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INFLUENCE OF BIOLOGICALLY TREATED *MORINGA OLEIFERA* LEAVES MEAL BY LACTOBACILLUS ACIDOPHILUS ON PRODUCTIVE PERFORMANCE AND PHYSIOLOGICAL STATUS OF GROWING RABBITS

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SUMMARY

The current study was conducted to shed more light on the beneficial effects of moringa leaves meal biologically treated with *L. acidophilus* (TMLM) as a promising feedstuff on growth performance, carcass traits, biochemical characteristics and digestibility coefficients of growing rabbits under different levels. This study was carried out at two stages; the first one was growth performance investigation that include eighty 5-weeks-old male rabbits were divided into four equal experimental groups, 20 rabbits of each in a complete random design and were allocated individually in double galvanized wire cages; the experimental groups were control 0% TMLM, 20% TMLM, 30%TMLM and 40% TMLM. The second was a digestibility study that investigates the effect of TMLM levels on digestibility coefficients of nutrients. The results showed that, rabbits fed diet containing 40 % treated moringa leaves meal (TMLM) had significantly ($P \leq 0.05$) the highest final body weight and daily weight gain being 2390 g and 31.13 g/day, respectively. In the same trend, rabbits fed 40 % TMLM had significantly ($P \leq 0.05$) the best feed conversion ratio (3.3), additionally; the carcass and dressing percentage were improved significantly ($P \leq 0.05$ or 0.01) in rabbits fed 40% MLM. The same trend was observed with nutrients digestibility and nutritive value, in comparing with control. Also, blood metabolites were significantly improved specially triglycerides and cholesterol. All of these results suggest that TMLM can be included in growing rabbit diets up to 40 % without any adverse effect on performance and physiological status of growing rabbits.

Keywords*: *Moringa oleifera, Lactobacillus acidophilus, rabbit performance, carcass traits and digestibility.

INTRODUCTION

The shortage of animal feedstuffs and the expensive cost of feeding are the major significant limiting factors for increasing the rabbit production (De Blas *et al.*, 1989). This problem can be reducing by using unconventional feedstuffs and agriculture by-products which are not directly used by human as food and have the capacity to produce the same yield as traditional feeds with low price. The leaf meal of some tropical shrubs is one conceivable wellspring of modest protein has been utilized as a part of rabbit feeding methodologies. *Moringa oleifera* is one of Moringaceae shrubs commonly grown in many countries around the world. Recently, it's cultivated in some areas at Egypt to help land reclamation and improve more land for agriculture. Moringa leaves meal represents a potential ingredient for animal feed, due to its high protein content (20-29%) on dry matter basis (Safwat *et al.*, 2014). What's more, it has a decent amount of essential amino acids, fatty acids, vitamins and minerals (Odetola *et al.*, 2012). Hence, it has the efficiency to replacement soybean meal in rabbit diets as untraditional protein source (Caro *et al.*, 2013).

Ufele *et al.*, (2013) reported that *Moringa oleifera* leaf meal is potential protein source for rabbits feeding at the level of 20%. Also, (Nuhu, 2010) cited that the performance of the weaning rabbits improved by inclusion of moringa leaf meal as a non-conventional protein source up to 20% in the diets. Moreover, it has a positive effect to reduce cholesterol level in blood and the meat of rabbits. Regarding to the supplementation of moringa in the feed of young post-weaning rabbits, Djakalia *et al.* (2011) showed that the addition of moringa at level of 3% led to an improvement in productive performance and digestibility of protein.

The species of *Lactobacillus acidophilus* bacteria are occasionally characterized probiotic are used in food and feed to induce nutrients availability (El-Adawy *et al.,* 2013). Additionally, these bacteria may have several therapeutic functions, such antimicrobial activity, anticholesterol activity and anticarcinogenic activity (Abou-Zeid *et al.,* 2014 and 2015).

Several studies have been conducted to incorporate *Lactobacillus acidophilus* bacteria in rabbit diets to improve growth performance and physiological status (Falcão-e-Cunha *et al*., 2007; El-Adawy *et al.,* 2013). Most of these studies reported that the biological treatments with *Lactobacillus acidophilus* improved performance traits and physiological status of rabbits (Abdel-Aziz *et al.,* 2015).

Therefore, the aim of this investigation is to study the effect of inclusion moringa leaf meal treated biologically as a protein and fiber source in complete pelleted New Zealand White (NZW) rabbit diets at different levels on performance and physiological status.

MATERIALS AND METHODS

A trail was carried out at the private commercial rabbit's farm under supervision of Animal Production Department, Faculty of Agriculture, Tanta University.

Moringa leaf meal preparation:

Moringa oleifera leaves were collected from trees (2 to 3 years old) at north Sinai governorate, Egypt, and preparing as mentioned by Abou-Elezz *et al.,* (2011), then dried for a day under shade. After that, it were dried at air oven at 60^{o}c for 24 hrs. The dried leaves were grounded to pass a 4.0 mm screen with a hammer mill to make the MLM, which were included to the experimental diets after treated with *L. acidophilus*.

Biological treatment of MLM:

Lactobacillus acidophilus bacteria which were used in biological treatment were obtained from the Microbiological Resources Centre (MIRCEN), Faculty of Agriculture, Ain Shams University, Cairo, Egypt. The bacteria were enrichment on deMan, Rogosa & Sharpe (MRS) broth at (22-26°C). The MLM was autoclaved at 121°C and 1.5 psi for 15 min to get rid of any microbes. The autoclaved MLM was allowed to cool and later inoculated with *L. acidophilus* at a rate of 50 mL of the colony suspension containing 10^7 CFU per mL/kg DM of the content. Thereafter, the inoculated substrate was incubated under anaerobic condition for 10 days at 26°C. By the end of the incubation period, the granular MLM treated biologically (TMLM) was tray dried overnight in a forced air oven at 75°C until a constant weight, and then stored in polyethylene bags until assayed.

Animals and experimental design:

Eighty NZW rabbits male, five weeks of age with an average live body weight of 648.5+ 22.5g, were used in the present experiment. Rabbits were divided randomly into four experimental groups of 20 rabbits. Feed and water were available *ad-libitum*. Experiment lasted for 8 weeks. Animals were individually weighed weekly throughout the 8-week experimental period. Feed consumption, body weight gain, feed conversion ratio and performance index were also determined weekly.

Experimental diets:

Four experimental diets were formulated to cover all essential nutrients requirements for growing rabbits. The diets were control, 20, 30 and 40% TMLM. Diets were presented in form of pelleted feed. The composition and chemical analysis of all experimental diets are shown in Table (1).

Chemical composition:

Conventional analysis of MLM treated or untreated, experimental diets and proximate analysis of carcass meat samples were determined according to the standard AOAC (2000).

Slaughter trial:

Nine rabbits from each treatment were randomly slaughtered at the end of the 13th week of age. Rabbits were weighed and slaughtered after fasting for 12 h. After slaughtering and complete bleeding, stomach, small intestine, caecum and large intestine weights were taken and carcass traits were evaluated according to *Blasco et al.* (1993).

Table (1): Composition and chemical analyses of the experimental diets.

Ingredient	Levels of TMLM (%)			
	0	20	30	40
Treated MLM (TMLM)	00	20.00	30.00	40.00
Yellow corn	18.00	16.00	18.50	18.50
Wheat bran	16.50	15.00	12.00	5.00
Barley grain	13.00	13.00	13.00	15.00
Soybean meal (44%)	15.00	8.00	5.00	2.00
Berseem hay	33.00	23.50	17.00	15.00
Molasses	2.00	2.00	2.00	2.00
Limestone	1.00	1.00	1.00	1.00
Dicalcium Phosphate	0.60	0.60	0.60	0.60
Premix[1]	0.20	0.20	0.20	0.20
DL-Methionine	0.20	0.20	0.20	0.20
Common salt	0.50	0.50	0.50	0.50
Total	100	100	100	100
Chemical analyses (% as DM)				
CP	16.66	16.64	16.63	16.77
DE, kcal/kg[2]	2582	2590	2582	2561
CF	12.86	12.31	12.20	11.95
Ether extract (EE)	2.31	2.46	2.54	2.95
Ash	8.65	8.72	8.80	9.00
DL-Methionine	0.50	0.48	0.47	0.46
Lysine	1.02	0.96	0.91	0.88
Calcium	0.94	0.93	0.93	0.94
Total phosphorus	0.45	0.42	0.46	0.47

[1]: Each 3 kg of premix contained: Vitamin A 12000000 IU, V.D3 2200000 IU, V.E 10000 mg, V.K3 2000 mg, V.B1 1000 mg, V.B2 4000 mg, V.B6 1500 mg, V.B 12 10 mg, Pantothenic Acid 10000 mg, Niacin 20000 mg, Biotin 50 mg, Folic Acid 1000 mg, Coline chloride 500 gm, Selenium 100 mg, Copper 10000 mg, Iron 30000 mg, Manganese 55000 mg, Zinc 50000 mg, Iodine 1000 mg and carrier CaCoi to 3000 gm.
[2]: Calculated according to Fekete and Gippert (1985): DE (kcal/kg) = 4253 - 32.8(%CF) – 144.4 (% ash).

Blood biochemical Traits:

Blood plasma was obtained by centrifugation of heparinized blood for 15 min at 3000 rpm and kept in ependorf tubes until chemical analysis. Total protein was determined according to Tietz (1995). However, albumin was measured according to Young (2001). Globulin was calculated as the difference between total protein and albumin. Glucose, cholesterol, triglyceride, ALT, AST, urea and creatinine were measured using specific diagnostic kits produced by MDSS GmbH, Schiffgraben 41 Germany, as recommended by Young (2001).

Digestibility trial:

Ileal digestibility

Six adult of NZW rabbits males from each experimental group weighing 3 - 3.5 kg were fitted with a single T glass cannula in the terminal of ileum according to the technique described by Gidenne (1988). Cannulated rabbits were kept individually in metabolic wire cages (45 x 45 x 35cm). After 7 days of adaptation to each experimental diet, rabbits were housed in a special hammock with an opening to admit cannula. Plastic neck collars were used to prevent the caecotrophy. A series of six collection of ileal digesta (ileal flow) were performed during three days (2 collections/day) with a time interval such to cover a 24h cycle. Ileal apparent digestibility coefficients (IADC) were calculated according to Gidenne (1988).

All tract digestibility

A digestibility trial was performed using 32 NZW rabbits male (8 per experimental group) at least three months of age and nearly similar body weight to determine the nutrients digestion coefficients and nutritive value of the four experimental diets. Eight rabbits males in each group were housed individually in metabolic wire cages (50×50×40 cm) that allow collecting faeces and urine separately. Faecal samples were collected daily over 5 consecutive days according to the European reference method for rabbit digestion trials (Perez *et al.*, 1995). Sample of daily faeces (20%) of each rabbit were collected every day, dried at 60-70°C for 48 hrs., finally bulked, mixed, ground and kept for chemical analysis. Nutritive value in terms of total digestible nutrients (TDN) and the digestible crude protein (DCP) were calculated according to formula of Cheeke *et al.* (1982).

Economic efficiency:

Economic efficiency was calculated according to Raya *et al.* (1991) from the following equation:

Economic efficiency (%) = $\frac{\text{Net revenue (PT)}}{\text{Total feed cost (PT)}} \times 100$

Where;

Net revenue = Price of weight gain (PT) - Total feed cost (PT).

Price of weight gain (PT) = Average weight gain (kg/head) ×Price/kg live body weight (PT).

Total feed cost (PT) = Average feed consumption (kg/head) × price /kg feed (PT).

Statistical Analysis:

Data were analyzed according using SAS program (SAS, 2003).The application of the least of significance test for the differences among the different treatment means were done according to Duncan (1955).

The following model was used:

$Yij = \mu + \alpha i + eijk$

Where:

Yij = An observation.

μ = Overall mean.

αi = Effect of using different levels of treated MLM (i=0, 20, 40, and 40%).

eijk = Residual (Random error).

RESULTS AND DISCUSSION

Major components in raw and treated MLM:

The data of chemical compositions of dry matter (DM), crude protein (CP), ether extract (EE), crude fiber (CF), ash and nitrogen free extract (NFE) for raw and treated MLM are shown in Table (2). It is clearly showed that, both of raw and treated MLM have nearly similar composition, with an increasing in the content of CP% in treated MLM by 13.54% compared to raw MLM.

The obtained results of MLM chemical composition were nearly similar to that finding by Safwat *et al.* (2014). On the other hand, chemical analysis of MLM were lower than the CP and CF values cited by Aboh *et al.* (2012) and Dougnon *et al*. (2012). The differences in the current data and those reported in literature may be due to various factors such as the differences in varieties, agronomic practices, soil, and climatic conditions additionally methods of processing (Nuhu, 2010 and Abou-Elezz *et al.,* 2011).

The increase of crude protein in TMLM may be due to the effect of *L. acidophilus*, it able to convert the crude fiber to microbial protein in their bodies. Studies indicated that *L. acidophilus* was produced some enzymes able to degrading crude fiber and non-protein nitrogen, bacteria grown on it as a sole carbon and nitrogen source, and converted them to carbon chains and amides compounds (El-Shennawy, 2003). The bacteria consumed these compounds and used it in their bodies as microbial protein as previously mentioned by Abbott *et al.,* (1999).

Table (2): Chemical analysis of raw and treated MLM.

MLM	DM	Nutrient content (%on dry matter basis)				
		CP	CF	EE	Ash	NFE
Raw	91.73	21.12	15.36	6.34	8.83	39.99
Treated	90.12	23.98	13.80	6.35	8.86	37.13

Performance traits:

The effect of treated moringa leaf meal (TMLM) on performance characteristics of growing NZW rabbits from 5 to 13 weeks of age are presented in Tables (3)**.** The data showed that at 13 weeks of age, significant differences in the live body weight could be detected among the levels of TMLM. Rabbits fed diet with 40% TMLM possessed significantly (P≤0.05) the highest value of final live body weight by 6.98 compared to control. At the same time the lowest value (P≤0.05) of final live body weight was noticed in rabbits fed diet containing 20% TMLM by 1.61% when compared to control group. The same trend was observed with the daily weight gain (DWG) and daily feed consumption (DFC); which were significantly increased (P≤0.05) in group fed 40% TMLM by 9.76 and 3.8%, respectively, compared to control. While, the group fed 20% TMLM recorded the lowest values of DWG and DFC by 2.47 and 3.6% decrement than control group.

Concerning to the feed conversion ratio (FCR), the results showed that the FCR was improved significantly (P≤0.05) for rabbits fed diet containing 40% followed by 20% and 30% TMLM; meanwhile, the control group had the worst FCR.

Regarding to the growth rate, there was insignificant differences between the rabbits fed diet with 40, 30% TMLM and control. While, the group fed 20% TMLM had the lowest growth rate. Additionally, Performance index (PI) was significantly (P≤0.05) increased by 13 and 3% for rabbits fed diet with 40 and 30% TMLM, respectively, as compared to control. At the same time the lowest value (P≤0.05) of PI was noticed for rabbits fed diet containing 20% TMLM.

In general, the increments of body weight and daily weight gain for the rabbits fed diets with 30 and 40% TMLM that observed in Table (3) could be attributed to the improve of feed conversion ratio. The improvement in FCR may be due to the adaptability of rabbits to TMLM in the diets and the increase of protein and fiber digestion coefficients as noticed in the current investigation (Table 6 and 7). The improvement of fiber digestibility coefficient leads to increase the rate of microbial protein synthesis in soft faces. The increase in the microbial protein is the result of increase the utilization of crude fiber that offers the suitable environment to bacterial growth in caecum (El-Adawy *et al.,* 2013). Also, *L. acidophilus* improved palatability of TMLM which improved the FCR. In addition, TMLM has a good protein content (23.98%) and quality (source for essential amino acids, nearly similar to soybean meal) (Odetola *et al.,* 2012). These results are harmony with the results of (Dougnon *et al.,* 2012; Ufele, *et al.,* 2013; Safwat *et al.,* 2014) that pointed out that the performance traits of rabbits fed MLM were improved when fed growing rabbits on diet containing 30% MLM.

Table (3): Performance traits of growing NZW rabbits fed different levels of treated MLM.

Item	Treated MLM levels (%)				SEM	Sig.
	0	20	30	40		
No. of rabbits	20	20	20	20	--	--
Body weight:						
Initial (5 wks.)	646	649	652	647	19.7	NS
Final (13 wks.)	2234^{c}	2198^{d}	2296^{b}	2390^{a}	62.3	*
Daily weight gain (g)	28.36^{bc}	27.66^{c}	29.36^{b}	31.13^{a}	1.62	*
Daily feed consumption (g)	98.98^{ab}	95.43^{b}	102.14^{a}	102.73^{a}	1.71	*
Feed conversion ratio	3.49^{a}	3.45^{ab}	3.48^{a}	3.30^{b}	0.9	*
Growth rate[1] (%)	110.3^{ab}	108.8^{b}	111.5^{ab}	114.8^{a}	1.82	*
Performance index (PI)[2] (%)	64.01^{b}	63.7^{b}	65.9^{b}	72.4^{a}	1.13	*

[1]*: Calculated from the equation; growth rate =* $\frac{w2 - w1}{1/2(w1 + w2)} \times 100$
Whereas:
Wl = The initial weight *W2 = The final body weight*

[2] *:Calculated according to (North, 1981); Performance index=* $\frac{\text{Final body wt.(kg)}}{\text{Feed conversion ratio}} \times 100$

a, b and c: Means within the same row with different letters are significantly different (P≤0.05).
**: Significant at (P≤0.05)* *Sig.: Significance* *NS: Not Significant*
SEM: Standard error of means,

Carcass traits:

Data of carcass characteristics of growing rabbits fed different levels of TMLM are tabulated in Table (4). Rabbits fed 40% TMLM had significantly the highest carcass and dressing percentage, while those fed 20% TMLM had the lowest carcass and dressing percentage. But, the differences in dressing percentage were not significant differ between rabbits fed 40, 30% TMLM and control. A significant increase ($P \leq 0.05$ or $P \leq 0.01$) in the relative weights of gastro-intestinal tract (GIT), small intestine and stomach were found for rabbits fed 20% TMLM, while there were no significant differences among the rabbits fed all feeding treatments in the relative weight of caecum. This increase in weights of GIT, stomach and small intestine in this group caused the noticeable decrease in the dressing percentage as compared to rabbits fed diets with 30 or 40% TMLM.

The relative weights of liver and kidney were significantly higher ($P \leq 0.01$) by 9.90 and 21.31 %, respectively for rabbits fed diet containing 40% TMLM as compared with those fed control diet. A significant effect of TMLM levels was obtained in the length of caecum, it was higher ($P \leq 0.05$) by 5.01% in the diet with 40% TMLM as compared with control diet, but the TMLM level did not affect the length of small intestine.

Meat composition as CP and ash were increased ($P \leq 0.01$) by 6.26 and 22.93%, respectively, while DM and EE were decreased ($P \leq 0.05$ or $P \leq 0.01$) by 3.54 and 13.45%, respectively, as the level of TMLM increased from 0 to 40% in the rabbit diets.

Improvements in carcass and dressing weights in rabbits fed 30 and 40% TMLM diets may be due to improvements in body weight and daily gain. These results are consistent with Aboh *et al.* (2012), Odetola *et al.* (2012) and Safwat *et al.*(2014) they observed an improvement in dressing percentage when the rabbits fed diets contained 15 % MLM. Regarding to the chemical composition of meat, the increasing in CP content may be due to high biological value of TMLM protein. Additionally, the decreasing of EE in meat may be due to the bioactive substances in MLM which reduce fat deposition in body and increase fat metabolism rate.

Table (4): Effect of different levels of TMLM on carcass traits of growing NZW rabbits.

Item	Level of TMLM (%)				SEM	Sig.
	0	20	30	40		
Carcass %	49.1^{b}	48.4^{c}	49.3^{ab}	49.7^{a}	0.23	*
Dressing weight (%):						
With head	59.2^{b}	58.9^{b}	60.1^{a}	60.5^{a}	0.29	*
Gastro-intestinal tract (%) LBW	18.4^{a}	19.0^{a}	16.9^{b}	16.2^{b}	0.52	**
Small intestine:						
Weight (%) LBW	3.58^{ab}	3.81^{a}	3.23^{bc}	3.04^{c}	0.24	*
Length (cm)	305	307	306	297	14.2	NS
Caecum percent:						
Weight (%) LBW	5.33	5.41	5.23	5.15	0.36	NS
Length (cm)	49.9^{b}	49.7^{b}	51.1^{ab}	52.4^{a}	1.19	*
Stomach (%) LBW	5.17^{a}	4.44^{b}	3.81^{c}	3.52^{c}	0.46	**
Liver (%) LBW	3.84^{c}	3.87^{c}	4.15^{b}	4.22^{a}	0.05	**
Kidney (%) LBW	0.61^{c}	0.63^{bc}	0.66^{b}	0.74^{a}	0.03	**
Meat composition¶:						
DM	25.4^{a}	25.2^{ab}	24.7^{ab}	24.5^{b}	0.45	*
EE	17.1^{a}	16.7^{ab}	16.4^{b}	14.8^{c}	0.39	**
CP	67.1^{c}	68.7^{b}	69.4^{b}	71.3^{a}	0.69	**
Ash	6.63^{c}	6.72^{c}	7.26^{b}	8.15^{a}	0.24	**

a, b and c: Means within the same row with different letters are significantly different at (P≤0.05) or (P≤0.0).
**: P≤0.05, **: P≤0.01 NS: Non significant*
SEM: Standard error of means, Sig.: Significance
¶: On dry matter basis.

Blood biochemical constituents:

Some blood parameters of growing rabbits as affected by dietary TMLM levels are presented in Table (5). Plasma total protein was increased significantly ($P \leq 0.01$) by 18.02% for rabbits fed diet with 40% TMLM as compared with those fed control diet. While, plasma albumin concentration was insignificant increased by 4.58% for group fed diet with 40 TMLM compared to control group and increased significantly (P≤0.05) by 16.51% when compared to group fed 20%TMLM. The differences among the rabbits fed tested diets were not significant in the globulin, creatinine, urea-N and transaminases activities (AST and ALT). Plasma glucose was significantly decreased (P≤0.01) by 13.96% as the level of TMLM increased from 0 to 40% in the diets. The same trend was observed for plasma cholesterol and triglycerides which were decreased (P≤0.05 or P≤0.01) by 43.4 and 30.88%, respectively, as the level of TMLM increased in the diets. However, the obtained results on the effect of TMLM on the blood parameters in this study were within the normal levels.

Plasma total protein increment of the rabbits fed 30 and 40% TMLM may be due to the higher CP digestibility (Table 6 and 7). On the other hands, the decreasing in plasma glucose by increasing the level of TMLM in the diet may be attributed to the changing in the source of starch in the diets (Lerer *et al.*, 1996). Also, the decreasing in concentration of cholesterol and triglycerides may be due to the bioactive substances in TMLM that able to decomposition of these compounds. The same results were observed by (Nuhu, 2010).

Table (5): Effect of TMLM levels on some blood parameters of growing NZW rabbits.

Item	Levels of TMLM (%)				SEM	Sig.
	0	20	30	40		
No. of samples	6	6	6	6	---	---
Total protein (g /d1)	5.05[c]	4.91[c]	5.36[b]	5.96[a]	0.23	**
Albumin (g /d1)	3.71[ab]	3.33[c]	3.83[a]	3.88[a]	0.12	*
Globulin (g /d1)	1.70	1.18	1.51	2.06	1.07	NS
Glucose (mg /dl)	132.1[a]	128.2[a]	120.7[b]	113.8[c]	5.92	**
ALT (μ /L)	17.1	15.4	18.5	16.6	4.26	NS
AST (μ /L)	45.3	46.0	47.99	47.6	6.45	NS
Cholesterol (mg /dl)	78.3[a]	61.7[b]	54.1[b]	44.3[c]	9.21	*
Triglycerides(mg /dl)	163.2[a]	128.4[b]	116.3[c]	112.8[c]	4.39	**
Creatinine (mg /d1)	0.83	0.90	1.00	0.96	0.24	NS
Urea-N (mg /d1)	18.3	19.0	18.7	19.5	2.94	NS

a, b, c: Means in the same row with different superscripts are significantly different (P≤0.05).
**: P≤0.05*   ***: P≤0.01*   *NS: Non significant*
SEM: Standard error of means   *Sig.: Significance.*

Ileal and faecal digestibility coefficients and nutritive values:

Ileal digestibility

Little information is available about ileal digestibility in the connulated rabbits. The feeding treatments had significant (P≤ 0.01 or 0.05) effects on the ileal digestion coefficients of all nutrients, except EE as shown in Table (6). Ileal digestibility of DM and OM were increased (P≤ 0.01) by 8.17 and 10.88%, respectively for rabbits fed diet with 40% TMLM and their values were 71.07 and 71.75% of the all tract digestibility. The ileal digestibility of CP and CF were improved (P≤ 0.05) by 4.8 and 37.2%, respectively, in rich TMLM diet and their values were 90.18 and 62.61% of all tract digestibility.

All tract digestibility

Data of all tract digestion coefficients of nutrients and nutritive values are presented in Table (7). Feeding TMLM had significant effect on the apparent digestibility of all nutrients, except EE. From the results of the all tract digestion coefficients of DM, OM, CP, CF, NFE and gross energy (GE), it could be observed that the rabbits fed diet with TMLM at level 40% had the highest values of all nutrients followed by those received the diets containing 30, 0 and 20% TMLM, respectively. It was observed that the inclusion of TMLM in the rabbit diets was improved most the all tract digestion coefficients of all nutrients.

The data of TDN%, DCP% and DE (kcal/kg diet) as affected by feeding TMLM are presented in Table (7). The TDN, DCP and DE were increased (P≤0.01 or P≤0.001) by 5.37, 5.36 and 4%, respectively for the rabbits fed diet with 40% TMLM as compared with those fed control diet.

Table (6): Effect of TMLM levels on ileal digestibility coefficients of growing NZW rabbits.

Digestion coefficients (%)	Level of TMLM (%)				SEM	Sig.
	0	20	30	40		
DM	50.2^{bc}	49.1^{c}	52.5^{ab}	54.3^{a}	2.34	**
OM	51.0^{b}	49.8^{b}	52.3^{ab}	56.4^{a}	3.22	**
CP	66.6^{b}	63.7^{b}	67.5^{a}	69.8^{a}	4.62	*
CF	19.9^{b}	17.4^{b}	24.1^{a}	27.3^{a}	6.16	*
EE	48.9	49.1	48.7	49.2	2.93	NS

a, b and c: Means in the same row with different superscripts are significantly different (P≤0.05).
**: P≤0.05 **: P≤0.01 NS: Non significant SEM: Standard error of means, Sig.: Significance.*

Table (7): Effect of TMLM levels on all tract digestion coefficients and nutritive values of growing NZW rabbits.

Item	Level of TMLM (%)				SEM	Sig.
	0	20	30	40		
Digestion coefficients (%):						
DM	70.2^{c}	68.9^{c}	73.8^{b}	76.4^{a}	1.33	**
OM	72.3^{c}	70.7^{d}	74.2^{b}	78.6^{a}	0.96	**
CP	73.8^{c}	70.6^{d}	75.2^{b}	77.4^{a}	0.65	**
CF	31.7^{c}	27.8^{d}	38.3^{b}	43.6^{a}	2.15	**
EE	48.8	50.1	49.6	50.2	1.86	NS
NFE	77.2^{b}	75.4^{c}	76.9^{b}	79.5^{a}	0.78	**
Nutritive values:						
TDN (%)	68.9^{b}	66.2^{c}	70.2^{b}	72.6^{a}	1.52	**
DCP (%)	12.69^{b}	12.30^{b}	13.05^{a}	13.37^{a}	0.18	**
DE (kcal/kg)	2605^{c}	2576^{c}	2667^{b}	2709^{a}	28.6	**

a, b, c, d Means in the same row with different superscripts are significantly different (P≤0.01).
***: P≤0.01 NS: Non significant SEM: Standard error of means Sig.: Significance*

The results of digestion coefficients were confirmed with those obtained by Gidenne and Ruckebusch (1989). They reported that the ileal digestibility obtained from the cannulated rabbits, indicate that about the half of digestible dry or organic matters and two-thirds of digestible protein apparently disappeared before the caecum. The improvement of most digestion coefficients may be attributed to some of compounds produced from biological treatment, which activate the animal digestibility or increase the caecum microbial activity. In addition, Fahey *et al.* (2001) reported that MLM is a native source of highly digestible protein.

The balance of dietary fiber fractions in terms of the proportions of cellulose, hemicellulose and lignin from the leaf meals could be a possible item for improvement of fiber digestive capacity (Safwat *et al.*, 2015). This result is in agreement with the results of Sarwatt *et al.* (2003) who observed higher CF digestibility for diets contained leaf meals than for the control diet.

As a result for improvement of all digestion coefficients, except EE the TDN of dietary 30 and 40% TMLM. Additionally, comparing the results of estimated DE with the calculated DE values for all experimental diets, it can be noticed that estimated results were nearly higher to the calculated values, because the calculation sometimes fails to consider food associative effects which can influence whole diet digestibility (Calabro *et al*., 1999). The same results were mentioned by Nieves *et al.* (2008), Nuhu (2010) and Safwat *et al.* (2015).

Economic efficiency:

The results of growth performance (weight gain and feed intake) were subjected to economic evaluation in Table (8). The results of the economic efficiency showed that the cost of total feed intake was decreased by 21.66% as the level of TMLM increased from 0 to 40% in the diets. This decrease was mainly due to the lower price of 1 kg of diet containing 40% TMLM by 24.52% as compared with the control diet. The total live weight yield and selling price were increased in the rabbits fed diet containing 40% TMLM. In addition, the highest value of net revenue (580.92) was obtained in the rabbits fed diet with 40% TMLM, while the lowest value for those fed control diet (405.54 L.E.). These results are compatible with those observed by Zanu *et al*. (2012) who pointed out that the economic efficiency of broiler fed MLM were significantly increased compared with control.

Table (8): Effect of different levels of TMLM on economic efficiency of growing NZW rabbits during 5 to 13 weeks of age.

Item	Level of TMLM (%)			
	0	20	30	40
Number of survival rabbits	20	20	20	20
Average feed intake (kg/rabbit)	5.54	5.34	5.72	5.75
Total feed intake (kg)	110.8	106.8	114.4	115.0
Price/kg diet (L.E.)	2.65	2.40	2.20	2.00
Total feed cost (L.E.)	293.62	256.32	251.68	230.00
Average body gain (kg/rabbit)	1.589	1.549	1.644	1.743
Total yield (kg)	31.78	30.98	32.88	34.86
Selling price* (L.E.)	699.16	681.56	723.36	810.92
Net revenue** (L.E.)	405.54	425.24	471.51	580.92
Relative E.EF.***	100	104.85	116.26	143.24

**: Selling price of 1kg = 22 L.E. X Total yield.*
***: Net revenue = Selling price of meat yield-feed cost.*
****: Assuming that the relative economic efficiency of control diet equal to 100.*

CONCLUSION

In conclusion, treated Moringa oleifera leaves meal with *L. acidophilus* could be included up to 40% in the growing rabbit diets without any obvious negative effects from the practical point of view on the productivity performance and physiological status, during period 5 to 13 weeks of age under Egyptian environmental conditions. Therefore, *M. oleifera* leaves meal may be an alternative feedstuff in rabbit production.

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تأثير مسحوق أوراق المورينجا المعاملة حيويا ببكتريا اللاكتوباسيلس أسيدوفيلس علي الكفاءة الانتاجية والحالة الفسيولوجية للأرانب النامية

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أجريت هذه الدراسة لالقاء مزيدا من الضوء علي التأثيرات النافعة للمستويات المختلفة من مسحوق أوراق المورينجا المعاملة حيويا ببكتريا اللاكتوباسيلس أسيدوفلس كمكون غذائي واعد علي الاداء الانتاجي ، خصائص الذبيحة ، الصفات البيوكيميائية ومعاملات الهضم في الارانب النامية. أجريت هذه الدراسة علي مرحلتين الاولي منها تجربة تغذية تم فيها استخدام 80 أرنب ذكر من سلالة النيوزيلندي الأبيض عمر 5 أسابيع ، قسمت عشوئيا الي 4 مجموعات تجريبية طبقا لمعدلات إضافة مسحوق اوراق المورينجا الي العلائق التجريبية (0 ، 20 ، 30 ، 40٪) ، اما التجربة الثانية فهي تجربة هضم أجريت لدراسة تأثير أضافة اوراق المورينجا علي معاملات هضم العناصر الغذائية في الارانب. أشارت النتائج الي ان اضافة مسحوق اوراق المورينجا الي علائق الارانب النامية بنسبة 40٪ حسنت معنويا من متوسط وزن الجسم الحي وكذلك معدل الزيادة اليومية في وزن الجسم بالإضافة الي معدل التحويل الغذائي ، علاوة علي ذلك حدث أيضا تحسن معنوي في خصائص الذبيحة للمجموعة التجريبية المغذاه علي علائق بها 40٪ من مسحوق اوراق المورينجا مقارنة بالعلائق التجريبية الأخري. نفس الاتجاه تم مشاهدته مع معاملات هضم العناصر الغذائية والقيمة الغذائية التي تحسنت معنويا مع مستوي 40٪. وبالنظر الي بعض الصفات البيوكيميائية للدم فقد حدث تحسن معنوى وخاصة في مستوي الكولستيرول والجلسيردات الثلاثية بالدم. كل هذه النتائج تقترح ان نضيف مسحوق اوراق المورينجا المعاملة حيويا بواسطة بكتريا اللاكتوباسيلس اسيدوفلس الي علائق الارانب النامية بمعدلات تصل الي 40٪ لتعزيز الكفاءة الإنتاجية والحالة الفسيولوجية بدون أي اثار سلبية.