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Determination of Proximate, Phytochemical and Nutritive Composition of Bitter Gourd (*Memordica charantia*) Seed Flour

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ABSTRACT: This study investigated the proximate, phytochemical and nutritive composition of Bitter gourd (*Memordica charantia*) seed flour using appropriate standard techniques. The proximate composition in (%) were; moisture 8.50 ± 0.15, ash 2.90 ± 0.01, crude protein 14.30 ± 0.50, crude fibre 2.44 ± 0.01, crude fat 20.57 ± 0.10 and carbohydrate 51.29 ± 0.10. The mineral composition (mg/100g) of seed flour revealed that Iron (371.50 ± 0.00) was the most abundant miner, followed by magnesium (205.10 ± 0.50), phosphorous (17.10 ± 0.05), sodium (11.42 ± 0.50), calcium (8.90 ± 0.15), while potassium (5.27 ± 0.05) was the least. The phytochemical contents of the seed flour were; Alkaloids (14.41 ± 0.05 mg/100g), Flavonoid (12.09 ± 0.10 mg/100g), Tannin (6.20 ± 0.50 mg/100g), saponin (3.42 ± 0.01 mg/100g) and Cyanide 2.10 ± 0.01 mg/100g). However, the low cyanide content indicated that the seed flour would be save for consumption. The results of functional properties in (%) were; Bulk Density 0.0451, Swelling capacity 103.87, least gelatinous capacity 1.75, Water absorption capacity 241.40, Oil absorption capacity 297.40 and Solubility was in the range of 2.93 to 10.75. The high swelling, water absorption, oil absorption capacity, least gelation and Solubility reported in this study suggested that the seed flour contained high amount of carbohydrate, protein, and oil which made it suitable for domestic consumption and weaning food formation. The results obtained in this study showed that the bitter gourd seed flour contained an appreciable amount of essential nutrients and phytochemicals and could be incorporated into existing foods, to solve the problems of malnutrition and micronutrients deficiency.

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Vegetables play an important role in human dietary routine as they serve as sources of vitamins, minerals, dietary fibre and other phytonutrients. These compounds are associated with other reduced incidence of cancer, cardiovascular diseases and other chronic diseases due its consumption which have been discovered to possess great nutritional and medicinal value. Bitter gourd (*Memordica charantia*), is one of the beneficial vegetables (Behera *et al*., 2010). *M. charantia* is a member of the *Cucurbitacae* family, widely grown in Asia, South America, India, Carribean, East Africa, Middle East and America (Cetalu *et al*., 2008; Cousense *et al*., 2008). Bitter gourd is an annual fruity vegetable and referred to as bitter melon (Saktar *et al*., 2013). It is a popular plant used for the treatment of aliments like diabetes related conditions amongst the indigenous populations of Asia and West Africa. The fruit has a distinguishing bitter taste, which is more pronounced as it ripens. It is widely referred to as "Ejinrin" by Yorubas in Southwestern Nigeria, "Kakayi" in Southeast and "Garaafunji" in the Northern part of Nigeria by Hausas (Egbon *et al.*, 2015).

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The excellent nutritive and therapeutic value of this fruit offers great potential for processing of quality product (Deepa 2015). The fruits of bitter gourd are very much consumed as fresh and dried vegetable for curries, bakery products, pickled or stuffed products of meat. It is also used for the preparation of several dishes. It can be fried, deep fried, boiled, pickled, juiced, and oven dried for tea preparation (Myojin *et al* 2018). Bitter melon is rich in iron and has twice the beta-carotene of broccoli, calcium of spinach, the potassium of bananas and contains vitamin B_1 to B_3, C and good dietary fibre. It is believed to contain Insulin. Bitter gourd leaf, paste or hot water extracts could be used to treat ringworm, bowel movement, cough, congestion and chest pain. Moreover, the seed could produce spontaneously vomiting and also used to reduce fat (Abdullah and Kamarudin, 2013). Hence, the objective of this study is to evaluate the proximate, phytochemicals and nutritive composition of Bitter Gourd (Memordica charantia) seed flour.

MATERIALS AND METHOD

Sample collection: The bitter gourd seeds were obtained from Oluode market in Olorunda Local Government Area of Osun State, Nigeria. The seeds were sundried, ground into fine powder using local blending machine and stored in an air-tight container prior to analysis.

Determination of moisture content: 5.0 g of Bitter gourd (*M. charantia*) seed flour was weighed into a clean, dried evaporating dish and weighed. This was transferred into an oven set at 105°C for 3 hours. The oven-dried sample was removed and cooled in a desiccator. This was done in triplicates until a constant weight was obtained.

$$\%M = \frac{w_2 - w_3}{w_2 - w_1} x100 \qquad (1)$$

Where; W_1 =weight of empty evaporating dish; $W_{2=}$ weight of sample + evaporating dish; $W_{3\,=}$ weight of sample + evaporating dish after drying at 105°C; %M = percentage moisture content

Ash content: 2g of Bitter gourd (*M. charantia*) seed flour was weighed into a clean dried crucible and transferred into a furnace set at 550 °C for 6 hours. The ashed sample was removed and allowed to cool in desiccator and weighed. This was done in triplicates.

$$\%Ash = \frac{w_2 - w_3}{w_2 - w_1} x100$$

Where; W_1 =weight of empty crucible; $W_{2=}$ weight of sample + crucible; $W_{3\,=}$ weight of sample + crucible after ashing at 550°C

Determination of Crude fat content: 5 g of the seed flour was weighed and carefully placed inside a fat free thimble covered with cotton wool to avoid the loss of sample. The content in the thimble was put in the Soxhlet extractor. 200 ml of petroleum ether were poured into a weighed fat free Soxhlet flask attached to the extractor. The flask was placed on a heating mantle for refluxing. Cooling was achieved by a running tap connected to the extractor for at least 6hrs after which the solvent was completely siphoned into the flask. Rotary vacuum evaporator was used to evaporate the solvent leaving behind the extracted lipids in the soxhlet. The flask was removed from the evaporator and dried to a constant weight in the oven at 60°C. The flask was then cooled in a desiccator and weighed. This was done in triplicates. The amount of fat extracted was calculated by difference.

$$EEDM\,(100g) = \frac{WEL}{WSD} X100 \qquad (2)$$

Where: EEDM = Ether extract dry matter; WEL = Weight of extracted lipids; WDS = Weight of dry sample

Protein determination: 5 g of the samples were weighed into a filter paper and put into a Kjeldahl flask, 10 tablets of Na_2SO_4 were added with 1 g of $CuSO_4$ respectively. 20 mL of conc.H_2SO_4 was added and digested in a fume cupboard until the solution becomes colourless. It was cooled overnight and transferred into a 500 mL flat bottom flask with 200 mL of water. This was cooled with the aid of packs of ice block. About 60 to 70 mL of 40% NaOH were poured into the conical flask which was used as the receiver with 50 mL of 4% boric acid using 3 days of screened methyl red indicator. The ammonia gas was then distilled into the receiver until the whole gas evaporates. Titration was done in the receiver with 0.01M HCl until the solution turns colourless. The percentage protein is calculated as follows:

$$V_s = \frac{V_b x0.01401xN(6.25)x100}{W} \qquad (3)$$

Where: Vs = Vol (ml) of acid required to titrate sample V_b = Vol (ml) of acid required to titrate blank, N = normality of acid; W = Original weight of the sample

Crude fiber determination: 5 g of the different samples were defatted with diethyl ether for 8 hours and boiled under reflux for exactly 30 mins with 200 mL of 1.25% H_2SO_4. It was then filtered through cheese cloth on a flutter funnel. This was later washed with boiling water to completely remove the acid. The residue was boiled in a round bottomed flask with 200 mL of 1.25% sodium hydroxide (NaOH) for another 30 min and filtered into previously weighed couch crucible. The crucible was

dried with samples in an oven at 100°C, cooled in a desiccator and weighed. This was later incinerated in a muffle furnace at 550°C for 3 hours and finally allowed to cool in desiccator and weighed.

$$WF = (w_2 - w_3) \qquad (4)$$

Where: WF = Weight of fibre

$$\%F = \frac{w_2 - w_3}{w_2 - w_1} x100 \qquad (5)$$

Where: %F = percentage of fibre

Carbohydrate determination

$$\%C = 100 - (P + M + A + CF + F\%). \quad (6)$$

Where: %C = Percentage carbohydrate; %P = Percentage protein; %M = Percentage moisture; %A = percentage Ash; %CF = percentage crude fibre; % F = percentage fat

Mineral analyses: The mineral contents were analyzed from the solution obtained by dissolving the dried ashed sample in 10 % (v/v) HCl, filtered and made up to the mark in a 100ml volumetric flask using de-ionized water. Sodium and potassium were determined by flame photometry while calcium, magnesium and iron were determined by Atomic absorption spectrophotometer (AOAC 2005).

Total flavonoid determination: Total flavonoid content was determined by Aluminum chloride colorimetric assay. 1 ml of extracts or standard solution of Quarcetin (500 µg/ml) was added to 10 ml volumetric flask containing 4 ml of distilled water. 0.3 ml of 5% $NaNO_2$ was added to the above mixture after 5 minutes. This was followed by addition of 0.3 ml of 10% $AlCl_3$ and 2 ml of 1 M NaOH after 5 and 6 mins before making the total volume up to 10 ml with distilled water. The solution was thoroughly mixed and the absorbance measured against prepared reagent blank at 510 nm. Total flavonoid content of the seed flour was expressed as percentage of Quarcetin equivalent per 100 g of fresh mass.

Saponins: 1g of the finely ground dried sample was weighed into a 250 ml beaker and 100 ml of isobutyl alcohol was added. The mixture was shaken on a UDY shaker for 5 hours to ensure uniform mixing. Thereafter, the mixture was filtered through a Whatman No. 1 filter paper into a 100 ml beaker containing 20 ml of 40% saturated solution of $MgCO_3$. The resulting mixture was filtered to obtain a clear colourless solution. 1 ml of the colourless filtrate was pipetted into a 50 ml volumetric flask and 2 ml of 5% $FeCl_3$ solution added and made up to the marked level with distilled water. This was allowed to stand for 30 minutes for a blood red colour to develop. 0-10 ppm saponin standard was prepared from saponins stock solution. The standard solutions were treated similarly with 2 ml of 5% $FeCl_3$ solution as earlier described. The absorbance of the samples as well as standard saponin solutions was read after colour development using a Jenway V6300 spectrophotometer at wavelength of 380 nm. Percentage saponin was calculated as;

$$\%S = \frac{AxARxDF}{Wx1000} \qquad (7)$$

Where: % S = percent saponin; A = absorbance; AR = average gradient; DF = dilution factor; W = Weight of the sample

Alkaloids: 2 g of finely ground sample was weighed into 100 ml beaker and 20 ml of 80% absolute alcohol were added to give a smooth paste. The mixture was transferred into a 250 ml flask and made up to mark with alcohol. Further, 1 g of magnesium oxide was then added to the mixture. The content was digested in a boiling water bath for 60 min under a refluxed air condenser with occasional shaking. The mixture was filtered while hot through a Buchner funnel. The residue was poured back into the flask and re-digested for another 30 minutes with 50 ml alcohol after which the alcohol was evaporated. Distilled water was added to replace the lost alcohol. When all alcohol has evaporated, 3 drops of 10% HCl was added. The whole solution was later transferred into 250 ml volumetric flask; 5 ml of Zinc acetate solution and 5 ml of potassium ferric cyanide solution were thoroughly mixed to give a homogenous mixture. The flask was allowed to stand for a few minutes, filtered through a dry filter paper and 10 ml of the filtrate was transferred into a separating funnel and the alkaloids present were extracted vigorously by shaking with five successive portions of chloroform. The residue obtained was dissolved in 10 ml of hot distilled water and transferred into a Kjeldahl tube with the addition of 0.2 g of selenium for digestion to a clear colourless solution. The clear colourless solution was used to determined Nitrogen using Kjeldahl distillation apparatus the distillate was back titrated with 0.01N HCl and the titre value obtained was used to calculate the % Nitrogen as:

$$\%N = VxAMNxNx100 \qquad (8)$$

Where: %N = Percentage of Nitrogen; V = titre value; AMN = Atomic mass of Nitrogen; N = Normality of HCl

$$\%A = \%Nx3.26 \quad (9)$$

Where: %A = Percentage alkaloid; %N = Percentage Nitrogen; 3.26 = A constant

Tannins: 0.2 g of sample was measured into a 50 ml beaker. 20 ml of 50% methanol was added to the sample and covered with paraffin before placing it in a water bath at 77-80˚C for 1 hour. It was shaken thoroughly to ensure uniform mixing. The extract was filtered using a double layered Whatman filter paper and poured into a 100 ml volumetric flask. 20 ml water was added and 2.5 ml Folin-Denis reagent and 10 ml of 17% Na_2CO_3 were added and mixed properly. The content was thoroughly mixed and made up to mark with distilled water. This was allowed to stand for 20 minutes until a bluish-green colour appeared at the end. The standard Solutions of Tannic acid (0-10 ppm) was treated as above. The absorbance of the Tannic acid standard solutions as well as sample was read after colour development on a 2D spectrophotometer at a wavelength of 760nm. % Tannin was calculated as:

$$\%T = \frac{AxAGxDf}{Wx10{,}000} \quad (10)$$

Where: %T = Percentage Tannin; A = Absorbance of sample; AG = Average gradient; W = Weight of sample; Df = Dilution factor; 10,000 = A constant

RESULTS AND DISCUSSION

The moisture content of Bitter gourd (*M. charantia*) seed flour was 8.50 %, This value was higher than *Monodora myristica* seed flour (4.88±0.13) reported by Adeleke *et al.* (2019) and 5.20 ±0.02%, reported for *Hura crepitan* seed flour by Olatidoye *et al.* (2010) and lower than 11.70 ±0.04 and 13.67± 0.07% for African nutmeg and Byrosocurpus drink layer by Adegbite *et al*. (2021). This value was in agreement with *Tamarindus indica* seed flour (8.0%) Adeleke *et al.* (2021). However, this value was below the 10% recommended limit for storage stability of flour. Thus, the low moisture content in this work indicated that the seed flour can be stored for a long period without deterioration in quality (Agomuo *et al*, 2011).. The ash content 2.90 ± 0.01% reported in this work was lower compared to 4.93% reported for *Afzelia Africana* (Ogungbenle, 2014), 10.41± 0.01, and 8.8±0.05% Adegbite *et al*. (2021) for African nutmeg and Byrosocurpus drink layer and in close range with 3.12± 0.01% reported for soy flour Olatidoye *et al.* (2010). The ash content in this study falls within the recommended value 1.5-3.5%, thus suggesting its suitability for livestock feeds and human consumption. It has been reported that crude protein serves as enzymatic catalyst, mediate cell responses, control growth and cell differentiation (Whitney and Rolfes, 2005). The crude protein 20.90±0.05 was lower than *Canaralia cantharitical*, 31.2± 0.01 (Seena and Sridhar, 2006) and Roselle 32.3 ± 0.01% (Mohammed *et al.*, 2007) but higher than 54±0.05% reported for Byrosocurpus drink layer (Adegbite *et al*, 2021), and in close range with 22.20± 0.60 for *Hura crepitan* seed flour (Oderinde *et al.*, 2009). The amount of protein obtained in this study suggested that the seed flour can serve as protein supplement for animals and human. Fat is important in diet because it facilitates the solubility of fat soluble vitamins (Bogert *et al.*, 1994). The fat content 20.57 ± 0.10% reported in this work was significantly lower than that of periwinkle (74.74%), Ogungbenle (2012). 50.50% for gourd seed flour (Ogungbenle, 2002), and 34.44±0.1% for *M. myristica* seed flour (Adeleke, *et al.*, 2017). Crude fiber decreases the absorption of cholesterol from the gut in addition to delaying the digestion and conversion of starch to simple sugars, an important factor in the management of diabetes (Cust *et al.*, 2009). The crude fibre (2.44 ± 0.01) in this study was lower when compared with (7.63%) reported for *Hura Crepitan* seed flour (Olatidoye *et al.*, 2010). This indicted that Carbohydrate content (51.29 ± 0.10%) in this work was higher than 34.6% for *Caesapinia bonduc* seed flour (Adeleke *et al.* (2019). 16.89% for *J. curcas* (Oladele and Oshodi, 2008), and 8.05±0.01% for *M. myristica* seed flour (Adeleke, *et al*., 2017). However, the value in this study was in close range with those reported for millet seed flour (Sandeep *et al*., 2009). The high value reported in this study suggested that the seed flour will be a source of energy for daily requirement in food formulation.

Table 1: Proximate composition (%) of Bitter gourd seed

Parameter	(%) Composition
Moisture Content	8.50 ± 0.15
Ash Content	2.90 ± 0.01
Crude Fat	20.57 ± 0.10
Crude Fibre	2.44 ± 0.01
Crude Protein	14.30 ± 0.50
Carbohydrate	51.29 ± 0.10

The mineral composition of bitter gourd seed flour was shown in Table 2. The least mineral was K (5.27 ± 0.05 mg/100g), while Fe (371.50 ± 0.20 mg/100g) was found to be the most abundant. This was followed by Mg (205.10 ± 0.50 mg/100g), P (17.10 ± 0.05 mg/100g), Na (11.42 ± 0.50 mg/100g) and Ca (8.90 ± 0.15 mg/100g) respectively. These minerals are known to play vital roles in both plants and animals (Schwartz, 2007), and they were accumulated in different amount in the seeds and the amount extracted along with the oils also varied. Iron helps in the formation of blood and in the transfer of oxygen and carbon dioxide from one tissue to other (Jacob *et al*., 2015). Iron deficiency results in impaired learning ability and behavioral problems in children and

also anemia (McDonald, 1995). The iron content (371.50 ± 0.20 mg/100g reported in this study was significantly higher than 11.80 mg/100g and 9.00 mg/100g for defatted and undefatted cashew kernel flour reported by Emelike and Barber (2015), 27.81 mg/100g reported for brebra (Andualem and Gessesses, 2014). Also, 144.70 mg/100g for melon seeds, Jacob *et al*. (2015) and 61.50± 11.50 mg/100g for *Phoenex dactylifera* L. Shaba *et al*, (2015). The high content of iron reported in this study suggested that the seed flour can be incorporated or used as supplements in iron deficient diet prevent anemia. Magnesium is beneficial to blood pressure and helps to prevent sudden heart attack, cardiac arrest and stroke Jacob *et al.* (2015). Magnesium is an important component of bone and contributes to its structural development. The magnesium content in seed flour was 205.10 ± 0.50 mg/100g. This value was very low compared to 11238 mg/100g reported for melon seeds by Jacob *et al*. (2015), but higher than 190 mg/100g reported for undefatted cashew seed flour by (Emenike and Barber, 2015). Phosphorus is important for healthy bones and teeth formation, it is found in every cell and it forms part of the system that maintains acid-base balance (Olaofe *et al.*, 1994). Modern foods rich in animal protein and phosphorus can promote the loss of calcium in urine (Shills and Young, 1992). The Phosphorus content in this study was 17.10 ± 0.05 mg/100g. This value was significantly lower than (483.23±0.030 mg/100g) reported for *N. sativa* seed flour (Adeleke *et al*., (2021). However, this value was in agreement with 17.20±0.20 mg/100g, for *M. myristica* seed flour Adeleke *et al*. (2020). Calcium is an important mineral required for bone and teeth formation and neurological functions (Olaofe *et al.*, 1994). The calcium content in the study was 8.90 ± 0.15 mg/100g. This was a bit higher than 4.83 mg/100g reported for *Citrullus lanatus* seed flour (Adeleke *et al*., 2021), and significantly lower than 61.55± 0.01 mg/100g for brebra seed flour (Andualem and Gessesses, 2014), 73.2 mg/100g, pumpkin and 54.9 mg/100g gourd seeds Olaofe *et al.*, (1994). The Ca/P ratio of *M. charantia* seed flour is 0.52 which was in agreement with the standards of 0.50 (WHO, 2012). The Ca/P ratio in this study showed that the seed flour will help in calcium absorption by the body. Sodium is a macronutrient which constitutes 2% of the total mineral content of the body. It plays a vital role in maintaining the body fluid volume, osmotic equilibrium and acid base balance Soetan *et al.* (2010). The Sodium content 11.42 ± 0.50 mg/100g obtained in this work was significantly lower than 1264.19±0.03 mg/100g reported for *M. myristica* seed flour Adeleke *et al*. (2020), and higher than (3.0 ± 0.10 mg/100g) reported for *T. indica* seed flour. Adeleke *et al*. (2021). Potassium is needed for maintaining fluid balance, nerve transmission and muscle contraction (Soetan *et al*., 2010). The value (5.27 ± 0.05 mg/100g) in this study was significantly lower than 281.00± 0.10 mg/100g) reported for brebra seed flour (Andualem and Gessesses, 2014). However, this value was higher than 3.57 mg/100g for soursop seed flour by Onyechi *et al*. (2014). Na/K ratio less than the one recommended by WHO (2012). The Na/K ratio of 2.17 for bitter gourd seed flour indicated that it might be helpful in the prevention of hypertension and lowering of blood pressure in hypertensive patients.

Table 2: Elemental composition of Bitter gourd seed

Parameter	mg/100g
K	5.27 ± 0.05
Ca	8.90 ± 0.15
Mg	205.10 ± 0.50
Na	11.42 ± 0.50
Fe	371.50 ± 0.10
P	17.10 ± 0.05

Table 3 presented the photochemical composition of bitter gourd seed flour. Phytochemicals are non-nutritive chemicals that occur naturally in plants. Certain phytochemicals (such as saponins) were reported to have pharmacologically active effects (Soetan and Oyewole, 2009). These phyto-constituents were reported as antibiotic principles of plants and they offer benefits (prevent cell damage and fight infections) in plants and animals when ingested Ajayi *et al.* (2011). Saponin is used in various drug preparations, controlling blood cholesterol level, healthy bone and building of immune system Okwu (2004). The saponin content in this study was 3.42 ± 0.01%. This value was lower than 8.41 mg/100g in soursop seed flour reported by Onyechi, *et al*. (2014**).** However, the value was higher than benoil seed flour, 1.368%, watermelon seed flour, 1.237%, pear seed flour, 1.279% and 1.197% reported for pawpaw seed flour Olorode *et a*l. (2014). Therefore, the seed flour can be used as phytochemical supplements in diets. Osuagwu and Ihenwosu reported that saponins expectorant and as emulsifying agents as well as elution of anti-fungal properties. This further indicated that the seed flour will be of great value medicinally in food supplements. Flavonoids have been reported to possess substantial anti-carcinogenic and anti-mutagenic activities due to their anti-oxidant, anti– inflammatory properties and also active in reducing high blood pressure Ayinde, *et al*. (2007), Li-Weber (2009). The flavonoid content of the seed flour was 12.09 ± 0.10%. This value was higher than 5.33± 0.11% reported for soursoup seed flour, Onyechi *et a*l. (2014) and in agreement with 12.94% reported for pawpaw seed flour Olorode *et a*l. (2014). The value was lower than benoil seed flour, 13.09, 16.08, watermelon seed flour, 14.07, pear seed flour, and 15.91, melon seed flour Olorode *et a*l. (2014). However, this value was significantly higher than 0.99 ± 0.41, African oil bean (*P. macrophyla*) seed flour, 0.85 ± 0.03 African bush mango (*I. gabonensis*) *seed* flour and 1.07 ± 0.04, African walnut (*T.*

conophorum) *seed flour* reported by Okwulehie and Ukasoanya (2021). The high flavonoid content obtained in this seed flour suggested its usefulness in the prevention of cancer, inflammation and high blood pressure when used as supplement in food. Cyanide and tannins bind essential minerals such as calcium, iron, magnesium and zinc in the digestive tract to form insoluble salts, thereby decreasing or reducing bioavailability or absorption of nutrients. Tannins are sometimes expanded as anti-nutrients due to their ability to coagulate proteins. However, reports show that tannins possess medicinal and health benefits including inhibition of pathogenic fungi, stimulation of phagocytic cell for body defense and lost mediated tumor activity (Burkill, 1995). The tannin content 6.20 ± 0.50% in study was higher than unfermented Hura crepitan seed 0.53 ± 0.34% Ahaotu *et al. (*2020). African oil bean (*P. macrophyla*) 0.67 ± 0.01, African bush mango (*I. gabonensis*) 0.51 ± 0.03, and African walnut (*T. conophorum*) 0.67 ± 0.01) (Okwulehie and Ukasoanya 2021). However, the value was in close range with Benoil seed flour 5.32%, Watermelon seeds flour, 6.83% Pear seeds flour 5.64% and Pawpaw seeds flour, 6.10% Olorode *et a*l. (2014). The results indicated that *M. charantia* seed flour possessed medicinal and health benefits when used as supplement in weaning foods. Alkaloids are widely used as basic medicinal agents for their analgesic, antispasmodic and bactericidal effect Stray (1998). It plays some metabolic roles and control development in living organisms Edeoga *et al*. (2006). The alkaloid content of the seed flour (14.41 ± 0.05%) was higher than (3.09%) in soursop seed flour Onyechi *et al. (*2014), 9.53% Ahaotu *et al.* (2020), *P. macrophyla* 1.33 ± 0.02%, *I. gabonensis* 1.19 ± 0.03% and *T. conophorum* 1.57 ± 0.07% (Okwulehie and Ukasoanya, 2021), and lower than 17.33 ± 0.17% for Moringa oleifera seed flour, Ijarotimi *et al*. (2013). However, the value was in agreement with benoil seed flour, 12.28%, watermelon seed flour, 15.36 %, pawpaw seed flour, 13.3% and melon seed flour 11.1% Olorode *et a*l. (2014). This implied that Bitter gourd seed flour can be used in diet supplementation as photochemical supplements which will improve the medicinal quality of diets. The cyanide content 2.10 ± 0.01 in this study was higher than 0.00073 Hura crepitan seed flour Ahaotu *et al.* (2020), benoil seed flour, 0.052, watermelon seed flour, 0.078, pear seed flour 0.0.067, pawpaw seed flour 0.062 and melon seed flour 0.057% reported by Olorode *et a*l. (2014). However, the value was lower than African oil bean 14.02 ± 0.18, African bush mango 5.69 ± 0.29, and African walnut 9.33 ± 0.01 (Okwulehie and Ukasoanya, 2021). The low cyanide content in bitter gourd seed further suggested that when consumed as supplement, it will not bind essential minerals or reduce the absorption of nutrients in diet. Table 4 presented the results of protein functional properties of bitter gourd seed. Functional properties are the intrinsic physicochemical characteristics which may affect the behavioural pattern of food during processing or storage.

Table 3: Phytochemical composition of Bitter gourd seed flour

Parameter	% composition
Saponin	3.42 ± 0.01
Tannin	6.20 ± 0.50
Flavonoid	12.09 ± 0.10
Alkaloids	14.41 ± 0.05
Cyanide	2.10 ± 0.01

The bulk density of the seed flour was 0.04510 %. The bulk density was lower than 0.16 ± 0.00 for moringa seed flour reported by Ijarotimi *et al.* (2013), 0.380, soya bean flour Edema, *et al*. (2005), benoil seed flour, 0.533, watermelon seed flour, 0.501, pear seed flour 0.463, pawpaw seed flour 0.347, and melon seed flour 0.357% reported by Olorode *et a*l. (2014). Low bulk density is an advantage because high bulk reduces the caloric and nutrient intake per feed per child and infants sometimes are unable to consume enough to satisfy their energy and nutrient requirements. Bulk density is also important in the packaging requirement and material handling in products. The decrease in loose and packed densities in some of the seeds' flours shows that it is an advantage since according to (Akubor and Chukwu, 1999), a large free space is undesirable in packaging of foods because it constitutes a large oxygen reservoir, whereas a low loose and packed densities result in greater oxygen transmission. The swelling capacity of bitter gourd seed flour at 50, 70 and 90% were; 102.70, 105.36 and 103.54 respectively. These values were significantly higher than 20.24, 4.00, 1.90, 1.90 at 65, 75, 85 and 95% reported for benoil seed flour Olorode *et a*l. (2014), 6.60± 0.01, *M. myristica* seed flour Adeleke *et al.* (2020), 1.33 ± 0.00, moringa seed flour by Ijarotimi *et al.* (2013) and 16.37 ± 0.21 reported for okra seed flour, Ofori *et al.* (2020). However, the high swelling capacity obtained in this study could be attributed to the high carbohydrate content of the bitter gourd seed flour because the swelling ability is a function of the carbohydrate content of the seed flour. According to (Obatolu and Cole, 2000), a lower water absorption capacity is desirable for making thinner gruels with high caloric density per unit volume. The value 241.40% reported in this study was significantly higher than 80.33± 0.33 in *M. oleifera* seed flour Ijarotimi *et al.* (2013), 199.60 melon seed flour and lower than 296.77% watermelon seed flour Olorode *et a*l. (2014). The high water absorption capacity observed in bitter gourd seed flour is an indication of high protein content of the seed flour which has high affinity for water molecules Yusuff *et al.* (2008). The oil absorption capacity was an indication of aroma and oil content of the seed flour. It is an implication of mouth-feel, flavor retention and shelf stability of baked or fried foods especially meat products. Oil absorption capacity in this

study was 297.40%. This value was lower than 321.34 in pear seed flour and 307.27 % Pawpaw Seed flour, Olorode *et a*l. (2014). However, the value was significantly higher than 88.37 ± 8.62 okra seed flour Ofori *et al*. (2020) and in close range with 279.33 and 278.19% reported for watermelon Seed flour and melon seed flour Olorode *et al*. (2014). This suggested that the seed flour will likely give good aroma and a good source of oil. The least gelation capacity of 1.75% in this study was in agreement with 1.80, 1.80, 1.60, and 1.80 reported for benoil seed flour, watermelon seed flour, pear seed flour and melon seed flour Olorode *et a*l. (2014). The high gelation capacity obtained in this seed flour level suggested a reduction in viscosity which led to increase in nutrient density and low dietary bulk which is highly favourable for a good weaning food. Solubility is an index of protein functionality such as denaturation and its potential applications (Obatolu and Cole, 2000). Often, the solubility and swelling power are influenced by the water-binding capacity of the flour sample, which is a function of proteins and carbohydrates present in the flour (Abe-Inge *et al.,* 2018; Baah, *et al.,* 2005; Dossou *et al*., 2014). The solubility content of the seed flour at 50, 70 and 90% were 10.75, 4.26 and 2.93 respectively. The values were higher than 1.80, 0.43, 1.75 and 2.3 at 65,75,85,95 obtained for melon seed flour Olorode *et a*l. (2014).

Table 4: Functional properties of Bitter gourd seed

Parameter		**Composition**
Bulk Density g/cm^3		0.0451
Swelling		103.87
Water absorption capacity % (WAC)		241.40
Oil absorption capacity % (OAC		297.40
Least gelatinous capacity %		1.75
Solubility	50%	10.75
	70%	4.26
	90%	2.93

Conclusion: The study shows that bitter gourd has high carbohydrate, and rich in fat, which serves as a good dietary supplement. The high iron content of the unshelled bitter gourd shows that it is a good source of hemoglobin while a high magnesium helps in building the immune system. Hence, *M. charantia* is suitable for domestic and industrial utilization.

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