CHEMICAL, FUNCTIONAL AND SENSORY PROPERTIES OF WATERMELON (*Citrullus lanatus*) SEEDS' FLOUR BLENDS AS SOUP THICKENERS

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ABSTRACT

Background: Ways to alleviate hunger and poverty does not always depend on new varieties but should consider local sourcing of raw materials like watermelon seeds which are discarded after consuming the pulp.

Objectives: The study determined chemical, functional and sensory properties of melon seed flours and their blends.

Materials and methods: Watermelon seeds separated from fruit pulp were cleaned, washed, dried, dehulled mechanically, air dried, milled into flourusing locally fabricated machine and the flour stored in air tight container. Dehulled melon seeds were sorted, sun dried, milled and stored as above. Watermelon (w) and melon (m) flour were formulated into blends of 400 (70%w:30%m), 401 (30%w:70%m), 402 (50%w:50%m), 403 (100%w) and 404 (100%m) for analysis and soup for sensory evaluation by twenty panelists using 9-point hedonic scale.

Results: Carbohydrate (29.85%) of sample (30%m:70%w) was significantly higher than the other samples while protein (29.57%)of (100%m)was significantly higher. Fat(44.71%) of 402 was higher than 43.78%, 42.58%, 36.64% and 36.33% for 400, 404, 403 and 401.Sample 403 had the highest fibre (4.95%). Magnesium (20.11mg/100g), phosphorus (5.69mg/100g), potassium (4.97mg/100g), iron (14.40mg/100mg), zinc (20.74mg/100g), sodium (0.23mg/100g), manganese (21.87mg/100g),niacin (0.82mg/100g), vitamin C (0.37mg/100g) and vitamin E (0.57mg/100g)for 404 were significantly higher; calcium (0.15mg/100g) for 400 and thiamine (0.07mg/100g) of403 were higher. No significant difference (P>0.05) existed in riboflavin for all the samples. Anti-nutrients of the samples were below their lethal dosages except for tannin. Higher oil absorption capacity (4.77g/ml) and water absorption capacity (2.99g/ml) were from sample 400. Least gelation capacity (7.01w/v) of 100%w was significantly higher. Soup from404 was most accepted and 403 moderately liked in all the sensory attributes.

Conclusion: Watermelon seed flour proved an acceptable soup thickener with nutritional and functional properties that can fill food diversity and economic gaps generally.

Keywords: ***Chemical, functional, watermelon, melon, soup thickener***

Introduction

A variety of fruits and vegetables are consumed in Nigeria on daily basis, and they form an integral part of the diet (1). However, most times only the fleshy pulps of these fruits are consumed leaving the seed and the rind (1) whereas the seeds are promising sources of useful compounds because of their favourable technological or nutritional properties (2).

Watermelon (*Citrullus lanatus)*is mainly propagated by seeds and thrives best in warm areas (3). It is a popular fruit and the seeds are rich in oil and protein and this oil could be exploited as edible oil (4).Watermelon seeds are known to be highly nutrient dense as they are rich sources of protein, vitamins B complex, minerals (such as magnesium, potassium, phosphorous, sodium, iron, zinc, manganese and copper) and fat among others as well as phytochemicals (5). The USDA (6) data on the lipid content of dried watermelon seed kernels revealed that watermelon seeds have zero mg cholesterol but have substantial amount of 28.094g of polyunsaturated fatty acids, 9.779g of saturated fatty acids and 7.47g of monounsaturated fatty acids. Although the seed of watermelon is often discarded as waste; it contains various amounts of carbohydrate, phenol, flavonoids, protein, fibre, phosphorus and iron (7).

Melon (*Citrullus Colocynthis*L.) commonly known as the colocynth, bitter apple, bitter cucumber, egusi, or vine of Sodom, also referred to as *Curcurbita citrullus*L., *Colocynthis citrullus* L. or *Citrullus lanatus* Thumb belongs to the cucurbitaceae family(8,9). In Nigeria, the seeds are used to prepare food condiment with characteristic aroma, used as flavouring and thickening agent in stews, soups and sauces (10). Melon seeds have been reported to have therapeutic effects, such as anti-oxidant, anti-inflammatory, and analgesic effects (11, 12).Accordingto FAO (13), high food prices tend to worsen poverty, food insecurity and malnutrition. UNICEF/WHO/World Bank Group (14)reported that globally, approximately 155 million children under 5 years of age suffer stunting and 52 million are wasted globally and in Africa alone, 59 million are stunted and 14 million are wasted and wasting in children is the life-threatening result of hunger and/or disease and these children begin their lives at a marked disadvantage of learning difficulties in school, earn less as adults, and face barriers to participation in their communities.

Watermelon seed which is usually discarded by many after eating the pulp could help to fill the gap in food and nutrition security but much information on its edible properties is lacking. Thus, the introduction of watermelon seed as soup thickener can help to address food insecurity among the developing African countries like Nigeria if found to possess the necessary nutrients. It will further help to reduce the market prices of melon seeds that have gone so high in the last few years as well as other soup thickeners or flours in the food system especially in the preparation of soups, sauces and bakery products and make them more readily available within the reach of the users. Thus, the objective of this study is to evaluate the chemical, functional and sensory properties of flour blends of watermelon (*citrullus lanatus*) and melon (*cucumis colocynthis l.*) seeds as soup thickeners with the melon seed as the control.

MATERIALS AND METHODS

Source of materials: The watermelon (*citrulus lanatus)* fruits and melon seeds used for the study as well as all the ingredients for preparing the sauces (soup) were purchased from Afor-Oru market in Ahiazu Mbaise Local Government Area in Imo State, Nigeria.

Preparation of watermelon and melon flour: The watermelon seeds were manually separated from fruit pulp, cleaned, washed properly with tap water, air dried, shelled mechanically to remove the seed coats. The dehulled seeds were air dried and milled into flour using a locally fabricated milling machine and the flour was stored in air tight container. Also, the dehulled melon seeds were properly sorted to remove extraneous materials and bad seeds. It was then sun dried and milled still using the locally fabricated milling machine. The resultant flour was also stored in an air tight container.

Flour blending: Watermelon seed flour and melon seed flour were blended in different ratios for chemical analysis and sauce preparation for sensory evaluation. The ratios were 70%w:30m (400), 30%w:70%m (401) and 50%w:50%m (402) watermelon: melon respectively; 100% watermelon (403) and 100% melon (404).

Sauce (soup) preparation: The sauces were produced using the caking method of cooking melon soup as described by Kings Cooking Magazine (15). The ingredients for preparing the sauces included 80g blended flour, 400gstockfish, 35g fluted pumpkin vegetable, ground crayfish, 25ml red palm oil, 25g sliced onions, 3.5g dried pepper, 520mlwater and 5gsalt. The stockfish was boiled in 520ml of water until tender and the stock was strained into another pot. The flour blends for the sauce was stirred into the pot containing the stock. The thick consistency obtained was covered and allowed to boil and cook, stirring intermittently to avoid it getting burnt until the paste form a soft cake and tastes cooked (about 25 mins). Red palm oil was added and the sauce allowed to cook for another 7 minutes. The cooked fish, vegetable, pepper, crayfish and salt were then added and the sauce was allowed to simmer in low heat for another 2 minutes, left to cool and served for sensory evaluation. This was repeated for all the flour blends.

Chemical composition: The proximate, mineral and vitamin contents of the flour samples were carried out in duplicates using standard methods. Moisture by gravimetric method; ash by furnace incineration gravimetric method; protein by micro-Kjedahl method (N×6.25);fat by Soxhlet extraction and crude fibre were all determined using the standard methods described (16).Carbohydrate content of all the samples was calculated by difference i.e.
% carbohydrate = 100 - % (protein + fat + ash + fibre + moisture). Energy (kcal) was calculated using the At water factors of 4 × carbohydrate + 4 × protein and 9 × fat. Minerals (potassium and sodium by flame photometry; calcium, phosphorus and magnesium by colorimetric methods; zinc, iron and manganese by atomic absorption spectrophotometric method) all by AOAC (16) as described by Onwuka (17). Riboflavin, thiamin and niacin were determined by spectrophotometry and vitamin C and E as described by AOAC (16). Tannin content was determined using the Folin-Denis spectrophotometric method as described by Pearson (18). Alkaloid, flavonoid, phytate and saponin contents were determined using the methods described by Harborne (19).The phenol content was determined using the Folin-Ciocatean spectrophotometric method (16).Functional properties (bulk density and water absorption capacity) were determined using the procedure described by Otutu *et al.* (20).
Sensory evaluations of taste, flavor, colour, mouth feel and general acceptability were carried out using twenty panelists (20)randomly selected from lovers of melon soup.A9-point Hedonic scale with 9 as liked extremely and 1 as disliked extremely was used.

Statistical analysis: Analysis of variance for all the data was done using IBM SPSS Statistics for windows (Version 23), while means were separated using Duncan multiple range test at 95% confidence level.

RESULTS

Table 1 shows the proximate compositions and energy per 100g edible portions of the different flour blends. There were significant differences ($p < 0.05$) among the flour blends in the dry matter, crude protein and fibre, ether extract and carbohydrate contents. The ash content of sample 403 (100%w) was 3.98 ± 0.01 and significantly higher ($p < 0.05$) than the others while sample 404 (100%m) had the lowest ash value (3.69 ± 0.00).The crude protein of sample 404 (100%m) was the highest (28.57 ± 0.01), followed by sample 400 (70w:30m)of 24.57%. Sample 403 (100%w) had the least (19.33 ± 0.01). Sample403 (100%w) had the highest moisture content (5.86 ± 0.01) which differed from the least (4.59 ± 0.01) for sample 402 (50w:50m); that of sample 404 (100%m) was 5.32 ± 0.01, while sample 400 (70%w:30%m) and 401 (30%w:70%m) was not significantly different ($P < 0.05$). There was significant difference ($P<0.05$) among all the samples in fat content with sample 402 (50w:50m) having (44.71 ± 0.01) followed by sample 400 (70%w:30%m) with (43.78 ± 0.01) while sample 401 (30%w:70%m) had the lowest.*Sample404 (100%m) had a higher dry matter content (*94.68 ± 0.01)*and sample 403 (100%w) had the least value (94.14* ± 0.01).The crude fibre content of the blends varied from 4.94 ± 0.01to 3.53 ± 0.01. The value for (100%w) was significantly higher (p <0.05) than that of (100%m).The carbohydrate compositions for all the samples were significantly different from one another at (p <0.05) with ample 30%w:70%m having the highest (29.85%) followed by sample 403 (29.25%) and sample 404 having the least (14.31%).

Table 1: Proximate composition (%) and energy value (kcal) of the flour samples

Sample	Dry matter (%)	Moisture (%)	Crude protein (%)	Crude fibre (%)	Fat (%)	Ash (%)	Carbohydrate (%)	Energy value Kcal
400	94.84^{b} ± 0.01	5.16^{c} ± 0.01	24.57^{b} ± 0.01	3.83^{cd} ± 0.01	43.78^{b} ± 0.01	3.71^{c} ± 0.014	18.95^{c} ± 0.01	568.10^{b} ± 0.13
401	94.78^{b} ± 0.11	5.29^{b} ± 0.01	20.65^{d} ± 0.03	3.97^{c} ± 0.01	36.33^{e} ± 0.01	3.92^{b} ± 0.21	29.85^{a} ± 0.01	528.95^{d} ± 0.27
402	95.41^{a} ± 0.01	4.59^{d} ± 0.01	24.45^{c} ± 0.01	4.37^{b} ± 0.01	44.71^{a} ± 0.01	3.95^{ab} ± 0.01	17.93^{d} ± 0.01	571.91^{a} ± 0.13
403	94.14^{d} ± 0.01	5.86^{a} ± 0.01	19.33^{e} ± 0.01	4.94^{a} ± 0.01	36.64^{d} ± 0.01	3.98^{a} ± 0.01	29.25^{b} ± 0.01	524.08^{e} ± 0.13
404	94.8^{c} ±0.01	5.32^{b} ± 0.01	28.57^{a} ± 0.01	3.53^{d} ± 0.01	42.58^{c} ± 0.01	3.69^{c} ± 0.00	16.31^{e} ± 0.28	562.7^{c} ± 0.95

Values are means ± standard deviation of duplicate samples

$^{a-e}$Means with similar superscripts in the same column are not significantly different (P>0.05).

Key:w = watermelon seedflour;m = melon seed flour

Sample 400 = 70% watermelon seed flour:30% melon seed flour
Sample 401 = 30% watermelon seed flour:70% melon seed flour
Sample 402 = 50% watermelon seed flour:50% melon seed flour
Sample 403 = 100% watermelon seed flour: Sample 404 = 100% melon seed flour

The mineral compositions of the sample are shown in Table 2. Manganese for all the samples ranged from 9.40% to 21.87%with sample 404 (21.87%) being significantly higher (p <0.05) than others and sample 402 having the least value (9.40%).Zinc was highest (20.74± 0.01) for sample404 and least (8.94± 0.01) for sample 403 with all the values significantly different from each other. Magnesium content ranged from 20.11 ± 0.01 for sample 404 to 8.35 ± 0.01 in sample 403.Sample 404 (100%m) had the highest iron content of 14.40 ± 0.01 which differed significantly (p < 0.05) from the other samples. The highest calcium content (0.15 ± 0.01) was in sample400 (70%w, 30%m). There was significant difference (p <0.05) among all the samples for phosphorus, however, sample 404 (100%m) had the highest value (5.69 ± 0.01)and 403 (100%w) had the least (2.77 ± 0.01).Similarly, potassium was highest for sample 404 (4.97 ± 0.01) and least for sample 403 (2.02 ± 0.00). There was no significant difference (p <0.05) in sodium values for the other samples which differed from sample 403 (0.12 ± 0.01) which had the least value.

Table 2: Mineral composition of the flour samples

Sample	Ca (mg/100g)	Mg (mg/100g)	Phosphorus(mg/100g)	K (mg/100g)	Fe (mg/100g)	Zn (mg/100g)	Na (mg/100g)	Mn (mg/100g)
400	0.15^{a} ± 0.01	16.87^{b} ± 0.00	4.99^{b} ± 0.01	4.20^{b} ± 0.01	9.85^{d} ± 0.01	16.95^{b} ± 0.03	0.22^{a} ± 0.03	18.25^{b} ± 0.01
401	0.11^{bc} ± 0.01	12.55^{d} ± 0.01	3.87^{d} ± 0.01	3.31^{d} ± 0.01	12.90^{b} ± 0.01	12.91^{d} ± 0.01	0.19^{a} ± 0.01	13.95^{c} ± 0.01
402	0.14^{ab} ± 0.01	14.74^{c} ± 0.03	4.62^{c} ± 0.01	3.94^{c} ± 0.01	11.15^{c} ± 0.01	15.45^{c} ± 0.03	0.21^{a} ± 0.01	9.40^{e} ± 0.01
403	0.08^{c} ± 0.01	8.35^{e} ± 0.01	2.77^{e} ± 0.01	2.02^{e} ± 0.00	7.90^{e} ± 0.01	8.94^{e} ± 0.01	0.12^{b} ± 0.01	10.02^{d} ± 0.01
404	0.13^{ab} ± 0.01	20.11^{a} ± 0.01	5.69^{a} ± 0.01	4.97^{a} ± 0.01	14.40^{a} ± 0.01	20.74^{a} ± 0.01	0.23^{a} ± 0.01	21.87^{a} ± 0.01

Values are means ± standard deviation of duplicate samples

$^{a\text{-}e}$Means with similar superscripts in the same column are not significantly different (P>0.05).

Key: Sample 400 = 70% watermelon seed flour:30% melon seed flour
Sample 401 = 30% watermelon seed flour:70% melon seed flour
Sample 402 = 50% watermelon seed flour:50% melon seed flour
Sample 403 = 100% watermelon seed flour: Sample 404 = 100% melon seed flour.

Table 3 shows the vitamin compositions of the samples. Sample 404 (100%m) was (0.82mg/100g) for niacin which was significantly higher (p <0.05) than the other samples. However, samples 400 and 401 were not significantly different (p > 0.05). Vitamin E ranged from 0.57mg/100gin sample 404 to 0.33 mg/100gin sample 401.Sample 404 (100%m)had 0.37mg/100gof vitamin C which was significantly higher than the other samples. There were no significant difference (p >0.05)in vitamin C for samples 401, 402 and 403.The samples had riboflavin content ranging from 0.02mg/100g (403) to 0.08mg/100g(400) with no significant difference (P>0.05) among all the samples. The thiamin content ranged from 0.03mg/100g in sample 404 (100%m) to 0.07mg/100g in sample 403 (100%w).

Table 4: Phytochemical composition of the flour samples

Sample	Phytate (%)	Phenol (mg/100g)	Saponin (mg/100g)	Tannin (mg/100g)	Alkaloid (%)	Flavonoid(mg/100g)
400	0.16^{ab} ± 0.1	0.39^{ab} ± 0.1	0.19^{a} ± 0.1	37.98^{b}± 0.1	27.77^{b} ± 0.0	0.17^{b} ± 0.0
401	0.19^{a} ± 0.1	0.32^{bc} ± 0.6	0.13^{b} ± 0.1	30.33^{d}± 0.1	26.06^{c} ± 0.1	0.09^{d} ± 0.1
402	0.14^{c}± 0.02	0.34^{ab} ± 0.1	0.10^{c} ± 0.1	34.11^{c} ± 0.1	25.45^{d} ± 0.3	0.14^{c} ± 0.1
403	0.15^{ab} ± 0.1	0.24^{c} ± 0.1	0.14^{b} ± 0.1	28.68^{e} ± 0.1	24.62^{e} ± 0.3	0.04^{e} ± 0.1
404	0.15^{ab} ± 0.1	0.41^{a} ± 0.1	0.05^{d} ± 0.1	39.42^{a} ± 0.1	29.09^{a} ± 0.1	0.23^{a} ± 0.1

Values are means ± standard deviation of duplicate samples

$^{a\text{-}c}$ Means with similar superscripts in the same column are not significantly different (P>0.05).

Key: Sample 400 = 70% watermelon seed flour:30% melon seed flour
Sample 401 = 30% watermelon seed flour:70% melon seed flour
Sample 402 = 50% watermelon seed flour:50% melon seed flour
Sample 403 = 100% watermelon seed flour; Sample 404 = 100% melon seed flour

Table 5 shows the functional properties of the samplesshowing sample400 (70%w:30%m) with the highest oil absorption capacity (4.77g/ml),403 (4.26g/ml) and 404 (4.16g/ml). The water absorption capacity (2.13 g/ml) for sample 403 (100%w) was significantly (p <0.05) lower than (2.62 g/ml) for sample404 (100%m).In least gelation capacity (LGC), the values ranged from 6.00 ± 0.00 for sample404 to 7.01 ± 0.01 for 403. There was no significant difference between the LGC for samples 404 (100%w) and 401 (30%w: 70%m).

Table 5: Functional properties of the flour samples

Sample	Oil absorption capacity (g/ml)	Water absorption capacity (g/ml)	Least gelation capacity (w/v)
400	4.77^{a} ± 0.01	2.99^{a} ± 0.01	6.77^{b} ± 0.02
401	4.31^{c} ± 0.01	2.59^{c} ± 0.00	6.99^{a} ± 0.01
402	4.58^{b} ± 0.01	2.72^{b}± 0.02	6.53^{c} ± 0.01
403	4.26^{d} ± 0.01	2.13^{d}± 0.01	7.01^{a} ± 0.01
404	4.16^{e} ± 0.01	2.62^{c} ± 0.03	6.00^{d} ± 0.00

Values are means ± standard deviation of duplicate samples
$^{a-c}$Means with similar superscripts in the same column are not significantly different (P>0.05).
Key:Sample 400 = 70% watermelon seed flour:30% melon seed flour
Sample 401 = 30% watermelon seed flour:70% melon seed flour
Sample 402 = 50% watermelon seed flour:50% melon seed flour
Sample 403 = 100% watermelon seed flour; Sample 404 = 100% melon seed flour

Table 5 shows the functional properties of the samples showing sample 400 (70%w:30%m) with the highest oil absorption capacity (4.77g/ml),403 (4.26g/ml) and 404 (4.16g/ml). The water absorption capacity (2.13 g/ml) for sample 403 (100%w) was significantly (p <0.05) lower than (2.62 g/ml) for sample 404 (100%m). In least gelation capacity (LGC), the values ranged from 6.00 ± 0.00 for sample404 to 7.01 ± 0.01 for 403. There was no significant difference between the LGC for samples 404 (100%w) and 401 (30%w: 70%m).

Table 5: Functional properties of the flour samples

Sample	Oil absorption capacity (g/ml)	Water absorption capacity (g/ml)	Least gelation capacity (w/v)
400	4.77^{a} ± 0.01	2.99^{a} ± 0.01	6.77^{b} ± 0.02
401	4.31^{c} ± 0.01	2.59^{c} ± 0.00	6.99^{a} ± 0.01
402	4.58^{b} ± 0.01	2.72^{b}± 0.02	6.53^{c} ± 0.01
403	4.26^{d} ± 0.01	2.13^{d}± 0.01	7.01^{a} ± 0.01
404	4.16^{e} ± 0.01	2.62^{c} ± 0.03	6.00^{d} ± 0.00

Values are means ± standard deviation of duplicate samples
$^{a-c}$Means with similar superscripts in the same column are not significantly different (P>0.05).
Key:Sample 400 = 70% watermelon seed flour:30% melon seed flour
Sample 401 = 30% watermelon seed flour:70% melon seed flour
Sample 402 = 50% watermelon seed flour:50% melon seed flour
Sample 403 = 100% watermelon seed flour; Sample 404 = 100% melon seed flour

The result for the sensory evaluation of the soup samples shown on Table 6 revealed no significant difference in the taste for sample 400 (70%w:30%m) (7.25 ± 1.41) and 402 (50%w:50%m) (7.55 ± 1.10).There was no significant difference ($p > 0.05$)in appearance forsamples402 (50%w:50%m), 401 (30%w:70%m) and 403 (100%w),however, sample 404 (100%m) was significantly higher ($P<0.05$) than the other soup samples. Nevertheless,sample 403 (100%w) was moderately liked (7.20 ± 1.11).In mouth feel, sample 404 was liked very much (8.40 ± 0.10) while 403was liked moderately (7.15 ± 1.31). There was significant different ($p < 0.05$)in texture for almost all the samples with 403 scoring 6.550± 1.79 and 404 (8.300 ± 0.92). In general acceptability, sample 404 (100%m) had the highest value (8.15 ± 1.42).

Table 6: Sensory evaluation (%) of soup samples

Sample	Taste	Appearance	Mouth feel	Texture	General acceptability
400	7.25^{bc} ± 1.41	6.90^{b} ± 1.41	7.50^{b}± 1.43	7.30^{b} ± 1.4	7.24^{bc} ± 1.17
401	8.00^{ab} ± 1.70	7.55^{ab}± 1.19	7.80^{ab}± 1.15	7.65^{ab} ± 1.23	7.75^{ab}± 0.94
402	7.55^{bc} ± 1.10	7.65^{ab} ± 14	7.65^{ab} ± 1.23	7.50^{ab} ± 1.36	7.59^{bc} ± 1.11
403	7.00^{c}± 1.30	7.20^{ab} ± 1.11	7.15^{b}± 1.31	6.55^{c}± 1.79	6.98^{c} ± 0.98
404	8.60^{a}± 0.60	8.10^{a} ± 1.83	8.40^{a} ± 0.10	8.30^{a} ± 0.92	8.35^{a} ± 0.90

Values are means ± standard deviation of soup samples used for the sensory evaluation

$^{a-c}$ Means with similar superscripts in the same column are not significantly different ($P>0.05$).

Key:
w = watermelon kernel flour; m = melon kernel flour
Sample 400 = 70% watermelon seed flour:30% melon seed flour
Sample 401 = 30% watermelon seed flour:70% melon seed flour
Sample 402 = 50% watermelon seed flour:50% melon seed flour
Sample 403 = 100% watermelon seed flour
Sample 404 = 100% melon seed flour

DISCUSSIONS

The proximate compositions of 100% watermelon seed and melon seed flours in this study varied from the values previously reported (21, 22, 23).These variations could be attributed to differences in climatic conditions, average rainfall, freshness, storage, harvesting time of the seeds, varietal and regional/soil differences of the plants as well as differences in the formulation of products with watermelonseed flour (3, 21, 22, 23, 24).

The ash content of sample 100%watermelon seed flour was significantly higher ($P<0.05$) than the others with 100% melon seed flour having the lowest value. These values where higher when compared to the range (2.00 to 3.0%) reported for three different varieties of water melon by Betty *et al.* (3) and the study by Tak and Jain (22). The ash value in 100% watermelon seed flour in this study however agrees with that of the study by Ibeanu*et al.* (21). In another study where watermelon seed flour was substituted with wheat flour, the product with the highest ratio of watermelon seed flour had the highest ash value (23).High mineral element in foods enhances growth and development, and also catalyzes metabolic processes in human body (25).

The crude protein of sample 404 (100%m) was the highest, followed by sample 400 (70w:30m)while 403 (100%w) had the least. Crude protein (19.33 ± 0.01) for 100% watermelon seed flour in this study was higher than the protein values for *Afzeliaafricana/African oak tree (*13.29%), *Brachystegianigerica/African mahogany/achi (*14.45%), *Mucunasloanei/Velvet beans (*12.52%) and *Detariummicrocarpum(*12.19%) used as soup thickeners (24). Furthermore, this result for crude protein of watermelon seed flour was higher compared to 10.40%, 10.38% and 16.52% from dika nut kernel, *Pachiraglabra* and *Afzeliaafricana* seed flours respectively (26, 27). However, the value (19.33%) was found to be lower than 28.33% found in USDA database (6) for watermelon seed kernel; 25.33% watermelon seed flour reported by Akusuand Kiin-Kabar (28) and other studies on watermelon seed flour (21, 22). The protein values in the samples give watermelon seeds positive attributes as plant proteins which can furnish the essential amino acid needed for healthy growth and repair of tissues(24). The moisture content for watermelon (100%w) seed flour and melon (100%m) seed flour in this study were lower than 9.13 ± 0.02 and 9.49 ± 0.01 reported for *Pachiraglabra* (*Bombacaceae*/Guinea peanut/French peanut/Lucky tree) and *Afzeliaafricana* (Caesalpiniaceae) seed flours respectively (26). Nevertheless, the moisture values for 100%w and 100%m are comparable tothat reported for dika nut (ogbono) powder (27). However, low moisture in the study samples could predict better storage and keeping quality.

Fat for the study samples were higher than values obtained for some oil seeds (*Afzelia africana/African oak tree, 18.50±2.02*, *Brachystegia nigerica/African mahogany/achi*7.91±2.10, *Mucuna sloanei/Velvet beans* 6.25±2.02 and *Detariummicrocarpum*7.41±2.61) (29).They were also higher than those reported for guava seeds, tamarind seeds, watermelon seeds, orange seeds, papaya seed and date seeds respectively (29). This indicates that watermelon seed flour could provide better potentials than some oil seeds in emulsifying properties. *Melon (100%m) seed flour had higher dry matter; however, watermelon (100%w) seed flour had the lowest dry matter but was higher than* 92.90 ± 0.40 *reported earlier for Citrullus lanatus (25).* The crude fibre value from this study was significantly higher than 3.8 ± 0.1 and 3.9 ± 0.1 obtained by Oyeleke *et al*. (30) and Otutu*et al*. (20) respectively for watermelon seed but was similar to 4.61% found in mung bean (31). The crude fibre value for watermelon further revealed that watermelon seeds which are often discarded as waste could usefully serve as good source of dietary fibre in the diets of households. Carbohydrate (29.25%) for watermelon in this study was significantly higher than 17.31 ± 0.40 reported for dika nut (ogbono) powder (27) but was lower than the values reported for *Afzelia africana*, *Brachystegia nigerica*, *Mucuna sloanei* and *Detarium microcarpum which were 53.66±0.80, 65.97±0.70, 70.71±0.90 and 70.38±0.6 respectively (26). In the same vein, the carbohydrate value of sample 100%w was slightly lower than that reported on dehulled watermelon seed (21). The carbohydrate value of watermelon seed flour and melon seed flour would be useful for people that need low carbohydrate foods thereby leading to enhanced health for overweight and obese people.*

Manganese content of sample 404 (100%m) was significantly higher ($P<0.05$) than the others. Zinc and magnesium content of the samples were similar to the observation made for *Citrullus lanatus*(25). Zinc is essential in the metabolism of carbohydrates, lipids, proteins, and nucleic acids as well as other micronutrients and stabilizes the molecular structure of cellular components and membranes thus contributing in this way to the maintenance of cell and organ integrity (32). Thus, the zinc in watermelon seed flour when supplemented with other soup ingredients can serve effectively as a good source of zinc. Magnesium has been reported to be important in regulating potassium fluxes and it is involved in calcium metabolism in bones and prevention of circulatory diseases as well as helps in regulating blood pressure and insulin release (3, 32). The magnesium value of watermelon (100%w) seed flour in this study is comparatively higher than 0.15±0.01, 0.14±0.02 and 0.17±0.02 reported for the three varieties (charleston gray, crimson sweet and black diamond) of watermelon(3). Although the magnesium content of 100%w and 100%msamples were low, dietary deficiency of magnesium of a severity sufficient to provoke pathologic changes is rare (32). Magnesium is widely distributed in plant and animal foods. Therefore, the presence of most of these food components in soup will help supplement the magnesium content of the soup prepared with *Citrullus lanatus* seed flour as the soup thickener. The iron values of the blends between 7.90 ± 0.01 to 14.40 ± 0.01 were higher than 2.40 ± 0.10 to 8.09 ± 0.20 reported for dika nut kernel powder and other four different formulations made from dika nut powder, crayfish, stock fish, Ugwu (mix of locust bean, onion, seasoning, and Cameroon powder) (27). Therefore, the iron content of the blends when compared to other soup thickeners could contribute to the iron needs of consumers and could be recommended as additional source of iron in populations with high prevalence of anaemia. The calcium value obtained in this study for sample 403 (100%w) was significantly lower compared to 0.16±0.02, 0.11±0.01 and 0.14±0.03 obtained for seeds of three varieties of watermelon(3). This variance could be as a result of varietal difference which was not considered in this study. Phosphorus, a principal mineral for bones and teeth, part of every cell and maintains acid-base balance (9), was higher in samples (100%m) and (100%w)than 0.17±0.00 - 0.22±0.03 reported for some varieties of water melon and 0.26 ± 0.22 for dika nut powder (3, 27). However, the low phosphorus value in the study samples is not far linked to the fact that plant food sources are usually low in phosphorus (25). There were no significant differences ($P>0.05$) among all the samples for sodium except for 100%w.The values for sodium in this study are lower than that of bambara nuts (0.05mg/100 g), Jack beans (0.07 mg/100g), pigeon peas (0.05 mg/100g) (3). The potassium content in the different blends is equally low. Therefore, as opined by Jacob *et al.* (25), the low sodium and potassium contents of *Citrullus lanatus* make it necessary for this seed flour to be considered useful especially in sodium and potassium restricted diets and available evidence supports an association between sodium intake and adverse outcomes in renal disorders (25, 33, 34).

Niacin for sample 403 (100%w) was significantly lower than 1.33mg/100g reported for *Citrullus lanatus* seed (35).However, it was comparatively higher than 0.01 mg/100g, 0.36mg/100g and 0.19mg/100g reported for dika nut kernel, *Brachystegia eurycoma* and *Mucuna flagellipes* respectively which are all soup thickeners (27, 36). The vitamin E content of the blends are low but it can complement the vitamin E which can be gotten from other soup ingredients. However, Omoboyowa *et al*. (35) reported a value of 20.62mg/100g for watermelon seed for vitamin E. This high disparity may be due to variances in the processing methods used or difference of varieties of watermelon seed used. No significant difference existed in most of the blends for vitamin C content of the blends were comparatively lower than 10.12mg/100g and 4.84mg/100g reported for *Brachystegia eurycoma* and *Mucuna flagellipes* respectively (36). This means that watermelon seed flour can complement the soup thickener (*Brachystegiaeurycoma*) when used in soup. There was no significant difference ($P>0.05$) in the riboflavin content of all the samples and that for100%w was lower than 0.12mg/100g reported for dried watermelon seed (1). Thiamin was highest in 100%w and lowest in 100%m. Tannin was similar to the observation earlier made for melon seed flour(25). However, the tannin content of the study samples were all higher than the safe level (0.15 - 0.20 mg) for tannin as reported by Ukam *et al*. (37). This indicates that processing methods that can reduce the tannin content of these seeds should be used to reduce its intake whenever these seed flours are used as in meal preparation. The alkaloid content reported in this study was higher than the alkaloid values 25.80 ± 0.51, 14.60 ± 0.16 and 12.22 ± 0.10 reported for seed shell pericarp, fruit pulp and fruit skin of *Chrysophyllum albidum* fruit (also known as African star apple) respectively (38) and that reported for dehulled watermelon seed (39). The values obtained in this study are less than the lethal dose (20mg/100g) reported for alkaloid (40). Betty *et al*. (3) noted that phenol has the ability to scavenge free radicals and neutralize their effects thereby preventing diseases like cancer and cardiovascular diseases. The values of phenol in all the study samples were lower than the lethal dose (3-30g) for phenol (41). The flavonoid content of the samples ranged from 0.04 to 0.23mg/100g with sample 404 (100%m) being significantly higher ($p < 0.05$) than the other samples. The flavonoid content of the samples studied were lower than those reported from other studies on watermelon seed (1, 39, 42). Hurrel *et al*. (43) reported that phytic acid intake of 4-9mg/100g can decrease iron absorption by 4-5 folds in humans. However, phytate levels of all the samples in this study were low and within the acceptable level of 5.00 mg/100g as reported (37). Saponin values in the samples were lower than the values of 1.01 to 3.08 reported by Johnson *et al*. (1, 39, 42). Sample 400 had the highest oil absorption capacity and 100%w was also higher than 100%m an indication that watermelon seed flour would require lesser quantity of oil when used as soup flour. This oil absorption capacity for watermelon (100%w) was similar to 4.25 g/g reported by Akusu and Kiin-Kabari (31) for boiled/oven dried watermelon seed flour. The water absorption capacity (WAC) result from this study were similar those reported for wheat, sweet potato and hamburger bean seed flour blends(44). The 100%wsample had the highest least gelation capacity (LGC) value which could predict the food value of watermelon seed flour if incorporated in food systems in soup preparation as a thickener. All the same, the functional properties in the study samples were lower than those reported by Tak and Jain (22) which could be due to varietal differences.

The sensory properties showed that sample 404 (100%m) had the highest mean score indicating 'liked very much' and 100%w 'liked moderately' for all the parameters showing that the 100%m had better acceptability in terms of taste, appearance, mouth feel, texture and general acceptability while the 100%w soup sample was higher than 70%w:30%m soup sample in terms of appearance. This agrees with the opinion of Adamu*et al*. (45) that consumers are inclined to choose more of products they are familiar with. However, sample 403 (100%w) was significantly lower than others in terms of taste, mouth feel, texture and general acceptability. These higher scores in melon seed flour over watermelon seed flours has been reported(28). However, the scores for watermelon has shown the possibility of using the seed flour as an acceptable soup thickener which can be recommended because of its availability, affordable, nutritional benefits and in dietary diversification in the bid to overcome food and nutrition insecurity.

Conclusion: This study has demonstrated that watermelon seed flour has some potentials for acceptability in soup making because of its proximate, mineral, vitamin, phytochemical, functional and sensory properties. It was found to be low in sodium and potassium and thus could be recommended to be included in the preparation of sodium and potassium restricted diets. The use of this seed flour in soup preparation and food system would also increase its importance in the food chain concerning production, consumption, utilization, economic power of local farmers. Reducing the wastage of watermelon seeds along with their decomposed fleshy pulp and harnessing the use could contribute to the food diversity projects of the developing countries in the fight against food and nutrition insecurity.

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