Chemical and Functional Properties of Full Fat and Defatted White Melon (*Cucumeropsis mannii*) Seed Flours

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Abstract: *Cucumeropsis mannii*, an underutilized oil seed was processed into raw full fat and defatted seed flours and its chemical, functional properties and anti-nutritional factors were determined using standard techniques. The effects of sample concentration and pH on the foaming properties of the seed flours were determined. The results showed that the full fat and defatted seed flours contained the following in g/100 g sample; 5.0 and 5.1; 45.8 and 1.0; 39.4 and 78.7; 3.45 and 4.40; 1.50 and 3.05; 4.85 and 7.75 for moisture, crude fat, protein, ash, crude fibre and carbohydrate, respectively. The most abundant mineral elements in the seed flour (mg/100 g) are potassium (198.5), followed by nickel (30.0) and magnesium (28.4). The water absorption capacity, oil absorption capacity, foaming capacity and stability, least gelation concentration, emulsion capacity and bulk density are 55.5% and 125.0%; 128.8% and 184.0%; 10.5% and 17.0%; 3.0% and 1.5%; 16.0% and 10.0 g/mL; 85.0 and 115.0 mL/g; 0.42 and 0.25 g/mL, respectively. Defatting influenced the functional properties. The foaming capacity is dependent on sample concentration and pH. The protein solubility of the full fat and defatted seed flours was minimum between pH 3 and 4 and maximum at pH 11. The anti-nutritional composition of the seed flour revealed the following: tannic acid, 1.54 mg/100 g; phytin phosphorus, 0.70 mg/g; phytic acid, 2.48 mg/g; oxalate, 1.85 mg/g; alkaloids 1.97% and saponin 0.50%. The seed flours (full fat and defatted) have potential as nutrient supplement, thickeners and emulsifiers in food system.

Key words: *Cucumeropsis mannii*, full fat, defatted, chemical and functional properties.

1. Introduction

Cucumeropsis mannii belongs to the *Cucurbitaceae* family. It is a climber that grows in wet humid climate, particularly in the Southwestern Nigeria. This white seeded melon is grown mostly as an oil rich seed crop and it is also a source of dietary proteins [1, 2]. The seeds when shelled serve as thickener in soups and they can also be dry roasted and eaten as snacks. The seeds can be fermented to give the local condiment called “Ogiri”.

Developing nations do not produce enough food and of the right nutritional quality to meet daily needs of their ever growing population, therefore, there is a

great need to search for nutritious and locally available underutilized food products in order to ensure that all the potential sources of foods are effectively exploited [3]. The effective utilization of any plant protein sources in food supplementation or in new food product formulation is based on the knowledge of their nutritional composition and functional properties. Studies on *Cucurbitaceae* have been limited to *Colocynthis citrullus*, *Citrullus vulgaris*, and fluted pumpkin [4-8]. *Cucumeropsis mannii* is a good source of dietary oil and protein [2]. Previous report has showed that the seed flour contained nutritionally important amino acids [9]. Its industrial application, however, depends on the knowledge of their protein quality and functional properties. This work is aimed at

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determining the proximate composition, anti-nutritional and functional properties of full fat and defatted *Cucumeropsis mannii* seed flours.

2. Materials and Methods

2.1 Collection and Preparation of Samples

The seeds of *Cucumeropsis mannii* were bought from a farm in Omuo Ekiti, Ekiti State, Nigeria. The seeds were manually shelled, washed and later dried in a hot air oven at 50 °C. The seeds were pulverized using a Brabender blender and sieved to pass through a 500 µm sieve. The flour obtained was divided into two portions, one part was defatted continuously for 8 h using n-hexane while the other part was packaged and kept in cool dry area for further analysis.

2.2 Chemical Analysis

The full fat and defatted seed flours were analyzed for proximate composition according to the standard method of association of official analytical chemist (AOAC) [10]. The nitrogen content was determined by the micro Kjeldahl method described by Kirk and Sawyer [11]. The metabolizable energy was calculated using the Atwater factor. The mineral analysis of the seed flour was determined using the dry ashing procedure, followed by analysis using atomic absorption spectrophotometer. Sodium and potassium were determined using a flame photometer and phosphorus by spectrophotometric method. The standard method of AOAC [10] was used to determine the total cyanide and oxalate content. The tannin was determined as described by Makkar [12] with slight modification, phosphorous and phytic acid were also determined [13]. The method of Harbone [14] was employed for alkaloid determination while saponin was determined using the method of Price et al. [15] with slight modification.

2.3 Determination of Functional Properties

The water and oil absorption capacity (water absorption capacity (WAC) and oil absorption capacity

(OAC)), of the full fat and defatted seed flours was determined [5]. The OAC was determined by replacing the distilled water with executive chef vegetable oil (0.92 g/mL) obtained from Jof Ideal family farm, Owo, Nigeria. The bulk density (BD) of the seed flours was determined [16] and the protein solubility (PS) of the seed flours was also determined [6]. The effect of pH on protein solubility of the seed flours was determined. Foam capacity and stability (FC, FS) at different sample concentration and pH levels were determined [17]. The emulsion capacity (EC) and least gelation concentration (LGC) were determined [18-20].

2.4 Statistical Analysis

Determinations were carried out in triplicates and errors were reported as standard deviation from the mean. Results were subjected to ANOVA and means separated by Duncan using SPSS 15 computer programme.

3. Results and Discussion

3.1 Proximate Composition

Defatting significantly ($P \leq 0.05$) affected the proximate composition, calculated metabolizable energy and predicted fatty acid value of *Cucumeropsis mannii* seed flour (Table 1). The low moisture content 5.0 and 5.1 g/100 g compared well with 5.63% reported for *Cucumeropsis mannii* [2], and with 4.97% in *Colocynthis citrullus* and 5.0% in fluted pumpkin flour [4, 21]. This low moisture content obtained in this work may afford a good keeping quality, hence, longer shelf life for the seed flour. The high crude fat content 45.8 g/100 g obtained for the full fat sample is expected of oil seed flour. The value was higher than 22.8% and 23.5% reported for soybeans flour [22, 23]. The value, however, compared very well with 47.9%-51.1% in full fat *Citrullus vulgaris* [6]. The crude protein content (39.4 g/100 g) in the full fat seed flour is higher than the crude protein content of some legumes and oil seed flours such as fluted pumpkin 30.42% [8], pigeon pea 21.64% [24], Lima bean 21.64% [25] and *Colocynthis citrullus* 28.44% [4] but

Table 1 Proximate composition of full fat and defatted *Cucumeropsis mannii* seed flours (g/100 g).

Composition	Full fat	Defatted
Moisture content	5.00 ± 0.10 ^a	5.10 ± 0.20 ^a
Crude fat	45.80 ± 0.01 ^a	1.00 ± 0.05 ^b
Crude protein	39.40 ± 0.20 ^b	78.70 ± 0.40 ^a
Ash	3.45 ± 0.10 ^b	4.40 ± 0.10 ^a
Crude fibre	1.50 ± 0.10 ^b	3.05 ± 0.05 ^a
Carbohydrate	4.85 ± 0.20 ^b	7.75 ± 0.50 ^a
Metabolizable energy (kJ/100 g)	2,309 ± 3.40 ^a	1,504 ± 0.10 ^b
Calculated fatty acid	36.64 ± 0.08 ^a	0.80 ± 0.04 ^b

Values with different alphabets on the same row are significant ($P \leq 0.05$).

compared well with 33.8% crude protein in lupin seed flour [26]. About 123.7 g and 61.9 g respectively of full-fat and defatted *Cucumeropsis mannii* seed flour are needed by a man to meet his daily recommended protein requirement of 0.75 g/day kg body weight [27]. These amounts are not too high to be consumed daily. The full fat and defatted seed flours have total ash content of 3.45 and 4.40 g/100 g; crude fibre, 1.50 and 3.05 g/100 g and carbohydrate content of 4.85 and 7.75 g/100 g, respectively. These values compared favourably with some reported works for oil seeds in the literature [2, 25, 28].

The low calculated fatty acid composition in the defatted sample may afford the seed flour better keeping quality. The defatted seed flour may found use in food preparation where protein supplementation is required. The calculated metabolisable energy value obtained for the full fat seed flour 2,309 kJ/100 g showed that the full fat seed flour had energy concentration higher than that of soybeans (17.98 kJ/g) and alfalfa (16.34 kJ/g) [28]. The high energy value in the seed flours showed that they may be good sources of energy.

3.2 Mineral Composition

The result of the mineral composition in mg/100 g of *Cucumeropsis mannii* seed flour is depicted in Table 2. Potassium was found to be the most abundant mineral element (198.5 mg/100 g) in the sample followed by nickel, magnesium and calcium. Similar observation

Table 2 Mineral composition (mg/100 g) of *Cucumeropsis mannii* seed flour.

Mineral element	Composition
Na	2.50 ± 0.04
K	198.50 ± 0.04
Ca	9.30 ± 0.02
Fe	5.50 ± 0.09
Cu	1.70 ± 0.01
Mg	28.40 ± 0.01
Mn	1.70 ± 0.01
P	2.40 ± 0.02
Ag	0.03 ± 0.01
Al	0.01 ± 0.00
Cd	ND
Se	ND
Ni	30.0 ± 0.01
Cr	ND
Na/K	0.01
Ca/P	3.9
Ca/Mg	0.33

ND = not detected.

was reported for cashew nut and two varieties of *Lagenaria siceraria* seed flours [9, 29]. The highest value of potassium agreed with the observation that potassium was the most predominant mineral in Nigerian agricultural products [30]. Copper, manganese, phosphorus, silver and aluminium were generally low in the seed flour. Cadmium, selenium and chromium were not detected in the seed flour. Hence, the seed flour may be safe from cadmium and selenium toxicity. The Na/K ratio (0.01) obtained is less than 1. The seed flour would probably reduce high blood pressure. Since the Ca/P ratio obtained 3.9 is higher than 1, less calcium would be lost in the urine of animal fed with diet based on the seed flour. The Ca/mg weight ratio obtained in the seed flour (0.33) is very low compared with the recommended ratio of 2.2 [31]. This may be due to the low calcium content of the seed flour. Supplementation with calcium may be necessary if the seed is to be used for diet formulation particularly as weaning food.

3.3 Functional Properties

Defatting significantly increased the WAC, OAC,

FC, EC, LGC of *Cucumeropsis mannii* seed flour, while FS, and BD were decreased (Table 3). The high WAC associated with the defatted seed flour may be due to the exposure of water binding sites present on side chain groups of proteins previously blocked in a lipophilic environment. The water absorption capacity of the full fat and defatted seed flours 55% (g/g) and 125% (g/g) are lower than 174.53% (fluted pumpkin) and 210.0% (g/g) (winged bean) [16, 32]. However, the defatted seed flour may find use as functional ingredients in soups, gravies and baked products. The FC and FS of the seed flours (10.5%-17.0% and 1.5%-3.0%) respectively are generally low; however, the defatted sample may be a better aerating agent. The LGC of the full fat and defatted seed flours (16% and 10%) respectively compared well with 12.0% in fluted pumpkin [32]. The ability of seed flour to form gel is desirable in the preparation of extended meat products; the defatted seed flour may found use in such food preparation. The emulsion capacity of the seed flours (85%-115% mL/g) in full fat and defatted seed flours respectively are higher than 60% mL/g in fluted pumpkin [32]. The seed flours may be good emulsifying agents and may be useful in vegetable milk production, pastries and as ingredient in frozen desserts.

The FC increases with increased sample concentration in both full fat and defatted seed flours (Fig. 1). Similar observations were reported for full fat fluted pumpkin flour and plantain flour [32]. Minimum foaming capacity was recorded at pH 4.0 in the defatted seed flour and the foaming capacity increases on either sides of this pH (Fig. 2). The FC of the full fat sample decreased at pH 4.0, FC then increased and later decreases at pH 8.0. Minimum protein solubility was recorded at pH 3 and 4, respectively in the full fat and defatted seed flours (Fig. 3). The protein solubility increases at either side of these pH values. Generally, plant proteins are reported to have minimum protein solubility between pH 3.5 and 4.5, these values may be the isoelectric point (IP) of the seed flours.

Table 3 Functional properties of full fat and defatted *Cucumeropsis mannii* seed flours.

Properties	Full fat	Defatted
Water absorption capacity (%) (g/g)	55.0 ± 4.1 ^b	125.0 ± 4.1 ^a
Oil absorption capacity (%) (g/g)	128.8 ± 3.8 ^b	184.0 ± 7.5 ^a
Foaming Capacity (%)	10.5 ± 0.4 ^b	17.0 ± 0.8 ^a
Foaming stability % (6 h)	3.0 ± 0.8 ^a	1.5 ± 0.4 ^b
Least gelation concentration (%) (g/mL)	16.0 ± 1.6 ^a	10.0 ± 1.6 ^b
Emulsion capacity (%) (mL/g)	85.0 ± 4.1 ^b	115.0 ± 4.1 ^a
Protein solubility in water (%)	3.7 ± 0.20 ^b	5.7 ± 0.01 ^a
Bulk density g/mL	0.42 ± 0.01 ^a	0.25 ± 0.01 ^b

Values with different alphabets on the same row are significant ($P \leq 0.05$).

3.4 Anti-nutritional Properties

The result of the anti-nutritional composition of *Cucumeropsis mannii* seed flour is depicted in Table 4. The phytic acid content of the seed flour 2.48 mg/g is lower than the range of values 2.8-5.3 g/kg, 6.0-9.9 g/kg and 2.8-13.8 g/kg reported for raw dried and processed breadnut, cashew nut and fluted pumpkin seed flours, respectively [33]. Phytic acid has ability to chelate polyvalent mineral elements such as Ca, Mg and Fe thereby rendering them metabolically unavailable and leading to development of osteomalacia in some growing animals [34]. The tannic acid (15.4 mg/100 g) of the seed flour is much higher than the range of values 13.3-99.2 g/kg reported for raw dried breadnut, cashew nut and fluted pumpkin flours [33]. Tannins have been reported to interfere with digestion by displaying anti-trypsin, anti-proline and anti-amylase activities in higher animals [34]. The content of oxalate, alkaloids and saponin (1.85 mg/g, 1.97% and 0.50%, respectively) in the seed flour showed that the seed flour is safe from these antinutrients toxicity and may not lead to kidney stone in consumers, hence, may found use in weaning food formulation.

4. Conclusions

This work has shown that *Cucumeropsis mannii* seed flour is a potential source of dietary oil, proteins

Fig. 1 Effect of sample concentration on foaming capacity of full fat and defatted *Cucumeropsis mannii* seed flours.

Fig. 2 Effect of pH on foaming capacity of full fat and defatted *Cucumeropsis mannii* seed flours.

Fig. 3 Effect of pH of protein solubility of full fat and defatted *Cucumeropsis mannii* seed flours.

Table 4 Anti-nutritional factors of *Cucumeropsis mannii* seed flour.

Antinutrients	Composition
Tannic acid (mg/100 g)	1.54 ± 0.08
Phytin phosphorus (mg/g)	0.70 ± 0.06
Phytic acid (mg/g)	2.47 ± 0.20
Oxalate (mg/g)	1.85 ± 0.09
Alkaloid (%)	1.97 ± 0.11
Saponin (%)	0.50 ± 0.02
Flavonoid (%)	0.25 ± 0.01
Cyanide (mg/kg)	2.53 ± 0.17

Values with different alphabets on the same row are significant ($P \leq 0.05$).

and mineral elements for use in food formulation. Its functional properties suggest that it has potential for use as functional ingredients in soups and frozen dessert. The low anti-nutritional composition of the seed flour may further enhance its utilization.

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