

GROWTH PERFORMANCE AND FEED UTILIZATION OF GROWING RABBITS FED DIETS CONTAINING OLIVE CAKE MEAL SUPPLEMENTED WITH OR WITHOUT CITRIC ACID

I.A. Azazi* ; S. Gadelrab. H.A. EL-Komy and A.S. Ahmed

*Animal Production Research Institute ,Agricultural Research Center ,Dokki, Giza, Egypt.*Corresponding author: I_Azazi@yahoo.com*

This study carried out to evaluate the effect of feeding diets containing olive cake meal (OCM) at 10 % and 20 % with or without citric acid at levels 0.1 % or 0.2 % on growing rabbits performance. One hundred and five weaning New Zealand white (NZW) rabbits about 4 weeks old were allotted at random to seven experimental groups with 15 rabbits in each group contained three replicates (five rabbits in each) in a growth trail lasted for forty days. The experimental diets were as follows: Diet 1 was used as a control without adding olive cake or citric acid, and Diets 2, 3 and 4 : contained 10 % olive cake and were supplemented with zero, 0.1 and 0.2 % citric acid respectively, Diets 5, 6 and 7 : contain 20 % olive cake and were supplemented with zero, 0.1 and 0.2 % citric acid respectively.

Results could be summarized as follows:*Addition of olive cake plus citric acid to growing rabbit diets significantly increased live body weight (LBW) and daily weight gain (DWG). Feed conversion ratio (FCR) was improved and mean values of feed intake (FI) were increased along with adding 10% olive cake plus 0.1% citric acid in the rabbit diets .*

Economic efficiency percentage (EEf), relative economic efficiency (REE) and performance index (PI) were higher in growing rabbits fed diets containing 10% olive cake meal plus 0.1% citric acid than the other groups.

A significant increase in apparent digestibility coefficients of CF, EE, NFE, and TDN were detected while, there was insignificant increase in DM, OM, CP, DCP and DE % and apparent digestibility coefficient with addition olive cake plus citric in the rabbit diets. Carcass, liver, heart, giblets and dressing percentages in rabbits fed 10% olive cake recorded higher values compared with other dietary treatments.

Cholesterol and triglycerides in rabbits fed diet containing 10% olive cake without or with 0.1% citric acid showed lower values

compared to the other treatment. Total lipids, total protein, albumin, globulin, albumin /globulin ratio, and liver enzymes activity ALT and AST levels were not affected by the dietary treatments.

***Conclusively,** dietary incorporation of 10% olive cake meal supplemented with 0.1% citric acid could be recommended to improve growth performance, feed utilization and economic return of growing rabbits production.*

Keywords : Olive cake meal, citric acid, growth performance, digestibility coefficients, blood constituents, economic efficiency.

The lack of animals feed resources is considered one of the major constraints for improving its productivity (Zosangpui *et al.*, 2015). Improving the utilization of low nutritive value of feed resources is essential for overcoming the limits of available feedstuff in the developing countries (Al-Saffar *et al.*, 2013). Olive cake is the raw material resulting after extraction of olive oil. Olive cake represents about 30% of the seeds. Chemical composition of Olive cake was determined to be: Crude Protein 6.79 %, Crude Fibre 33.32 %, Crude Fat 18.92 %. (Abdallah *et al.*, 2015). In another chemical analysis ,the average composition of olive cake was [in dry matter (DM) basis]: ash (9.64%), neutral detergent fibre (52.0%), acid detergent fibre (36.8%), acid detergent lignin (19.1%), crude protein (CP) (11.3%), insoluble neutral (8.0%) and acid detergent crude protein (5.15%), ether extract (10.9%) and gross energy (21.9 MJ/kg) (De Blas *et al.*, 2015). Indeed, the olive cake meal could be of particular interest due to two reasons, firstly, its level of residual oil (6.8%), this can constitute a complementary energy source. Secondly, for its particular composition of unsaturated fatty acids (62.4% of oleic acid, 18.2% of linoleic acid, 1.1% of linolenic acid and 2.7% of palmitoleic acid) which could influence the accumulation of fatty acid in the various body compartments during the animal's life and as such could have a certain impact on the quality of meat (El hachemi *et al.*, 2007). The utilization of olive by-products as animal feed is undoubtedly a good way of recycling these waste products (Sadeghil *et al.*, 2009). Olive pulp polysaccharides are composed mainly of pectic polysaccharides rich in arabinose, glucuronoxylans, cellulose, xyloglucans, mannans and glycoproteins components (Isabel *et al.*, 2001). El-Sheikh (2012) found that olive cake meal contains high level of tannins (12.05 %). Dietary tannins inhibit the intestinal uptake and transport of simple sugars, amino acids and minerals (Kim and Miller, 2005).The presence of tannins in the diets of fowl resulted in lowered protein digestibility, reduced activities of

digestive enzymes (trypsin, chymotrypsin, alpha-amylase, dipeptidase and disaccharidases) in the gut lumen and increase in the relative weight of the pancreas (Mahmood *et al.*, 2007). Tannins are considered to have both beneficial and detrimental nutritional effects, including better utilization of dietary protein, faster body weight, higher milk yield, increase fertility and improving animal welfare and health (Mueller-Harvey, 2006, and Sudipta, 2012). Attempts to improve the nutritive value of OCM have been made through different chemical treatments (alkaline, acidic or oxidative agents). A treatment with alkali agents (sodium hydroxide, ammonia and urea) was investigated, but results have been more or less satisfactory (Rowghani *et al.*, 2008). Kadi *et al.* (2004) concluded that OCM can be included in fattening rabbit diets at the level of 20 % in replacement of alfalfa as source of crude fibre without deleterious effects on main parameter of growth. The treatment with sodium bicarbonate and acetic acid are more effective in reducing hydrolysable and condensed tannin contents. Treatment with sodium bicarbonate solution is more economical and easier to handle. The effect of acidic solution on hydrolysable tannins was higher among the treatments. Treatments with (0.67 % acetic acid (pH 2.4) and 0.67 % sodium bicarbonate reduced condensed and hydrolysable activity of the salseed meal by about 80-84% (Mahmood *et al.*, 2007).

Citric acid can be classified as a growth promoter, acidifier, bacterial inhibitor, antioxidant and antitoxin (Rostamzad *et al.*, 2011). Chowdhury *et al.*, (2009) reported that citric acid lowers the pH in the gut, thus reducing harmful microbiota and modifying the distribution of bacterial species in the gut and improving the health status of the animal.

Using olive cake meal at 10 % or 20 % of diets increased feed intake and impaired the feed conversion ratio (FCR) of laying hens those fed the compared with control group. However, adding the citric acid at 0.1% to the diet containing 20% olive cake yielded similar FCR recorded by dietary supplementation with the control (Al-Harathi *et al.*, 2015). On this topic, Yesilbagand Çolpan (2006) reported that citric acid increased villus height/crypt depth ratio and increased beneficial bacteria while decreasing pathogenic organisms in the feed and gut of laying hens. Soaking soybean seeds in 1% citric acid solution had maximum reduction in most of the ant nutritional factors studied (Sharma *et al.*, 2013).

Therefore, the aim of the present study was to investigate the possibility of incorporate 10 and 20 % of olive cake in the rabbit diets with or without 0.1% and 0.2% citric acid effect of these diets on growth performance parameters of growing rabbits.

MATERIALS AND METHODS

This study was carried out at Experimental Station of Inshas, Animal Production Research Institute, Egypt. A total number of 105 unsexed, New Zealand White (NZW) weaned rabbits 4 weeks old were randomly divided into 7 experimental groups of 15 rabbits each. Each group was subdivided into 5 replicates, each of 3 rabbits in cage. Seven *isocaloric*, *isonitrogenous* and *isofiberous* diets were formulated in which olive cake was incorporated at levels 0, 10, 20 % of the diet, without or with citric acid supplementation at levels 0.1, 0.2 %. Experimental diets were as follows: diet 1 : A control without olive cake meal or citric acid, diet 2, 3 and 4 : contained 10 % olive cake and supplemented with zero, 0.1 and 0.2 % citric acid respectively, diets 5, 6 and 7 : contain olive cake at 20 % of the diet and diets were supplemented with zero, 0.1 and 0.2 % citric acid respectively. All experimental diets were formulated to meet the recommended nutrient requirements of rabbits according to (Agriculture Ministry Decree, 1996). Ingredients and chemical composition of the experimental diets are shown in Table (1).

The experimental rabbits were housed (three rabbits together) in galvanized metal wire cages (60x50x40 cm) which raised 120 cm from the concrete floor. The cages were provided with feeders and automatic nipple drinkers. Food and water were available *ad libitum*. All rabbits were kept under the same managerial, hygienic and environmental conditions. Individual live body weight and feed consumption throughout the experimental period were weekly recorded. Body weight gain, feed conversion ratio and mortality rate were also calculated. The feeding trial continued for forty days.

Metabolism trials:

At the end of the growth period, a metabolism trial was conducted using 21 rabbits (3 from each group). Rabbits were kept in individual metabolic cages that allow feces and urine separation. The digestibility trial consisted of 10 day as a preliminary period followed by 7 days as a collection period. The experimental diets were offered once a day at 8.00 a.m. During the collection period, total daily excreted feces were weighed and dried in an oven at 65°C for 48 h. At the end of the collection period, dried feces of each rabbit were mixed, ground and kept in plastic vials for laboratorial analysis. Total daily urine excreted by each rabbit was collected in a Jar containing 50 mL-1 of 20% H₂SO₄ to prevent ammonia loss.

Table 1. Ingredients and chemical composition of the experimental diets.

Ingredient	Control	Olive cake 10 %			Olive cake 20 %		
		0.0% CA	0.1% CA	0.2% CA	0.0% CA	0.1% CA	0.2% CA
Clover hay	33.16	23.10	23.10	23.10	13.28	13.28	13.28
Barely	15.50	16.25	16.25	16.25	16.40	16.40	16.40
Wheat bran	10.45	10.50	10.50	10.50	10.55	10.55	10.55
Corn	15.00	13.20	13.20	13.20	11.40	11.40	11.40
SBM	20.00	21.00	21.00	21.00	22.20	22.20	22.20
Limestone	0.70	0.70	0.70	0.70	0.70	0.70	0.70
Di cal.	1.40	1.40	1.40	1.40	1.60	1.60	1.60
Premix*	0.30	0.30	0.30	0.30	0.30	0.30	0.30
NaCl	0.35	0.40	0.40	0.40	0.40	0.40	0.40
DI-Meth.	0.14	0.15	0.15	0.15	0.17	0.17	0.17
Molasses	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Olive cake	-	10	10	10	20	20	20
Total	100	100	100	100	100	100	100
Calculated analysis %¹							
OM	90.37	90.30	90.30	90.30	90.29	90.29	90.29
CP	17.56	17.38	17.38	17.38	17.24	17.24	17.24
DE	2532.33	2537.60	2537.60	2537.60	2535.91	2535.91	2535.91
CF	13.68	14.06	14.06	14.06	14.49	14.49	14.49
EE	2.30	2.69	2.69	2.69	3.08	3.08	3.08
Ash	9.63	9.70	9.70	9.70	9.71	9.71	9.71
NFE	56.8	56.18	56.18	56.18	55.52	55.52	55.52
Ca	1.17	1.16	1.16	1.16	1.20	1.20	1.20
Av. Ph	0.32	0.30	0.30	0.30	0.32	0.32	0.32
T.ph	0.65	0.64	0.64	0.64	0.67	0.67	0.67
Lysine	0.93	0.91	0.91	0.91	0.89	0.89	0.89
Meth	0.41	0.40	0.40	0.40	0.41	0.41	0.41
Meth+Cys	0.69	0.67	0.67	0.67	0.67	0.67	0.67

*Each 3 kg of Vit. and Min in Premix contain: 6000000IU Vit. A, 900000 IU Vit. D3 40000mg Vit. E, 2000mg Vit. K, 2000mg Vit. B1, 4000mg Vit. B2, 2000mg Vit. B6, 10mg Vit. B12, 50000mg Niacin, 10000 mg pantothenic acid, 50mg Biotin, 3000mg Folic acid, 250000 mg Choline, 50000mg Zn, 8500mg Mn, 50000mg Fe, 50000mg Cu, 200mg I, 100mg Se and 100mg Co.

¹ According to Feed composition for animal and poultry feed stuff used in Egypt (2001).

Daily samples of 20% were taken from each animal. Samples of feeds, feces and urine were chemically analyzed according to AOAC (2000). The apparent digestion coefficients of DM, OM, CP, CF, EE and NFE for experimental diets were estimated. Tannins in olive cake were analyzed according to Makker and Googchild (1996).

Carcass traits:

At the end of the growth trial, 5 random rabbits from each group were slaughtered according to cheeke *et al.* (1987) and carcass traits were estimated and recorded. Dressing percentage included relative weights of carcass, giblets and head.

Blood metabolites:

Blood samples were collected at slaughtering from each slaughtered animal. Within one hour of collection, the samples were centrifuged at 3000 r.p.m. for 15 min. The serum was separated and stored at -20°C until analysis. Serum total protein, albumin, cholesterol, total lipids, triglycerides, ALT and AST levels were determined by a colorimeter using commercial kits. The globulin values were obtained by subtracting albumin values from total protein values.

Chemical analysis:

The chemical composition of the olive cake meal (OCM), diets and faeces were analyzed according to AOAC(2000). Total digestible nutrient (TDN) were calculated according to the classic formula Cheeke *et al.* (1982).

Economical evaluation:

The economical efficiency (EEf) was calculated according to the following equation:

$$EEf = A - B / B \times 100.$$

Where A is selling cost of obtained gain (LE per kg) and B is the feeding cost of this gain.

The performance index (PI) was calculated according to the equation described by North (1981) as follows: $PI = \text{Live body weight (kg)} / \text{Feed conversion} \times 100$.

Statistical analysis:

Data were subjected to statistical analysis by SAS (2004) computer program using the General Linear Models (GLM). The model used was:

$$Y_{ij} = \mu + T_i + E_{ij}.$$

Where, Y_{ij} is the observation of ij , μ is the overall mean, T_i is the effect of i , (treatments) and E_{ij} is the experimental random error. Significance among treatment means were tested at 5% level of probability using Duncan's multiple range tests (Duncan, 1955).

RESULTS AND DISCUSSION

Proximate analysis of olive cake meal (OCM):

Results of proximal analysis of olive cake meal (OCM) are presented in Table (2). It is clear that, the olive cake meal has lower amount of CP (6.70%) and reasonable amount of NFE (47.51%) and DE recorded 1900 k cal /kg diet. Tannins, ether extract and ash contents were 7.80, 5.90 and 8.30 %, respectively. Amici *et al.*, (1991) reported that the CF in OCM is mainly constituted by lignin which limits its feeding value. The nutritive values of OCM are within the results reported by Walaa Salamaa *et al.* (2016) who found that olive cake meal with contained 7.68 % CP, 27.11 % CF, 9.20 % EE and 33.01 % NFE. Abdallah *et al.* (2015) found that olive cake meal contains 6.79 % CP, 33.32 % CF 57 % NDF, 41 % ADF 13 % lignin and 10.92 % ash. On the other hand, Vera *et al.* (2009) found that olive cake contents were 16.5 % EE, 32 % NDF, 25.5 % ADF and 15.5 % ADL. El-Sheikh (2012) and Walaa Salamaa *et al.* (2016) found that olive cake meal contains high level of tannins (12.05 and 11.09%, respectively). Makkar, (1993) recorded moderate amount of tannins 9.67 % in OCM. The chemical analysis of olive cake meal varies widely due to the oil extraction method, year of harvest and geographical origin of olives (Moicet *et al.* 2007).

Table 2. The chemical composition of olive cake meal (% on as fed basis).

Items	DM	OM	CP	EE	CF	NFE	ASH
	91.68	83.38	6.70	5.90	32.18	47.51	8.30
Items	DE	Tannins%	NDF	ADF	ADL	H. cell	Cellulose
	1900	7.80	55.10	42.33	17.90	12.77	24.43

*DE (k cal/g) = 4.36-0.0491 x NDF, Where NDF % = 28.924 + 0.657 x CF % (according to Cheeke, 1987).

NDF: Natural detergent fiber, ADF: Acid detergent fiber, ADL: Acid detergent lignin, Hemi Cellulose = NDF – ADF ; Cellulose = ADF – ADL.

Growth performance:

Live body weight and daily weight gain:

Results of LBW and DWG are illustrated in Table 3. Significant differences ($P < .05$) were recorded in the final (LBW) live body weight, total body weight gain and daily body weight gain between treatments.

Table 3. Growth performance of growing rabbits as affected by dietary treatments.

Items	Control	Treatment groups						Sig.
		10% OCM	10%OCM+0.1%CA	10% OCM +0.2% CA	20% OCM	20% OCM +0.1% CA	20%OCM+0.2% CA	
Initial body weight(g)	554.34 ±40.45	564.00 ±20.88	547.34 ±20.04	557.00 ±19.12	543.34 ±20.41	544.67 ±18.82	542.67 ±18.94	NS
Final body weight(g)	1735.72 ±18.71 ^b	1740.00 ±22.68 ^b	1817.86 ±28.57 ^a	1803.34 ±21.5 ^a	1632.15 ±18.83 ^c	1660.00 ±25.64 ^c	1736.67 ±27.35 ^b	**
Total gain (g)	1182.15 ±25.62 ^{bc}	1176.00 ±29.72 ^{bc}	1267.15 ±26.05 ^a	1246.34 ±30.27 ^{ab}	1085.72 ±33.50 ^d	1115.34 ±32.11 ^{cd}	1194.00 ±34.10 ^b	**
Daily weight gain(g)	29.56 ±0.65 ^b	29.40 ±0.75 ^{bc}	31.68 ±0.66 ^a	31.16 ±0.76 ^{ab}	27.15 ±0.84 ^d	27.89 ±0.81 ^{bc}	29.85 ±0.86 ^b	**
Daily feed intake(g)	125.64 ±1.59 ^a	110.57 ±1.21 ^c	116.7 ±1.86 ^b	117.54 ±1.53 ^b	118.80 ±0.37 ^b	118.67 ±1.32 ^b	119.67 ±0.85 ^b	**
Total feed intake(g)	5025.34 ±63.43 ^a	4449.34 ±70.60	4668.00 ±74.09 ^{bc}	4741.34 ±24.7 ^b	4752.00 ±14.43 ^b	4746.67 ±52.48 ^b	4786.67 ±33.66 ^b	**
Feed conversion ratio (g feed/g gain))	4.25 ±0.08 ^{ab}	3.79 ±0.10 ^{cd}	3.69 ±0.07 ^{cd}	3.81 ±0.02 ^{cd}	4.38 ±0.07 ^a	4.26 ±0.05 ^{ab}	4.01 ±0.03 ^{bc}	**

a, b and c --- Means within the same row with the different superscripts are significantly different (P<0.05).

NS: Not significant, ** (P<0.01).

OCM: Olive Cake meal, AC: Citric Acid.

Rabbits received 10 % OCM 0.1 % CA had the highest final body weight, total body weight gain and daily body weight gain, followed by rabbits received 10 % OCM plus 0.2 % CA and those given 20 % OCM + 0.2 % CA, while group fed on diet with 20 % OCM without CA had the lowest final live body weight, total body weight gain and daily body weight gain.

The results obtained in this study agree with those reported by Walaa, salama *et al.*, (2016) who recorded significant differences in final body weight, total body weight gain and daily weight gain between rabbits received 9.9% olive cake meal and other treatments. Additionally, Mvan and Suresh (2013) concluded that citric acid supplementation at level 0.9% in the diet improved the daily weight gain, the efficiency of feed utilization and nutrient digestibility of crossbred pigs. While, El-Kerdawy (1997) observed, no significant differences in live body weight and weight gain of rabbits given diets contained 5, 10 and 15 % olive pulp. Also, Mousa and Abd El-Samee (2002) reported no significant differences in live body weight and body weight gain for rabbits fed diets contained 0, 10, 20 % olive pulp meal.

Daily feed consumption and feed conversion ratio:

Values of feed intake (FI) and feed conversion ratio (FCR) are presented in Table 3. The highest FI during the experimental period was recorded by rabbits fed the control diet. The lowest FI was recorded by rabbit groups fed 10 % OCM without CA.

Data in Table (3) show that values of FCR for groups fed diets with 10% OCM levels plus 0.1 % CA were the best followed by groups fed the same levels of OCM without CA, while rabbits given 20 % OCM without CA had the highest FCR value. The obtained results indicated that rabbits fed the different levels of OCM with CA were more efficiently in feeding utilization than those received the control diet.

The present results are in accordance with those obtained by Walaa salama *et al.* (2016) who found that, rabbits fed diets with 9.9% OCM recorded the best feed conversation ratio, but, feed intake were not significantly affected by the dietary treatments. Moreover, Francisco *et al.*

(1989) reported that, weight gain and food intake were increased significantly ($P < .05$) by the inclusion of 30% olive pulp in the diets. However, increasing levels of olive pulp in the diets decreased the efficiency of feed conversion ratio. Al-Harhi *et al.* (2015) concluded that, OCM could be used in the laying hens' diets at 20% with 0.1% CA without any negative effects on laying performance, egg quality and blood metabolites.

On this topic, Yesilbag and Çolpan (2006) reported that citric acid increased villus height/crypt depth ratio and increased the beneficial bacteria while decreasing pathogenic organisms in the feed and gut (Deepa *et al.*, 2011). Organic acids may be useful alternative for improving production performance and animal health (Attia *et al.*, 2013). Organic acids exert their antimicrobial action both in the feed and in the gastrointestinal tract of the animal. (Radcliffe, 2000). Organic acids in their undissociated forms are able to pass through the cell membrane of bacteria. Once inside the cell, the acid dissociates to produce H^+ ions, which lower the pH of the cell, causing the organism to use its energy trying to restore the normal balance. The $RCOO^-$ anions produced from the acid can disrupt DNA and protein synthesis, putting the organism under stress and making it unable to replicate (Rostamzad *et al.*, 2011). Citric acid can be classified as a growth promoter, acidifier, bacterial inhibitor, antioxidant and antitoxin (Salgado-Tránsito *et al.*, 2011).

Carcass characteristics:

Results of carcass traits in Table (4) showed that, rabbits fed diets contained 10 % OCM without CA had significantly increase of empty carcass with head, liver, heart, giblets and dressing percentage. However, there were insignificant differences in kidney percentage between all treatments. In this connection, Walaa salama *et al.* (2016) reported that carcass traits were significantly affected by olive pulp inclusion. However, El-Kerdawy (1997) observed that, carcass weight, giblets and dressing percentage, did not differ significantly for rabbits fed diets containing olive pulp up to 15 %. Also, Abd El-Galil (2001) found no significant differences in carcass traits of rabbits received either control or 20 % olive pulp. Mousa and Abd El-samee (2002) reported that no significant differences in carcass weight and giblets weight with including olive pulp up to 20% of rabbit diets. Francisco *et al.* (1989) concluded that, carcass yield and liver weight were not affected by olive pulp

diet, but the rabbits fed on the 20 or 30% olive pulp diets showed significant differences in kidney weight.

Table 4. Carcass characteristics of growing rabbits as affected by dietary treatments.

Items	Control	Treatment groups					Sig.
		10% OCM	10%OCM +0.1%CA	10%OCM +0.2%CA	20% OCM	20%OCM +0.1%CA	
Pre-slaughter weight (g)	1800 ±28.87	1783.34 ±16.67	1816.67 ±44.10	1850 ±28.87	1616.67 ±16.67	1666.67 ±44.10	NS
Carcass (%)	56.48 ±0.39 ^{ab}	58.50 ±0.17 ^a	54.22 ±0.85 ^c	56.42 ±0.37 ^{ab}	58.12 ±0.13 ^{ab}	53.99 ±0.44 ^c	**
Liver (%)	2.12 ±0.01 ^a	2.14 ±0.05 ^a	2.00 ±0.03 ^a	2.11 ±0.03 ^a	2.12 ±0.07 ^a	1.81 ±0.03 ^b	**
Heart (%)	0.45 ±0.02 ^{ab}	0.49 ±0.03 ^a	0.41 ±0.02 ^b	0.41 ±0.02 ^b	0.42 ±0.02 ^{ab}	0.45 ±0.01 ^{ab}	**
Kidney (%)	0.18 ±0.01	0.21 ±0.02	0.16 ±0.02	0.17 ±0.01	0.17 ±0.01	0.19 ±0.01	NS
Giblets (%)	2.74 ±0.03 ^{ab}	2.84 ±0.08 ^a	2.56 ±0.04 ^{bc}	2.68 ±0.03 ^{ab}	2.70 ±0.09 ^{ab}	2.44 ±0.04 ^c	**
Dressing (%)	59.21 ±0.41 ^b	61.34 ±0.2 ^a	56.78 ±0.84 ^c	59.10 ±0.39 ^b	60.81 ±0.07 ^{ab}	56.43 ±0.47 ^c	**

a, b and c --- Means within the same row with the different superscripts are significantly different (P<0.05).

NS: Not significant, ** (P<0.01).

OCM: Olive Cake Meal, AC: Citric Acid.

Nutrients digestibility coefficients and nutritive values:

Results in Table (5) show that incorporation of OCM in rabbit diets had no significant differences in digestion coefficients of dry matter (DM), organic matter (OM), crude protein (CP), digested energy (DE) and digestive crude protein (DCP). However, the difference were significant ($p < .05$) for the digestibility coefficients of crude fiber (CF) and NFE. Rabbits fed on 10 % or 20 % OC supplemented with 0.2 % CA had higher digestion coefficients of crude protein (CP), ether extract (EE), total digestible nutrient (TDN) and crude fiber (CF). Also rabbits fed on 10 % OCM plus 0.2% CA recorded higher digestibility coefficients of NFE.

Generally, these results indicate that, digestibility coefficients of nutrients and nutritive values improved with adding citric acid levels up to 0.2 % in rabbit diets which contain olive cake meal up to 20 %.

The diets contain 10 % or 20 % OCM without citric acid recorded lower digestibility coefficients in comparison to diets supplemented by citric acid. These results may explain the improvement in DWG and FCR for rabbits fed these diets during the experimental period. The results of these study are in agreement with those reported by Walaa, salama *et al.*, (2016) who reported that the digestibility coefficients of EE, NFE and DE differ significantly ($p < .05$) by inclusion up to 60.0% of OCM in the diets, The author found that no significant differences in DM, OM, CP, CF, digestibility and DCP and TDN different percentages of values . Mehrez and Mousa (2011) observed that the digestibility coefficients of ether extract significantly increased when replaced barely grains (0, 20, 25 or 30%) by olive cake in the diets of growing rabbits. Moustafa *et al.*, (2008) found that the values of TDN and DCP for buffalo fed

on diets containing 20 to 30% of olive pulp were lower than that containing 15 to 20 % level of olive pulp.

In this concern, Drinah *et al.*, (1990) reported that tannin containing sorghums was decreased by alkaline or acidic treatment . Francisco *et al.*, (1989) concluded that, Digestibility of crude protein, neutral and acid detergent fiber and crude fiber were reduced by feeding diet containing 30% olive pulp. Mahmood *et al.*, (2007), reported that Tannins in the fowls diets results in lowered digestibility coefficients and reduced enzymes activity and had deleterious effects on the animal growth, .The author added that supplementation with citric acid or fumaric acid to chicks diets result in significantly improvement in digestibility coefficient of DM , OM , CP , EE and ash and reduction in total bacterial counts in all acid treatments compared to the control.

Table 5. Digestibility coefficients and nutritive values of the experimental diets.

Items	Control	Treatment groups						Sig.
		10% OCM	10% OCM +0.1% CA	10% OC M +0.2% CA	20% OCM	20% OCM+ 0.1% CA	20% OCM+ 0.2% CA	
DM	66.40 ±1.04	64.72 ±1.02	65.59 ±0.61	66.21 ±0.0.89	63.62 ±0.83	74.12 ±1.19	65.66 ±0.83	NS
OM	65.50 ±1.06	64.70 ±0.67	65.40 ±0.71	65.60 ±0.70	64.48 ±0.91	65.22 ±0.91	65.42 ±0.96	NS
CP	74.86 ±1.33	74.65 ±1.36	75.24 ±1.64	76.71 ±1.03	74.00 ±1.17	75.77 ±0.28	76.53 ±1.47	NS
CF	32.11 ±0.56 ^{ab}	30.14 ±0.65 ^b	32.33 ±0.87 ^{ab}	35.41 ±0.93 ^a	29.09 ±0.96 ^b	32.37 ±1.05 ^{ab}	34.58 ±0.85 ^a	**
EE	61.34 ±1.57 ^c	65.88 ±1.09 ^{abc}	67.40 ±1.28 ^{abc}	69.18 ±1.86 ^{ab}	64.64 ±1.39 ^{bc}	70.43 ±1.58 ^{ab}	71.78 ±1.08 ^a	**
NFE	74.12 ±1.19 ^a	71.69 ±0.91 ^{ab}	74.35 ±0.38 ^a	75.13 ±0.59 ^a	70.08 ±0.86 ^b	74.19 ±1.02 ^a	74.25 ±1.07 ^a	*
TD N	62.78 ±1.00 ^{ab}	61.47 ±0.77 ^{ab}	63.61 ±0.11 ^a	64.55 ±0.67 ^a	60.12 ±0.24 ^b	63.72 ±0.87 ^a	64.20 ±0.87 ^a	**
DCP	12.39 ±0.78	12.21 ±0.67	12.39 ±0.28	12.98 ±0.57	12.06 ±0.35	12.35 ±0.35	12.50 ±0.31	NS
DE	2497.67 ±26.34	2590.34 ±173.33	2524.34 ±26.43	2557.67 ±29.76	2436.0 ±22.54	2481.67 ±23.39	2509.00 ±32.08	NS

a, b and c - Means within the same row with the different superscripts are significantly different (P<0.05).

NS: Not significant, * (P<0.05), ** (P<0.01).

OCM: Olive Cake meal, AC: Citric Acid.

Blood plasma constituents:

Values of blood plasma constituents of rabbit as affected by feeding the experimental diets are presented in Table 6. It could be observed that, there were no significant differences ($P > 0.05$) in total lipids, total protein, albumin, globulin, albumin/globulin, ALT and AST at the end of the experiment among all dietary treatments. However, rabbits received the diet containing 10 % OCM plus 0.1 citric acid scored the lowest values for plasma cholesterol or triglyceride and the differences in these two parameter (cholesterol or triglyceride) between rabbits fed 10% OCM with citric acid diets and those given the other diets were significant ($P < 0.05$). In this concern, Mousa and Abd-El-samee (2002) revealed that the concentration of blood plasma of total lipid, globulin, ALT and AST did not differ significantly among the rabbit groups fed olive cake containing diets. In addition to El-Kerdawy (1997) observed that plasma levels of total

Table 6. Blood plasma constituents of rabbits as affected by feeding the experimental diets.

Items	Control	Treatment groups						Sig.
		10%OCM	10%OCM +0.1%CA	10%OCM +0.2%CA	20%OCM	20%OCM +0.1%CA	20%OCM +0.2%CA	
Cholesterol	66.74 ±1.83 ^b	90.71 ±2.42 ^a	54.65 ±0.75 ^c	57.57 ±1.33 ^c	93.98 ±2.68 ^a	67.61 ±1.97 ^b	62.27 ±1.64 ^{b,c}	**
Total lipids	1.98 ±0.12	2.02 ±0.12	1.87 ±0.13	1.97 ±0.17	2.15 ±0.10	2.08 ±0.13	1.94 ±0.13	NS
Triglyceride	141.59 ±5.53 ^{a,b,c}	151.28 ±6.21 ^{a,b}	122.94 ±4.23 ^c	132.97 ±4.04 ^{b,c}	162.19 ±5.2 ^a	143.43 ±3.75 ^{a,b,c}	135.00 ±3.54 ^{b,c}	**
Total protein	6.48 ±0.50	6.53 ±0.62	6.45 ±0.45	6.48 ±0.50	6.07 ±0.62	6.52 ±0.41	6.59 ±0.35	NS
Albumin	3.32 ±0.12	3.15 ±0.12	3.37 ±0.12	3.26 ±0.09	3.01 ±0.12	3.48 ±0.18	3.50 ±0.15	NS
Globulin	3.16 ±0.46	3.38 ±0.45	3.09 ±0.34	3.26 ±0.44	3.07 ±0.51	3.04 ±0.52	3.09 ±0.21	NS
Albumin/ Globulin	1.09 ±0.14	0.98 ±0.15	1.11 ±0.09	1.05 ±0.12	1.03 ±0.14	1.25 ±0.31	1.14 ±0.04	NS
ALT	22.15 ±1.18	22.43 ±0.79	20.50 ±1.41	20.68 ±0.95	23.47 ±0.90	22.27 ±1.03	21.21 ±0.053	NS
AST	35.83 ±0.83	36.71 ±0.95	33.75 ±0.72	34.10 ±0.61	37.44 ±0.78	36.05 ±0.90	35.60 ±0.89	NS

a, b and c --- Means within the same column with the different superscripts are significantly different (P<0.05).

NS: Not significant, ** (P<0.01).

OCM: Olive Cake meal, AC: Citric Acid.

protein, ALT, AST and globulin were not affected significantly with including olive pulp in fattening rabbit diets. Capcarova *et al.*, (2014) found that treatment of broiler diet with citric acid did not negatively affect serum total protein, but significantly increase serum albumin. El-Afifi(2003) cited that total plasma protein, albumin and globulin were not affected by feeding broiler chicks diet containing citric acid. Yesilbagand Çolpan (2006) reported that the response to citric acid supplementation depends on the citric acid concentration, dietary composition and hygienic conditions. However, Al-Harthiet *al.* (2015) found that the increase in plasma total protein and globulin is due to 0.2% citric acid supplementation to the diets, the author reported that, adding of 0.5% citric acid to chicks diets improved humeral and cellular immunity. Rupic *et al.*, (1999) showed that no significant differences in the concentration of total proteins, albumin, alpha1, alpha2, beta and gamma globulin, total lipids, triacylglycerols and glucose of control rabbits and in those fed 10% and 20% of dried olive cake diets.

Economic efficiency:

The results presented in Table (7) show that, the best economic efficiency EEF, performance index and relative economic efficiency REEF were of rabbits fed diets containing 10% OCM supplemented with 0.1% citric. These results agree with those reported by Mehrez and Mousa (2011) who revealed that feeding fattening rabbits on diet including 15, 20, 25, and 30 % olive pulp decreased the cost of feed per kg gain, whilst economic efficiency and performance index were raised with olive pulp supplementation compared with rabbits fed the control diet. The same trend was recorded Mostafa *et al.*, (2003) who reported that the feed cost were relatively lower in lambs fed rations contained 15 - 35 % olive cake those fed than the control diet . Marzouk *et al.*, (2017) found that feeding of growing lambs or ewes on 20 % olive cake level replacer with berseem hay could be recommended to improve their productive and reduce feed cost.

Conclusively, dietary incorporation of 10% olive cake meal supplemented with 0.1% citric acid could be recommended to improve growth performance parameters and feed utilization of NZW growing rabbits.

Table 7. Economic Efficiency of feeding rabbits the experimental diets..

Items	Control	Treatment groups					
		10% OCM	10%OCM +0.1%CA	10%OCM +0.2%CA	20% OCM	20%OCM +0.1%CA	20%OCM +0.2% CA
Weight gain kg	1.182	1.176	1.267	1.246	1.085	1.115	1.194
Price LE/kg	35	35	35	35	35	35	35
Price/rabbit LE (A)	41.37	41.16	44.35	43.61	37.98	39.03	41.79
Feed intake kg	5.025	4.449	4.668	4.741	4.752	4.746	4.786
Price kg feed LE	4.71	4.35	4.37	4.39	4.11	4.13	4.15
Cost / rabbit LE (B)	23.79	19.35	20.40	20.81	19.53	19.60	19.86
Net revenue LE	17.58	21.81	23.95	22.80	18.45	19.43	21.98
Economic Efficiency EEF	73.90	112.71	117.40	109.56	94.47	99.13	110.42
Relative EEF	100	152.5	158.9	148.3	128.4	134.1	110.93
Performance Index	57.3	59.3	58.3	68	65	64.6	62.7

OCM: Olive Cake Meal, AC: Citric Acid.

(1) Net revenue = A – B,

(2) Economic Efficiency = (A – B/B) x 100,

(3) Relative Economic Efficiency = Economic Efficiency of treatment other than the control / Economic Efficiency of the control group

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أداء النمو والاستفادة الغذائية للأرانب النيوزيلندي البيضاء النامية المغذاة على علائق تحتوي علي تفل الزيتون مع إضافة أو بدون حمض الستريك

إبراهيم عاطف عزازي و صابر صبحى جاد الرب و حمدى محمد الكومى و عادل سيد احمد
معهد بحوث الإنتاج الحيواني - مركز البحوث الزراعية- الدقي - مصر

أجريت هذه التجربة بهدف دراسة تأثير علائق تحتوي على تفل الزيتون بمستويات 10، أو 20% من العليقة بدون أو مع إضافة حمض الستريك بمستوي 0.1 أو 0.2% علي الأداء الإنتاجي للإنتاجي للأرانب النامية. تم تقسيم عدد 105 أرنب نيوزيلندي أبيض مفطوم وغير مجنس عمر أربعة أسابيع عشوائيا إلي 7 معاملات غذائية (كل معاملة تجريبية تحتوي علي 15 أرانب وزعت إلي 3 تكرارات (كل تكرار بة 5 أرانب) استمرت تجربة النمو لمدة 40 يوما وكانت العلائق التجريبية كالتالي: العليقة الأولى استخدمت كعليقة كنترول بدون إضافة كسب تفل الزيتون أو حمض الستريك، العلائق الثانية والثالثة والرابعة تحتوي علي 10% تفل الزيتون من العليقة (مع إضافة حمض الستريك بنسبة صفر، 0.1، 0.2% علي التوالي. و العلائق الخامسة و السادسة و السابعة تحتوي علي 20% تفل الزيتون) من العليقة (مع إضافة حمض الستريك بنسبة صفر 0.1، 0.2% علي التوالي (%).

وكانت النتائج كالتالي: إضافة تفل الزيتون وحمض الستريك في علائق الأرانب النامية أدى إلي زيادة معنوية في وزن الجسم الحي ومعدل الزيادة اليومية.

تحسن معامل التحويل الغذائي مع زيادة معدل الاستهلاك اليومي من الغذاء بإضافة 10% تفل الزيتون و 0.1% حمض الستريك في علائق الأرانب . سجلت أعلى معدل في الكفاءة الاقتصادية و الكفاءة الاقتصادية النسبية ودليل الأداء للأرانب المغذاة علي علائق تحتوي علي 10 % تفل الزيتون و 0.1% حمض الستريك بالمقارنة بالعلائق الأخرى.

وجدت زيادة معنوية في المعاملات الهضمية للألياف الخام و مستخلص الأثير و الكربوهيدرات الذائبة والطاقة المهضومة بينما يوجد زيادة غير معنوية في المعاملات الهضمية للمادة الجافة والمادة العضوية و البروتين الخام ومجموع المركبات الغذائية المهضومة و الطاقة المهضومة بإضافة تفل الزيتون وحمض الستريك لعلائق الأرانب .

سجلت الأرانب المغذاة علي 10 % تفل الزيتون أعلى قيم للتصافي والذبيحة والكبد و الحوائج المأكولة كنسب مئوية مقارنة بالمعاملات الغذائية الأخرى .

أظهرت الأرانب المغذاة علي العلائق التجريبية المحتوية علي 10 % تفل الزيتون و 0.1 % حمض الستريك أو 10 % تفل الزيتون انخفاض معنوي في مكونات بلازما الدم : الكوليسترول و التراي جلسرايد علي التوالي مقارنة بالمعاملات الأخرى بينما لا يوجد تأثير نتيجة للمعاملات الغذائية علي مستوى الدهون الكلية والبروتين الكلي والجلوبيولين , ونسبة الألبومين /الجلوبيولين و أنزيمات الكبد .

التوصية: يمكن التوصية باستخدام كسب تفل الزيتون بمعدل 10 % مع إضافة 0.1 % حمض الستريك لأنه يحسن من معدل الأداء للنمو واستهلاك العلف و العائد الاقتصادي في الأرانب النامية.