Egyptian Journal of Rabbit Science, 28 (2): 263-286 (2018)

EFFECT OF ADDING MORINGA LEAF MEAL TO RABBIT DIETS ON SOME PRODUCTIVE AND REPRODUCTIVE PERFORMANCE TRAITS

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Two experimental studies carried out in order to study the effect of incorporating Moringa leaf meal (MLM) in the diets on the productive and reproductive performance of New Zealand White (NZW) does and their kids. In the first experiment, twenty-seven mature NZW does and nine bucks with an average live body weight of 2.75-3.00 Kg and 5-6 months of age were divided into 3 experimental groups, with 3 replicates each, to study does productive and reproductive performance. Three experimental diets were formulated for does and bucks. Diet 1 (T1) served as the control and contained no Moringa oleifera leaf meal (0%). Diet 2 (T2) and Diet 3 (T3) contained Moringa oleifera leaf meal at the levels of 3% and 6%, respectively. In T2, the 3% MLM replaced 1% soybean meal and 2% barley. In T3, MLM at the level of 6% replaced 2.5% soybean meal and 4.5% barley. In the second experiment, the resulted bunnies of the used does in the first experiment (48 kids distributed to 4 replicates; 4 rabbits each) with an average weight of (800±20 g) were used in a fattening period lasted for 56 days starting after weaning (at 35 days age) and lasted till the 13th week of age. The growing rabbits continued to receive 3 and 6% MLM in their diets (T2 and T3) in a comparison to those received diets without MLM (T1) which served as the control. The second diet (T2) was contained 3% MLM substituted 2% yellow corn and 1% soybean meal. The third diet (T3) contained 6% MLM substituted 4% yellow corn and 2% soybean meal. Productive performance and carcass traits were measured. Economic efficiency of using these materials during the two experiments was considered as well.

***The obtained results showed that** incorporating MLM in diets of mature NZW rabbits reduced significantly number of services for per*

conception (*NSC), days open (DO) and kidding interval (KI). On the other hand, it had no significant effect on gestation period length (GPL) of does. Litter size (LS) significantly (P<0.05) increased with increasing MLM in the diets compared to the control diet. Litter weight (LW, g) followed the same trend of litter size with the superiority of high level of MLM in most cases. Mean bunny weight (MBW, g) significantly improved (P<0.05) with substituting MLM in the experimental rations. Daily weight gain (DWG, g) increased significantly (P<0.05) with feeding on T2 or T3 (26.28 and 29.28 g/day, respectively) than feeding on T1 (23.12 g/day). The highest No. of parity recorded with using 3% MLM, which significantly differed than that recorded with the control group, but without significant difference with the third group (received 6% MLM). Feed intake / parity (Kg) was reduced in both groups of MLM and the noticed significant (P<0.05) reduction recorded between the control and the group received 3% MLM in their diets. The two MLM groups produced the highest (P<0.05) litter weight / parity (Kg) as compared to the control group, but without significant differences between them in the same trait.*

During fattening period of bunnies, with age order advancement the two groups received 3 or 6% MLM in their diets showed significant increase (P<0.05) in live body weight (LBW) with the superiority to those in the group fed high level (6%) of MLM when compared to those in the other two experimental groups. The DWG followed the same trend of LBW in the two groups fed MLM either in a periodical' intervals or for the whole period. Daily feed intake decreased with using MLM in diets of growing rabbits and mean feed intake (g) showed no significant differences among the three experimental groups during the fattening period. Feed conversion (FC) improved significantly (P<0.05) in the tested groups with the best of group received 6% Moringa over that of 3% and 0% (control). The dressing percentages were higher (P<0.05) with feeding on T2 or T3 (62.41 and 62.60%, respectively) than feeding on T1 (59.88%), while the live weight was 2126, 2185 and 2220 g with T1, T2 and T3 diets, respectively.

In point of economic efficiency, the use of MLM at different levels in rabbit diets improved average weight rabbits (Kg/doe), total

return, net return as well as economic efficiency and relative economic efficiency for does and growing rabbits.

***Conclusively,** it could be concluded that Moringa oleifera leaf meal has a strong potent and can play a vital role in rabbit nutrition since it improved economic benefits without any adverse effects on animal performance.*

Keywords: *Moringa*, production, reproduction, carcass, economic efficiency.

To make rabbit production more attractive to small-scale business people, there is need for the development of cheap alternative sources of feed to supplement or replace cereal or protein sources in diets of rabbit to make production more profitable. The high cost of conventionally used plant protein sources in developed and poor countries became major problem. *Moringa oleifera* is one member of the family *Moringaceae* which can be grown in a variety of soil conditions.

Moringa oleifera leaves is a natural source of protein with great potential, since it contains more than twice the amount of protein (2.8 g/100 g fresh weight) found in spinach (Olugbemi *et al.*, 2010). Moreover, Ozumba (2000) stated that, *Moringa oleifera* leaves contains four times the calcium in milk, seven times the vitamin C in orange, three times the potassium in banana, two times the protein in milk and four times the vitamin A in carrot. Moringa leaves contains also magnesium, potassium, and all of the essential amino acids and probably ranked as the best of all the vegetables in the tropical areas. As reviewed by El-Harairy, *et al.* (2016) several authors reported that phytochemical analyses have shown that its leaves are rich in several nutrients as well as antioxidants such as β-carotene, vitamin C, and flavonoids which give it unique possibility for various domestic purposes (Bennett *et al.*, 2003; Aslam *et al.*, 2005; Manguro and Lemmen, 2007; Amaglo *et al.*, 2010; Gowrishankar *et al.*, 2010). Ahmed (2017) stated that Moringa leaves are considered good source of high-quality protein (ranging 15-30%) in the daily ration of farm animals, because it is rich in both essential and sulfur-containing amino acids and true protein presents about 87% of total crude protein. It contains a relatively high concentration of lipids (up to 10%) with a proportion of 33-45% α-linolenic acid. It also contains a number of beneficial bioactive compounds, e.g. phenolics and flavonoids, tocopherols, ascorbic acid, selenium, antimicrobial compounds, immune modulating compounds and antinutritive substances.

Theau-Clement (2000) reported that nutrition may influence reproductive performance by number of mechanisms, including central effects on gonadotrophin secretion and local effects on ovarian function. Moringa leaves found to be effective in improving conception rate in different farm animals (Wubalem *et al.*, 2016 and Ewuola *et al.*, 2015). Several authors, worked on rabbits, reported that moringa leaves or extract or hay at different levels did not show significant effect on conception rate, gestation length, litter size and litter weight (Ola *et al.*, 2012, Emmanuel *et al*., 2014, Ewuola *et al*., 2015, Kelani, 2016, Odeyinka *et al*., 2016 and Mohamady, 2017). Moringa leaves had a positive effect on mean bunny weight (Folasade and Simisola, 2012 and Emmanuel *et al.*, 2014).

Several investigators as reviewed and discussed by Abd-Allah (2017) and Ahmed (2017) found that *Moringa oleifera* can be incorporated in the diets of growing NZW rabbits with different levels without any deleterious effects on growth performance, nutrient utilization, carcass traits and organ weights.

Therefore, the present study aimed at studying the effect of incorporating *Moringa oleifera* leave meal in the diets of mature rabbit does and their kids on the reproductive and productive traits. The economic evaluation of using such feed source on both does and their resultant bunnies' growth were studied as well.

MATERIALS AND METHODS

Two experimental studies carried out in a special Rabbit Production Farm at Dekkrns District, Dakahlia Governorate, Egypt, in order to study the effect of incorporating moringa leaves meal (MLM) in the diets of New Zealand White (NZW) does. In the first experiment, does productive and reproductive performance were considered. In the second experiment, the resultant bunny growth (fattening) and carcass traits were studied. Economic efficiency of using these materials during the two experiments was considered as well.

Experimental diets and formulation:

Moringa leaves were harvested and air dried under shade to prevent the leaves from being denatured until they were crispy to touch. The leaves were thereafter crushed with a blender before incorporation in the tested diets. Three experimental diets were formulated for both does and bucks feeding during the experimental period. Samples of barley, yellow corn, soybean meal and MLM were analyzed according to A.O.A.C. (1990) and the results are shown in Table 1.

Table (1): Chemical analysis for the ingredients of the experimental diets.

Ingredient	% (On dry matter basis)							Dig. energy (Kcal/ Kg feed)
	Dry matter (DM)	Organic matter (OM)	Crude protein (CP)	Ether extract (EE)	Crude fiber (CF)	Nitrogen free extract (NFE)	Ash	
Barley	89.47	77.52	11.00	1.85	6.20	79.27	2.48	3300
Yellow corn	87.50	98.11	8.50	2.36	2.50	83.94	1.90	3750
Soybean meal (44%)	89.92	93.21	44.0	3.42	7.30	41.71	6.82	3200
MLM	90.97	80.01	27.00	6.96	11.02	36.96	10.33	3524

The basal pelleted diet (T1) served as the control diet and contained no MLM (0%). The second diet (T2) was contained 3% MLM substituted 2% barley and 1% soybean meal. The third diet (T3) contained 6% MLM substituted 4.5% barley and 2.5% soybean meal. The third diet (T3) provided with 1% yellow corn more the other two diets in order to have the three experimental diets nearly isonitrogenous and iso caloric (Table 2).

The system provided animals with fresh water and diets which were offered *ad libitum* all over the experimental period on pelleted rations, which formulated in the farm from the available ingredients to cover the nutrient requirements of rabbits as recommended by NRC (1977).

Animals and their management:

Twenty-seven mature NZW does and nine bucks (5-6 months of age and 2.75-3.00 Kg of body weight) were used in the present study. Experimental animals divided into three groups (nine mature does and three bucks each per treatment distributed on 3 cages). Each group of rabbits was fed one of the three diets, which contained MLM (0, 3, and 6%). The rabbits were housed separately in individual wired-cages (50 x 50 x 35 cm).

Rabbits were kept under similar management system. Cages and nest boxes were cleaned and disinfected regularly before each kindling. Light in their houses was allowed 12-14 hours per day during the period of the study, urine and faces dropped from the cages on the floor were cleaned every day in the morning.

Each doe was transferred to the cage of buck assigned for mating and returned back to her own cage after being mated. Each doe was palpated at 10 days thereafter to determine pregnancy and those failed to conceive were

Table (2): The composition and calculated chemical analysis of the tested diets fed to rabbits during the experimental period.

Ingredients	**Control (T1)**	**3% MLM (T2)**	**6% MLM (T3)**
Yellow corn	9	9	10
Barley	17.5	15.5	13
Wheat bran	25	25	25
Soybean meal (44%)	14	13	11.5
Alfalfa hay	30	30	30
Molasses	2	2	2
Di-calcium phosphate	1.2	1.2	1.2
Lime stone	0.7	0.7	0.7
Salt	0.3	0.3	0.3
Premix of Min. &Vit[1]	0.3	0.3	0.3
Moringa Leaf Meal (MLM)	0	3	6
Total	**100**	**100**	**100**
Calculated chemical analysis of diets (on DM basis)[2]			
Digestible energy (DE)	2800	2812	2825
CP (%)	17.90	17.98	17.89
CF (%)	12.18	12.32	12.40
EE (%)	2.77	2.83	2.92
Calcium	1.04	1.10	1.12
Phosphorus	0.78	0.76	0.75
Available phosphorus	0.47	0.51	0.52
Lysine	0.85	0.82	0.79
Methionine	0.30	0.30	0.31
Price/kg (L.E)	4.90	4.72	4.50

1- **Each 1 Kg of the Premix contains**: Vitamin A 2 MIU, Vit. D_3 150000 IU, Vit. E 8.33 g, Vit. K 0.33 g, Vit. B_1 1 g, Vit. B_2 1.09 g, Vit. B_6 0.33 g, Vit. B_5 8.33 g, Vit. B_{12} 1.7 mg, Pantothenic acid 3.33 g, Folic acid 0.83 g, Biotin 33 mg, Choline chloride 20 g, Mg 66.79 g, Zn 11.79 g, Fe 12.5 g, Cu 0.5 g, I 0.3 g, Se 16.6 mg, Co 1.33 mg and carrier $CaCO_3$ up to 1000 g.

2- According to NRC (1977).

returned to the same mated buck. On 27th day of pregnancy, the nest boxes were supplied with wooden straw to help the doe in preparing a worm suitable comfortable nest for the bunnies of her litter. Within 12 hours after kindling, litter were checked and date of birth, number of kits, stillbirth removed and weight of kits were recorded. Afterwards, litter were examined each morning during the suckling period and the dead ones were removed from the nest.

Young rabbits were weaned at five weeks of age (35 day) and transferred to the progeny cages with group of five rabbits per cage.

Does' reproductive traits:

Reproductive performance of doe rabbits including number of services per conception (NSC), days open (DO, interval from kindling to next conception), gestation period length (GPL) and kindling interval (KI) were recorded.

Does' productive traits:

Litter size (LS) as well as litter weight (LW) were recorded at 21 days and 35 days of age. Mean bunny weight (MBW) was measured at birth, 21 days and 35 days of age and thereafter daily weight gain (DWG) calculated for the periods of from birth till 21 days, from 21 till 35 days and for the whole period from birth till weaning (at 35 days) age. Mortality rate (MR) as one of the sensitive parameters related to the economical return of production was also recorded in the present investigation at birth, 21 days (from birth up to 21 days of age) and 35 days (from birth up to 35 days of age).

Bunny fattening experiment:

The resulted bunnies of the used does in the first experiment (48 kids distributed to 4 replicates; 4 rabbits each) with an average weight of (800±20 g) were used in a fattening period lasted for 56 days starting at the 5^{th} week of age (after weaning at 35 days age) and lasted till the 13^{th} week of age. The growing rabbits continued to receive 3 and 6% MLM in their diets (T2 and T3) in a comparison to those received diets without MLM (T1) which served as the control. The second diet (T2) was contained 3% MLM substituted 2% yellow corn and 1% soybean meal. The third diet (T3) contained 6% MLM substituted 4% yellow corn and 2% soybean meal. The three formulated diets were nearly *isonitrogenous* and *iso caloric* (Table 3).

Rabbits live body weight (LBW) were recorded throughout weighing at 5 weeks age (The beginning of fattening period), at 9 weeks age and at 13 weeks age (The end of fattening period). Accordingly, daily weight gain (DWG, g) were calculated for the three intervals 5-9, 9-13 and 5-13 weeks, respectively. Also, body weight gain (BWG, g), daily feed intake (DFI, g) and feed conversion rate (FC; g feed/g gain) were calculated.

Carcass traits:

At the end of fattening period (91 days age), growing rabbits in the three experimental groups fasted for 12 hours and a number of 4 rabbits

Table (3): The composition and calculated chemical analysis of the tested diets fed to growing NZW rabbits during the experimental period.

Ingredients	**Control (T1)**	**3% MLM (T2)**	**6% MLM (T3)**
Yellow corn	9	7	5
Barley	15	15	15
Wheat bran	30	30	30
Soybean meal (44%)	8	7	6
Alfalfa hay	35	35	35
Di-calcium Phosphate	1.2	1.2	1.2
Lime stone	1.0	1.0	1.0
Salt	0.5	0.5	0.5
Premix*	0.3	0.3	0.3
MLM	0	3	6
Total	**100**	**100**	**100**
Calculated chemical analysis of diets **			
DE	2732	2730	2728
CP (%)	16.52	16.60	16.80
CF (%)	13.18	13.40	13.6
EE (%)	2.96	2.98	3.00
Calcium	1.23	1.25	1.30
Phosphorus	0.81	0.79	0.79
Available Phosphorus	0.53	0.54	0.54
Lysine	0.78	0.74	0.72
Methionine	0.33	0.33	0.30
Price/kg (L.E)	4.58	4.44	4.29

* **Each 1 Kg of the Premix contains**: Vitamin A 2 MIU, Vit. D_3 150000 IU, Vit. E 8.33 g, Vit. K 0.33 g, Vit. B_1 1 g, Vit. B_2 1.09 g, Vit. B_6 0.33 g, Vit. B_5 8.33 g, Vit. B_{12} 1.7 mg, Pantothenic acid 3.33 g, Folic acid 0.83 g, Biotin 33 mg, Choline chloride 20 g, Mg 66.79 g, Zn 11.79 g, Fe 12.5 g, Cu 0.5 g, I 0.3 g, Se 16.6 mg, Co 1.33 mg and carrier $CaCO_3$ up to 1000 g.

** According to NRC (1977).

randomly chosen from each treatment weighed and slaughtered. Slaughtered animals were de-skinned, dressed out and the hot carcass including head was weighed and recorded. Edible parts (head, liver, heart, abdomen fat, kidneys, testes and fore part) were separately weighed and recorded.

Dressing percentage was calculated as follows:

Dressing (%) = 100 x (Carcass weight + Head weight + Giblets weight) / Live body weight.

Where: Giblets weight(%) = Liver weight + Heart weight + Kidneys weight/ Live body weight x100.

Economic Efficiency:

Economic Efficiency (E.E) for meat production was calculated as follows:

- Total feed intake (Kg/doe) = (Pregnant doe daily feed intake x 30) + (Lactating doe daily feed intake x 35).
- Total feed cost (L.E) = Total feed intake (Kg) x Price/kg feed (L.E).
- Total return/doe (L.E) = Total weight rabbits/doe (kg) x Price/kg live body weight (L.E).
- Total feed intake (Kg/Rabbits) = Daily feed intake x 56.
- Total return/Rabbits (L.E)= Total weight gain / Rabbits (kg) x Price/kg live body weight (L.E).
- Net return/ doe or growing rabbits (L.E) = Total return/ doe or growing rabbits (L.E) - Total feed cost /doe or growing rabbits (L.E).
- Economic Efficiency (E.E) = Net return/ doe or growing rabbits (L.E) / Total feed cost /doe or growing rabbits (L.E).
- Relatively to control group, the relative economic efficiency (REE) calculated by dividing E.E/E.E of control.

Statistical analysis:

Data were statistically analyzed using Computer Program of SAS (2004) using the General Linear Models (GLM). Significance among treatment means were tested at ($P<0.05$) using Duncan's New Multiple Rang Test (Duncan, 1955).

RESULTS AND DISCUSSION

Reproductive and productive traits:

Data in Table (4) showed that incorporating *Moringa oleifera* leaf meal in diets of mature NZW rabbits reduced significantly NSC, DO and KI. On the other hand, it had no significant effect on GPL of does.

The improvement in NSC, DO and KI can be explained as a result of using *Moringa oleifera*, which have different phytochemicals that diverse antioxidant activity and reduce accumulation of the free radicals which reported to be associated with stress conditions and adversely affect animal performance. In this concern, Agarwal *et al.* (2008) and Ahmad *et al.* (2012)

Table (4): Reproductive and productive performance of rabbit does fed levels of *Moringa oleifera* leaf meal.

Parameters			Treatments				Sign. test
			T1	T2	T3	SEM	
Reproductive parameter		**NSC**	2.45[a]	1.31[b]	1.37[b]	0.16	**
		GPL	30.51	30.47	30.30	0.10	NS
		DO	21.40[a]	11.30[b]	13.26[b]	1.68	**
		KI	52.15[a]	41.85[b]	43.72[b]	1.52	**
Productive parameters	**Litter Size** (LS)	At birth	7.08[b]	7.80[ab]	8.25[a]	0.31	*
		At 21days	6.45[b]	7.40[a]	7.82[a]	0.25	**
		At 35 days	6.23[b]	6.87[b]	7.67[a]	0.26	**
	Litter Weight (LW, g)	At birth	392[b]	447[a]	459[a]	18.70	*
		At 21 days	2167[b]	2498[a]	2633[a]	92.05	**
		At 35 days	5103[b]	5724a[b]	6207[a]	224.99	**
	Mean bunny weight (MBW, g)	At birth	55.31	56.77	56.09	0.65	NS
		At 21 days	335.20	338.61	337.13	3.20	NS
		At 35 days	820.76	834.95	810.60	10.50	NS
	Daily weight gain (DWG, g)	At birth	13.51	13.30	13.31	0.15	NS
		At 21 days	35.41	34.04	34.44	0.63	NS
		At 35 days	22.29	21.60	21.76	0.28	NS
No. of parity			2.33[b]	2.88[a]	2.66[ab]	0.14	*
Feed intake/parity (Kg)			16.10[a]	14.12[b]	15.03[ab]	0.52	*
Litter weight/Parity (Kg)			5.05[b]	5.81[a]	6.64[a]	0.25	**

[a, b:] Means with different superscripts are significantly different at P<0.05.
NS: Not significant, * P<0.05, ** P<0.01
(NSC): Number of services per conception, (DO): Days open (interval from kindling to next conception), (GPL): Gestation period length, (KI): Kindling interval, (NS): Not significant.

stated the stimulates the hypothalamo–pituitary–adrenal axis activity evoking the sympathetic system functions, thus increase levels of free radicals and imbalances in the antioxidant-defense system.

The same trend recorded for GPL in the present study, which falls within the same range of gestation period observed and reported by Odeyinka *et al.* (2008) and Ayodele *et al.* (2014) with using *Moringa oleifera*. They also concluded that *Moringa oleifera* can be used to replace *Centrosema pubescens* without adverse effects on the reproductive performance of rabbits. They added that replacing soybean with *Moringa oleifera* leaf meal in breeding rabbits' does diet at 10, 20 or 30% pose no negative effect on their reproductive performance.

The productive parameters of experimental does as shown in Table (4), such as litter size significantly (P<0.05) increased with increasing *Moringa*

oleifera leaf meal in the diets as compared to the control ones. While, it showed significant (P<0.05) reduction with the time interval advancement (at 21 and 35 days of age) as compared to that obtained at birth. Litter weight (g) followed the same trend of litter size with the superiority of high level of *Moringa oleifera* leaf meal in most cases. Mean bunny weight (g) remarkably improved with significant (P<0.05) differences among the three treatment groups all over the three testing intervals. On the other hand, daily weight gain (g) recorded a nonsignificant reduction among the tested groups during the three testing periods.

The improvement in litter size at birth and at weaning (35 days of age) due to addition of *Moringa oleifera* leaf meal to rabbit does came on line with the results of Ayodele *et al.* (2014) who recorded increased litter size at birth with replacing soybean meal at the rate of 10%. Moreover, Alemede *et al.* (2014) obtained higher litter size at weaning with using 20 & 30% *Moringa oleifera* leaf meal as compared to that received 10% and the control group.

Terzungwe *et al.* (2013) stated the progressive increases in litter weight (g) at birth as the level of *Moringa oleifera* leaf meal increases in the diet of the rabbit does may be referred back to the availability of methionine and cystine in Moringa leaves.

Data of litter weight (g) obtained herein in agreement with those obtained by Alemede *et al.* (2014) who found increments of litter weight at weaning with increasing *Moringa oleifera* leaf meal in the diet from 0 (control) to 30%. Moreover Ayodele *et al.* (2014) reported that litter weight at birth showed significant difference (P<0.05). El-Harairy *et al.* (2016) reported that does mated with bucks treated with *Moringa oleifera* leaf extract at the rate of 60 mg for 21 days before mating gave the highest (P<0.05) value of litter size at weaning and litter weight at birth and weaning. On the other hand, Odeyinka *et al.* (2008) reported that no significant differences among treatments in litter weight (g) at birth of rabbit does fed on *Moringa oleifera* leaf meal.

Although mean bunny weight (MBW) showed no significant differences among the three treated groups, there is a tendency to increase MBW in the two *Moringa oleifera* leaf meal groups when compared to the control ones. Ayodele *et al.* (2014) reported that average bunny weight at weaning had highest value for animals on 20% MLM. They added that this result might be due to the high crude protein content of Moringa made available in the milk before the kits were weaned. El-Harairy *et al.* (2016) obtained significantly

(P<0.05) the highest average bunny weight at birth (g) from rabbit does mated by bucks given 120 mg whole extract of *Moringa oleifera* for 21 days.

The reduction noticed in *Moringa oleifera* leaf meal groups compared to the control ones in terms of daily weight gain contradict the findings of several researchers as discussed and reviewed by Abd-Allah (2017) and Ahmed (2017). Also, Ibrahim *et al.* (2014) recorded that daily weight gain increased significantly in the rabbits received 2 g *Moringa Peregrine* seeds/kg diet. On the other hand, the results obtained in the present study came on line with Ewuola *et al.* (2012) who reported that rabbits fed diets contained 0, 5, 10 and 15% MLM showed sharp decrease of average daily gain with increasing its replacement level. The highest No. of parity (2.88) recorded with using 3% *Moringa oleifera* leaf meal, which differed significantly than that recorded with the control group, but without significant difference with the third group (received 6% MLM). This can be used as an evident for increasing conception rate of does with using MLM. In this concern, Ayodele *et al.* (2014) stated that it can be predicted that MLM had no negative implication on rabbit does conception.

Feed intake / parity (Kg) was reduced in both groups of *Moringa oleifera* leaf meal and the noticed significant (P<0.05) reduction recorded between the control and the group received 3% *Moringa oleifera* leaf meal in their diets. Owen *et al.* (2013) recorded significant differences in feed intake in a study of the economics of raising rabbits using *Moringa oleifera* leaf meal (MOLM) as a replacement for soybeans in the rabbit's feed. However, El-Badawi *et al.* (2014) found that daily feed intake did not significantly influenced by feeding *Moringa oleifera d*ry leaves supplemented rations.

The two *Moringa oleifera* leaf meal groups produced the highest (P<0.05) litter weight / parity (Kg) as compared to the control group, but without significant differences between them. In this concern, it is of interest to mention that Alemede *et al.* (2014) indicated that the large litter sizes at birth will not likely result in a large weight at weaning and that parity could influence weaning weight of rabbits.

Fattening period:

Data in Table (5) showed that, during fattening period of 65 days for bunnies, the 3 groups were significant difference among their LBW at 5 weeks of age. With age order advancement the two groups received MLM in their diets showed significant increase (P<0.05) in LBW with the superiority to those in the group fed high level (6%) of MLM as compared to those in the other two

Table (5): Effect of dietary levels of *Moringa oleifera* leaf meal on live body weight (LBW) and daily weight gain (DWG) during fattening period of kids.

Treatments	LBW (g)			DWG (g)		
Age (weeks)	5	9	13	5-9	9-13	5-13
T1	815.37	1155.12^{c}	2114.37^{c}	26.20^{b}	20.04^{c}	23.12^{c}
T2	820.62	1649.37^{b}	2322.50^{b}	28.52^{a}	24.04^{b}	26.28^{b}
T3	824.87	1708.75^{a}	2521.87^{a}	29.53^{a}	29.04^{a}	29.28^{a}
SEM	4.79	10.70	26.337	0.37	1.03	0.52
Sign. test	NS	*	**	*	**	**

$^{a, b:}$ Means with different superscripts are significantly different at P<0.05.
NS: Not significant, * P<0.05, ** P<0.01

experimental groups. Daily weigh gain (DWG) followed the same trend of LBW in the two groups fed MLM either in a periodical' intervals or for the whole period of 13 weeks. The DWG values showed no significant difference between the two Moringa groups (T2 & T3) during the first month of fattening period (5-9 weeks age). While, such difference was significant (P<0.05) with the control group (T1). For the whole fattening period (5-13 weeks age) these differences were significant (P<0.05) with superiority of T3 over both T2 and T1 groups.

The obtained results in agreement with Kpodékon *et al.* (2008 and 2009) and El-Badawi *et al.* (2014) fond that feeding rabbits on rations supplemented with Moringa was associated with significant (P<0.05) increases of weight gain. Moreover, El-Harairy *et al.* (2016) found that there were significant differences in average daily weight gain per kid, on the different *Moringa oleifera* extract treatments (P<0.05).

As for TBWG, data in Table (6) clearly indicated that, during the first month of fattening period (5-9 weeks age), growing rabbits in T3 group (6% Moringa) increased significantly (P<0.05) by about 12.69% and while, rabbits in T2 group (3% Moringa) increased by about 8.85% as compared with those in T1 (control group, 0% Moringa). The increment of TBWG value was estimated by about 3.52% without significant difference between them. While these BWG differences were significant (P<0.05) among the three experimental groups for the whole fattening period from 5 to 13 weeks age being 26.64%, 13.66% for T3, T2 groups compared to T1 and 11.42% for T3 compared to T2 group. Although feed intake decreased with using MLM in diets of growing rabbits, DFI (g) showed no significant differences among the three experimental groups, during the fattening period. On the other hand, FC

ratio showed significant differences (P<0.05) among the treated groups with superiority of T3 group (6% Moringa) over that of T2 and T1 by about 16.37 and 37.01%, respectively.

In this concern, Nuhu (2010) considered the better growth rate to protein quality and amino acids content of Moringa leaves. Other authors attributed the improvement of rabbit growth to the higher level of vitamin A in Moringa (Grubben and Denton, 2004). These explanations confirmed the trend obtained in this study and supported with the results obtained by Adeniji and Lawal (2012) when they replaced ground nut cake with Moringa (as a protein feed) at levels of 0, 20, 40, 60, 80 and 100%. Also, Dougnon *et al.* (2012) came to the same conclusion with replacing whole rabbit's commercial diet with Moringa leaves at the rate of 0, 10 and 15%.

Table (6): Effect of dietary levels of *Moringa oleifera* leaf meal on total body weight gain (TBWG), daily feed intake (DFI) and feed conversion (FC) during fattening period of kids.

Treatments / **Age (weeks)**	**TBWG (g)**			**DFI (g)**			**FC (g)**		
	5-9	**9-13**	**5-13**	**5-9**	**9-13**	**5-13**	**5-9**	**9-13**	**5-13**
T1	733.75^{b}	561.25^{c}	1295.00^{c}	66.11	112.88	89.50	2.52	5.61	3.85^{a}
T2	798.75^{a}	673.12^{b}	1471.87^{b}	64.34	107.40	85.87	2.25	4.50	3.27^{b}
T3	826.87^{a}	813.12^{a}	1640.00^{a}	63.11	101.46	82.28	2.13	3.50	2.81^{c}
SEM	10.51	28.93	29.44	1.12	3.96	2.54	0.03	0.17	0.08
Sign. test	*	*	*	NS	NS	NS	NS	NS	*

$^{a, b:}$ Means with different superscripts are significantly different at P<0.05.
NS: Not significant, * P<0.05.

The obtained figures for FC are in harmony with the results of El-Badawi *et al.* (2014) who suggested that supplemented Moringa dry leaves at levels between 0.15 to 0.30% of ration could boost feed utilization of NZW rabbits by increasing the absorptive area of the small intestine in an action most likely to that of bacterial probiotics. They added that Moringa dry leaves when fed as feed additive at proper level could play a role as natural growth promoter for rabbits, since it improved (P<0.05) feed conversion efficiency in terms of g. DM intake/ g. weight gain than the control. On the other hand, Ibrahim *et al.* (2014) obtained comparable results to the present study results. They found that daily feed intake (g) increased with increasing *Moringa peregrine* seeds meal (g/Kg diet) compared with those in the control group. While, El-Desoky *et al.* (2017) found that feed intake and BW of rabbit bucks

supplemented with Moringa leaves ethanolic extract during summer season were not affected significantly by the treatment. Moreover, Ahmed (2017) found that final body weight, daily weight gain and relative growth rate were insignificantly increased with NZW rabbits fed MLM at the rate of 12.5 and 19%. The value of feed intake decreased with 19% MLM than those recorded with 12.5% and the control group. The same author obtained similar trend for feed conversion with lower values than those obtained in the present study.

Carcass characteristics:

Data in Table (7) showed that, except for dressing and back quarters percentages and the improvement in carcass weight, all carcass traits did not record significant differences among the three experimental groups. Dressing percentage was improved significantly ($P<0.05$) by about 4.23 and 4.54% for both T2 and T3 (without significant differences between them) compared to the control ones, respectively. Moreover, back quarters percentage for T2 reduced significantly ($P<0.05$) by about 5.67% than those in T1, while such reduction was only 1.79% for T3 than that of T1 without significant differences with both T1 and T2. These changes in the two Moringa groups may be due to the improvement noticed in carcass weight which might refer back to the increased weights of liver, abdomen fat, kidney and back quarters.

The results of the present study came on line with those of El-Badawi *et al.* (2014) who found that lean meat + fat to bone ratio was significantly ($P<0.05$) higher with Moringa supplemented rations than control. These results supported also with findings of Nuhu (2010) who reported that rabbits fed MLM had better slaughter weight and dressed weight than those fed Moringa free diet. They noticed also that the such weights were increased with increasing Moringa supplemented level.

In addition, Ahmed (2017) reported that carcass traits were not significantly ($P>0.05$) influenced by the dietary treatment of NZW growing rabbits with 12.5 and 19% MLM. He obtained lower dressing percentage (52.34, 54.04 and 53.435 with the control, 12.5 and 19% groups, respectively) than those recorded in the present study. Moreover, the results of the present investigation supported with the findings of several authors who concluded that *Moringa oleifera* can be incorporated in the diets of growing rabbits without any deleterious effects on the carcass and organ weights as reviewed and discussed by Abd-Allah (2017).

Table (7): Carcass characteristics and carcass yield (% carcass weight) of rabbits fed different levels of *Moringa oleifera* leaf meal.

Parameters	Treatment groups				Sign. Test
	T1	T2	T3	SEM	
Live weight (g)	2126.25	2185.00	2220.00	112.48	NS
Carcass weight (g)	1271.25	1363.75	1390.00	65.44	NS
Head weight (g)	126.87	126.01	126.63	5.54	
%	9.98	9.24	9.11	0.31	NS
Liver weight (g)	87.33	97.51	106.75	10.16	
%	6.87	7.15	7.68	0.66	NS
Heart weight (g)	7.50	7.36	7.37	0.48	
%	0.59	0.54	0.53	0.03	NS
Kidney weight (g)	12.97	15.00	17.10	0.82	
%	1.02	1.10	1.23	0.07	NS
Abdomen fat weight (g)	11.19	13.64	15.71	2.64	
%	0.88	1.00	1.13	0.16	
Testes weight (g)	6.23	6.14	6.67	1.08	NS
%	0.49	0.45	0.48	0.07	NS
Back quarters (g)	405.27	411.44	435.35	21.53	NS
%	31.88^{a}	30.17^{b}	31.32^{ab}	0.42	*
Dressing percentage*	59.88^{b}	62.41^{a}	62.60^{a}	0.60	*

a, b: Means in the same raw bearing different superscript are significantly different (P<0.05).
NS: Not significant, * P<0.05.

Economical efficiency of does and their kids:

Data in Table (8) represented the economic evaluation of using MLM in diets of rabbit does and their kids. It is worth mentioning that MLM increased insignificantly total feed intake/doe (Kg). In the meantime, average number of parity/doe improved significantly (P<0.05) by 23.61 and 14.16% for T2 and T3, respectively as compared to T1. The noticed nonsignificant increase in total weight rabbits (Kg/doe) may be attributed to the increase in total feed intake of does. Moreover, MLM in diets of rabbit does improved non-significantly average weight rabbits (Kg/doe) by 15.05 and 23.56% for T2 (3% Moringa) and T3 (6% Moringa) over those in T1 (Control group, 0% Moringa).

It is of interest to notice that total return, net return as well as economic efficiency and relative economic efficiency were the highest with using 6% Moringa in does and growing rabbit diets (T3). Such positive impact may be due to its effect in increasing doe productivity (total weight rabbits/doe). The results recorded in the present study came on line with Alemede *et al.* (2014)

Table (8): Economic efficiency of using MLM in does and growing rabbit diets.

Parameters	Treatment groups		
	T1	T2	T3
Economic efficiency for does			
Total feed intake (Kg/doe)[1]	36.94	40.30	39.04
Total weight rabbits (Kg/doe)	12.02	16.72	16.50
Price/Kg MLM (L.E)	7.50	7.50	7.50
Price/kg feed (L.E)	4.90	4.72	4.50
Total feed cost (L.E)[2]	181.00	190.21	175.68
Price/kg live body weight (L.E)	35	35	35
Total return (L.E)[3]	420.7	585.2	577.5
Net return (L.E)[4]	239.7	394.99	401.82
Economic efficiency (EE)[5]	1.32	2.08	2.29
Relative economic efficiency (REE)[6]	100	158	173
Economic efficiency for growing rabbits			
Total feed intake (Kg/Rabbits)[7]	5.01	4.80	4.60
Total weight gain (Kg/ Rabbits)	1.29[c]	1.47[b]	1.64[a]
Price/kg feed (L.E)	4.58	4.44	4.29
Total feed cost / Rabbits (L.E)[2]	22.95	21.31	19.73
Price/kg live body weight (L.E)	35	35	35
Total return/ Rabbits (L.E)[8]	45.15	51.45	57.40
Net return (L.E)[4]	22.20	30.14	37.67
Economic efficiency (EE)[5]	0.97	1.41	1.90
Relative economic efficiency (REE)[6]	100	145	195

1- Total feed intake (Kg/doe) = (Pregnant doe daily feed intake x 30) + (Lactating doe daily feed intake x 35).
2- Total feed cost (L.E) = Total feed intake (Kg) x Price/kg feed (L.E).
3- Total return/ doe (L.E) = Total weight rabbits /doe (kg) x Price/kg live body weight (L.E)
4- Net return/ doe or growing rabbits (L.E) = Total return/ doe or growing rabbits (L.E) - Total feed cost /doe or growing rabbits (L.E)
5- Economic Efficiency (E.E) = Net return/ doe or growing rabbits (L.E) / Total feed cost /doe or growing rabbits (L.E)
6- Relative economic efficiency (REE) = E.E / E.E of control
7- Total feed intake (Kg/Rabbits) =Daily feed intake x 56
8- Total return/ Rabbits (L.E) = Total weight gain / Rabbits (kg) x Price/kg live body weight (L.E)

who showed progressive decrease in the cost of feed with increase in horseradish (*Moringa oleifera*) leaf meal in the diet. Moreover, the obtained total weight rabbits (Kg/doe) confirmed with the results of Adeniji *et al.* (2010) who stated that feed cost per kg weight gain was decreased with increasing the inclusion level of MLM in rabbit diets. On the other hand, Nuhu (2010) reported that feed cost increased as the level of MLM increased from 0% to 20%.

With growing rabbits total feed intake (Kg/rabbits) presented in Table (8) reduced non-significantly in T2 and T3 group as compared to T1 group, but was higher in T2 than T3. Meanwhile, total weight gain (Kg/rabbits) significantly ($P<0.05$) increased with increasing MLM in the diets of growing rabbits at levels 0 to 3 and 6%, respectively. Although as Moringa addition increased in diets of growing rabbits, total feed cost/rabbits decreased, while total return/rabbits, net return, economic efficiency and relative economic efficiency were increased and recorded the best results with T3 followed by T2 and T1, respectively.

From economic point of view, the results in the present study generally are in harmony with Owen *et al.* (2013) who studied the economics of raising rabbits using *Moringa oleifera* leaf meal (MOLM) as a replacement for soybeans in the rabbit's feed. They obtained significant differences existed in weight gain, feed intake, feed conversion ratio, cost of feed (kg), cost of weight gain and net benefit. It also revealed that MOLM can conveniently replace up to 15% of expensive sources of protein in rabbit diet without compromising performance. Similarly, Tarha (2013) reported that *Moringa oleifera* leaf meal could be used at levels up to 20% of the diets of the rabbits without any deleterious effects on the performance. Moreover, Abd-Allah (2017) concluded that economic efficiency and relative economic efficiency of NZW rabbits improved when they fed moringa hay at the levels of 10 and 15%.

Conclusively, it could be concluded, regardless the expense of protein sources in the diets, that rabbit growers can use *Moringa oleifera* leaf meal in the formation of their animals diets to improve economic benefits without any adverse effects on animal performance.

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تأثير إضافة مستويات مختلفة من مسحوق أوراق المورنجا في علائق الارانب على آدائها الإنتاجي والتناسلي

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أجريت تجربتين بهدف التعرف على تأثير إضافة مسحوق أوراق المورنجا في علائق الأرانب النيوزيلندي الابيض وخلفاتها. في التجربة الأولى تم استخدام عدد ٢٧ أنثى ناضجة و٩ ذكور من الأرنب النيوزلندى الأبيض بمتوسط وزن ٢.٥-٣.٠٠ كجم وعمر ٥-٦ شهور مقسمة على ثلاث مجموعات تجريبية بكل مجموعة ٣ مكررات لدراسة الأداء الإنتاجي والتناسلي للحيوانات المختبرة. تم تكوين ٣ علائق تجريبية للإناث والذكور. استخدمت العليقة الأولى للمقارنة ولا تحتوى على المورنجا (٠% مورنجا). واحتوت العليقتان الثانية والثالثة على مسحوق أوراق المورنجا بمعدل ٣ ، ٦% على التوالي. في العليقة الثانية تم استبدال ١% مسحوق فول صويا و ٢% شعير بنسبة ٣% مسحوق أوراق المورنجا. وفي العليقة الثالثة تم استبدال ٢.٥% مسحوق فول صويا و ٤.٥% شعير بنسبة ٦% مسحوق أوراق المورنجا. وفي التجربة الثانية تم استخدام نتاجات الأمهات وعددها ٤٨ أرنب بمتوسط وزن (٨٠٠±٢٠ جم) موزعة على ٤ مكررات (بكل مكررة ٤ أرانب) لكل معاملة ، وذلك في تجربة نمو استمرت لمدة ٥٦ يوماً من بعد الفطام (عمر ٣٥ يوم) حتى الأسبوع الثالث عشر. واستمرت الأرانب النامية في التغذية على ثلاث علائق تجريبية الأولى خالية من المورنجا (مجموعة المقارنة) والثانية بها ٣% مسحوق أوراق المورنجا (إحلال محل ٢% أذرة صفراء و ١% مسحوق فول الصويا) والثالثة بها ٦% مسحوق أوراق المورنجا (إحلال محل ٤% أذرة صفراء و ٢% مسحوق فول الصويا). وذلك لدراسة خصائص النمو خلال فترة تسمين وخصائص الذبيحة. كما تم دراسة الكفاءة الإقتصادية لاستخدام مسحوق أوراق المورنجا في التجربتين.

أوضحت النتائج المتحصل عليها أن إدخال مسحوق أوراق المورنجا في عليقة أمهات الأرنب النيوزلندي الأبيض الناضجة قد نتج عنه نقص معنوى في كل من عدد مرات التلقيح اللازم للإخصاب والفترة المفتوحة والفترة بين ولادتين. وعلى العكس ، لم يكن لها تأثير معنوى على طول مدة الحمل. حدثت زياده معنوية (على مستوى ٥%) فى حجم البطن بزيادة نسبة المورنجا في العليقة مقارنة بمجموعة الكونترول. وأخذ وزن البطن نفس الاتجاه مع تفوق المعاملة ذات المحتوى الأكبر من المورنجا في معظم الحالات. وحدث تحسن (على مستوى

٥%) في متوسط وزن النتاجات في العلائق المحتوية على المورنجا. وتحسنت معنوياً (على مستوى ٥%) متوسط الزيادة اليومية في الوزن عند التغذية على عليقة ٣% أو ٦% مورنجا (٢٦.٢٨ و ٢٩.٢٨ جم/يوم) عن المغذاة على عليقة المقارنة (٢٣.١٢ جم/يوم). تم الحصول على أعلى عدد للبطون عند استخدام ٣% مورنجا حيث اختلفت معنوياً عن مجموعة المقارنة ولكنها لم تختلف معنوياً عن تلك المسجلة لمجموعة ٦% مورنجا. حدث نقص في الغذاء المأكول للبطن (كجم) في مجموعتي المورنجا وكان هذا النقص الملحوظ معنوياً (على مستوى ٥%) بين مجموعة المقارنة والمجموعة المغذاة على العليقة التى بها ٣% مورنجا. أعطت مجموعتى المورنجا أعلى (على مستوى ٥%) وزن خلفات / البطن (كجم) مقارنة بمجموعة الكونترول ولكن الفرق لم يكن معنوياً بينهما لنفس الصفة.

خلال فترة تسمين النتاجات ، أظهرت المجموعتان المغذيتين على ٣ و ٦% مورنجا تحسناً معنوياً (على مستوى ٥%) وزن الجسم الحى مع التقدم في العمر مع تفوق المجموعة المغذاة على المستوى المرتفع من المورنجا (٦%) مقارنة بالمجموعتين التجريبيتين الأخريين. أخذت الزيادة اليومية في وزن الجسم نفس اتجاه التغير فى وزن الجسم الحى لمجموعتي المورنجا سواء على مستوى فترات التجربة أو خلال الفترة الكلية. حدث نقص في العلف المأكول مع استخدام المورنجا في علف الأرانب النامية ولم تظهر أية فروق معنوية بين الثلاث مجموعات التجريبية في متوسط الغذاء المأكول طوال فترة التجربة. وحدث تحسن معنوى (على مستوى ٥%) في معامل تحويل الغذاء للمجموعات المختبرة وكان أفضلها في المجموعة المغذاة على عليقة ٦% مورنجا عن تلك المسجلة لمجموعة ٣% أو الكونترول. كانت نسبة التصافى مرتفعة معنوياً (على مستوى ٥%) عند التغذية على المعاملتين الثانية والثالثة T2 &T3(٦٢.٤١ و ٦٢.٦٠%، على الترتيب) عن المسجلة عند التغذية على عليقة المقارنة T1 (٥٩.٨٨%)، بينما كان متوسط الوزن الحي ٢١٢٦و ٢١٨٥ و ٢٢٢٠ جم مع علائق المعاملة الأولى والثانية والثالثة على التوالي.

من وجهة النظر الاقتصادية ، فإن استخدام مسحوق أوراق المورنجا بمستويات مختلفة فى علائق أمهات الأرانب أو الأرانب النامية تسبب في تحسن متوسط وزن النتاج (كجم/أم) ، العائد الكلى ، وصافى العائد وكذلك تحسن الكفاءة الاقتصادية والكفاءة الاقتصادية النسبية.

التوصية: يمكن استنتاج أن مسحوق أوراق المورينجا يلعب دوراً حيوياً فى تغذية الأرانب وأن إضافتها بنسبة ٦% أدت إلى تحسن العائد الاقتصادى دون أثار ضارة على آداء الحيوانات.