



Nutritional Evaluation of *Moringa oleifera* Leaf and the Effect of its Bio-fortification with Animal Feed on Physical Changes and Organ Weights in Male Albino Rats

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The current research investigated the nutritional value of the *Moringa oleifera* leaves. Four diets, different in their composition were used on sixteen male albino rats (n=4). Commercial vitamins and minerals premix (75.0 g) were used solely in diet 1; diet 2 contained 37.5 g of the vitamin-mineral premix and 37.5 g MOL. Diet 3 contained 19.0 g of vitamin-mineral premix and 56.0 g of MOL. Diet 4 contained only MOL (75.0 g) as the sole source of vitamins and minerals. Diets 1, 2, 3 and 4 were provided for groups A (control), B, C and D respectively. Nutritional evaluation of the *Moringa oleifera* leaves contained protein (28.23±0.02%), dry matter (25.56±0.05%), Calcium (723.01 ±0.11 mg), Magnesium (677.28±0.00 mg) and Zinc (214.51±0.02 mg). Concerning the respective diets on feed consumption, bodyweight gain and growth performance, results showed a significant decrease ($p < 0.05$) in dose-dependent manners compared with control (A). Groups C and D showed a significant decrease ($p > 0.05$) in the efficiency of feed conversion when compared to control. The organs of all the test groups showed no significant difference ($p > 0.05$) in weight compared to control. Conclusively, the study suggests the use of MOL may be needful only as a supplement, condiment or ingredient to enrich diets with essential vitamins and minerals but not for growth or bodyweight gain.

Keywords: *Moringa oleifera* leaves; bio-fortification; animal feed; bodyweight gain; efficiency of feed conversion.

1. INTRODUCTION

In different parts of the world, *Moringa oleifera* (MO) is a widely cultivated species of *Moringaceae* [1]. It is known by different names. Among the Yorubas, it is known as ewe igbal, the Igbos call it okwe oyibo, the Hausas call it zogale, the Fulani call it "gawara. In the English language, it is called many names (miracle tree, mother's best friend, never die and Benzolive tree) [2]. The *Moringa oleifera* has been used as a regular ingredient in conventional foods in Nigeria and many other countries [3], and according to Fuglie [4], The *Moringa oleifera* plant forms the basis for several nutritional programs in many poor countries by charitable organizations, given that the leaves of the trees contain essential nutrients. The leaves are considered to provide immense possibilities for those who are nutritionally challenged as they may be regarded as protein and minerals supplements [5]. The plant possesses the potential to improve blood supply, improve nutrition, and boost food security, and

support sustainable land practice use [6]. Researchers at the Asian Vegetable Research and Development Center [7] reported that leaves from four (4) different moringa species (*Moringa oleifera*, *Moringa peregrina*, *Moringa stenopetala* and *Moringa drouhardii*) contained high levels of nutrients, vitamins and antioxidants [6]. Bureau of plant industry reported MO as an outstanding source of nutrients among the *Moringa* species. Its leaves (weight per weight) have the calcium equivalent of four times that of milk, the vitamin C content is seven times that of oranges, while its potassium is three times that of bananas, three times the iron of spinach, four times the amount of vitamin A in carrots, and two times the protein in milk [8]. The nutritional and medicinal properties of MOL suggest it as a good option for the replacement [9-12,4,13]; hence this study investigated the nutritional composition of *Moringa oleifera* leaves and the effect of its bio-fortification with animal feed on physical changes and organ weight.



Fig. 1a. Fresh *Moringa oleifera* leaves



Fig. 1b. *Moringa oleifera* leaves powder

2. MATERIALS AND METHODS

2.1 Chemicals and Reagents

Vitamins, mineral-premixes and other chemicals used for the study were of standard food grades.

2.2 Plant Collection and Preparation

Moringa oleifera fresh leaves were obtained from Oke-Ijetu, Osogbo, Osun State, Nigeria. The harvested moringa leaves were air-dried until they were crispy. The crispy *Moringa oleifera* leaves were pulverized with a clean and dry electric blender (Model: DMN/DIC/PMT/02-03/206) to obtain *Moringa oleifera* leaves powder (MOLP).

2.3 Extraction for MO Leaves for Proximate, Mineral and Vitamins Analyses

Moringa oleifera leaves powder (5 g) was weighed and transferred to a 150 ml round flask, then 10 ml of 33% potassium hydroxide, KOH_(aq) and 40 ml absolute ethanol were added, and boiled at reflux for 30 mins. It was then cooled very rapidly, followed by the addition of 17 ml of 25% hydrochloric acid, HCl and cooled again. Petroleum ether (50 ml) was added, rocked vigorously for 3 mins and waited to complete separation of the two phases. The organic phase was removed and filtered through anhydrous sodium phases, evaporated to dryness in vacuum at a temperature of 35°C and concentrated until 1 ml was obtained.

2.4 Proximate Analysis

The proximate chemical composition of the *Moringa oleifera* leaves samples were determined by adopting the procedures of AOAC [14].

2.5 Mineral Analysis

Sample (1.0 g) was weighed and subjected to dry ashing in a well-cleaned crucible at 550 °C in a muffle furnace. The resultant ash was dissolved in 5.0 ml of HNO₃/HCl/H₂O (1:2:3) and heated gently on a heating mantle until brown fumes disappeared. Distilled water (5.0 ml) was added to each of the samples in a crucible and heated until a colourless solution was obtained. The mineral solution was filtered into a 100.0ml volumetric flask through filter paper, and the

volume was made to the mark with distilled water. The solution was analyzed twice for its elemental composition using the parking Elmer 403 model of atomic absorption spectrophotometer.

2.6 Vitamins Analysis

The general technique for determining vitamins can be used for biological liquids and plants or animal tissue. The general principle is the same but the extraction methods differ depending on the matter being analyzed. This analysis was conducted following the method of AOAC [14].

2.6.1 Vitamin A

The aqueous phase obtained in 2.10.1 was concentrated in a vacuum, the extract was re-dissolved in a mixture containing chloroform and trifluoroacetic acid (4:1v/v). Absorbance was taken at 620 nm following the method of AOAC [14].

2.6.2 Vitamins B

After the action of potassium ferricyanide in the presence of potash, on little quantity of the sample extract, fluorescence was determined using a 360 nm primary filter and a 460 nm secondary filter to determine the vitamins B1, 2 and 3 following the method of AOAC [14].

2.6.3 Vitamin C

A solution of the sample was made and 20 ml of the solution was pipetted into a 100 ml volumetric flask and diluted to volume with the extracting solution (ethanol). It was then filtered through a fluted filter paper and a suitable aliquot was titrated with the dyestuff solution following the method of AOAC [14].

A blank correction was made for the volume of extracting solution involved. The ascorbic acid content was calculated as stated below.

$$\text{Ascorbic acid (mg/100 g)} = (x B) \times (F/E) \times (V/Y)$$

x = average ml for sample titration

B= the average ml for blank titration

F = ml of the ascorbic acid equivalent to 1.0 ml indophenol standard solution

E = volume of the ascorbic acid/ml

V = volume of the initial assay solution

Y = volume of the sample aliquot titrated by an analytical chemist [14].

2.7 *Moringa oleifera* Meal Preparation

The Blanch diet and premix were purchased from Blessing feed mill at Niyi Ibikunle store, Osogbo, Osun State, Nigeria. The *Moringa oleifera* powder was then mixed in different proportions of the rats' diet per test group before administration to the animals.

2.8 Experimental Diets

The basic ingredients used for the formulated diets (per 25 kg of feed) used are shown in Table 1. Commercial vitamins and mineral premix were used solely in diet 1, diet 2 consists of 37.5 g of the vitamin-mineral premix and the other half (37.5 g) was replaced with *Moringa oleifera* leaves (MOL). Diet 3 consists of 19.0 g of vitamin-mineral premix in diet and 56.0 g of MOL. Diet 4 contains only MOL (75.0 g) as the sole source of vitamins and mineral premix.

2.9 Experimental Animals and Design

Sixteen (16) male albino rats weighing 155.50 - 165.50 g were randomly distributed into four groups per treatment. Allocation to groups was based on the initial weight of the rats and group mean weight. Rats were acclimatized for two weeks, after which group A (Control) was given diet containing 75.0 g of vitamin and mineral premix only, groups B, C and D were provided with diets containing 37.5 g vitamin-mineral premix + 37.5 g MOL, 19.0 g vitamin-mineral premix + 56.0 g MOL and 75.0 g MOL respectively, fed *ad libitum* for 21 days.

2.10 Housing and Feeding

The rats were housed in metabolic cages and provided diets. Feeds were weighed each morning and fed in two portions (morning and evening) to minimize wastage. At the end of the day, feed left in the troughs were weighed and subtracted from the total weight of feed (a total of 160 g) provided for the day to get the daily feed intake. The average weekly feed intake for each of the rat groups was calculated for the entire experimental period. Water was provided *ad libitum* daily. Weights of all the animals were taken before and during the experiment, and records kept weekly, following Serem et al. [1].

2.11 Determination of Feed Consumption

Feed consumption (FC) is the difference between the quantity of the leftover feed and the quantity of the feed provided.

Feed consumption, FC (g) = quantity of feed provided (QFP) - quantity of leftover feed (QLF).

2.12 Determination of Body Weight Gain

The bodyweight gain (BWG) was determined weekly. It represents the difference between the weight of the current week (Wc) and that of the previous week (Wp). It is determined as follows:

Bodyweight gain (g) = the weight of the previous week – the weight of the current week.

2.13 Determination of Efficiency of Feed Conversion

This is the quantity of feed required to affect one unit of bodyweight gain. It is calculated as follow: Efficiency of feed conversion (EFC) = BWG/FC

2.14 Growth Study

All animals were weighed before and during the experimental period. Their weights were taken daily and bodyweight gains were determined weekly.

2.15 Statistical Analysis

Values were expressed as the mean \pm standard error of mean. The data were analyzed using one-way analysis of variance and significant means were separated by post hoc Duncan's multiple range test at $p < 0.05$.

3. RESULTS

Table 1 showed the proximate, minerals and vitamins analysis of MOL, with high values of $25.56 \pm 0.05\%$, $46.48 \pm 0.03\%$, $28.23 \pm 0.02\%$ and $5.62 \pm 0.01\%$ for dry matter, carbohydrate, protein and fat respectively. The mineral content of the leaves indicated that Ca (723.01 ± 0.11 mg), Mg (677.28 ± 0.00 mg), Zn (548.51 ± 0.01 mg) and Na (214.51 ± 0.11 mg) are the most abundant amongst other. Among the vitamins, Vitamins C and B2 are the most abundant. The proximate composition, vitamins and mineral contents of the *Moringa oleifera* leaves could be attributed to differences in ecological zones, climatic conditions and the physiological stage of harvesting the *Moringa oleifera* plants.

Table 2 showed the weekly feed consumption of all the rats. All groups showed a remarkable weekly increase ($p < 0.05$) in feed consumption.

Groups fed with diets containing MOL showed a significant increase ($p < 0.05$) in feed consumption, in dose manners compared with control (A).

In figure 2, no significant difference ($p > 0.05$) was observed in bodyweight gain in all the groups at week 1. A significant reduction ($p < 0.05$) was observed in bodyweight of MOL fed groups at week 2 and 3 compared with control (A).

Table 3 showed no significant difference ($p > 0.05$) in the weekly efficiency of feed conversion of each group. Group B showed no significant difference ($p > 0.05$) at weeks 1, 2 and 3 when compared with control (A). Groups C and D showed a significant decrease ($p < 0.05$) in the efficiency of feed conversion at weeks 1, 2 and 3 when compared with control (A).

Table 1. Proximate, minerals and vitamins analysis of *Moringa oleifera* leaves

Composition	Quantitative content
Proximate	
% Protein	28.23±0.02
% Moisture content	7.49±0.11
% Fat	5.62±0.01
% Ash content	4.29±0.15
% Crude fiber	0.95±1.25
% Carbohydrate	46.48±0.03
% Dry matter	25.56±0.05
Energy	250.20±0.05Kcal
Minerals	
Ca	723.01 ±0.11 mg
Mg	677.28±0.00 mg
Zn	548.51±0.01 mg
Na	214.51±0.02 mg
Vitamins	
Vitamin A	16.88±0.06 mg
Vitamin B1	2.65±0.01 mg
Vitamin B2	20.60±0.03 mg
Vitamin B3	9.20±0.03 mg
Vitamin C	30.10±0.08 mg

Values were expressed as the mean of three determinations ± SEM

Table 2. Effect of MOL on feed consumption (g) a: raw data; b: statistical data

a			
Group	Week 1	Week 2	Week 3
A (control)	924	990	1044
B	920	966	982
C	894	956	934
D	513	537	616
B			
Group	Week 1	Week 2	Week 3
A (control)	6.16± 0.17 ^c	8.30± 0.19 ^e	11.02± 1.11 ^f
B	6.14± 0.09 ^c	8.00± 0.11 ^d	8.00± 0.15 ^d
C	4.99± 0.01 ^b	7.97± 0.03 ^d	7.90± 0.09 ^d
D	4.00± 0.25 ^a	4.60± 0.02 ^b	5.10± 0.06 ^b

^b Values were expressed as mean of three determinations ± SEM. Differences were considered significant at $p < 0.05$. The different alphabets across the rows and down the columns represent a significant difference.

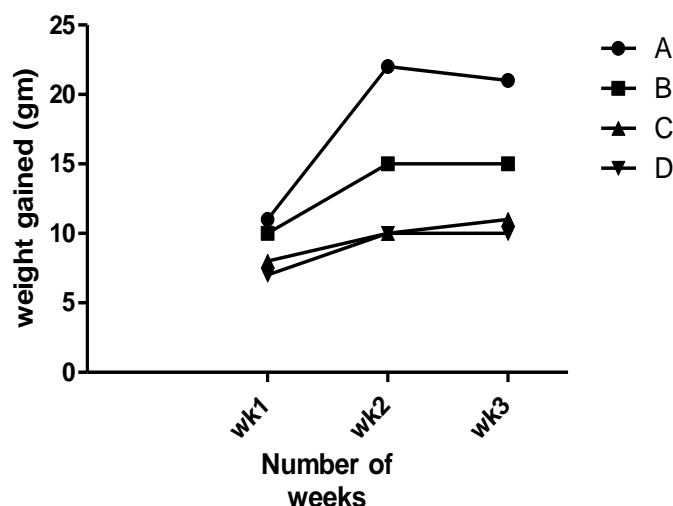


Fig. 2. Effect of MOL on weekly bodyweight gain

Table 3. Effect of MOL on efficiency of feed conversion

Groups	Week 1	Week 2	Week 3
A (Control)	0.012±0.05 ^c	0.012±0.03 ^c	0.012±0.05 ^c
B	0.012±0.03 ^c	0.012±0.00 ^c	0.012±0.01 ^c
C	0.011±0.05 ^b	0.011±0.04 ^b	0.011±0.06 ^b
D	0.010±0.03 ^a	0.010±0.01 ^a	0.010±0.00 ^a

Values were expressed as mean of three determinations ± SEM. Differences were considered significant at $p < 0.05$. Different alphabets across the rows and down the columns represent significant difference

Table 4. Effect of MOL on organ weight (g)

Rat organs	A	B	C	D
Liver, L	4.83±0.01	4.82±0.01	4.80±0.02	4.81±0.01
Heart, H	4.59±0.00	4.56±0.03	4.55±0.03	4.52±0.04
Kidney, K	4.81±0.03	4.86±0.01	4.77±0.05	4.81±0.01

Values were expressed as mean of three determinations ± SEM. Differences were considered significant at $p < 0.05$. Different alphabets across the rows and down the columns represent significant difference

In Table 4, MOL showed no significant changes ($p > 0.05$) in organ weights of the rats treated with MOL in graded levels compared with control (A).

4. DISCUSSION AND CONCLUSION

Moringa oleifera leaves have been reported to be a rich source of minerals (like iron, magnesium, zinc amongst others), vitamins (most especially the B-vitamins) and natural anti-oxidant (like vitamin C) [15]. The use of inexpensive alternative substances from plant sources that possess pharmaceutical potentials which can be used as a substitute to the costly modern vitamins and mineral supplements is thus essential [16].

The proximate result, percentage (dry matter, proteins and ash contents) of MOL was different with the findings of Patel et al. [17] as 93.16, 24.44 and 7.44 respectively. The crude protein content of MOL in this study was within the ranges of the studies reported by Oduro et al. [18], and 29.55% recorded by Nuhu [19] in Ghana but higher than 23.30% reported by Gakuya et al. [20]. Some of the results on the minerals and vitamins present in MOL are similar to the findings of Zanum et al. [21]; Madukwe et al. [22]; Gakuya et al. [20]; Patel et al. [17]. This may be due to the differences in soil type, activities done on the soil where the plant is, ecological zone and other climate factors.

This study revealed a remarkable decrease ($p < 0.05$) in the feed consumption of rats fed with MOL, particularly at graded levels of 56.0 and 75.0 g, at week 2 and week 3 as compared with control (A). The study was in agreement with Kout et al. [9] who observed lowered cumulative feed consumption at graded levels of MOL (0.0, 0.2, 0.4 and 0.6%) in broilers. This may simply imply that MOL did not enhance the feed intake of the rats, which may be due to the taste of MO leaves in the diets in which the rats could be deterred from the feed.

Our findings showed that MOL has a bodyweight reducing potency. This is in contrast with the findings of Okafor et al. [10]; Banjo [11]; Gadzirayi et al. [12]; Kout et al. [9] who reported that *M. oleifera* supplemented groups recorded a higher daily weight gain and showed that birds fed on moringa leaf powder gained significantly higher bodyweight than birds fed with control diet respectively. Our study thus suggests the use of MOL may be needful in the management of excessive bodyweight gain or obesity.

The efficiency of feed conversion of MOL in the experimental rats as shown in the group provided diet containing 37.5 g vitamin-mineral premix + 37.5 g MOL (Table 4) showed no significant changes when compared with the control rats. However, the reduction in the efficiency of feed conversion observed in other MOL diets treated groups might be due to the low feed intake or low feed consumption in dose-dependent manners observed in Table 2.

Changes not observed in the MOL treated groups (Table 5) might simply suggest MOL does not affect organ weight.

Conclusively, the study suggests the use of MOL may be needful only as a supplement, condiment or ingredient to enrich diets with essential vitamins and minerals but not for growth or bodyweight gain.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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