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Compositional Evaluation of Bitter Melon (*Momordica charantia*) Fruit and Fruit Pulp of Ebony Tree (*Diospyros mespiliformis*)

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Abstract: In this study, proximate, mineral, amino acid and anti–nutrient compositions of *Mormodica charantia* fruit and *Diospyros mespiliformis* fruit pulp were determined using standard analytical techniques. The respective proximate composition values (g/100 g sample) of *M. charantia* and *D. mespiliformis* were: Moisture (3.88 and 4.64), ash (5.22 and 5.5.13), crude protein (20.36 and 4.68), crude fibre (8.41 and 3.58), ether extract (4.39 and 2.00), and carbohydrate by difference (57.56 and 79.68). The calculated fatty acids and metabolizable energy for *M. charantia* and *D. mespiliformis* were (3.51 and 1.60 %) and (148.07 and 1508.12 kJ/100 g). The most abundant minerals were Na (612.42 and 425.21 mg/100 g) followed by Na (521.71 and 368.25 mg/100g), respectively. Generally, the two samples were found to be good sources of essential minerals. The levels of Na/K and Ca/Mg ratios were desirable compared with recommended values. The amino acid profiles revealed that both samples contained nutritionally useful quantities of most of the essential amino acids with total essential amino acid (TEAA) (with His) were 34.38 and 22.37 g/100 g for *Mormodica charantia* and *Diospyros mespiliformis*, respectively. However, essential amino acid supplementation may be required in dietary formula except Ile and Leu in *Mormodica charantia* and Met + Cys and Val in *Diospyros mespiliformis* when comparing the essential amino acids (EAAs) in this report with the recommended FAO/WHO provisional pattern. Met + Cys (TSAA) was the first limiting amino acids (LAA) for the two plant fruits. The study showed that *Mormodica charantia* and *Diospyros mespiliformis* can be better sources of some of the essential nutrients with potential health beneficial constituents than some of the members of the family to which they belong. However, some of the anti–nutrient contents may pose nutritional problems in their consumption.

Keywords: Proximate, Minerals, Amino Acids, Anti-Nutrients, Fruit, Pulp

Introduction

Many underutilized plant seeds and fruits are being investigated for their nutrient and anti–nutrient compositions. Some of the recent works directed towards increasing utilization of plant seeds and fruits include; *in-vitro* assessment of proximate and phytochemical quantifications of some edible fruits [1], some nutrient and anti–nutrient components of *Pterygota macrocarpa* [2], proximate analysis, mineral contents, amino acid composition, anti-nutrients and phytochemical screening of *Brachystegia eurycoma* Harms and *Pipper guineense* Schum and Thonn [3], amino acid composition of pulp and seed of baobab (*Adansonia digitata* L.) [4], fruit nutritive composition of *Maesobotrya barteri*, an underexploited tropical African tree [5], compositional evaluation of pulp and seed of blood plum (*Haematostaphis barteri*), a wild tree found in Taraba State, Nigeria [6], nutrient composition of tree commonly consumed indigenous vegetables of north–central Nigeria [7], phytochemical and nutritive quality of dried seeds of *Bacchhotzia coriacea* [8], nutritive and energy values of some wild fruit species in south–eastern Nigeria [9], proximate composition and selected physicochemical properties of the seed, pulp and oil of soursop *Annona muricata* [10], nutrient and anti-nutrient composition of shea (*Vitellaria paradoxa* C.F. Gaetn) kernel and pulp in the north–east Nigeria [11], chemical composition of the raw fruit coat, seed and pulp of passion fruit *(Passiflora edulis)* [12], amino acids composition of fermented African locust bean (*Parkia biglobosa*) seeds [13], chemical composition of wonderful kola (*Bucchhozia coriacea*) and breadfruit (*Artocarpus altilis*) seeds grown in south–south Nigeria [14], comparative studies on the lipid

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composition of blood plum (*Haematostaphis bateri*) pulp and seed oils [15] and compositional evaluation of raw and processed harms (*Brachystegia eurycoma*) seed flour [16].

In continuation of our research efforts on investigation of nutrients and anti–nutrients composition of underexploited plant fruits and seeds, the fruit of bitter melon (*Momordica charantia)* and ebony tree (*Diospyros mespiliformis)* fruit pulp were studied.

Momordica charantia is commonly known as bitter gourd, is widely planted in tropical areas. It has also been frequently used as medicinal herb, because of its anti-diabetic, anti-helminthic, abortifacient, antibacterial, antiviral and chemopreventive functions [17] (Fig. 1).

Fig. 1: Dry fruit of bitter melon (*Momordica charantia)*

Fig. 2: Dry fruit pulp of ebony tree (*Diospyros mespiliformis)*

The ebony tree (*Diospyros mespiliformis)* is planted for re-afforestation, as ornamental shade tree and as windbreak. The flowers serve as source of nectar for honey bees. The fruits are traded on local markets and may provide vital supplementary income for poor households (Fig 2). The raw, cooked, dried fruit are made into beverages by fermentation. A sweet flavor similar to the persimmon, a kind of soft coffee can be made from the fruits, such as figs and dates [18].

The objective of this study was to determine the chemical composition of fruit of bitter melon (*Momordica charantia) and* ebony tree (*Diospyros mespiliformis)* fruit pulp grown in north–east, Nigeria. The information would improve the existing information on the food composition table of *Momordica charantia and Diospyros mespiliformis.*

Materials and Methods

Samples collection

The samples were collected from Zing local government Area of Taraba State, Nigeria. Identification of the samples was done in the Biology laboratory of Federal University Wukari.

Sample preparation and treatment

The dried fruits of both samples were washed with distilled water to remove foreign materials and then drained through filter paper. Bitter melon (*Momordica charantia)* was prepared by sundried and ground into powder using pestle and mortar, sieved and stored in well labeled air tight plastic container and taken for analysis. Ebony tree (*Diospyros mespiliformis)* fruit pulp was prepared by removal of the seeds from the ripe fruit in order to get the pulp seperated, dried in an air-draught oven at 130^0C for 8 h. The dried fruit was ground into powder using pestle and mortar, sieved and stored in well labeled air tight plastic container and taken for analysis.

Proximate analysis

The ash, crude fat, moisture, crude protein (N x 6.25), crude fibre and carbohydrate (by difference) were determined in accordance with the standard methods of AOAC [19]. All proximate analyses of the sample flours were carried out in triplicate and reported in percentage. All chemicals were of Analar grade.

Mineral analysis

The standards of Na, Ca, K, Mg and Mn solutions of 0.2, 0.4, 0.6, 0.8 and 1.0 mgL^{-1} were prepared from each of the metal solutions of 1000 mgL^{-1} stock solutions. The filtrates of the digested samples were analysed by atomic absorption spectrophotometer (AAS). The detection limit of the metals in the sample was 0.000 mgL^{-1} by means of the UNICAM 929, London, AAS powered by the solar software. The optimal analytical range was 0.1 to 0.5 absorbance units with coefficient of variation from 0.9% to 2.21%. Phosphorus was determined colorimetrically using a Spectronic 20 (Gallenkamp, London, UK) instrument, with KH_2PO_4.

Amino acid analysis

The amino acid analysis was by Ion Exchange Chromatography (IEC) [20] using the Technico Sequential Multisample (TSM) Amino Acid Analyzer (Technicon Instruments Corporation, New York). The period of analysis was 76 min for each sample. The gas flow rate was 0.50 $mLmin^{-1}$ at 60^oC with reproducibility consistent within ± 3%. The net height of each peak produced by the chart recorder of the TSM (each representing an amino acid) was measured and calculated. Amino acid values reported were the averages of two determinations. Nor–leucine was the internal standard. Tryptophan was determined after alkali (NaOH) hydrolysis by the colorimetric method.

Determination of isoelectric point (pI), quality of dietary protein and predicted protein efficiency ratio (P–PER)

The predicted isoelectric point was evaluated according to Olaofe and Akintayo [21]:

$$plm = \sum_{i=1}^{n=1} pliXi \quad ----(1)$$

Where:

pIm = the isoelectric point of the mixture of amino acids;

pIi = the isoelectric point of the ith amino acids in the mixture;

Xi = the mass or mole fraction of the amino acids in the mixture.

The quality of dietary protein was measured by finding the ratio of available amino acids in the sample protein compared with the needs expressed as a ratio. Amino acid score (AAS) was then estimated by applying the formula [20]:

$$AAS = \frac{mg\ of\ amino\ acid\ in\ 1g\ of\ test\ protein}{mg\ of\ amino\ acid\ in\ reference\ protein} \times \frac{100}{1} \quad ------(2)$$

The predicted protein efficiency ratio (P–PER) of the seed sample was calculated from their amino acid composition based on the equation developed by Alsmeyer *et al*. [22] as stated thus;

P–PER = –0.468 + 0.454(Leu) – 0.105(Tyr) - - - - (3)

Anti–nutritient content determination

The contents of tannin, alkaloid, saponin, phytate, oxalate and cyanide were determined on each of the sample flours by methods described by some workers [23, 24].

Statistical analysis of the samples

The fatty acid values were obtained by multiplying crude fat value of each sample with a factor of 0.8 (i.e. crude fat x 0.8 = corresponding to fatty acids value [25]. The energy values were calculated by adding up the carbohydrate x 17 kJ, crude protein x 17 kJ and crude fat x 37 kJ for each of the samples. Errors of three determinations were computed as standard deviation (SD) for the proximate composition.

Results and Discussion

The proximate composition values of *M. charantia* fruit and pulp of *D. mespiliformis*, are shown in Table 1. The Values obtained for moisture content, fat, protein, crude fibre and ash of both samples proved that there incorporation in foods as an additive can improve the nutritional composition of such foods. The moisture content (% dry matter) for *M. charantia* fruit and pulp of *D. mespiliformis* were 3.88% and 4.64%, respectively. The values are comparable to the moisture content obtained for mesquite bean (5.59 %) [26], cowpea flour 4.0 % [27], pumpkin seed 5.5% [28] and *Luffa cylindrical* 5.8% [29]. The result of the analysis showed that the moisture content of *M. charantia* was slightly low compared to the values (7.99 - 10.12) % reported by Ijaratomi *et al.* [30] but higher than 1.34% as reported [31] for *M. charantia.* The low moisture content is an indication that the fruits will last long when stored at that condition because of little water activity for microbial proliferation and spoilage. The different methods of preparation of the samples for analysis could be behind the observed difference in moisture contents as well as season and climatic condition.

Proteins, another class of food often times referred to as the 'Nitrogen– containing natural product' has been proved to be essential for the survival of human beings and animals [32]. The crude protein values were 20.36 % for *M. charantia* fruits and 4.68% for *D. mespiliformis* pulp which are slightly comparable to that of bambara groundnut, (11.1) %, kersting's groundnut, (12.00%) [33], *Treculia africana*, 15.76 % [34], this result showed that the protein content of both *M. charantia* fruits are higher and pulp of *D. mespiliformis* are lower than that of *Cola nitida* (8.68%), *Cola acumimata* (8.65 %), and *Garcina kola* (8.70 %) [35]. These showed that the seeds have appreciable amount of protein which are good for growth and repair of worn out tissue and so can be used as a good source of protein.

As regards the crude fat content, the values were (4.39 %) *M. charantia* and (2.00 %) for *D. mespiliformis.* The values do not qualify the two samples as oil – rich when compared with soybean 22 – 23.5 % [28] and some plant seeds grown in Nigeria such as *Citrullus vulgaris* Schrad (47.9 – 51.1 %) [35] and pumpkin seed 47.0 – 49.2% [36]. Consequently the low fat contents of *M. charantia and D. mespiliformis* suggests they may not be good sources of oil.

The crude fibre values of the samples were 8.41 %

for *M. charantia* and 3.58 % for *D. mespiliformis*. The values are higher than (1.65 %) reported for yam flour [37], cassava (1.00 %)[38], Africa yam bean, 3.5% [39], and 3.6 % red kidney bean seed flour [40] but slightly comparable to 9.17% *Parkia biglobosa* [41] and lower to *Brachystegia eurycoma* [16]. It is a well known fact that dietary fibre plays an important role in the maintenance of internal distention intestinal track as its physiological effects. Adequate intake of dietary fibre from a variety of foods will help the protection against colon cancer and also help minimize blood lipids, thereby reducing the risk of cardiovascular diseases [16] and also play a vital role in providing roughage that aids digestion [42]. Reports have shown it is an essential component of a well-balanced diet that will help minimize some common health problems. Some type of fibres can also slow D-glucose absorption and reduce insulin secretion, which is of great important for non–diabetic as well [43]. The result indicates that *M. charantia* has higher fibre content than *D. mespiliformis*. *M. charantia* fruits could be incorporated with cassava flour in the bread industry to increase its fibre content. The values of the ash content as presented in Table 1 were comparable to *Prosopis africana* flour (4.4 %) [26] and 4.3% *Luffa cylindrical* [29]. But higher than 2.05 % *Treculia africana* [44], the implication is that both *M. charantia* fruits and pulp of *D. mespiliformis* could be used as a good source of minerals.

The carbohydrates calculated from the result were 57.56 % and 79.68 % for *M. charantia fruits and pulp of D.mespiliformis* respectively; these values are comparable to *Cola nitida* (61.11%), *Cola acumimata* (64.05 %), *Garcina kola* (62.23 %) [35] and (76.58%) for *Artocarpus heterophyllus* [45]. The seeds are good sources of carbohydrate when consumed because it meets RDA value of 40% for children, 40% for adult 30% for pregnant women and 25% for lactating mothers. Due to this high level of carbohydrate in *D. mespiliformis*, the fruits pulp has been regarded as a good source of energy. This probably could be the reason for its use as a staple in the Caribbean [46].

The calculated fatty acids and metabolizable energy values for *M. charantia and D.mespiliformis* were 3.51 to 1.60 kJ/100 g and 1487.07 to 1508.12 kJ/100 g, respectively. The energy showed that the sample had an energy concentration more favourable than cereals [25, 47].

Table 1: Mean proximate composition (g/100 g sample)[a] of *M. charantia* fruit and fruit pulp of *D. mespiliformis*

Parameter	*M. charantia*	*D. mespiliformis*
Moisture content	3.88 ± 0.08	4.64 ± 0.13
Crude protein	20.36 ± 0.28	4.68 ± 0.25
Crude fat	4.39 ± 0.05	2.00 ± 0.66
Crude fibre	8.41 ± 0.44	3.58 ± 0.11
Ash	5.22 ± 0.18	5.13 ± 0.12
Carbohydrate	57.56 ± 2.08	79.68 ±1.38
[b]Energy (kJ 100 g^{-1})	1487.07	1508.12
[c]Fatty acid	3.51	1.60

[a]Each value represent the mean ± standard deviation of three replicate determinations; [b]Calculated fatty acids (0.8 x crude fat); [c]Calculated metabolisable energy (kJ 100 g^{-1}) (protein x 17 + fat x 37 + carbohydrate x 17).

Table 2: Mean mineral composition (mg/100g sample) of *Momordica charantia* fruit and fruit pulp of *Diospyros mespiliformis*

Mineral	*M. charantia*	*D.mespiliformis*
Na	521.71	368.25
Ca	612.42	425.21
K	413.02	332.22
Mg	421.76	315.23
P	421.73	362.85
Mn	4.61	3.88
Na/K	1.26	1.11
Ca/P	1.45	1.17
Ca/Mg	1.45	1.32

Na/K = Sodium to potassium ratio; Ca/P = Calcium to phosphorus ratio; Ca/Mg = Calcium to magnesium ratio

The mineral compositions in mg/100 g of *Mormodica charantia* fruits and pulp of *Diospyros mespiliformis* are presented in Table 2. The result showed that sodium content of *M. charantia* and pulps of *D.mespiliformis* were 521.71 mg/100 g and 368.25 mg/100 g, respectively. Sodium is an important mineral that assist in the regulation of body fluid and in the maintenance of the body tissue [48]. The world health organization (WHO) recommended intake of sodium per day as 500 mg for adult and 400 mg for children [49]. The result indicates that sodium content of *Mormodica charantia* fruits were higher than WHO recommended standard while sodium content of *Diospyros mespiliformis* is lower than the standard. Therefore *M. charantia* fruits and pulp *of D.mespiliformis* are regarded as rich sources of sodium.

The most abundant mineral in both samples of *M. charantia* fruits and pulp *of D.mespiliformis* was calcium 612.42 and 425.21 mg/100 g followed by sodium 521.71 and 368.25 mg/100 g. Magnesium is an activator of many enzyme systems and maintains the electrical potential in nerves. Magnesium is required for all reactions involving ATP (Adenosine Triphosphate). ATP supplies the energy for physical activity by releasing energy stored in phosphate bonds. Report has shown that magnesium may help support mineral bone density in elderly women and men. It has been reported that calcium in conjunction with phosphorus, magnesium, manganese, vitamin A, C and D, chlorine and protein are all involved in bone formation [50].

Modern diets that are rich in phosphorus may promote the loss of calcium to phosphorus ratio. This has led to the concept of calcium to phosphorus ratio (Ca/P). The Ca/P ratios of *M. charantia* fruits and pulp of *D. mespiliformis* were found to be 1.45 and 1.17. Food is considered good if Ca/P ratio is above 1 and poor if the ratio is less than 0.5 while Ca/P ratio above 2 helps to increase the absorption of calcium in the small intestine. The Na/K ratios were found to be 1.26 (*M. charantia)* and 1.11 (*D. mespiliformis)*. This ratio is of great significant for the prevention of high blood pressure. Na/K ratio less than 1 is recommended. Thus, consumption of *M. charantia* fruits and pulp of *D, mespiliformis* would probably increase high blood pressure because it had Na/K ratio greater than 1. The values of Ca/Mg in *M. charantia* fruits and pulp of *D. mespiliformis* were 1.45 and 1.32, respectively. The recommended value of Ca/Mg ratio is 1.00 [51]. Consequently the two samples (*M. charantia* fruits and pulp of *D. mespiliformis*) will meet the required RDA for Ca/Mg ratio.

The result of amino acid composition of the samples of *M.charania* fruits and pulp of *D. mespiliformis* are presented in Table 3. The most abundant and non–essential amino acids (NEAA) in both samples of *M.charania* fruits and pulp of *D. mespiliformis* were glutamic acid with concentrations (11.35 g/100 g and 7.26 g/100 g crude protein, cp) and aspartic acid with concentrations of 7.31 g/100 g and 3.20 g/100 g, cp, respectively.

The value obtained in this study is comparable to the glutamic acid value (10.22 – 19.70 g/100 g cp) obtained for *Cyperus esculentus* [52], and lower to *Anarcadium occidentale* (13.6 g/100 g cp) [53] and *Prosopis Africana* flour (13.3 g/100 g cp) [26]. Leucine was the next most abundant essential amino acid which is highest in *M. charantia* with concentration of 7.20 g/100 g cp compared to 3.62 g/100 g cp for *D. mespiliformis* as required in food samples. The value of the leucine obtained is higher than the value of leucine for *Artocarpus camans*i (2.60 mg/100 g) [54].

Arginine which is an essential amino acid (EAA) in the sample and is responsible for growth in children has concentrations of 5.33 and 3.01 g/100g cp for both samples. The lysine content of both samples is less than the 6.3 g/100 g content of the reference egg protein. Isoleucine (4.12 and 2.30 g/100 g cp) is an essential amino acid for both old and young. Maple syrup urine disease is an inborn error of metabolism in which brain damage and early death can be avoided by diet low in isoleucine and two other essential amino acid, valine and leucine. Phenylalanine with its paired partner tyrosine had concentrations of 3.30 and 2.13 g/100 g cp and 2.41 and 0.86 g/100 g cp respectively in both samples of *M. charantia* fruit and pulp of *D. mespiliformis*. Phenylalanine is the precursor of some hormones and pigment melanin in hair, eyes and tanned skin. Phenylketonuria is the commonest inborn error of metabolism successfully treated by diet. The absence of enzymes in the liver blocks the normal metabolism of phenylalanine and the brain is irreversibly damaged unless a diet low phenylalanine is given in the first few weeks of life [55]. Tyrosine, though regarded as a non essential amino acid it is the precursor of some hormones like the thyroid hormones and the brown pigment melanine formed in hair, eyes and tanned skin [55]. Tryptophan concentrations (0.42 and 0.72 g/100 g) for both samples (*M.charantia* fruits and pulp of *D. mespiliformis* respectively) were found to be the least concentrated amino acids. Cystine was found to be higher than trytophan (1.09 and 1.33 g/100 g cp) in both samples of *M. charantia* fruits and pulp of *D. mespiliformis.*

Table 3: Amino acid composition (g/100 g) of *M. charantia* fruit and fruit pulp of *D. mespiliformis*

Amino Acid	*M. charantia*	*D. mespiliformis*
Leucine (Leu)[a]	7.20	3.62
Lysine (Lys)[a]	1.83	2.33
Isoleucine (Ile)[a]	4.12	2.30
Phenylalanine (Phe)[a]	3.30	2.13
Valine (Val)[a]	3.60	5.92
Methionine (Met)[a]	1.52	5.41
Proline (Pro)	4.46	1.62
Arginine (Arg)[a]	5.33	3.01
Tyrosine (Tyr)	2.41	0.86
Histidine (His)[a]	2.04	0.70
Cystine (Cys)	1.09	1.33
Alanine (Ala)	4.24	3.00
Glutamic acid (Glu)	11.35	7.26
Glycine (Gly)	3.39	2.24
Threonine (Thr)[a]	3.00	2.60
Serine (Ser)	4.00	2.16
Aspartic acid (Asp)	7.31	3.20
Trytophan (Try)[a]	0.42	0.73
Isoeletric point	3.52	4.05
(P-PER)[c]	2.55	1.09
Leu/Ile	1.75	1.57

P-PER = predicted protein efficiency ratio; pI=isoelectric point

Table 4: Classification of amino acid composition (g/100 g sample) of *M. charantia* fruit and fruit pulp of *D. mespiliformis*

Parameter	*M. charantia*	*D. mespiliformis*
Total amino acid (TAA)	74.29	54.42
Totalnon–essential amino acid (TNEAA)	38.25	21.67
%TNEAA	51.49	39.82
Total essential amino acid (TEAA)		
With histidine	34.38	22.37
Without histidine	32.34	21.67
%TEAA		
With histidine	46.28	41.11
Without histidine	43.53	39.81
Essential aliphatic amino acid (EAAA)	17.92	14.44
Essential aromatic amino acid (EArAA)	5.78	3.56
Total neutral amino acid (TNAA)	26.03	43.46
%TNAA	35.04	79.86
Total acidic amino acid (TAAA)	18.66	10.46
%TAAA	25.12	19.14
Total basic amino acid (TBAA)	7.37	3.71
%TBAA	9.92	6.82
Total sulphur amino acid (TSAA)	1.52	5.41
% Cystine in TSAA	71.71	24.58

Table 5: Amino acid scores of *M. charantia fruit* and fruit pulp of *D. mespiliformis*

EAA	PAAESP (g/100 g protein)	*M. charantia*		*D. mespiliformis*	
		EAAC	AAS	EAAC	AAS
Ile	4.0	4.12	1.03	2.30	0.58
Leu	7.0	7.20	1.03	3.62	0.52
Lys	5.5	1.83	0.33	2.33	0.42
Met + Cys (TSAA)	3.5	2.61	0.75	6.74	1.93
Phe + Tyr	6.0	5.71	0.95	2.99	0.49
Thr	4.0	3.00	0.75	2.60	0.65
Try	1.0	0.42	0.42	0.73	0.73
Val	5.0	3.60	0.72	5.92	1.18
Total	**36.0**	**28.49**	**5.98**	**27.23**	**6.50**

EAA = Essential Amino Acid**; PAASEP** = Provisional Amino Acid (Egg) Scoring Pattern**; EAAC** = Essential Amino Acid Composition (See Table 3)**; AAS** = Amino Acid Score

The calculated isoelectric points (pI) were 3.52 in *M. charantia* and 4.05 in *D. mespiliformis*. This is useful in predicting the pI for protein isolate from biological sample [21]. The predicted protein efficiency ratio (P–PER) is one of the quality parameters used for protein evaluation [20]. The P–PER values in this report were 2.55 for *M. charantia fruits* and 1.09 for pulp of *D. mespiliformis*. These values are higher than the reported P–PER values of some legume flours/concentrates: *Prosopis africana*, *Kerstingella geocarpa and Vigna subterranean* (1.03) [26, 33, 56]. However, it is in close agreement with that of *Cyperus esculentus* [52], kidney bean [40]. It can be said that the fruits of *M. charantia* and pulp of *D. mespiliformis* under investigation could satisfy the FAO/WHO [20] requirements. The Leu/Ile values from the study were 1.75 g/100 g cp for *M. charantia* and 1.57 g/100 g cp for *D. mespiliformis*, respectively.

The evaluation result based on the classification of amino acids of both samples of *M. charantia fruit and pulp of D. mespiliformis* is shown in Table 4. The nutritive value of a protein depends primarily on its capacity to satisfy the needs for nitrogen and essential amino acids [57]. Total amino acids (TAA) were 74.29 and 54.42 g/100 g cp for both samples. Total essential amino acids (TEAA) with histidine and total sulphur amino acids (TSAA) were 34.38 and 1.52 g/100 g cp for *M. charantia* fruit; 22.37 and 5.41 g/100 g cp for *D. mespiliformis* fruit pulp. The TSAA for any of the processed fruits is lower than the 5.8 g/100 g cp, recommended for infants [58]. The essential aromatic amino acid (EArAA) varied between 5.78 g/100 g cp in *M. charantia* to 3.36 g/100 g cp in *D. mespiliformis*. These values fall below the ideal range suggested for infant protein (6.8– 11.8 g/100 g cp) [58]. Table 4 also shows the TAAA, which were found to be greater than the TBAA, indicating that the protein for the two samples are probably acidic in nature [16].

The total essential amino acids (TEAA) with His of both samples represent 46.28 % and 41.11%, respectively. This is comparable with values obtained for selected oil seeds [28], *Prosopis africana* protein concentrate (31.9 g/100 g cp) [26] and *Anarcadium occidentale* protein concentrate (35.3 g/100 g cp) [53]. However, it is less than that of some Nigerian legume protein concentrates; lima bean (44.88 g/100 g cp), pigeon pea (48.11 g/100 g cp), and African yam bean (48.28 g/100g cp) [59] and tiger nut (41.21 g/100 g cp) [52]. Nevertheless, the TEAA contents (%) in this report are well above the 39 % considered to be adequate for ideal protein food for infants, 26 % for children and 11 % for adults [58]. The observed values of *M. charantia* and *D. mespiliformis* for essential aliphatic amino acid (EAAA) constitute 17.92 g/100 g cp and 14.44 g/100 g cp, respectively. The Leu, Ile, Val, and Met+Cys (TSAA), which constitute the hydrophobic region, were both abundant in the two samples; this implies that better emulsifier properties will be expected.

The scoring Table 5 reveals the first limiting amino acid as Met + Cys (TSAA) for *M. charantia* (0.75 g/100 g) and *D. mespiliformis* (1.93 g/100 g) while Val came second in both of the two plant seeds. The current report on limiting amino acid does not agree with Bingham [55] who has reported that the essential amino acid most often acting in a limiting capacity is Lys. When comparing the result obtained for AAS in both samples with the recommended FAO/WHO [20] provisional pattern, it was only in the pulp of *D. mespiliformis* that Met + Cys (TSAA) and Val; Ile and Leu of *M. charantia* fruits are superior.

Table 6: Mean anti–nutrient composition (g/100 g sample) of *M. charantia* fruit and *D. mespiliformis* fruit pulp

Parameter	*M. charantia*	*D. mespiliformis*
Oxalate (%)	0.11 ± 0.22	0.34 ± 0.01
Saponins (%)	1.03 ± 0.00	0.94 ± 0.01
Alkaoids (%)	2.67 ± 0.01	2.47 ± 0.38
Phylate (%)	0.49 ± 0.01	0.91 ± 0.01
Tannin (mg/100 g)	61.59 ± 1.08	37.24 ± 0.25
Cyanogenic glycosides (mg/100 g)	5.20 ± 0.15	4.42 ± 0.24

Tannin, polyphenols or condensed tannins are products of secondary plant metabolism. They cause reduction in protein and amino acid digestibility by forming indigestible linkages with protein and in particular by reacting with lysine and methionine [60]. Also tannins decrease carbohydrate digestibility by forming enzyme-resistant complexes with starch. Tannins in a dried seed of *Buchholzia coriacea* were 6.46 and 6.73 % [31]. The tannin content of dried seed is given as (0.11 ± 0.004 mg/100 g). The tannin contents of *M. charantia and D.mespiliformis* were (61.59 and 37.24 mg/100 g), respectively (Table 6), but Oladunjoye *et al.* [61] reported that the compositions of tannin in a peeled and unpeeled raw, cooked and soaked *Artocarpus altilis* meal were determined to be from **(**6.06 - 6.70 mg/kg,) which are found to be lower than the values recorded for both *M. charantia and D.mespiliformis.* Phytates are mainly met in two forms; as phytic acid and as phytin (phytate salts). Phytates are chelating agents, their non-nutritional activity is mainly due to their ability to bind metals (Ca^{+2}, Mg^{+2}, Fe^{+2}, Zn^{+2} and Cu^{+2}), thus leading to their deficient absorption. Additionally the formation of protein-phytate complexes causes negative effects on protein utilization [62]. Also, phytates impact amylase, pepsin and trypsin activity. Phytate content of fermented *Buchholzia coriacea* was estimated as Ca (0.062 – 0.0092 %), Zn (49.833 – 92.412 %) and Fe (0.35 – 0.483 %) as demonstrated by Oluwole *et al.* [63] and that of a dried seed as (3.18 ± 0.01 mg/100 g). The values of phytates (0.58 - 0.75 g/100 g) as reported by Oladunjoye *et al.* [61] in *Artocarpus altilis* sample are comparable with that of *M charantia and D.mespiliformis* (0.49 and 0.91 g/100 g). Oladunjoye *et al.* [61] also reported that the oxalate contents of *Artocarpus altilis* were (2.70 - 3.30 g/100 g), which are higher than the oxalate that was found in of *M charantia and D.mespiliformis* to be 0.11 and 0.34 mg/100 g, respectively**.** Alkaloids are low molecular weight nitrogenous compounds and 20 % of plant species have been found to contain them, mainly involved in plant defense against herbivores and pathogen. According to Ibrahim and Fagbohun [31] the content of alkaloids in *Buchholzia coriacea* were estimated as (3.16 - 3.32 %) which are higher than the value obtained in *M charantia and D.mespiliformis* samples (2.67 and 2.45 %), respectively. A glycoside is a molecule in which a sugar is bound to another functional group via a glycosidic bond and was estimated for *Buchholzia coriacea* (2.16 - 2.46 %) [31] which are lower than the values obtained from the samples of *M. charantia and D. mespiliformis* (5.20 and 4.42 %). Saponin content of dried seed of *Buchholzia coriacea* was 2.23% [31] which is higher than both samples of *M.charantia and D.mespiliformis* (1.03 and 0.94 %), respectively (Table 6).

Conclusion

The proximate, mineral, amino acid and anti–nutrient compositions of *M. charantia* fruit and pulp of *D. mespiliformis* are presented in this study. The study showed that *M. charantia* fruits and pulp of *D. mespiliformis* have moderate fat and protein contents with nutritionally valuable minerals (such as sodium, calcium, potassium and phosphorus) and useful amino acids expected for infants. There are also potential health beneficial constituents to be derived from the incorporation of these fruits into diets and this indicates the need for their exploitation in seeking optimum health benefits of the fruits for the populace. The study indicates that *M. charantia* fruit and fruit pulp of *D. mespiliformis* may be better sources of some of the essential nutrients than some of the members of the family to which they belong. However, some of the anti–nutrient contents may pose nutritional problems in their consumption.

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Conflict of Interest

Authors declare that there are no conflicts of interest in the study.

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