P-ISSN: 2304-3075; E-ISSN: 2305-4360
International Journal of Veterinary Science
www.ijvets.com; editor@ijvets.com

Research Article https://doi.org/10.47278/journal.ijvs/2022.155

Evaluation of Olive Leaves and Pomace Extracts in Growing Rabbit Diets on Productive Performance, Nutrient Digestibility, Carcass Characteristics, Antioxidant Status and Economic Efficiency

Fatma TF Abd-El Ghany[1], Shama H Morsy[1], HMA Hassan[2] and A Samy[2*]

[1]Animal Production Research Institute, Agricultural Research Center, Giza, Egypt
[2]Department of Animal Production, National Research Centre, 12622, Giza, Egypt
***Corresponding author:** Asamy1@yahoo.com

Article History: 22-565 Received: 11-Mar-22 Revised: 03-Apr-22 Accepted: 05-Apr-22

ABSTRACT

This study aimed to detect how supplementing olive leaves extract (OLE) and olive pomace extract (OPE) to growing rabbit diets has affected productive performance, nutrient digestibility, carcass characteristics, antioxidant status, and economic efficiency. At 42 days of age, 75 APRI growing rabbits were separated into five groups, 15 rabbits each. Control (without additives), OLE1 (200ppm of OLE), OLE2 (400ppm of OLE), OPE1 (200ppm of OPE), and OPE2 (400ppm of OPE) were the experimental diets. Throughout the trial, we computed feed consumption and increase in body weight on a weekly basis. Compared to the control group, the body weight, weight gain, and feed conversion ratio of rabbits fed OLE or OPE were significantly (P<0.05). The digestibility coefficient of crude protein-enhanced significantly (P<0.05) in rabbits fed OLE or OPE than in control rabbits. In addition to using OLE or OPE, the percentage of the carcass was improved dramatically (P<0.05). Total antioxidant capacity, Superoxide dismutase, and catalase levels were significantly (P<0.05) raised with OLE or OPE, while malondialdehyde levels were lowered. In conclusion, supplementing rabbit diets with 200 or 400ppm of OLE or OPE enhanced productive performance and antioxidant status without any negative effect on their health.

Key words: Olive leaves extract, Olive pomace extract, Growing rabbits, Productive performance, Nutrients digestibility, Antioxidants status.

INTRODUCTION

Population growth has demanded a necessary increase in animal protein sources, particularly from poultry and rabbits. Using feed additives may help for achieving this aim. Consequently, a variety of approaches were employed to boost animal production (Abd-Elsamee et al. 2012; Hassan et al. 2016, 2018; Mohamed et al. 2016; Elsherif et al. 2021). Antibiotics should not be used as a growth promoter in poultry, but only for treatment. This is because antibiotics as growth promoters not only raise the chance of multiple drug resistance in human pathogenic microorganisms, but they also cause cross-resistance. Furthermore, it has a negative impact on animal health and wellbeing. Furthermore, natural feed additives (herbs, plant extracts, and essential oils) have a positive effect on animal and poultry health (Abd-Elsamee et al. 2012; El-Banna et al. 2013; Vázquez 2015; Hassan et al. 2018; Elsherif et al. 2021) such as olive leaves extract (El-Damrawy et al. 2013; Shafey et al. 2013).

Olives (Olea europaea) are planted largely in the Mediterranean. Olive waste (leaves and pomace) is a serious environmental issue. Olive farming creates a wide range of by-products each year, (Abaza et al. 2015), including oil extraction by-products, pruning, and harvest wastes. As a result, incorporating these residues into farm animal diets may assist to reduce pollution and costs related with waste management and animal feeding. Olive leaves and pomace extract also contain a wide range of phenolic chemicals. Žuntar et al. (2019) reported that, the most abundant phenolic component in olive leaf extract is oleuropein. The polyphenols in olive leaves extract protect against bacterial development and lipid oxidation (Caponio et al. 2019). Several studies have discovered that phenolic compounds present in olive leaves have a wide range of biological properties, including antioxidant (Hamad 2015), anti-inflammatory (Laaboudi et al. 2016), antibacterial (Korukluoglu et al. 2010; Thielmann et al. 2017), antitumor and anticancer effects (Morsy and Abdel-Aziz 2014;

Cite This Article as: Ghany FTFA, Morsy SH, Hassan HMA and Samy A, 2023. Evaluation of olive leaves and pomace extracts in growing rabbit diets on productive performance, nutrient digestibility, carcass characteristics, antioxidant status, and economic efficiency. International Journal of Veterinary Science 12(1): 37-44. https://doi.org/10.47278/journal.ijvs/2022.155

Boss et al. 2016). Additionally, calves' digestive health may also be improved by adding Olea europaea extracts (Morrison et al. 2017). According to Gisbert et al. (2017), adding olive oil to sea bream diets improved growth performance by boosting hepatic lipid metabolism and intestinal function. Furthermore, phenolic compounds derived from olive leaves have antibacterial activity against intestine pathogenic bacteria, which may have advantageous effect on broilers health (Sarica and Ürkmez 2016). Furthermore, natural antioxidants may increase the activity of digestive enzymes in broilers, resulting in better meal digestion (Leskovec et al. 2018). Consequently, the goal of this study was to detect how supplementing olive leaves and pomace extracts to growing rabbit diets affected the growth, nutrient digestibility, carcass characteristics, blood parameters, and economic efficiency.

MATERIALS AND METHODS

Study Ethical Approval

The authors confirm that the ethical policies of the journal have been adhered to and the appropriate ethical review committee approval has been received. The authors followed EU standards for the protection of animals used for scientific purposes. The experimental work was conducted at Sakha Research Station in Kafrelsheikh Governorate, Animal Production Research Institute, Agricultural Research Center, the Ministry of Agriculture, Egypt. The laboratory part conducted at laboratories of National Research Centre, Animal Production Department, Egypt, and By-Products Research Department, Animal Production Research Institute, Agricultural Research Center, Egypt.

Extracts of Olive Leaves and Olive Pomace

Olive leaves and pomace were extracted using 65 percent ethanol with vigorous stirring for three hours adopting a heat reflux extraction procedure. The extract was then separated at 40°C using a rotary evaporator (Loghmanifar et al. 2020; Elsherif et al. 2021). Finally, Calcium carbonate was added as a carrier material to load the extracts separately, giving them the ability to use and mix with feed ingredients.

Experimental Diets

According to Agriculture Ministry Decree, 1996 requirements, the control diet was formed to meet all the nutritional needs of growing rabbits. Control (without additives), OLE1 (Olive leaves extract, 200ppm), OLE2 (olive leaves extract, 400ppm), OPE1 (olive pomace extract, 200ppm) and OPE2 (olive pomace extract, 400ppm) were the five treatments. The experiment lasted 56 days (from 42-98 days of age). Table 1 shows the composition of the control diet as well as the computed analyses.

Animals and Management

Seventy-five APRI growing rabbits were divided into five groups of 15 rabbits each at 42 days of age (624g average body weight). Rabbits were kept in battery cages with separate feeding units. Water and diets were available ad libitum. All the rabbits were kept in the same sanitary and managerial settings. Weekly feed intake and live body weight were recorded and the feed efficiency and body weight gained were computed.

Digestibility Trail

At the end of this experiment, seven rabbits from each group were used in a digestibility test. Feces were collected daily, weighed, dried at 60°C for 24 hours, roughly powdered, and stored for AOAC, 2000 chemical analysis. According to Pérez et al. (1995), the coefficients of digestion and nutritional values of the dietary treatments were calculated using data from amounts and chemical analyses of feed and feces.

Carcass Characteristics and Blood Samples

Five rabbits from each treatment were starved for 24 hours and slaughtered for carcass and internal organs at the end of the experiment. The percentages of carcass and organs as a percentage of live weights were calculated. Blood samples were taken from the slaughtered rabbits as well.

Analyses of Antioxidants Status

Blood serum samples were separated by centrifugation at 4000 rpm for 10 minutes, then stored at -20°C until chemical analysis. Total antioxidant capacity (TAC) and malondialdehyde (MDA) levels in blood serum were examined. The livers were also obtained for the measurement of hepatic CAT, SOD, and GSH antioxidant enzymes in an automated calibration spectrophotometer with high-performance readings (bio diagnostic, Cairo, Egypt) (FlexorEL200 Biochemical Analyzer).

Thyroid Hormone Concentration

Total T3 and T4 levels in the blood were measured using commercial ELISA kits (MyBioSource, Inc., San Diego, CA). By dividing the T3 value by the T4 value, the T3/T4 ratio was computed.

Cecum pH, Ammonia Nitrogen Concentration and Total Volatile Fatty Acids

Cecum contents samples were taken from slaughtered rabbits and utilized to measure cecum pH using a digital pH meter immediately. Conway (1958) technique was used to determine the ammonia nitrogen concentration. According to Eadie et al. (1967), the total volatile fatty acids in caecum were determined using steam distillation unit.

Economic Efficiency

At the end of the trial period, the economic efficiency profit of rabbit production were calculated using the following formula:

- (Total feed cost + additives cost) Equals total cost per rabbit.
- (Body weight gain (kg) x selling price of kg rabbit) Equals total return per rabbit (Egyptian pound, L.E).
- Total return per rabbit - total cost per rabbit equals net return per rabbit (L.E.).
- Net return per rabbit divided by total cost per rabbit equals economic efficiency (L.E.).
- Economic efficiency of each treatment calculated for each one with multiplying by 100 (control economic efficiency).

Table 1: Composition and chemical analysis of the control diet

Ingredient %	%	Chemical analysis	
Alfalfa hay	34.95	DM %	87.57
Barley grain	25.60	OM %	81.55
Soybean meal 44%	14.40	CP %	17.04
Wheat bran	20.55	CF %	13.38
Molasses	3.00	EE %	2.275
Limestone	0.40	DE (kcal/kg)[2]	2502
Salt	0.30	P %	0.534
Dicalcium phosphate	0.30	Ca %	0.795
Mimeral-vitamin premix*	0.30	Methionine %	0.445
DL-Methionine	0.20	Lysine %	0.805
Total	100		

*Mineral and vitamin premix: each 3kg contain the following: Vit. A (12000000IU), Vit. D3 (200000g), Vit. E (10g), Vit. K3 (2.5g), Vit. B1 (1.0g), Vit. B2 (5.0g), Vit. B6 (1.5g), Vit. B12 (10g), Pantothenic acid (10g), Niacin (30g), Choline chloride (500g), Zn (45mg), Folic acid (1.0g), Fe (30mg), Biotin (50mg) Mn (40mg), Co (100mg), Cu (3g), I (300mg), and Se (100mg). [2]DE was calculated according to values given in the feed composition tables of the NRC (1977).

Statistical Analysis

SAS, 2001 General Linear Models technique was used to examine the data. The statistical data of 95 percent dependability was analysed using one-way analyses of variance. Duncan's multiple rang test (Duncan 1955) was used to evaluate differences in means that were significant (P<0.05).

RESULTS

Performance Parameters

Table 2 shows the effects of olive leaves and pomace extracts on body weight (bwt), weight gain (WG), feed intake (FI), and feed conversion ratio (FCR) in growing rabbits. The results revealed that adding 200ppm (OLE1, OPE1) or 400ppm (OLE2, OPE2) of olive leaves extract or olive pomace extract raised the final bwt linearly (P<0.05). In comparison to the control diet, which had a final body weight of 2011g, OPE1 had the highest value (2175g). There were no significant variations in bwt between the groups given OLE or OPE at the two levels tested. The addition of OLE or OPE greatly improved WG at all ages, and the results of WG followed the same trend as bwt. OPE had a better effect on WG than OLE, although there were no significant differences between them. The feed intake of rabbits fed varied amounts of OLE or OPE in their diets was unaffected linearly (P<0.05). In terms of FCR, adding OLE or OPE to growing rabbit diets enhanced FCR linearly (P<0.05) during the period of the trial compared to the control group. The addition of OPE improved FCR more than the addition of OLE. At the overall ages of the rabbits, the results of the performance index (PI percent) and relative growth rate (RGR percent) demonstrated significant (P<0.05) differences across the dietary treatments. In comparison to the control, adding OLE or OPE to the rabbits' diets enhanced PI and RGR considerably. The rabbits fed on OPE1-enriched diet had the highest PI and RGR with values 69.31 and 113.12, respectively. In terms of PI and RGR, there were no significant changes between OLE and OPE.

Digestibility Coefficients and Nutritive Values

Table 3 shows the effect of olive leaves and pomace extracts on the digestibility coefficients and nutritional values of growing rabbits. The addition of OLE or OPE had no effect on the digestibility coefficients of CF, EE, or NFE. The addition of OLE or OPE raised the digestibility coefficient of CP substantially (P<0.05). The groups fed OLE2 and OPE2 had the best digestibility coefficients for DM, OM and CP. When compared to the control, the addition of OLE or OPE significantly (P<0.05) enhanced total digestible nutrients (TDN), digestible energy (DE), and digestible crude protein (DCP).

Carcass Characteristics

Table 4 shows the effects of dietary treatments on carcass traits. The addition of OLE or OLP enhanced significantly (P<0.05) carcass percent. The groups supplemented with OLE2 or OPE2 had the highest carcass percent. The proportion of live body weight of the liver, heart, kidney, giblets, and spleen did not change because of the varied additions. The control group had the greatest GIT percent, and dietary treatments supplementation with different levels of extracts significantly (P<0.05) reduced GIT weight as a proportion of live body weight.

Antioxidant Status

Table 5 shows the effects of dietary treatments on rabbit antioxidant enzymes. When compared to the control group, the addition of olive leaves extract or olive pomace extract at 200 and 400ppm significantly improved total antioxidant capacity (TAC), superoxide dismutase (SOD), and catalase (CAT). MDA, on the other hand, was considerably (P<0.05) reduced when OLE or OPE were added.

Thyroid Hormones

The results of thyroid hormones were found in growing rabbits, as shown in Fig. 1. The addition of olive leaves extract or olive pomace extract to growing rabbit diets at 200 or 400 ppm had no effect on T3, T4, or T4/T3 in any of the groups.

Caecum Fermentation Activities

Fig. 2 shows the effects of olive leaves and olive pomace extracts on caecum total volatile fatty acids (TVFAs), ammonia nitrogen and pH. The addition of OLE or OPE had a significant (P<0.05) influence on caecum TVFAs and ammonia concentrations. The TVFA values for the treatment groups varied from 4.16 to 4.14 (ml eq/100mL) compared to 3.85 for the control group. Treatment ammonia concentrations were from 8.49 to 8.32 mg/100mL, compared to 9.76mg/100 ml for the control. The pH levels were unaffected and varied from 5.80 to 5.57 for the treatment groups compared to 5.97 for the control group.

Economic Efficiency

Table 6 shows the impact of dietary treatments on economic efficiency (EE) and relative economic efficiency (REE). The results showed that adding OLE or OPE to the diet of rabbits improved their relative economic efficiency (REE) compared to the control group. When compared to the control diet, REE levels increased by 13.56 and 18.64 percent with OLE1 and OLE2, and by 25.42 and 19.49 percent with OPE1 and OPE2 for rabbit diets, respectively.

Table 2: Effect of olive leaf and pomace extracts on growth performance of rabbit

Item	Control	OLE1 200 ppm	OLE2 400 ppm	OPE1 200 ppm	OPE2 400 ppm	SE of mean	P value
Body weight (g)							
IBW (6 wk)	628	631	630	604	625	±5.75	0.310
At 10 wk	1329	1385	1389	1408	1415	±11.06	0.115
At 14 wk	2011^{b}	2133^{a}	2153^{a}	2175^{a}	2171^{a}	±16.71	0.001
Weekly gain (g)							
7-10 wk	701^{b}	754^{ab}	760^{ab}	804^{a}	790^{a}	±11.52	0.027
11-14 wk	683^{b}	748^{a}	764^{a}	768^{a}	757^{a}	±10.32	0.030
7-14 wk	1384^{b}	1502^{a}	1524^{a}	1572^{a}	1547^{a}	±17.59	0.001
FI (g)							
7-10 wk	1944	1968	1890	1918	1918	±10.80	0.198
11-14 wk	3043	3015	3004	3008	3030	±10.65	0.220
7-14 wk	4987	4983	4894	4926	4948	±15.21	0.270
FCR (g/g)							
7-10 wk	2.77^{a}	2.61^{ab}	2.49^{b}	2.39^{b}	2.44^{b}	±0.05	0.014
11-14 wk	4.46^{a}	4.03^{b}	3.94^{b}	3.92^{b}	3.99^{b}	±0.06	0.022
7-14 wk	3.60^{a}	3.32^{b}	3.22^{b}	3.14^{b}	3.20^{b}	±0.04	0.001
PI%	55.84^{b}	64.35^{a}	67.05^{a}	69.31^{a}	67.91^{a}	±1.31	0.001
GR	104.88^{b}	108.68^{ab}	109.40^{ab}	113.12^{a}	110.70^{a}	±0.86	0.017

^{a,b,c} Means in the same row with different superscript are significantly different (P< 0.05): bwt: body weight, WG: weight gain, FI: feed intake, FCR: feed conversion ratio Performance index% (PI) = final live body weight (kg)/feed conversion ratio x 100: Relative growth rate% (RGR) = (W2-W1)/(1/2(W2+W1))x100. Whereas: W1= initial bodyweight, W2= Final body weight (g).

Table 3: Effect of olive leaf and pomace extracts on nutrients digestibility of rabbit

Item	Control	OLE1 200 ppm	OLE2 400 ppm	OPE1 200 ppm	OPE2 400 ppm	SE of mean	P value
Nutrients digestibility%							
DM	61.33^{c}	63.03^{bc}	65.17^{ab}	62.83^{bc}	66.07^{a}	±0.55	0.011
OM	62.53^{c}	63.40^{c}	66.23^{ab}	64.30^{bc}	67.13^{a}	±0.54	0.007
CP	73.97^{b}	75.80^{b}	78.47^{a}	76.60^{ab}	79.23^{a}	±0.59	0.007
CF	34.80	35.57	35.77	36.10	37.87	±0.39	0.113
EE	77.87	75.27	74.27	75.67	74.90	±0.45	0.110
NFE	75.20	75.90	76.40	75.67	75.80	±0.27	0.212
Feeding value%							
DCP	12.84^{b}	13.16^{b}	13.62^{a}	13.30^{ab}	13.76^{a}	±0.10	0.007
DE	2825.27^{c}	2851.83^{bc}	2884.89^{a}	2857.12^{ab}	2880.71^{ab}	±6.75	0.007
TDN*	63.78^{c}	64.37^{bc}	65.12^{a}	64.50^{ab}	65.03^{ab}	±0.15	0.007

^{a,b} Means in the same row with different superscript are significantly different (P<0.05): *Total Digestible Nutrients (TDN).

Table 4: Effect of olive leaf and pomace extracts on carcass characteristics of rabbit

Item (%)	Control	OLE1 200 ppm	OLE2 400 ppm	OPE1 200 ppm	OPE2 400 ppm	SE of mean	P value
Carcass	59.53^{b}	64.16^{a}	64.94^{a}	64.19^{a}	64.94^{a}	±0.58	0.001
Liver	2.65	3.04	2.85	2.86	2.75	±0.05	0.121
Heart	0.33	0.36	0.33	0.34	0.35	±0.01	0.217
Kidney	0.56	0.58	0.55	0.55	0.57	±0.01	0.315
Giblets	3.54	3.99	3.72	3.74	3.67	±0.05	0.071
Spleen	0.06	0.05	0.06	0.06	0.06	±0.01	0.471
GIT	20.58^{a}	16.80^{b}	18.67^{ab}	17.52^{b}	18.25_{b}	±0.41	0.013
Abdominal fat	0.42^{a}	0.35^{c}	0.34^{c}	0.33^{c}	0.38^{b}	±0.01	0.003

^{a,b,c} Means in the same row with different superscript are significantly different (P<0.05).

Table 5: Effect of olive leaf and olive pomace extract on antioxidants status of rabbit

Item	Control	OLE1 200 ppm	OLE2 400 ppm	OPE1 200 ppm	OPE2 400 ppm	SE of mean	P value
TAC (mM/L)	0.88^{c}	1.22^{b}	1.48^{a}	1.49^{a}	1.49^{a}	±0.07	0.001
SOD (mM/g)	0.52^{d}	0.71^{bc}	0.75^{b}	0.67^{c}	0.82^{a}	±0.03	0.001
CAT (U/g)	0.46^{b}	0.54^{a}	0.54^{a}	0.53^{a}	0.54^{a}	±0.01	0.007
GSH (U/g)	138	147	145	146	146	±1.21	0.082
MDA (µM/ml)	13.88^{a}	13.74^{ab}	13.47^{bc}	13.65^{abc}	13.32^{c}	±0.06	0.020

^{a,b,c} Means in the same row with different superscript are significantly different at (P< 0.05): TAC: Tot al antioxidant capacity; SOD: Superoxidase dismutase; CAT: Catalase enzyme; GSH: Glutathione; MDA: Malondialdehyde.

DISCUSSION

Performance Parameters

Results finding are confirmed by Oke et al. (2017), who detected that supplementing olive leaves extract in the drinking water of broiler chicks enhanced final body weight, weight gain, and feed conversion ratio linearly (P<0.05). The induction of antimicrobial activity with olive leaves extract components may be linked to growth performance improvements of broilers fed with OLE in drinking water (10mL/L) (Jabri et al. 2017). Furthermore, the enhanced performance rate of rabbits given olive leaves

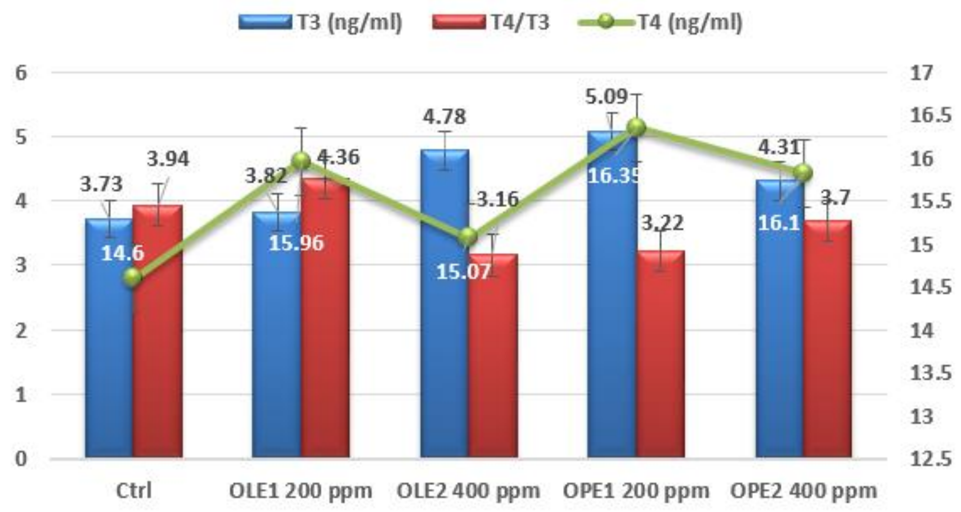

Fig. 1: Effect of olive leaf and olive pomace extracts on thyroid hormones of rabbit

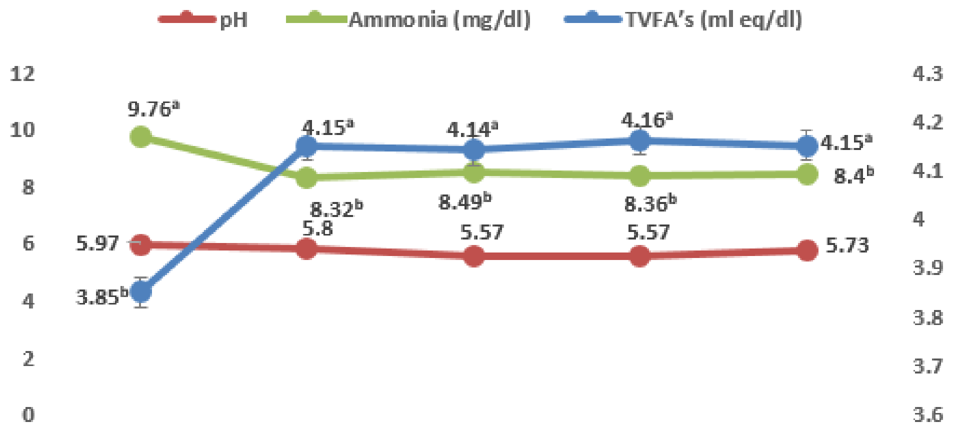

Fig. 2: Effect of olive leaf and olive pomace extract on cecum activity of rabbit.

Table 6: Economic efficiency and relative economic efficiency in rabbits

Item	Control	CE1 200 ppm	CE2 400 ppm	GE1 200 ppm	GE2 400 ppm
Body weight gain (g)	1384	1502	1524	1572	1547
Feed intake/rabbit (g)	4987	4983	4894	4926	4948
Feed cost/rabbit (LE[1])	34.91	34.88	34.26	34.48	34.64
Additives cost/rabbit (LE)*	0.00	0.40	0.65	0.40	0.65
Total cost/rabbit (LE)	34.91	35.28	34.91	34.88	35.29
Sale price/rabbit (LE)**	76.12	82.61	83.82	86.46	85.09
Net profit (LE)	41.21	47.33	48.91	51.58	49.80
Economic efficiency (EE)***	1.18	1.34	1.40	1.48	1.41
Relative EE (%)	100	113.56	118.64	125.42	119.49

Feed cost was calculated according to the price of different ingredients available in the market at experimental time: [1] LE=Egyptian Pound: *Include materials and solvent price: ** Body weight gain X 55.00 LE/kg: ***EE=Net profit/Total cost /rabbit.

extract might be attributable to the antioxidant, antibacterial, anti-inflammatory, and antiviral characteristics of olive leaves extract (Aliabadi et al. 2012). According to Shafey et al. (2013), adding olive leaves extract (0, 1.8, 3.6, and 6.25g/kg) to broiler diets had no effect on feed consumption. According to Bahsi et al. (2016), adding 400 ppm of oleuropein to Japanese quail meal boosted feed conversion ratio considerably. Ahmed et al. (2017) found that feeding laying hens 50, 100, or 150mg of oleuropein/kg diet enhanced egg production, egg mass, and feed conversion ratio considerably. Héla et al. (2019) found that adding olive leaves aqueous extract to the drinking water of developing rabbits at a concentration of 20ml/L boosted daily body weight growth and feed conversion ratio linearly ($P<0.05$). The inclusion of 750 ppm of an olive pomace extract containing 10% total triterpenes and 2% polyphenols considerably increased broiler chick development performance (Herrero-Encinas et al 2020). When OLE (75, 150, 300 and 600mg/kg) was added to broiler chicken diets, body weight gain, carcass weight, and feed conversion ratio were improved ($P<0.05$) linearly (Erener et al. 2020). The results of current study found that enhanced growth performance in rabbits given OLE or OPE might be linked to FCR, digestive enzyme activity, and nutrient absorption improvement, as well as controlling the gut microbiota, these findings also agreed with the findings of Zeng et al. (2015).

Digestibility Coefficients and Nutritive Values

The inclusion of OLE2 and OPE2 resulted in the greatest improvement in TDN, DCP, and DE percent. In terms of TDN, DCP, and DE percent, there were no significance differences between OLE1 and control. Broiler diets which contain olive leaves extracts, enhancing growth performance and feed efficiency due to the improvement in nutritional digestibility, digestive enzyme activation, and intestinal morphology (Leskovec et al. 2018). This improvement might be attributed to a decrease in digesta viscosity, which boosts nutrient and enzyme diffusion rates, allowing the animal to digest and absorb more nutrients, resulting in improved intestinal health (Morrison et al. 2017). Furthermore, phenolic compounds in olive leaves can act as antioxidants and antibacterial, resulting in the growth of beneficial microflora and the degradation of harmful or pathogenic microflora in the digestive tract and caecum, resulting in improved nutrient digestibility (Korukluoglu et al. 2010; Hamad 2015; Sarica and Ürkmez 2016; Thielmann et al. 2017; Elsherif et al. 2021).

Carcass Characteristics

Dietary treatments had significant (P<0.05) effect on abdominal fat. When compared to the control, adding OLE or OPE reduced abdominal fat significantly (P<0.05). These findings confirmed by those of Shafey et al. (2013), who found that adding 6.25g OLE/kg to the broiler chicken feed dramatically decreased carcass abdominal fat when compared to the control. The addition of 400ppm oleuropein to the diets of quail increased the performance and quality of breast muscle lipids (Bahsi et al. 2016). Decrease in abdominal fat might be linked to active components. That, polyphenol-rich plant extracts influence lipid metabolism and bile acid composition, which may lead to a reduction in abdominal fat (Fotschki et al. 2017).

Antioxidant Status

Total antioxidant capacity (TAC) is a crucial metric for all antioxidants found in the blood. In current study, increasing level of TAC in blood serum after supplementation with high antioxidant materials offers information on the absorption and bioavailability of ingested antioxidant chemicals (Ghiselli et al. 2000). Increased TAC, SOD, and CAT in response to dietary OLE or OPE supplementation may enhance rabbits' total antioxidant status. Olive leaves are a source of several phytochemicals that are considered as possible antioxidant sources (Jemai et al. 2008). Ahmed et al. (2017) detected that adding oleuropein to layer hen diets (50, 100 and 150mg/kg) enhanced SOD and TAC while decreased MDA concentrations considerably (P<0.05).

Thyroid Hormones

These results support the detection that phytogenic components and extracts are safe and have had no negative impact on poultry nutrition when used at these levels (Hassan et al. 2015; Elsherif et al. 2021).

Caecum Fermentation Activities

The addition of OLE or OPE led to increase in TVFAs and decrease in ammonia level might be due to phenolic compounds in olive leaves that have antibacterial action against intestinal or caecum pathogenic bacteria (Korukluoglu et al. 2010; Sarica and Ürkmez 2016; Thielmann et al. 2017). Furthermore, phenolic substances can enhance the formation of TVFAs by increasing the activity of digestive enzymes (Leskovec et al. 2018). As a result of improved intestinal and caecum health, ammonia levels are decreased (Morrison et al. 2017).

Economic Efficiency

These results revealed that adding OLE or OPE to rabbit diets lowers the relative cost per unit of body weight, making it more cost-effective to achieve maximal rabbit production. When compared to the control diet, Mehrez and Mousa (2011) detected that feeding growing rabbits diets enriched with olive pulp lowered the cost of diet/kg body weight growth while increased the values of economic efficiency. The increase in economic efficiency might be linked to the increase in FCR and body weight shown in rabbits fed on a diets supplemented with OLE or OPE.

Conclusion

These results suggested that including 200 and 400ppm of olive leaves or olive pomace extracts into the diet of growing rabbits might increase growth, carcass characteristics, antioxidant status, and economic efficiency without any negative effect on their health.

Author's Contribution

All authors contributed equally to study design methodology, interpretation of results, and writing of the manuscript.

REFERENCES

Abaza L, Taamalli A, Nsir H and Zarrouk M, 2015. Olive tree (Oleaeuropeae L.) leaves: Importance and advances in the analysis of phenolic compounds. Antioxidants 4: 682–698. https://doi.org/10.3390/antiox4040682

Abd-Elsamee MO, El-Sherbiny AE, Hassan HMA, Samy A and Mohamed MA, 2012. Adding phytase enzyme to low phosphorus broiler diets and its effect upon performance, bone parameters and phosphorus excretion. Asian Journal of Poultry Science 6: 129-137. https://dx.doi.org/10.3923/ajpsaj.2012.129.137

Ahmed MM, El-Saadany AS, Shreif EY and El-Barbary A M, 2017. Effect of dietary olive leaves extract (oleuropein) supplementation on productive, physiological and immunological parameters in Bandarah chickens 2-during production period. Egyptian Poultry Science Journal 37: 277-292.

Aliabadi MA, Darsanaki RK, Rokhi ML, Nourbakhsh M and Raeisi G, 2012. Antimicrobial activity of olive leaf aqueous extract. Annals of Biological Research 3: 4189-4191.

AOAC, 2000. Official Methods of Analysis 17th Ed. Association of Official Analytical Chemists. Washington DC, USA.

Bahsi M, Ciftci M and Simsek UG, 2016. Effects of olive leaf extract (oleuropein) on performance, fatty acid levels of breast muscle and some blood parameters in Japanese quail (*Coturnix coturnix* Japonica) reared in different stocking densities. Ankara University of Veterinary Fak Derg 63: 61-68.

Boss A, Bishop KS, Marlow G, Barnett MP and Ferguson LR, 2016. Evidence to support the anti-cancer effect of olive leaf extract and future directions. Nutrients 8: 513 https://doi.org/10.3390/nu8080513

Caponio F, Difonzo G, Calasso M, Cosmai L and De Angelis M, 2019. Effects of olive leaf extract addition on fermentative and oxidative processes of table olives and their nutritional properties. Food Research International 116: 1306-1317. https://doi.org/10.1016/j.foodres.2018.10.020

Conway EJ, 1958. Micro-Diffusion Analysis and Volumetric Error. 4th Ed. The McMillan Co., New York

Duncan DB, 1955. Multiple Range and Multiple F Tests. Biometric 11: 1- 42.

Eadie JM, Hobson PN and Mann SO, 1967. A note on some comparisons between the rumen content of barley fed steers and that of young calves also fed on high concentrate rations. Journal of Animal Production 9: 247. https://doi.org/10.1017/S0003356100038514

Banna AH, Latif A and Soliman M, 2013. Anticoccidial activity of *Allium sativum* and *Aloe vera* in broilers. International Journal for Agro Veterinary and Medical Sciences 7: 117-125.

El-Damrawy SZ, Khalifah MM and Fares WA, 2013. Dietary olive leaf and antioxidative status in chickens "performance, some physiological traits and immunological responses of Mandarah chicks supplemented olive leaves powder in their diets. Egyptian Poultry Science Journal 33: 279-287.

Elsherif HMR, Orabi A, Ali AS and Samy A, 2021. Castor and propolis extracts as antibiotic alternatives to enhance broiler performance, intestinal microbiota and humoral immunity. Advance in Animal and Veterinary Sciences 9: 734-742. http://dx.doi.org/10.17582/journal.aavs/2021/9.5.734.742

Erener G, Ocak N, Ozturk E, Cankaya S, Ozkanca R and Altop A, 2020. Evaluation of olive leaf extract as a growth promoter on the performance, blood biochemical parameters, and caecal microflora of broiler chickens. Revista Brasileira de Zootecnia 49: 1-11. https://doi.org/10.37496/rbz4920180300

Fotschki B, Juśkiewicz J, Jurgoński A, Rigby N, Sójka M, Kołodziejczyk K, Mackie A and Zduńczyk Z, 2017. Raspberry pomace alters cecal microbial activity and reduces secondary bile acids in rats fed a high-fat diet. The Journal of Nutritional Biochemistry 46: 13-20. https://doi.org/10.1016/j.jnutbio.2017.03.004

Ghiselli A, Serafini M, Natella F and Scaccini C, 2000. Total antioxidant capacity as a tool to assess redox status: critical view and experimental data. Free Radical Biology Medicine 29: 1106–1114. https://doi.org/10.1016/s0891-5849(00)00394-4

Gisbert E, Andree KB, Quintela JC, Calduch-Giner JA, Ipharraguerre IR and Pérez-Sánchez J, 2017. Olive oil bioactive compounds increase body weight and improve gut health and integrity in gilthead sea bream (Sparus aurata). British Journal of Nutrition 117: 351–363. https://doi.org/10.1017/s0007114517000228.

Hamad I, 2015. Antioxidant activity and potential hepato - protective effect of Saudi olive leaf extract. 2nd Int'l Conference on Advances in Environment, Agriculture & Medical Sciences, pp.10–13.

Hassan H, Youssef AW, Ali HM and Mohamed MA, 2015. Adding phytogenic material and/or organic acids to broiler diets: Effect on performance, nutrient digestibility and net profit. Asian Journal of Poultry Science 9: 97-105. https://dx.doi.org/10.3923/ajpsaj.2015.97.105

Hassan HMA, Samy A, El-Sherbiny AE, Mohamed MA and Abd-Elsamee MO, 2016. Application of nano-dicalcium phosphate in broiler nutrition: performance and impact on environmental pollution. Asian Journal of Animal and Veterinary Advances 11: 477-483. https://dx.doi.org/10.3923/ajava.2016.477.483.

Hassan HM, Samy A, Youssef AW and Mohamed MA, 2018. Using different feed additives as alternative to antibiotic growth promoter to improve growth performance and carcass traits of broilers. International Journal of Poultry Science 17: 255-261. https://dx.doi.org/10.3923/ijps.2018.255.261

Héla Y, Aymen H, Jihen J, Khalil A, Mohamed K, Jamel R and Atef M, 2019. Use of olive leaf aqueous extract (Olea europaea) in growing rabbits' diets. Journal of New Sciences 68: 4209-4213.

Herrero-Encinas J, Blanch M, Pastor JJ, Mereu A, Ipharraguerre IR and Menoyo D, 2020. Effects of a bioactive olive pomace extract from Olea europaea on growth performance, gut function, and intestinal microbiota in broiler chickens. Poultry Science 99: 2-10. https://doi.org/10.3382/ps/pez467

Jabri J, Kacem H, Yaich H, Abid K, Kamoun M, Rekhis J and Malek A, 2017. Effect of Olive leaves extract supplementation in drinking water on zootechnical performances and cecal microbiota balance of broiler chickens. Journal of New Sciences, Sustainable Livestock Management 4: 69-75.

Jemai H, Bouaziz M, Fki I, El Feki A and Sayadi S, 2008. Hypolipidimic and antioxidant activities of oleuropein and its hydrolysis derivative-rich extracts from Chemlali olive leaves. Chemico-Biological Interaction 176: 88–98. https://doi.org/10.1016/j.cbi.2008.08.014

Korukluoglu M, Sahan Y, Yigit A, Ozer ET and Gücer S, 2010. Antibacterial activity and chemical constitutions of oleaeuropaea l. leaf extracts. Journal of Food Processing and Preservation 34: 383–396. http://dx.doi.org/10.1111/j.1745-4549.2008.00318.x

Laaboudi W, Ghanam J, Aissam H, Merzouki M and Benlemlih M, 2016. Anti-inflammatory and analgesic activities of olive tree extract. International Journal of Pharmacy and Pharmaceutical Sciences 8: 414-419.

Leskovec J, Levart A, Žgur S, Jordan D, Pirman T, Salobir J and Rezar V, 2018. Effects of olive leaf and marigold extracts on the utilization of nutrients and on bone mineralization using two different oil sources in broilers. Journal of Poultry Science 55: 17–27. https://doi.org/10.2141/jpsa.0170059

Loghmanifar S, Roozbeh Nasiraie L, Nouri H and Jafarian S, 2020. Effects of different extraction methods on antioxidant properties and allicin content of garlic. Journal of Food Science and Hygiene 1: 16-25.

Mehrez AZ and Mousa MRM, 2011. Growth performance of rabbits fed olive pulp in North Sinai. Asian Journal of Animal Sciences 5: 317-329. http://dx.doi.org/10.3923/ajas.2011.317.329

Mohamed MA, Hassan HMA, Samy A, Abd-Elsamee, MO and El-Sherbiny AE, 2016. Carcass characteristics and bone measurements of broilers fed nanodicalcium phosphate containing diets. Asian Journal of Animal and Veterinary Advances 11: 484-490. http://dx.doi.org/10.3923/ajava.2016.484.490

Morrison SY, Pastor JJ, Quintela JC, Holst JJ, Hartmann B, Drackley JK and Ipharraguerre IR, 2017. Short communication: promotion of GLP-2 secretion in dairy calves with a bioactive extract from Olea europea. Journal of Dairy Science 100: 1940–1945. https://doi.org/10.3168/jds.2016-11810

Morsy NFS and Abdel-Aziz EM, 2014. Efficiency of olive (Oleaeuropaea) leaf extract as antioxidant and anticancer agents. Journal of Agroalimentary Processes and Technologies 20: 46-53.

NRC, 1977. National Research Council. Nutrient requirements of rabbits. National Academy of Sciences, Washington, DC, USA.

Oke OE, Emeshili UK, Iyasere OS, Abioja MO, Daramola JO, Ladokun AO, Abiona JA, Williams TJ, Rahman SA, Rotimi SO, Balogun SI and Adejuyigbe AE, 2017. Physiological responses and performance of broiler chickens offered olive leaf extract under a hot humid tropical climate. Journal of Applied Poultry Research 26: 376-382. http://dx.doi.org/10.3382/japr/pfx005

Pérez JM, Lebas F, Gidenne T, Maestens L, Xiccato G, Parigi-Bini R, Dalle zotte A and Coccu ME, 1995. Eurtopean reference method for in vivo determination of diet digestibility in rabbit. World Rabbit Science 3: 41-43.

Sarica S and Ürkmez D, 2016. The use of grape seed-, olive leaf- and pomegranate peel-extracts as alternative natural antimicrobial feed additives in broiler diets. European Poultry Science 80: 1–13. http://dx.doi.org/10.1399/eps.2016.121

Shafey TM, Al-Ruqaei IM and Almufarij SI, 2013. Effect of feeding olive leaves extract (oleuropein) on the performance, nutrient utilization, small intestine and carcass characteristics of broiler chickens. Journal of Animal and Veterinary Advances 12: 740–746. http://dx.doi.org/10.3923/javaa.2013.740.746.

Thielmann J, Kohnen S and Hauser C, 2017. Antimicrobial activity of Olea europaea Linné extracts and their applicability as natural food preservative agents. International Journal of Food Microbiology 251: 48–66. https://doi.org/10.1016/j.ijfoodmicro.2017.03.019

Vázquez RS, 2015. Performance of broiler chickens supplemented with Mexican oregano oil (Lippiaberlandieri Schauer). Revista Brasileira de Zootecnia 44: 283–289. https://doi.org/10.1590/S1806-929020150 00800003.

Zeng Z, Zhang S, Wang H and Piao X, 2015. Essential oil and aromatic plants as feed additives in non-ruminant nutrition: A review. Journal of Animal Science and Biotechnology 6: 1-10. https://doi.org/10.1186/s40104-015-0004-5

Žuntar I, Putnik P, Bursać Kovačević D, Nutrizio M, Šupljika F, Poljanec A and Režek Jambrak A, 2019. Phenolic and antioxidant analysis of olive leaves extracts (Olea europaea L.) obtained by high voltage electrical discharges (HVED). Foods 8: 248. https://doi.org/10.3390/foods8070248