J. Animal and Poultry Prod., Mansoura Univ., Vol. 2 (6): 185-199, 2011

GROWTH PERFORMANCE OF RABBITS AS AFFECTED BY DIETARY FIBER LEVEL AND PROBIOTIC ADDITION DURING THE POSTWEANING PERIOD

Rabie, M.H.*; Kh. El. Sherif*; M.A.A. Hussein and Azza R.F. El-Desouqi****

*** Poultry Production Dept., Faculty of Agriculture, Mansoura University**

**** Anim. Prod. Res. Inst., Agric. Res. Center, Ministry of Agric., Dokki, Giza.**

ABSTRACT

A factorial experiment (3×2) was conducted to investigate the influence of feeding diets containing three crude fiber levels (12.52, 14.51 and 16.51%) with or without (0.0 or 0.03%) a probiotic supplementation on performance, nutrient digestibility, carcass traits and blood constituents of growing New Zealand White (NZW) rabbits. A total of 72, six-week-old NZW rabbits were individually weighed, randomly divided into 6 equal experimental groups, each with four equal replications, and kept at battery cages in a naturally-ventilated house. All groups of rabbits were reared under similar hygienic and managerial conditions. Six experimental diets were formulated and used during the experimental period from 6 to 12 weeks of age. Performance were evaluated in terms of live body weight, daily weight gain, daily feed intake, feed conversion ratio, protein efficiency ratio, efficiency of energy utilization and performance index. Digestibility of nutrients [dry matter (DM), organic matter (OM), crude protein (CP), ether extract (EE), crude fiber (CF) and nitrogen-free extract (NFE)], carcass traits (relative weights of carcass, total edible parts and abdominal fat) lengths stomach, caecum and small and large intestines, and some blood plasma constituents (glucose, cholesterol, triglycerides, total protein, albumin and globulin) were also determined. The results obtained can be summarized as follows: Growth performance, carcass traits and lengths of alimentary tract segments, blood constituents were not significantly affected by dietary crude fiber level or probiotic supplementation. Increasing dietary crude fiber level from 12.5% to 14.5 or 16.5% decreased the digestibility of DM, OM and NFE but significantly improved CF digestibility for 12-week-old NZW rabbits, while the digestibility of CP and EE was not affected. Dietary supplementation with probiotic had no significant effect on the digestibility of nutrients, with the exception of a significant improvement in CP digestibility compared with that of the control rabbits. The interactions between dietary fiber level and probiotic supplementation were not significant for all criteria examined in the present study. Based on the obtained results, it is concluded that the optimal level of dietary crude fiber for fattening rabbits to achieve maximal growth rate and best efficiency of feed utilization is 12.5%.

Keywords: Dietary crude fiber, Probiotic, Performance, Nutrient digestibility, Carcass traits, Blood parameters, New Zealand White rabbits.

INTRODUCTION

Rabbit is a mono-gastric herbivore but its ability to digest dietary fiber is lower than that of other herbivores such as the guinea pig and the horse, and as a result the rabbit derives less digestive energy from roughage than do other herbivores and ruminants (Cheeke, 1987). However, dietary fiber plays an important role in the diet of rabbit because of its influence on caecal microbial activity (Gidenne *et al.,* 1998; Gidenne *et al.,* 2010). An inadequate nutrient supply (especially fiber) can cause caeco-colic digestive disturbances, resulting in diarrhea and mortality (Gidenne, 2003). In addition, dietary fiber level affects the digestibility of the other nutrients in the diet and can also influence growth rate of rabbits (De Blas *et al*., 1986; Gidenne and Garcia, 2006). Several years ago, rabbit nutritionists are looking for developing feeding strategies capable of 1) reducing digestive diseases and the consequent high mortality and morbidity (Gidenne and Garcia, 2006), and 2) increasing feed efficiency, and thus lowering feeding and total production costs (Maertens, 2009; Xiccato and Trocino, 2010). The role of dietary fiber in rabbit nutrition is not limited to nutrient supply. It is required to achieve a high rate of passage of feed through the gut and optimize cecal fermentation, although an excess of dietary fiber limits energy intake and growth performance (Gidenne *et al.*, 1998; De Blas *et al.*, 1999; Garcia *et al*., 1999). It also plays a major role in the maintenance of intestinal mucosa (De Blas *et al*., 1999). Recently, Alvarez *et al.* (2007) showed that a reduction in dietary fiber content from 36-38 to 30-32% neutral detergent fiber (NDF) reduced mortality and enhanced performance and feed efficiency, in association with an improvement of mucosal structure.

According to the available literature, the optimal dietary fiber level for growing rabbits is variable and may depend largely upon other factors such as type of fiber, age and breed of rabbit, and/or digestible energy content of the diet (De Blas *et al*., 1999; Gidenne *et al.,* 1998; Gidenne *et al.,* 2010). In this context, the dietary crude fiber requirement recommended by the National Research Council (NRC, 1977) for normal growth of rabbits is 10-12%. De Blas *et al.* (1986) concluded that a minimum of 10% dietary crude fiber is necessary for maximum growth rate of rabbits, while levels in excess of 17% depress growth by restricting energy intake. De Blas and Mateos (1998) and Gidenne *et al*. (1998) recommended that optimal dietary fiber concentration for fattening rabbits is 14.5% crude fiber on as-fed basis. Recently, De Blas and Mateos (2010) indicated that the requirement of intensively reared fattening rabbits for dietary crude fiber is 15.5%.

Probiotics have been used in rabbit production in an attempt to improve the feed conversion ratio and digestibility of nutrients (Sonbol and El-Gendy, 1992; El-Hindawy *et al*, 1993). The mechanism of action of probiotics has not been elucidated, but might include: (i) reduction of toxin production; (ii) stimulation of enzyme production by the host; (iii) production of some vitamins or antimicrobial substances; (iv) competition for adhesion to epithelial cells and increased resistance to colonization; and (v) stimulation of the immune system of the host (Simon *et al.*, 2003; Falcao *et al.,* 2007; Mateos *et al*., 2010). Therefore, the present study was performed to investigate the influence of feeding diets containing three CF levels (12.52, 14.51 and 16.51%) with or without a probiotic supplementation on the performance, nutrient digestibility, carcass traits and blood parameters of growing New Zealand White rabbits.

MATERIALS AND METHODS

The present study was carried out at the Rabbitry of Poultry Production Department, Faculty of Agriculture, Mansoura University during the period from February to March, 2008. Seventy two 6-week-old New Zealand White (NZW) rabbits were randomly divided into 6 treatments. Each treatment had 4 replicates, each of 3 rabbits. Three diets were formulated to contain crude fiber levels of 12.5, 14.5 and 16.5% (Table 1) without or with the probiotic supplementation (0.03 kg Avian Plus per 100 kg diet). Thus, six experimental diets were prepared and used during the experimental period from 6 to 12 weeks of age.

All diets were formulated to meet all the essential nutrient requirements of growing rabbits (NRC, 1977). Feed and fresh water were offered *ad libitum* to the experimental groups throughout the experimental period from 6 to 12 weeks of age. All rabbits were housed in galvanized wire cages provided with feeders, automatic nipple drinkers. Cages were kept in an open-sided well ventilated pen. Weekly live body weight (LBW) and feed intake (FI) were recorded on a replicate group basis. Thus, body weight gain (BWG), feed conversion ratio (FCR; feed: gain), protein efficiency ratio (PER), efficiency of energy utilization (EEU) and performance index (PI) were determined weekly. PER was calculated as BWG gain (g)/crude protein consumed (g). EEU was estimated as the digestible energy (DE) consumed (kcal)/ BWG (g). PI was calculated as 100 [LBW (kg) ÷ FCR].

During the last week of the experiment, 6 digestibility trials were carried out according to the European reference method for rabbits (Perez *et al*., 1995). The proximate analysis of diets and feces was performed using the official methods of analysis (Association of Official Analytical Chemists; AOAC, 1984). Apparent digestibility of nutrients was calculated for dry matter (DM), organic matter (OM), crude protein (CP), ether extract (EE), crude fiber (CF) and nitrogen-free extract (NFE). Digestible energy (DE) of diets was also estimated using the equation adopted by Schiemann *et al*. (1972), as follows:

DE (kcal/kg)=5.28(DCP g/kg)+9.51 (DEE g/kg) + 4.20 (DCF g/kg) + 4.20 (DNFE g/kg).

At the end of the experiment (12 weeks of age), four rabbits from each treatment were randomly chosen and slaughtered after fasting for 18 hours. Just after recording individual LBW of rabbits at slaughter, they were carefully sacrificed, skinned and emptied. The individual weights of hot carcass, liver, heart, kidneys and abdominal fat were recorded. The total edible parts consisted of the carcass with head plus total giblets (*i.e.* the sum of liver, heart and kidneys) were also calculated. In addition, the length of stomach, cecum and small and large intestines were also measured.

Concurrently at slaughter, four blood samples per treatment were taken in heparinized test tubes. They were immediately centrifuged for separating blood plasma. Plasma samples were frozen at – 20°C until later analysis. The concentrations of plasma glucose (Trinder, 1969), cholesterol (Allain *et al.*, 1974), total protein (Doumas *et al.*, 1981), albumin (Doumas *et al.*, 1971) and triglycerides (Fossati and Prencipe, 1982) were determined using commercial kits. Plasma globulin concentration was calculated by subtracting level of plasma albumin from that of total protein, neglecting the fibrinogen fraction. Data were statistically processed by a multifactor analysis of variance using the Statgraphics Program (Statistical Graphics Corporation, 1991), with P≤0.05 considered to be significant.

Table 1: Formulation and chemical analysis of the experimental diets

Ingredients %	**Dietary crude fiber levels (%)**		
	12.52 (diets 1+2)	**14.51 (diets 3+4)**	**16.51 (diets 5+6)**
Yellow corn	4.00	5.75	7.50
Soy bean meal (44%)	20.00	18.75	17.50
Wheat bran	28.25	22.00	13.0
Alfalfa hay	29.50	41.75	54.75
Dicalcium phosphate	1.20	1.60	2.20
Limestone	1.00	0.60	-
Molasses	2.00	2.00	2.00
Common salt	0.50	0.50	0.50
Vit. & Min. Premix *	0.40	0.40	0.40
Barley	13.00	6.50	2.00
Methionine	0.15	0.15	0.15
Total	100.00	100.00	100.00
Calculated analysis (NRC, 1977)			
Crude protein (%)	20.50	20.54	20.54
Ether extract (%)	2.57	2.54	2.45
Crude fiber (%)	12.52	14.51	16.51
Calcium (%)	1.16	1.25	1.32
Phosphorous (%)	0.83	0.83	0.83
Lysine (%)	1.08	1.09	1.10
Methionine (%)	0.40	0.40	0.39
Methionine + Cystine (%)	0.74	0.73	0.73
Digestible energy (kcal/kg)	2662	2576	2506
Determined analysis (AOAC, 1984)			
Dry matter (%)	90.60	90.30	90.40
Organic matter (%)	81.30	80.50	80.60
Crude protein (%)	20.11	20.11	20.12
Crude fiber (%)	13.11	15.03	16.17
Ether extract (%)	2.22	2.13	2.11
Nitrogen free extract (%)	45.86	43.23	42.20
Ash (%)	9.30	9.80	9.80
Digestible energy (kcal/kg)	2883	2717	2768

Each kilogram contains: Vit A, 2000000 IU; Vit D_3, 150000 IU; Vit E, 8.33 g; Vit K, 0.33 g; Vit B_1, 1.0 g; Vit B_2, 1.09; Vit B_6, 0.33 g; Vit B_{12}, 1.7 mg; Vit B_5, 8.33 g; Pantothenic acid, 3.33 g; Niacin, 8.33 g; Biotin, 33 mg; Folic acid, 0.83 g; Choline chloride, 20 g; Zn, 11.79 g; Fe, 12.5 g; Cu, 0.5 g; Co, 1.33 mg; Se, 16.6 mg; Mg, 66.79 mg and Mn, 5 g.

Avian plus (was added to diets 2, 4 and 6) is a probiotic containing *Lactobacillus acidophilus*, 90,000,000 CFU/kg; *Bifedobacteruim longhum*, 90,000,000 CFU/kg; *Bifedobacterium thermophilum*, 90,000,000 CFU/kg; *Enteroccus faecium*, 90,000,000 CFU/kg and *Lactobacillus planetarium*, 400,000,000 CFU/kg, as declared by the manufacturer.

RESULTS AND DISCUSSION

Performance of growing rabbits:
Effect of dietary crude fiber level:

As shown in Table 2, average initial LBW of rabbits ranged between 972 and 1008 g, with no significant differences among the different experimental groups. Data also indicated that dietary crude fiber (CF) level had no significant effect on final LBW, DWG, DFI, FCR, PER, EEU or PI of rabbits fed the experimental diets from 6 to 12 weeks of age. It is interesting to note that no mortality occurred during the course of this study. Increasing dietary CF levels from 12.5 to 16.5% had no significant effect on DFI, FCR and EEU of the experimental animals; consequently, their final live body weight and body weight gain were comparable. This may imply that the range of dietary CF, tested herein, was normal for maintaining optimal growth of fattening rabbits.

This result is in accord with the findings of De Blas et *al.* (1986) who studied the effects of variable dietary levels of crude fiber and starch on growth and enteritis of fryer rabbits and found that the growth rate of rabbits was optimal in the range of 10-15% dietary CF (corresponding to 13-25% acid detergent fiber), while levels in excess of 17% depress growth by restricting energy intake. In this connection, Blas *et al.* (1994) fed early weaned crossbred rabbits two diets containing 11.6 or 15.3% CF from 28 to 49 days of age and found that live weight gain was not affected by dietary fiber level while feed intake and feed conversion were higher for rabbits fed the high-fiber diet. On the other hand, Yu and Chiou (1996) studied the effects of feeding diets having crude fiber levels of 5.5, 8.5, 11.5 and 14.5% on growth performance of four-week-old early weaned rabbits. They reported that after a 5-week feeding period, food intake and body weight gain increased with increasing dietary fiber levels while feed conversion was highest with 11.5% dietary fiber. Recently, Alvarez *et al.* (2007) evaluated three fattening rabbit diets containing different levels of dietary fiber fractions [*i.e.* neutral detergent fiber (NDF, being 29.1, 36.1 and 33.3%), acid detergent fiber (ADF, being 16.0, 18.6 and 19.4%) and soluble fiber (SF, being 9.6, 8.51 and 11.0%)] in diets 1, 2 and 3, respectively, during the fattening from 35 to 63 days of age. They found that rabbits fed diet 1 showed a 5.9% higher weight gain and 8.8% lower feed conversion than those fed diet 2, whereas animals fed diet 2 had a higher weight gain (7.6%) and a worse feed conversion (6.5%) than animals fed diet 3. They also indicated that rabbits fed the diet with the lowest level of fiber had the highest growth rate and the lowest feed conversion among the fattening diets studied. Accordingly, Alvarez *et al.* (2007) concluded that in a context of low mortality, diets with 29-30% NDF would lead to better performances in the fattening period than diets containing 33-36% NDF levels.

Table 2: Performance of growing NZW rabbits as affected by dietary fiber level and probiotic supplementation from 6 to 12 weeks of age

Treatments	Initial LBW[1]	Final LBW	DWG[2]	DFI[3]	FCR[4]	PER[5]	EEU[6]	PI[7]
Fiber level (A)	**(g)**	**(g)**	**(g)**	**(g)**	**(g:g)**	**(g:g)**	**kcal/g**	**(%)**
12.5% A1	968	2084	27	102	3.865	1.29	11.14	54.1
14.5% A2	948	2101	27	103	3.754	1.32	10.19	56.2
16.5% A3	988	2160	28	103	3.696	1.34	10.23	58.5
SEM	42.2	37.0	0.54	0.52	0.07	0.03	0.21	1.5
Significance	NS	NS	NS	NS	NS	NS	NS	NS
Probiotic (B)								
(0.0%) B1	979	2138	28	103	3.743	1.33	10.4	57.4
(0.03%) B2	957	2092	27	103	3.799	1.31	10.6	55.2
SEM	34.5	30.2	0.45	0.42	0.06	0.02	0.17	1.22
Significance	NS	NS	NS	NS	NS	NS	NS	NS
AB Interaction								
A1×B1	976	2103	27	103	3.841	1.30	11.07	54.9
A1×B2	960	2065	26	102	3.889	1.28	11.21	53.2
A2×B1	955	2119	28	102	3.721	1.34	10.11	57.2
A2×B2	942	2084	27	102	3.786	1.31	10.28	55.2
A3×B1	1008	2193	28	103	3.668	1.36	10.15	59.9
A3×B2	968	2127	27	102	3.723	1.34	10.30	57.1
SEM	59.7	52.3	0.78	0.73	0.10	0.04	0.29	2.1
Significance	NS	NS	NS	NS	NS	NS	NS	NS

1-4: Refer to live body weight, daily weight gain, daily feed intake, feed conversion ratio, protein efficiency ratio, efficiency of energy utilization and performance index, respectively. NS: Not significant.

Effect of probiotic supplementation:

Dietary supplementation with probiotic (Avian Plus) had no significant effects on criteria of growth performance of rabbits, measured in the present study, including final LBW, DWG, DFI, FCR, PER, EEU and PI during period from 6 to 12 weeks of age.

The present finding is in line with findings of Kamra *et al*. (1996) who found that feeding probiotics-supplemented diets had no significant effect on growth performance in New Zealand White rabbits under Indian hot climate environmental conditions. Similar results were also obtained by Radwan *et al.* (1996) and Ismail *et al.* (2004), who observed that live body weight and daily weight gain of New Zealand White rabbits were not affected by adding probiotics (Lacto-Sacc) to their diets. Moreover, Eiben *et al.* (2008) observed no improvement in growth performance of rabbits fed a probiotic (BioPlus 2B)-supplemented diet from 35 to 63 days of age. On the other, Amber *et al.* (2004) fed growing New Zealand White rabbits diets containing probiotic (Lact-A-Bac) and found significant improvements in final live body weight, average daily gain and performance index and feed conversion as compared to their control counterparts, while feed intake was not affected. In a later study, Trocino *et al.* (2005) reported that dietary supplementation with *Bacillus cereus* var. *toyoi* improved growth performance (in terms of final live weight, daily weight gain and feed conversion) and reduced morbidity of rabbits reared in farms with or without severe health problems. The lack of consistency in the results obtained with probiotics can be partly explained by different experimental protocols and hygienic conditions (Falcão *et al*., 2007); type or composition of the applied probiotic may also be involved. The interactions between dietary fiber level and probiotic supplementation were not significant for all growth performance criteria examined in this study.

Digestibility of nutrients of rabbits:

Effect of dietary fiber level:

As illustrated in Table 3, increasing dietary crude fiber level from 12.5% to 14.5 or 16.5% significantly decreased digestibility of DM (P≤0.05), OM (P≤0.05) and NFE (P≤0.01) but significantly improved (P≤0.01) CF digestibility for 12-week-old New Zealand White rabbits, while the digestibility of CP and EE was not affected. The improvements in CF digestibility for rabbits fed the diets containing 14.5% and 16.5% CF were estimated to be 11.64 and 13.46 percentage points higher that of the control rabbits (fed the 12.5% CF-diet). Although EE digestibility was not significantly affected by dietary CF level, rabbits fed the diets containing 14.5% and 16.5% CF exhibited slightly better means of EE digestibility compared with their controls.

Table 3: Digestibility of nutrients for 12-wk-old NZW rabbits as affected by dietary fiber level and probiotic supplementation

Treatments	DM (%)	OM (%)	CP (%)	EE (%)	CF (%)	NFE (%)
Fiber level (A)						
12.5% A1	68.03^{a}	69.17^{a}	74.67	72.61	53.51^{b}	70.74^{a}
14.5% A2	64.46^{b}	65.21^{b}	73.32	77.53	65.15^{a}	61.65^{b}
16.5% A3	65.51^{b}	66.50^{b}	74.58	76.93	66.97^{a}	62.79^{b}
SEM	0.81	0.8	0.61	1.8	1.08	1.30
Significance	*	*	NS	NS`	**	**
Probiotic (B)						
(0.0%) B1	65.18	66.24	73.28^{b}	76.06	61.14	64.36
(0.03%) B2	66.81	67.68	75.12^{a}	75.33	62.62	65.77
SEM	0.66	0.66	0.50	1.5	0.88	1.06
Significance	NS	NS	*	NS	NS	NS
AB Interaction						
A1×B1	67.41	68.67	73.91	71.8	52.87	70.38
A1×B2	68.65	69.68	75.43	73.4	54.17	71.11
A2×B1	62.54	63.45	72.02	78.61	62.05	59.98
A2×B2	66.37	66.97	74.63	76.47	68.24	63.32
A3×B1	65.59	66.6	73.9	77.77	68.49	62.73
A3×B2	65.43	66.40	75.27	76.1	85.45	62.87
SEM	1.15	1.15	0.86	2.59	1.53	1.84
Significance	NS	NS	NS	NS	NS	NS

$^{a-b}$: Means in the same column bearing different superscripts are significantly different (P≤0.05).

***: Significant at P≤0.05, **: Significant at P≤0.01, NS: Not significant**

The present results harmonize with the findings obtained by Chaudhary *et al.* (1995) who found that digestibility coefficients of DM, OM, EE and NFE were significantly better in rabbits given low-crude fiber diet (9.73% DM basis) as compared to those fed high-crude fiber diet (12.86% DM basis). Similar results were also obtained by El-Deep and Kobeisy (2000) who indicated that as the percentage of crude fiber increased in growing rabbit diets the digestibility of OM and NFE were significantly decreased. The higher CF digestibility achieved by rabbits fed the diets containing 14.5% and 16.5% CF, reported herein, is in harmony with the finding of Nagadi (2008) who found that CF digestibility was significantly increased with increasing the crude fiber level from 10.6 to 16.4 % in New Zealand White rabbit diets. In partial agreement with the current results, De Blas et *al.* (1986) reported that digestibility of DM, OM and CP were significantly decreased in response to increasing the acid detergent fiber in rabbit diets.

Effect of probiotic supplementation:

The results of present study showed that dietary supplementation with probiotic had no significant effect on the digestibility of nutrients, with the exception of a significant ($P\leq0.05$) improvement in CP digestibility compared with that of the control rabbits. In this regard, it should be noted that the potential of the added probiotic to improve nutrient digestibility in rabbit diets is disputable, with different degrees of success. Some authors failed to find any beneficial effect of adding probiotic to growing rabbit diets (*e.g.* Gippert *et al.*, 1992; Chaudhary *et* al., 1995; Ismail *et al.*, 2004; Zanato *et* al., 2008). On the other hand, Yamani *et al* (1992) indicated that rabbits fed Lacto-Sacc-supplemented diets achieved better crude fiber digestibility at 8 and 12 weeks compared with their control group. While El-Gaafary *et al.* (1992) reported higher CP and CF digestibility in rabbits fed Lacto+Sacc culture. Also, Kamra *et al.* (1996) fed rabbits diets supplemented with lactic acid producing bacteria (Lacto) or Lacto plus *Saccharomyces cerevisiae* and observed a significant improvement only in CP digestibility but the digestibility of DM, NDF, ADF, cellulose and hemicellulose were not affected. In later study, Amber *et al.* (2004), using a probiotic containing *Lactobacillus acidophilus* in rabbit diets, got improvements in the digestibility of DM, CP, CF and EE as compared to the control rabbits. The dietary crude fiber level and probiotic supplementation were not interrelated for all digestibility coefficients of nutrients determined in the present study.

Carcass traits and lengths of some alimentary tract segments of rabbits:

Effect of dietary fiber level:

As shown in Table 4, the dietary fiber level had no significant effect on either carcass traits (fasted LBW, carcass weight, total edible parts and abdominal fat) or lengths of stomach, caecum, and small and large intestines) of 12-week old New Zealand White rabbits. It interesting to note that feed intake and growth rate of rabbits in the present study were not affected by increasing dietary crude fiber level (Table 2), and thus their carcass traits were not altered. On the other hand, when dietary fiber level exceeds the recommended range for rabbits (14.0-17.5%), dressing percentage is reduced as a consequence of sub-optimal growth performance (Aboul-Ela *et al.*, 1996).

These results are in line with those reported by Soliman *et al*. (2005) who found that carcass characteristics of fattening rabbits were not significantly affected by feeding different dietary CF levels (10, 12 or 14%). Contrary to the present results, Amber and Gad (2001) found that dressing percentages were decreased while lengths of caecum and colon of rabbits were increased in response to increasing dietary fiber level to 18 or 21%. In addition, Nagadi (2008) reported that dressing percentage of rabbits were significantly higher in rabbits fed high-starch (25.8%) low crude fiber (10.6%) diet than that of rabbits fed low-starch (10.1%) high-crude fiber (16.4%) diet. It seems that fiber in rabbit diets may affect the weight and volume (or capacity) of alimentary tract segments of the animal rather than its influence on their length, as the case applied in the present study.

Table 4: Carcass traits and lengths of alimentary tract segments for growing NZW rabbits as affected by dietary fiber level and probiotic supplementation from 6 to 12 weeks of age

Treatments	Fasted LBW	Carcass weight	Total edible parts	AF[♕]	Stomach	Small intestine	caecum	Large intestine
Fiber level (A)	**(g)**	**(%)**	**(%)**	**(%)**	**(cm)**	**(cm)**	**(cm)**	**(cm)**
12.5% A1	2004	52.2	56.0	0.35	9.1	320.3	54.6	112.1
14.5% A2	2052	53.3	57.0	0.85	9.1	305.4	52.1	120.8
16.5% A3	1977	53.4	58.0	0.28	9.8	322.3	54.1	114.6
SEM[§]	58.0	0.83	0.76	0.04	0.28	7.58	1.39	5.45
Significance	NS	NS	NS	NS	NS	NS	NS	NS
Probiotic (B)								
(0.0%) B1	2084[a]	53.0	57.0	0.33	9.3	308.9	54.3	116.9
(0.03%) B2	1939[b]	52.7	57.0	0.35	8.8	323.0	53.0	114.8
SEM[§]	47.0	0.68	0.62	0.03	0.23	6.19	1.13	4.45
Significance	*	NS	NS	NS	NS	NS	NS	NS
AB Interaction								
A1×B1	2111	52.3	56.0	0.34	9.5	309.0	55.0	113.8
A1×B2	1897	52.0	56.0	0.36	8.8	331.5	54.3	110.5
A2×B1	2041	52.9	57.0	0.43	9.5	382.0	52.3	119.8
A2×B2	2062	53.6	57.0	0.36	8.8	328.0	52.0	121.8
A3×B1	2098	54.5	59.0	0.21	8.8	335.8	55.5	117.3
A3×B2	1856	52.3	57.0	0.33	8.8	308.8	52.8	112.0
SEM[§]	81.50	1.18	1.08	0.06	0.39	10.7	1.96	7.7
Significance	NS	NS	NS	NS	NS	**	NS	NS

[a-b]: Means in the same column bearing different superscripts are significantly different (P≤0.05).
§ and ♕: Refer to standard errors of the means and abdominal fat, respectively.
NS: Not significant, *: Significant at P≤0.05 and **: Significant at P≤0.01.

Effect of probiotic supplementation:

Data presented in Table 4, indicate that dietary supplementation with probiotic had no significant effect on either carcass traits (fasted LBW, carcass weight, total edible parts and abdominal fat) or lengths of stomach, caecum, and small and large intestines) of 12-week old New Zealand White rabbits. Lack of significant differences in carcass traits and alimentary tract measurements of rabbits, observed in the present study, coincides with the findings obtained by Radwan *et al.* (1996), Ayyat *et al.* (1996); Soliman *et al.* (2000) and Ismail *et al.* (2004) who found that feeding different types of Lacto-Sacc had no significant effect on carcass traits or certain caecal characteristics of the growing rabbits. Dietary crude fiber level by probiotic supplementation interaction was not significant for all carcass traits and alimentary tract measurements with the exception of length of small intestine which was significant.

Blood constituents of rabbits:

Effect of dietary fiber level:

As shown in Table 5, the dietary fiber level had no significant effect on all blood plasma constituents, examined herein, (including glucose, total cholesterol, triglycerides, total protein, albumin and globulin) of 12-week old New Zealand White rabbits. The lack of effect of dietary fiber level on growth performance and on blood biochemical parameters, measured herein, with no mortality or morbidity occurred in the experimental rabbits might be an indication for their normal health and metabolic status. The slight variations in blood plasma cholesterol and triglycerides levels between rabbits fed the low level of crude fiber (12.5% CF) and those fed the higher fiber levels (14.5 and 16.5%CF) might not be related to dietary treatments and could accidentally be occurred.

Table 5: Blood plasma constituents for 12-wk-old NZW rabbits as affected by dietary fiber level and probiotic supplementation

Treatments	**GLU[1]**	**CHO[2]**	**TRI[3]**	**TPR[4]**	**ALB[5]**	**GLO[6]**
Fiber level (A)	**mg/dL**	**mg/dL**	**mg/dL**	**g/dL**	**g/dL**	**g/dL**
12.5% A1	105.00	63.3	85.30	4.00	2.50	1.50
14.5% A2	101.80	78.10	98.60	4.20	2.90	1.30
16.5% A3	112.40	71.30	98.00	3.80	2.60	1.20
SEM[7]	6.61	15.20	10.00	0.26	0.20	0.16
Significance	NS	NS	NS	NS	NS	NS
Probiotic (B)						
(0.0%) B1	110.30	72.20	102.10	3.10	2.80	1.10
(0.03%) B2	102.40	69.60	85.80	4.00	2.50	1.50
SEM[7]	5.40	4.20	8.20	0.21	0.14	0.13
Significance	NS	NS	NS	NS	NS	NS
AB Interaction						
A1×B1	114.60	65.75	89.80	3.80	2.60	1.30
A1×B2	95.80	60.80	80.80	4.20	2.40	1.80
A2×B1	102.00	82.80	114.80	4.30	3.10	1.15
A2×B2	101.50	74.00	82.50	4.03	2.60	1.40
A3×B1	114.80	68.50	101.80	3.80	2.80	0.98
A3×B2	110.00	74.00	94.30	3.80	2.40	1.40
SEM[7]	9.40	7.30	14.10	0.36	0.24	0.23
Significance	NS	NS	NS	NS	NS	NS

[1-7:] Refer to glucose, total cholesterol, triglycerides, total protein, albumin, globulin and standard error of the means, respectively. NS: Not significant. **: Significant at P≤0.01.

In this regard, it has been reported that large variations in levels of blood cholesterol and triglycerides can occur between individual rabbits (Yu *et al.*, 1979), essentially because feed withdrawal without preventing cecotrophy before blood sampling is not enough for getting a fasting blood sample (Harcourt-Brown, 2002). In general, values of blood constituents, given in Table 5, were within the normal reference range of blood biochemistry in rabbits (Harcourt-Brown, 2002). In agreement with the present results, Champe and Maurice (1983) fed growing rabbits on isonitrogenous, equicaloric diets containing 3, 6, 9 or 12% crude fiber, from 4 to 8 weeks of age, and found that dietary fiber level did not alter blood plasma mineral profile. However, Nagadi (2008) reported that plasma total protein, glucose, cholesterol and total lipids were significantly increased in rabbits fed high-starch (25.8%) low crude fiber (10.6%) diet than that of rabbits fed low-starch (10.1%) high-crude fiber (16.4%) diet.

Effect of probiotic supplementation:

Data illustrated in Table 5, indicate that dietary supplementation with probiotic had no significant effect on blood constituents, measured herein, of 12-week old New Zealand White rabbits. In general, the present results are in good keeping with the findings of Khalil *et al.* (2002) and Ismail *et al*. (2004) and who observed no significant changes in the levels of serum (or plasma) total protein, albumin, globulin, urea, creatinine or cholesterol, or in activities of serum transaminases of rabbits fed Lacto-Sacc supplemented diets. However, Shrivastava and Jha (2010) reported that feeding probiotic-supplemented diets to growing rabbits led to higher serum levels of glucose and total protein but total cholesterol level was lower compared with their control rabbits, while levels of total lipids and activities of serum alanine aminotransferase, aspartate aminotransferase, and alkaline phosphatase were not affected. The interaction between dietary fiber level and probiotic supplementation with respect to blood plasma constituents of 12-week-old New Zealand White rabbits was not significant.

Conclusion

Based on the obtained results, it is concluded that the optimal level of dietary crude fiber for fattening rabbits to achieve maximal growth rate and best efficiency of feed utilization is 12.5%.

REFERENCES

Allain, C.A.; L.S. Poon; C.S.G. Chang; W. Richmond and P.C. Fu (1974). Enzymatic determination of total serum cholesterol. Clin. Chem., 20:470-475.

Aboul-Ela, S.; G.A. Abdel-Rahman; F.A. Ali; H.S. Khamis and H.K. Abd El-Galil (1996). Practical recommendations on minimum and maximum fiber levels in rabbit diets. In: Proceedings of the 6th World Rabbit Congress, 9-12 July, Toulouse, France. ITAVI, Paris, pp. 67-72.

Alvarez, J.L.; I Marguenda; P. García-Rebollar; R. Carabaño, C. De Blas; A. Corujo and A.I. García-Ruiz (2007). Effects of type and level of fiber on digestive physiology and performance in reproducing and growing rabbits. World Rabbit Sci., 15: 9-17.

Amber, K.H. and S.M. Gad (2001). Effect of using high level of berseem hay (*Trifolium alexandrinum*) in rabbit diets on performance, feeding values, caecotrophy, characteristics of gastrointestinal tract and relative revenue. Egypt. J. Rabbit Sci., 11(1): 23-39.

Amber, K.H.; H.M. Yakout and Rawya S. Hamed (2004). Effect of feeding diets containing yucca extract or probiotic on growth, digestibility, nitrogen balance and caecal microbial activity of growing New Zealand White rabbits. In Proc. of the 8th World Rabbit Congress, Puebla, México, pp. 737-741.

AOAC; Association of Official Analytical Chemists (1984). Official Methods Of Analysis, 14th edition, Washington, USA.

Ayyat, M.S.; I.F.M. Marai and T.A. El-Aasar (1996). New Zealand White rabbit does and their growing offsprings as affected by diets containing different protein levels with or without Lacto-Sacc supplementation. World Rabbit Sci., 4(4): 225-230.

Blas, E.; C.Cervera and J. Fernandez-Carmona (1994). Effect of two diets with varied starch and fiber levels on the performance of 4-7 weeks old rabbits. World Rabbit Sci., 2(4): 117-121.

Champe, K.A. and D.V. Maurice (1983). Response of early weaned rabbits to source and level of dietary fiber. J. Anim. Sci., 56: 1105-1114.

Chaudhary, L.C.; R. Singh; D.N. Kamra and N.N. Pathak (1995). Effect of oral administration of yeast (*Saccharomyces cerevisiae*) on digestibility and growth performance of rabbits fed diets of different fiber content. World Rabbit Sci., 3(1): 15-18.

Cheeke, P.R. (1987). Rabbit Feeding and Nutrition, 1st ed. Academic Press, INC., London, UK.

De Blas, J.C.; J. Garcia and R. Carabano (1999). Role of fiber in rabbit diets: A review. Ann. Zootech. (Paris) 48:3–13.

De Blas, J.C. and G.G. Mateos (1998). Feed formulation, pp. 241–253. In: The Nutrition of the Rabbit, edited by De Blas, J.C. and J. Wiseman. Commonwealth Agricultural Bureaux, CABI Publishing, Wallingford, U.K.

De Blas, J.C. and G.G. Mateos (2010). Feed formulation, pp. 222–232. In: Nutrition of the Rabbit, 2nd ed., edited by De Blas, J.C. and J. Wiseman, CABI Publishing, Wallingford, U.K.

De Blas, J.C.; G. Stantoma; R. Carabano and M.J. Fraga (1986). Fiber and starch levels in fattening rabbit diets. J. Anim. Sci., 63: 1897-1904. B

Doumas, B.T.; D.D. Bayse; R.J. Carter; T. Peters and R. Schaffer (1981). A candidate reference method for determination of total protein in serum. 1. Development and validation. Clin. Chem., 27(10): 1642-1650. T.'

Doumas, B.T.; W.A. Watson and H.G. Biggs (1971). Albumin standards and the measurement of serum albumin with bromocresol green. Clin. Chim. Acta , 31: 87-96.

Eiben, Cs.; T. Gippert; K. Gódor-Surmann and K. Kustos (2008). Feed additives as they affect the fattening performance of rabbits. In: Proc. of the 9th World Rabbit Congress, June 10-13, 2008,Verona, Italy

El-Deeb, M.A and M.A. Kobeisy (2000). Nutrients digestibility, function and development of gastrointestinal tract in rabbits fed different levels of crude fiber. In: Proc. of the 11th Conf. Egyptian Soc. Anim. Prod., Alexandria, Egypt, 6-9 November, PP. 527-534.

EL-Gaafary, M.N.; A.A. Rashwan, D.M.A. El-Kerdawy, and K.A. Yamani (1992). Effect of feeding pelleted diet supplemented with probiotic (Lacto-Sacc) on digestibility, growth performance, blood constituents, semen characters and reproductive traits of rabbits. Egyptian J. Rabbit Sci., 2(2): 95-105.

El-Hindawy M.M.; K.O.Yamani and M.I. Tawfeek (1993). Effect of probiotic (Lacto-Sacc) in diets with different protein levels on growth performance, digestibility and some carcass aspects of growing rabbits. Egypt. J. Rabbit Sci., 3(1): 13-28.

Falcão-e-Cunha, L.; L. Castro-Solla; L. Maertens; M. Marounek; V. Pinheiro; J. Freire and J.L. Mourão (2007). Alternatives to antibiotic growth promoters in rabbit feeding: A review. World Rabbit Sci., 15: 127–140.

Fossati, P. and L. Prencipe (1982). Serum triglycerides determined colorimetrically with an enzyme that produces hydrogen peroxide. Clin. Chem., 28: 2077-2080.

Garcia, J.; R. Carabano and J.C. De Blas (1999). Effect of fiber source on cell wall digestibility and rate of passage of rabbits. J. Anim. Sci., 77: 898–905.

Gidenne, T. (2003). Fiber in rabbit feeding for digestive troubles prevention: respective role of low-digested and digestible fiber. Livest. Prod. Sci., 81: 105-117.

Gidenne, T.; R. Carabano; J. Garcia and C. De Blas (1998). Fiber digestion, pp. 69-88. In: The Nutrition of the Rabbit, edited by De Blas, J.C. and J. Wiseman. Commonwealth Agricultural Bureaux, CABI Publishing, Wallingford, U.K.

Gidenne, T.; R. Carabano; J. Garcia and C. De Blas (2010). Fiber digestion, pp. 66-82. In: Nutrition of the Rabbit, 2nd ed., edited by De Blas, J.C. and J. Wiseman, CABI Publishing, Wallingford, U.K.

Gidenne, T. and J. Garcia (2006). Nutritional strategies improving the digestive health of the weaned rabbit. pp. 229-238. In: Recent Advances in Rabbit Sciences, edited by Maertens, L. and P. Coudert, Published by Institute for Agricultural and Fisheries Research, ILVO, Melle, Belgium.

Gippert, T.; G. Virag and I. Nagy (1992.). Lacto-Sacc in rabbit nutrition. J. Appl. Rabbit Res., 15: 1101-1104.

Harcourt-Brown, F. (2002). Clinical pathology, pp. 140-166. In: Textbook of Rabbit Medicine, published by Butterworth–Heinemann, UK.

Ismail, F.S.A.; M.H. Rabie and A.E. Abdel-Khalek (2004). Effects of some sources of yeast cultures as feed additives on growth performance of New Zealand White rabbits. Egypt. J. Rabbit Sci., 14(2): 101-116.

Kamra, N.D.; L.C. Chaudhary; R. Singh and N.N. Pathak (1996). Influence of feeding probiotics on growth performance and nutrient digestibility in rabbits. World Rabbit Sci., 4(2): 85-88.

Maertens, L. (2009). Possibilities to reduce the feed conversion in rabbit production. In: Proc. of the Giornate di Coniglicoltura ASIC, Forli, Italy, pp. 1-10.

Mateos, G.G.; P.G. Rebollar and C. De Blas (2010). Minerals, vitamins and additives. pp. 119-150. In: Nutrition of the Rabbit, 2nd ed., edited by De Blas, J.C. and J. Wiseman, CABI Publishing, Wallingford, U.K.

Nagadi, S.A. (2008). Effect of dietary starch and fiber levels on performance of weanling New Zealand White rabbits. Egypt. Poultry Sci., 28(IV): 1083-1096.

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

Perez, J.M.; F. Lebas; T. Gidenne; L. Maertens; G. Xiccato; R. Parigi-Bini; A. Dalle Zotte; M.E. Cossu; A. Carazzolo; M.J. Villamide; R. Carabano; M.J. Fraga; M.A. Ramos; C. Cervera; E. Blas; J. Fernandez; L. Falcao-e-Cunha and J. Bengala Freire (1995). European reference method for *in vivo* determination of diet digestibility in rabbits. World Rabbit Sci., 3(1): 41-43.

Schiemann, R.N.; L. Hoffmann; W. Jestsch and A. Chundy (1972). Energetische Futterbewertung und Energianormen. VEB Deuoscher Landwirscha Fsverlags, Berlin, P. 72.

Shrivastava, A.K. and R.R. Jha (2010). Effect of different chemical composition and probiotic on the haematobiochemical profile of rabbit. EJEAFChe, 9 (9): 1507-1513.

Simon, O.; V. Vilfried and L. Scharek (2003). Micro-organisms as feed additives-probiotics. In Proc. of the 9th International Symposium on Digestive Physiology in Pigs, Banff, AB, Canada, pp. 295-318.

Soliman, A.Z.; Selim, A.D. and A.M. Abdel-Khalek (2005). Effect of dietary crude fiber levels and supplemental lipid sources on performance of heat stressed rabbits. In: Proc. of the 4th International Conference on Rabbit Production in Hot Climate, Sharm El-Sheikh, Egypt, 24-27 February, pp. 325- 333.

Sonbol, S.M. and K.M. El-Gendy (1992). Effect of dietary probiotics on performance of weaning New Zealand White rabbits. Egypt. J. Rabbit Sci., 2(2): 135-144.

Statistical Graphics Corporation (1991). Statgraphics Program, Version 5.0 Reference Manual. Rockville, M.D.: Statistical Graphics Corporation.

Trinder, P. (1969). Determination of glucose in blood using glucose oxidase with an alternative oxygen acceptor. Annals of Clinical Biochemistry, 6:24-27.

Trocino, A.; G. Xiccato; L. Carraro and G. Jimenez (2005). Effect of diet supplementation with Toyocerin® (*Bacillus cereus* var. *toyoi*) on performance and health of growing rabbits. World Rabbit Sci., 13: 17-28.

Xiccato, J. and A. Trocino (2010). Feed and energy intake in rabbits and consequences on farm global efficiency. In: Proceedings of the 6th International Conference on Rabbit Production in Hot Climate, Assiut, Egypt, pp. 1-18.

Yamani, K.A.; H. Ibrahim; A.A. Rashwan and K.M. El-Gendy (1992). Effects of a pelleted diet supplemented with probiotic (Lacto-Sacc) and water supplemented with a combination of probiotic and acidifier (Acid-Pak 4Way) on digestibility, growth, carcass and physiological aspects of weanling New Zealand White rabbits. J. Appl. Rabbit Res., 15: 1087-1100.

Yu, B. and P.W.S. Chiou (1996). Effects of crude fiber level in the diet on the intestinal morphology of growing rabbits. Laboratory Animals, 30: 143-148.

Yu, L.; D.A Pragay; D. Chang and L. Whicher (1979). Biochemical values of normal rabbit serum. Clin. Biochem., 12: 83–87.

Zanato, J.A.F.; J.F. Lui; M.C. Oliveira; A.C. Neto; O.M. Junqueira; E.B. Malheiros and C. Scapinello (2008). Digestibility of diets containing an antibiotic, a probiotic and a prebiotic in growing rabbits. Revista Biotemas, 21 (4): 131-136.

تأثير مستوي الألياف الخام فى الغذاء وإضافة المنشطات الحيوية علي الأداء الانتاجي للأرانب فى مرحلة ما بعد الفطام

محمود حسن ربيع *، خليل الشحات شريف *، مجدي أحمد عوض حسين ** و عزة رفعت فوزي الدسوقي**

*** قسم أنتاج الدواجن - كلية الزراعة - جامعة المنصورة**

**** معهد بحوث الانتاج الحيواني بالقاهرة**

أجريت تجربة عاملية (3×2) لمعرفة تأثير التغذية علي علائق تحتوي علي ثلاثة مستويات من الألياف (12.5، 14.5، 16.5%) مع منشط حيوي (Avian Plus) بمستويان (صفر أو 0.03%) علي الأداء الانتاجي ومعاملات هضم العناصر الغذائية ومواصفات الذبيحة ومكونات الدم لأرانب النيوزيلاندي الأبيض النامية. تم توزيع عدد 72 أرنباً عمر 6 أسابيع إلي 6 معاملات تجريبية في أربعة مكررات متساوية في بطاريات موضوعة في عنبر مفتوح. تم تربية كل المجاميع التجريبية تحت نفس الظروف الصحية والرعاية. تم تكوين 6 علائق تجريبية للتغذية عليها خلال الفترة التجريبية (من 6 وحتي 12 أسبوعاً من العمر). تم تقييم الأداء الانتاجي للأرانب بأخذ قياسات عن وزن الجسم والزيادة اليومية في الوزن واستهلاك العلف اليومي ونسبة التحويل الغذائي وكفاءة استخدام البروتين والطاقة ودليل الأداء الإنتاجي. كما تم أخذ قياسات عن معاملات هضم العناصر الغذائية (المادة الجافة والمادة العضوية والبروتين الخام والمستخلص الإثيري والألياف الخام والمستخلص الخالي من الآزوت) وبعض صفات الذبيحة (وتشمل الأوزان النسبية لكل من الذبيحة والأجزاء الكلية المأكولة) وكذلك أطوال بعض أعضاء القناة الهضمية (المعدة والأعور والأمعاء الدقيقة والغليظة) وبعض مكونات بلازما الدم (الجلوكوز والكولستيرول والجلسريدات الثلاثية والبروتين الكلي والألبيومين والجلوبيولين).

ويمكن تلخيص النتائج المتحصل عليها فيما يلى : لم يكن هناك تأثير معنوى لمستوى الألياف الخام فى الغذاء أو إضافة المنشط الحيوى على أداء النمو، صفات الذبيحة ، وأطوال الأجزاء المختلفة للقناة الهضمية أو مكونات الدم. نتج عن زيادة مستوى الألياف الخام فى الغذاء من 12.5% الى 14.5% او 16.5 % انخفاض معاملات هضم المادة الجافة والمادة العضوية والمستخلص الخالى من الأزوت بينما حدث تحسناً معنوياً فى معامل هضم الألياف الخام ولم يتأثر معنوياً معامل هضم البروتين الخام والمستخلص الإثيرى. لم يكن لإضافة المنشط الحيوى إلى الغذاء تأثير معنوى على معاملات هضم العناصر الغذائية، بإستثناء حدوث تحسن معنوى فى معامل هضم البروتين الخام بالمقارنة بالمجموعة التى غذيت على العليقة غير المدعمة بالمنشط الحيوي. لم يكن للتفاعل بين مستوى الألياف الخام فى الغذاء وإضافة المنشط الحيوى تأثير معنوى على كل الصفات المدروسة. بناءً على النتائج التحصل عليها يمكن استنتاج أن المستوى الأمثل من الألياف فى علائق الأرانب النامية من أجل تحقيق أقصى معدل نمو وأفضل كفاءة للإستفادة من الغذاء هو 12.5%.

قام بتحكيم البحث

أ.د / فوزي صديق عبد الفتاح إسماعيل	**كلية الزراعة – جامعة المنصورة**
أ.د / تاج الدين حسن تاج الدين	**كلية زراعة دمياط – جامعة المنصورة**