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RESPONSE TO β-PRO DIETARY SUPPLEMENTATION IN GROWING RABBITS REARED AT DIFFERENT STOCKING DENSITIES UNDER HOT ENVIRONMENTAL CONDITIONS

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ABSTRACT: The current study was conducted to investigate the effect of β-Pro (probiotic-enzymes preparation) supplementation to 54 weaned rabbits (6-week-old with an average weight of 600 g) stocked at different stocking densities on some growth performance traits, carcass measurements, some blood parameters and cecal micoflora under heat stress. A factorial design arrangement with 2 diets (basal diet and basal diet + 0.2 g β-Pro/Kg from 6 to 14 weeks of age) and 3 stocking densities [2, 3 and 4 rabbits/cage (45 × 45 × 35 cm), equivalent to 10, 15 and 20 rabbits/m^2] during summer season from June to August.

The results showed that, dietary inclusion of β-Pro achieved significant ($P \leq 0.05$) improvements of marketing live weight and daily weight gain with no influences on feed intake, feed conversion ratio, blood variables or carcass characteristics of rabbits during the experimental period from 6 to 14 weeks of age. The incorporation of β-Pro dietary also resulted in significantly higher ($P < 0.01$) cecal colonization of beneficial bacteria like lactobacilli, and a significant lower ($P < 0.05$) of viable coliform counts with no changes of clostridia.

The low stocking density of 2 rabbits/cage (10 rabbits/m^2) revealed higher ($P < 0.01$) marketing live weight, daily weight gain and feed consumption when compared with higher densities. Interactions between stocking density and dietary β-Pro supplementation exhibited significant ($P < 0.05$) changes in daily weight gain, globulin, HDL, total bacterial, coliform and lactobacilli counts, with no influences on other evaluated measurements.

Conclusively, the present study concluded that lower cage density (10 rabbits/m^2) with probiotics-enzymes inclusion is recommended for the post-weaning period of rabbits under hot environmental conditions.

Keywords: Rabbits- β-Pro probiotic-Stocking density-Growth performance-Cecal microflora

INTRODUCTION

Developing countries suffer from huge protein deficiency as a result of higher demands with lower animal production and low individual incomes. Rabbits' meat characteristics of high protein and vitamin B content, low fat, cholesterol and sodium percent make it highly desirable for human consumption (Ramirez et al., 2006).

Rabbits/m^2 in a cage, pen or building is expressed as stocking density, which is a key factor influence labor, investment cost, performance, and consequently, rabbit production sustainability (Dorra et al., 2013). The optimum stocking density for rabbits is 13.3 rabbits/m^2 in semi-humid tropical regions (Grace and Olorunju, 2005), while in European commercial farms, it ranges from 14 to 23 rabbits/m^2 (Trocino and Xiccato, 2006). Higher densities than 19 rabbits/m^2 decrease feed intake and growth rates of rabbits (Aubret and Duperray, 1992). Based on production parameters, a stocking density of 40 kg/m^2 has long been considered as a maximum load in commercial fattening rabbit units (EFSA, 2005).

Currently, there is an urgent need to reduce antibiotics' residues in animal products. Probiotics serve as suitable growth promoters in animal nutrition to avoid such problem. Probiotics had a positive effect on growth measurements, feed consumption and conversion and viability of rabbits (Kritas et al., 2008; Ezema and Eze, 2010; Bhatt et al., 2017).

Cecal microbial fermentation is an integral part of the digestive process in rabbits. Rabbits are sensitive to enteric diseases during weaning and heat stress, which can be prevented by using drugs, probiotics or prebiotics (Marzo, 2001). Probiotics can increase gut colonization and competitive growth against harmful bacteria, decrease pH of intestine with lactic acid production and may encourage nutrient digestion by producing some digestive enzymes and thus can improve the animal's immunity (Fortun-Lamothe and Drouet-Viard, 2002). Probiotic-supplemented diet can decrease the colonization of E. coli and their counts in the rabbit digestive tract (Kritas et al., 2008). Moreover, El-Kholy et al. (2012) showed that feeding diets containing probiotic microorganisms from mothers' feces increased cell-mediated immunity in weaning rabbits.

Non-specific enteric problems arise in post-weaning period would be attributed to diet formulation, which unsuitable for young rabbit digestive burden (Debray et al., 2003). To sustain the profitability of rabbit production, decreasing feed cost and increasing feed utilization are important. Dietary enzymes supplementation in rabbits achieved improvements in both fiber digestibility (Gutiérrez et al. 2002) and nutrient utilization (Eiben et al., 2004), along with reduction in the mortality rates (García et al., 2005).

In Egypt, high ambient temperatures are major limiting factor for rabbit productivity, since it adversely affects rabbit's performance (Askar and Ismail, 2012). To overcome such adverse effect, probiotics that contain yeast, live bacteria or bacterial spores, as well as enzyme supplementation could be possible solutions. These feed additives can increase the resistance to pathogenic bacteria and enhance the mucosal immunity of the host animal; leading to

reducing the pathogen load and improving health status of rabbits (Choct, 2009).

The current experiment was carried out to study the effect of different stocking density with or without β-Pro (probiotics-enzymes preparation) dietary supplementation on the performance, carcass traits, some blood parameters and cecal microbial burden of weaned rabbits during summer season.

MATERIALS AND METHODS

Experimental Design

The current experiment was carried out at the Rabbit Unit, Mansoura University, Egypt, during June through August, 2015. Fifty four New Zealand White (NZW) weaner rabbits (6-wk-old) with average body weights (BW) of 600 ± 20.5 g were randomly assigned into 5 experimental treatment groups (A1, A2, A3, B1 and B2), each with three replicates (Table 1). A factorial arrangement of treatments (3×2) was used in this study. The rabbits were kept in battery cages at three stocking densities [2, 3 and 4 rabbits/cage (45 × 45 × 35 cm), equivalent to 10, 15 and 20 rabbits/m^2] during summer. The means of minimum and maximum ambient temperatures were 30.1 °C and 32.3 °C, respectively, while the corresponding values of relative humidity were 89.6%, and 93%, respectively (Table 3).

Rabbits were fed on two experimental diets from 6-14 week-old. Feed composition and proximate analysis of the ration are shown in Table (2). Rabbits fed on diet without β-Pro served as a control (group B1), while rabbits received a fortified diet with β-pro product (ProByn International, Inc. USA) served as group B2.

The β-pro is composed of 100 g betaine-HCl, 100 g Lactobacillus plantarum (1.0×10^8 CFU/g), 50 g Enterococcus faecium (5.0×107 CFU/g), 2.0 g Bifidobacterium bifidum (2×106 CFU/g), 50 g Aspergillus oryzae fermentation extracts, 12500 units xylanase, 2750 units hemicellulase, 2250 units β-glucanase, 50 g Bacillus subtilis fermentation extract, 25000 units α-amylase, 4500 units cellulase and 12500 units protease and dextrose as a carrier. It was supplemented at a level of 0.2 g/kg diet. All experimental rabbits were kept in cages (45 × 45 × 35 cm) and reared under the same managerial and hygienic conditions. Rabbits were given fresh water and pelleted diets on an ad libitum basis during the course of study.

Measurements and analytical methods

During the experimental period, live weight, feed intake, daily weight gain and feed conversion rate were determined weekly. Economic efficiency of feeding was calculated as follows: [(Sale price per kg gain – Feed cost per kg gain)/Feed cost per kg gain] × 100. The sale price of one kg weight gain was 25 EGP, however, the price of one kg diet was 2.5 EGP. Rabbits were fasted for 12 h with available drinking water and pre-slaughter live weight was recorded prior to slaughtering. Slaughtered rabbits were skinned, eviscerated and the carcass traits were analyzed for each treated group. The liver, heart with lungs and kidney were separated and weighed.

At slaughtering, 4 rabbits from each treatment were chosen to collect 4 blood plasma samples. The blood plasma was separated by centrifugation process. The plasma contents of glucose, total protein, albumin, triglycerides, cholesterol, high density lipoprotein, plasma

aminotransferases (ALT, AST) were analyzed with semi-automatic spectrophotometer (BM-Germany,5010) using commercial test kits (Randox Co. UK and Biodiagnostic, Egypt).

For measuring cecal microbial load, one rabbit per cage (3 from each treatment) was randomly selected and sacrificed for collection of cecal fluid by squeezing cecal contents in sealed sterile glass bottles and transported immediately on ice box for microbiological analyses as described by Skřivanová et al. (2010). Briefly, 1 g of fresh cecal content was homogenized in 9 ml of buffer peptone water and then10 folds serial dilutions were done using 0.85 % sterile saline solution. Diluted contents were inoculated by pour plate method in duplicate plates and the mean values of colony forming units were counted. Plate count agar, de Man–Rogosa–Sharpe agar, MRS (BD, Mississauga, Ontario, Canada), Reinforced Clostridial agar, RCM (Oxoid, Thermo Fisher Scientific Inc. UK) and MacConkey agar (Oxoid, UK) were used for counting of total bacterial count (TBC), Lactobacillus, Clostridia and Coliforms, respectively. The plates inoculated were incubated aerobically except those for Clostridia and Lactobacillus, which were incubated anaerobically at 37°C for 24 h. The bacterial load was expressed as $\log^{10}$ cfu/g of cecal content.

Data analysis

The effects of β-pro (0.2 g/Kg diet) supplementation with different stocking density levels under hot environmental conditions were evaluated in a 3 x 2 factorial design; three stocking densities by two dietary treatments, with or without β-pro supplementation were used. All data were analyzed using diet supplementation, stocking density, and their interactions as main factors by two-way ANOVA using Statgraphics Program (Rockville, 1991). The statistical model 3 × 2 factorial design was used as follows: $Yij = \mu + Ti + Rj + (TR)ij + eij$ where: Yij = an observation; μ = Overall mean: T = Effect of stocking density; i= (1 , 2 and 3) ; R= Effect of β-Pro; j = (1 and 2): TR=Effect of interaction between stocking density and β-Pro; eij = Experimental random error. Duncan's multiple range test (Duncan, 1955) was used to declare significant differences at $P < 0.05$.

RESULTS

Performance of rabbit's traits

Low stocking density (2 rabbits/cage equivalent to the 10 rabbits/m^2) improved significantly ($P < 0.05$) total feed intake, daily weight gain and final live weights with no influences on FCR. Higher densities (3, 4 rabbits/cage) did not reveal any changes upon measured growth parameters under hot rearing conditions (Table 4). β-Pro dietary inclusion produced significant improvements ($P < 0.05$) of daily weight gain and final live weight with slight insignificant increases of feed intake or FCR. The interactions between β-pro dietary supplementation and stocking density, however, revealed no significant effects on feed consumption, FCR, weight gain, and marketing live weight throughout the study period (6-14 wks) as shown in Table 4. No mortality was found in this study. Economic efficiency of feeding in Table 4 indicated that there were no significant differences among stocking density, feed additives (β-Pro**)** or the interaction between them.

Blood constituents

Blood constituents as affected by stocking density levels and β-pro probiotic supplementation are presented in Table 5. Rabbits kept at lower stocking density levels showed significant effects ($P < 0.05$) on plasma levels of globulin and HDL. On the other hand, β-Pro inclusion did not alter all evaluated blood parameters. The effect of interaction between stocking density and dietary β-Pro supplementation was not significant on the most blood parameters of NZW rabbits, except for the concentration of plasma globulin and HDL, which was significant.

Carcass traits

The data of carcass traits (Table 6) revealed that neither β-Pro treatment nor stocking density or their interactions had significant effects on evaluated carcass traits except the positive effects ($P < 0.05$) induced by β-Pro dietary inclusion on live weights.

Cecal microbial activity

The influence of dietary probiotic treatments and stocking density levels on cecal microbial load is illustrated in Table 7. The different levels of stocking density studied did not produce changes in total viable counts of cecal microflora. Meanwhile, dietary inclusion of β-Pro resulted in higher total aerobic and Lactobacillus counts ($P < 0.05$) along with significant ($P < 0.05$) reduction of coliform populations in rabbits fed diets fortified with β-Pro in comparison with rabbits received diets with no additives. Clostridial counts, however, exhibited no differences between both dietary treated groups. The interactions between probiotic supplementation and stocking density induced significant ($P < 0.05$) effects on total viable counts of aerobic bacteria, Lactobacillus, Coliforms and Clostridia.

DISCUSSION

Rabbit performance

The low stocking density (2 rabbits/cage) improved significantly both feed intake and daily weight gain throughout the study period. Nonetheless, it attained limited influences on FCR and final live weight, which may be attributed to the hot rearing conditions during summer months. A profound effect of heat stress on growth performance and intestinal status of broilers had been reported by Burkholder et al. (2008) and Quinteiro-Filho et al. (2010), who elucidated that the crowding along with high ambient temperatures might stimulate thermal receptors to export inhibitive nerve impulses to the hypothalamus appetite center leading to reduction of rabbit feed consumption. The current results are in consistent with those illustrated worldwide by many authors. Villalobos et al. (2008) in Italy showed a decrease in feed consumption of rabbits when the density increased from 6 to 24 rabbits/ m^2. In Cameron, Mbanya et al. (2010) recorded significantly higher daily weight gains in rabbits housed at stocking density of 5 rabbits/m^2 than those kept at 10 rabbits/m^2. Grace and Olorunju (2005) found that low stocking density (6.7, 10 and 13.3 rabbits/m^2) exhibited a positive influence on the average daily gain compared with those stocked at higher densities (16.7 and 20 rabbits/m^2). On the contrary, Oliveira and Almeida (2002) and Trocino et al. (2004) indicated that different levels of stocking densities had no impact on rabbit feed consumption.

Stocking density levels in the present study did not reveal marked effects neither on FCR nor final live weights.

This finding is in harmony with those of Oliveira and Almeida (2002), who found no significant changes in feed efficiency of growing rabbits when stocking levels of 11.67 or 16.67 rabbits/m^2. Similarly, Verga et al. (2004) reported that stocking levels up to 16 rabbits/m^2 did not affect the productivity of weaning rabbits. Also, study conducted by Szendrő et al. (2009) revealed that rabbit stocking density had no effect on FCR during fattening period. Aboegla et al. (2013), however, observed that rabbits stocked in groups at levels of 1, 2 and 3 rabbits/cage had better feed conversion than those kept at 4 rabbits/cage. High stocking density had been also reported to reduce the feed utilization of rabbits (Grace and Olounja, 2005).

Supplementation of probiotic improved both daily weight gain and final live weight, nonetheless did not achieve any impact on feed conversion ratio, which may be due to a linear feed intake with daily weight gain. In accordance with our findings, Manjunatha et al., (2016) indicated that body weight gain was higher in rabbits fed diets containing probiotics. Moreover, Abdel-Aziz et al. (2015) and Simonová et al. (2015) found that rabbit weight gain and feed utilization were significantly improved by feeding diets containing probiotic than those of the control group, who indicated that the enhanced growth performance could be related to improving feed digestion and absorption due to improved intestinal morphology in rabbits. Additionally, Kustos et al. (2004) and Matusevičius et al. (2006) reported insignificant differences in FCR in rabbits fed probiotic supplemented diets (BioPlus 2B®; B. licheniformis, B. subtilis). In contrast to our findings, Kritas et al., (2008) recorded better feed conversion of rabbits fed probiotic supplemented diets (B. licheniformis and B. subtilis). Likewise, Bersenyi et al., (2002) reported that amylase supplementation of rabbit diets had no effect on daily weight gain. Dietary exogenous enzymes for broiler rabbits had been also reported to produce no effect on weight gain (Eiben et al., 2004).

The interaction between stocking density and probiotic supplementation indicated that lower cage density and β-Pro dietary inclusion improved body weight gain in housed rabbits during summer conditions (Table 4). This may be attributed to the protective effect of probiotic during the fattening period of growing rabbits (Matusevičius et al., 2006).

Blood parameters

According to our results, both stocking density levels and β-Pro dietary inclusion showed insignificant effects on all measured blood parameters except for plasma globulin and HDL. Similar to this finding, Onbaslar and Onbaslar (2007) observed no significant differences in serum levels of cholesterol, and triglyceride among rabbit groups kept at 1, 3 and 5 rabbits/cage. Also, Aboegla et al. (2013) reported higher concentrations of total protein and globulin in rabbits stocked at 1 and 2 rabbits/cage compared with those stocked at high cage density but albumin percent and activity of ALT were not changed.

Regarding the effect of probiotic on blood parameters, Fathi et al. (2017) found that serum cholesterol significantly decreased due to probiotic supplementation, while triglyceride, total protein, and globulin concentration were increased. Probiotic treatments achieved high globulin level and may be considered as a good

indicator for increasing immunoglobulin and enhanced immunity status of rabbits. In consistent with our results, Veselin et al., (2003) showed that enzyme-inclusion diets had no effect on serum total protein, albumin and globulin of rabbits. Similar observations were recorded by Selim et al., (2005) who mentioned that plasma glucose of rabbits was not changed by feeding the enzyme supplemented diets. On the contrary, Abdelhady and El-Abasy (2015) recorded a reduction in blood cholesterol by probiotics dietary inclusion and they related such effect to the influence of bile salt hydrolase activity or to inhibition of cholesterol synthesis involved enzyme.

Abd El-Latif et al. (2008) showed an increase in serum total protein, albumin, globulin and glucose values when rabbits were given water enriched with enzymes and attributed this to the elevation of liver function values and the digestibility of nutrients. Ismail et al. (2002) and Azoz and Al-Kholy (2006) indicated that, plasma content of total protein and globulin are good indices of immunity response, however, albumin level reflects liver function.

Carcass characteristics

Our findings revealed that neither stocking density nor β-Pro feeding nor their interactions exhibit a beneficial response on carcass traits of NZW rabbits. In consistent with this result, Trocino et al., (2008) reported that stocking density did not change rabbit carcass traits. Similarly, Villalobos et al., (2008) reported that cage density had little effect on carcass as compared to the growth traits. Moreover, no significant differences were observed in average carcass weight under different rabbit densities, although a significantly higher weight of liver and kidney were observed in rabbits stocked in group having one rabbit /cage than the other groups (Aboegla et al., 2013).

Rotolo et al. (2014) showed that carcass yield was not influenced by added dietary probiotic for rabbits. Bhatt et al. (2017) found that dietary probiotic did not affect carcass traits of growing rabbits. On the other hand, Lambertini and Zaghinig (2001) reported that lower stocking densities (8 rabbits/m^2) produced a significant higher carcass percent than those of 16 rabbits/m^2.

On the contrary to our data, Matusevicius et al. (2011) found that probiotic increased total carcass weight and the weight of valuable carcass parts of rabbits. Feeding rabbits diets supplemented with probiotic led to the highest dressing percent followed by the rabbits fed diet supplemented with probiotic plus enzymes (Abdel-Aziz et al., 2015). Low stocking density (12 rabbit/m^2) had higher carcass weight than those of high density (Trocino et al., 2015). Improvements in carcass percentage of rabbits were recorded when fed a probiotic supplemented diet compared with those fed a basal diet (Fathi et al., 2017).

Cecal microbial activity

Cecum is the main site of fermentative activity in rabbits, which harbor a wide range of microflora (Gidenne, 2003), once rabbit feeding manner shift from milk to dry feed at weaning, the microbial community change significantly (Lebas, 1996), notably influencing nutritional, physiological, immunological and immune defense in the animal (Reitman and Frankel, 1957). Weaned rabbits are exposed to stressful factors such as nutritional transformation, environmental

and social distress as a result of separation of their mothers. Particularly, nutritional modifications result in disturbances of intestinal microflora levels and disruption of immunological processes prompting higher rate of enteric diseases (O'hara and Shanahan 2006).

Feeding rabbits diets supplemented with probiotics have a growth promoting effect by reducing pathogenic intestinal bacteria and enhancing the immunity (Kritas et al., 2008).

Probiotics, as a lactic acid producing bacteria, potentially improve the beneficial bacteria and hush pathogenic bacteria in the intestine, where they can generate acidic environment unfavorable for the growth of opportunistic pathogens (Rodríguez-Cabezas et al., 2010). In this context, Zulkifli et al. (2000) demonstrated that probiotics are adhesive to the intestinal epithelium, resist acidic conditions, and so competitively exclude some pathogenic germs in vivo.

In the present study, feeding probiotics to rabbits resulted in increased viable mean counts of total aerobic bacteria and lactobacillus populations and reduced coliform counts regardless of stocking density. In accordance with these results, Giannenas et al. (2012) recorded higher lactobacillus counts in the ileum and cecum of broilers fed probiotics supplemented diets. Moreover, Mattar et al. (2001) revealed that E.coli and C. perfringens get suppressed in rabbits after probiotic supplementation and they attributed such inhibitory effect to the adverse changes of enteric microbiota that resulting in inability of pathogens to adhere effectively. In another study, Copeland et al. (2009) found lower gut microbial colonization in a long-term weaned rabbit model fed diets fortified with probiotics.

Our results revealed no influence of stocking density on the microbial population in the cecum. This finding agree with that of Burkholder et al. (2008), who found that cecal mean viable counts of E.coli and Lactobacilli were not affected by stocking density.

CONCLUSIONS

Dietary inclusion of β-Pro (probiotics + enzymes mixture) was effective in improving feed intake and final body weight besides, conferring intestinal health by promoting Lactobacillus growth and inhibiting pathogenic bacteria as Coliforms. Moreover, low stocking density (2 rabbits/cage, equivalent to 10 rabbits/m^2) induced superior growth performance and some blood fractions; globulin and HDL with no influences on carcass traits and cecal microbial load. Therefore, dietary incorporation of β-Pro preparation with much space allocation for rabbits is highly recommended to optimize rabbit performance under Egyptian summer conditions.

Table (1): Composition of experimental groups (design)

Group	
Density	
A1	10 rabbits/m^2 (2 rabbits/cage, 45 × 45 × 35 cm)
A2	15 rabbits/m^2 (3 rabbits/cage, 45 × 45 × 35 cm)
A3	20 rabbits/m^2 (4 rabbits/cage, 45 × 45 × 35 cm)
Dietary treatment	
B1	Basal diet without β-Pro
B2	Diet supplemented with β-Pro

Table (2): Feed components (%) and proximate analysis of the experimental ration

Feed components *	**Basal diet**	**Calculated values (air-dry basis; NRC 1977)**	
Yellow corn	17.5		
Soybean meal (44% CP)	17.0	DE Kcal/Kg	2508
Wheat bran	14.0	Crude protein %	18.03
Alfalfa hay meal	37.0	Ether extract %	2.54
Barley	10.0	Crude fiber %	13.70
Molasses	2.0	Calcium %	1.14
Dicalcium phosphate	0.7	Phosphorus %	0.59
Limestone	1.0	Lysine%	0.88
Common salt	0.5	Methionine%	0.24
Vit. and Min. Premix**	0.3	Methionine+Cysteine	0.57
Total	100		

* Feed additive (β-pro) was added instead of the same amount of corn.

** Each 3 kg premix contains: Vitamin A, 12,000,000 IU; Vitamin D_3, 2,700,000 IU; Vitamin E, 20 g; Vitamin K, 1.5 g; Vitamin B1, 1.5 g; Vitamin B_2, 5.5 g; Vitamin B_6, 2.5 g; Vitamin B_{12}, 10 mg; Biotin, 200 mg; Folic acid, 5 g; Nicotinic acid, 30 g; Pantothenic acid, 10 g; phytase, 100 g; Choline chloride, 400 g; Manganese oxide, 60 g; Copper sulfate, 4 g; Zinc oxide, 70 g; Iron sulfate, 70 g; Calcium iodine, 1.1 g; Sodium selenite, 150 mg; Cobalt sulfate, 100 mg; Magnesium, 400g; Organic selenium, 50 g.; and Calcium carbonate up to 3 kg.

Table (3): Average of ambient temperature and relative humidity during summer season from June to August, 2015

Weeks of study	Ambient temperature ˚C		Relative humidity (%)	
	Minimum	Maximum	Minimum	Maximum
1	20.9	31.1	49	96
2	21.0	32.7	49	95
3	22.1	34.1	40	95
4	22.2	35.5	30	96
5	23.3	35.3	40	94
6	23.0	34.3	50	95
7	22.1	34.1	41	95
8	21.5	33.7	34	96

Table (4): Performance of NZW rabbits as affected by experimental treatments

Treatment	Rabbit performance traits from 6-14 weeks of age					
	IW, g	FW, g	DWG, g	DFI, g	FCR	Economic efficiency, %
Density (A)						
A1	640.0	2302.5^{a}	29.69^{a}	98.58^{a}	3.32	201.6
A2	583.1	2073.3^{b}	26.61^{b}	91.29^{b}	3.43	191.9
A3	578.1	1953.8^{c}	24.56^{c}	82.35^{c}	3.35	198.9
SEM	24.4	38.0	0.35	2.04	0.06	5.11
Significance level	NS	**	**	**	NS	NS
Feed additive (B)						
B1	576.8	2053.9^{b}	26.38^{b}	88.70	3.36	197.7
B2	624.0	2165.8^{a}	27.53^{a}	92.78	3.37	197.2
SEM	19.9	31.0	0.28	1.67	0.05	4.17
Significance level	NS	*	*	NS	NS	NS
Interactions (AB)						
A1×B1	639.1	2314.2	29.91	100.4	3.36	198.1
A1×B2	640.8	2290.8	29.46	96.76	3.29	205.1
A2×B1	553.3	1977.3	25.42	86.43	3.40	194.8
A2×B2	612.8	2169.4	27.80	96.16	3.46	189.1
A3×B1	537.9	1870.4	23.79	79.26	3.33	200.3
A3×B2	612.3	2037.1	25.33	85.43	3.37	197.4
SEM	34.4	53.8	0.49	2.89	0.08	7.23
Significance level	NS	NS	*	NS	NS	NS

a-c Means in the same column having the same letter (s) superscripts are not significantly different.
IW= Initial weight, FW=Final weight, DWG= Daily weight gain, FI= Daily feed intake, FCR=feed conversion ratio

Table (5): Some blood parameters of NZW rabbits as affected by experimental treatments

Treatment	Total protein (g/dl)	Albumin (g/dl)	Globulin (g/dl)	Triglyceride (mg/dl)	Cholesterol (mg/dl)	Glucose (mg/dl)	HDL (mg/dl)	AST (U/L)	ALT (U/L)
Density (A)									
A1	5.83	3.11	2.72[a]	61.88	79.84	112.4	28.11[b]	65.10	15.69
A2	5.73	3.05	2.68[a]	64.70	84.17	115.2	32.30[a]	64.26	14.27
A3	5.45	3.03	2.42[b]	66.94	86.55	114.1	29.78[ab]	63.03	13.63
SEM	0.15	0.11	0.07	2.46	3.13	2.71	0.95	2.37	0.70
Sig.	NS	NS	*	NS	NS	NS	*	NS	NS
Feed additive (B)									
B1	5.69	3.09	2.60	64.87	83.76	114.7	29.39	62.73	14.81
B2	5.65	3.04	2.61	64.14	83.28	113.2	30.73	65.53	14.25
SEM	0.12	0.09	0.06	2.01	2.55	2.21	0.78	1.93	0.57
Sig.	NS	NS	NS	NS	NS	NS	NS	NS	NS
Interactions (AB)									
A1×B1	5.72	3.11	2.61	62.93	81.83	113.5	25.69	63.12	15.08
A1×B2	5.95	3.11	2.84	60.84	77.86	111.3	30.53	67.09	16.30
A2×B1	5.95	3.09	2.86	62.73	81.18	115.3	31.0	63.54	15.39
A2×B2	5.51	3.01	2.50	66.67	87.16	115.2	33.59	64.99	13.15
A3×B1	5.42	3.07	2.35	68.96	88.28	115.3	31.48	61.53	13.96
A3×B2	5.50	3.0	2.50	64.91	84.81	113.0	28.08	64.53	13.30
SEM	0.21	0.15	0.11	3.49	4.42	3.83	1.35	3.35	0.99
Sig.	NS	NS	*	NS	NS	NS	*	NS	NS

a-b Means in the same column having the same letter(s) superscripts are not significantly different

Table (6): Carcass traits of rabbits as affected by experimental treatments

Treatment	Live weight (g)	Feet +fur%	Carcass%	Lungs %	Kidneys %	Heart%	Liver %	Total edible parts %
Density (A)								
A1	1943	17.28	61.43	0.81	1.0	0.26	2.39	66.0
A2	2008	16.75	62.58	0.71	0.66	0.24	2.75	66.95
A3	2010	17.96	59.87	0.77	0.65	0.23	2.84	64.36
SEM	42.8	0.45	2.04	0.05	0.22	0.02	0.24	2.04
Significance	NS	NS	NS	NS	NS	NS	NS	NS
Feed additive (B)								
B1	1919[b]	17.69	61.56	0.75	0.69	0.23	2.80	66.04
B2	2054[a]	16.97	61.03	0.77	0.86	0.25	2.53	65.0
SEM	35.01	0.37	1.67	0.04	0.18	0.02	0.19	1.67
Significance	*	NS	NS	NS	NS	NS	NS	NS
Interactions (AB)								
A1×B1	1854	17.54	62.31	0.82	0.71	0.23	2.71	66.79
A1×B2	2032	17.03	60.56	0.79	1.30	0.29	2.08	65.01
A2×B1	1902	17.0	61.54	0.69	0.68	0.22	2.93	66.07
A2×B2	2113	16.49	63.61	0.73	0.65	0.25	2.57	67.83
A3×B1	2002	18.52	60.85	0.73	0.69	0.24	2.75	86.26
A3×B2	2018	17.40	58.90	0.80	0.62	0.22	2.63	63.47
SEM	60.6	0.64	2.89	0.06	0.31	0.03	0.34	2.89
Significance	NS	NS	NS	NS	NS	NS	NS	NS

a-b Means in the same column having the same letter(s) superscripts are not significantly different

Table (7): Total microflora counts (log^{10} cfu/g) in cecal content of rabbits reared under different stocking densities with/without probiotic-enzyme preparation

Treatment	T.B.C.*	Coliforms count	Lactobacilli counts	Clostridia counts
Density (A)				
A1	11.96	4.90	7.00	4.05
A2	13.15	5.03	6.91	4.13
A3	12.48	5.14	7.04	3.88
SEM	0.23	0.12	0.20	0.18
Sig.	NS	NS	NS	NS
Feed additive (B)				
B1	12.56^{b}	4.65^{b}	7.12^{b}	4.00
B2	14.57^{a}	3.02^{a}	8.40^{a}	3.96
SEM	0.18	0.05	0.25	0.21
Sig.	*	*	*	NS
Interactions (AB)				
A1×B1	12.86	4.98	6.55	4.11
A1×B2	11.99	5.13	6.93	4.02
A2×B1	12.54	5.42	5.98	3.98
A2×B2	14.33	4.00	7.94	4.00
A3×B1	13.93	3.95	8.06	4.06
A3×B2	14.52	3.82	8.11	3.99
SEM	0.189	0.194	0.181	0.205
Sig.	*	*	*	NS

*: TBC: Total bacterial count

a–c Means in the same column with unlike superscripts differ significantly at ($P \leq 0.05$)

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الملخص العربى

الاستجابة للبيتا برو فى علائق الأرانب المرباه بكثافات إسكان مختلفة تحت الظروف البيئية الحارة

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أجريت هذه الدراسة لتقييم تأثير β-Pro (مستحضر من البروبيوتيك- والإنزيمات) على 54 أرنب مفطوم (عمر 6 اسابيع ومتوسط وزن الأرنب 600 جرام) لتربى بكثافات اسكان مختلفة على أداء النمو ، وصفات الذبيحة وبعض مقاييس الدم وميكوفلورا الأعور تحت الظروف الحارة.

صممت تجربة عاملية (2×3) تشمل نظامين غذائيين [العليقة الأساسية (العليقة الكنترول) ، والعليقة الأساسية + 0.2 جرام β-Pro /كجم من الأسبوع 6 إلى 14] و 3 كثافات اسكان [2 ، 3 و 4 أرانب / قفص حيث مساحة القفص (45 ×45×35سم) وتمثل كثافة اسكان 10، 15،20حيوان /م2] خلال اشهر الصيف من يونيو إلى أغسطس.

أظهرت النتائج أن إضافة ال β-Pro للعلائق أدى إلى تحسن معنوى ($P \leq 0.05$) فى الوزن الحي للتسويق و الزيادة الوزنية اليومية دون تأثير على المأكول من العلف ومعامل التحويل الغذائى وموصفات الدم أو خصائص الذبيحة للأرانب خلال فترة التجربة من 6 إلى 14 أسبوع من العمر. نتج عن الامداد الغذائي بال β-Pro زيادة معنوية ($P < 0.01$) فى البكتيريا النافعة مثل لاكتوباسلاس ، وانخفضًا كبيرًا ($P < 0.05$) فى عدد بكتيريا الكوليفورم بدون أي تغيرات في الكلوستريديا.

الكثافة المنخفضة للارانب (2 أرانب / قفص أى 10 أرنب/م2) حققت أعلى ($P <0.01$) وزن حي للتسويق ، والزيادة الوزنية اليومية واستهلاك العلف بالمقارنة مع كثافات الاسكان الأعلى. أظهرت التفاعلات بين كثافة الإسكان وإضافة β-Pro للعلائق تغيرات معنوية ($P < 0.05$) في الزيادة الوزنية اليومية ، الجلوبيولين ، HDL ، عدد البكتيريا الكلية و بكتيريا الكوليفورم و بكتيريا اللاكتوبسيلاس، وبدون تأثير على القياسات الأخرى التي تم تقييمها.

التوصية: خلصت الدراسة الحالية إلى أن استخدام أقل كثافة إسكان (10 أرانب/م2) مع الامداد بمخلوط البروبايوتيك مع الانزيمات يوصى بها لفترة ما بعد الفطام للأرانب المرباه تحت الظروف البيئية الحارة.