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Growth Performance and Economic Efficiency of Growing New Zealand White Rabbits Fed Different Levels of Crud Fiber by Using Corn Cob With and Without Enzyme Supplementation

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ABSTRACT

A total of fifty weanling New Zealand White (NZW) rabbits that were five weeks old (800 g live weight on average) were randomly allocated into five groups of 10 rabbits each and were housed in individual cages. The groups were control (12% CF and 30.08 NDF), (14% CF without enzymes and 30.69 NDF), (14% CF with enzymes and 30.69 NDF), (16% CF without enzymes and 31.76 NDF), (16% CF with enzymes and 31.76 NDF) for groups 1, 2, 3, 4, and 5, respectively. All groups received pelleted diets ad libitum for 6 weeks. Daily feed intake was recorded and total feces were collected daily and weighed individually during four days for digestibility trial. Daily weight gain (WG), live body weight (BW), feed intake and feed conversion ratio (FCR) were evaluated. Apparent digestibility of nutrients [crude protein (CP), Dry matter (DM), ash], carcass traits, and some blood serum constituents (glucose, total protein, albumin, AST, and ALT) were determined. Also, the economic efficacy of this study was determined. The results showed significant reduction ($P<0.05$) in FBW and WG in G3 (14% CF with enzyme supplementation) compared with other treatment groups. No significant differences in feed conversion ratio (FCR) were detected among treatment groups. Also, there were no significant differences in dressed carcasses, and relative weight % of spleen and kidney. However, there was a significant difference in liver percentage. The longest cecum length (50.50 and 50.00 cm) and lowest pH (6.23 and 6.04) were recorded with rabbits in G4 and G5, respectively. However, significant increases in apparent nutrients digestibility (CP, DM, Ash) were found in G4 and G5. No significant differences were detected in serum liver enzymes (AST & ALT) between treatment groups. However, there was a significant increase in total serum protein and decrease in serum glucose in G2, G4 and G5 compared to the control group. For economic production, the study revealed that the growing rabbits fed diets containing 16% CF (G4) gave the best economic value whereas the lowest efficiency was for group 3 (14% CF plus enzymes supplementation).

1. INTRODUCTION

The broad extension of rabbit production to provide meat is mainly attributed to a rapid growth rate, high prolificacy, short reproductive cycle, ability to thrive on high fibrous ingredients and adaptability to farm conditions (Hernandez and Dalle Zotte, 2010). In addition, Hermida *et al.* (2006) postulated that rabbit meat is considered to be one of the healthiest meats because of its easy digestibility and excellent dietetic properties, e. g. high protein (20–21%) and unsaturated fatty acids (oleic and linoleic acid; 60% of all fatty acids), potassium, phosphorus and magnesium concentrations and also low fat, cholesterol and sodium contents. However, the rabbit meat is expensive because of high cost of ration that represents about 60-70 % of the total productive cost. Obtaining least cost diets that fully match animal requirements is the challenge for the feed formulation (Maertens *et al*., 2002). The use of untraditional cheaper feed ingredients or improving utilization feeds by using some feed additives could achieve minimizing the feed cost. In the recent years, some studies have been designed to utilize in rabbit feeding some agricultural and agro-industrial by products, especially as alternatives to clover hay, that represents about 30-40% of pelleted diets of rabbits (Hayam, *et al* 2014). The increasingly prices for diets owed to that the available amount of clover hay is usually in sufficient for animal feeding. Rabbit is usually fed with diets containing at least 40% to 50% of fibers.

The role of dietary fiber in rabbit nutrition is not limited to nutrient supply. It is required to optimize cecal fermentation and achieve a high rate of passage of feed through the gut, although an excess of dietary fiber limits growth performance and energy intake (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). Earlier, 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 feed efficiency and performance, in association with an improvement of mucosal structure. The dietary crude fiber requirement recommended by the National Research Council (NRC, 1977) for normal growth of rabbits is 1012%. De Blas *et al*. (1986) concluded that a minimum of 10% dietary crude fiber is necessary for achieving high 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%.

There is a wide gap between the available feedstuffs and farm animal requirements. Part of these needs can be covered by agricultural residues which include cereals crops, leguminous hays, cotton field's residues, vegetable crops residues and waste products of pruning trees. The primary factors limiting the utilization of crop residues are their low digestibility, low protein content and low palatability. The low digestibility is attributed to high cellulose content (30-40%), hemicellulose (25-35%) (Theander and Aman, 1984**)**. Corn cobs are a by-product obtained during the production of corn grains and Abo-Khashaba (1999) demonstrated that it contains high CF fractionation (cellulose, hemicelluloses, NDF, ADF, and ADL), NFE and digestible energy (DE) for (35.46, 43.14, 83.79, 40.65, 5.19%), 55.09 % and 2402 Kcal/Kg, respectively. Mahrous *et al.* (2005) found that CF and CP of corn cobs were 40 and 4.2 %, respectively.

It has been reported that dietary enzyme supplementation is used widely in mono-gastric diets in attempts to improve health and nutrient utilization. Also, it is used to improve product quality, reduce pollution and increase the choice and content of ingredients which are acceptable for inclusion in diets (Acamovic, 2001). Enzyme cocktails containing more than one enzyme will often improve the response compared to pure, single enzymes, assuming that cost considerations are not ignored. Several studies have been attempted to improve nutrient availability through incorporating exogenous enzymes into rabbit diets. However, rabbits appeared less responsive in most trials and variable effects were observed on their performances (Garcia *et al*., 2005; Falcao-e-Cunha *et al*., 2007).

This study was designed to determine the growth performance, nutrient digestibility and economic benefits of feeding different dietary levels of crude fiber (CF) by using corn cob meal in the diets of growing rabbits

2. MATERIALS AND METHODS

2.1. Experimental design

Fifty unsexed weanling NZW rabbits of 5 weeks old with average initial weight 800g were individually housed and assigned at random to 5 groups of 10 rabbits each (5 groups x 5 treatments x 2 replicates = 50 rabbits). A total of 10 fabricated wired rabbit hutches (each of dimension 200 cm × 80 cm × 80 cm (LWH) were used in all for the study. Each hutch was partitioned into 5 equal cage units. A total of 3 hutches were assigned to a treatment. Five diets were formulated to contain different levels of crude fiber, control one (12% CF) and other groups fed 14% or 16% CF either supplement with or without enzyme (500 g of amultienzyme complex "Enziver" per ton of diet, containing 40 g cellulase, 40g xylunase, 2g pectinase, 15g amylase, 40g glucanase, 8g protease, 4g phytase). Corn cobs which used in this study to replace alfalfa hay was purchased from local market, sun-dried and ground in a heavy-duty high rotation hummer mill to obtain a suitable powder for feed industrialization. Feed and water were offered ad libitum throughout the experimental period from 5 to 11 weeks of age. All experimental diets were formulated to meet all the essential nutrient requirements of growing rabbits (NRC**,** 1977). The rabbits were weighed individually every week and the live body weight change was taken, body weight gain (expressed in grams) was calculated by subtracting the initial live body weights from final weight of each feeding period. The diets were provided regularly two times every day at 8 o'clock a.m. and 4 o'clock p.m. daily and the daily feed intake was calculated. The feed to gain ratio (FCR) were also computed by dividing the amount of feed consumed/ rabbit by the corresponding weight gain**.**

2.2. Digestibility trial

At the end of the experimental period, a digestibility trial was carried out for 5 days to determine the digestion coefficients of nutrients. The total excreted feces during the collection period were pooled, well mixed, weighed and sampled for analysis. The chemical analysis of feeds and feces was carried out according to AOAC (1990). Apparent digestibility nutrients were calculated for dry matter (DM), crude protein (CP), and ash.

2.3. Carcass evaluation and organs weight

At the end of the experimental period at 11 weeks of age, a total of 20 rabbits (four rabbits from each group) were randomly taken for slaughter. Rabbits were fasted for 16 hours before slaughtering and were individually weighed as pre-slaughter weight. Animals were slaughtered by cutting the jugular veins of the neck. Skinning of rabbits was carried out as soon as possible after complete bleeding, and then the carcass was opened down and all entrails were removed and the empty carcass, liver, kidneys and spleen were separately weighed. Each of them was proportioned to the live pre-slaughter weight. Dressing percentage was calculated according to Steven *et al.,* (1981). The ceci were weighed with their content and then the content of ceci were removed and their empty weights were taken. The cecal chyme was collected individually from the rabbits of each group and filtrated to estimate the pH of the ceci by using a PH meter. Finally, the ceci lengths were calculated.

2.4. Serum metabolites

During slaughter, four blood samples per treatment were taken in test tubes. They were immediately centrifuged to separate blood serum. The serum samples were frozen at – 20◦ C until later analysis. The blood serum were assigned for determination of glucose (Burtis *et al*, 1999), total protein (Cannon *et al*, 1974), albumin (Young, 2001), and liver function (AST and ALT) (Young, 1990) by commercial kits.

2.5. Economic evaluation parameters

2.5.1. Reduction % in the feed costs

Reduction percent depend on the cost of manufactured diet per ton for each group which depends on the prices of ingredients in each diet. Also, reduction percent depend on the cost of feed consumed during the experiment period which depends on the amount of feed intake of each group. The reduction percentages of the experimental groups were compared to the percentages of the control group (Shewita, 2004).

2.5.2. Increase % in returns

Increase percent in return from weight gain of each experimental group was compared to that of the control. The return of weight gain of each group depends on the total weight gain during the experiment period which depends on the feed conversion ratio of each group (Shewita, 2004 and El -Tahawy, 2004).

2.5.3. Regression functions

The production and return functions were tried to assess the effect of change in the feed on total body weight and returns to compare between groups. It was done by using SPSSPC+ in the (Forward, Backward, Mixer, Enter, and Stepwise methods).Simple regressions were carried out in the forms of logarithmic (Lg) forms according to Sankhayan (1983).

2.5.4. Economic efficiency

The economic efficiency was calculated for the five different experimental diets as the ratio between return from total weight gain and total cost of feed consumed during the experiment period (Abdella *et al*., 1988 and Atallah *et al.*, 199). According to the price of ingredients in the market at the time of the experiment and priceof rabbit meat the cost of each kg of each experimental diets and returns from weight gains were calculated. Economic efficiency was calculated from the following equation:

$$\text{Economic efficiency \%} = \frac{\text{net return (EGP)}}{\text{total feed cost (EGP)}} \times 100$$

Where:

Net revenue = return of weight gain (EGP) - total feed cost (EGP).

Return of weight gain (EGP) = total weight gain × price/ kg live body weight (EGP).
Total feed cost (EGP) = total feed intake (kg/ head) × price/ kg feed (EGP).

2.6. Statistical Analysis

Statistical analysis was performed using the software SPSS 20 (SPSS Inc, Chicago, Illinois).to test the effect of dietary fiber of different levels on growth performance and economic efficiency of early weaned rabbit. To compare data obtained one-way ANOVA and Duncan's multiple comparisons of the means were used. Data were expressed as means standard errors. Differences between treatments were considered significant when P<0.05.

3. RESULTS AND DISCUSSION

The nutrient profile of corn cob which used to replace alfalfa hay in this study is reported in table 1. Digestible energy (kcal/kg), CP%, fat%, crude fiber%, ash%, and carbohydrates% constituted 1795, 5.7, 1.50, 47, 1.5 and 35.79, respectively.

3.1. Growth performance

The growth performance of NZW rabbits fed different dietary treatment of crude fiber using sun dried corn cob as a substitute of alfalfa hay is presented in table 3. The data revealed that the final body weight (FBW) and weight gain (WG) of growing rabbits in G3 recorded the lowest FBW and WG among the treatment groups (2160 g and 1356.7 g, respectively). However, there were no significant differences in feed conversion ratio (FCR), FBW, WG between NZW rabbits fed control group and G2 and G4&. This result is similar to A study by El-Sayaad (1997) who found that rabbits fed on sun dried corn plant as a substitute for clover hay grew as much as rabbits in the control group. Also, Alvarez *et al.* (2007) concluded that diets with 29-30% NDF (nutrient detergent fiber) would lead to better performances in the fattening period than diets containing 33-36% NDF level. In addition, Margüenda *et al.* (2012) showed that the average body weights of rabbits fed high fiber beet pulp, high fiber straw and low fiber straw were 2.13, 2.10 and 2.11 kg/rabbit, respectively. Similarly, 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 and feed conversion were higher for rabbits fed the high-fiber diet. However, Battaa *et al.* (2013) studied the effect of including corn cob as a source of CF and ADF (acid detergent fiber) and found that rabbits fed diets contained high CF, NDF and ADF consumed significantly (P<0.05) less feed than those fed the control diet and had the best feed conversion. Also, Ramadan *et al.*, (2009) found that feeding growing rabbits on 16% crude fiber level led to improv body weight gain when compared with the other crude fiber levels (12, 14 and 18%). Also, 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 found that after a 5-week feeding period, feed intake and body weight gain increased with increasing dietary fiber levels while feed conversion was highest with 11.5% dietary fiber.

The interaction between corn cob and enzyme supplementation in this study revealed that inclusion of corn cob at 17% of diet to increase CF 16% with alfalfa hay without enzyme supplementation (G4) had good results of apparent digestibility and numerically higher in FBW than other treatment groups was in G4. On contrary, Abaza and Omara (2011) studied the effect of supplementation of a cocktail enzyme with different levels of corn cob (0, 10, 20%). They found that rabbits fed the control and corn cobs diets both with enzymes showed significant increases in body weight, body weight gain and relative growth rate. While, rabbits fed diet containing 20% corn cobs without enzymes showed the significant (P< 0.05) decreases in final body weight, daily body gain.

3.2. Carcass traits and organs evaluation

The results of carcass traits are presented in Table (4). The dressed carcass of rabbits fed different dietary CF were 1187.5, 1298, 1292, 1290, 1222 for G1, G2, G3, G4.G5, respectively and are equal but were numerically higher in groups G2, G3, and G4. Pre-slaughter weight is considered to be one of the most important factors affecting carcass traits in rabbits. The proportion of the kidney and spleen in this study showed no significant difference among treatment groups. These results are in agreement with the result of Defang *et al*. (2011) who found no significant differences between carcass traits of growing rabbits fed different levels of CF (8, 13,21% CF). Also, Soliman *et al*. (2005) found that carcass characteristics of fattening rabbits were not significantly affected by feeding different dietary CF levels (10, 12 or 14%). In addition, Ramadan *et al.* (2009) reported insignificant variation between different dietary CF for dressed weight percentage. Similarly**,** Abaza and Omara (2011) observed that there were no significant differences in carcass and dressing percentages when feeding the growing (NZW) rabbits different levels of corn cobs (0, 10, 20%). Also, they found the interaction between corn cobs levels and enzymes addition had no significant effect on carcass and dressing percentage. On the contrary, Nagadi (2008) found that dressing percentages of rabbits were significantly higher in rabbits fed high-starch (25.8%) and low crude fiber (10.6%) diet than that of rabbits fed low-starch (10.1%) and high-crude fiber (16.4%) diet. However, There was a significant decrease in relative liver % with increasing the dietary level of CF (G4 & G5). Partially with these results**,** Abaza and Omara (2011) observed that the highest significant (P< 0.05) values of giblets were observed with rabbits fed the control diet followed by those fed the diet containing 10% corn cobs and rabbits fed 20 % corn cobs. Also, the rabbits fed diet containing 20% corn cobs without enzymes recorded the lowest value of giblets percentages. On the contrary, Battaa *et al*. (2013) found that rabbits received 18% CF had the heaviest liver, relative to carcass weights than other rabbits fed dietary treatments. However, Ramadan *et al*. (2009) found no significant differences between giblets weight percentages (liver, kidney and heart) and abdominal fat % among rabbit groups fed different dietary CF.

Cecum length, cecum weight and cecum pH are shown in Table (4). The longest cecum length was recorded with rabbits fed 16 % CF (31.75% NDF) with and without enzyme supplementation followed by those fed 14 % CF(30.69% NDF). This result is consistent with the result obtained by Batta *et al.* (2013) who found that there was significant increase of cecum length with increasing dietary CF of growing rabbits. Also, El-Kerdawy *et al*. (1992) found that the alimentary tract percentage of rabbits was increased with the high fiber diet.

There was linear decrease of cecum pH in groups fed 14 or 16 % CF with and without enzyme supplementation Table (4). Abo Egla *et al*. (2013) reported that caecum pH value is one of the most important factors which affect bacterial fermentation in the caecum. Caecum pH value depends on many factors one of which is the amount and composition of the diet. Fluctuations in pH value reflect the changes of organic acids quantity accumulated in the ingesta. However, it remains relatively constant, because produced acids are removed by absorption across the caecum wall. Omara (2005) found that pH values in the caecum of NZW rabbits averaged 5.75 and 6.15 and they were significantly decreased in groups fed diets containing peanut vines instead of 50-100% clover hay. Similarly, Ying Chang *et al.* (2007) and Ramadan *et al.,* (2009**)** reported that the highest acidity was recorded for rabbits fed diets containing 16% crude fiber. However, Some researchers found that cecal pH increased slightly with increase in dietary NDF (Bellier and Gidenne, 1996**).**

3.3. Apparent nutrient digestibility

The results of apparent nutrient digestibility as shown in Table (5) revealed significant differences (P<0.05) in all measured nutrients (DM, CP, and Ash). Digestibility of nutrients increased with increased CF%, except in G3 (14% CF plus enzyme supplementation**).** Apparent digestibility of nutrients in G4 and G5 were significantly (< 0.05) higher than other treatment groups. There was a decrease of nutrients digestibility in G3 coupled with reduction in FBW and BWG of this group. With the same concept, Ramadan *et al*. (2009) reported that there was a slight increase for digestibility and nutritive value when rabbits were fed a diet containing 16 or 18% CF compared to the other treatments. Also, Batta *et al* (2013) found that there was an improvement in digestibility of DM and CP in the three groups fed high CF (16, 18 and 20% CF) and corn cob as a source of crude fiber. These authors attributed this improvement to the role of CF in reduction of the passage rate of digesta, therefore, gastric juice seems to be more effective. Also, Ramadan *et al*., (2009) reported that there was a slight increase in digestibility and nutritive value when rabbits were fed diet containing 16 or 18% CF compared to the other treatments except in the CF digestibility. However, Rabie *et al* (2011) found a significant decrease of DM digestibility with increasing dietary crude fiber level from 12.5% to 14.5 or 16.5% in NZW rabbits, where the digestibility of CF was not affected.

3.4. Serum metabolites

As shown in table (6), the different dietary levels of CF had no significant effect on serum liver enzymes (ASL and ALT) constitutes and serum albumin. On the other hand, the serum glucose was decreased with increasing the crude fiber with or without enzyme compared to control groups. Also, Battaa *et al.* (2013) found no significant differences in values of liver enzymes among treatment groups that received different levels of CF (12, 14, 16, 18, 20%) when using corn cob as a source of CF. There was a significant increase in serum total protein (p< 0.05) in

G4 and G5 compared to other treatment groups. The increase of total serum protein may be associated with improvement of crude protein digestibility as shown in Table (5). Similarly, Battaa *et al.* (2013) found an increase in total serum protein and albumin in blood rabbits received high CF. El-Harairy *et al.* (2003) postulated that increasing the plasma total protein and their fractions (Albumin and Globulin) within the normal range may reflect an increase in the hepatic function. Our results are partially in agreement with the results of Rabie *et al.* (2011). However, Nagadi (2008) reported that plasma total protein, glucose, cholesterol and total lipids were significantly increase in rabbits fed high-starch (25.8%) and low crude fiber (10.6%) diet than that of rabbits fed low starch (10.1%) and high-crude fiber (16.4%) diet.

The interaction between corn cob and enzymes in this study revealed that there were no significant differences between serum albumin between all treatment groups. Also, Abaza and Omara (2011) found that the differences between rabbits fed all levels of corn cobs with or without enzymes and the control diet in serum albumin levels were not significant. In contrast to our results , those author found that the addition of enzymes in diets containing corn cobs significantly improved the liver functions.

3.5. Economic efficiency

According to economical evaluation and analysis, production and return functions are presented in tables (3&8.) Table (7) shows reduction % in cost of manufactured diet / ton, reduction in cost of total feed consumed for each group, increase % in return for each group and economic efficiency.

The results of return functions showed that the change in FI (feed intake) by about 1% causes change in return by about 1.12 % in control group (G1) and by about 1.09% in G2. Meanwhile, the change in FI by 1% causes change in return by about 1.06% and by about 1.22% and 1.14 % in group 3, 4 and group 5, respectively. These results indicate that the effect of diet in G4 is the highest on return among the other treatment groups as the change in FI G5 then control group, 2nd group and lastly 3rd group. Also, the production functions indicate that the effect of diet in G4 is the highest numeric on body weight among the different treatment groups as the change in FI by 1% causes change in body weight by about 1.21 % followed by 1.15% in group 5, 1.11%, 1.07% , 1.04% in control, 2nd and 3rd group, respectively.

Dietary treatments in treated groups with different levels of crude fiber resulted in a positive effect of increasing total return and net revenue when compared to the control group. The highest increasing % in return present in group 4 by about 3.45% more than control group followed by group 5 by 0.85% then group 2 and group 3were lower than control by 3.66% and 6.33%, respectively. This may be owed to the difference in the total weight gain among the treated groups which also depend on FCR. Rabbits fed on diets of high levels of crude fiber specially G4 (16% crude fiber) utilized feed more efficiently than other treated groups and the commercial diet. These results are in agreement with Brown (1994) who mentioned that increasing the level of crude fiber in rabbit will improve the cecal digestion which result in improving the FE (feed efficiency).

The highest reduction% in costs of manufactured diet is present in G4 by 2.77% which lower than control group followed by G2 at 1.73% then 0.96% for G5. However, in G3 the cost of manufacture diet increased by 0.76% (Table 7). This may be attributed to the ingredients used each diet which differ in prices specially the price of corn cob that is used in treated groups and not used in commercial diets. Meanwhile, the highest reduction% in costs of consumed feed during the experiment period present in G4 by 11% lower than control group then 4.66% for G2 followed by 2.6% and 2.32% for G5 and G3, respectively. This result is due to the difference in cost of manufactured diet for each group plus the difference among groups in the feed intake during the experiment period.

In regards to the economic efficiency, from the economical point of view, feeding growing rabbits on G4 diet gave the best economic efficiency value (1.77), whereas the lowest efficiency value was in G3 (1.28) followed by control group (commercial diet), G2 and G5 at 1.38, 1.40 and 1.46 respectively. Similarley, Ramadan *et al*. (2009) indicated that diets containing 16% CF had the best economic efficiency at 157% compared to the other dietary treatments (14 and 18% CF) at 128% and 135%, respectively, relative to the control (12% crude fiber). Also, Mohamed (1999) found that peanut hay inclusion to replace clover hay contributed in increased economic efficiency and lowering the feeding cost. Also, Sarhan (2005) postulated that the best economic efficiency values were for rabbits fed pea pods hulls or pea vines hay inclusion over the control diet. However, Abaza and Omara (2011) found that the rabbits fed 10% corn cobs with enzymes supplementation showed the highest net revenue and economic efficiency followed by those fed the control diet with enzyme. Rabbits fed 20% corn cobs diet without enzymes showed a reverse trend.

The present study showed that the use of corn cob in replacement of alfalfa hay can be successfully used at level of 17 % for feeding growing rabbits to improve performance and economic efficiency without addition of enzyme supplementation.

Table 1. Ingredient % and chemical composition of experimental diets

Ingredients, %	Dietary treatments (CF %)		
	12	14	16
	---------------------------%---------------------------		
Yellow corn (8.5%)	9.45	11	14.15
Soybean meal (44%)	5.7	10	12.5
Wheat bran	20.5	18.11	18.5
Alfalfa hay	38	28	20.5
Barley	22	19	13
Molasses	3	3	3
Corn Cobs	0.00	9.54	17
DL-Methionine	0.1	0.1	0.1
Dicalcium-phosphate	0.1	0.1	0.1
salt	0.5	0.5	0.5
Premix*	0.25	0.25	0.25
antitoxin	0.1	0.1	0.1
anticoccidia	0.1	0.1	0.1
charcoal	0.2	0.2	0.2
Total	100	100	100
Calculated analysis			
DE, Kcal/ Kg	2502	2512.9	2510
Crude protein (CP)	16	16.08	15.87
Ether extract (EE)	3.1	2.8	2.75
Ca %	1.2	1.1	0.96
Total P %	0.4	0.43	0.43
Lys %	0.47	0.56	0.61
Meth %	0.43	0.4	0.37
Methionine + cystine	0.6	0.59	0.58
Fiber fractions:			
Crude fiber (CF)	12.19	14	16.3
NDF %	30.07	30.69	31.75
ADF %	17.12	17.03	17.10

***The mineral-vitamin premix provide per kg diet: vitamin A, 12,000 IU; vitamin D, 2,500 IU; vitamin E, 12mg; vitamin K, 2.5 mg; vitamin B1, 1.2 mg; vitamin B2, 6 mg; pantothenic acid, 12mg; folic acid, 1.2mg; niacin, 36mg; pyridoxine, 2mg; vitamin B12, 0.01mg; biotin, 0.06mg; Cholin, 100mg; iron, 36mg; copper, 5mg; manganese, 72mg; zinc, 60mg, iodine, 0.45mg; selenium, 0.12 mg.

Table 2 Analyzed composition of corn cobs used in experimental diets

Items	Value
Moisture %	8.5
Protein%	5.71
Fat%	1.50
Crude fiber%	47
Ash%	1.5
Carbohydrates%	35.79
Digestible Energy (DE) (kcal/kg)	1795

Table 3. Effect of different dietary fiber levels on growth performance and total feed intake and cost of growing NZW rabbits

Parameters	Dietary treatments*				
	G1	G2	G3	G4	G5
Initial weight (g)	803 ± 23.81	800.5±35.07	800.5±34.62	811.11±15.04	800.5±23.55
Final weight (g)	2258.8±59.82[a]	2265.5±61.18[a]	2160.00±74.18[b]	2271.2±72.66[a]	2259.7±35.51[a]
Weight gain (g)	1452.20±38.15[a]	1447.22±29.89[a]	1356.70±57.84[b]	1460.11±61.65[a]	1431.50±25.24[a]
FCR	3.18±0.079	3.08±0.060	3.33±0.135	3.32±0.109	3.16±0.056
Total Feed intake (kg)	45.91±5.12[a]	44.55±5.14[a]	44.5±4.15[a]	42±3.41[b]	45.15±5.16[a]
Price of kg of feed ((EGP)	2.600±1.12[a]	2.555±1.25[b]	2.620±2.14[a]	2.528±2.14[b]	2.575±2.16[b]
Price of kg meat (EGP)	20	20	20	20	20
Total feed cost (EGP)	119.36±9.12[a]	113.8±7.14[c]	116.59±6.18[b]	106.18±8.14[d]	116.26±7.14[b]
Return from total BWT gain (EGP)	284±14.18[c]	273.6±12.14[d]	266±9.14[e]	293.8±13.14[a]	286.4±12.18[b]
Net return (EGP)	164.64±6.14[c]	159.8±8.14[d]	149.41±9.14[e]	187.62±8.17[a]	170.14±7.16[b]

* G1: control (12%CF), G2: 14%CF, G3: 14% CF with enzymes, G4:16% CF, G5: 16%CF with enzymes

Table 4. Impact of different dietary fiber levels on carcass trait of growing NZW rabbits

Parameters	Dietary treatments*				
	G1	G2	G3	G4	G5
Dressed carcass	1187.50±27.72	1298 ±61.65	1292.50±70.37	1290.00±22.82	1221.25±46.29
Relative liver%	7.24±0.43[ab]	8.22±0.62[a]	7.06±0.48[ab]	6.00±0.64[b]	6.45±0.18[b]
Relative kidney%	1.15±0.086	1.26±0.103	1.19±0.133	1.007±0.095	1.112±0.063
Relative spleen%	0.107±0.008	0.092±0.013	0.095±0.018	0.087±0.011	0.100±0.009
Cecum weight (g)	121.25±10.68	116.25±11.43	126.25±8.26	117.50±11.08	121.25±10.48
Cecum length(cm)	36.50±3.12[b]	42.50±5.04[ab]	48.25±2.39[a]	50.50±2.98[a]	50.00±1.15[a]
Cecum weight after remove content (cm)	40.00±3.53	36.25±4.26	40.00±2.04	43.75±3.75	41.25±2.39
Cecum pH	6.47±0.108[a]	6.42±0.041[a]	6.40±0.141[ab]	6.23±0.059[ab]	6.04±0.098[b]

* G1: control(12%CF), G2: 14%CF, G3: 14% CF with enzymes, G4:16% CF, G5: 16%CF with enzymes

Table 5 Influence of different level of dietary fiber on apparent digestibility of nutrients

Parameter	Dietary treatmment				
	D1	D2	D3	D4	D5
DM	66.02± 0.57[b]	66.05± 0.91[b]	60.76±0.05[c]	69.47± 0.35[a]	69.69± 0.35[a]
CP	60.43± 0.19[e]	66.06± 0.13[c]	61.50± 0.15[d]	67.93± 0.36[b]	71.56± 0.11[a]
Ash	64.03±0.53[b]	64.04±0.74[b]	57.5±0.5[c]	67.08±0.25[a]	68.02±0.35[a]

[a-e]Means with different superscripts along the same row are significant (P<0.05)

*G1: control(12%CF), G2: 14%CF, G3: 14% CF with enzymes, G4:16% CF, G5: 16%CF with enzymes

Table 6 Effect of different dietary level of fibers on serum metabolites

Parameters	Dietary treatment*				
	D1	D2	D3	D4	D5
Glucose (mg/dL)	118.06± 3.6 [a]	71.24± 1.41[c]	70.45± 0.39[c]	87.24± 7.21[b]	80.94± 3.45[cb]
AST (U/I)	9.76± 0.39	9.86± 0.06	10.70± 0.15	10.26± 0.43	10.50± 0.28
ALT (U/I)	6.61± 0.61	5.49± 0.64	6.02± 0.32	6.24± 0.64	6.12± 0.20
Total protein (g/dL)	5.36± 0.31[c]	6.18± 0.03[b]	4.92± 0.15[c]	7.70± 0.16[a]	7.44± 0.11[a]
Albumin (g/dL)	3.13±0.46[ab]	4.74± 0.04[a]	3.67± 0.36[a]	4.14±0.28[a]	4.5±0.73[a]

[a-e]Means with different superscripts along the same row are significant (P<0.05)

*G1: control(12%CF), G2: 14%CF, G3: 14% CF with enzymes, G4:16% CF, G5: 16%CF with enzymes

Table 7.Economic efficiency, reduction% in cost of manufactured diet per ton and in cost of total consumed feed and increase% in return among different groups compared to control group.

Group*		Economic efficiency	reduction% in cost of manufactured diet per ton	reduction% in cost of total consumed feed	increase% in return
1	12% C.F	1.38	0	0	0
2	14% C.F	1.40	1.73	4.66	- 3.66
3	14% C.F +enzymes	1.28	- 0.76	2.32	- 6.33
4	16% C.F	1.77	2.77	11	3.45
5	16% C.F +enzymes	1.46	0.96	2.6	0.85

* G1: control (12%CF), G2: 14%CF, G3: 14% CF with enzymes, G4:16% CF, G5: 16%CF with enzymes

Table *8* Effect of dietary treatments on regression functions

Group*		Return functions	Production functions
Group 1	12% C.F	Log return = 1.49 + 1.12 Log FI T (8.39) ** (16.81) *** R-2 = 0.82 F= 282.74**	Log bwt = 0.20 + 1.11 Log FI T (8.39)** (16.81)*** R-2 = 0.83 F= 282.74**
Group 2	14% C.F	Log return = 1.75 + 1.09 Log FI T (5.34) ** (9.86) *** R-2 = 0.79 F= 97.24**	Log bwt = 5.19 + 1.07 Log FI T (3.15)** (9.88)*** R-2 = 0.62 F= 98.25**
Group 3	14% C.F +enzymes	Log return = 0.40 + 1.06 Log FI T (5.68) ** (13.22) ** R-2 = 0.74 F= 174.79**	Log bwt = 1.11 + 1.04 Log FI T (5.68)** (13.22)** R-2 = 0.75 F= 175.79**
Group 4	16% C.F	Log return = 0.31 + 1.22 Log FI T (5.89) ** (10.05) ** R-2 = 0.66 F= 101.08**	Log bwt = 1.31 + 1.21 Log FI T (1.31)** (10.05)** R-2 = 0.68 F= 102.05**
Group 5	16% C.F +enzymes	Log return = 0.05 + 1.14 Log FI T (4.29) ** (17.95) ** R-2 = 0.84 F= 322.40**	Log bwt = 0.44 + 1.15 Log FI T (3.30) ** (15.14) ** R-2 = 0.85 F= 311.12**

* G1: control(12%CF), G2: 14%CF, G3: 14% CF with enzymes, G4:16% CF, G5: 16%CF with enzymes

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