1991). This is probably due to the exposure of some hydrophobic group at pH above 8, which causes the reduction in the solubility.

Table 4. Functional Properties of Oilseed Flour

functional property	sample (%)		
	melon seed	pumpkin seed	gourd seed
fat absorpn capacity	122	87	96
water absorpn capacity	120	70	100
least geln capacity	12	14	18
foaming capacity	40	50	40

Table 4 presents the functional properties of oilseed flours. The water absorption capacities (70–120%) for the oilseeds were lower than that for soy flour [130% (Lin *et al.*, 1974)], pigeon pea [138% (Oshodi and Ekperigin, 1989)], defatted flours of oilseeds [100–266% (Ige *et al.*, 1984)], and cowpea flours [212–275% (Olaofe *et al.*, 1993a) but comparable with the water absorption capacity (85%) reported for fluted pumpkin seed flour (Fagbemi and Oshodi, 1991). The oil absorption capacities (87–122%) were highly comparable to the fat absorption capacity for soy flour [84.2% (Lin *et al.*, 1974)] and pigeon pea [89.7% (Oshodi and Ekperigin, 1989) but much lower than that for defatted flours of oilseeds [98.5–301.8% (Ige *et al.*, 1984)], cowpea flour [281–321% (Olaofe *et al.*, 1993a)], and fluted pumpkin seed flour [142.5% (Fagbemi and Oshodi, 1991)]. The least gelation capacity for the oilseed flours (12–18%) was highly comparable with that reported for pigeon pea flour [12% (Oshodi and Ekperigin, 1989)], lupin seed flour and winged bean (14 and 18%, respectively (Sathe *et al.*, 1982)], and Great Northern bean flour [10% (Sathe and Salunkhe, 1981). This suggests that oilseed flours may be good gelating and forming agents. The foaming capacity for the oilseed flour (40–80%) is comparable with those reported for cowpea [40.80% (Olaofe *et al.*, 1993a)] but was lower than that for soy flour [160% (Lin *et al.*, 1974)] and defatted flours of oilseeds [66–146% (Ige *et al.*, 1984)] and higher than that reported for fluted pumpkin seed flour [10.8% (Fagbemi and Oshodi, 1991)]. The present results show that oilseed flours have good protein solubility in the basic region and moderately low gelating and foaming capacities, which made oilseed protein suitable for food formulation and stabilizing colloidal food systems.

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