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INTERNATIONAL JOURNAL OF Aquaculture and Fishery Sciences OPEN ACCESS JOURNAL

ISSN: 2455-8400 DOI: https://doi.org/10.17352/ijafs

Research Article

Nutritional, phytochemical and biochemical composition of (*Moringa Oleifera*) raw seed, seed cake, and leaf meal for Aquaculture feeds

Argungu LA[1]*, Umar F[1], Jibrin H[2] and Hashim A[1]

[1]Department of Fisheries and Aquaculture, Usmanu Danfodiyo University, Sokoto, Nigeria

[2]Department Biotechnology Nigerian Institute for Oceanography and Marine Research, V.I., Lagos, Nigeria

Received: 11 January, 2022
Accepted: 21 May, 2022
Published: 23 May, 2022

***Corresponding authors:** Argungu LA, Department of Fisheries and Aquaculture, Usmanu Danfodiyo University, Sokoto, Nigeria, Tel: +2348125164538; E-mail: alkali.lawal@udusok.edu.ng

Keywords: Nutritional values; Phytochemical; Biochemical composition and *Moringa Oleifera* plants

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Abstract

The study was conducted on the nutritional and biochemical composition of the *Moringa oleifera* plant (Seed, Seed Cake, and leaf meal) at two different locations. The proximate and mineral composition were carried out at the Central Laboratory of the National Institute for Fresh-water Fisheries Research (NIFFR), New Bussa, Niger State, while the Biochemical and phytochemical analyses were conducted at Usmanu Danfodiyo University, Sokoto. The result for the proximate composition of the *M. oleifera* plant revealed that the moisture content for the *M. oleifera* leaves sample (8.88 ± 0.39%) was significantly higher when compared with the *M. oleifera* seed (4.81 ± 0.99%) and seed cake (7.43 ± 0.24%) while the seed having the lowest moisture content (4.81 ± 0.99). The crude protein content for *M. oleifera* seed cake (53.23 ± 0.42) was significantly ($p<0.05$) higher than that of *M. oleifera* seed (40.66 ± 0.34%) and the leaves meal had the lowest crude protein (27.26 ± 0.55). The ash contents for *M. oleifera* leaves meal (10.61 ± 0.14%) were significantly higher compared with *M. oleifera* seed cake (8.34 ± 0.07%), and the seed had the lowest ash content (3.44 ± 0.14%). The lipid content of *M. oleifera* leaves meal (17.17 ± 0.65%) was significantly higher when compared with *M. oleifera* seed, and the seed cake had the lowest lipid content (13.51 ± 1.23). The fiber content for *M. oleifera* seed (17.08 ± 0.61) was significantly higher when compared with *M. oleifera* leaves meal (8.91 ± 0.33%), and the seed has the lowest fiber content (2.48 ± 0.16). The NFE for M. *oleifera* leaves meal (27.17 ± 0,45%) was significantly higher when compared with *M. oleifera* seed (18.24 ± 0.94), and the seed cake had the least NFE content (15.02 ± 1.42%). The result of mineral composition showed that the plant contained a higher amount of some minerals; This includes potassium, calcium sodium, magnesium, and manganese. For the amino acid composition, it clearly stated that the plant contains some essential and non-essential amino acids. The results of the phytochemical test revealed that all the plant parts analyzed contain anti-nutritional factors. Further research should be carried out to test the nutritional and biochemical values of *Moringa oleifera* seed cake and leaf meal using culture fish species.

Introduction

Aquaculture has been the fastest-growing food sector for over 25 years, supplying 49% (8.6 kg/capita) of the total global food fish supply (17.6 kg/capita) in 2010 [1]. Fish is an important source of both food and income for many people in developing countries. In Africa, as much as 5% of the population, some 35 million people depend wholly or partly on the fisheries sector for their livelihood [2]. Due to the increase in world population and demand for animal protein, there will be a need for an increase in farm or cultured fish production. The ultimate goal of any fish industry is the attainment of sustainable fish production with minimum cost in the shortest time possible [3]. This has proved difficult in the developing nations because of the dependency on some conventional ingredients that are either imported or expensive where they locally exist, for instance, fish meal an essential dietary animal protein component of fish feed is usually imported from Demark, America, and some European countries [4]. Hence, aquaculture utilizes a lot of fishmeal to remain one of the fastest-growing animal food-producing sectors. The aquaculture sector alone consumed the equivalent of about 23.8 mmt of fish (live weight equivalent) or 87% of non-food fish in the form of feed inputs in 2006 [5]. Soya beans meal, groundnut cake, and some other plant protein sources have also become too expensive [6]. Recently, researchers have increasingly been paying attention to moringa (*Moringa oleifera* Lam).

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In Nigeria, a greater proportion of fish supply is derived from capture fisheries, which do not satisfy the demand of the ever-growing populace [7]. The need to increase the mass production of fish through aquaculture is imperative but this desire has been drawn back by the high cost of commercial feeds [8]. The rapid progress and success of commercial fish culture depend on the availability of good quality and cheap feed. Non-conventional feed resources are feedstuffs that are not consumed or utilized by humans and are utilized by animals for continuous metabolisms such as growth, reproduction, respiration, digestion, and maintenance activity in the body system [9]. Non-conventional are credited for being non-competitive in terms of human consumption, very cheap to purchase, by-product or waste from agriculture, farm-made feeds, and processing industries and can serve as a form of waste management in enhancing good sanitation [7,10,11].

Moringa oleifera Lam. (Moringaceae) is native to the southern foothills of the Himalayas in northwestern India and is the most widely cultivated species of the genus Moringa. *Moringa oleifera* is a fast-growing plant widely available in the tropics and subtropics countries of Africa, Arabia, South East Asia, Pacific Caribbean Islands, and South America, with several economic-important industrial and medicinal uses. It is grown and widely cultivated in the northern part of Nigeria and many countries in tropical Africa [12]. Moringaceae is a single genus family of shrubs and trees, which comprise 13 species, distributed in the Indian subcontinent (*M. oleifera* and *M. concanensis*), Kenya (*M. longituba* and *M. rivae*), north-eastern and southwestern Africa (*M. stenopetala*), Arabia, and Madagascar (*M. drouhardii* and *M. hildebrandtii*) [13,14]. The plant has many domestic names depending on the geographical location. In Nigeria, the Igbos call it "*okwe oyibo*", the Yoruba call it "*eweigbale*", while the Hausas call it "*sogele*" [15]. Moringa is a plant that contains high nutritive, agricultural, medicinal, industrial, and environmental benefits. The leaves and seeds were reported to have nutritive and medicinal value. The aim of the study is to assess the biochemical and nutritional values of *Moringa oleifera* seed cake and leaf meal for Aquaculture feeds.

Materials and methods

Sampling site

The research was conducted at two different locations. The proximate and mineral composition of the plant samples were carried out at the central laboratory of the National Institute for Fresh-water Fisheries Research (NIFFR), New Bussa, Niger state, while the biochemical and phytochemical analysis was conducted at Usmanu Danfodiyo University Sokoto.

Sample collection

The sample was collected from the Teaching and Research Fish Farm of the Department of Fisheries and Aquaculture at Usmanu Danfodiyo University Sokoto, Sokoto state. Fresh leaves and seeds were plucked from the Moringa tree at the fish farm, the leaves were removed from their branches. Both the leaves and seeds were placed on a tray separately and were allowed to dry for 2 weeks at room temperature for the removal of complete moisture. After which the seeds were removed from their pods. The seed cake was formed and oil was extracted using a mini oil extractor machine from the Department of Fisheries and Aquaculture. All the samples were for analysis.

Proximate analysis

Proximate analysis of the samples was carried out using the standard Methods of Analysis of the Association of Official Analytical Chemists [16]. The parameters analyzed and the methods were stated below:

Determination of moisture content

The empty flask (W_1) was weighed and 2g of the sample was added and weighed again (W_2). The sample was dried in an oven drier, at 105°C – 110°C for 24hrs. The sample was allowed to cool in a desiccator. The dried sample (W_2) was weighed again. Heating, cooling, and weighing were repeated on the fixed sample until constant weight is obtained. The moisture was then calculated following the procedure of [16] and based on the formula;

$$\%\text{Moisture} = \frac{w_3 - w_2}{w_2 - w_1} \times 100$$

Determination of ash content

An empty crucible was weighed (W_1) and 2g of fish sample was added to the crucible and weighed again (W_2). The sample was placed in a muffle furnace at 500°C – 600°C for 3hrs and allowed to cool in a desiccator [16]. The weight of the crucible and dry sample (W_3) was then taken and calculated using the following formula;

$$\%\text{Ash} = \frac{w_3 - w_2}{w_2 - w_1} \times 100$$

Determination of crude protein content

The estimation of crude protein involves the estimation of total nitrogen usually by the Kjeldahl procedure. The percentage of crude protein was obtained by multiplying the nitrogen content with a factor of 6.25 [16].

$$\%\ \text{Nitrogen} = \frac{\text{Titre value (TV)} \times 0.01\text{m} \times 0.014\text{m} \times 50 \times 100}{\text{Weight of sample} \times \text{mol.ofAliquots}}$$

% CP = % Nitrogen x 6.25

Determination of crude fat content

The fat content of the fish tissue (muscle) was extracted with petroleum ether using the Soxhlet extraction method. 250ml extraction flask was dried in the oven at 105-110°C and allowed to cool in the desiccator. The extraction flask was weighed (W_2). 2g of fish sample was weighed in a labeled porous thimble (W_1), and the porous thimble mouth was added to the dry 250ml extraction flask. The covered porous thimble was placed into the condenser and the apparatus was assembled and then extracted for about 5-6 hrs. The flask was allowed to

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cool in the desiccator and weighed (W_3). The percentage was then estimated using the formula below;

$$\% \text{ Fat} = \frac{w_3 - w_2}{w_2 - w_1} \times 100$$

Determination of soluble carbohydrate content

The Nitrogen free extract (N.F.E) referred to as soluble carbohydrate cannot be determined directly but was obtained by the difference between crude protein and the sum of ash, protein, crude fat, and crude fiber.

N.F.E = 100 (% Ash + % crude fiber + % crude fat + % crude protein).

Mineral's analysis

The percentage mineral element concentration was determined using Atomic Absorption Spectrometry. The concentration of Sodium (Na), Potassium (K), Calcium (Ca), Magnesium (Mg), Phosphorus (P), and Iron (Fe) was analyzed. Na and K in solution were determined by flame photometer while phosphorus was determined by Spectrophotometer. The concentrations of all the nutrients were observed by calculating the transmitted reading from the flame photometer and spectrometer.

Determination of phosphorus

Ash residue was dissolved with 5ml of 20 percent HCI and diluted to 50ml with distilled water. 2ml aliquot of the extract was pipetted into a 50ml volumetric flask. 2ml of ammonium molybdate solution was added and mixed, distilled water was also added to make a volume of 48ml. Finally, 1ml of the freshly diluted stannous chloride solution was added, and a volume was made with distilled water and mixed immediately. Then, the sample was analyzed using a spectrophotometer and calculated using the formula;

$$\text{Phosphoeus} = \frac{\text{Abs} \times 0.61 \times \text{DF}}{\text{Atomic weight of P}} \times \text{DF}$$

Determination of calcium and magnesium

1ml aliquots of the extract were pipetted in two titration flasks and diluted to 20ml of distilled water. 5ml of buffer solution and 10 drops each of KCN, and $NH_2OH.HCl$, $K_4Fe(CN)_6$, and triethanolamine were added and allowed for a few minutes for the reaction to take place. A 3ml drop of EBT indicator was added and the solution was titrated with EDTA to the permanent blue color. From the calibration of EDTA, you know the amount of Ca equivalent to 1ml of EDTA solution. Calculate the amount of Ca in 5ml extract and finally in the fish sample considering all the solutions.

$$\% \text{ Ca} = \frac{\text{Tv} \times \text{conc.EDTA} \times 1000}{20}$$

For Mg = net ml for (Ca + Mg) – net ml for Ca alone.

Determination of sodium and potassium

The flame photometer was set up according to the instruction in the instrument [17] using standard solutions; the instrument's readout was calibrated accordingly. The corresponding values of the standards on the instrument readout were recorded and used to plot the standard (Na^+) and (K^+) curves on the linear graph paper. Digested sample of the different samples was then aspirated into the flame photometer and the reading record in % (potential difference).

Biochemical analysis

Determination of amino acids: The amino acid composition of the moringa seed, leaf meal, and seed cake was determined using methods described by [18] as modified by [19]. The dried samples were defatted, hydrolyzed, evaporated in a rotary evaporator, and then loaded into the Technicon Sequential Multi-Sample Amino Acid Analyzer (TSM). Each of the defatted samples was weighed (200mg) into a glass ampoule, 5ml of 6 mol/L HCL was added and the content was hydrolyzed in an oven at 105 ± 5°C for 22 h. Oxygen was expelled into the ampoule by passing nitrogen gas into it. Amino acid analysis was done by ion-exchange chromatography [18] using a Technicon Sequential Multi-Sample Amino Acid Analyzer (Technicon Instrument Corporation, New York, NY). The period of analysis was 76min, with a gas flow rate of 0.50 mL/min at 60°C, and the reproductivity was ± 3%. The amino acid composition was calculated from the areas of standards obtained from the integrator and expressed as percentages of the total protein.

Phytochemical's analysis

The extracts of *Moringa oleifera* were screened for the presence of major phytochemicals such as flavonoids, alkaloids, tannins, steroids, glycosides, saponins, cardiac glycosides, balsam, volatile oil, and anthraquinone

Test for flavonoids

To 3ml aliquot of the filtrated, 1 ml of 10% NaOH sodium hydroxide was added. If the yellow color was developed, this indicates the possible presence of flavonoid compounds [20,21].

Test for tannins

Ferric chloride solution 5% was added drop 2-3 ml of the extract and the color produced was noted. Condensed tannins usually give a dark green color; hydrolyzable tannins give a blue-black color [21,22].

Test for saponin

5ml of the extract was placed in a test tube + 5 ml of water and sharked strongly. The whole tube was filled with froth that lasts for several minutes [21].

Test for glycosides

2.5 ml of 50% H_2SO_4 was added to 2.5 ml of the extracts in a test tube. The mixture was heated in boiling water for 15minutes. Cool and neutralized with 10% NaOH, added, 5 ml

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of Fehling's solution was added and the mixture was boiled. A brick-red precipitate was observed which indicates the presence of glycosides [23].

Test for alkaloids

About 2ml of each extract was stirred with 2 ml of 10% aqueous hydrochloric acid. 1ml was treated with a few drops of Wanger's reagent and the second 1ml portion was treated similarly with Mayers reagent. Turbidity or precipitation with either of these reagents was taken as preliminary evidence for the presence of alkaloids [23].

Test for cardiac glycosides (Keller-Killian's test)

To one of each extract 2 ml of 3.5 ferric chloride solution was added and allowed to stand for one minute. 2 ml of concentrated H_2SO_4 was carefully poured down the wall of the tube so as to form a lower layer. A reddish-brown ring in the interface indicates the presence of cardiac glycoside.

Test for steroids (Salkwoski)

This was carried out according to the method of [23]. 0.5g of the extract was dissolved in 2 ml of chloroform, and 2ml of Sulphuric acid was carefully added to form a lower layer. A reddish-brown color at the interface indicates the presence of a steroidal ring.

Test for saponin glycosides

To 2.5ml of the extract was added 2.5 ml of Fehling's solutions A and B. A bluish-green precipitate showed the presence of saponin glycosides [20].

Test for basalms

The extract was mixed with an equal volume of 90% ethanol, and 2 drops of alcoholic ferric chloride solution were added to the mixture. The dark green color indicates the presence of basalms [20].

Test for anthraquinones

5ml of each extract was shaken with 10 ml benzene and 5 ml of 10% ammonia solution. The mixture was shaken and the presence of a pink, red, or violet color in the ammoniacal (lower) phase indicates the presence of anthraquinones.

Test for volatile oil

1ml of the fraction was mixed with diluted HCL. A white precipitate was formed which indicated the presence of volatile oils [22].

Data analysis

All the data obtained were subjected to analysis of variance (ANOVA) and the treatment means were separated for significant differences following the procedure of Duncan's multiple range test [24]. The analysis was carried out using the computer software statistical package for the social sciences version 23.0 [25].

Results

Proximate composition of *M. oleifera* plant

The result for the proximate composition of the *M. oleifera* plant were presented in Table 1. The moisture content for the *M. oleifera* leaves sample (8.88 ± 0.39%) was significantly higher when compared with the *M. oleifera* seed (4.81 ± 0.99%) and seed cake (7.43 ± 0.24%) while the seed having the lowest moisture content (4.81 ± 0.99). The crude protein content for *M. oleifera* seed cake was significantly ($p<0.05$) higher than that of *M. oleifera* seed (40.66 ± 0.34%), and the leaves had the lowest crude protein (27.26 ± 0.55). The ash contents for *M. oleifera* leaves (10.61 ± 0.14%) were significantly higher compared with *M. oleifera* seed cake (8.34 ± 0.07%), and the seed had the lowest ash content (3.44 ± 0.14%). The lipid content of *M. oleifera* leaves (17.17 ± 0.65%) was significantly higher when compared with *M. oleifera* seed, and the seed cake had the lowest lipid content (13.51 ± 1.23). The fiber content for *M. oleifera* seed (17.08 ± 0.61) was significantly higher when compared with *M. oleifera* leaves (8.91 ± 0.33%), and the seed had the lowest fiber content (2.48 ± 0.16). The NFE for *M. oleifera* leaves (27.17 ± 0,45%) was significantly higher when compared with *M. oleifera* seed (18.24 ± 0.94), and the seed cake had the least NFE content (15.02 ± 1.42%).

Mineral composition of *M. oleifera* plant

The mineral composition presented in Table 2 shows that there was no significant difference in potassium percentage between *M. oleifera* leaves, seed, and seed cake (0.66 ± 0.33), (0.89 ± 0.01), and (0.68 ± 0.00) respectively. The percentage of sodium was significantly higher in *M. oleifera* seed (0.68 ±

Table 1: Proximate composition of *Moringa oleifera* plant.

Plant materials			
Parameters	**Leaf**	**Seed**	**Seed cake**
Moisture content	8.88 ± 0.39^a	4.81 ± 0.99^c	7.43 ± 0.2^{4}b
Crude protein	27.26 ± 0.55^c	40.66 ± 0.34^b	53.23 ± 0.42^a
Ash	10.61 ± 0.14^a	3.44 ± 0.14^c	8.34 ± 0.07^b
Lipid	17.17 ± 0.65^a	15.78 ± 0.51^{ab}	13.51 ± 1.23^b
Crude fiber	8.91 ± 0.33^b	17.08 ± 0.61^a	2.48 ± 0.16^c
NFE	27.17 ± 0.45^a	18.24 ± 0.94^b	15.02 ± 1.42^b

Note: Means with the same superscript along the column indicate no significant ($p < 0.05$) difference.
NFE= Nitrogen Free Extract

Table 2: Mineral composition of *Moringa oleifera* plant.

Plant materials			
Parameters (g/100g)	**Leaf**	**Seed**	**Seed cake**
Potassium(K)	0.66 ± 0.33^a	0.89 ± 0.01^a	0.68 ± 0.00^a
Sodium (Na)	0.14 ± 0.00^c	0.68 ± 0.00^a	0.46 ± 0.00^b
Calcium (Ca)	1.90 ± 0.02^a	0.23 ± 0.01^b	0.29 ± 0.02^b
Magnesium (Mg)	0.35 ± 0.00^a	0.19 ± 0.03^b	0.19 ± 0.00^b
Manganese (Mn)	0.01 ± 0.00^b	0.01 ± 0.00^a	0.01 ± 0.00^b

Note: Means with the same superscript along the column indicates no significant ($p<0.05$) difference

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0.00) than in *M. oleifera* leaves and seed cake and *M. oleifera* leaves had the lowest percentage (0.66 ± 0.33). The percentage of calcium was significantly higher in *M. oleifera* leaves (1.90 ± 0.02) than in *M. oleifera* seed and seed cake (0.23 ± 0.01) and (0.29 ± 0.02) respectively. Statistically no significant difference between the seed and the seed cake. The table shows that there was a significant difference in magnesium between *M. oleifera* leaves (0.35 ± 0.00) and the seed and seed cake. Statistically no significant difference in magnesium between the seed (0.19 ± 0.03) and seed cake (0.19 ± 0.00). There was no significant difference in manganese between *M. oleifera* seed cake and leaves, but between seed and seed cake there was a significant difference and between the seed and leaves there was a significant difference ($p < 0.05$).

Amino acids composition *M. oleifera* plant

Table 3 shows the amino acid composition of the *M. oleifera* plant. The study analyzed 9 amino acids (AA) in the seed and leave while the seed cake has 10 AA. Aspartic acids had the highest concentration in seed, with glycine having the least concentration followed by tryptophan. Aspartic acid is a non-essential amino acid and is acidic.

Phytochemical composition of *Moringa oleifera* plant

The results of a phytochemical test of *M. oleifera* were presented in Table 4. The qualitative tests revealed the presence of a large number of flavonoids, tannins, glycosides, alkaloids, cardiac glycosides, balsam, and volatile oil in *M. oleifera* leaves. The seed also reveals a moderate amount of saponins and saponin glycosides, with a trace number of steroids and anthraquinone, which were not detected.

The result in Table 4 shows that seed cake contains a large amount of basalm and alkaloids and also a moderate amount of volatile oil, cardiac glycosides, steroids, and glycosides with a trace number of flavonoids, tannins and saponins with saponin glycosides and anthraquinone not detected.

A large number of saponins, glycosides, alkaloids, cardiac glycosides, basalm, and volatile oil were present in the *M. oleifera* seed. A moderate number of tannins and steroids was revealed in the table. The Table revealed a trace number of flavonoids with saponin glycosides and anthraquinone not detected.

Discussion

Proximate composition *Moringa oleifera* plant

The proximate composition of *Moringa oleifera* leaf meal in the present investigation revealed that the crude protein in Table 1 was higher than that reported by [26]. The nitrogen-free extract (NFE) and lipids reported in Table 4 were higher than those obtained by [27]. Carbohydrate (NFE) deficiency causes depletion of body tissues [28]. Carbohydrates of legumes are known to reduce plasma cholesterol and gradually elevate the levels of blood glucose [29,30]. The moisture content and crude fiber of *the Moringa* oleifera leaf meal presented in Table 1 were lower than those obtained by [26]. But the ash content of the leaf meal reported here was higher than that obtained by [26].

Table 3: Amino acids composition of *Moringa oleifera* plant.

S/N	Amino acids	Seed	Seed cake	Leaf
	Alanine	0.47	0.49	-
	Aspartic	2.32	0.96	0.59
	Histidine	0.53	-	0.28
	Tryptophan	0.35	0.70	-
	Serine	0.40	-	-
	Isoleucine	0.36	0.59	0.41
	Proline	0.67	0.67	0.43
	Glycine	0.33	-	-
	Threonine	0.42	1.05	0.70
	Leucine	-	1.23	0.67
	Tyrosine	-	-	0.57
	Phenylalanine	-	1.24	0.86
	Valine	-		0.29
	Lysine	-	0.58	-
	Methionine	-	0.84	-

Table 4: Phytochemical composition of *Moringa oleifera* plant.

S/N	Parameters	Seed	Seed cake	Leaf
	Flavonoids	+++	+	+
	Tannins	+++	+	++
	Saponins	++	+	+++
	Glycosides	+++	++	+++
	Alkaloids	+++	+++	+++
	Steroids	+	++	++
	Cardiac glycosides	+++	++	+++
	Saponin glycosides	++	ND	ND
	Balsam	+++	+++	+++
	Anthraquinone	ND	ND	ND
	Volatile oil	+++	++	+++

Note: Trace amount +, Moderate amount ++, Large amount +++; Not detected (ND)

The seed of *Moringa oleifera* crude protein and crude fiber in Table 1 were higher than those obtained by [27]. The moisture content, ash, and lipids of *Moringa oleifera* seed reported here were lower than those reported by [27]. NFE content of the seed obtained here was higher than that reported by [27]. The crude protein, lipids, and ash of *Moringa oleifera* seed cake reported here were higher than those reported by [27]. Whereas, *Moringa oleifera* seed cake moisture content and crude fiber obtained were lower than those reported by [27]. NFE content of the seed cake was lower than that reported by [27]. The variations in proximate compositions with the other study may be due to environmental factors such as soil types, season, geographical location, provenances, harvesting time, and stage of maturity [31].

Mineral composition of *Moringa oleifera* plant

The mineral composition of plants is dependent on the soil edaphic factors, including the generic origin and geographical sources [32]. The *Moringa oleifera* plant contains considerable

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amounts of some minerals analyzed. This includes potassium, calcium sodium, magnesium, and manganese. The result in Table 2 revealed the mineral composition of *M. oleifera* leaves, seed, and seed cake. The leaves, seed, and seed cake contain an appreciable amount of potassium. *M. oleifera* leaves shown in Table 2 have higher values of calcium and magnesium. The seed shows higher values of potassium and sodium. Calcium in seed was lower than that obtained by [33]. The percentage of potassium in *M. oleifera* leaves reported here was higher than that reported by [34]. It was also higher than what was obtained in some common Nigerian vegetables reported by [35]. *Basellatubra* (5.80g/100g) and *Amaranthus hybridus* (4.2g/100g). The potassium level of the seed and seedcake revealed in the table was higher than that obtained by [27]. Calcium is an important dietary mineral for strong bones and muscle/neurological function [34]. The sodium of leaves, seed, and seed cake was higher than those obtained in *C. Tora* (0.10g/100g) and *C integrifolia* (0.07g/100g) reported by [31].

Amino acids composition of *M. oleifera* plant

Table 3 shows the amino acid composition of the *M. oleifera* plant. The study analyzed 9 amino acids (AA) in the seed and leave while the seed cake has 10 AA. Aspartic acids had the highest concentration in seed, with glycine having the least concentration followed by tryptophan. Aspartic acid is a non-essential amino acid and is acidic. The aspartic, tyrosine and isoleucine acid of the leaves reported were lower than that obtained by [36]. The leaves were shown to lack methionine which is commonly deficient in green leaves [37]. Moreover, the leucine concentration of leaves differed from that of [37]. Phenylalanine was also the highest concentrated amino acid in the seed cake, while leucine and threonine were the second and third concentrated amino acids in seed cake, but leucine and phenylalanine were absent in seed. Methionine was present in seed cake; methionine is a powerful antioxidant that helps in the detoxification of harmful compounds and protects the body from radiation [38]. The highest value of essential amino acids in each sample was histidine in seeds and phenylalanine in seed cake and leaves respectively.

Each amino acid has a specific function in the animal's body [36]. In general, amino acids are required for the production of enzymes, immunoglobins, hormones, growth, repair of body tissues, and form of the structure of red blood cells [38].

Phytochemical test of *Moringa oleifera* plant

The results of the phytochemical and anti-nutrient test in Table 4, revealed the presence of flavonoids, tannins, saponin, alkaloids, steroids, cardiac glycosides, glucoside, balsam anthraquinone, and volatile oil. These phytochemicals exhibit diverse pharmacological and biochemical actions when ingested by animals [39]. Phytochemicals/ANFs are a class of compounds that are generally not lethal. They diminish animal productivity but may also cause toxicity during periods of scarcity or confinement when the feed rich in these substances is consumed by animals in large quantities. Tannins have been reported to cause poor palatability in high Tannin diet due to the astringent property as a result of their ability to bind with protein of saliva and mucosa membranes [40,41]. The effect of high condensed tannin concentrations is to make the animal both energy and protein deficient, causing reduced growth or weight loss and poor reproduction [42]. Tannins also have the ability to bind dietary proteins and digestive enzymes into complexes that are not readily digestible [40,41]. The importance of alkaloids, sterols, saponins, and tannins comes from their uses as an antimicrobial for treating many pathogens [43]. Saponins form a group of compounds, on consumption in large quantities causes deleterious effects such as hematolysis and permeabilization of the intestine [44]. Saponins have also been shown to have hypocholesterolemia as well as anticarcinogenic effects [45]. Saponins from some plants have an adverse effect on the growth of animals but those present in Moringa leaves did not show hemolytic activity, and humans consume them without apparent harm. The cholesterol-lowering effect in animals and humans is reported to be through the formation of mixed micelles and bile acids into micelle bile acid molecules [46].

Conclusion and recommendation

From the present study, it can be concluded that the leaf meal, seed meal, and seed cake with a crude protein content of 27.26%, 40.66%, and 53.23% respectively, and Nitrogen free extract of 27.17%, 18.24%and 15.02% could serve as both protein and energy supplement respectively. Furthermore, the Moringa plant contained the appropriate dietary nutrients that are required for growth, metabolism, and reproduction. The results of the phytochemical test revealed that the leaf contains anti-nutritional factors. Moreover, the plant contains a suitable number of amino acids needed for growth and hormone development. Therefore, the Moringa plant can be explored as a viable supplement for fish which will help to reduce the cost of feed production in aquaculture and increase the profit of fish farmers and feed manufacturers.

It was recommended that this finding could serve as a guide in providing nutritional and biochemical information about the *M. oleifera* plants. Further research should be carried out to test the nutritional and biochemical values of the *Moringa oleifera* plant using culture fish species.

It was also recommended that further investigation on the processing methods of removing the anti-nutritional factors to enhance feed palatability and acceptability can improve nutrient utilization to produce healthy fish when tested to culture fish species.

Acknowledgments

We greatly acknowledge the guidance and assistance given by the technical staff of the Department of Fisheries and Aquaculture, Faculty of Agriculture, Usmanu Danfodiyo University, Sokoto, Nigeria.

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Citation: Argungu LA, Umar F, Jibrin H, Hashim A (2022) Nutritional, phytochemical and biochemical composition of (*Moringa Oleifera*) raw seed, seed cake, and leaf meal for Aquaculture feeds. Int J Aquac Fish Sci 8(2): 037-044. DOI: https://dx.doi.org/10.17352/2455-8400.000076

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