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Influence of Weaning Age and Dietary Beta-Pro Fortification on Performance and Carcass Traits of Rabbits

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ABSTRACT

A factorial experiment (3×2) was carried out to study the effects of weaning age (at 4 and 5 weeks old) and dietary β-pro supplementation () 0.0, 0.02 and 0.04%) on growth and carcass traits in fattening rabbits. Seventy two unsexed New Zealand White (NZW)× Californian (CAL) rabbits, weaned at 4 or 5 weeks old, were randomly distributed into six equal groups of four replications, each contained three rabbits. Three experimental diets were fortified with three levels of β-Pro (0.0, 0.02 and 0.04%) and formulated to meet the nutrient requirements of growing rabbits. Rabbits of each replication were weighed, kept in a battery cage, fed their respective experimental diet and managed similarly during the duration of this study. Deaths was monitored and registered daily. Weekly records on live body weight (LBW) and feed intake (FI) were maintained on a replicate group basis, and thus, body weight gain (BWG) and feed conversion ratio (FCR) were estimated. The efficiency of protein (PER) and energy utilization (EEU) and economic efficiency of feeding (EEF) were calculated for the whole experimental period. Some carcass traits were also determined. The results obtained could be summarized as follows: No mortality was observed in the experimental rabbits during this feeding trial. Regardless of dietary β-pro supplementation, delaying weaning age to 5 weeks significantly increased ($P \leq 0.01$) total FI and final LBW of rabbits compared with those of rabbits that were weaned at 4 weeks old. Dietary supplementation with β-pro failed to significantly affect the final LBW of rabbits but caused a significant ($P \leq 0.01$) increase in total FI and when the level of its addition reached 0.04% total BWG improved significantly($P \leq 0.01$), irrespective of weaning age. Neither weaning age nor dietary β-pro supplementation could significantly alter FCR, PER, EEU or EEF during this study. The interactions between weaning age and dietary β-pro supplementation were not significant ($P > 0.05$) for all growth performance criteria, except for the total FI the interaction was significant ($P \leq 0.01$). Carcass traits of rabbits were not affected by weaning age, dietary β-pro supplementation or the interactions between them. Based on the present results, delaying weaning of rabbits to 5 weeks old along with addition of 0.04% β-pro to their diets are recommend to achieve better growth performance, with no adverse effects on carcass traits.

Keywords: Weaning age, β-pro, performance, carcass traits, fattening rabbits.

INTRODUCTION

It is well known that rabbits are categorized as hindgut fermentors according to the site of microbial fermentation in their digestive systems (Moore, 2017). In rabbits, cecum is the main site of microbial fermentation (Carabano *et al.*, 2010). Owing to the high energy requirements of rabbits they possess unique behavioral and adaptive mechanisms. These mechanisms include high rates of voluntary feed intake, feeding frequency, digestion and utilization of the non-fibrous carbohydrates, elimination of the indigestible lignified feed materials, and pushing the fibrous materials that can be digested by microorganisms to the cecum where they are broken down, and thus the nutrients become available via microbial fermentation (McNitt *et al.*, 2013; Moore, 2017). In addition, Gidenne *et al.* (2010) demonstrated that the behavior of cecotrophy (the ingestion of soft feces of cecal origin) potentiates the importance of microbial digestion in the cecum for nutrient utilization. According to Carabano *et al.* (2010), the major age-related changes in the morphological and developmental maturation of the digestive organs in young rabbits are considered to be relevant to the transition period from suckling to solid feeding. They also stated that high solid-feed intake in this critical period is positively correlated with rabbit growth performance and survivability during the growing period. It seems that weaning has a beneficial effect on the maturation of the cecum. In this regard, early weaning has been reported to increase the weight of the digestive organs and their contents, stimulate the microbial colonization, elevate the fermentative activity and hasten the maturation of gut-associated lymphoid tissue (Carabano *et al.*, 2008; Kovacs *et al.*, 2008).

When young rabbits are under stress such as during the weaning period some digestive disorders may occur (McNitt *et al.*, 2013; Moore, 2017). Under such stressful situations, the supplementation with probiotics for rabbits would be beneficial to encourage the growth and proliferation of certain strains of beneficial bacteria in the gastrointestinal tract at the expense of less desirable ones (Sharma *et al.*, 2016). Probiotic supplementation has been found to improve the growth rate and the efficiency of feed utilization in rabbits (Amber *et al.*, 2014; Ren *et al.*, 2016; Bhatt *et al.*; 2017; Lam Phuoc and Jamikorn, 2017; Sherif, 2018). Other studies, however, showed no positive effects of probiotics on growth performance of rabbits (Ewuola *et al.*, 2011; Shrivastava *et al.*, 2012; Fathi *et al.*, 2017).

On the other side, exogenous feed enzymes may improve growth performance, as reported by some authors (Onu and Oboke, 2010; Abaza and Omara, 2011; Attia *et al.*, 2012). Such beneficial effects induced by supplemental enzymes could be attributable to an alteration in certain characteristics of gut morphology, an elevation in activity of the digestive enzymes or both; and thus, improving the rates of nutrient digestion and utilization. Other investigators observed no positive effects to enzyme supplements on performance of fattening rabbits (García-Palomares *et al.*, 2006; Garcia-Ruiz *et al.*, 2006; El-Sagheer and Hassanein, 2014). Therefore, the purpose of this study was to evaluate the effects of weaning age and dietary supplementation with Beta-Pro (a mixture of probiotics and enzymes) on growth performance and carcass characteristics of New Zealand White × Californian rabbits.

MATERIALS AND METHODS

The present experiment was carried out at the Rabbit Research Unit, belonging to the Center of Agricultural Researches and Experiments, Faculty of Agriculture, Mansoura University, from December, 2015 to February, 2016. The purpose of study was to evaluate the effects of weaning age and dietary supplementation with β-Pro (a combined mixture of probiotics and enzymes) on growth performance and carcass traits of New Zealand White × Californian rabbits.

Housing system of rabbits:

Seventy two unsexed New Zealand White (NZW)× Californian (CAL) rabbits, weaned at two different ages (4 and 5 weeks old), were randomly distributed into six treatment groups of four equal replications. Within each weaning age, the initial live body weights in all groups of rabbits were approximately similar. Each replicate group of rabbits were housed in a galvanized-wire cage with dimensions of 44 cm width, 35 cm height and 53 cm depth. Each battery cage was fitted with a feeder and an automatic nipple drinker. All cages were set up in an open-sided well-ventilated rabbitry.

Experimental diets and management:

Three experimental diets were formulated and processed as pellets to meet the nutrient requirements of growing rabbits, as recommended by the National Research Council (NRC, 1977). A basal diet composed mainly of alfalfa hay, wheat bran, barley grain, soy bean meal and yellow corn, without any supplement, was used as a control. Other two diets were formulated using the same feed components but fortified with β-Pro at levels of 0.02 or 0.04%. Composition and calculated analysis of the experimental diets are shown in Table 1. All groups of rabbits were fed their respective diets and exposed to the same environmental, managerial and hygienic conditions and had free access to feed and fresh water throughout the experimental period for eight weeks.

Table 1. Composition and calculated analysis of the experimental diets (as pellets) fed to growing rabbits for eight weeks

Ingredients (%)	Control diet	Diet 2	Diet 3
Alfalfa hay	29.00	28.98	28.96
Wheat bran	29.00	29.00	29.00
Ground barley grains	12.00	12.00	12.00
Soy bean meal (44% CP)	11.00	11.00	11.00
Ground yellow corn	14.3	14.3	14.3
Molasses	3.00	3.00	3.00
Ground limestone	1.00	1.00	1.00
Common salt (NaCl)	0.30	0.30	0.30
Vit. & Min. Premix[§]	0.30	0.30	0.30
DL-Methionine	0.10	0.10	0.10
β-Pro[¶]	0.00	0.02	0.04
Total	100	100	100
Calculated analysis: As fed basis (NRC, 1977)			
Digestible energy (kcal/kg)	2504	2504	2504
Crude protein (%)	16.50	16.50	16.50
Ether extract (%)	2.76	2.76	2.76
Crude fiber (%)	12.98	12.98	12.97
Calcium (%)	0.88	0.88	0.88
Phosphorous (%)	0.58	0.58	0.58
Lysine (%)	0.75	0.75	0.75
Methionine (%)	0.31	0.31	0.31
Methionine + Cystine (%)	0.63	0.63	0.63

[§]: Each 3 kg of premix contains: Vit. A, 12,000,000 IU; Vit. D3, 2,500,000 IU; Vit. E, 10 g; Vit. K, 2.5 g; Vit. B6, 1.5 g; Vit. B12, 10 mg; Biotin, 50 mg; Folic acid, 1.0 g; Nicotinic acid, 30 mg; Pantothenic acid, 10 g; Antioxidant, 19 g; Mn, 60 g; Cu, 10 g; Zn, 55 g; Fe, 35 g; I, 1.0 g; Co, 250 mg and Se, 150 mg. ¶: A blend of probiotics and enzymes.

Growth performance of rabbits:

The growth performance of rabbits, as affected by weaning age and dietary supplementation with β-Pro (probiotics plus enzymes) throughout the fattening period, was examined in terms of feed intake (FI), live body weight (LBW), body weight gain (BWG), feed conversion ratio (FCR), mortality rate, protein efficiency ratio (PER), efficiency of energy utilization (EEU) and economic efficiency of feeding (EEF). Live body weights of each replicate group of rabbits were estimated at the start of feeding trial and on a weekly basis thereafter. Feed intake and body weight gain of rabbits were also determined weekly on a replicate group basis. Thus, feed conversion ratio was calculated weekly on a replicate group basis as the quantity of feed eaten per unit of BWG. The PER was calculated as crude protein intake (g) divided by BWG (g).

The EEU was estimated as:

digestible energy intake (kcal) ÷ BWG (g).

The EEF was calculated as:

100 [(sale price per total gain – total feed cost) / total feed cost].

Deaths of rabbits was monitored and recorded daily.

Carcass characteristics:

At the end of the study, four rabbits per treatment were randomly chosen and fasted for 18 hours. Just after recording the live body weights (LBW), rabbits were slaughtered according to the Islamic method of sacrifice, skinned and eviscerated. The weights of carcass yield (CY), liver (LI), heart (HE), kidneys (KI), total giblets (GI) and perirenal fat (PF) were determined on a hot carcass weight basis for each rabbit. The total edible parts were calculated as CY plus total GI (*i.e.* the sum of liver, heart and kidneys weights). The percentages of carcass yield, liver, heart, kidneys, total giblets, total edible parts (dressing-out percentage) and perirenal fat were also calculated.

Statistical analysis:

In this study, a completely randomized design was used. Six experimental treatments were arranged factorially (2×3); two weaning ages (28 or 35 days old) by three levels of added dietary β-Pro (0.0, 0.02 and 0.04%). Data were statistically processed by a two-way analysis of variance using the procedures of SAS (SAS, 2006), with P≤0.05 considered to be significant. According to this program, significant differences among means of different variables were identified.

RESULTS AND DISCUSSION

Growth performance of rabbits:

It is interesting to note that no deaths occurred in the experimental rabbits during the feeding trial in this study. The effects of weaning age and dietary β-pro supplementation on the growth performance of fattening NZW×CAL rabbits are presented in Table 2.

Effect of weaning age:

From Table 2, it was observed that rabbit kits weaned at 4 weeks old consumed significantly less feed (P≤0.01) and had lower (P≤0.01) final LBW than those weaned at 5 weeks of age, regardless of the effect of added dietary β-pro. supplementation. However, cumulative means of BWG, FCR, PER, EEU and EEF of rabbits were not significantly affected (P>0.05) by weaning age. The heavier LBW achieved by kits weaned at 5 weeks of age could be attributed mainly to their higher milk and solid feed consumption coincided with more developed digestive system than did those weaned at 4 weeks old.

Table 2. Effects of weaning age and dietary β-pro supplementation for eight weeks on growth performance of NZW × CAL rabbits

Treatments	Final LBW (g)	FI[1] (kg)	BWG[2] (kg)	FCR[3] (kg: kg)	PER[4] (g CP intake: g gain)	EEU[5] (kcal DE intake: g gain)	EEF[7] (%)
Main effects:							
Weaning age (A)							
28 days (A1)	2250[b]	7.14[b]	1.55	4.65	0.77	11.6	116
35 days (A2)	2427[a]	7.75[a]	1.59	4.87	0.81	12.3	105
SEM[8]	39.4	0.04	0.04	0.11	0.02	0.28	4.39
Significance	**	**	NS	NS	NS	NS	NS
β-pro level (B)							
0.00 % (B1)	2271	7.33[b]	1.48[b]	5.01	0.83	12.5	112
0.02 % (B2)	2339	7.46[a]	1.58[ab]	4.73	0.78	11.9	111
0.04 % (B3)	2405	7.53[a]	1.65[a]	4.54	0.75	11.4	119
SEM[8]	48.3	0.05	0.04	0.14	0.02	0.34	5.38
Significance	NS	**	*	NS	NS	NS	NS
AB Interactions							
A1B1	2375	7.84	1.48	5.38	0.89	13.4	96.9
A1B2	2467	7.72	1.65	4.65	0.77	11.7	113
A1B3	2440	7.68	1.65	4.58	0.77	11.6	105
A2B1	2168	6.81	1.48	4.65	0.77	11.6	127
A2B2	2211	7.20	1.51	4.80	0.79	12.00	109
A2B3	2370	7.39	1.65	4.50	0.74	11.2	113
SEM[8]	68.3	0.06	0.06	0.19	0.03	0.48	7.61
Significance	NS	**	NS	NS	NS	NS	NS

a-b: For each of the main effects, means in the same column with different superscripts differ significantly (P≤0.05). NS: Not significant; *: Significant at P≤0.05. **: Significant at P≤0.01.

1-8: Refer to cumulative feed intake, body weight gain, feed conversion ratio, protein efficiency ratio, efficiency of energy utilization, economic efficiency of feeding and standard error of the means, respectively.

Owing to the similarity between rabbit kits weaned at 4 or 5 weeks of age in total BWG, the higher total FI of the latter led to insignificantly inferior means of FCR, PER and EEU compared with those of the former. The insignificant differences in the EEF of rabbits between the two weaning ages, in the present study, are mainly due to the fact that they achieved approximately similar total BWG and thus similar total revenue, with slight differences in total feed cost between the two groups of rabbits.

The superior final LBW of kits weaned at 5 weeks old to those weaned at 4 weeks of age, found in this study, harmonizes with the finding of El-Sabrout and Aggag (2017) that market weight of rabbits (63 days old) was significantly lower when rabbits were weaned at 23 days old than that of rabbits weaned at 28 or 33 days of age. Similar results were obtained by Kovacs *et al.* (2008), Bivolarski *et al.* (2011), Salama *et al.* (2015) and Gabr *et al.* (2017), who observed that early weaning caused a significant reduction in body mass of rabbits as compared to that of normally weaned ones. The lack of effect of weaning age on most criteria of growth performance, observed herein, was also observed by other investigators (Zita *et al.*, 2007; Zita *et al.*, 2012; Obike *et al.*, 2014).

Effect of dietary β-pro supplementation:

As given in Table 2, dietary supplementation with β-pro (a mixture of probiotics and enzymes) significantly increased total FI (P≤0.01) of rabbits compared with their control counterparts, independently from the effect of weaning age. Similarly, the high dose of the feed supplement (0.04%) caused a significant (P≤0.05) improvement (11.5%) in total BWG of rabbits compared with the control group. But the total BWG of rabbits fed the diet supplemented the low dose of β-pro (0.02%) was comparable to those of rabbits received either the basal diet or the diet supplemented the high dose of β-pro (0.04%), with no significant differences among them. However, dietary supplementation with β-pro had no significant effect (P>0.05) on final LBW, FCR, PER, EEU or EEF of rabbits during the entire experimental period (Table 2).

The improved BWG of rabbits fed the 0.04% β-pro-supplemented diet harmonize with the observation of Ren *et al*. (2016) that dietary supplementation with probiotic (*Bacillus coagulans*) increased daily weight gain of rabbits by 20% for the period from 5 to 13 weeks of age. The current finding is in harmony also with the result of Bhatt *et al*. (2017), who found that rabbits given probiotic(*Lactobacillus acidophilus*)-enriched drinking water displayed significantly better daily weight gain compared with the control group. The positive effects of supplemental probiotics on growth rate of rabbits have also been reported by El-Deek *et al*. (2013), Amber *et al*. (2014), Chandra *et al*. (2014), Lam Phuoc and Jamikorn (2017) and Sherif (2018). On the contrary, other authors found no positive effect of probiotics on growth performance of rabbits (Matusevicius *et al*., 2006; Kimse *et al*., 2008; Rabie *et al*., 2011; Fathi *et al*., 2017). Some studies have indicated a negative growth response due to dietary supplementation of probiotics (El-Katcha *et al*., 2011; Oso *et al*., 2013).

According to the literature, the improved growth performance of rabbits due to dietary supplementation with probiotics are suggested to be attributed their beneficial effects on intestinal microbial balance, cecal fermentation, nutrient digestibility and/or immune functions (Ewuola *et al*., 2011; Gogineni *et al*., 2013; Lam Phuoc and Jamikorn, 2017). But the negative response of rabbits to probiotics is perhaps due to a depression in nutrient digestibility, as suggested by some authors. However, the lack of rabbit responsiveness to supplemental probiotics might be related to some factors such as rabbit age and health status of its gastrointestinal tract, the probiotic type, composition and dose, and diet composition. On the other hand, exogenous feed enzymes have been reported to improve growth performance (Onu and Oboke, 2010; Abaza and Omara, 2011; Attia *et al*., 2012). Other investigators found that performance of fattening rabbits was not affected by dietary enzyme supplementation (Garcia-Ruiz *et al*., 2006; El-Sagheer and Hassanein, 2014).

The effect of interaction between weaning age and dietary β-pro supplementation was not significant (P>0.05) for all growth performance criteria, except for total feed intake which was significant (P≤0.01).

Carcass traits of rabbits:

The effects of weaning age and dietary supplementation with β-pro for eight weeks are presented in Table 3.

Effect of weaning age:

It was observed that weaning age did not significantly (P>0.05) affect the relative weights of carcass yield, liver, kidneys, heart, giblets, total edible parts and perirenal fat, independently from the effect of dietary supplementation with β-pro.

Table 3. Effects of weaning age and dietary β-pro supplementation for eight weeks on relative weights of carcass characteristics of NZW × CAL rabbits

Treatments	LBW[1] (g)	CY[2] (%)	LI[3] (%)	KI[4] (%)	HE[5] (%)	GI[6] (%)	TEP[7] (%)	PF[8] (%)
Main effects:								
Weaning age (A)								
28 days (A1)	2451	55.2	3.93	0.88	0.28	5.09	60.3	0.98
35 days (A2)	2548	55.5	4.01	0.84	0.33	5.19	60.7	0.75
SEM[8]	61.5	0.54	0.18	0.04	0.03	0.20	0.58	0.098
Significance	NS	NS	NS	NS	NS	NS	NS	NS
β-pro level (B)								
0.00 % (B1)	2463	54.8	3.86	0.85	0.28	4.98	59.8	0.95
0.02 % (B2)	2565	55.5	3.88	0.90	0.35	5.13	60.7	0.93
0.04 % (B3)	2471	55.7	4.17	0.84	0.30	5.31	61.00	0.72
SEM[8]	75.4	0.66	0.23	0.05	0.03	0.25	0.72	0.12
Significance	NS	NS	NS	NS	NS	NS	NS	NS
AB Interactions								
A1B1	2533	55.8	4.13	0.77	0.32	5.23	61.0	0.84
A1B2	2611	55.1	4.06	0.85	0.34	5.26	60.4	0.83
A1B3	2501	55.7	3.83	0.90	0.34	5.08	60.7	0.56
A2B1	2394	53.9	3.59	0.92	0.23	4.74	58.6	1.05
A2B2	2519	56.0	3.70	0.94	0.36	5.00	61.0	1.03
A2B3	2440	55.7	4.51	0.77	0.26	5.54	61.2	0.87
SEM[8]	107	0.93	0.32	0.08	0.05	0.35	1.01	0.17
Significance	NS	NS	NS	NS	NS	NS	NS	NS

NS: Not significant. SEM: Standard error of the means.

[1-8]: Refer to percentages of carcass yield, liver, kidneys, heart, giblets, total edible parts and perirenal fat (relative to LBW at slaughter), respectively.

The insignificant differences in carcass characteristics between the two weaning age might be related to their similarity in slaughter weights. In this regard, Trocino *et al*. (2004) clarified that rabbits of similar body weights are not expected to differ in their carcass traits. The present findings harmonize with those of Zita *et al*. (2007) that weaning age did not affect carcass characteristics in Hyplus® rabbits. Similarly, Gabr *et al*. (2017) found that dressing percentage of 10-week-old rabbits was not affected by weaning age; 53.33 *vs*. 54.13% for rabbits weaned at 21 and 27 days old, respectively. In disagreement with the present results, Bivolarski *et al.* (2011) found that dressing percentage in early-weaned rabbits was significantly lower than that of normally-weaned ones. However, Zita *et al.* (2012) found that rabbits weaned at 21 days of age achieved significantly higher hot and chilled carcass weights, higher relative liver weight and insignificantly higher dressing-out percentage than those of rabbits weaned at 35 days of age, while the latter exhibited a higher drip loss percentage than did the former. Similarly, Mahunguane *et al.* (2016) reported that when California white and New Zealand white rabbits were weaned at 4 weeks of age they displayed better carcass quality for both the first (loin and hind legs) and the second retail cuts (thoracic cage) than those weaned at 8 weeks of age but with the Chinchilla rabbits the reverse was true.

Effect of dietary β-pro supplementation:

Apart from the effect of weaning age, dietary β-pro supplementation did not significantly affect (P>0.05) carcass characteristics of rabbits, examined herein (Table 3).

These findings agree with those of Sherif (2018), who observed no positive effect of added dietary β-pro on carcass traits of New Zealand White rabbits. In addition, El-Sagheer and Hassanein (2014) found that dietary supplementation with Veta-zyme (a mixture of enzymes and a probiotic) had no effect on carcass criteria. Similarly, Bhatt *et al*. (2017) reported that added dietary probiotics had no significant effect on carcass traits of growing Chinchilla rabbits. Also, Rabie *et al*. (2011) observed no effect of supplemental dietary probiotic on carcass traits of rabbits. Additionally, El-Katcha *et al*. (2011) demonstrated that added dietary probiotics has no adverse effect on rabbit dressing percentage or relative weights of internal organs. Moreover, El-Deek *et al.* (2013) reported that relative weights of carcass traits and internal organs of rabbits were not affected by the dietary supplementation with probiotic.

As regards the response of fattening rabbits to dietary supplementation with enzymes, Abaza and Omara (2011) indicated that rabbits fed diets fortified with enzymes had comparable carcass and dressing percentages to those of rabbits fed on the basal diet. Also, Aguda and Omage (2014) demonstrated that dietary supplementation with enzymes did not alter most carcass characteristics of rabbits. Amber (2007) reported that rabbits fed diets fortified with enzymes exhibited higher and lower percentages of carcass and abdominal fat, respectively; but meat composition did not alter, compared with the control group. On the other hand, Abdel-Aziz *et al.* (2015) evaluated the effect of added dietary *Lactobacillus acidophilus* (probiotic), exogenous enzymes or their combination on carcass traits of rabbits and found that dressing percentage of rabbits fed the probiotic- or probiotic plus enzymes-supplemented diets was significantly higher than that of the control rabbits. The positive effects of probiotics on carcass traits were also observed by on carcass traits were also observed by Ewuola *et al.* (2011), Abdel-Khalek *et al.* (2012) and Fathi *et al.* (2017). The effect of interaction between weaning age and dietary β-pro supplementation was not significant (P>0.05) for all carcass traits measured in this study (Table 3).

CONCLUSION

Based on the present results, delaying weaning of rabbits to 5 weeks old along with addition of 0.04% β-pro to their diets are suggested to achieve better growth performance, with no adverse effects on carcass traits.

REFERENCES

Abaza, I.M. and M.E. Omara (2011). Effect of dietary corn cobs and enzymes supplementation on growing rabbits performance. J. Prod. Develop., 16(3): 507-527.

Abdel-Aziz, N.A.; M. El-Adawy; M.A. Mariezcurrena-Berasain; A.Z.M. Salem; J. Olivares-Pérez; A.E. Kholif and B.E. Borhami (2015). Effects of exogenous enzymes, *Lactobacillus acidophilus* or their combination on feed performance response and carcass characteristics of rabbits fed sugarcane bagasse. J. Integ. Agric., 14(3): 544-549.

Abdel-Khalek, A.E.; A.M. Abdelhamid; A.F. Mehrez and I. El-Sawy (2012). Growth performance, digestibility coefficients, blood parameters and carcass traits of rabbits fed biologically treated diets. J. Anim. Poultry Prod., Mansoura Univ., 3(5): 227-239.

Aguda, A.Y. and J. J. Omage (2014). Effect of feeding different processed pigeon pea (*Cajanus cajan*) supplemented with Maxigrain® on the performance and carcass characteristics of weaner rabbits. J. Anim. Poultry Sci., 3(2): 38-46.

Amber, Kh. (2007). Effects of yeast cultures, enzymes and mint extract as feed additives on performance and caecal microbial activity of growing New Zealand White rabbits. Egypt. Poult. Sci., 27(III): 769-783.

Amber, Kh.; F.M. Abd El-Nabi; W.A. Morsy and S.H.A. Morsy (2014). Effect of dietary supplementation of probiotic and prebiotic on preventing post weaning digestive disorders and productive performance of growing rabbits. Egypt. Poult. Sci., 34(I): 19-38.

Attia, K.A.; S.Y. Saleh; S.S. Abd El-hamid; A.A. Zaki and M.A. El-Sawy (2012). Effects of exogenous multi-enzyme feed additive (Kemzyme) on the activities of certain digestive enzymes and intestinal morphology in growing rabbits. J. Agric. Sci., 4(3): 35-44.

Bhatt, R.S.; A.R. Agrawal and A. Sahoo (2017). Effect of probiotic supplementation on growth performance, nutrient utilization and carcass characteristics of growing Chinchilla rabbits. J. Appl. Anim. Res., 45(1): 304-309.

Bivolarski, B.L.; Vachkova, E.V. and S.S. Ribarski (2011). Effect of weaning age upon the slaughter and physicochemical traits of rabbit meat. Vet. Arhiv., 81(4): 499-511.

Carabano, R.; I. Badiola; S. Chamorro; J. Garcia; A.I. Garcia-Ruiz; P. Garcia-Rebollar; M.S. Gomez-Conde; I. Gutierrez; N. Nicodemus; M.J. Villamide and J.C. de Blas (2008). New trends in rabbit feeding: influence of nutrition on intestinal health. Spanish J. Agric. Res., 6 (Special issue): 15-25.

Carabano, R.; J. Piquer and D. Menoyo and I. Badiola (2010). The digestive system of the rabbit. Chapter one In: Nutrition of the Rabbit. 2nd Edition. Edited by De Blas, C. and J. Wiseman, Published by CAB International, Wallingford, Oxfordshire OX10 8DE, UK, pp. 1-18.

Chandra, S.; M. Mahender; M.G. Prakash; T. Raghunandan and K.K. Reddy (2014). Productive performance of broiler rabbits fed diets supplemented with probiotic and enzymes under two systems of housing. Indian J. Anim. Res., 48(4): 355-361.

El-Deek, A.A.; M.A. Albanoby and M.K. Abou El-Naga (2013). Evaluation of Super Action probiotic as a natural growth promoter for growing rabbits. Egypt. Poult. Sci., 33(2): 407-419.

El-Katcha, M.I.Y.; E.Y. Ismail; M.A. Soltan and Karima M. El Naggar (2011). Effect of dietary probiotics supplementation on growth performance, immune response, some blood parameters and carcass quality of growing rabbits. Alex. J. Vet. Sci., 34(1): 153-169.

El-Sabrout, K. and S.A. Aggag (2017). The gene expression of weaning age and its effect on productive performance of rabbits. World Rabbit Sci., 25: 1-7.

El-Sagheer, M. and H.H.M. Hassanein (2014). Effect of enzymes and probiotic mixture supplementation to the diet of growing female rabbits on performance and carcass criteria. Egypt. Poult. Sci., 34(I): 259-272.

Ewuola, E.O.; C.U. Amadi and T.K. Imam (2011). Performance evaluation and nutrient digestibility of rabbits fed dietary prebiotics, probiotics and symbiotics. Int. J. Appl. Agric. Apicul. Res., 7(1/2): 107-117.

Fathi, M.; M. Abdelsalam; I. Al-Homidan; T. Ebeid; M. El-Zarei and O. Abou-Emera (2017). Effect of probiotic supplementation and genotype on growth performance, carcass traits, hematological parameters and immunity of growing rabbits under hot environmental conditions. Anim. Sci. J., 88: 1644-1650.

Gabr, A.A.; N.A. Shalaby and H.M. Rahma (2017). Effect of weaning age and using mixture of cumin, mentha extracts with cow milk as a supplementation on growing rabbits performances. Asian J. Anim. Vet. Adv., 12(2): 96-102.

Garcia-Palomares, J.; R. Carabano; P. Garcia-Rebollar; C. de Blas; A. Corujo and A.I. Garcia Ruiz (2006). Effects of a dietary protein reduction and enzyme supplementation on growth performance in the fattening period. World Rabbit Sci., 14: 231–236.

Garcia-Ruiz, A.I.; J. Garcia-Palomares; P. Garcia-Rebollar; S. Chamorro; R. Carabano and C. de Blas (2006). Effect of protein source and enzyme supplementation on ileal protein digestibility and fattening performance in rabbits. Spanish J. Agric. Res., 4: 297-303.

Gidenne, T.; F. Lebas and L. Fortun-Lamouthe (2010). Feeding behaviour of rabbits. Chapter thirteen In: Nutrition of the Rabbit. 2nd Edition. Edited by De Blas, C. and J. Wiseman, Published by CAB International, Wallingford, Oxfordshire OX10 8DE, UK, pp. 233-252.

Gogineni, V.K.; L.E. Morrow and M.A. Malesker (2013). Probiotics: Mechanisms of action and clinical applications. Journal of Probiotics and health, 1(1): 101 doi: 10.4172/2329- 8901.1000101

Kimsé, M.; C. Bayourthe; V. Monteils and T. Gidenne (2008). Live yeast stability in the digestive tract of the rabbit: Relationship with digestion, growth and digestive health. In: Proc. 9th World Rabbit Congress, June 10-13, Verona, Italy, pp.695-699.

Kovacs, M.; G. Milisits; Zs. Szendro; H. Lukacs; A. Bonai; R. Posa; G. Tornyos; F. Kovacs and P. Horn (2008). Effect of different weaning age (days 21, 28 and 35) on caecal microflora and fermentation in rabbits. In: Proc. 9th World Rabbit Congress, June 10-13, Verona, Italy, pp.701-704.

Lam Phuoc, T. and U. Jamikom (2017). Effects of probiotic supplement (*Bacillus subtilis and Lactobacillus Acidophilus*) on feed efficiency, growth performance, and microbial population of weaning rabbits. Asian-Aust. J. Anim. Sci., 30(2): 198-205.

Mahunguane, S.J.S.; M.K. Ambula and B.O. Bebe (2016). Effects of weaning age on carcass quality of rabbits reared on smallholder farms in Kenya. In: Proc. 11th World Rabbit Congress, Organized by World Rabbit Science Association, June 15-18, 2016, Qingdao, China.

Matusevicius, P.; L. Asmenskaite; A. Žilinskiene; A. Gugolek; M.O. Lorek and A. Hartman (2006). Effect of probiotic BioPlus 2B® on performance of growing rabbits. Vet. Med. Zoot., 36(58): 54-59.

McNitt, J.I.; S.D. Lukefahr; P.R. Cheeke and N.M. Patton (2013). Rabbit Production. 9th Edition. Published by CAB International, Wallingford, Oxfordshire OX10 8DE, UK.

Moore, L.C. (2017). Rabbit Nutrition and Nutritional Healing, Third edition, Illustrated by Evonne Vey.

National Research Council, NRC (1977). Nutrient requirement of rabbits. National Academic of Sciences, National Research Council, Washington, DC., USA.

Obike, O.M.; C.I. Ugwumba and P.A. Omo (2014). Effect of age at weaning on growth performance and post-weaning survival rate of different rabbit genotypes in South-Eastern agro-ecological zone of Nigeria. Global J. Anim. Sci. Res., 2(4): 390-395.

Onu, P.N. and S.A. Oboke (2010). Evaluation of enzyme and probiotic supplementation of maize processing waste-based diets on performance and nutrient utilization of weaner rabbits. Indian J. Anim. Res., 44(2): 87-93.

Oso, A.O.; O.M.O. Idowu; A.S. Haastrup; A.J. Ajibade; K.O. Olowonefa; A.O. Aluko; I.M. Ogunade; S.O. Osho and A.M. Bamgbose (2013). Growth performance, apparent nutrient digestibility, caecal fermentation, ileal morphology and caecal microflora of growing rabbits fed diets containing probiotics and prebiotics. Livestock Science, 157: 184-190.

Rabie, M.H.; Kh.El. Sherif; M.A.A. Hussein and Azza R.F. El-Desouqi (2011). Growth performance of rabbits as affected by dietary fiber level and probiotic addition during the post-weaning period. J. Anim. Poultry Prod., Mansoura Univ., 2(6): 185-199.

Ren, Y.J.; L. Zhu; X.H. Xie; L.D. Kuang; Z.Q. Guo; X.Y. Zhang; C.Y. Li; C. Yang; C.X. Zhang; J. Zheng and M. Lei (2016). Effects of *Bacillus coagulans* on performance and intestinal physiology of growing rabbits. In: Proc. 11th World Rabbit Congress, June 15-18, Qingdao, China, pp. 327-329.

Salama, Maha S.; W.A. Morsy; R.A. Mohamed; M.M. Eltholth and S.A. El-Midany (2015). Effect of weaning age and housing model on feed intake, growth performance, hemato-biochemical parameters and economic efficiency of post weaning New Zealand White rabbits. Alex. J. Vet. Sci., 46: 48-56.

SAS Institute (2006). SAS/STAT User's Guide. Release 9.1. SAS Inst. Inc., Cary, NC.

Sharma, K.G.; V.K. Vidyarthi; K. Archana and R. Zuyie (2016). Probiotic supplementation in the diet of rabbits - A review. Livestock Res. Int., 4(1): 1-10.

Sherif, Sara Kh. (2018). Effect of dietary additives on growth performance, carcass traits and some blood constituents of rabbits. J. Agric. Sci., 10(1): 139-151.

Shrivastava, A.K.; K.K. Tiwari; R. Kumar and R.R. Jha (2012). Effects of feed additives on body weights at different ages in rabbit. Schol. J. Agric. Sci., 2(11): 277-282.

Trocino, A.; G. Xiccato; A. Sartori and P.I. Queaque (2004). Group housing of growing rabbits: effect of stocking and cage floor on performance, welfare and meat quality. In: Proc. 8th World Rabbit Congress, 7-10 September, Puebla, Mexico, pp. 1277-1282.

Zita, L.; E. Tůmova; V. Skřivanova and Z. Ledvinka (2007). The effect of weaning age on performance and nutrient digestibility of broiler rabbits. Czech J. Anim. Sci., 52(10): 341–347.

Zita, L.; Z. Ledvinka; K. Mach; J. Kočár; L. Klesalová; A. Fučíková and H. Härtlová (2012). The effect of different weaning ages on performance in Hyla rabbits. In: Proc. 10th World Rabbit Congress, 3-6 September, Sharm El-Sheikh: Egypt, pp. 61-64.

تأثير عمر الفطام وتدعيم الغذاء بالبيتابرو على أداء النمو وخصائص الذبيحة للأرانب

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أجريت تجربة عاملية (٢×٣) لدراسة تأثير عمر الفطام (٤، ٥ أسابيع) وتدعيم الغذاء بالمنشط الحيوي بيتابرو (صفر، ٠.٠٢، ٠.٠٤%) على أداء النمو وخصائص الذبيحة لأرانب التسمين. تم استخدام ٧٢ أرنبا من سلالة خليط النيوزيلندي الأبيض مع كاليفورنيا (تم فطام نصفها عند عمر٤ أسابيع، والنصف الآخر عند عمر ٥ أسابيع). تم توزيع أرانب كل عمر فطام عشوائيا إلى ٣ مجموعات تجريبية تضمنت كل منها ٤ مكررات متساوية. تم تكوين ٣ علائق تجريبية مدعمة بثلاثة مستويات من المنشط الحيوي بيتابرو (صفر، ٠.٠٢ أو ٠.٠٤%) وتغطي احتياجات الأرانب النامية من العناصر الغذائية. تم وزن أرانب كل مكررة عند بدء التجربة (ثم أسبوعيا بعد ذلك) وسكنت في أحد أقفاص بطاريات التسمين، وغذيت على العليقة التجريبية الخاصة بها. أخضعت جميع الأرانب التجريبية لنفس ظروف الرعاية خلال فترة الدراسة. تم مراقبة النفوق وتسجيله يوميا إن وجد. تم أخذ قياسات أسبوعية لكل مكررة عن وزن الجسم، وإستهلاك الغذاء والزيادة الوزنية، معامل التحويل الغذائي، كفاءة استخدام بروتين وطاقة الغذاء، والكفاءة الإقتصادية للتغذية. في نهاية التجربة تم أخذ قياسات عن بعض صفات الذبيحة. وخلاصة النتائج المتحصل عليها هي: لم يلاحظ أي حالات نفوق للأرانب التجريبية طوال فترة الدراسة. بغض النظر عن تدعيم الغذاء بالبيتابرو، أدى تأخير عمر فطام الأرانب إلى ٥ أسابيع إلى زيادة معنوية في استهلاك الغذاء الكلي ووزن الجسم الحي النهائي مقارنة بالأرانب التي تم فطامها عند عمر ٤ أسابيع. لم يكن لتدعيم الغذاء بالبيتابرو تأثير معنوي على ووزن الجسم الحي النهائي للأرانب، لكنه أحدث زيادة معنوية في استهلاك الغذاء الكلي، كما تحسنت الزيادة الكلية في وزن الجسم عند إضافة البيتابرو بمعدل ٠.٠٤%، وذلك بصرف النظر عن تأثير عمر الفطام. لم يكن لعمر الفطام أو التدعيم الغذائي بالبيتابرو تأثير معنوي على معامل التحويل الغذائي، كفاءة استخدام بروتين وطاقة الغذاء، أوالكفاءة الإقتصادية للتغذية. لم يكن للتفاعل بين العاملين الرئيسيين بالدراسة تأثير معنوي على كل معايير أداء النمو، باستثناء استهلاك الغذاء الكلي. لم تتأثر خصائص الذبيحة معنويا بالعاملين الرئيسيين بالدراسة أو التفاعل بينهما. وبناءا على نتائج هذه الدراسة، فإنه ينصح بتأخير عمر فطام الأرانب إلى ٥ أسابيع بالتزامن مع تدعيم الغذاء بالبيتابرو بمعدل ٠.٠٤% من أجل تحقيق أداء نمو أفضل، دون حدوث تأثيرات سلبية على خصائص الذبيحة.