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Proximate Compositions on Leaves & Seeds of Selected Drumsticks (*Moringa oleifera* lam.) from Northern Nigeria

Nafisat Muhammad Ndayankpa*, Olamide Ahmed Falusi, Oladipupo Abdulazeez Yusuf Daudu, Mathew Omoniyi Adebola, Abdulhakeem Abubakar

Department of Plant Biology, School of Life Sciences, Federal University of Technology, Minna, Nigeria

Email address:

nafisatndayankpa@gmail.com (Nafisat Muhammad Ndayankpa)

*Corresponding author

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Abstract: Drumsticks, *Moringa oleifera* (Lam.) is one of the most important cultivated and economic plant in the genus Moringa of the family Moringaceae. It is a multi-purpose foods and medicinal plants that have the potential to contribute to food and nutritional security, health care and the environment as well as the socio-economic livelihood of Sub-Sahara Africa people. A total of twenty three (23) selected unique genotypes based on phenotypic markers characterisation of 40 accessions collected in germplasm survey of 47 towns and 12 villages of 11 states including federal capital territory (FCT), in Northern Nigeria were collected from gene bank of Federal University of Technology, Minna for assessment of proximate composition of the seeds and leaves using standard procedures. The results of proximate composition of the leaves showed that NGR-ZFR-14, SOK-32, BCH-11 and ZFR-16 had the highest ash content (12.95), crude protein (35.46), fibre (8.2) and carbohydrate content (64.70) respectively. While for the seed, BEN-28 showed the highest ash (4.89) and fiber content (3.23), NG-02 had the highest fat content (43.60), the highest protein was recorded in YOB-29 (39.10). *Moringa oleifera* is an impressive and outstanding tree due to its exceptional value, from a nutritional as well a therapeutic point of view. It has remarkable potential in providing an inexpensive and credible alternative to not only good nutrition, but also a positive contribution to health due to the vast medicinal properties that it offers. The presence of tested nutritional chemical compounds proves why leaves and seeds of *M. oleifera* are used as a food source to overcome malnutrition especially in children, infants and nursing mothers.

Keywords: Drumsticks, Genetic Diversity, Germplasm and *Moringa oleifera*

1. Introduction

Drumsticks, *Moringa oleifera* (Lam.) of the Moringaceae family is one of the important multi-purpose foods and medicinal plants that has the potential to contribute to food and nutritional security, health care and the environment as well as the socio-economic livelihood of Sub-Sahara Africa people [1]. It is one of the most cultivated and economic species in the genus *Moringa* of the family Moringaceae [2].

A total of 13 tropical and subtropical species of the Moringa genus are known, and of these, many are in danger of extinction, only *M. oleifera* L. is cultivated in Nigeria [3]. Also, it is one of the newly discovered vegetable which is gaining wide acceptance and widely cultivated in the northern parts of Nigeria where it is locally called “zogale” (among the Hausa speaking people), ‘igbale igi iyanu” and “odudu oyibo” in Yoruba and Igbo languages, respectively [2]. Inspite of the economic values of the plant to the Northern Nigeria populace, there were little research on the proximate composition of cultivated species. The neglection may be probably due to loss of local knowledge and lack of established varietiess with little or no research attention [4, 5]. Hence, this study intends to evaluate the proximate compositions of seeds and leaves of selected genotypes *M. oleifera* from the cultivated regions in northern Nigeria.

2. Materials and Methods

2.1. Collection of Materials

The selected genotypes used were collected from gene bank of Federal University of Technology, Minna.

2.2. Nutritional Composition of M. oleifera Leaves and Seeds

Proximate analyses to determine the moisture, protein, carbohydrates, crude fibre, Ash, ether extract, and energy value compositions were carried out according to the procedure of Association of Official Analytical Chemist [6].

2.2.1. Determination of Moisture Contents

Moisture content of each sample was determined as described by Onwuka [7], using vacuum oven method. Two grams of the sample was weighed into a pre-weighed dried dish (W1) and weighed with the dish (W2). It was dried to a constant weight at 100°C at a pressure that was not exceeding 100 mmHg for 5 hours. The dried samples and the dish were placed in the desiccators to cool and reweighed (W3) and the loss in weight was recorded. The percentage moisture was calculated as below;

$$\% \text{ moisture} = \frac{W2 - W1}{W3 - W1} \times 100 \quad (1)$$

Where;
W1 = Initial weight of the empty crucible
W2 = Weight of the crucible plus (+) the sample before drying
W3 = Final weight of crucible + sample after drying
% total solid (dry matter) = 100 % moisture.

2.2.2. Crude Fiber Determination

A non-enzymatic method of Association of Official Analytical Chemist [8] was used to determine crude fiber content. Two grams of the dried sample was defatted with petroleum ether and boiled under reflux for 30 minutes with 200ml of solution containing 1.5 g of H2SO4 /100 ml of the solution. The solution was filtered through linen on a fluted funnel and washed with boiling water until the washing was no longer acidic. The residue was transferred to a beaker and boiled for 30 minutes in 200 mL of solution containing 1.25 g of carbonate-free NaOH per 100 mL. Final residue was filtered through a thin but closed pad of washed and ignited asbestos in porcelain crucible. It was dried in electric oven, weighed, incinerated, cooled and reweighed. The loss in the weight after incineration x 100 was calculated as the percentage (%) of the crude fiber.

$$\% \text{ crude fibre} = \frac{\text{Loss in weight(g)}}{\text{Original mass (2.0)}} \times 100 \quad (2)$$

2.2.3. Carbohydrate Content Determination

Carbohydrate content was determined by difference as described by AOAC [9] where the total proportion of carbohydrate in the samples were obtained by calculation, using the percentage weight method by subtracting the % sum of food nutrients: (% protein, % crude fiber, fat % and % ash %) from 100 %.

$$\text{Percentage (\%) of carbohydrates (=) (CF + CP + F + A + M} - 100\%) \quad (3)$$

Where;
CF = Crude Fibre,
CP= Crude Protein,
M = Moisture, F = Fat and A = Ash.
Note: Triplicate values were obtained for each sample.

2.2.4. Crude Protein Determination

The crude protein of the samples was determined using the micro–Kjeldahl method described by AOAC [8]. Two grams was weighed along with 20 ml of distilled water into a micro – Kjeldahl digestion flask. It was shaken and allowed to stand for some times. One tablet of selenium catalyst and 20 mL tetraoxo sulphate (VI) acids were added. The flask was heated on the digestion block at 100°c for 4 hours until the digest became clear. The flask was removed from the block and allowed to cool and the content was transferred into 50 mL volumetric flask and diluted to the mark with water. An aliquot of the digest (10ml) was transferred into another micro-Kjeldahl flask along with 20ml of distilled water, placed in the distilling outlet of the micro – Kjeldahl distillation unit. A conical flask containing 20 mL of boric acid indicator was placed under the condenser outlet and sodium hydroxide solution of 20 mL was added to the content in the Kjeldahl flask by opening the funnel stopcock. The distillation started and the heat supplied was regulated to avoid sucking back. Distillate was collected in 4% boric acid and the distillation was stopped. Nitrogen in the distillate was determined by titrating with 0.014 M of H_2SO_4; the end point was obtained when the color of the distillate changed from green to pink.

Calculation;

$$\% \text{ Crude protein} = \% \text{ N x } 6.25 \text{ (conversion factor)} \quad (4)$$

The nitrogen content of the sample is given by the formula below.

$$\% \text{ N} = \text{TV x Na x } 0.014 \text{ x V1 x } 100 \text{ x G x V2} \quad (5)$$

Where;
TV = Titre value of acid (cm^3)
Na = Normality of acid
V1 = Volume of distilled water used for distilling the digest (50 ml).
V2 = Volume of aliquot used for distillation (10ml)
G = Original weight of sample grams

2.2.5. Ash Content Determination

Ash content was determined; using incineration at 600°C in a muffle furnace, according to the method described by AOAC [10]. Two grams of each sample was weighed into a weighed and ignited tarred crucible (W1). The crucible and weighed sample were placed on a hot plate inside a fume cupboard to prevent smoke accumulation, the remaining residue was

transferred to a preheated muffle furnace and maintained at 600°c for 6 hours to ash until the sample was reduced to a light ash, the crucible was removed, placed in the desiccators, cooled and weighed (W2) and the ash content was calculated:

$$\% \text{ ash (on dry basis)} = \frac{W2-W1}{2.0g} \times 100 \quad (6)$$

2.2.6. Energy Level

The energy level was calculated using the formula;

$$Energy\ (Kcal) = [(\%\ CHO \times 4) + (\%\ CP) + (\%\ Fat + 9)] \quad (7)$$

Where; CHO, CP and CL stand for carbohydrate, crude protein and crude lipid respectively.

3. Results and Discussion

3.1. Proximate Composition of Moringa oleifera Seeds

The result of dry matter revealed a significant difference at p≤0.05 as the highest and lowest content was recorded in accessions ZFR-14 and NSR-09 with mean value of 97.97% and 72.81% respectively. These values were significantly different from one another and from all the accessions (Table 1). The highest moisture content of the seed was recorded in NSR-09 (7.19%), this value was significantly different (p≤0.05) with all other accessions The lowest moisture content was recorded in accession ZFR-14 with the mean value of 2.03 %. This value was not significantly different from accession KAD-18, but differs significantly from all other accessions (Table 1).

Accession NGR-BEN-31 recorded the highest ash content (4.89%) which differ significantly from all other accessions while the lowest was recorded in accession NGR-NG-02 with mean value of 1.53%, this value also differ significantly from all other accessions (Table 1). The result for fat content revealed a high significant difference (P≤0.05) as the lowest and highest fat content was recorded in accession NGR-SOK-36 and NGR-NG-02 with the values of 19.77% and 43.60%. These values differ significantly from one another and from all other accessions (Table 1). The highest crude protein content was recorded in accession NGR-YOB-32 (39.10 %) which was not significantly different from the value obtained from accession NGR-KN-22 (38.70%), but differs significantly from the values of other accessions. The lowest protein content was recorded in accession NGR-NG-03 with the mean value of (15.54%). This value was not significantly different (p≥0.05) from the value 15.94% obtained in accession NGR-ZFR-14 but differs significantly from the values of all other accessions (Table 1).

Crude fiber content was lower in accession NGR-JGW-27 with the mean value of 1.34% while the content was higher in accession NGR-BEN-31 with mean value of 3.23%. This value does not differ significantly with the value (3.09%) obtained from NGR-ZFR-14 but differs significantly from all other accessions. The result for carbohydrate (CHO) content showed that accession NGR-NG-01 with the mean value 49.46% had the highest CHO content and accession NGR-KN-22 with the value 16.85% recorded the lowest CHO content. These values were significantly different from each other and from all other accessions at p≤0.05 (Table 1). The energy value recorded for seed in this study revealed that the content was lower in accession NGR-SOK-32 (460.43 kcal/100g) and higher in accession NGR-NG-02 (579.02 kcal/100g), these values differ significantly from one another and also differ significantly from the values of all other accessions (Table 1).

Table 1. *Proximate composition of selected Moringa oleifera seeds from Northern Nigeria.*

Accession	Dry Matter %	Moisture %	Ash %	Fat %	Crude Protein %	Crude Fibre %	CHO %	Energykcal/100g
NGR-NG-01	95.02±0.03^{e}	4.98±0.03^{g}	2.46±0.03^{c}	23.40±0.01^{b}	17.07±0.35^{c}	2.63±0.01^{cdef}	49.46±0.36^{q}	476.69±0.10^{b}
NGR-NG-02	94.54±0.02^{d}	5.46±0.02^{h}	1.53±0.05^{a}	43.60±1.23^{m}	23.95±0.13^{f}	2.75±0.03^{def}	22.72±1.06^{fg}	579.02±6.33^{m}
NGR-NG-03	93.57±0.00^{b}	6.43±0.00^{j}	3.94±0.02^{f}	26.11±0.11^{c}	15.54±0.22^{a}	2.60±0.01^{cdef}	45.37±0.30^{o}	478.64±0.68^{b}
NGR-BEN-30	96.51±0.02^{h}	3.49±0.02^{d}	3.02±0.07^{d}	38.16±0.15^{k}	34.38±0.38^{i}	2.00±0.04^{abc}	19.45±0.89^{bc}	558.79±0.73^{k}
NGR-BEN-29	97.09±0.42^{i}	2.91±0.42^{c}	3.97±0.01^{f}	32.53±0.02^{efg}	35.94±0.04^{k}	2.62±0.00^{cdef}	22.03±0.40^{ef}	524.69±1.63^{f}
NGR-BEN-31	95.05±0.00^{e}	4.95±0.00^{g}	4.89±0.03^{i}	41.65±0.06^{l}	16.46±0.09^{bc}	3.23±0.02^{f}	28.81±0.10^{jk}	555.93±0.52^{k}
NGR-SOK-35	95.52±0.02^{f}	4.48±0.02^{f}	3.09±0.09^{d}	19.77±0.56^{a}	36.82±0.04^{l}	2.04±0.06^{abcd}	33.81±0.68^{l}	460.43±2.12^{a}
NGR-SOK-36	95.07±0.00^{e}	4.93±0.00^{g}	2.45±0.01^{c}	25.21±0.04^{c}	23.99±0.00^{f}	1.62±0.01^{ab}	41.80±0.06^{n}	490.02±0.16^{c}
NGR-SOK-39	96.49±0.05^{h}	3.51±0.05^{d}	2.67±0.01^{c}	33.35±0.97^{gh}	31.52±0.26^{h}	1.76±0.01^{ab}	25.68±0.29^{h}	539.49±0.48^{hi}
NGR-BCH-11	93.59±0.00^{b}	6.41±0.00^{j}	2.48±0.00^{c}	33.47±0.00^{ghi}	34.70±0.15^{ij}	1.63±0.00^{ab}	21.32±0.14^{de}	525.26±0.00^{f}
NGR-BCH-12	94.09±0.00^{c}	5.92±0.00^{i}	2.64±0.00^{c}	27.84±0.26^{d}	35.79±0.07^{k}	1.74±0.00^{ab}	26.06±0.33^{h}	498.01±1.26^{d}
NGR-JGW-26	93.68±0.00^{b}	6.32±0.00^{j}	4.46±0.00^{g}	32.67±0.01^{efg}	23.60±0.04^{f}	2.94±0.00^{ef}	30.02±0.05^{k}	508.47±0.03^{e}
NGR-JGW-27	96.02±0.02^{g}	3.98±0.02^{e}	2.02±0.10^{b}	37.24±0.26^{jk}	20.31±0.09^{d}	1.34±0.07^{a}	35.10±0.19^{m}	556.86±1.88^{k}
NGR-ZFR-14	97.97±0.03^{k}	2.03±0.03^{a}	4.68±0.22^{h}	41.36±0.23^{l}	15.94±0.09^{ab}	3.09±0.15^{f}	32.91±0.26^{l}	567.60±2.73^{l}
NGR-ZFR-16	97.53±0.01^{j}	2.47±0.01^{b}	4.45±0.00^{g}	33.09±0.09^{fgh}	34.19±0.04^{i}	2.94±0.00^{ef}	22.86±0.05^{fg}	525.99±0.43^{f}
NGR-KN-21	97.04±0.00^{i}	2.96±0.00^{c}	4.36±0.01^{g}	34.05±0.06^{hi}	31.96±0.70^{h}	2.88±0.01^{ef}	23.80±0.63^{g}	529.45±0.22^{fg}
NGR-KN-22	94.10±0.01^{c}	5.90±0.01^{i}	3.91±0.00^{f}	32.07±0.05^{ef}	38.70±0.09^{m}	2.58±0.00^{cdef}	16.85±0.04^{a}	510.80±0.26^{e}
NGR-KAD-19	96.03±0.01^{g}	3.97±0.01^{e}	2.66±0.20^{c}	36.33±0.32^{j}	35.11±0.09^{j}	1.76±0.13^{ab}	20.17±0.09^{cd}	548.07±2.91^{j}
NGR-KAD-18	97.83±0.18^{jk}	2.17±0.18^{ab}	2.49±0.02^{c}	31.61±0.51^{e}	34.67±0.09^{ij}	1.65±0.01^{ab}	27.41±0.81^{i}	532.81±1.70^{g}
NGR-NSR-06	96.55±0.00^{h}	3.45±0.00^{d}	2.52±0.00^{c}	25.16±0.04^{c}	19.96±0.17^{d}	2.65±0.99^{cdef}	47.24±0.14^{p}	495.29±0.21^{d}
NGR-NSR-09	92.81±0.23^{a}	7.19±0.23^{k}	3.05±0.03^{d}	36.63±0.01^{j}	22.50±0.09^{e}	2.01±0.02^{abc}	28.62±0.10^{ij}	534.13±0.66^{gh}
NGR-YOB-32	96.47±0.03^{h}	3.53±0.03^{d}	2.48±0.00^{c}	34.66±0.00^{i}	39.10±0.13^{m}	1.63±0.00^{ab}	18.61±0.10^{b}	542.74±0.09^{i}
NGR-FCT-05	96.63±0.05^{h}	3.37±0.05^{d}	3.48±0.03^{e}	34.29±0.03^{hi}	26.93±0.04^{g}	2.30±0.02^{bcde}	29.64±0.11^{jk}	534.86±0.56^{gh}

* Values are mean of triplicate data; mean value follow by the same latter(s) along the column are not significantly different at p ≤ 0.05 by Duncans Multiple Range Test.

3.2. Proximate Composition of Moringa oleifera Leaves

It was observed that accession NGR-ZFR-16 had the highest dry matter content of 98.64%. This value was significantly different at p≤0.05 from all other accessions. The lowest value was obtained in accession NGR-ZFR-14 (96.30%) which was significantly the same with accessions NGR-NSR-09, NGR-BCH-12, NGR-KN-21, NGR-JGW-26 and NGR-BEN-31, but significantly different from other accessions (Table 2). The moisture content of the leaves was higher in accession NGR-ZFR-14 with a mean value of 3.70, this value was the same significantly with accessions NGR-NG-02, NGR-NSR-09, NGR-BCH-12, NGR-KN-22, NGR-BEN-31 and NGR-JGW-26, but significantly different from other accessions. The lowest value was recorded in NGR-ZFR-16 (1.36%) this value was significantly different from all other accessions (Table 2).

The result of ash content showed a significant difference as the lowest percentage was recorded in accession NGR-ZFR-16 (4.77%), this value differ significantly (p<0.05) from all other accessions. The highest value was observed and recorded in accession NGR-ZFR-14 with a mean value of 12.95% which was significantly the same with accessions NGR-NG-01 and NGR-BCH-11 but significantly different from other accessions. Accession NGR-NG-01 recorded the highest value of ether extract content on moringa leaves with the mean value of 12.77%. This value was significantly different from all other accessions. The least value was recorded in accession NGR-ZFR-16 (3.55%) which was the same significantly with accession NGR-BCH-11 and NGR-KN-22 (4.00) but different significantly from other accession (Table 2).

The crude protein content was higher in accession NGR-SOK-35 with mean value of 35.46%, this value was significantly different from all other accessions while the least was recorded in accession NGR-BEN-31 (13.57%) which was significantly the same with accession NGR-NSR-09 (14.10%) but significantly different from other accessions. The result of crude fibre showed that accession NGR-BCH-11 had the highest crude fibre content with a mean value of 8.21%, this value was the same significantly with NGR-NG-01 (8.16%) but significantly different from all other accessions. The least value of the crude fibre was observed and recorded in NGR-ZFR-16 (3.15%) which was different from all other accessions significantly (Table 2).

The carbohydrate content was higher in accession NGR-ZFR-16 with mean value of 64.70%. This value was significantly different (p≤0.05) from all other accessions. The lowest value was recorded in accession NGR-BEN-29 (38.65%) which was different significantly from all other accessions. The highest energy value content was recorded in accession NGR-KAD-18 with mean value of 388.00 kcal/100g, this value was significantly the same with 387.75 kcal/100g, 385.75 kcal/100g, and 382.55 kcal/100g of accessions NGR-NG-02, NGR-SOK-35 and NGR-KN-21, respectively but significantly different from other accessions (Table 2). The lowest energy value content was recorded in NGR-BCH-11 (325.94 kcal/100g), this value was different from all other accessions significantly.

Table 2. *Proximate composition of selected Moringa oleifera Leaves from Northern Nigeria.*

Accession No.	Matter %	Moisture %	Ash %	Ether extract (%)	Crude protein %	Crude fibre %	CHO %	Energy value Kcal/100g
NGR-NG-01	97.09±0.00bc	2.91±0.00bc	12.37±0.01klm	12.77±0.64j	18.52±0.04f	8.16±0.01k	45.27±0.58c	370.10±3.25hi
NGR-NG-02	97.05±0.00abc	2.95±0.01bcd	5.98±0.04bc	7.84±0.00fg	18.65±0.18f	3.94±0.02b	60.64±0.11h	387.75±0.28jk
NGR-NG-03	97.62±0.00c	2.38±0.00bc	10.34±0.06ghi	6.97±0.01de	17.73±0.22e	6.82±0.04gh	55.75±0.30g	356.67±0.40cde
NGR-FCT-05	97.58±0.00bc	2.42±0.00bc	8.46±0.01e	6.86±0.16de	16.16±0.04cd	5.59±0.00d	60.52±0.22h	368.43±0.73ghi
NGR-NSR-06	97.56±0.00bc	2.44±0.00bc	8.53±0.01e	6.32±0.00d	14.40±0.04b	5.63±0.01de	62.69±0.03i	365.22±0.11fghi
NGR-NAS-09	96.83±0.01ab	3.17±0.01cd	11.10±0.02ij	7.20±0.01ef	14.10±0.09ab	7.33±0.02hi	57.11±0.14g	349.60±0.11c
NGR-BCH-11	97.56±0.03bc	2.45±0.03bc	12.44±0.00lm	3.67±0.18a	25.61±0.04l	8.21±0.00k	47.62±0.25d	325.94±0.79a
NGR-BCH-12	97.01±0.00 abc	2.99±0.00bcd	10.45±0.00hi	8.60±0.35gh	24.04±0.04j	6.90±0.00gh	47.02±0.41cd	361.67±1.72efg
NGR-ZFR-14	96.30±0.24a	3.70±0.24d	12.95±0.84m	6.61±0.14de	21.80±0.09g	7.55±0.44ij	47.38±0.87d	336.23±1.84b
NGG-ZFR-16	98.64±0.13d	1.36±0.13a	4.77±0.45a	3.55±0.10a	22.46±0.04hi	3.15±0.30a	64.70±1.02j	380.60±3.00j
NGR-KAD-18	97.51±0.00bc	2.49±0.00bc	8.70±0.00ef	11.31±0.17i	21.98±0.26gh	5.74±0.00de	49.78±0.44e	388.80±0.85k
NGR-KAD-19	97.44±0.01bc	2.56±0.01bc	8.96±0.02ef	5.56±0.15c	21.54±0.09g	5.91±0.02de	55.47±0.28g	358.11±0.53def
NGR-KN-21	97.05±1.01abc	2.95±1.01bcd	6.77±0.00cd	7.85±0.84fg	16.68±0.04d	4.47±0.00c	61.28±0.14hi	382.55±8.39jk
NGR-KN-22	97.78±0.01c	2.22±0.01bc	7.34±0.45d	4.00±0.12ab	24.82±0.04k	4.84±0.30c	56.77±0.92g	362.40±2.42efgh
NGR-JGW-26	97.02±0.00abc	2.98±0.00bcd	10.44±0.01hi	8.76±0.03h	22.81±0.04i	6.89±0.00gh	48.11±0.08de	362.52±0.09efgh
NGR-JGW-27	97.28±0.24bc	2.72±0.24bc	9.50±0.84fg	4.69±0.24b	15.98±0.22c	6.27±0.56ef	60.84±2.09hi	349.46±5.34c
NGR-BEN-29	97.64±0.02bc	2.36±0.02b	11.89±0.01jkl	8.74±0.00h	30.52±0.04m	7.85±0.01ijk	38.65±0.05a	355.29±0.00cde
NGR-BEN-30	97.59±0.00bc	2.41±0.00bc	12.01±0.00kl	8.86±0.00h	16.16±0.31cd	7.92±0.00jk	52.64±0.30f	354.98±0.06cde
NGR-BEN-31	97.05±0.00abc	2.95±0.00bcd	11.49±0.01jk	8.92±0.00h	13.57±0.44a	7.58±0.01ij	55.49±0.43g	356.50±0.07cde
NGR-YOB-32	97.60±0.00bc	2.41±0.00bc	8.42±0.00e	7.17±0.00ef	14.56±0.11b	5.56±0.00d	61.89±0.11hi	370.36±0.04i
NGR-SOK-35	97.52±0.00bc	2.48±0.00bx	5.88±0.00b	6.94±0.00de	35.46±0.44n	3.88±0.00b	45.36±0.44c	385.75±0.00jk
NGR-SOK-36	97.53±0.00bc	2.47±0.00bc	10.40±0.01hi	7.28±0.00ef	30.21±0.44m	6.87±0.01gh	42.77±0.45b	357.45±0.07cdef
NGR-SOK-39	97.32±0.20bc	2.69±0.20bc	9.98±0.03gh	5.82±0.00c	18.78±0.04f	6.59±0.02fg	56.14±0.29g	352.11±1.00cd

* Values are mean of triplicate data; mean value follow by the same latter(s) along the column are not significantly different at p ≤ 0.05 by Duncans Multiple Range Test.

3.3. Discussion

The observed moisture content value in this study was between the ranges of 2.03%-7.19%, this is lower than the values 10.50% and 9.40% reported by Adegbe *et al.* and Peter and Philip [11, 12]. The highest ash content of 4.89% recorded was lower than the value 6.2% and 5.00% reported by Oliveira *et al.* and Adegbe et al but higher than 3.87% recorded by Peter *et al.* [11-13]. The crude fiber content of 3.23% obtained in this study was higher than 2.87% reported by Peter and Philip [12] but lower than 5.00% reported by Adegbe *et al*. [11] and 20.0% recorded Aja *et al* [14]. The value 3.23% recorded was in conformity with the findings of Somali *et al* [15] who recorded the the crude fiber content value of 3.6%, but was contrary to the records of Compaoré *et al.* (4.7%), Anwar and Bhanger (7.20%) and Anwar *et al.* (9.0%) [17-19]. The crude fiber content has been established to help in bowel movement. Thus adequate intake of dietary fiber can lower cholesterol level, risk of coronary heart disease, constipation, hypertension, diabetes, colon and breast cancer [20, 21].

The crude protein content recorded in this study is between the ranges of 15.54% to 39.10%, this is in agreement with the findings of Adegbe et al. [11] who recorded the crude protein content value of 39.57% but higher than 35.97%, 31.4% and 9.98% reported by Peter and Philip, Peter *et al.* and Aja *et al.* [12-14] respectively. While the observed fat content in this study is between the ranges of 19.77 to 43.60%, this is higher than the highest value of 40% recorded by Aja *et al* [14], 38.62% and 32.50% [11, 12]. Plant food that provide more than 12% of its calorific value from protein, is considered good source of protein [22]. Therefore, *M. oleifera* is a good source of protein.

The high Carbohydrate (CHO) content value of 49.46% recorded was higher than 18.4%, 7.44% and 18.00% [11, 13, 14] which were in line with the work of Abdulkarim *et al.* [23] who reported that *M. oleifera* seed contains 16.5 to 17.8% of CHO.

The result of proximate analysis on leaves is in line with the observations of some researchers [18, 24-26]. The low moisture content of *M. oleifera* leaves recorded in this study is between the ranges of 2% – 3%, this is an attribute of a very high shelf-life. Hence, long storage of the leaf powder will not lead to spoilage due to microbial attack, which supports the practice of storage in dry form by the users. These results were contrary to the work of Sultana *et al.* [27]. The results of the lowest and highest ash content recorded in this study therefore, indicates that dried moringa leaves have high deposit of mineral element with the ranges of 4.77% to 12.95% which is in agreement with the previous findings of Sultana *et al* and Moyo *et al.* [27, 28]. The crude protein was recorded within the ranges of 13.57% and 35.46%. This is similar to the study of Ogbe & Affiku, [29] who reported the crude protein value of moringa leaves as 17.01%; [29-31] reported the higher value of crude protein to be 27.44% and 30.65% respectively. Also, Moyo *et al.* [27] recorded high protein content of 29.36%, [32] recorded crude protein ranges of 16% to 40%, which is in line with the findings of Sarwatt *et al.* [33]. The ranges of crude fiber content (3.15-8.21%) obtained in this study was considered to be at the acceptable level, making Moringa leaves a promising ingredient for human and animal diets. The highest mean value obtained was in agreement with the value of 8.00% recorded by [27].

4. Conclusion

Moringa oleifera is an impressive and outstanding tree due to its exceptional value, from a nutritional as well a therapeutic point of view. It has remarkable potential in providing an inexpensive and credible alternative to not only good nutrition, but also a positive contribution to health due to the vast medicinal properties that it offers. *M. oleifera* contains more than 90 nutritional chemical compounds including proteins, lipids, carbohydrates and dietry fibers [18, 26]. This proves why leaves and seeds of this plant are used as food supplements and essential for infants and nursing mothers [24, 25]. It is also used as a food source to overcome malnutrition especially in children and infants [28].

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ORCID

Nafisat Muhammad Ndayankpa: http://orcid.org/0009-0000-7292-4884

Conflicts of Interest

The authors declare no conflicts of interest.

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