Global Veterinaria 12 (4): 573-582, 2014
ISSN 1992-6197

DOI: 10.5829/idosi.gv.2014.12.04.8380

# Response of Growing New Zealand White Rabbits to Rations Supplemented with Different Levels of *Moringa oleifera* Dry Leaves

[1]*A.Y. El-Badawi,* [1]*H.A.A. Omer,* [1]*A.A. Abedo and* [2]*M.H.M. Yacout*

[1]Animal Production Department, National Research Centre, Dokki, Giza, Egypt
[2]By-Product Utilization Department, Institute of Animal Production,
Agriculture Research Centre, Dokki, Giza, Egypt

**Abstract:** In a feeding experiment lasted 56 days, thirty six growing New Zealand White (NZW) rabbits aged five weeks and weighed in average 566.5 $\pm$ 24.07g were randomly blocked by weight into four groups (9 animals each), where the $1^{st}$ group fed a basal ration free of Moringa dry leaves ($R_1$-control), while the $2^{nd}$, $3^{rd}$ and $4^{th}$ groups were fed respectively, on the same basal ration supplemented with dried moringa leaves 0.15% ($R_2$), 0.30% ($R_3$) and 0.45% ($R_4$). Experimental rations almost iso-caloric-iso-nitrogenous were individually offered *ad lib*. Nutrients digestibility and carcass traits were evaluated at the end of the feeding experiment. The results showed that, moringa dry leaves (MDL) composition was on DM basis; 31.68% CP, 8.78% EE, 6.41% CF, 38.25% NFE and 14.88% ash and its cell-wall constituents were 1.81% hemicellulose, 5.27% cellulose and 4.94% acid detergent lignin. Feeding rabbits on rations supplemented with MDL up to 0.30% was associated with significant ($P<0.05$) increases of nutrients digestibility, dietary nitrogen utilization and weight gain. However, daily feed intake did not significantly influenced by feeding MDL supplemented rations. Feed conversion efficiency in terms of g. DM intake/ g. weight gain was ($P<0.05$) better with rations contained 0.15 and 0.30% MDL than control. In similar trend carcass dressing percentage, carcass traits and lean meat yield were higher ($P<0.05$) for rabbits fed 0.15 and 0.30% MDL supplemented rations than control. However all measured parameters were clearly decreased with the ration contained 0.45% MDL in comparison to other tested rations. Under the condition of the present study, it is concluded that, MDL supplementation might play a role as growth enhancer for rabbits when fed at maximum 0.30% of the daily ration, while adverse effects on growth performance and carcass characteristics were occurred with the highest moringa supplementation level (0.45% MDL).

**Key words:** Moringa Dry Leaves · Rabbits · Growth Performance · Nutrients Digestibility · Carcass Traits

## INTRODUCTION

*Moringa oleifera lam* commonly known as "The Miracle Tree or Horseradish Tree" is the best known and most widely distributed species of Moringaceae family, having an impressive range of medicinal uses with high nutritional value throughout the world. Moringa trees are native to India, Pakistan, Asia and Africa, where it can be grown in a variety of soil conditions preferring well-drained sandy or loamy that is slightly alkaline [1-3]. It can grow well in the humid tropics or hot dry lands and can survive under drought conditions [4]. Almost every part of the Moringa tree; roots, leaves, flowers, seeds, fruits (pods) and even tree trunk have been consumed by humans and used for various domestic purposes as for alley cropping, animal forage, fertilizer, foliar nutrient, green manure, gum, sugar-cane juice-clarifier (powder seeds), biopesticide, water purification (seeds meal) and machine lubrication (oil). Several biological properties ascribed to various parts of this tree, the leaves have been reported to be a valuable source of â-carotene (precursor of vit. A), vitamins (B-complex, C, D and K) beside some important macro-elements as calcium, potassium, zinc, iron, copper and selenium [5 and 6]. Moreover, it was reported that *Moringa oleifera* leaves and fruits prevent effectively morphological changes and

**Corresponding Author:** Hamed A.A. Omer, Animal Production Department, National Research Centre, Dokki, Giza, Egypt.

oxidative damage in human and animals by enhancing the activities of antioxidant enzymes, reducing the intensity of lipid peroxidation and inhibiting generation of free radicals [7 and 8]. It was also used to promote the immune system against infections [9] and its extracts have positive effects on hematological parameters of rabbits [10]. The chemical composition of Moringa leave meal has been investigated by many workers, the results showed differences among authors for crude protein, crude fiber, ether extract, ash, acid detergent lignin, macro and micro-elements [2, 11, 12]. The difference in chemical constituents of fairly related to type of soil, irrigated-water quality, ambient temperature and relative humidity, plant age, stage of maturity and the way in which leaves are collected, dried and sieved [2, 13].

In Egypt great attention has been given by plant breeders to implant *Moringa oleifera* imported seeds in agricultural and newly reclaimed lands for human and animal uses. Little studies have been conducted on lactating cattle, laying hens and rabbits, with either fresh (green fodder) or dry leaves. But most people in Egypt, however, are not aware of the potential benefits of Moringa, beside the expensive price of its products (about 70.000 US$ / ton dry leaves). Based on claims that Moringa leaves increase animal productivity as it has nutritional and therapeutically properties.

For that, this study was conducted on growing New Zealand White rabbits to verify the nutritional impact of feeding different supplementation levels of *Moringa oleifera* dry leaves on feed and water intake, nutrients digestibility, dietary nitrogen utilization, average daily gain, feed conversion and carcass characteristics.

## MATERIALS AND METHODS

**Plant Collection and Preparation:** *Moringa oleifera* leaves were collected from a private commercial farm cultivated solely with Moringa shrubs over an area of 10 feddans (42000 $m^2$ area). The farm is located in Nubaria province (160 km North Western Cairo city, Egypt) of sandy soil and the ambient temperature during six month of plantation as between 22-34°C. The leaves were harvested, air-dried under shade until the moisture of collected leaves reached 10%. The dry leaves were finally milled, sieved (1 mm mesh) and stored in a well tight polyethylene bags at room temperature 25°C. Composite sample of Moringa powder dry leaves was taken in sample plastic bag for chemical analysis.

**Rabbits Ration and Moringa Supplementation:** Four batches of rabbits ration each of 100 kg were formulated to contain; 30% alfalfa hay, 25% ground yellow corn, 25% wheat bran, 14% soybean meal (44%), 3% cane-molasses, 1.5% lime stone, 1% sodium chloride and 0.5% vitamin & mineral premix. Moringa powder dry leaves was added and thoroughly hand mixed with other feed ingredients of each batch at 0, 0.15, 0.30 and 0.45% for $R_1$ (control), $R_2$, $R_3$ and $R_4$, respectively. Experimental rations were pelleted at 0.3 cm diameter and packed in polyethylene bages until feeding.

**Procedures of the Feeding Experiment:** In a feeding trial lasted 56 days, thirty six male growing New Zealand White rabbits (NZW) aged five weeks old with an average body weight of 566.5 $\pm$ 24.07g were blocked by weight in four equal groups (9 animals each). Experimental rabbits were housed individually in galvanized metal wire cages equipped with feeding and water troughs, where the first group of animals was fed $R_1$ (free Moringa ration-control) while $2^{nd}$, $3^{rd}$ and $4^{th}$ groups fed $R_2$, $R_3$ and $R_4$, respectively. Rations were offered *ad lib*. at 8.30 a.m. and feed refusals were daily collected, weighed and recorded. Amounts of drinking water were daily measured and individual body weight was weekly recorded.

**Digestibility Trials:** At the end of the feeding experiment, four digestibility trials were carried out over a period of seven days where three days were for adaptation and the other four days for quantitative collection of feces and urine. Three random rabbits from each group were individually confined in stainless-steel metabolic cages equipped with feeding and water troughs. Daily amounts of feeds and water consumption, feces and urine out-put were determined and daily recorded during the collection period. Representative sample of feces from each animal (10% of the whole amount) was oven-dried over-night and finally ground, while 10% of whole acidified urine was collected in glass bottles. Individual composite samples of dry feces and urine were kept in clean plastic bottles at 4°C until chemical analysis.

**Slaughter Technique:** After termination of the feeding experiment, three representative rabbits randomly chosen from each group were fasted for 12 hrs, weighed and handly slaughtered. After complete bleeding, the drained blood was collected and weighed. Slaughtered animals were de-skinned, dressed out and the hot carcass including head was weighed and recorded. Edible offals (liver, heart, spleen and kidneys), non-edible offals (lungs & trachea, clean empty G.I.T. and testicles) and trimmings (fur, four legs, blood and G.I.T. contents) were separately weighed and recorded. The whole carcass of each rabbit was de-boned and the resultant flesh and bone were separately weighed and recorded.

**Chemical Analysis and Calculations:** Chemical composition of feeds and feces were determined for dry matter (DM), crude protein (CP), crude fiber (CF), ether extract (EE) and ash according to the standard methods of A.O.A.C. [14]. Nitrogen free extract (NFE) was calculated by difference. Urine nitrogen (UN) was determined by the macro-kjeldahl method [14]. Fiber fractions of neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) were determined according to Van Soest *et al.* [15]. Hemicellulose was calculated as the difference between NDF and ADF, while cellulose was the difference between ADF and ADL. Gross energy (kcal/g DM) of unsupplemented or supplemented rations was estimated according to Blaxter [16]. Nutritive value of different rations expressed as TDN (total digestible nutrients) was calculated according to the equation suggested by Cheeke *et al.* [17] as follows:

TDN% = DCP% + DCF% + DNFE% + DEE% x 2.25.

Where:

DCP = digestible crude protein, DCF = digestible crude fiber, DNFE = digestible nitrogen free extract and DEE = digestible ether extract.

**Statistical Analysis:** Collected data of digestibility, nutritive value, nitrogen balance, water and feed intake, daily gain, feed conversion and carcass traits were subjected to statistical analysis as one way analysis of variance according to Snedecor and Cochran [18] applying the general linear model procedure of SPSS [19]. Duncan's Multiple Range Test [20] was used to separate significant means.

Statistical Model: $Y_{ij} = \mu + T_i + e_{ij}$

Where:
$Y_{ij}$ = observation
$\mu$ = the overall mean,
$T_i$ = the effect of treatment.
$e_{ij}$ = the experimental error.

**Economic Evaluation:** Economical efficiency (%) of experimental rations was calculated according to the local market price of feed ingredients and rabbit live body weight as follows:

Net revenue= Total revenue – Total feed cost.

Economical efficiency (%) = Net revenue / Total feed cost %.

## RESULTS AND DISCUSSION

**Chemical Analysis:** Results of chemical analysis Table (1) showed that Moringa dry leaves had high contents of CP (31.68%), EE (8.78%) and ash (14.88%) but low contents of CF (6.41%) and NFE (38.25%). Cell wall constituents of moringa leaves were 12.02%, 10.21% and 4.94% for NDF, ADF and ADL, respectively. Calculated gross energy of Moringa leaves was 4.468 kcal/ g, (Table 1). Same previous studies reported different chemical contents of moringa leaves. Gupta *et al.* [21] found that crude protein, crude lipids and ash values of unextracted leaves were 26.4%, 6.5% and 12%, respectively; 28.8% for NDF and 13.9% for ADF. Fuglie [22] stated that chemical analysis of unextracted Moringa leaves were 25.1, 5.4, 11.5, 21.9, 11.4, 1.8 and 18.7 for crude protein, lipid, ash, NDF, ADF, ADL and gross energy (MJ/ $kg^{-1}$), respectively. Oduro *et al.* [12] reported that *Moringa oleifera* leaves contained crude protein 27.51%, crude fiber 19.25%, crude fat 2.23%, ash 7.13%, moisture 76.53%, carbohydrates 43.88% and caloric value 1296kJ/ g (305.62 cal/ g). In the same studies Nuhu [23]recorded that the moringa leaves contained 24.65% DM, 29.25% CP, 2.23% EE, 19.25% CF, 7.13% ash and 41.98% NFE. Different values were also mentioned by Djalalia *et al.* [24] where 23.63, 18.30, 4.77 and 13.34% were reported for CP, cellulose, fat and ash, respectively on DM basis of Moringa leaves. In South Africa Moyo *et al.* [2] reported that the chemical composition of dry Moringa leaves was 30.29% (CP), 6.50% (EE), 7.64% ash, 11.40% (NDF), 8.49% (ADF) and 1.80% (ADL). These values seem to same extent comparable to the chemical composition of dry Moringa leaves in the present study. There are considerable variation among the nutritional values of Moringa, which depend on factors like genetic background, agro-climatic conditions, age of shrubs or trees, season of harvesting, leaves collection and drying procedures and the method applied to get the final form of the product. In general, all previous studies confirmed

Table 1: Chemical composition and cell-wall constituents of Moringa dry leaves and experimental rations.

| | | Experimental rations | | | |
|---|---|---|---|---|---|
| | | R1 | R2 | R3 | R4 |
| Item | Moringa dry leaves (M) | 0% M | 0.15% M | 0.30% M | 0.45% M |
| Moisture | 8.89 | 10.00 | 10.00 | 10.01 | 10.00 |
| *DM composition, %* | | | | | |
| OM | 85.12 | 84.18 | 84.30 | 84.41 | 84.56 |
| CP | 31.68 | 19.11 | 19.16 | 19.20 | 19.25 |
| CF | 6.41 | 8.29 | 8.29 | 8.30 | 8.31 |
| EE | 8.78 | 2.76 | 2.77 | 2.80 | 2.80 |
| NFE | 38.25 | 54.02 | 54.08 | 54.11 | 54.20 |
| Ash | 14.88 | 15.82 | 15.70 | 15.59 | 15.44 |
| *Cell wall constituents, %* | | | | | |
| NDF | 12.02 | 39.57 | 39.60 | 39.60 | 39.63 |
| ADF | 10.21 | 24.36 | 24.37 | 24.40 | 24.40 |
| ADL | 4.94 | 5.45 | 5.45 | 5.46 | 5.47 |
| Hemicellulose | 1.81 | 15.21 | 15.23 | 15.20 | 15.23 |
| Cellulose | 5.27 | 18.91 | 18.92 | 18.94 | 18.93 |
| Calculated gross energy, kcal/ g | 4.468 | 3.925 | 3.931 | 3.938 | 3.945 |

*[1]Gross energy was calculated according to Blaxter (16) where g CP = 5.65 kcal, EE= 9.40 kcal and NFE & CF = 4.15 kcal.*

Table 2: Digestion coefficients and nutritive values of the experimental rations.

| | Experimental rations | | | | |
|---|---|---|---|---|---|
| | R1 | R2 | R3 | R4 | |
| Item | 0% M | 0.15% M | 0.30% M | 0.45% M | SEM |
| *Digestion coefficients:* | | | | | |
| Organic matter (OM) | 72.17$^{b}$ | 72.12$^{b}$ | 75.55$^{a}$ | 70.19$^{c}$ | 0.61 |
| Crude protein (CP) | 59.61$^{c}$ | 66.50$^{b}$ | 71.63$^{a}$ | 67.42$^{ab}$ | 1.42 |
| Crude fiber (CF) | 44.51$^{b}$ | 54.55$^{a}$ | 57.11$^{a}$ | 46.28$^{b}$ | 1.79 |
| Ether extract (EE) | 92.91 | 93.86 | 92.26 | 94.11 | 0.63 |
| Nitrogen free extract (NFE) | 79.84$^{a}$ | 75.70$^{b}$ | 78.89$^{a}$ | 73.61$^{c}$ | 0.76 |
| *Nutritive value %* | | | | | |
| Total digestible nutrients (TDN) | 63.95$^{b}$ | 64.05$^{b}$ | 66.99$^{a}$ | 62.64$^{c}$ | 0.43 |
| Digestible crude protein (DCP) | 11.39$^{c}$ | 12.74$^{b}$ | 13.75$^{a}$ | 12.98$^{b}$ | 0.26 |

*a, b and c: Means in the same row having different superscripts are significantly different at (P<0.05).*
*SEM: standard error of means.*

that moringa leaves are rich in protein, amino acids and mineral elements that are important for growth and health of human and animals. Chemical composition of experimental rations shown in Table (1) illustrated that rations were iso-caloric iso-nitrogenous where gross energy was between 3.925 and 3.945 kcal/g and CP was between 19.11% and 19.25% for experimental rations. Cell wall constituents were almost similar among rations. Energy density, crude protein content, cellulose and hemicelluloses of rations were within the limits recommended by the NRC [25] for rabbit's nutrition.

**Nutrient Digestibility and Nutritive Value of Experimental Rations:** Nutrient digestion coefficients of experimental rations given in Table (2) indicated that OM, CP and CF digestibilities were significantly (P<0.05) higher for moringa supplemented rations than control (0% Moringa), particularly rations supplemented with 0.15 or 0.30% moringa dry leaves. No significant effect was recorded for EE digestibility among un-supplemented or Moringa supplemented rations. However, NFE digestibility showed tendency to decline with Moringa rations in comparison to control. Nutritive value of experimental rations expressed in terms of TDN or DCP were increased (P<0.05) as the moringa supplementation level increased up to 0.30%, while values were nearly comparable to control ration as the level of supplementation increased to 0.45%. It might hold true that, moringa dry leaves in a powder form could have some digestion promoting effects investigated from the gradual improvement of OM, CP and CF digestibilities and dietary TDN and DCP value with increasing the

Table 3: Dietary nitrogen utilization (g) of rabbits fed experimental rations.

| | → Experimental rations | | | | |
|---|---|---|---|---|---|
| | $R_1$ | $R_2$ | $R_3$ | $R_4$ | |
| Item | 0% M | 0.15% M | 0.30% M | 0.45% M | SEM |
| Nitrogen intake (NI) | 4.52 | 4.48 | 4.76 | 4.43 | 0.19 |
| Fecal nitrogen (FN) | $1.83^a$ | $1.50^b$ | $1.35^c$ | $1.44^{bc}$ | 0.08 |
| Digestible nitrogen (DN) | $2.69^c$ | $2.98^b$ | $3.41^a$ | $2.99^b$ | 0.21 |
| Urinary nitrogen (UN) | $1.76^a$ | $1.65^{ab}$ | $1.43^b$ | $1.41^b$ | 0.06 |
| Total nitrogen excretion | $3.59^a$ | $3.15^b$ | $2.78^c$ | $2.85^c$ | 0.11 |
| N-balance (NB) | $0.93^d$ | $1.33^c$ | $1.98^a$ | $1.58^b$ | 0.13 |
| NB of NI, % | $20.57^d$ | $29.68^c$ | $41.60^a$ | $35.66^b$ | 1.88 |
| NB of DN, % | $34.57^d$ | $44.63^c$ | $58.06^a$ | $52.84^b$ | 1.68 |

*a, b, c and d: Means in the same row having different superscripts are significantly different at ($P<0.05$).*

*SEM: standard error of means.*

supplementation level to 0.15% and 0.30%; however this assumption has not been realized with the highest moringa supplementation level (0.45%). Many previous studies carried out on rabbits stated that feeding *Moringa oleifera* dry leaves was associated with improvement of nutrients digestibility in particularly CP [23, 24, 26-28]. However, Adeniji *et al.* [29] did not find any significant difference in nutrients digestibility between un-supplemented or Moringa supplemented rations on rabbits. Its worth saying that, most previous studies had introduced moringa to replace up to 15% of the whole rabbits diet[28] or from 20 to 100% of the dietary ground nut cake [27] without recording any adverse effect on nutrients digestibility as has been recorded in the present study with the high moringa (0.45%) supplementation level.

**Dietary Nitrogen Utilization:** The results of nitrogen balance trial given in Table (3) pointed out to that, rabbits fed moringa supplemented rations had lower ($P<0.05$) fecal and urine nitrogen losses than those fed control ration (0% M). However, the maximum N-balance value (g/h/day) was recorded for rabbits fed $R_3$ (0.30% M) followed by significantly ($P<0.05$) lower value with $R_4$ (0.45% M) then 1.33 g N which was recorded by rabbits fed $R_2$ (0.15% M). The lowest N-balance value was attained by rabbits fed $R_1$ (0% M). Similar trend was reflected on N-balance values calculated relative to N-intake or digestible N, where moringa supplemented rations recorded 29.68, 41.60 and 35.66% with $R_2$, $R_3$ and $R_4$, respectively, VS. 20.57% for $R_1$ (control) for N-balance of N intake. The values were much higher for N-balance % of digestible N where moringa rations recorded 44.63, 58.06 and 52.84% with $R_2$, $R_3$ and $R_4$, respectively VS. 34.57% for $R_1$ (control). These results indicate that moringa leaves might contain some phytochemical compounds that enhanced dietary crude protein digestibility and absorption. In this concern, Asaolu *et al.* [30] reported that, the minimum fecal and urinary nitrogen losses were recorded on goats fed 100% moringa fodder in comparison with rations contained 50% moringa with either 50% leucaena or gliricidia. In the contrary, Adeniji and Lawal [27] did not find differences among rabbits for fecal and urinary N losses with diets contained moringa leaves in replacement ground nut cake at 0, 20, 40, 60, 80 and 100%. The better dietary protein utilization associated diets containing different supplementation or replacement levels of moringa leaves was refaired by many others to its protein quality and amino acid profile [2, 24, 27 and 28]. However, according to our results the better dietary N utilization of Moringa rations is more likely related to some effective compounds that enhanced N utilization. Since the CP content of experimental rations was almost of comparable values (19.11, 19.11, 19.20 and 19.25% for $R_1$, $R_2$, $R_3$ and $R_4$, respectively).

**Water Balance:** Water balance of rabbits fed experimental rations is presented in Table (4). Dietary treatments had no significant effect ($P>0.05$) on drinking water, however there was a slight decrease with increasing moringa level supplementation. Drinking water relative to DM intake (ml/g) was significantly ($P<0.05$) lower for rabbits fed 0.30 or 0.45% moringa supplementation in comparison to control (0% moringa) and 0.15% moringa ration. Inclusion of moringa dry leaves at 0.15% or 30% increased water out-put % of water intake in comparison with control and 0.45% moringa groups.

Table 4: Water balance of rabbits fed experimental rations.

| Item | Experimental rations $R_1$ 0% M | $R_2$ 0.15% M | $R_3$ 0.30% M | $R_4$ 0.45% M | SEM |
|---|---|---|---|---|---|
| Drinking water, ml | 340 | 338 | 351 | 322 | - |
| Dietary water content, g | 16 | 16 | 17 | 16 | - |
| Total water intake, ml | 356 | 354 | 368 | 338 | - |
| Urinary water, ml | 122 | 95 | 133 | 88 | - |
| Fecal water content, g | 46 | 45 | 42 | 47 | - |
| Sensible water out-put, ml | 168 | 140 | 175 | 135 | - |
| Water out-put of water intake, % | $47.20^{b}$ | $52.28^{a}$ | $49.86^{ab}$ | $41.89^{c}$ | 2.64 |
| Drinking water of DM intake, ml/ g | $2.30^{a}$ | $2.31^{a}$ | $2.26^{b}$ | $2.24^{b}$ | 0.06 |

*Assuming that ml of water = g of moisture content.*

*a, b and c: Means in the same row having different superscripts are significantly different at (P<0.05).*

Table 5: Growth performance of experimental groups.

| Item | Experimental rations $R_1$ 0% M | $R_2$ 0.15% M | $R_3$ 0.30% M | $R_4$ 0.45% M | SEM |
|---|---|---|---|---|---|
| Animal number | 9 | 9 | 9 | 9 | --- |
| Duration period | | 56 days | | | |
| Initial weight, g | 560 | 573 | 571 | 562 | 24.07 |
| Final weight, g | 2024 | 2192 | 2219 | 1997 | 62.01 |
| Body weight gain, g | $1464^{b}$ | $1619^{a}$ | $1648^{a}$ | $1435^{b}$ | 64.66 |
| Average daily gain, g | $26.14^{b}$ | $28.91^{a}$ | $29.43^{a}$ | $25.63^{b}$ | 1.15 |
| *Feed intake, g* | | | | | |
| Dry matter intake (DMI) | 148 | 146 | 155 | 144 | 2.74 |
| Total digestible nutrient intake (TDNI) | $94.64^{b}$ | $93.51^{b}$ | $103.83^{a}$ | $90.20^{c}$ | 1.71 |
| Digestible crude protein intake (DCPI) | $16.86^{b}$ | $18.60^{b}$ | $21.31^{a}$ | $18.69^{b}$ | 0.43 |
| Feed conversion (g DM intake/ g gain) | $5.66^{a}$ | $5.05^{b}$ | $5.27^{b}$ | $5.62^{a}$ | 0.11 |

*a and b: Means in the same row having different superscripts are significantly different at (P<0.05).*

*SEM: standard error of means.*

The results pointed out to that insensible water loss comes from breathing and evaporation from skin were greater for rabbits fed control (0% M) or (0.45% M) than rabbits fed 0.15% and 0.30% moringa supplemented rations. Such results might reveal that rabbits fed control or 0.45% moringa rations were under biological stress. These results were in agreement with those reported by Marai *et al.* [31] who found that rabbits exposed to biological or environmental stresses decreased their feed intake, feed utilization and increase water retention particularly in hot climatic conditions.

**Growth Performance:** Body weight gain, average daily gain (ADG) and feed conversion efficiency of rabbits fed experimental rations are shown in Table (5). Weight gain and ADG of rabbits fed 0.15 and 0.30% moringa supplemented rations were higher (P<0.05) than those fed 0% or 0.45% moringa rations. There was no significant difference for weight gain of rabbits either between groups $R_2$ (0.15% M) and $R_3$ (0.30% M) or $R_1$ (0% M) and $R_4$ (0.45% M), however the mean daily DM intake was almost comparable among experimental groups. In similar trend, the feed conversion (g. DM intake/ g. weight gain) was of lower (P<0.05) values for rabbits fed $R_2$ and $R_3$ (5.05 and 5.27, respectively) than those fed $R_1$ (control) and $R_4$ (5.66 and 5.62, respectively). Body weight gain of rabbits fed R2 and R3 calculated relative to those fed control ration (0% M) was (P<0.05) higher by 10.6% and 12.5%, respectively. The positive effect of moringa leaves on growth performance of rabbits was noticed in some previous studies [32, 33], Nuhu [23], regarded the better growth rate to protein quality and amino acids content of moringa leaves. Adeniji and Lawal [27], who replaced moringa as a protein feed instead of ground nut cake at levels 0, 20, 40, 60, 80 and 100%. Similar conclusion was stated by Douganon *et al.* [28], who replaced 0, 10 and 15% of the whole rabbit's commercial diet with moringa leaves.

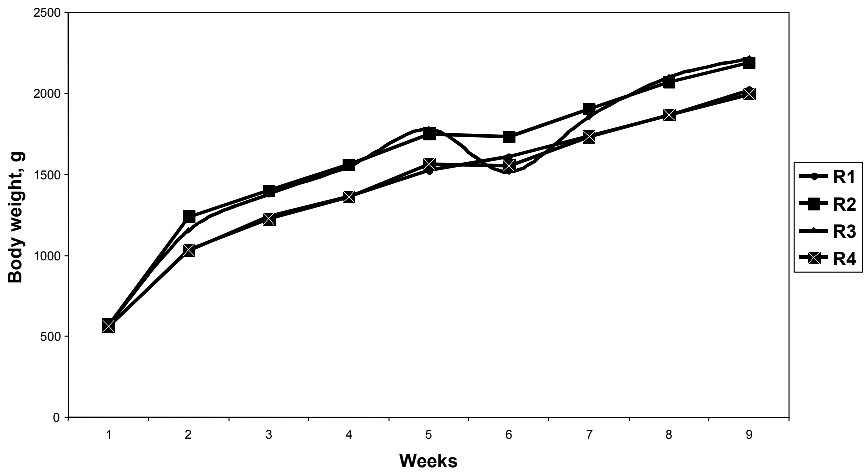


Fig. 1: Body weight development of rabbits fed experimental rations.

The previous studies did not mention any adverse effect on growth rate with increasing Moringa replacement levels. However, Ewuola *et al.* [34] reported that, rabbits fed diets contained 0, 5, 10 and 15% *Moringa oleifera* leaf meal (MOLM) showed sharp decrease of ADG with increasing MOLM replacement level being; 6.80, 5.40, 6.49 and 3.80 g/d with diets 0, 5, 10 and 15% containing MOLM, respectively. Meanwhile, the daily feed intake was nearly comparable among groups. The results of the present study suggest that, moringa dry leaves when fed as feed additive at proper level (0.15 or 0.30%) could play a role as natural growth promoter for rabbits. In the same time, certain adverse effect could be happened with high dosage of moringa supplementation (0.45% as in this study) due to the high content of some phytochemical compounds (phenols, cumarens, alkaloids and tannins) which are naturally occurring at high levels in moringa leaves.

The response of rabbits to moringa supplemented rations was observed during the first tow weeks of feeding (Fig. 1). Body weight development curve showed clear positive effect of feeding $R_2$ (0.15% M) and $R_3$ (0.30% M), while with the higher moringa supplementation level $R_4$ (0.45% M) their was no real influence of moringa on body weight development at all times of the feeding experiment.

**Carcass Characteristics:** Mean slaughter weight, empty body weight, dressing percentage and physical body composition of slaughtered rabbits fed experimental rations are shown in Table (6). Slaughter weight, empty body weight, total edible offals, non-edible offals and trimmings were significantly ($P<0.05$) higher for rabbits fed $R_1$ (0% M) and $R_4$ (0.45% M).

Corresponding values of rabbits fed $R_2$ and $R_3$ or $R_1$ and $R_4$ were nearly comparable. Carcass physical composition showed significant ($P<0.05$) increase of lean meat yield and lower bone weight for rabbits fed moringa supplemented rations than corresponding values of control group. Knife separable fat did not show clear influence with experimental rations, where fat yield calculated relative to carcass weight was 2.84, 1.83, 2.25 and 1.72% for rabbits of groups $R_1$, $R_2$, $R_3$ and $R_4$, respectively. These values are too small and the difference between groups could be neglected; since rabbits meat is known by its high protein and low fat content [35, 36] lean meat + fat to bone ratio was significantly ($P<0.05$) higher with moringa supplemented rations than control, however the best results was recorded on carcasses of groups $R_2$ and $R_3$ (0.15%M and 0.30% M, respectively). These results were in accordance with the findings of Nuhu [23] and Dougnon *et al.* [28], who stated that rabbits fed moringa leaf meal had better slaughter weight and dressed weight than those fed moringa free diet and the values were increased with increasing moringa supplemented level. It seems very interesting to note that, digestive tract weight and length of rabbits fed 0.15 or 30% Moringa leaves supplementation were significantly ($P<0.05$) higher by 10.5 to 14.5% than those fed either control or 0.45% M rations which showed comparable G.I.T. weight and length.

Such results might lead to support our suggestion that, supplemented moringa dry leaves at levels between 0.15 to 0.30% could boost feed utilization of rabbits by increasing the absorptive area of the small intestine in an action most likely to that of bacterial probiotics. However, this effect was not entirely happened with 0.45% M ration with unknown reason.

Table 6: Carcass characteristics, dressing percentage and physical composition of slaughtered rabbits in experimental groups.

| Item | → Experimental groups R1 0% M | R2 0.15% M | R3 0.30% M | R4 0.45% M | SEM |
|---|---|---|---|---|---|
| Animal No. | 3 | 3 | 3 | 3 | --- |
| Pre-slaughter weight (PSW), g | 1862[b] | 2343[a] | 2272[a] | 1956[b] | 68.16 |
| Slaughter weight after bleeding, g | 1809[b] | 2281[a] | 2210[a] | 1889[b] | 67.59 |
| Hot carcass weight including head ($HCW_1$) | 1020[b] | 1368[a] | 1336[a] | 1106[b] | 48.28 |
| $HCW_1$ + total edible offals ($HCW_2$) | 1100[b] | 1459[a] | 1427[a] | 1190[b] | 49.67 |
| *Dressing percentage* | | | | | |
| $HCW_1$/ EBW | 62.96[b] | 64.93[a] | 65.55[a] | 63.71[b] | 0.43 |
| $HCW_2$/ EBW | 67.90[b] | 69.25[a] | 70.02[a] | 68.55[b] | 0.34 |
| *Digestive tract weight, g* | | | | | |
| Full | 391 | 403 | 401 | 357 | 1026 |
| Empty | 149[b] | 167[a] | 167[a] | 137[b] | 4.22 |
| Digestive tract length, cm | 464[b] | 513[a] | 531[a] | 460[b] | 9.59 |
| Empty body weight, g (EBW) | 1620[b] | 2107[a] | 2038[a] | 1736[b] | 87.88 |
| *Edible offals (Giblets) weight, g* | | | | | |
| Heart | 8 | 8 | 10 | 13 | --- |
| Liver | 56 | 67 | 67 | 56 | --- |
| Kidneys | 15 | 15 | 13 | 14 | --- |
| Spleen | 1 | 1 | 1 | 1 | --- |
| Total | 80[b] | 91[a] | 91[a] | 84[b] | 2.09 |
| *Non-edible offals weight, g* | | | | | |
| Clean empty G.I.T | 149 | 167 | 167 | 137 | --- |
| Lungs & trachea | 12 | 12 | 10 | 17 | --- |
| Testicles | 7 | 8 | 8 | 7 | --- |
| Total | 168[b] | 186[a] | 185[a] | 161[b] | 3.97 |
| *Trimmings weight, g* | | | | | |
| External offals (fur, tail, ears and four legs) | 299 | 399 | 364 | 318 | --- |
| G.I.T. content | 242 | 236 | 234 | 220 | --- |
| Blood | 53 | 62 | 62 | 67 | --- |
| Total | 594[b] | 697[a] | 660[a] | 605[b] | 18.46 |
| *Carcass physical composition* | | | | | |
| Lean weight, g | 740[d] | 1089[a] | 1051[b] | 853[c] | 41.54 |
| % of $HCW_1$ | 72.55[c] | 79.61[a] | 78.67[a] | 77.12[b] | 0.68 |
| Fat weight, g | 29[a] | 25[b] | 30[a] | 19[c] | 1.40 |
| % of $HCW_1$ | 2.84[a] | 1.83[c] | 2.25[b] | 1.72[d] | 0.13 |
| Bone weight, g | 251[a] | 254[a] | 255[a] | 234[b] | 9.37 |
| % of $HCW_1$ | 24.61[a] | 18.56[c] | 19.09[c] | 21.16[b] | 0.61 |
| Lean + Fat: Bone | 3.06[c] | 4.39[a] | 4.24[a] | 3.73[b] | 0.13 |

*a, b, c and d: Means in the same row having different superscripts are significantly different at (P<0.05).*
*SEM: standard error of means.*
Empty body weight (EBW) = slaughter weight – digestive tract contents.

Table 7: Economic evaluation for experimental rations.

| Item | → Experimental rations R1 0% M | R2 0.15% M | R3 0.30% M | R4 0.45% M |
|---|---|---|---|---|
| Live body weight (LBW), kg | 2.024 | 2.192 | 2.219 | 1.997 |
| Total feed consumed for each rabbit, kg | 9.212 | 8.988 | 9.509 | 8.882 |
| Costing of one kg feed, (LE)[1] | 2.40 | 2.70 | 3.00 | 3.30 |
| Total feed cost, (LE) | 22.11 | 24.27 | 28.53 | 29.31 |
| Managerial cost / Rabbit, (LE)[2] | 4 | 4 | 4 | 4 |
| Total cost, (LE)[3] | 41.11 | 43.27 | 47.53 | 48.31 |
| Total revenue, (LE)[4] | 50.60 | 54.80 | 55.48 | 49.93 |
| Net revenue | 9.49 | 11.53 | 7.95 | 1.62 |
| Economic efficiency[5] | 0.23 | 0.27 | 0.17 | 0.03 |
| Relative economic efficiency[6] | 100 | 117.4 | 73.91 | 13.04 |
| Feed cost / kg LBW (LE)[7] | 10.92 | 11.07 | 12.86 | 14.68 |

[1] *Based on prices of year 2014.*
[2] *Include management, labors and veterinary care.*
[3] *include the feed cost of experimental rabbit which was LE 15/ rabbit + management.*
[4] *Body weight x price of one kg at selling which was LE 25.* [5] *net revenue per unit of total cost (37).*
[6] *Assuming that the relative economic efficiency of control diet equals 100 %.*
[7] *Feed cost/kg LBW = feed intake * price of kg / live weight.*
*LE = Egyptian pound equals 0.15 US$ approximately.*

**Economic Evaluation:** Economic evaluation of feeding growing rabbits on graded levels of moringa leaves supplementation is presented in Table (7). The best economic efficiency was recorded on rabbits fed $R_2$ (0.27) followed by $R_1$ (0.23) then $R_3$ (0.17), while the lowest value was recorded on rabbits fed $R_4$ (0.03). The relative economic efficiency calculated relative to control group ($R_1$) was 117.4%, 73.9% and 13.04% for groups $R_2$, $R_3$ and $R_4$, respectively.

The high feeding cost of Moringa supplemented rations is due to the high price of moringa dry leaves which equals 100.000 L.E./ ton or about 15.000 US $/ ton. Nuhu [23] reported that the feed cost increased as the level of moringa leaf meal increased from 0% to 20%. However, Adeniji *et al.* [29] and Adeniji and Lawal [27] stated that feed cost per kg weight gain was decreased with increasing the inclusion level of moringa leaf meal in rabbit diets. The differences of feeding cost for diets containing Moringa leaves are undoutedly regarded to the common selling prices in different countries.

## CONCLUSION

Under the conditions of the present study, it could be concluded that inclusion of *Moringa oleifera* dry leaves in growing rabbit rations as a natural feed additive is highly recommended to improve nutrients digestibilities, dietary N utilization, growth performance and carcass dressing percentage. The best results were achieved with moringa leaves supplemented at maximum 0.30%. However, adverse effects were occurred with 0.45% moringa supplementation for all measured parameters. More future studies are needed to understand side effects and proper supplementation dosage of moringa leaves in rations of rabbits and ruminant animals.

## REFERENCES


1. Kristin, D., 2000. The moringa tree. Echo technical note. Florida, U.S.A.
2. Moyo, B., P.J. Masika, A. Hugo and V. Muchenje, 2011. Nutritional characterization of moringa (*Moringa oleifera*) leaves. Africa. J. of Biotechnology, 10(60): 12925-12933.
3. Luqman, S., S. Srivastava, R. Kumar, A.K. Maurya and D. Chanda, 2012. Experimental assessment of Moringa oleifera leaf and fruits for its antistress, antioxidant and scavenging potential using in vitro and in vivo assays. Research Article, Evidence-Based complementary and Alternative Medicine, 81: 12.
4. Anwar, F., S. Latif, M. Ashraf and A.H. Gilani, 2007. Moringa oleifera: a food plant with multiple bio-chemical and medicinal uses- a review. Phytother. Res., 21: 17-25.
5. Dorga, P.D. Sngh and S. Tandon, 1975. Vitamin content in moringa. J. Current Sci., 44: 30-31.
6. Booth, F.E. and G.E. Wickens, 1988. Non-timber uses of selected arid zone trees and shrubs in Africa. FAO conservation Guide, pp: 92-101, Rome.
7. Sreelather, S. and P.R. Padma, 2009. Antioxidant activity and total phenolic content of Moringa oleifera leaves in two stages of maturity. J. Plant Food Human Nutri, 64: 303-311.
8. Osman, H.M., M.E. Shayoub and E.M. Babiker, 2012. The effect of Moringa oleifera leaves on blood parameters and body weights of Albino rats and rabbits. Jordan J. of Biological Sci., 5(3): 147-150.
9. Jaiswall, D., P. Kumar Rai, A. Kumar, S. Mehta and G. Watal, 2009. Effect of Moringa oleifera lam. Leaves aqueous extract therapy on hyperglycemic rats. J. Ethnopharmacol., 123(3): 392-396.
10. Chinwe, C. and N. Isitua, 2010. Studies on the hematological impact of Moringa oleifera in rabbits. A poster presented at 2nd International Conference on Applied Biotechnology, Khartoum, Sudan.
11. Kakengi, A.M.V., M.N. Shen, S.V. Sarwart and T. Fujihara, 2003. Can Moringa oleifera be used as protein supplement to ruminant diet? Asian-Australian Journal of Animal Science, 18(1): 42-47.
12. Oduro, I., W.O. Ellis and D. Owusu, 2008. Nutritional potential of two leafy vegetables: Moringa Oleifera and Impomea batatas leaves. Scientific research and essay, 3(2): 57-60.
13. Onu, P.N. and A.O. Aniebo, 2011. Influence of Moringa oleifera leaf meal on the performance and blood chemistry of starter broilers. International Journal of Food, Agriculture and Veterinary Sciences, 1(1): 38-44.
14. A.O.A.C., 2000. Official Methods of Analysis, 17th ed. Association of Official Analytical Chemists, Washington, DC, USA.
15. Van Soest, P.J., J.B. Robertson and B.A. Lewis, 1991. Methods for dietary fiber, neutral detergent fiber and non-starch polysaccharides in relation to animal nutrition. J. Dairy Sci., 74: 3583-3597.
16. Blaxter, K.L., 1968. The energy metabolism of ruminants. 2nd ed. Charles Thomas Publisher. Spring field. Illinois, U.S.A.
17. Cheeke, P.R., N.M. Patton and G.S. Templeton, 1982. Rabbits Production. 5th Ed., Interstate Printers and Publishers Inc. Danville, IL, USA.

18. Snedecore, G.W. and W.G. Cochran, 1984. Statistical Methods. 6th ed. Lowa State University Press. Ames, Lowa, U.S.A.
19. S.P.S.S., 1998. Statistical Package for Social Sciences, Chicago, U.S.A.
20. Duncan, D.B., 1955. Multiple Rang and Multiple F–Test Biometrics, 11: 1-42.
21. Gupta, K., G.K. Barat, D.S. Wagle and H.K.L. Chawla, 1989. Nutrient contents and anti-nutritional factors in conventional and non-conventional leafy vegetables. Food chemistry, 31: 105-116.
22. Fuglie, L., 1999. Producing food without pesticides: local solution to crop pest control in West Africa. CTA., Wageningen, the Netherlands.
23. Nuhu, F., 2010. Effect of moringa leaf meal (MOLM) on nutrient digestibility, growth, carcass and blood indices of weaner rabbits. M. Sc. Thesis in Animal Nutrition, Kwame Nkrumah University of Science and Technology, Kumasi.
24. Djakalia, B., B.L. Guichard and D. Soumalia, 2011. Effect of Moringa oleifera on performance and health status of young post-weaning rabbits. Research Journal of poultry sciences 4(1): 7-13.
25. N.R.C., 1977. National Research Council. Nutrient requirements of rabbits, National Academy of Science, Washington, D.C.
26. Fahey, J.W., A.T. Zakmann and P. Talalay, 2001. The chemical diversity and distribution of glucosinolates and isothiocyanates among plants, Phytochemistry, 59: 200-237.
27. Adeniji, A.A. and M. Lawal, 2012. Effects of replacing groundnut cake with Moringa oleifera leaf meal in the diets of grower rabbits. International Journal of Molecular Veterinary Research, 2(3): 8-13.
28. Dougnon, T.J., B.A. Aboh, T.M. Kpodékon, S. Honvou and I. Youssao, 2012. Effects of substitution of pellet of Moringa oleifera to commercial feed on rabbit's digestion, growth performance and carcass trait. Journal of Applied Pharmaceutical Science, 2(9): 015-019.
29. Adeniji, A.A., E.S. Gana, I.C. Chibuogwu and R.U. Onyia, 2010, The feeding value of Moringa oleifera leaves for growing rabbits, In: Proc. 36th Ann. Conf., Nig. Soc. Animal Production (NSAP), March 13-16, 2011, University of Abuja, Nigeria, pp: 610-613.
30. Asaolu, V.O., R.T. Binuomote, J.A. Akinalade, O.S. Oyelami and K.O. Kolapo, 2011. Utilization of Moringa olifera fodder combinations with Leucaena leucocephala and Gliricidia sepium fodders by African Dwarf Goats. International Journal of Agricultural Research, 6(8): 607-619.
31. Marai, I.F.M., A.A.M. Habeeb and A.E. Gad, 2002. Rabbits' productive, reproductive and physiological performance traits as affected by heat stress: a review. Livestock Production Science, 78: 71-90.
32. Kpodékon, T.M., A.K.I. Youssao, C.M. Tossou, A.Y. Djago and P. Coudert, 2008. Effects of Molasses Incorporation In Rabbit Fattening Diet On Growth Performances 9th World Rabbit Congress–June 10-13, 2008-Verona-Italy, pp: 123-125.
33. Kpodékon, M., A.K.I. Youssao, G.B. Koutinhouin, I.L. Baba, J.M. Dessou and Y. Djago, 2009. Effect de la granulation sur les performances de croissance, l'efficacité alimentaire et la viabilité des lapereaux en condition d'élevage tropical Revue Élev. Méd. Vét. Pays trop.; 62(1): 75-80.
34. Ewuola, E.O., O.A. Jimoh, O.V. Atuma and O.D. Soipe, 2012. Haematological and serum biochemical response of growing rabbits fed graded levels of Moringa oleifera leaf meal. Proceedings of 10th World Rabbit Congress, Sharm El-Sheikh, Egypt, pp: 679-683.
35. Lebas, F. and G. Matheron, 1982. Rabbits Livest Prod. Sci., 7: 235-250.
36. Fielding, D., 1991. Rabbits: In Tropical Agricultural Series C.T.A. / Macmillan Education Ltd. London, pp: 39-50.
37. Khial, A.A., 1997. Nutritional effects of rabbit manure on the performance of growing rabbits. M. Sc. Thesis, Faculty of Agriculture, Moshtohor, Zagazig University.