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Impacts of the Dietary Supplementation of Oregano Leaves Extract and Its Bioactive Lipid Components on Nutrients Digestibility, Growth, and Carcass Traits in Rabbits.

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Abstract

The objective of the present study was to assess the effect of dietary supplementation of oregano leaves exctract (OLE) and its bioactive lipid compounds (BLC) as a natural feed additive on nutrient digestibility, growth performance, and carcass traits of rabbits. A total of 48 male weaned Sinai Gabali kits with an average live body weight of 806.24 gm were randomly divided into equal (12 kits/group) four experimental groups. The 1st group (T1) was fed the basal diet with no additives (control). The 2nd group (T2) was fed the basal diet supplemented with oxytetracycline antibiotic (OTC) at a level of 50 mg/ kg diet. The 3rd group (T3) was fed the basal diet supplemented with 8 ml/kg diet OLE + 0.75 ml/kg diet BLC. The 4th group (T4) was fed the basal diet supplemented with 12 ml/kg diet OLE + 1 ml/kg BLC. A total of nineteen active components in OLE were identified. The highest components were Rosemarinic acid (15.590 mg/L), Hesperidin (8.175 mg/L) and Myricetin (4.14 mg/L). The oregano BLC was mainly composed of carvacrol (14.6%), thymol (12.7%), β-fenchyl alcohol (12.9%), and δ-terpineol (7.6%). Supplementation of different levels of OLE and its BLC significantly improved dry matter, crude protein, and ether extract digestibility compared to the control group. Regarding the total digestible nutrients (TDN), rabbits fed the T4 diet recorded the highest value (78.73%), followed by the groups of T3, then T2. However, the control group had the lowest TDN (77.23%). Final live body weight, total weight gain, average daily weight gain, and feed conversion ratio were significantly improved with the dietary inclusion of OLE and its BLC compared with the control group. No significant differences between the treatment and control groups in liver, heart, lung, trachea, and leg weights were identified. However, T4 had significantly ($P<0.05$) higher body weight at slaughtering, kidneys, and belt weights compared with the control group.

Keywords*: Oregano; Exctract; Bioactive Lipid Compounds; Growth performance; Sinai Gabali*

Introduction

Recently, in Egypt, the rabbit production increased significantly to meet the rising demand for meat for human use and providing an additional source of revenue for farms or small families (Abdel-Wareth *et al*., 2018). The use of antibiotics as growth promoters in animal feed was prohibited by EU laws (Regulation (EC) No. 1831/2003; Anon, 2003) because of antibiotic resistance and the possible existence of antibiotic residues in products derived from animals meant for human consumption. Therefore, the search for alternatives to antibiotic growth promoters has become critical. Consequently, studies have been conducted investigating the potential of phytogenic feed additives for rabbit nutrition (Dalle Zotte *et al*., 2020; Ahmed *et al.*, 2022; Mohamed *et al.*, 2023).

The medicinal plants and their extracts are rich organic sources of necessary nutrients for human and animal species, herbs have been used for a long time to treat a wide range of diseases and support good health (Kuralkara and Kuralkarb, 2021). Nutritional researchers from all over the world worldwide have been interested in using these natural herbs and their extracts as dietary supplements to enhance animal performance, nutritional value, and carcass quality. In animal feed, extracts from well-known herbs such as clove, garlic, thyme, turmeric, and cinnamon can be used as a natural feed additive (Elsherif *et al.*, 2021), Because and because of their antimicrobial effects on the animal digestive system, herbal plants, and essential oil extracts received more attention. Since they improve the gut health and intestinal microbiota, simulate the antioxidant status, increase the immune response, improving the animal performance and carcass traits (Lamiaa *et al.,* 2022). To improve the health, growth, and productivity of rabbits, diets might include herbs and plant bioactive lipid compounds, which are sometimes referred to as "essential oils" (Hausmann *et al*., 2017).

Oregano (*Origanum vulgare*) is a popular medicinal herb that is recognized for its antioxidant, antibacterial, and immunity-boosting characteristics, due to its active components (Abdel-Wareth *et al.*, 2018). Oregano and plant bioactive lipid compounds were proven to have the desired impacts on broiler growth performance, health, metabolism, and gastrointestinal secretions (Pukrop *et al*., 2019). Although However the positive effects of the combination between herbs and their BLC are proven. The studies assessing the effects of different levels of oregano leaves extract and their respective BLC on the nutritional statuses and productive performance of growing rabbits are scarce (Ahmed *et al.*, 2022). So, this study aims to evaluate the inclusion of different levels of OLE and its BLC as feed additives in rabbit diets and their influence on growth performance, nutrients digestibility, and carcass characteristics of weaned Sinai Gabali rabbits.

Materials and Methods

This experiment was carried out from June to October 2022 in the rabbitry of the Department of Animal Production, Faculty of Agriculture, Benha University. Oregano leaves exctract and its bioactive lipid compounds were prepared at the laboratory of the Food Science Department, Faculty of Agriculture, Cairo University. The OLE and BLC were quantitively identified at the Research Park of the Faculty of Agriculture, Cairo University.

Preparation of Oregano Extract

Preparation of aqueous extract

The oregano leaves were obtained from the Agriculture Research Centre, Ministry of Agriculture, Egypt. The bioactive lipid compounds and cold-water extracts were made from the dried leaf sections. The extracts were made by soaking 100 g of dried plant material in water for three days at room temperature. Filtered with filter paper in a funnel (Whatman no. 5). A modified Clevenger apparatus was used to hydro distill 75 g of dry plant material for three hours in order to extract the bioactive lipid compounds of oregano. The dried material absorbs water during the boiling process, allowing the essential oil (bioactive lipid molecules) of oregano to seep through the cell walls by osmosis. Afterward, the oil vaporizes and is removed by the stream. Following the procedure described by Zinno *et al*. (2023), extract and bioactive lipid compounds were prepared.

Preparation of Oregano emulsified Oregano bioactive lipid compounds.

Tween 80 was given by Sigma Aldrich Company, and the water had been distilled. The emulsion was prepared at the Laboratory of the Department of Animal Production, Faculty of Agriculture, Benha University, Egypt. As reported by Mohamed *et al.* (2022), the BLC was prepared by blending oregano bioactive lipid compounds with 10 mL of Tween 80 as a surfactant, and then adding 80 mL of distilled water. After good mixing, the components were homogenized for 5 minutes using a homogeneous blender (1500 watt), and distilled water was slowly added to the mixed oil phase.

Oregano leaves extract composition identification by high liquid gas chromatography (HPLC)

The Agilent1260 infinite HPLC Series (Agilent, USA) has a Quaternary pump and a Kinetex@1.7µm EVO, C150 mm x 4.6 mm column (Phenomenex, USA). The system was set to 30 degrees Celsius. A ternary linear elution gradient is used to produce the separation, utilizing (A) HPLC grade water and 0.1% Trifluoroacetic acid. (B) acetonitrile (c) methanol, flow rate 1 mL/min. The injection volume was 20 µL. Detection: varied wavelengths detector setup at 280 nm at 20 °C and 38% relative humidity.

The total phenolic content of oregano leaves

The Folin- Ciocalteu reagent was used to measure the colorimetry of total phenols. The total phenolic content was computed using the standard plot regression equation "y=1001.1x+4.4832, r2=0.9993", and the results have been expressed as milligram gallic acid equivalent/L sample. The temperature and humidity were 24.6 °C and 32.3% rH, respectively **(Singleton and Rossi, 1965**).

Identifying the bioactive lipid components in oregano leaves

Using an Agilent 6890 gas chromatograph connected to an Agilent 5973N mass selective detector (Agilent Technologies, PaloAlto), the bioactive lipid components (essential oil) of oregano were examined.A fused silica capillary column ‘30 m length ×0.32 mm internal diameter ×0.25 µm film thickness, HP-5MS, 5% diphenyl, 95% dimethyl poly dimethyl siloxane, Agilent Technologies” was inserted into a vaporization injector running in the split mode (1:50) at 250◦C. The oven temperature was set to 45°C for one minute, then increased to 250°C at 5°C min−1, and stayed there for five minutes. A 1 µL injection volume and a carrier gas of helium operating at 30 cm s−1 were utilized. The temperatures of the quadrupole analyzer, ion source, and transfer line were kept at 150◦C, 280◦C, and 230◦C, respectively. A turbo molecular pump (10−5 Torr) was employed. At 70 eV electron energy, electron ionization mass spectra in the 40–400 Da range were acquired in the full-scan mode. Three minutes was chosen as the solvent delay.

Animals and experimental design

A total of 48 weaned male Sinai Gabali rabbits with an average live body weight of 806.24 g were randomly assigned to four experimental groups (12 kits/group). The 1st group (T1) was fed on the basal diet with no additives (control). The 2nd group (T2) was fed on the basal diet supplemented with oxytetracycline antibiotic (OTC) at a level of 50 mg/ kg diet. The 3rd group (T3) was fed on the basal diet supplemented with 8 ml/kg diet OLE + 0.75 ml/kg diet BLC. The 4th group (T4) was fed on the basal diet supplemented with 12 ml/kg diet OLE + 1 ml/kg BLC. The composition of the basal ration is presented in Table 1. The BLC has been emulsified for easy addition and homogeneous distribution in the rabbit's different treatment diets. The additives were applied by spraying completely on the pelleted rabbit feed, and then dried and kept in a clean, well-ventilated feed store until use.

Table 1. Feed ingredients and chemical composition of the basal diet

Basal diet			
Composition		**nutrient content**	
Ingredient	**(%)**	**Component**	**(g/kg)**
Yellow corn	9.4	Organic matter	93.06
Soybean meal	18.85	CP	17
Wheat bran	7.2	EE	2.18
Barley grain	27.78	CF	13.4
Berseem hay	30.6	Ash	5.3
Molasses	3	[2]Calculated DE (kcal/ kg DM)	2796.42
Dicalcium phosphate	1.3		
Limestone	0.7		
Premix[1]	0.57		
Salt	0.6		
Total	100		

DE: Digestible energy (kcal/kg), CP: Crude protein%, CF: Crude fiber%, EE: Ether extract%,
1vitamin contains 6000.0 IU of A, 900.0 IU of D, 40.0 mg of E, 2.0 mg of K3, 2.0 mg of B1, 2.0 mg of B2, 4.0 mg of B6, 2.0 mg of B12, 10.0 mcg of Nicotinic acid, 50.0 mg of Biotin, 10.0 mg of Folic acid, 250.0 mg of Choline chloride, 50.0 mg of Zinc, 85.0 mg of Manganese, 50.0 mg of Iron, 5.0 mg of Copper, 5.0 mg of Iodine, 0.2 mg of Selenium, 0.1 mg, and Cobalt, 0.1 mg of Vitamin B12.

[2]Digestible energy (kcal/kg DM)= 4253 - 32.6 CF (% DM) – 114.4 Ash (% DM). According to **Fekete and Gippert (1986).**

Growth performance trial

In order to protect the experimental kits from weaning shock, immediately after weaning and prior to the feeding trial, the young rabbits were fed on barley and dry experimental feed for one week as an adaptation period. The growth trial continued for 90 days. The rabbits' nutritional requirements have been modified in accordance with **NRC (1977)**. The dietary requirements were changed for the experimental animals depending on their weights which were recorded biweekly. Over the entire experimental period, fresh water was freely provided.

Nutrients digestibility trial

After the end of the growth trial, twelve rabbits (three from each experimental group) randomly chosen were used in a digestion trial to determine the apparent digestibility coefficient and nutritional value of the experimental diets. During the four-day collection period, a plastic net was placed under the animal cages for collecting non-urine waste. Afterwards, 2% boric acid was sprayed on the nets to trap ammonia. The feces were ground up after drying in an oven at 60°C to get two constant weights during the collection time. Feed and feces samples were chemically analyzed according to A.O.A.C (2005) to estimate the nutritional value and digestibility coefficients of nutrients for each dietary treatment following the procedure described by Abou–Raya *et al.* (1974).

Carcass trait

After the end of the growth trial, twelve rabbits (three from each experimental group) were randomly chosen, weighed, and slaughtered according to the Islamic procedure. The individual live body weight, head, front legs, back legs, hot carcass, liver, gut, kidneys, lungs, back, ribs, and shoulders were weighed (Steven *et al.*, 1996).

Statistical analysis

According to the following statistical model, data were analyzed using one-way analysis of variance: $Y_{ij} = \mu + T_i + e_{ij}$ where Y_{ij} is the observation; μ is the overall mean; T_i is the treatment fixed effect ($T1$ to $T4$); and e_{ij} is the residual of the model. Duncan's Multiple Range Test (Duncan, 1955) checked the significance ($P < 0.05$) of the differences between treatment means. Statistical analyses were performed by using SAS software (SAS, Version 9.4. SAS Institute Inc., Cary, NC, 2014).

Results and discussion

Identifying the composition of Oregano leaves extract and its bioactive lipid components.

Chemical composition of the Oregano leaves Extract.

Nineteen compounds were identified in oregano leaves extract (Table 2). The oregano leaves extract was mainly composed of Gallic acid, Catechol, Catechin, Vanillic acid, Chlorogenic acid, Syringic acid, P Coumaric, Ferulic, O Cumaric, Rutin, Hesperidin, Resveratrol, Myricetin, Rosemarinic acid, Quercetin, Kaempferol, Apigenin7-O-glucoside, Caffeic acid and P hydroxybenzoic. The highest components in the extract were Rosemarinic acid (15.590 mg/L), Hesperidin (8.175 mg/L), and Myricetin (4.14 mg/L), as shown in Figure 1. Table 3 shows the total phenols were (395.76 mg gallic acid equivalent /I). The major compounds identified were luteolin-7-O-glucoside, apigenin-7-O-glucoside, taxifolin, phloridzin, scutellarein, eriodictyol, luteolin, quercetin, pinocembrin, naringenin and galangin; the study also presented the detection and measurement of 23 flavonoids as previously found in Mexican oregano leaves (Lin *et al*., 2007).

HPLC analysis was used by Chun *et al*., (2005) to determine the phenolic profiles in various oregano extracts, coumaric acid, Quercetin, rosmarinic acid, protocatechuic acid, and caffeic acid are the five main phenolic metabolites that have been found. GC-MS was used to examine the volatile fragrance components found in the extracts. Using GC-FID and GC-MS, 46 chemicals, or more than 98% of the overall composition, were identified from the essential oil extracted from oregano leaves (*Origanum compactum*). The most common chemical substance was carvacrol (36.46%), which was followed by p-cymene (24.31%) and thymol (29.74%). El Babili *et al.*, (2011) reported that several chemical substances were extracted from parts of oregano through serial extractions using petroleum ether, ethanol, ethyl acetate, and water. These extracts included polyphenols (equivalent gallic acid to 21.2 to 858.3 g/kg), tannins (equivalent catechin to 12.4 to 510.3 g/kg), anthocyanins (equivalent to cyanidin equivalent 0.38 to 5.63 mg/kg), and flavonoids (equivalent quercetin to 14.5 to 54.7 g/kg). A phenolic acid with the highest anti-inflammatory and antioxidant properties was the rosmarinic acid (Peng *et al*., 2019).

Zouari *et al*. (2013) found that monoterpenes like γ-terpinene, a monoterpene hydrocarbon that gives oregano its distinct aroma, are the second major class of bioactive chemicals commonly present in oregano extracts. They also added the presence of p-Cymene, another mono- terpene molecule, in oregano extracts. β-Caryophyllene, a sesquiterpene molecule having analgesic and anti-inflammatory features, is one of the key bioactive chemicals commonly present in oregano extracts (Karkovic Markovic *et al.*, 2018). Linalool, a monoterpene alcohol with antibacterial and sedative effects, is also present in oregano extract (Zouari et al., 2013). Borneol, as a bicyclic monoterpene alcohol, has a variety of medicinal uses (Markovic et al., 2018). Many factors, such as the plant part (flowers, leaves, or stems), the extraction process (e.g., supercritical fluid extraction, hydro distillation), and the geographic origin have been found to affect the extract amount of these compounds (Zouari et al., 2013).

Table 2. The major bioactive compounds of the oregano leaves extract

Name	Compound Expected Ret (time)	Retention time RT [min]	Area	Amount [mg/L]
Gallic acid	2.900	2.89	301.1286	0.898
Catechol	3.230	3.29	96.6254	0.955
Catechin	5.700	5.79	11.9673	0.174
Vanillic acid	6.200	6.16	293.5392	1.462
Chlorogenicacid	6.725	6.60	91.1951	0.855
Syringic acid	6.941	7.07	37.2425	0.106
P Coumaric	7.900	7.89	251.7607	0.559
Ferulic	9.270	9.34	68.8804	0.783
OCumaric	9.550	9.81	30.1528	0.053
Rutin	10.900	10.83	42.4129	0.183
Hesperidin	12.000	11.66	1349.2063	8.175
Resveratrol	12.300	12.31	12.4400	0.108
Myricetin	12.600	12.84	1156.6847	4.142
Rosemarinic acid	13.700	13.60	1223.4545	15.590
Quercetin	14.405	14.28	9.4510	0.302
Kaempferol	16.060	15.80	227.2796	0.953
Apigenin7-*O*-glucoside	16.280	16.41	208.6385	0.094
Caffeic acid	12.000	11.66	1349.2063	6.4
P hydroxybenzoic	12.600	12.84	1156.6847	4.8

Signal: VWD1 A, Wavelength=280 nm

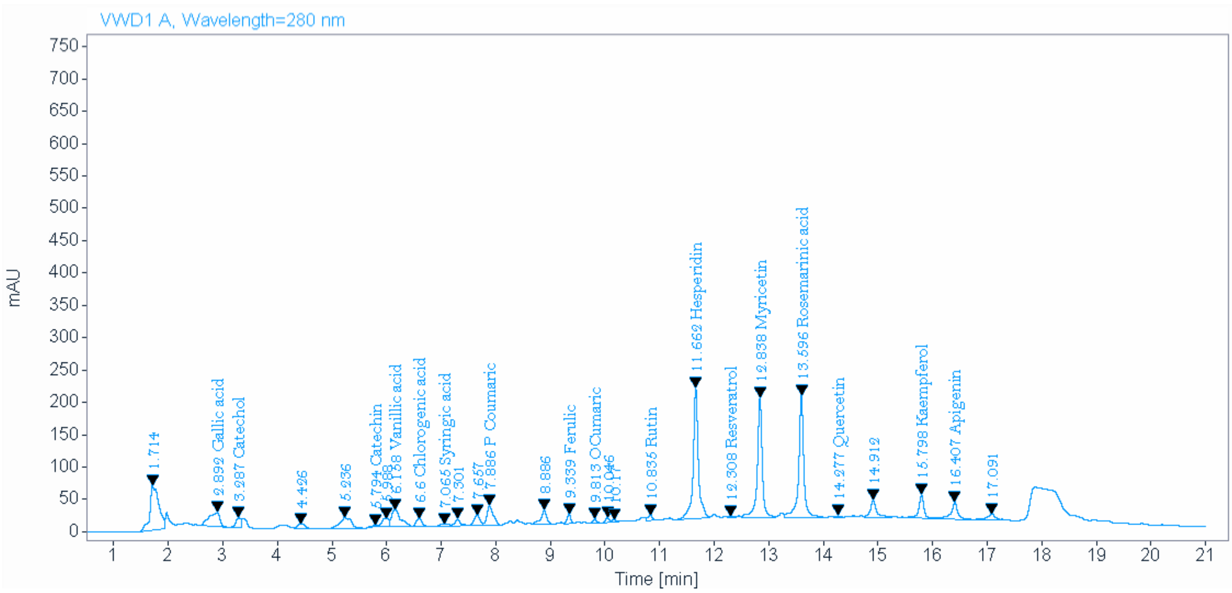


Figure 1. The main biologically active compounds in the extract of oregano leaves

Table 3. Determination of Oregano leaves extract total phenols

item Identifier	Determination of Total phenols (mg gallic acid equivalent /l)
Phenolic extract	395.76

Chemical composition of the Oregano bioactive lipid compounds

Oregano essential oil was found to contain fourteen various components (Table 4 and Figure 2). Carvacrol (14.6%), thymol (12.7%), β-fenchyl alcohol (12.9%), and δ-terpineol (7.6%) were the main chemicals found in the oregano bioactive lipid components. The most common monoterpene hydrocarbons found were γ-terpinene (11.7%) and α-terpinene (3.8%). Additionally, a significant portion of the oregano essential oil was comprised of 1-methyl-3-(1-methylethyl)-benzene (6.9%).

The type of plant, growth environment, and extraction techniques can all affect the content of oregano extracts. However, phenolic chemicals like carvacrol, which comprised about 60–80% of the total phenolic content, are the first significant bioactive components commonly detected in oregano extracts (Gilling *et al*., 2014; Marchese *et al.*, 2016). The main phenolic component that is frequently found in substantial levels is thymol (Marchese et al., 2016). High antioxidant properties are possessed by carvacrol, thymol, linalool and γ-terpinene. Moreover, carvacrol and thymol have antibacterial activity against several microorganisms (Teixeira *et al.*, 2013).

Carvacrol is commonly recognized as the principal active component in oregano essential oil, accounting for 50% to 80% of the total composition of essential oils (Baser, 2008). Another important phenolic component that can be found in large quantities in oregano essential oil is thymol, which usually comprises between 5% and 30% of the oil's (Bakkali *et al*., 2008). Another monoterpene that is frequently found in oregano essential oil is γ-terpinene, which usually makes about 5% to 15% of the oil (Alavijeh *et al*., 2012).

Table 4. The percentage of the main bioactive components of the Oregano bioactive lipid compounds

item Identifier	%
Carvacrol	14.6
Thymol	12.7
β-fenchyl alcohol	12.9
δ-terpineol	7.6
γ –terpinene	11.7
α-terpinene	3.8
1-methyl-3-(1-methylethyl)- benzene	6.9
Carvacryl methyl ether	0.5
Thymyl methyl ether	0.2
α-Thujene	2.3
α-Pinene	0.8
Sabinene	1.1
cis-β-Ocimene	1.7
α-Terpinolene	0.9

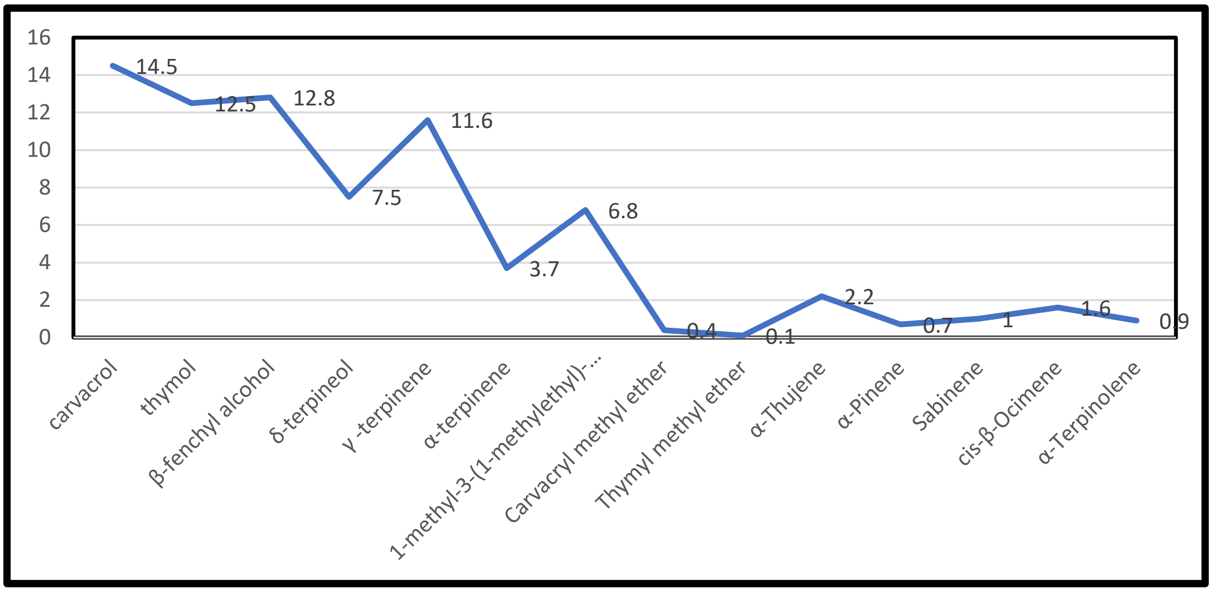


Figure 2. The proportion of the main bioactive compounds of the Oregano bioactive lipid compounds

Effect of oregano leaves extract and its bioactive lipid compounds on digestibility, and nutritive values of the experimental diets.

The effects of oregano leaves extract and its bioactive lipid components on the digestibility of some nutrients are presented in Table 5. The inclusion of OLE and its BLC in the rabbits' diets did not significantly affect CF, and NFE digestibility. However, dietary supplementation of different levels of OLE and its BLC significantly improved the digestibility of DM, CP, and EE compared to the control group. Regarding TDN, rabbits fed T4 diet recorded the highest value (78.73%) followed by group of T3, then T2 (Table 5). However, the control group had the lowest TDN (77.23%). These improvements may be attributed to the antimicrobial and antioxidant properties of the active compounds in oregano, such as carvacrol and thymol, which may have enhanced nutrient utilization and gut health. In this regard, Giannenas et al., (2016) observed that adding oregano extract to the diet of growing rabbits increased the apparent digestibility of ether extract, crude protein, and crude fiber when compared to the control group. Similarly, Giannenas et al. (2018) found that adding oregano extract to rabbit diets boosted the apparent digestibility of organic matter, dry matter, and crude protein. They attributed these desired effects to that the phytochemicals in oregano extract may have altered the gastrointestinal microbiota, enhancing digestion and absorption. Moreover, they hypothesized that oregano extract's antimicrobial properties may have minimized the proliferation of pathogenic bacteria, resulting in enhanced digestibility of nutrients (Al-Fataftah and Abdel Qader, 2017). Additionally, Botsoglou *et al.* (2019) stated that dietary supplementation with oregano extract improved the apparent digestibility of organic matter, dry matter, ether extract, and crude protein in rabbits due to the antioxidant and gut-health-promoting influences caused by the active compounds in oregano leaves essential oil.

Table 5. Digestibility, nutritive values of experimental diets.

Item	Treatments				SEM*
	Control T1	**T2**	**T3**	**T4**	
Digestibility coefficients %					
DM	79.27[b]	81.61[a]	81.11[a]	81.31[a]	0.46
OM	79.20[b]	81.16[a]	80.68[ab]	80.58[ab]	0.43
CP	86.73[b]	88.56[a]	88.29[a]	88.40[a]	0.33
CF	56.61	58.89	57.39	56.73	1.06
EE	81.65[c]	87.13[ab]	85.60[b]	88.62[a]	0.65
NFE	81.93	71.71	83.45	83.29	5.91
Nutritive value %					
digestible crude protein (DCP)	14.74	15.05	15.00	15.02	0.05
Total digestible nutrient (TDN)	77.23[b]	79.22[a]	78.70[a]	78.73[a]	0.44

a,b,c, mean within the same row with differing superscripts are significantly differ (P<0.05). *SEM- Standard error mean.

T1: Rabbits fed control diet without any supplementation.

T2: Rabbits fed control diet supplemented with antibiotics Oxytetracyclinne 50 mg/kg diet..

T3 Rabbits fed control diet supplemented with 8 ml/kg diet oregano leaves extract + 0.75 ml/kg diet Oregano bioactive lipid compounds T4: Rabbits fed control diet supplemented with and 12 ml/kg diet oregano leaves extract + 1 ml/kg Oregano bioactive lipid compounds.

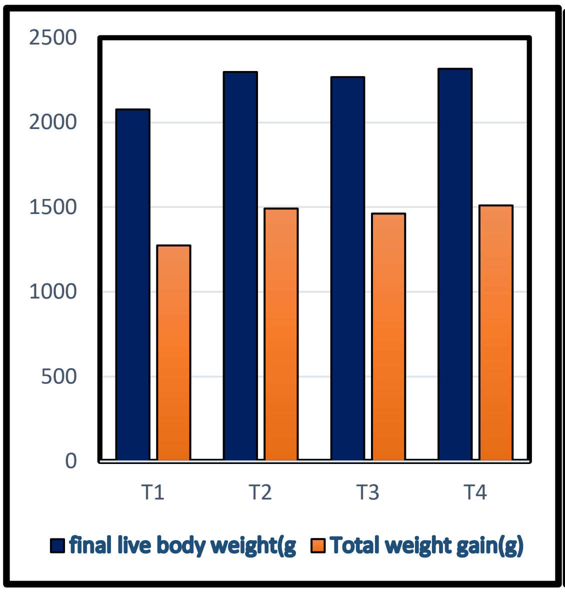
Effect of oregano leaves extract and its bioactive lipid compounds on growth performance.

Table 6 showed no significant (P>0.05) differences between the control and T2, and T3 and T4 in the initial live body weight were observed. Final live body weight, total weight gain, average daily weight gain, and feed conversion ratio for the T4 group were significantly (P<0.05) superior compared with the control group (Table 6 & Figures 3 and 4). The improvement in the rabbit growth performance may be due to the antimicrobial and antioxidant properties of the active compounds in oregano, such as carvacrol and thymol, and the phytochemicals in oregano extract (Table 4), which may have enhanced nutrient utilization and gut health in the growing rabbits. These results are in accordance with those of Bahakaim *et al.*, (2020), who evaluated the impact of dietary inclusion of 300 and 600 µl of oregano essential oil (OEO) in chicken diets and found that the chickens fed 600 µl OEO was significantly heavier than those fed 300 µl OEO and the control diet. These improvements in the growth performance of broiler dietary supplemented with OEO may be attributed to the OEO caused an increase in the height of intestinal villi and reducing pathogenic bacteria, boosts absorption of the area, and enhances digestion, absorption and utilization of nutrients (Skoufos *et al*., 2016). Similarly, Botsoglou *et al.* (2015) found that dietary inclusion of OLE in the rabbit diets significantly improved feed conversion ratio and average daily weight gain when compared to the control group. Moreover, Al-Fataftah and Abdelqader (2017) and Giannenas *et al*. (2018) stated that feeding rabbit diets supplemented with OLE resulted in higher body weight gain, and improved feed efficiency. Furthermore, Salama *et al.* (2023) found that adding OLE to broiler diets enhanced growth performance, feed efficiency, and the carcass characteristics. They added that the active compounds in oregano essential oil are likely to have antioxidant, antimicrobial, and gut-health-promoting properties, which are responsible for improving growth traits.

Table 6: Effect of oregano leaves extract and its bioactive lipid components on growth performance of rabbits

Items	Treatments				
	Control T1	**T2**	**T3**	**T4**	**SEM***
Initial live body weight (g)	805.83	806.66	805.41	807.08	1.56
Final live body weight (g)	2077.08[c]	2297.50[ab]	2266.67[b]	2316.50[a]	14.44
Total weight gain (g)	1273.33[c]	1490.83[ab]	1461.25[a]	1509.42[a]	13.54
Average daily weight gain (g)	14.15[c]	16.56[ab]	16.23[b]	16.76[a]	0.15
Average feed intake (g) DMI	100.00	100.00	100.00	100.00	0.00
Feed conversion ratio (FCR)	7.06[a]	6.04[bc]	6.16[b]	5.97[c]	0.05

a,b,c, mean within the same row with differing superscripts are significantly differ (P<0.05). *SEM- Standard error mean.
T1: Rabbits fed control diet without any supplementation.
T2: Rabbits fed control diet supplemented with antibiotics Oxytetracyclinne 50 mg/kg diet..
T3 Rabbits fed control diet supplemented with 8 ml/kg diet oregano leaves extract + 0.75 ml/kg diet Oregano bioactive lipid compounds T4: Rabbits fed control diet supplemented with and 12 ml/kg diet oregano leaves extract + 1 ml/kg Oregano bioactive lipid compounds.



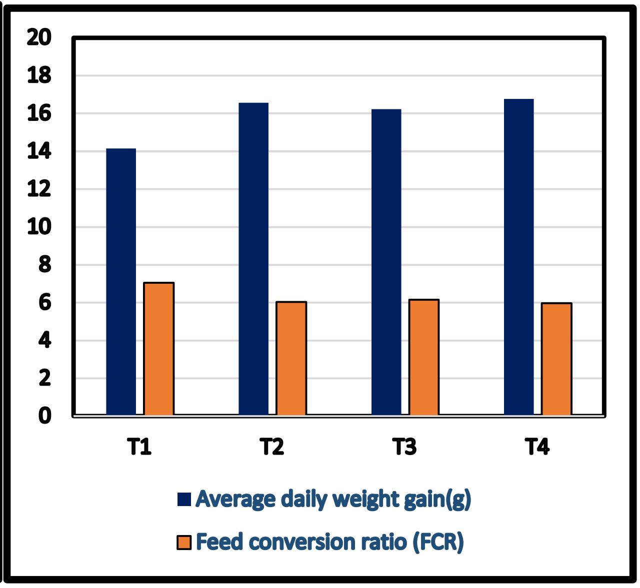


Figure 3: Effect of oregano leaves extract and its bioactive lipid components on final live body weight (g) and total weight gain (g)

Figure 4: Effect of oregano leaves extract and its bioactive lipid components on average daily weight gain(g) and Feed conversion ratio (FCR)

Effect of oregano leaves extract and its bioactive lipid components on carcass characteristics

No significant (P>0.05) differences between the control and T1, T2, T3, and T4 in liver, heart, lung and trachea, and leg weight were observed (Table 7). Conversely, body weight at slaughtering kidneys and weights were significantly (P<0.05) higher in the T4 compared with the control group. T1 and T2 had significantly lower belt weight values (P < 0.05) than T3 and T4. T3 and T2 had considerably higher rack and loin weights than the other experimental groups. The improved carcass traits in the treated groups may be attributed to the potential antimicrobial, antioxidant, and growth-promoting properties of the bioactive compounds in oregano extract and the potential gut-health-promoting effects of the active compounds in oregano essential oil, which may have enhanced nutrient utilization and overall carcass development. In this respect, Giannenas *et al*. (2018) and Botsoglou *et al.* (2019) observed that rabbits fed diets supplemented with OLE had heavier carcass weights, higher dressing percentages, and increased proportions of valuable market carcass cuts than the control group.

Table 7. Effect of oregano leaves extract and its bioactive lipid components on carcass characteristics of rabbits

Item	Treatments				SEM*
	Control T1	T2	T3	T4	
Carcass traits (g)					
Body weight at slaughtering	1752.50[c]	2276.67[b]	2333.33[a]	2370.00[a]	12.62
Kidneys weight	15.15[b]	13.72[b]	19.07[a]	16.88[a]	1.08
Liver weight	64.95	70.93	72.43	75.50	6.31
Heart weight	6.35	6.52	5.78	6.24	0.58
Digestive tract full weight	296.67	321.67	345.00	340.00	23.65
Hind up	60.50[b]	131.67[ab]	138.33[a]	126.67[ab]	6.18
Shoulder weight	165.00[b]	161.67[b]	208.33[a]	166.67[b]	12.74
Rack weight	145.00[b]	186.67[ab]	243.33[a]	201.67[ab]	17.79
Loin weight	190.00[ab]	170.00[b]	248.33[a]	218.33[ab]	17.53
Round weight	335.00[b]	350.00[b]	448.33[a]	396.67[ab]	22.94
Hot Carcass weight	940[b]	990[b]	1270[a]	1120[ab]	0.06
Lung and Trachea weight	15.14	12.62	15.59	14.47	1.73
Leg weight	68.33	76.66	80.00	65.00	6.56
Belt weight	245.00[b]	273.33[b]	338.33[a]	306.67[a]	17.05

a,b,c, mean within the same row with differing superscripts are significantly differ (P<0.05). *SEM- Standard error mean.

T1: Rabbits fed control diet without any supplementation.
T2: Rabbits fed control diet supplemented with antibiotics Oxytetracyclinne 50 mg/kg diet..
T3 Rabbits fed control diet supplemented with 8 ml/kg diet oregano leaves extract + 0.75 ml/kg Oregano bioactive lipid compounds T4: Rabbits fed control diet supplemented with and 12 ml/kg diet oregano leaves extract + 1 ml/kg Oregano bioactive lipid compounds.

Conclusion

The supplementation of rabbit diets with OLE (12 ml/kg diet) combined with BLC (1.0 ml/kg diet) had beneficial effects on nutritional values, and digestibility, of diets growth performance and carcass traits of growing rabbits. Instead of the antibiotic growth promoters in rabbit diets, OLE combined with BLC could be used as a natural alternative feed additive to promote gut health and consequently improve growth performance and carcass traits.

References

Abdel-Wareth, A.A., Eman M.M. Taha, Karl-Heinz Südekum, Jayant Lohakare 2018, Thyme oil inclusion levels in a rabbit ration: Evaluation of productive performance, carcass criteria and meat quality under hot environmental conditions. Animal Nutrition. Volume 4, Issue 4 Pages 410-416

Abou –Raya, A.K.; A.A. Abou-Seaud; F.E. Abdul Salam and A.D.Selim, 1974. The interrelationship between metabolizabla energy and some conventional feeding standards for poultry rations Egyptian .J. of Animal production, 14(1):59-68

Agriculture Ministry Decree 1996. The standard properties for ingredients, feed additives and feed manufactured for animal and poultry. El-Wakaee El-Masria, AmirriaPressCairo,Egypt.192:95.Availableat: https://www.ecolex.org/details/legislation/decree-no-22-of-1996-of-the-ministry-of-agriculture-on-veterinary-products-lex-faoc012988/

Ahmed A.A. Abdel-Wareth, Saskia Kehraus, Karl-Heinz Südekum, 2022, Evaluation of oregano leaves and plant bioactive lipid compounds as feed additives for growing rabbits: Effects on performance, nutrient digestibility, serum metabolic profile and carcass traits, Animal Feed Science and Technology, Volume 284, 115208, ISSN 0377-8401, https://doi.org/10.1016/j.anifeedsci.2022.115208.

Alavijeh, P. K., Alavijeh, P. K., & Sharma, D. 2012 A study of antimicrobial activity of few medicinal herbs. Asian Journal of Plant Science and Research, 2(4), 496-502.

Al-Fataftah, A. R., & Abdelqader, A. 2017. Effects of dietary supplementation of different levels of oregano essential oil on growth performance and intestinal microflora of broiler chickens. Journal of Applied Animal Research, 45(1), 485-489.

Anon European Commission, 2003. Regulation (EC) No 1831/2003 of the European Parliament and of the Council of 22...

AO.A.C 2005. "Association of Official Analytical Chemists" Official Methods of Analysis. 14th Ed., Horwitz.w; D. (Editor) , Academic Press, Washington D.C, USA.

Bahakaim, A.S.A., Abdel-Halim, H.A.H.S., Mousa, M.M., Fadl, A., 2020. Effect of dietary oregano supplementation on productive, physiology and immunological performance of broiler chicks. Egypt. Poult. Sci. 40 ,507-524.

Bakkali, F., Averbeck, S., Averbeck, D., & Idaomar, M. 2008. Biological effects of essential oils - a review. Food and Chemical Toxicology, 46(2), 446-475.

Baser, K. H. C. 2008. Biological and pharmacological activities of carvacrol and carvacrol bearing essential oils. Current Pharmaceutical Design, 14(29), 3106-3119.

Botsoglou, E., Govaris, A., Christaki, E., & Botsoglou, N. 2019. Effect of dietary olive leaves and/or α-tocopheryl acetate supplementation on the oxidative stability of rabbit meat. Animal Feed Science and Technology, 105-113.

Chun, S.-S.; Vattem, D.A.; Lin, Y.-T.; Shetty, K. 2005 Phenolic antioxidants from clonal oregano (*Origanum vulgare*) with antimicrobial activity against Helicobacter pylori. *Process. Biochem.* , *40*, 809–816.

Dalle Zotte Antonella, Chiara Celia, Marco Cullere, Zsolt Szendrő, Melinda Kovács, Zsolt Gerencsér, Alessandro Dal Bosco, Valerio Giaccone, Zsolt Matics 2020, Effect of an in-vivo and/or in-meat application of a liquorice (Glycyrrhiza glabra L.) extract on fattening rabbits live performance, carcass traits and meat quality, Animal Feed Science and Technology, Volume 260 114333, ISSN 0377-8401, https://doi.org/10.1016/j.anifeedsci.2019.114333

Duncan D.B., 1955. Multiple range and multiple F tests. Biometrics. 11, 1–42, https://doi.org/10.2307/3001478

El Babili, F., Bouajila, J.; Souchard, J.P.; Bertrand, C.; Bellvert, F.; Fouraste, I.; Moulis, C.; Valentin, A. 2011 Oregano: Chemical Analysis and Evaluation of Its Antimalarial, Antioxidant, and Cytotoxic Activities. *J. Food Sci. 76*, C512–C518.

Elsherif HMR, Orabi A, Ali AS, Samy A. 2021 Castor and propolis extracts as antibiotic alternatives to enhance broiler performance, intestinal microbiota and humoral immunity. Adv. Anim. Vet. Sci.; 9(5): 734-742.

Fekete, S. and T. Gippert 1986. Digestibility and nutritive value of nineteen important feedstuff for rabbits. *J. Appl. Rabbit Res.*, **9:** 103-108.

Giannenas, I., Bonos, E., Skoufos, J., Tzora, A., Paraskeuas, V., & Florou-Paneri, P. (2018). Effects of benzoic acid and essential oil compounds on growth performance, intestinal microbiota and morphometry in rabbits. South African Journal of Animal Science, 48(1), 101-112.

Giannenas, I., Skoufos, J., Giannakopoulos, C., Wiemann, M., Gortzi, O., Lalas, S., & Kyriazakis, I. 2016. Effects of essential oils on milk production, milk composition, and rumen microbiota in Chios dairy ewes. Journal of Dairy Science, 99(3), 1750-1760.

Gilling, D. H., Kitajima, M., Torrey, J. R., & Bright, K. R. 2014. Antiviral efficacy and mechanisms of action of oregano essential oil and its primary component carvacrol against murine norovirus. Journal of applied microbiology, 116(5), 1149-1163.

Hausmann Janis, Carolin Deiner, Irmgard Immig, Robert Pieper, Alexander Starke, Jörg R. Aschenbach, 2017 Effects of combined supplementation with plant bioactive lipid compounds and biotin on ruminal fermentation, body condition and energy metabolism in transition dairy cows, Animal Feed Science and Technology, Volume 225, Pages 27-37, ISSN 0377-8401, https://doi.org/10.1016/j.anifeedsci.2017.01.009.

Karkovic Markovic, A., Torić, J., Barbarić, M., & Končić, M. Z. 2018. Farmakološki učinci origana i njegovog eteričnog ulja. Farmaceutski glasnik, 74(1), 15-27.

Kuralkara,P, Kuralkarb SV. (2021) Role of herbal products in animal production – An updated review , J of Ethnopharmacology. 278:5-114246. https://doi.org/10.1016/j.jep.2021.114246.

Lamiaa N, Alatrony MM, Abdella GA El-Sayaad AS, Abd El-Hakim, Sherein H Mohamed. 2022 Role of Moringa, Thyme and Licorice Leave Extracts on Productive Performance of Growing Rabbits. Annals of Agric. Sci., Moshtohor.; 60(4):1077 – 1090.

Lin, L.-Z.; Mukhopadhyay, S.; Robbins, R.J.; Harnly, J.M.2007 Identification and quantification of flavonoids of Mexican oregano (*Lippia graveolens*) by LC-DAD-ESI/MS analysis. *J. Food Compos. Anal.* **2007**, *20*, 361–369.

Marchese, A., Orhan, I. E., Daglia, M., Barbieri, R., Di Lorenzo, A., Nabavi, S. F., ... & Nabavi, S. M. 2016. Antibacterial and antifungal activities of thymol: A brief review of the literature. Food chemistry, 210, 402-414.

Mohamed Sherein H., Abd El-Wahab and Walaa M. 2022. Influence of emulsified and nano-emulsified essential oils blend on performance and meat characteristics of weaned mountain rabbits. J. of Animal and Poultry Production, Mansoura Univ., Vol 13(3):43-50

Mohamed, Sherein & El Naggar, Soad & Hassan, Ayman & Mousa, Mohamed & Basyony, Mohamed & Sadek, Mohamed & Ahmed, Mohamed & Hashem, Saadia. 2023. Natural and Biological Dietary Herbal Extracts Supplement on Productive and

Physiological Parameters, Cecal Fermentation, and Meat Characteristics of Growing Rabbits. Advances in Animal and Veterinary Sciences. 11(9) https://doi.org/10.17582/journal.aavs/2023/11.9.1506.1523

NRC 1977. National Research Council: Nutrient Requirements of Rabbits. 2nd Ed., National Academy of Sciences, Washington, DC, USA.

Peng, C. H., Su, J. D., Chyau, C. C., Sung, T. Y., Ho, S. S., Peng, C. C., & Peng, R. Y. (2019). Supercritical fluid extracts of rosemary leaves exhibit potent anti-inflammation and anti-tumor effects. Bioscience, Biotechnology, and Biochemistry, 73(9), 1967-1973.

Pukrop J.R., B.T. Campbell, J.P. Schoonmaker. 2019 Effect of essential oils on performance, liver abscesses, carcass characteristics and meat quality in feedlot steers, Animal Feed Science and Technology, Volume 257, 114296, ISSN 0377-8401, https://doi.org/10.1016/j.anifeedsci.2019.114296.

Salama M. Asmaa, Soad S. Belih, Nasser E. Khedr. 2023 Influence of Dietary Oregano Plant Extract Supplementation on Growth Performance and Economic Efficiency of Broiler Chicks. Benha Veterinary Medical Journal 44 15-19.

SAS. User's guide: Basics. Institute Statistical Analysis System. Cary, North Carolina. SMN. 2014. Unidad del Servicio Meteorológico Nacional, CNA.

Singleton, V.L. and Rossi, JA Jr. 1965. Colorimetry of total phenolics with phosphomolybdic-phosphotungstic acid reagents, American Journal of Enology and Viticulture. 16:144-158.

Skoufos, I., Tzora, A., Giannenas, I., Tontis, D., Bartzanas, T., Kittas, C., Panagakis, P., 2016. Effects of oregano essential oil and attapulgite on growth performance, intestinal microbiota and morphometry in broilers. South African Journal of Animal Science 46(1), 77–88.

Steven., W.D.; Hohenboken, W.D.; Cheeke, P.R.; Patton, N.M. ; Kennick, W.H.1996 Carcass and meat characteristics of Flemish Giant and New Zealand White purebred and terminal cross rabbits. J. Applied Rabbit Res. 4, 66.

Teixeira B, Marques A, Ramos C, Serrano C, Matos O, Neng NR, Nogueira JM, Saraiva JA, Nunes ML. 2013 Apr Chemical composition and bioactivity of different oregano (Origanum vulgare) extracts and essential oil. J Sci Food Agric. 2013 Aug 30;93(11):2707-14. doi: 10.1002/jsfa.6089. Epub 2. PMID: 23553824.

Zinno, P.; Guantario, B.; Lombardi, G.; Ranaldi, G.; Finamore, A.; Allegra, S.; Mammano, M.M.; Fascella, G.; Raffo, A.; Roselli, M. 2023 Chemical Composition and Biological Activities of Essential Oils from Origanum vulgare Genotypes Belonging to the Carvacrol and Thymol Chemotypes. Plants, 12, 1344. https://doi.org/10.3390/plants12061344

Zouari, N., Ayadi, I., Fakhfakh, N., Rebah, A., & Zouari, S. 2013. Variation in chemical composition and biological activities of an essential oil of wild and cultivated Tunisian Origanum vulgare L. subsp. thyrsi. Industrial Crops and Products, 43, 613-619.

تأثير الإضافة الغذائية لمستخلص أوراق نبات الأوريجانو مع مكوناته الدهنية النشطة بيولوجياً على قابلية هضم العناصر الغذائية وصفات النمو والذبيحة في الأرانب

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الملخص

الهدف من الدراسة الحالية هو تقييم تأثير إضافة مستخلص أوراق نبات الاوريجانو ومركباته الدهنية النشطة بيولوجيا كإضافه غذائية طبيعية على هضم العناصر الغذائية، وأداء النمو، وصفات الذبيحة في الأرانب. تم تقسيم 48 أرنب مفطوم من سلالة سينا الجبلي، بمتوسط وزن جسم حي قدره 806.24 جرام، عشوائيًا إلى أربع مجموعات تجريبية متساوية (12 أرنب مفطوم/مجموعة). المجموعة الأولى :(T1) تلقت النظام الغذائي الأساسي دون إضافات (مجموعة الكنترول) والمجموعة الثانية :(T2) تلقت النظام الغذائي الأساسي مع إضافة مضاد حيوي الأوكسي تتراسيكلين بتركيز 50 ملجم/كجم والمجموعة الثالثة :(**T3**) تلقت النظام الغذائي الأساسي مع إضافة 8 مل/كجم عليفه من مستخلص أوراق نبات الاوريجانو +0.75 مل/كجم عليقة من المركبات الدهنية النشطه بيولوجيا والمجموعة الرابعة :(T4) تلقت النظام الغذائي الأساسي مع إضافة 12 مل/كجم عليقة من مستخلص أوراق نبات الاوريجانو +1 مل/كجم عليفة من المركبات الدهنية النشطه بيولوجيا . وتم تحديد تسعة عشر مكونًا نشطًا في مستخلص أوراق نبات الاوريجانو وكانت المكونات الرئيسية هي حمض الروزمارينيك (15.590 ملغ/لتر)، الهيبسيريدين (8.175 ملغ/لتر)، والمايريسيتين (4.14 ملغ/لتر). وكانت المركبات الدهنية النشطة بيولوجيا في الاوريجانو تتكون بشكل رئيسي من الكارفكرول (14.6%)، والثيمول (12.7%)، والكحول-β فينشيل (12.9%)، و-δتيربينول.(7.6%) . أظهرت نتائج الدراسة أن إضافة مستويات مختلفة من مستخلص أوراق نبات الاوريجانو و ومركباته الدهنية النشطة بيولوجيا حسّنت بشكل معنوي هضم المادة الجافة، والبروتين الخام، ومستخلص الإيثر مقارنة بمجموعة الكنترول. بالنسبة المركبات الكلية المهضومة، سجلت الأرانب التي تلقت النظام الغذائي T4 أعلى قيمة (78.73%)، تلتها مجموعةT3 ، ثمT2 ، بينما كانت مجموعة الكنترول أقل قيمة.(77.23%) وتحسنت بشكل معنوي أوزان الجسم النهائية، وإجمالي الزيادة في الوزن، ومعدل الزيادة اليومية في الوزن، وكفاءة التحويل الغذائي مع إضافة مستخلص أوراق الاوريجانو ومركباته الدهنية النشطة بيولوجيا إلى النظام الغذائي مقارنة بمجموعة الكنترول. لم تُلاحظ فروق ذات دلالة إحصائية بين المجموعات المعاملة ومجموعة الكنترول في أوزان الكبد، والقلب، والرئتين، والقصبة الهوائية، وأرجل الأرانب. ومع ذلك، كانت مجموعة T4 ذات وزن جسم أعلى بشكل معنوي عند الذبح، وكانت أوزان الكلى والفراء أعلى مقارنة بمجموعة الكنترول.