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EFFECT OF EARLY DIETARY SUPPLEMENTATION OF PROBIOTIC AND FEED RESTRICTION POST WEANING ON PRODUCTIVE AND ECONOMICAL PERFORMANCE OF GROWING RABBITS

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ABSTRACT:

This study aims to present the different effects produced by a post-weaning intake limitation strategy without or with early probiotic supplementation (Lacobacillus lactis 2.5 x 10^8 CUF, Bacillus subtilis 1.8 x 10^9 CUF/g) from 3 to 12 weeks of age on growth performance, digestibility, viability, and economic efficiency of growing rabbits. A total number of 54 local growing Black Balady rabbits, divided into six dietary treatment groups three replicates each. The dietary levels of feed restriction (FR) and probiotic (PR) included 3x2 factorial design as follow: T_1: Rabbits fed basal diet ad libitum ,T_2: Rabbits fed basal diet with early fed 0.4g probiotic/ kg diet (PR), T_3 : Rabbits fed restricted by 120% from the energy requirements for maintenance (FR_{120}), T_4: Rabbits fed restricted by 120% from the energy for maintenance with early fed 0.4g probiotic/ kg diet, T5: Rabbits fed restricted by 140% of the energy requirements for maintenance (FR_{140}) and T_6: Rabbits fed restricted by 140% of the energy requirements for maintenance with early fed 0.4g probiotic/ kg diet from 6 to 14 weeks of age.

The results showed that feeding probiotic (PR) early supplementation from 3 weeks of age to weaning (6 weeks of age) did not affect on body weight (BW) and viability % at weaning compared to the control groups.

Post weaning the rabbits fed ad libitum with early PR 0.4g/ kg diet at 3 weeks of age recorded significantly higher daily weight gain than control diet. Feed conversion was improved due to adding PR to the diet by about 10.8% compared to the control diet. Also, the Ad libitum diet with PR resulted in increase the performance index.

The growing rabbits fed ad libitum had the highest daily weight gain compared to those fed restricted diet. The best value of feed conversion ratio (FCR) achieved by fed sever feed restriction (FR_{120}) and moderate *feed restriction (FR_{140}) compared to ad libitum diet. The FR_{120} resulted in decrease all digestibility traits except for the digestibility of crude fiber compared to ad libitum feeding. The FR_{140} did not cause any detrimental effect on digestibility of nutrients. Viability % was significantly improved by about 5.7% as a result of FR_{120} compared to ad libitum group. The greatest value of economic efficiency produced by fed FR either FR_{120} or FR_{140}.*

Also all interaction treatments tend to significantly decrease daily feed intake and improve FCR except for the ad libitum with adding PR and FR_{120} without PR. The FR_{120} with PR and FR_{140} with or without PR increased PI. The ratio N/L increase significantly due to feeding on FR_{120} with PR early from 3 weeks of age compared to ad libitum feeding. Also, the most interaction dietary treatments improved V%. All interaction treatments except for ad libitum with probiotic resulted in a significant higher economic efficiency than caused by feeding on ad libitum diet.

The current study illustrated that rabbit's start fed PR product early from 3 to 6 weeks of age pre weaning and feeding PR continued to 12 weeks of age with FR_{120} post- weaning immediately or rabbits fed FR_{140} with or without PR product showed be taken with considerable in the commercial exploitation of rabbits production for its high economically value, under the Egyptian environmental condition.

Key words: Rabbits, Feed restriction, Probiotic, Growth performance, Nutrients, Digestibility

Weaning is a crucial period for all young animals is associated with a lot of stress and increased sensitivity to diseases (Kritas *et al.*, 2008). Also, weaning is a stressful period related to large economic losses in rabbits husbandries. It can increase the susceptibility of animals to several infections. Thus, much attention has been drawn to different alternative strategies for prevention this problems. For example, post-weaning intake limitation strategies are now frequently employed in rabbit breeding systems to reduce the incidence of post-weaning digestive troubles and improve the feed efficiency, where, feed restriction in growing rabbits could be used with some advantages such as increase digestive efficiency, modifies the partition of body energy retention as protein instead of fat and it could reduce mortality and morbidity due to digestive troubles (Xiccato and Trocino, 2010). Also, the same authors added that from productive and economic points of view, feed rationing was more severe (60-70%), mortality was significantly reduced with the minimum levels in growing rabbits. Generally, throughout the fattening period various restriction programs are possible: gradually declining or not, step by step, continuous or alternate restriction periods, etc. The restriction program must thus adapt to the objectives of the breeder, health status improvement, feed costs reduction or even reducing the pellet intake to encourage forage consumption (Yakubu *et al.,* 2007).

Probiotics are defined as live microbial food ingredients that have a beneficial effect on health (Salminen *et al.,* 1998). Probiotics have the ability to have a direct effect on pathogens by the production of an acidic environment, promoting the growth of a more beneficial microflora (Miettinen *et al.,* 1996). Also, they enhance mucosal immunity of the host by eliciting production of immunoglobulin A as well as various cytokines (Isolauri *et al.,* 2001). In addition, the beneficial effects of these microorganisms for their ability to modulate the intestinal micro flora have been postulated to include competition for substrate as well as competing for receptor sites at the mucosal surface (Vesterlund *et al.,* 2006). Use of probiotics is considered to be an important approach for stimulation of growth and development of animals, including rabbits (Mayorova, 2007). Several studies have been shown the positive effect of probiotics on the control of certain pathogens in animals, where they appear to control enteric diseases associated with Escherichia coli or other enteric pathogens (Kritas *et al.,* 2008). However, effects of probiotics depend on the microorganism species, their metabolic features, enzymatic activity, the nourishment regime of an animal, the composition and ratio of nutrients in a food, the structural features of the gastrointestinal tract, and its physiology.

For this reasons, the effects of feed restriction system with or without probiotic supplementation on the growth performance of growing rabbits were studied.

MATERIALS AND METHODS

This study was conducted at El-Serw Poultry Research Station, Animal Poultry Research Institute, Agriculture Research Center, Ministry of Agriculture, Egypt. Fifty four Black Balady rabbits 6 weeks of age were randomly assigned to one of six dietary experimental groups of (9 rabbits each) that was conducted from 6 to 12 weeks of age. At the onset of the experiment, rabbits were weighed and assigned to 6 treatments based on body weight so that mean body weight was similar for rabbits on all treatments and each treatment had three replicates (3 rabbits in each). The rabbits in each replicate were kept on in grower cages and fed their respective experimental diets (Table 1).

The experimental diets:

Initially, a total number of 10 Black Balady does during lactating wear randomly distributed individually into two experimental groups (5does/group), each group had nearly 27 growing rabbits weighing about 341.9 g / rabbit, the first group fed diets basal diet without probiotic product (PR) which contained *Lacobacillus lactis* 2.5 x 10^8 CUF, *Bacillus subtilis* 1.8 x 10^9 CUF/g, the second group fed basal diet with 0.4g PR/kg diet from 21days to weaning at 6 weeks. Post weaning the same growing rabbits (54 unsexed weaned growing rabbits, weaning about 684 g /rabbit, divided into six dietary treatment groups' three replicates each. The dietary levels of feed restriction (FR) and probiotic product (PR) included 3 x 2 factorial design as follow: T_1: Rabbits fed basal diet *ad libitum* without supplemented probiotic ,T_2: Rabbits fed basal diet *ad libitum* with early fed on 0.4g PR / kg diet, T_3: Rabbits fed restricted system by 120% from the energy requirements for maintenance, T_4: Rabbits fed restricted system by 120% from the energy for maintenance with early fed on 0.4g PR / kg diet, T5: Rabbits fed restricted system by 140% of the energy requirements for maintenance without supplemented probiotic and T_6: Rabbits fed restricted system by 140% of the energy requirements for maintenance with early fed on 0.4g PR / kg diet.

The ingredients and the nutrient composition of the basal diet presented in Table (1), calculated analysis of basal diet according to feed composition Tables for rabbits feedstuffs used by Villamide *et al.*, (2010), De Blas and Wiseman (2010) and NRC (1977) and the requirements of digestible energy (DE Kcal/kg diet) and crude protein % according to FEDNA (2013). Saltose Ex is a thermo stable probiotic where each 1 kg contains lactic acid bacteria (*Lacobacillus lactis*) 2.5 x 10^8 CFU, *Bacillus subtilis* 1.8 x 10^9 CFU and calcium carbonate up to 1 gram as carrier. This probiotic produced by Pic-Bio, Inc. Company- Japan. All rabbits were kept under the same managerial conditions.

The quantity of feed restriction given all at once and not several meals each day, where recently results illustrated that favorable effect of an intake limitation originates from the feed quantity itself and not from the feed distribution technique. The amount of feed allocated to restricted rabbits each distribution was calculated according to the live body weight and the energy requirements for maintenance (430 Kj DE/d/kg LW $^{0.75}$) according to Xiccato

Table (1): Composition and calculated analysis of the basal diet

Ingredients	%
Barley grain	24.60
Alfalfa hay	31.00
Soy bean meal (44 %)	13.25
Wheat brain	28.00
Di-calcium phosphate	1.60
Limestone	0.95
Sodium chloride	0.30
Mineral-vitamin premix [1]	0.30
Total	100
Calculated Analysis [2]	
Crude protein %	17.08
DE (Kcal / kg)	2416
Crude fiber %	12.55
Ether extract %	2.20
Calcium %	1.20
T. Phosphorus %	0.76
Lysine (%)	0.84
Methionine (%)	0.23
Lysine (%)	0.86
Price (LE/kg) [4]	4.68

(1) One kilogram of mineral–vitamin premix provided: Vitamin A, 150,000 UI; Vitamin E, 100 mg; Vitamin K3, 21mg; Vitamin B1, 10 mg; VitaminB2, 40mg; Vitamin B6, 15mg; Pantothenic acid, 100 mg; Vitamin B12, 0.1mg; Niacin, 200 mg; Folic acid, 10mg; Biotin, 0.5mg; Choline chloride, 5000 mg; Fe, 0.3mg; Mn, 600 mg; Cu, 50 mg; Co, 2 mg; Se, 1mg; and Zn, 450mg.

(2) Calculated analysis according to feed composition tables for rabbits feedstuffs used by De Blas and Mateos (2010); ME (Kcal/kg diet) estimated as 0.95 DE according to Santoma *et al.* (1989)

(4) Price of one kg (Egyptian pound/Kg) for different ingredients: Barley grain, 4.6.; Alfalfa hay, 2.8.; Soy been meal, 8.0.; Wheat bran, 2.1.; Di-calcium, 10.8; limestone, 0.20; Premix, 60.0; Sodium chloride, 0.50 and Kg of Probiotics, 200 (LE)

and Trocino (2010) then convert the energy from Kcal /kg diet to grams/day afterward addition 20 and 40% on the energy requirements for maintenance.

Growth performance traits:

Live body weight, daily feed intake and number of dead rabbits were recorded. Daily weight gain, feed conversion ratio was determined every week and mortality rate were estimated daily. The performance index (PI, %) was calculated according to North (1981) on a group basis:

PI (%)= (Final live body weight (kg)/ Feed conversion at any period studied x 100

Digestibility trail

A digestibility trail was performed on eighteen male rabbits, to determine the apparent nutrient digestibility of the six experimental diets (3 males in each treatment group). Animals were housed in metabolic cages that allowed separation of faeces and urine. Faeces produced daily were collected in polyethylene bags for three consecutive days. Chemical analysis was carried out for hard faeces according to A.O.A.C. (2005) for ash, dry matter (DM), crude protein (CP), crude fiber (CF) and ether extract (EE).

Serum biochemical parameters and Hematological:

At the end of study (14 weeks of age), three rabbits (3 males in each treatment group) were taken randomly from each treatment, fasted for 12 hrs, weighed and slaughtered to estimate some of carcass traits. Carcass parts were presented as a percent of preslaughter live body weight which included carcass, giblets, kidney, heart, liver, abdominal fat, gastrointestinal tract and cecum%. Blood samples were collected without anticoagulant and kept at room temperature then the tubes were centrifuged at 3500 rpm for 20 minutes to separate clear serum, afterward blood serum was used to determine serum total protein, triglycerides, total cholesterol and liver enzymes activities by using commercial kits. Another blood samples were taken in vial tubes containing anticoagulant from three rabbits per treatment to determine some hematological traits which included red blood cells (RBC $x10^{12}$), hematocrit (HCT %), hemoglobin (HEB (g/dl), white blood cells (WBC $x10^{9}$), lymphocyte (L%) neutrophil (N%), neutrophil/lymphocyte (N/L), monocyte (M%) and eosinophil (E%).

Economic efficiency:

At the end of the study, economical efficiency for weight gain was expressed as rabbit-production thought the study and calculated using the following equation:

Economic efficiency (%)= (Net return LE/ Total feed cost LE)×100. Where Net return= Total return- Cost of feeding

Statistical analysis:

Data were statistically analyzed using General Linear Models Procedure of the SPSS program (2008), A factorial design 3x2 was used; the following model was used to study the effect of main factors and interaction between feed restriction (FR) and probiotics (PR) on parameters investigated according to Snedecor and Cochran (1982) as follows:

$$Y_{ijk} = \mu + T_i + R_j + (TR)_{ij} + e_{ijk}$$

Where : Y_{ijk} =An observation; µ = Overall mean ; T_i = Effect of FR level(i= 1, 2 and 3); R_j = effect of PR level (j=(1 and 2); $(TR)_{ij}$ = Effect of interaction between FR and PR (ij = 1, 2….6); and e_{jik}= Experimental error.

Differences means among treatments were subjected to Duncan´ s Multiple Range- test (Duncan, 1955).

RESULTS AND DISCUSSION

Growth performance

The results showed that feeding probiotics early from 3 weeks pre-weaning to weaning at 6 weeks of age did not effect on body weight (BW) and viability at weaning as compared to the control groups (Data not show). The effect of feed restriction (FR), dietary early probiotics at 3 weeks of age before weaning (EPR) and the interaction between them on BW and weight gain (WG) is showed in Table 2. The results of the current study did not observe any significant differences in BW at 6 and 8 weeks of age due to applied strategy of strong FR (120% from the energy requirements for maintenance) (FR_{120}) or moderate FR (140% from the energy requirements for maintenance) (FR_{140}). However, at 10 and 12 weeks of age the statistical analysis revealed that FR at 120% of energy requirement for maintenance (FR_{120}) significantly decreased BW compared to *ad libitum* diet.

Regarding daily WG, the results showed that the dietary FR had no significant effect on daily WG of grower rabbits during the periods 6 and 8 weeks of age as compared to the control diet, but afterward it is clearly observed that grower rabbits received *ad libitum* feeding always had the highest daily WG records through the interval periods (8-10 and 10-12) and during the whole experimental period from 6 to 12 weeks of age as compared to the restricted diet.

In addition, the results illustrated that grower rabbits fed early PR by 0.4g/ kg diet at 3 weeks of age recorded significantly higher BW and WG than control diet during all periods of the study.

Results concerning BW and daily WG as influenced by the interaction between FR and PR showed that rabbits fed *ad libitum* diet with 0.4g EPR product/kg diet resulted in a significant increase in BW at 8 weeks of age compared to those on restricted feeding system up to 120% of energy for maintenance at 8 weeks of age, and nearly the same manner, BW was

Table (2): Effect of feed restriction system, probiotics product and their interaction between them on bogy weight and daily weight of grower rabbits from 6 to 12 weeks of age

Traits / Factors		Body weight (g/rabbit),weeks				Daily weight gain (g/rabbit/day)			
		6	**8**	**10**	**12**	**6-8**	**8--10**	**10-12**	**6-12**
Feed restriction system (FR)									
Ad-lib[1]		685.0	1108.0	1416.4^{a}	1849.8^{a}	30.2	22.0a	22.9a	25.0a
120 %[2]		683.8	1029.1	1243.7^{b}	1572.7^{b}	24.7	15.0c	17.3b	19.0c
140 %[3]		685.3	1061.5	1319.5^{ab}	1731.0^{a}	26.7	18.0b	22.3a	22.4b
±SE		**15.04**	**28.43**	**36.54**	**47.44**	**1.74**	**0.93**	**0.65**	**0.74**
Sig.		**NS**	**NS**	**0.05**	**0.05**	**NS**	**0.05**	**0.05**	**0.05**
Probiotic product (PR)									
(0)[4]		686.3	1057.9^{b}	1313.5^{b}	1684.2^{b}	26.3^{b}	18.1^{b}	18.8^{b}	21.1^{b}
0.4g[5]		683.3	1074.5^{a}	1339.5^{a}	1751.4^{a}	28.0^{a}	18.6^{a}	22.9^{a}	23.1^{a}
±SE		**12.29**	**23.2**	**29.8**	**38.74**	**1.42**	**0.76**	**0.53**	**0.61**
Sig.		**NS**	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**
Interaction effect (FR x PR)									
Ad-lib	0	686.7	1063.3^{ab}	1367.2^{ab}	1765.8^{ab}	26.7^{ab}	21.8^{a}	19.2^{cd}	22.6^{b}
	0.4	683.3	1152.6^{a}	1465.7^{a}	1933.7^{a}	33.7^{a}	22.1^{a}	26.7^{a}	27.4^{a}
120%	0	684.3	1011.4^{b}	1237.0^{b}	1579.3^{b}	23.3^{b}	15.8^{bc}	16.4^{d}	18.5^{c}
	0.4	683.3	1046.8^{ab}	1250.4^{b}	1566.1^{b}	26.0^{ab}	14.3^{a}	18.1^{cd}	19.5^{bc}
140%	0	687.7	1098.9^{ab}	1336.4^{ab}	1707.6^{b}	29.0^{ab}	16.6^{bc}	20.8^{ab}	22.3^{b}
	0.4	683.0	1024.2^{ab}	1302.5^{ab}	1754.4^{ab}	24.3^{b}	19.3^{ab}	23.8^{b}	22.5^{b}
±SE		**21.28**	**40.2**	**51.67**	**67.09**	**2.47**	**1.32**	**0.91**	**1.05**
Sig.		**NS**	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**

[1]The basal diet, which without probiotic and fed ad-lib; [2] the basal diet fed 120% of the energy for maintenance regardless the supplementation of the probiotic; [3] the basal diet fed 140% of the energy for maintenance regardless the supplementation of the probiotic; [4]fed the basal diets without probiotic regardless feed restriction; [5]fed the basal diet with 0.04g probiotic/Kg diet regardless feed restriction. a, b, c :means in the same column bearing different superscripts are significantly different ($P \leq 0.05$). NS= Non-significant

significantly increased by *ad libitum* diet with adding 0.4g EPR /kg diet compared to restricted feeding up to 120% with or without PR and 140% of energy for maintenance without PR. As for daily WG, it could be concluded that irrespective of the fluctuations observed during the interval periods, the daily WG as a result from *ad libitum* feeding with adding 0.4g PR/kg diet was significantly better than daily WG from control and other interaction treatments, but it is interesting to note that the lowest value was attained from restricted feeding up to FR_{120} by about 18.14% compared to *ad libitum* group. On the other hand, the other dietary interaction treatments had no significant impact on the daily WG comparing with *ad libitum* diet.

The mean values for daily feed intake (FI) (g/rabbit/day) and feed conversion ratio (FCR) are given in Table 3. It is evident that the two levels of FR (severe and moderate levels) resulted in a significant decrease in daily FI during interval and collective periods where rabbits fed 120% of energy requirements for maintenance recorded 53 g/day/rabbit followed by those fed FR_{140} (63.9 g/ day/ rabbit) while the rabbits fed Ad-libitum recorded 89.2 g/day/rabbit. In respect of FCR, it is logically to find that the best value was to rabbits fed FR_{120} and FR_{140} where FCR related to FI and daily weight gain.

No significant influence of dietary probiotic on FI, however, the FCR was improved due to adding the probiotic to the diet (0.4g/ kg diet) by about 10.8% compared to the control diet.

As for the interaction between FR and PR, the results showed that all interaction treatments tend to significantly decrease daily FI and improve the ratio of FCR except for the *ad libitum* with adding 0.4g probiotic/ kg diet and 120% FR without PR as compared to control group.

Regarding the effect of FR, it is interesting to note that the growth reduction was 14.98 and 6.62% to FR_{120} and FR_{140} (severe and moderate FR respectively) as compared to the *ad libitum* diet. While, the intake reduction was 40.5 for strong FR and 28.36% for moderate FR thus it is logically to found that FCR significantly improved by FR. These results are consist with Gidenne and Feugier, (2009) who mentioned that daily weight gain decrease by increasing intensity of feed restriction (90, 80, 70 or 60% of Ad-libitum). Also, Tumova *et al.* (2002) reported that feed efficiency improve by restricted feeding. The beneficial effect of FR on FCR may be explained as follow: 1) Feed restriction sometimes decreases the incidence of post-weaning digestive disorders (Di Meo *et al.,* 2007). 2) A moderate feed restriction system had some advantages in growing rabbits such as increase digestive efficiency, modifies the partition of body energy retention as protein instead of fat and it could reduce mortality and morbidity due to digestive troubles (Xiccato and Trocino 2010). The FCR improvement was observed irrespective of the diet's composition (Gidenne and Lebas, 2006).

Scientific publication stated that dietary adding of probiotics (PR) caused to improve growth rate and enhanced efficiency of feed conversion (Amber *et al.,* 2004). Also, Karitas *et al.* (2008) observed that administration of PR Bio-Plus at 400 g/ton of feed growing rabbits starting 4 days post weaning up to 5

Table (3): Effect of feed restriction system, probiotics product and their interaction between them on feed intake and feed conversion ratio of grower rabbits from 6 to 12 weeks of age

Traits / Factors		Feed intake (g) /rabbit/day				Feed conversion ratio			
		6-8	8-10	10-12	6-12	6-8	8--10	10-12	6-12
Feed restriction system (FR)									
Ad-lib[1]		67.5^{a}	89.3^{a}	110.9^{a}	89.2^{a}	2.7^{a}	4.1	5.1^{a}	3.9^{a}
120 %[2]		42.0^{c}	53.7^{c}	63.0^{c}	53.0^{c}	2.0^{b}	3.7	4.0^{b}	3.2^{b}
140 %[3]		50.3^{b}	64.2^{b}	77.5^{b}	63.9^{b}	2.2^{ab}	3.8	3.8^{b}	3.2^{b}
±SE mean		0.91	1.50	1.40	1.17	0.19	0.16	0.15	0.07
Sig.		0.05	0.05	0.05	0.05	0.05	NS	0.05	0.05
Probiotics product (PR)									
(0)[4]		52.4	69.4	84.0	68.6^{b}	2.4	3.9	4.8^{a}	3.7^{a}
0.4g[5]		54.1	68.7	83.6	68.8^{a}	2.1	3.9	3.8^{b}	3.3^{b}
±SE		0.75	2.22	1.14	0.95	0.16	0.13	0.12	0.06
Sig.		NS	NS	NS	0.05	NS	NS	0.05	0.05
Interaction effect (FR x PR)									
Ad-lib	0	65.0^{b}	89.3^{a}	111.2^{a}	88.5^{a}	3.0^{a}	4.1ab	5.9a	4.3^{b}
	0.4	70.0a	89.2^{a}	110.5^{a}	90.0^{a}	2.3^{a}	4.1ab	4.3^{bcd}	3.5^{ab}
120%	0	41.7^{d}	53.1^{c}	63.0^{c}	52.7^{c}	2.3^{a}	3.5b	4.4b	3.4^{bc}
	0.4	42.7^{d}	54.3^{c}	63.1^{c}	53.2^{c}	1.7^{b}	4.3a	3.6^{cd}	3.1^{c}
140%	0	50.7^{c}	65.9^{b}	77.8^{b}	64.7^{b}	2.0^{b}	4.0ab	4.1bc	3.3^{c}
	0.4	50.0^{c}	62.5^{b}	77.2^{b}	63.2^{b}	2.3^{a}	3.5ab	3.5d	3.1^{c}
±SE mean		1.29	1.11	1.98	1.65	0.27	0.23	0.21	0.10
Sig.		0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05

a, b, c, d, e: means in the same column bearing different superscripts are significantly different ($P \leq 0.05$). NS= Non-significant

days prior the slaughter age significantly improves body weight and daily weight gain. At sight on results (Oso *et al.*, 2013) it is illustrated that the highest feed FCR was obtained with growing rabbits fed diets containing Bacillus cereus ($1x10^9$ cfu/g: 0.05g/kg) as compared to the *ad libitum* diet. In addition, Amber *et al.*, (2014) found that rabbits fed with supplementing Bio-Mos (prebiotic), Bio-Plus (probiotic) or their mix of early period (at 3 weeks of age) in diets increased feed intake; also who illustrated that rabbits start fed PR early from 3 to 13 weeks of age improved relative growth by 3.13% as compared with those start fed PR later from 5 to 13 weeks of age. The beneficial effect of PR inclusion in the diet is speculative; it may be attributed to probiotics can alter the physical microenvironment of the intestinal tract in such a manner that opportunistic pathogens cannot survive (Chichlowski *et al.,* 2007). In addition, probiotic can improve the condition of digestive canal that is short of digestive enzymes (Wang *et al.,* 2008). Also, probiotic may improve weight gain due to better utilization of feed and larger absorption surface in the gut and also may positively influence the health status via enhancing the gut health in rabbits (Pogány *et al.,* 2015).

Performance index and viability:

Generally, irrespective of the fluctuations observed during the interval periods, performance index (PI) was not significantly affected by dietary FR compared to *ad libitum* feeding (Table 4). While, viability % was significantly improved by about 5.7% as a result of FR_{120} compared to *ad libitum* group. In respect of cecum microbial activity, the results indicated that total bacterial count (TBC) was significantly increased due to FR by 120 and 140% of energy for maintenance while, FR_{120} resulted in a significant increase in lactic acid bacteria (LAB) compared to *ad libitum* feeding. On the other hand, the ratio LAB/TBC was significantly lower as a result from FR_{140} than *ad libitum* diet.

Regarding dietary probiotics, no significant influence of dietary PR on total PI and V% could be detected. Results showed that rabbits start fed experimental probiotic early from 3 weeks of age before weaning had significantly higher TBC while no significant effect on LAB and the same treatment had significantly lower LAB/TBC than those fed the control diet.

All rabbits fed dietary probiotics early with FR at 6 weeks of age resulted in a significant improve in total PI compared to control diet. Also, viability % of rabbits fed all dietary interaction treatments except for those fed FR_{140} with PR was significantly higher than the values recorded by control diet.

These results showed that FR system improved viability %, several studies were published recently to analyze the different effects of FR on the growth, digestive physiology and health of the young rabbit. For example, Di Meo *et al.* (2007) reported that FR sometimes decreases the incidence of post-weaning digestive disorders. In addition, a moderate feed restriction in growing rabbits could be used with some advantages such as increase digestive efficiency, modifies the partition of body energy retention as protein instead of fat and it could reduce mortality and morbidity due to digestive troubles (Xiccato and Trocino 2010). While, some studies referred to FR did not effect on mortality in growing rabbits post weaning (Gidenne *et al.,* 2009).

Table (4): Effect of feed restriction system, probiotics product and their interaction between them on performance index, viability and microbial activity of grower rabbits

Traits / Factors		PI[1] 8	PI[1] 10	PI[1] 12	T. PI	V[2]
Feed restriction system (FR)						
Ad-lib		36.4	32.9^{b}	33.1^{b}	47.9	92.6^{b}
120 %		46.6	38.6^{ab}	32.4^{b}	48.9	98.2^{a}
140 %		43.0	42.6^{a}	35.6^{a}	54.4	94.4^{ab}
±SE mean		**3.50**	**2.73**	**0.82**	**2.01**	**1.51**
Sig.		**NS**	**0.05**	**0.05**	**NS**	**0.05**
Probiotics product (PR)						
(0)		39.4	35.9	28.8^{b}	46.7	95.1
With 0.4g		44.5	40.2	38.6^{a}	54.2	95.1
±SE		**2.86**	**2.23**	**0.05**	**1.64**	**1.23**
Sig.		**NS**	**NS**	**0.05**	**NS**	**NS**
Interaction effect (FR x PR)						
Ad-lib	0	29.^{7c}	29.2^{b}	26.3^{c}	41.2^{c}	88.9^{b}
	0.4	43.1^{abc}	36.7^{ab}	39.8^{a}	54.7^{ab}	96.3^{a}
120%	0	37.6^{bc}	40.9^{ab}	27.6^{c}	47.2^{bc}	96.3^{a}
	0.4	55.6^{a}	36.4^{ab}	37.2^{a}	50.6^{ab}	100.0^{a}
140%	0	51.0^{ab}	37.5^{ab}	32.4^{b}	51.6^{ab}	100.0^{a}
	0.4	35.0^{bc}	47.7^{a}	38.8^{a}	57.2^{a}	88.9b
±SE		**4.95**	**3.86**	**1.15**	**2.84**	**2.14**
Sig.		**0.05**	**0.05**	**0.05**	**0.05**	**0.05**

[1] = Performance index; [2]= viability; [3]= total bacterial count (x 10^7) germ counts expressed in CFU/g caecal digesta; [4]= Lactic acid bacteria (x 10^4) germ counts expressed in CFU/g caecal digesta; a, b, c, d: means in the same column bearing different superscripts are significantly different ($P \leq 0.05$). NS= Non-significant

The most remarkable result is that the *ad libitum* diet with PR, FR_{120} with PR and FR_{140} with or without PR increased PI and the most interaction treatments improved V%, these results may be due to FR sometimes decreases the incidence of post-weaning digestive disorders (Di Meo *et al.,* 2007), and PR supplementation improves intestinal environment and gut health directly influence the health status and growth performance of animals due to better nutrient absorption in the gut (Pogány Simonová *et al.,* 2015).

***Nutrients digestibility, nitrogen (N) and ash retention*:**

The effect of FR system, PR product and their interaction on nutrients digestibility is presented in Table 5. According to these results the FR_{140} did not cause any detrimental effect on digestibility of nutrients, but the sever FR caused to decrease values all these traits as compared to *ad libitum* feeding.

On the other hand, no significant influence of adding 0.4g probiotic /kg diet on all digestibility coefficients with exception ether extract where rabbits fed diet with probiotic had significantly lower digestibility ether extract than those fed control diet.

Regarding the interaction between FR and PR, the results illustrated that rabbits received FR_{120} with or without probiotic recorded the lowest values of nutrients digestibility coefficient. However, rabbits fed early 0.4 g PR /kg diet from 3 to 12 weeks with FR_{140} did not significant differ from the ad-libitum feeding but, only OM digestibility significantly increased due to 140% FR without adding probiotic, but rabbits fed 140% FR with probiotic resulted in a significant decrease in digestibility of OM compared to ad-libitum feeding.

The data obtained on nitrogen (N) and ash retention as affected by FR, PR and their interaction is showed in Table 6. Results obtained clearly observed that N intake and retention from *ad-libitum* rabbits were significantly ($P\leq0.05$) higher than that recorded by restricted groups. Nitrogen excretion and ash retention did not significantly affected by restricted feeding up to 120% of energy for maintenance.

No significant influence of dietary probiotics on N and ash retention could be detected. However, results of N intake did not come strange where all treatments resulted in a significant decrease in N intake except for *ad libitum* feeding with adding probiotics and FR by 140% of energy for maintenance with probiotics when compared to the control group.

The interaction between FR and PR had no significant effect on N excretion and ash retention while, *ad libitum* rabbits had significantly higher N retention than those fed a restricted diet (FR_{120}) with or without probiotics.

The results illustrated that dietary FR_{120} (severe FR) had the least values in digestibility of nutrients, this is consist with Gidenne *et al.,* (2009) who mentioned that OM and NDF digestion significantly decreased by FR (80% of control) from 35 to 68 day of age. This results may attributed to the reduction in digestive enzymes as a result of restriction strategy in the study by (Beshara *et al.,* 2017) where the ileal villus height and area, as well as crypt depth, increased after weaning (Gallois *et al.,* 2005) thus the severe FR during the grower period may be due to impairs the maturation of the gut that develops quickly in the young rabbit. However, the moderate FR resulted in non-

Table (5): Effect of feed restriction system, probiotics product and their interaction between them on nutrients digestibility of grower rabbits at 12 weeks of age

Traits / Factors		Digestibility of nutrients						
		DM	**CP**	**EE**	**CF**	**OM**	**NFE**	**TDN**
Feed restriction system (FR)								
Ad-lib		68.1^{a}	77.5^{a}	61.2^{a}	32.9^{ab}	72.5^{a}	82.1^{a}	55.8^{a}
120 %		48.1^{b}	63.5^{b}	48.3^{b}	24.1^{b}	56.1^{b}	71.6^{b}	46.9^{b}
140 %		64.2^{a}	75.0^{a}	65.0^{a}	41.2^{a}	69.5^{a}	79.5^{a}	55.6^{a}
±SE		**2.33**	**1.67**	**2.02**	**3.39**	**2.01**	**1.88**	**1.27**
Sig.		**0.05**	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**
Probiotics product (PR)								
(0)		60.9	72.6	61.1^{a}	33.5	66.9	78.6	53.5
0.4g		59.3	71.4	55.3^{b}	31.9	65.2	76.8	52.0
±SE		**1.90**	**1.36**	**1.65**	**2.77**	**1.63**	**1.53**	**1.04**
Sig.		**NS**	**NS**	**0.05**	**NS**	**NS**	**NS**	**NS**
Interaction effect (FR x PR)								
Ad-lib	0	70.1^{a}	79.1^{a}	64.6^{ab}	34.1^{b}	74.3^{a}	84.1^{a}	57.2^{a}
	0.4	66.1^{ab}	75.9^{a}	57.9^{b}	31.6^{b}	70.7^{ab}	80.1^{ab}	54.3^{ab}
120 %	0	42.9^{d}	59. 9^{c}	48.4^{c}	15. 5^{c}	51.4^{d}	68.3^{c}	43.7^{c}
	0.4	53.4^{c}	67.1^{bc}	48.3^{c}	32.7^{b}	60.9^{c}	74.9^{bc}	50.2^{b}
140%	0	69.8^{a}	78.7^{a}	70.3^{a}	50.9^{a}	74.9^{a}	83.5^{ab}	59.6^{a}
	0.4	58.5^{bc}	71.3^{ab}	59.7^{b}	31.5^{b}	64.0^{bc}	75.5^{abc}	51.7^{ab}
±SE		**3.29**	**2.36**	**2.85**	**4.80**	**2.84**	**2.66**	**1.79**
Sig.		**0.05**	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**

a, b, c: Means in the same column bearing different superscripts are significantly different ($P \leq 0.05$). NS= Non-significant

significantly improvement in digestibility of EE and CF by 6.2 and 12.5% respectively. In agreement with these results, Gidenne and Feugieir (2009) found that no significant influence due to dietary FR (80,70 and 60% of *ad libitum* diet) from 35 day (age at weaning) to 54 day of age on OM, CP and NDF digestion. Also, these results agree with Xiccato and Trocino (2010) who mentioned that a moderate FR in growing rabbits could be used with some advantages such as increase digestive efficiency modifies the partition of body energy retention as protein instead of fat.

Table (6): Effect of feed restriction system, probiotics product and their interaction between them on nitrogen and ash retention of grower rabbits at 12 weeks of age

Traits / Factors		Nitrogen and ash retention			
		N intake (g/rabbit)	**N excreta (g/rabbit)**	**N retention (%)**	**Ash retention (%)**
Feed restriction system (FR)					
Ad-lib		3.87^{a}	0.87	77.50^{a}	39.03
120 %		2.54^{c}	0.92	63.50^{b}	39.74
140 %		3.18^{b}	0.80	74.98^{a}	41.30
±SE mean		0.10	0.06	1.67	3.14
Sig.		0.05	NS	0.05	NS
Probiotics product (PR)					
(0)		3.23	0.84	72.56	41.17
0.4g		3.16	0.89	71.43	38.87
±SE		**0.08**	**0.05**	**1.36**	**2.56**
Sig.		**NS**	**NS**	**NS**	**NS**
Interaction effect (FR x PR)					
Ad-lib	0	4.20^{a}	0.88	79.14^{a}	42.31
	0.4	3.55^{ab}	0.86	75.87^{a}	35.75
120 %	0	2.40^{d}	0.96	59.89^{c}	34.92
	0.4	2.67^{cd}	0.87	67.11^{bc}	44.56
140%	0	3.09^{bc}	0.67	78.65^{a}	46.29
	0.4	3.27^{ab}	0.94	71.32^{ab}	36.31
±SE mean		**0.14**	**0.09**	**2.36**	**4.44**
Sig.		**0.05**	**NS**	**0.05**	**NS**

a, b, c,d: means in the same column bearing different superscripts are significantly different ($P \leq 0.05$). NS= Non-significant

Regarding probiotic product, no significant alternations were occurred in nutrients digestibility due to inclusion PR in diet of growing rabbits except for EE digestibility, an observation that agrees with Oso *et al.* (2013) who found that the apparent nutrient digestibility values were not affect by dietary inclusion of probiotics in growing rabbits. While, Amber et al. (2014) showed that rabbits start fed diet with probiotic (Bio-Plus® 2B, *Bacillus subtilis* and *Bacillus licheniformis*) early from 3 to 13 weeks of age had significantly higher CP, CF, NFE and TDN digestion compared to control die.

Cecum microbial:

The results in Table 7 illustrated that rabbits fed *ad libitum* with PR system and FR_{120} without PR tend to significantly lower TBC than control diet while the opposite was true in terms of rabbits fed FR_{120} with PR and those fed FR_{140} without PR as compared to control group. When the grower rabbits fed PR early with FR_{120}, LAB was significantly higher than control and other dietary interactions. Also, rabbits fed FR120 with PR and FR140 with or without PR resulted in a significant decrease in LAB/TBC as compared to control diet.

As for PR product on cecum microbial, these results are contradict with the results of Abdel-Azeem *et al.* (2009), who found that addition of Bioplus 2B (400 mg/ kg diet) in rabbit diets reduced number of total bacterial count in caecum content of rabbits. However, the reduced caecal LAB/TBC obtained from rabbits fed PR in current study when compared to those fed control diet could be implicative of positive health status (Casey *et al.,* 2007).

Serum biochemical:

As shown in Table 8, it is noticed that total protein and globulin significantly decreased due to FR_{140} but no significant influence on albumin as compared to *ad libitum* diet (Table 7). It is evident that *ad libitum* feeding significantly ($P \leq 0.05$) decreased serum triglyceride but no significant effect in serum cholesterol due to FR_{120} and FR_{140} as compared to *ad libitum* diet.

As a rule, the results indicated that the diet supplemented with probiotics product early from 3 weeks of age resulted in no significant differences in total protein, albumin and triglycerides while, cholesterol significantly decreased compared to the control diet.

In addition, the present study showed that grower rabbits fed FR_{120} with PR product and FR_{140} with or without PR recorded significantly lower total protein than control rabbits. But, statistical analysis could not reveal any significant differences among *ad libitum* diet and treatments in respect of serum albumin. On the other hand, both rabbits received FR_{120} with PR and those fed FR_{140} without PR recorded the lowest value of globulin as compared to control diet. All dietary interactions treatments resulted in a significant increase triglycerides while, the lowest value of serum cholesterol was observed by feeding on FR_{120} and FR_{140} without or with PR as compared to the control diet.

In respect of the effect of probiotic product, the results seems to contradict with findings by (Amber *et al.,* 2014) who reported that serum total

Table (7): Effect of feed restriction system, probiotics product and their interaction between them on performance index, viability and microbial activity of grower rabbits

Traits / Factors		Microbial activity		
		TBC[3]	LAB[4]	LAB / TBC
Feed restriction (FR)				
Ad-lib		4.4[b]	3.0[b]	0.68[a]
120 %		6.2[a]	3.8[a]	0.64[a]
140 %		5.9[a]	2.8[b]	0.47[c]
±SE mean		**0.09**	**0.08**	**0.02**
Sig.		**0.05**	**0.05**	**0.05**
Probiotics (PR)				
(0)		5.2[b]	3.2	0.63[a]
With 0.4g		5.9[a]	3.2	0.55[b]
±SE		**0.07**	**0.06**	**0.01**
Sig.		**0.05**	**NS**	**0.05**
Interaction effect (FR x PR)				
Ad-lib	0	5.4[c]	3.8[b]	0.70[a]
	0.4	3.4[d]	2.2[d]	0.65[a]
120 %	0	3.5[d]	2.5[d]	0.72[a]
	0.4	8.9[a]	5.0[a]	0.56[b]
140%	0	6.6[b]	3.2[c]	0.48[c]
	0.4	5.3[c]	2.4[d]	0.45[c]
±SE mean		**0.13**	**0.11**	**0.02**
Sig.		**0.05**	**0.05**	**0.05**

[1] = Performance index; [2]= viability; [3]= total bacterial count (x 10^7) germ counts expressed in CFU/g caecal digesta; [4]= Lactic acid bacteria (x 10^4) germ counts expressed in CFU/g caecal digesta; a, b, c, d: means in the same column bearing different superscripts are significantly different ($P \leq 0.05$). NS = Non-significant

protein, albumin and globulin significantly increased with supplementing Bio-Mos, Bio-Plus or their mix in diets. On the other hand, as for serum cholesterol, the results are in agreement with those reported by (El-deek *et al.*, 2013; Amber *et al.*, 2014). Lye *et al.*, (2010) who showed that there existed five possible probiotic mechanisms including assimilation of cholesterol during growth, binding of cholesterol to cellular surface, disruption of cholesterol micelle, deconjugation of bile salt and bile salt hydrolase activity.

Table (8): Effect of feed restriction system, probiotics product and their interaction between them on some serum biochemical of grower rabbits at 12 weeks of age

Traits / Factors		Serum biochemical: Total protein (g/dl)*	Albumin (A) (g/dl)*	Globulin (G) (g/dl)	A/G ratio	[1]Trig (mg/dl)	[2]Chol (mg/dl)
Feed restriction (FR)							
Ad-lib		5.4^a	3.11	2.29^a	1.37	108.0^b	78.5
120 %		5.3^a	3.09	2.18^a	1.42	126.0^a	75.0
140 %		4.9^b	2.96	1.93^b	1.56	122.5^a	72.0
±SE mean		**0.07**	**0.05**	**0.07**	**0.06**	**2.76**	**2.14**
Sig.		**0.05**	**NS**	**0.05**	**NS**	**0.05**	**NS**
Probiotics (PR)							
(0)		5.3^a	3.12^a	2.18	1.46	103.3^b	94.7^a
With 0.4g		5.1^b	2.98^b	2.09	1.44	114.7^a	75.3^b
±SE		**0.05**	**0.04**	**0.06**	**0.09**	**2.25**	**1.75**
Sig.		**0.05**	**0.05**	**NS**	**NS**	**0.05**	**0.05**
Interaction effect (FR x PR)							
Ad-lib	0	5.4^a	3.04^{ab}	2.40^a	1.27^b	72^e	143^a
	0.4	5.4^a	3.18^a	2.19^{ab}	1.47^{ab}	85^d	73^{ab}
120 %	0	5.6^a	3.27^a	2.35^a	1.40^b	130^{ab}	77^b
	0.4	4.9^b	2.90^b	2.00^c	1.45^{ab}	222^b	73^{ab}
140%	0	4.8^b	3.04^{ab}	1.78^{bc}	1.71^a	108^c	64^c
	0.4	4.9^b	2.87^b	2.07^{abc}	1.41^b	137^a	80^b
±SE		**0.09**	**0.07**	**0.10**	**0.09**	**3.90**	**3.04**
Sig.		**0.05**	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**

[1]trig, triglycerides; [2chol], cholesterol; * The normal range of total protein and albumin is 4.5 to 12.2 g/dl and 2.7 to 4.3 g/dl respectively (Ozkan *et a*l., 2012);
a, b, c ..: Means in the same column bearing different superscripts are significantly different ($P \leq 0.05$). NS= Non-significant;

Hematology traits:

The results in Table 9 illustrated that grower rabbits fed FR_{120} resulted in a significant decrease in the most of hematology traits while, a significant improvement in lymphocyte cells (L) was achieved by the FR_{140} as compared to *ad libitum* diet.

Concerning PR treatment, grower rabbits fed PR early at 3 weeks of age recorded significantly the highest values of red blood cells (RBC), hematocrits

Table (9): Effect of feed restriction system, probiotics product and their interaction between them on hematology traits of grower rabbits at 12 weeks of age

Traits / Factors		Hematology traits								
		[1]RBC ($x10^{12}$)	[2]HCT %	[3]HEB (g/dl)	[4]WBC ($x10^{9}$)	[5]L %	[6]N %	N/L	[7]M %	[8]E %
Feed restriction (FR)										
Ad-lib		5.44^{a}	33.1^{a}	11.1^{a}	7.1^{a}	25.5^{b}	68.0^{ab}	2.7^{a}	4.0	2.5
120 %		4.10^{b}	27.5^{b}	9.3^{b}	6.1^{b}	28.5^{a}	66.5^{b}	2.3^{b}	3.0	1.8
140 %		5.41^{a}	32.5^{a}	11.1^{a}	6.2^{b}	24.0^{b}	70.0a	2.9^{a}	3.83	2.2
±SE		**0.13**	**0.31**	**0.13**	**0.11**	**0.90**	**1.0**	**0.11**	**0.58**	**0.70**
Sig.		**0.05**	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**	**NS**	**NS**
Probiotics (PR)										
(0)		4.53^{b}	29.0^{b}	9.7^{b}	6.9^{a}	26.0	67.7^{b}	2.6	3.8^{a}	2.4
With 0.4g		5.43^{a}	33.1^{a}	11.3^{a}	6.0^{b}	26.0	86.7^{a}	2.7	3.4^{b}	1.9
±SE		**0.10**	**0.26**	**0.11**	**0.09**	**0.73**	**0.82**	**0.09**	**0.47**	**0.57**
Sig.		**0.05**	**0.05**	**0.05**	**0.05**	**NS**	**0.05**	**NS**	**0.05**	**NS**
Interaction effect (FR x PR)										
Ad-lib	0	5.29^{a}	32.0^{b}	10.5^{c}	7.6^{a}	25^{bc}	67^{b}	2.7^{b}	5.0	3.0
	0.4	5.58^{a}	34.2^{a}	11.6^{a}	6.6^{bc}	26^{abc}	69^{ab}	2.7^{b}	3.0	2.0
120 %	0	2.10^{b}	22.6^{c}	7.6^{d}	7.0^{b}	27ab	68^{ab}	2.5^{bc}	2. 7	2.0
	0.4	5.20^{a}	32.3^{b}	11.0^{bc}	5.2^{d}	30^{abc}	65^{b}	2.2^{c}	3.3	1.7
140%	0	5.30^{a}	32.3^{b}	10.9^{bc}	6.2^{c}	26^{a}	68^{ab}	2.6^{bc}	3.7	2.3
	0.4	5.51^{a}	32.7^{b}	11.2^{ab}	6.2^{c}	22^{c}	72^{a}	3.3^{a}	4.0	2.0
±SE		**0.18**	**0.44**	**0.18**	**0.15**	**1.27**	**1.41**	**0.09**	**0.82**	**0.99**
Sig.		**0.05**	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**	**NS**	**NS**

[1]RBC, Red blood cells; [2]HCT, Hematocrit; [3]HEB, Hemoglobin; [4]WBC, White bold cells, [5]L, Lymphocytes; [6]N, Neutrophils; [7]M, Monocytes; [8]E, Eosinophil; The normal range of RBC= 5.5±0.3 (10^12/L), HCT= 31.1±2.2 %, HEB= 11.5±0.8 (g/dl), WBC= 7±2.1 (10^9/L), L= 29±15%, N= 51±0.3% (Archetti et al., 2008); a, b, c, d: means in the same column bearing different superscripts are significantly different ($p \leq 0.05$). NS= non-significant;

(HCT), hemoglobin (HEB) and L% compared to control diet. On the other hand, both white blood cells (WBC) and monocytes (M) % significantly decrease by dietary PR. No significant effect of PR diet on N%, N/L and eosinophil cells could be detected.

In terms of interaction between FR and PR, the results showed that grower rabbits fed FR_{120} without PR had significantly the lowest value RBC, HCT, HEB and WBC. Also, the rabbits fed diet FR_{140} without PR supplementation tend to significantly lower WBC than those received *ad libitum* feeding while, the same treatment resulted in a significant increase in N% and L% compared to the control diet. Moreover, the ratio N/L increase significantly due to feeding on FR_{140} with PR early from 3 weeks of age when compared to *ad libitum* feeding while, regarding the feeding on FR_{120} with PR N/L significantly decreased as compared to the control group. On the other hand, all dietary interaction treatments resulted in no significant effect on M and E% compared to the *ad libitum* feeding.

Many metabolic parameters are modified under restriction, as reported for the rabbit by Van Harten and Cardoso (2010). The immune status of FR rabbits was briefly described through some blood characteristics, such as the cell profile. Tumova *et al.* (2007) reported an increased number of lymphocytes in FR rabbits. However, there is a dearth of information on the immune status of the growing rabbit.

The mode of action of probiotics is that enhance mucosal immunity of the host by eliciting production of immunoglobulin A as well as various cytokines including TNF-α, IL-6, IL-10, and INT-γ (Isolauri *et al.*, 2001). Also, they produce specific and intermediate metabolites which stimulate the body immune systems (Sherman *et al.*, 2009).

Carcass quality

In respect of carcass quality traits as shown in Table (10), no significant influence of all dietary treatments on carcass quality of grower rabbits at 12 weeks of age could be demonstrated with exception kidney, GIT and dressing% where, restricted diet by 120% of energy for maintenance without probiotics resulted in a heavier kidney % than *ad libitum* and other interaction treatments. Also, the dressing % significantly increased due to *ad libitum* diet supplemented with0.4g probiotic/ kg diet while the same treatment resulted in a significant decrease in GIT as compared to the control diet.

The results illustrated that the dressing % significantly increased while the opposite was true in respect of GIT% when rabbits fed *ad libitum* diet with adding the probiotic product as compared to the control diet also, the same treatment had significantly higher weight gain than control group (Table 2), thus this increment in dressing% may be due to the development in digestive tract depends on the weight gain (Je´rome *et al.*, 1998). There are insignificant decreased in abdominal fat by FR, the reduction in abdominal fat due to FR may be a moderate FR in growing rabbits could be used with some advantages

Table (10): Effect of feed restriction system, probiotics product and their interaction between them on carcass quality traits of grower rabbits at 12 weeks of age

Traits / Factors		Carcass quality traits %								
		BW at sl.[1]	Carcass %	Giblets % Heart	Liver	Kidney	DR[2] %	GIT[3] %	C[4] %	Ab. Fat[5] %
Feed restriction system (FR)										
Ad-lib		1635	56.3	0.33	3.91	0.78	61.4	18.9	7.06	0.99
120 %		1560	60.5	0.32	4.22	1.15	61.4	23.4	8.01	0.84
140 %		1599	56.0	0.31	4.59	0.82	61.9	21.7	7.08	0.61
±SE		**-**	**2.85**	**0.26**	**0.26**	**0.13**	**0.79**	**1.64**	**0.82**	**0.17**
Sig.		**-**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
Probiotics product (PR)										
(0)		1604	58.1	0.33	4.22	1.03	60.5	23.0	8.34	0.75
0.4g		1789	57.1	0.31	4.27	0.80	62.5	19.6	6.43	0.88
±SE		**-**	**2.32**	**0.03**	**0.21**	**0.11**	**0.65**	**1.34**	**0.67**	**0.14**
Sig.		**-**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
Interaction effect (FR x PR)										
Ad-lib	0	1382	54.0	0.32	3.80	0.74^{b}	58.9^{b}	21.2^{ab}	8.84	0.88
	0.4	1890	58.7	0..35	4.00	0.81^{b}	63.9^{a}	16.6^{b}	5.29	1.10
120 %	0	1320	64.3	0.36	4.26	1.54^{a}	60.9^{ab}	26.7^{a}	9.21	0.72
	0.4	1798	56.7	0.28	4.18	0.76^{b}	61.8^{ab}	20.0^{ab}	6.81	0.96
140%	0	1518	56.0	0.32	4.60	0.80^{b}	61.7^{ab}	21.1^{ab}	6.97	0.64
	0.4	1680	56.0	0.30	4.59	0.84^{b}	61.8^{ab}	$22.3a^{b}$	7.18	0.58
±SE		**-**	**4.03**	**0.05**	**0.37**	**0.19**	**1.12**	**2.32**	**1.16**	**0.24**
Sig.		**-**	**NS**	**NS**	**NS**	**0.05**	**0.05**	**0.05**	**NS**	**NS**

[1] = Body weight at slaughter; [2]= dressing %, [3] =Gastrointestinal tract, [4] = Cecum [5] = Abdominal fat a, b, c: means in the same column bearing different superscripts are significantly different ($p \leq 0.05$), NS= Non-significant

such as increase digestive efficiency, modifies the partition of body energy retention as protein instead of fat (Xiccato and Trocino, 2010).

The results showed that no significant influence of dietary PR on carcass traits, these findings are contrary to the report of Amber *et al.*, (2014) who showed that carcass percentage was significantly increased by supplementing Bio-Plus in growing rabbit's diet, also who reported that rabbits start fed experimental diets early (from 3 to 13 weeks of age) had significantly higher carcass percentage compared to those start fed experimental diets later (from 5 to 13 weeks of age). However, in agreement with theses results the same author showed that GIT decreased by BR in the diet also, there were no significant effects in carcass criteria due to PR in the diet of growing rabbits (El-Sagheer and Hassanein 2014).

Economic efficiency:

Results concerning the economic efficiency (EEF) are shown in Table 11. As EEF of fattening rabbits related to weight gain and the cost of feeding thus at sight on the results of the current study, it is shown that the greatest value of EEF was that produced by grower rabbits fed FR either FR_{120} or FR_{140} than *ad libitum* feeding as compared to the control group. But, no significant influence of dietary PR diet on EEF could be detected. In addition, it should be noted that all interaction treatments except for *ad libitum* with probiotic resulted in a significant higher EEF than caused by feeding on control diet.

As for FR, these results in agreement with Duperray and Gyonvarch, (2009) who reported that when an intake limitation strategy is applied, the margin on the feed cost is generally improved by 2% to 10%. Also, Amber *et al.,* (2014) reported that some economical traits as affected by dietary probiotic are shown.

Conclusively, the current study illustrated that rabbit's start fed PR product early from 3 till 12 weeks of age with FR_{120} post- weaning or rabbits fed FR_{140} with or without PR product showed be taken with considerable in the commercial exploitation of rabbits production for its high economically value, under the Egyptian environmental condition.

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Table (11): Effect of feed restriction system, probiotics product and their interaction between them on economic efficiency of grower rabbits at 14 weeks of age

Traits / Factors		Economic efficiency						
		TFI/ rabbit[1]	Price/kg feed[2]	TFC/ rabbit[3]	WG/ rabbit[4] Price/ kg BW[5]	T. return	Net return	R EEF[6,7]
Feed restriction (FR)								
Ad-lib		3764.8	4.72	17.69	1164.8	37.3	19.6	112.7[b]
120 %		2223.7	4.72	10.50	888.9	28.4	18.0	177.3[a]
140 %		2684.7	4.72	12.67	1045.7	23.5	20.8	169.8[a]
±SE								**14.65**
Significant								**0.05**
Probiotics (PR)								
(0)		2882.0	4.68	13.49	998.0	31.9	18.5	148.1
With 0.4g		2888.2	4.76	13.75	1068.2	34.2	20.4	158.4
±SE								**11.96**
Significant								**NS**
Interaction effect (FR x PR)								
Ad-lib	0	3716.8	4.68	17.40	1079.1	34.5	17.1	100.0[b]
	0.4	3776.7	4.76	18.00	1250.4	40.0	22.0	125.4[b]
120%	0	2211.8	4.68	10.35	895.0	28.6	18.3	183.3[a]
	0.4	2235.7	4.76	10.64	882.8	28.3	17.6	171.4[a]
140%	0	2717.3	4.68	12.72	1020.0	32.6	19.9	161.1[a]
	0.4	2652.1	4.76	12.62	1071.4	34.3	21.7	178.4[a]
±SE								**20.72**
Significant								**0.05**

[1] = Total feed intake/rabbit/overall period; [2]Price/ kg feed= the price of 1Kg feed by Egyptian pound; 3=Total feed cost/rabbit; [4]= Total weight gain/rabbit; [5]= the price 1 Kg of live body weight by Egyptian pound; [6]EEF= Economic efficiency (%) = (Net return/Total feed cost) x 100; [7]R FEE= (EEF of treatments/EEF of control diet) x100; a. b. c means in the same column bearing superscripts are significantly different (P≤ 0.05).

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تأثير التغذية المبكرة علي عليقة مضاف اليها منتج بكتريا داعمة للحيوية مع نظام تحديد كمية العليقة بعد الفطام على الأداء الإنتاجي والاقتصادي للأرانب النامية

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الهدف من الدراسة الحالية هو تحديد التأثيرات المختلفة الناتجة عن استخدام مستويات مختلفة من التحديد الغذائي بعد الفطام و الأضافة المبكرة لبكتريا (*Lacobacillus lactis* 2.5 x 10^8 CFU/g, *Bacillus subtilis* 1.8 x 10^9 CFU/g) الداعمة للحيوية من ٣-١٢ اسبوع من العمر علي الأداء الإنتاجي و معاملات هضم العناصر الغذائية و الحيوية و الأداء الإقتصادي للأرانب النامية. استخدم في هذه الدراسة عدد ٥٤ أرنب محلي بلدي اسود في مرحلة النمو عمر ٦ أسابيع حيث تم وزنها وتوزيعها في تصميم عاملي ٣x٢ علي ٦ معاملات تجريبية و لكل معاملة ٣ مكررات كما يلي: ارانب غذيت علي العليقة الأساسية حتي الشبع - العليقة الأساسية حتي الشبع مع اضافة ٠.٤جم بكتريا داعمة للحيوية/ كجم عليقة مبكرا من عمر ٣ اسابيع- ارانب غذيت علي عليقة محددة ١٢٠% من الطاقة الازمة لحفظ الحياة بعد الفطام وبدون اضافة بكتريا حيوية- عليقة محددة ١٢٠% من الطاقة اللازمة لحفظ الحياة مع اضافة ٠.٤جم بكتريا داعمة للحيوية/كجم علف مبكرا - ارانب غذيت علي عليقة محددة ١٤٠% من الطاقة اللازمة لحفظ الحياة وبدون اضافة بكتريا حيوية – عليقة محددة ١٤٠% من الطاقة اللازمة لحفظ الحياة مع اضافة ٠.٤حم بكتريا داعمة للحيوية مبكرا.

اوضحت النتائج ان التغذية علي عليقة بها البكتريا الداعمه للحيوبة من عمر ٣ أسابيع قبل الفطام لم تؤثر علي وزن الجسم والحيوية عند الفطام مقارنة بمجموعة المقارنه.

بعد الفطام وجد ان الأرانب النامية المغذاه علي العليقة حتي الشبع والمضاف اليها البكتريا الداعمة للحيوية مبكرا عند عمر ٣أسابيع حققت زيادة في وزن الجسم المكسب يوميا اعلي معنويا مقارنة بتلك المغذاه علي العليقة المقارنة. تحسن معدل التحويل الغذائي معنويا بالأضافة المبكرة للبكتريا الداعمة للحيوية بحوالي ١٠.٨% مقارنة بالعليقة المقارنة. وايضا تحسن دليل النمو بإضافة البكتريا الحيوية الي العليقة.

حققت الأرانب المغذاه علي العليقة حتي الشبع أعلي وزن جسم مكتسب يومي مقارنة بنظم التغذية المحدده. تم الحصول علي أفضل قيمه لمعدل التحويل الغذائي من التغذية علي العليقة المحددة سواء ١٢٠ او ١٤٠% من الطاقة الازمة لحفظ الحياة مقارنة بالعليقة حتي الشبع. ادت التغذية المحدده بمستوي ١٢٠% من الطاقة اللازمه لحفظ الحياه الي انخفاض معوي لمعاملات الهضم فيما عدا معامل هضم الألياف مقارنة بالتغذيه حتي الشبع. بينما لم تحدث التغذية علي ١٤٠% من الطاقة الحافظه اي تأثير سلبي علي معاملات الهضم المختلفة. وجد تحسن معنوي للحيوية % بحوالي ٥.٧% نتيجة التغذية المحدده بمعدل ١٢٠% من الطاقة الحافظه. تحققت افضل قيمه للكفاءه الأقتصادية نتيجة التغذية المحددة سواء ١٢٠ او١٤٠% من الطاقة اللأزمة لحفظ الحياه.

ادت كل التداخلات بين التحديد الغذائي والأضافة المبكرة للبكتريا الحيوية الي انخفاض معنوي في العلف المستهلك وتحسن معنوي للتحويل الغذائي فيماعدا العليقة حتي الشبع مع اضافة البكتريا الداعمه للحيوية والتحديد الغذائي ١٢٠% بدون اضافة البكتريا الحيوية. ادي التحديد الغذائي الحاد مع اضافة البكتريا الداعمة للحيويه او التحديد الغذائي المعتدل مع او بدون اضافة البكتريا الحيويه الي تحسن معنوي في دليل النمو مقارنة بالعليقة حتي الشبع. ذادت نسبة خلايا الدم البيضاءN/L نتيجة التغذية علي العليقة المحدده ١٢٠% مع اضافة البكتريا الداعمه للحيوية مقارنه بالعليقة حتي الشبع. أدت معظم التداخلات بين التحديد الغذائي والبكتريا الداعمه للحيويه الي تحسن الحيويه %. تم الحصول علي افضل قيمة للأداء الإقتصادي من التداخلات بين التحديد الغذائي والبكتريا الحيوية فيما عدا التغذية حتي الشبع مع اضافة البكتريا الحيوية مقارنة بالعليقة حتي الشبع.

اوضحت نتائج التجربة الحالية الأرانب النامية التي بدأت تتغذي مبكرا علي عليقة مضاف اليها بكتيريا داعمه للحيويه ابتداءا من عمر الي ٣-٦ اسابيع قبل الفطام مع استمرار اضافة البكتريا الداعمه للحيويه بعد الفطام حتي ١٢ اسبوع من العمر مع نظام غذائي محدد ١٢٠% من الطاقة اللأزمة حفظ الحياه بعد الفطام مباشرة أو التغذية المحدده بمعدل ١٤٠% من الطاقة اللأزمة لنحفظ الحياه مع أو بدون اضافة البكتريا الداعمه للحيويه يجب ان تأخذ بعين الأعتبار في الأستثمار التجاري لأنتاج الأرانب لما لتلك المعاملات من قيمه اقتصادية مرتفعة تحت ظروف البيئة المصرية.

التوصية: نستخلص من نتائج التجربة الحالية مدي اهمية استخدام نظام غذائي محدد معتدل بعد الفطام مباشرة يتم تحديده علي اساس الطاقة اللازمه لحفظ الحياه ووزن الجسم الحي وفي حالة اتباع النظام الغذائي المحدد الحاد يراعي اضافة البكتريا الداعمة للحيوية مبكرا ابتداءا من عمر ٢١يوم وذلك للحصول علي افضل اداء انتاجي واقتصادي.