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Effects of Different Levels of Two Types of Olive Pulp with or without Exogenous Enzyme Supplementation on Broiler Performance and Economic Parameters

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ABSTRACT

The effects of the dietary inclusion of olive pulp (OP) and supplementation birds with a commercial enzyme blend (ENZ) on the performance of broilers were evaluated. Six hundred one-day-old male Ross 308 broilers were divided according to a completely randomized design into 10 treatments in a 2×2×2+2 factorial arrangement, consisting of two olive pulp levels (50 and 100 g/kg diet), two pulp categories (processed and non-processed), the inclusion or not of an enzyme blend supplement, and two control treatments without OP and the inclusion or not of the enzyme blend in the diet. Feed intake (FI), weight gain (WG), feed efficiency (FE), energy intake (EI), energy efficiency (EE), protein intake (PI), protein efficiency (PE), feed cost per kg live weight (FC/kg), and production index (IP) were determined. There was no significant difference ($p>0.05$) between broilers fed the OP diets and the control diets for all parameters. Processed OP improved FE ($p\leq0.019$ from 1-21 days; $p\leq0.005$ from 22-42 days; and $p\leq0.008$ from 1-42 days of age) and EE ($p\leq0.012$ from 1-21 days; $p\leq0.012$ from 22-42 days; and $p\leq0.002$ from 1-42 days of age). The enzyme blend supplementation did not influence ($p>0.05$) any of the studied variables. The inclusion of OP in the diets at levels up to 100g/kg would does not have deleterious effects on broiler production performance.

INTRODUCTION

Feed accounts for up to 70% of total production costs, and therefore, agricultural and industrial byproducts have been evaluated as feed ingredients to reduce those costs. The advantages include less dependence of livestock production on grains that are consumed by humans and reduction of waste management costs (Zangeneh and Torki, 2011). The utilization of crop residues and byproducts in the past as alternatives to soybean meal in feeds was not successful, mainly due to their high fiber content and poor digestibility. Some exogenous enzymes may be added to broiler diets containing these byproducts to aid fiber digestion (carbohydrases) or to solubilize phytic phosphorus (phytase), thereby reducing their negative effects on broiler production parameters (Choct, 2006).

The olive tree (*Olea europea L.*) is widely cultivated in Mediterranean countries for its edible fruits and oil. Olive pulp (OP) is the residue remaining after the olive cake (raw material resulting from the extraction of olive oil) is dried. It is a good source of several biologically-active compounds with antioxidant, antifungal, and antibacterial properties (Benavente-García *et al.*, 2000). Despite being considered to be a good source of protein, fat, calcium, copper, and cobalt, the nutritional value of OP is poor due its low energy, digestible protein, and mineral content, and high lignin content. It is also poor in phosphorus, magnesium, and sodium, but has fair levels of manganese and zinc (Afsari *et al*., 2013).

The presence of xyloglucans in OP cell walls, which are non-starch polysaccharides (NSP) that have antinutritional effects on non-ruminants, was reported by several authors (Al-Harthi, 2014). In addition, Reis *et al*. (2002) extracted glucuronoxylans with a xylose/glucose ratio of 7:1 from OP samples, confirming the high content of these antinutritional factors in the feedstuff. However, OP contains oleuropeoside beneficial compounds, such as oleuropein and verbascoside; flavonoid compounds, such as luteolin, luteolin-7-glucoside, apigenin-7-glucoside, diosmetin, diosmetin-7-glucoside, and rutin; as well as flavanols, such as catechins; and simple phenolic compounds, such as tyrosol, hydroxytyrosol, vanillin, vanillic acid, and caffeic acid (Ryan *et al.*, 2002). Additionally, the ripening stage at harvest interferes with pectic polysaccharides found in the olive pulp cell walls, due to the presence of calcium chelating dimers, there by changing the nutritional value of this by product (Cardoso *et al*., 2007).

There are few studies on the inclusion olive byproducts in broiler diets. Feeding OC to broilers up to the level of 150g/kg did not affect performance parameters (El Hachemi *et al*., 2007). Zarei *et al*. (2011) reported that the inclusion of up to 86g/kg of olive pulp in the diet of laying hens had no negative effects on production parameters.

Other researchers found positive effects of the nutritional use of olive pulp. Abo Omar (2000) reported an increase in broiler feed intake (and decreased feed efficiency) with the inclusion of about 60g of olive pulp/kg diet. This author related this high feed intake to the fiber content and the consequent increase in passage rate in the gastrointestinal tract. Inclusion levels above 75g/kg of OP has a negative effect on weight gain, according to Rabayaa *et al*. (2001). On the other hand, the feasibility of including olive pulp up to the level of 160g/kg in broiler diets was reported (Abo Omar *et al*., 2003). The use of enzymes to improve the nutritional value of olive pulp was studied in laying hens, but no positive effects were observed on production or egg quality parameters (Afsari *et al*., 2013).

Studies evaluating diets including olive pulp and supplemented with enzymes fed to commercial broilers are scarce. The objective of this experiment was to determine the effects of different dietary levels of processed and non-processed olive pulp and of enzyme supplementation on the performance of broilers.

MATERIAL AND METHODS

Six hundred one- day-old Ross 308 male broilers were housed in cages measuring 1.25 × 1.25 m, which provided a floor area of 0.15 m2 per bird. Cages were located in a poultry house with thermostatically-controlled side curtains. The cage floor was covered with paper roll litter. Broilers remained in the cages for the duration of the experiment, which ended when broilers were 42 days of age. Each cage of 10 chickens was assigned to a specific dietary treatment group.

House temperature was maintained using supplemental heat provided by thermostatically-controlled gasoline stoves, and humidity was added via a water spray in order to maintain the relative humidity between 55-65%. House temperature was maintained at 32°C at the beginning of the experiment and was gradually reduced to 24°C when broilers were 3 weeks of age, after which it was maintained at 24°C until the end of the experiment. Lighting was provided by 23-watt fluorescent tubes in ceiling fixtures. Constant light was provided on day 1, for 21 hours per day from day 2 until the end of the study. Air circulation and tunnel ventilation within the poultry house were provided by three wall-mounted 60-cm diameter fans on one end of the barn, and 160-cm diameter wall-mounted fans on the other end of the barn.

A two-phase feeding program was applied, consisting of a starter feed fed on days 1-21 days and a grower feed supplied on days 22-42. The composition of the starter and grower diets are shown Tables 1 and 2. The diets met or exceeded the recommendations of the Ross 308 manual (Aviagen, 2009).

The OP product was obtained by washing fresh olive fruit with water. Olives were then milled, placed in hot water (80°C) and centrifuged. At this stage, the "water + oil" emulsion was extracted from the olives, and the remaining residue was designated as "olive cake" (OC). In the next step, alpha-tocopherol (antioxidant) and an anti-fungal toxin-binder (adsorbent) were added to the OC. The OC was then dried at 70°C using hot air, resulting in OP. Processing of the OP consisted in passing the fruits through a sieve (1.5-mm mesh diameter). During this process, part of the stones (seeds) was removed to produce "partially destoned OP" or processed OP.

Dried OP (processed = partly destoned, dried OP; non-processed = dried OP) was added to the basal starter and grower diets at levels of 50 and 100 g/kg, respectively, which were supplemented or not with an enzyme blend (50 or 0 mg/kg diet). The enzyme (Natuzyme P50®, Australia) contained, per g of product, 1000,000 IU phytase, 700 IU β-glucanase, 700 IU α-amylase, 6,000 UI cellulase, 700 IU pectinase, 10,000 IU xylanase, 30 IU lipase, and 3,000 IU protease.

The composition of the dried olive pulp (processed and non-processed) was determined according to the procedures 950.15, 942.05, 954.05, 954.39, 978.10, 927.02, 964.06, 973.18, 974.06 and 920.40 of the AOAC (1990) and is given in Table 3. Ash-free neutral detergent fiber content (aNDF) was determined using the method of Van Soest *et al*. (1991).

A total of 600 one-day-old male Ross 308 (Aviagen, New Bridge, Scotland, UK) were distributed according to a completely randomized design in a 2×2×2 factorial arrangement, consisting of two olive pulp levels (50 and 100 g/kg diet), two pulp types (processed and non-processed), and two enzyme inclusion levels (0 and 50 mg/kg diet). In addition, two control treatments, as described below, were evaluated. Therefore, 10 treatments with six replicates of 10 birds each were applied. The treatments were as follows:

- 50 p: inclusion of 50 g processed olive pulp/kg of diet and no enzyme supplementation;
- 50 p + ENZ: inclusion of 50 g processed olive pulp/kg of diet and enzyme supplementation (50 mg/kg);
- 100 p: inclusion of 100 g processed olive pulp/kg of diet and no enzyme supplementation;
- 100 p + ENZ: inclusion of 100 g processed olive pulp/kg of diet and enzyme supplementation (50 mg/kg);
- 50 u: inclusion of 50 g non-processed olive pulp/kg of diet and no enzyme supplementation;
- 50 u + ENZ: inclusion of 50 g non-processed olive pulp/kg of diet and enzyme supplementation (50 mg/kg);
- 100 u: inclusion of 100 g non-processed olive pulp/kg of diet and no enzyme supplementation;
- 100 u + ENZ: inclusion of 100 g non-processed olive pulp/kg of diet and enzyme supplementation (50 mg/kg);
- Ctrl: control diet containing no olive pulp and not supplemented with the enzyme blend;
- Ctrl + ENZ: control diet containing no olive pulp and supplemented with the enzyme blend (50 mg/kg).

The birds and feeds were weighed at the beginning and at the end of the rearing phases (1, 21, and 42 days) in order to calculate weight gain (WG), feed intake (FI), feed efficiency (FE = WG/FI), energy intake (EI = kcal intake/day), energy efficiency (EE = kcal/g WG), protein intake (PI = g of protein intake/day), and protein efficiency (PE = g of protein intake/g WG). The economic viability of the inclusion of OP and ENZ was determined by calculating feed cost (FC) per kg of live weight (FC/kg = Rial/kg WG). Mortality was recorded to allow for the correction of performance data. The production efficiency index (PEI) of 42-day-old birds was calculated according to the following equation: PEI = [(ABW * livability)/MA * FCR]*100, where ABW = average body weight at slaughter, MA = market age, and FCR = feed conversion ratio (FCR = 1/FE).

Data were submitted to two-way analysis of variance (SAS Institute, Inc., 2000). The following model was applied: $Y_{ijk}= \mu+A_i+B_j+C_k+AB_{ij}+AC_{ik}+BC_{jk}+ABC_{ijk}+e_{ijkl}$; where μ = general average, A_i = olive pulp levels, B_j = effect of processing, C_k = effect of enzyme supplementation, AB_{ij} = effect of the interaction between olive pulp levels and processing, AC_{ik} = effect of the interaction between olive pulp levels and enzyme supplementation, BC_{jk} = effect of the interaction between olive pulp processing and enzyme complex interaction effect, ABC_{ijk} = effect of the interaction among olive pulp levels, olive pulp processing, and enzyme supplementation, and e_{ijkl} = incidental residual effect of observation. After statistical differences were confirmed, the General Linear Model (PROC GLM) was used, and the differences among means ($p\leq0.05$) were evaluated by Duncan's multiple range test (SAS, 2000).

Table 1 – Feed ingredients and analyzed chemical composition of diets used during the starter period (1-21 days of age).

Ingredient (g/kg) \ Treatment	50[3] p[4]	50 p +ENZ[5]	100 p	100 p + ENZ	50 u[6]	50 u + ENZ	100 u	100 u + ENZ	Ctrl[7]	Ctrl +ENZ
Processed olive pulp	50	50	100	100	0	0	0	0	0	0
Non-processed olive pulp	0	0	0	0	50	50	100	100	0	0
Enzyme	0	0.05	0	0.05	0	0.05	0	0.05	0	0.05
Corn	507.3	507.3	456.6	456.6	482.5	482.5	407	407	558	558
Soybean meal	370.6	370.6	370.6	370.6	377.2	377.2	383.7	383.7	370.7	370.7
Soybean oil	30	30	32.1	32.1	47.6	47.6	67.4	67.4	27.8	27.8
Wheat bran	0.1	0.05	0.1	0.05	0.1	0.05	0.1	0.05	0.1	0.05
Dicalcium phosphate	19.3	19.3	19.6	19.6	19.4	19.4	19.7	19.7	19	19
Limestone	10.9	10.9	9.1	9.1	11.5	11.5	10.3	10.3	12.7	12.7
Vitamin Mixture[1]	3	3	3	3	3	3	3	3	3	3
Mineral Mixture[2]	3	3	3	3	3	3	3	3	3	3
Salt	2.3	2.3	2.1	2.1	2.4	2.4	2.4	2.4	2.5	2.5
Sodium bicarbonate	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
DL-Methionine	1.4	1.4	1.5	1.5	1.4	1.4	1.5	1.5	1.3	1.3
Lysine-Hydro-Chloride	0.6	0.6	0.8	0.8	0.4	0.4	0.4	0.4	0.4	0.4
Total	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Price (Rial/kg)	13512	13519	13509	13517	13880	13888	14246	14254	13512	13520
Dry Matter (%)	90.32	90.32	90.49	90.49	90.48	90.48	90.82	90.82	90.15	90.15
Energy (ME) (kcal/kg)	3025	3025	3025	3025	3025	3025	3025	3025	3025	3025
Crude Protein (%)	23.00	23.00	23.00	23.00	23.00	23.00	23.00	23.00	23.00	23.00
Ether Extract (%)	5.90	5.90	6.52	6.52	7.47	7.47	9.68	9.68	5.27	5.27
Linoleic Acid (%)	2.79	2.79	2.79	2.79	3.64	3.64	4.48	4.48	2.79	2.79
Crude Fiber (%)	4.58	4.58	6.49	6.49	5.07	5.07	7.47	7.47	2.67	2.67
Calcium (%)	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05
Phosphorus (%)	0.74	0.74	0.73	0.73	0.73	0.73	0.73	0.73	0.74	0.74
Available Phosphorus (%)	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Potassium (%)	0.95	0.95	0.99	0.99	0.94	0.94	0.95	0.95	0.92	0.92
Chlorine (%)	0.18	0.18	0.18	0.18	0.19	0.19	0.19	0.19	0.19	0.19
Manganese (mg/kg)	474.27	474.27	474.11	474.11	475.36	475.36	476.25	476.25	474.44	474.44
Sodium (%)	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
Zinc (mg/kg)	383.69	383.69	383.21	383.21	385.60	385.60	387.01	387.01	384.17	384.17
Choline (mg/g)	1.59	1.59	1.56	1.56	1.59	1.59	1.56	1.56	1.62	1.62
Folic acid (mg/kg)	2.19	2.19	2.18	2.18	2.21	2.21	2.20	2.20	2.21	2.21
Arginine (%)	1.48	1.48	1.46	1.46	1.49	1.49	1.49	1.49	1.50	1.50
Glycine (%)	0.92	0.92	0.91	0.91	0.93	0.93	0.92	0.92	0.94	0.94
Serine (%)	1.10	1.10	1.09	1.09	1.11	1.11	1.10	1.10	1.12	1.12
Gly+Ser (%)	2.02	2.02	2.00	2.00	2.04	2.04	2.02	2.02	2.06	2.06
Histidine (%)	0.59	0.59	0.58	0.58	0.59	0.59	0.58	0.58	0.60	0.60
Iso-Leucine (%)	0.93	0.93	0.92	0.92	0.94	0.94	0.93	0.93	0.94	0.95
Leucine (%)	1.89	1.89	1.84	1.84	1.89	1.89	1.84	1.84	1.94	1.94
Lysine (%)	1.27	1.27	1.27	1.27	1.27	1.27	1.27	1.27	1.27	1.27
Methionine (%)	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47
Cysteine (%)	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.37	0.37
Met+Cys (%)	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.84	0.84
Phenylalanine (%)	1.06	1.06	1.04	1.04	1.06	1.06	1.05	1.05	1.08	1.08
Tyrosine (%)	0.87	0.87	0.86	0.86	0.88	0.88	0.87	0.87	0.89	0.89
Phe+Tyr (%)	1.93	1.93	1.90	1.90	1.94	1.94	1.92	1.92	1.97	1.97
Threonine (%)	0.84	0.84	0.83	0.83	0.84	0.84	0.83	0.83	0.85	0.85
Tryptophan (%)	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Valine (%)	1.02	1.02	1.01	1.01	1.03	1.03	1.01	1.01	1.04	1.04

[1] Vitamin A: 3,600,000 IU/kg; Vitamin D_3: 800,000 IU/kg; Vitamin E: 7,200IU/kg; Vitamin K_3: 800 mg/kg; Vitamin B_1: 720 mg/kg; Vitamin B_2: 2,640 mg/kg; Vitamin B_3 (Calcium Pantothenate): 4,000 mg/kg; Vitamin B_5 (Niacin):12,000 mg/kg; Vitamin B_6: 1,200 mg/kg; Vitamin B_9 (Folic acid): 400 mg/kg; Vitamin B_{12}: 6 mg/kg; Vitamin H_2 (Biotin): 40 mg/kg; Choline: 100,000 mg/kg; Antioxidant: 40,000 mg/kg and 1mg/kg Excepient.

[2]Mn: 39,680 mg/kg; Fe: 20,000 mg/kg; Zn: 33,880 mg/kg; Cu: 4,000 mg/kg; I: 400 mg/kg; Se: 80 mg/kg; Choline: 100,000 mg/kg and 1 mg/kg Excepient.

[3] 50 g/kg olive pulp inclusion.

[4] Processed olive pulp inclusion,[5] Enzime inclusion,[6] non-processed olive pulp inclusion,[7] Control diet without olive pulp inclusion.

Table 2 – Feed ingredients and analyzed chemical composition of diets used during the finishing period (22-42 days of age).

Ingredient (g/kg) \ Treatment	50[3] p[4]	50 p +ENZ[5]	100 p	100 p + ENZ	50 u[6]	50 u + ENZ	100 u	100 u + ENZ	Ctrl[7]	Ctrl +ENZ
Processed olive pulp	50	50	100	100	0	0	0	0	0	0
Non-processed olive pulp	0	0	0	0	50	50	100	100	0	0
Enzyme	0	0.05	0	0.05	0	0.05	0	0.05	0	0.05
Corn	547.6	547.6	496.8	496.8	522.6	522.6	447.1	447.1	598.2	598.2
Soybean meal	323.2	323.2	323.2	323.2	329.8	329.8	336.3	336.3	323.3	323.3
Soybean oil	42.3	42.3	44.5	44.5	60	60	79.8	79.8	40.2	40.2
Wheat bran	0.1	0.05	0.1	0.05	0.1	0.05	0.1	0.05	0.1	0.05
Dicalcium phosphate	17	17	17.3	17.3	17.1	17.1	17.4	17.4	16.7	16.7
Limestone	8.7	8.7	6.9	6.9	9.3	9.3	8.2	8.2	10.5	10.5
Vitamin Mixture[1]	3	3	3	3	3	3	3	3	3	3
Mineral Mixture[2]	3	3	3	3	3	3	3	3	3	3
Salt	2.3	2.3	2.1	2.1	2.5	2.5	2.4	2.4	2.5	2.5
Sodium bicarbonate	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
DL-Methionine	1.1	1.1	1.2	1.2	1.1	1.1	1.2	1.2	1	1
Lysine-Hydro-Chloride	0.2	0.2	0.4	0.4	0	0	0	0	0	0
Total	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Price (Rial/kg)	13373	13381	13386	13393	13747	13754	14128	14136	13364	13372
Dry Matter (%)	90.36	90.36	90.53	90.53	90.52	90.52	90.85	90.85	90.19	90.19
Energy (ME) (kcal/kg)	3150	3150	3150	3150	3150	3150	3150	3150	3150	3150
Crude Protein (%)	21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00
Ether Extract (%)	7.24	7.24	7.87	7.87	8.82	8.82	11.02	11.02	6.62	6.62
Linoleic Acid (%)	3.49	3.49	3.49	3.49	4.34	4.34	5.18	5.18	3.49	3.49
Crude Fiber (%)	4.49	4.49	6.39	6.39	4.97	4.97	7.38	7.38	2.58	2.58
Calcium (%)	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Phosphorus (%)	0.68	0.68	0.68	0.68	0.68	0.68	0.67	0.67	0.68	0.68
Available Phosphorus (%)	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45
Potassium (%)	0.87	0.87	0.90	0.90	0.85	0.85	0.87	0.87	0.84	0.84
Chlorine (%)	0.18	0.18	0.17	0.17	0.18	0.18	0.18	0.18	0.19	0.19
Manganese (mg/kg)	471.74	471.74	471.58	471.58	472.83	472.83	473.72	473.72	471.91	471.91
Sodium (%)	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
Zinc (mg/kg)	381.73	381.73	381.25	381.25	383.63	383.63	385.05	385.05	382.21	382.21
Choline (mg/g)	1.48	1.48	1.45	1.45	1.48	1.48	1.46	1.46	1.51	1.51
Folic acid (mg/kg)	2.04	2.04	2.02	2.02	2.05	2.05	2.05	2.05	2.06	2.06
Arginine (%)	1.33	1.33	1.31	1.31	1.34	1.34	1.34	1.34	1.35	1.35
Glycine (%)	0.84	0.84	0.83	0.83	0.84	0.84	0.84	0.84	0.86	0.86
Serine (%)	1.00	1.00	0.99	0.99	1.01	1.01	1.00	1.00	1.02	1.02
Gly+Ser (%)	1.84	1.84	1.82	1.82	1.85	1.85	1.84	1.84	1.88	1.88
Histidine (%)	0.54	0.54	0.53	0.53	0.54	0.54	0.53	0.53	0.55	0.55
Iso-Leucine (%)	0.84	0.84	0.83	0.83	0.85	0.85	0.84	0.84	0.85	0.85
Leucine (%)	1.75	1.75	1.71	1.71	1.75	1.75	1.70	1.70	1.80	1.80
Lysine (%)	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11
Methionine (%)	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42
Cysteine (%)	0.33	0.33	0.32	0.32	0.33	0.33	0.32	0.32	0.34	0.34
Met+Cys (%)	0.75	0.75	0.74	0.74	0.75	0.75	0.74	0.74	0.76	0.76
Phenylalanine (%)	0.96	0.96	0.95	0.95	0.97	0.97	0.96	0.96	0.98	0.98
Tyrosine (%)	0.79	0.79	0.78	0.78	0.80	0.80	0.79	0.79	0.81	0.81
Phe+Tyr (%)	1.75	1.75	1.73	1.73	1.77	1.77	1.75	1.75	1.79	1.79
Threonine (%)	0.76	0.76	0.75	0.75	0.76	0.76	0.76	0.76	0.77	0.77
Tryptophan (%)	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27
Valine (%)	0.94	0.94	0.92	0.92	0.94	0.94	0.93	0.93	0.95	0.95

[1] Vitamin A: 3,600,000 IU/kg; Vitamin D_3: 800,000 IU/kg; Vitamin E: 7,200IU/kg; Vitamin K_3: 800 mg/kg; Vitamin B_1: 720 mg/kg; Vitamin B_2: 2,640 mg/kg; Vitamin B_3 (Calcium Pantothenate): 4,000 mg/kg; Vitamin B_5 (Niacin):12,000 mg/kg; Vitamin B_6: 1,200 mg/kg; Vitamin B_9 (Folic acid): 400 mg/kg; Vitamin B_{12}: 6 mg/kg; Vitamin H_2 (Biotin): 40 mg/kg; Choline: 100,000 mg/kg; Antioxidant: 40,000 mg/kg and 1mg/kg Excepient.

[2]Mn: 39,680 mg/kg; Fe: 20,000 mg/kg; Zn: 33,880 mg/kg; Cu: 4,000 mg/kg; I: 400 mg/kg; Se: 80 mg/kg; Choline: 100,000 mg/kg and 1 mg/kg Excepient.

[3] 50 g/kg olive pulp inclusion.

[4] Processed olive pulp inclusion,[5] Enzime inclusion,[6] non-processed olive pulp inclusion,[7] Control diet without olive pulp inclusion.

Table 3 – Chemical composition of two types of olive meal used in the experiment

Types of olive pulp / (g/kg dry matter)	Processed (partially destoned and dried) olive pulp	Non-processed olive pulp (original dried)
Dry matter	934.5	935.7
Energy (ME) (kcal/kg)	2980	1250
Crude protein	107.3	71.1
Crude fiber	256.0	350.0
Neutral detergent fiber (α-amylase)	716.0	744.0
Acid detergent fiber	550.0	584.0
Ash	85.0	62.0
Crude fat	130.0	85.0
Calcium	8.2	06.1
Phosphorus	0.7	0.6
Soluble sugars	1.7	1.4
Starch	9.7	10.5
Total polyphenols	3.7	1.9
Total tannins	22.9	17.9

RESULTS AND DISCUSSION

No significant interaction ($p>0.05$, Table 8) was observed between olive pulp (OP) levels and enzyme supplementation, OP levels and pulp processing, enzyme supplementation and pulp processing, or between OP levels, enzyme supplementation and pulp processing for the studied variables. Levels of OP did not influence ($p>0.05$, Tables 4, 5, 6 and 7) FI, WG, FE, EI, EE, PI, or PE at any rearing phase. The dietary supplementation of the ENZ did not influence ($p>0.05$, Tables 4, 5, 6 and 7) any of the studied performance parameters (FI, WG, FE, EI, EE, PI, and PE). OP processing has no effect on FI, PI, or EI ($p>0.05$, Tables 4, 5, 6 and 7). The dietary inclusion of processed OP promoted higher WG ($p\leq0.001$ in the period of 1-21 days of age; and $p\leq 0.005$ in the period of 1-42 days of age), FE ($p\leq0.019$ the period of 1-21 days of age; $p\leq0.005$ in the period of 22-42 days of age; and $p\leq0.008$ in the period of 1-42 days of age), EE ($p\leq0.012$ the period of 1-21 days of age; $p\leq0.012$ in the period of 22-42 days of age; and $p\leq0.002$ in the period of 1-42 days of age), and PE ($p\leq0.035$ the period of 1-21 days of age; $p\leq0.017$ in the period of 22-42 days of age; and $p\leq0.018$ in the period of 1-42 days of age) compared with non-processed OP (Tables 4, 5, 6 and 7).

These results indicate that OP can be included the level of up to 100g/kg in the feed with no adverse effects on broiler performance. Broiler performance was not impaired when olive cake (OC) was included in the diet at 150g/kg (El Hachemi *et al*., 2007). Olive cake is a byproduct of the olive industry derived from wet extraction (without posterior drying). The presence of water in the feed greatly reduces its nutritional value due to the dilution. Therefore, the nutritional value of OP considerably increases after drying, allowing a greater level of inclusion in the diets without impairing broiler performance. Another important fact is that feed rapidly deteriorates when feedstuffs with high moisture content are included, as they promote the development of fermentative bacteria and fungi, which can harm bird health.

A study reported that an OP inclusion level of up to 86g/kg in a layer feed did not impair laying percentage or other performance parameters (Zarei *et al*., 2011). Afsari *et al*. (2013), working with layers, also obtained similar results when including 90g/kg of OP in the diet. Other papers report much higher OP inclusion levels. For instance, Abo Omar *et al*. (2003) included 160g/kg of OP in broiler diets and did not observe any influence on FI, WG, or FE. Differently from the present study, other authors were not as successful when adding high OP levels (up to 100g/kg) in the diets for non-ruminants. Abo Omar (2000) reported an increase in feed intake (and reduced feed efficiency) associated with broiler diets with the inclusion up to 60g/kg of olive pulp. Rabayaa *et al*. (2001) utilized a maximum OP level of 75g/kg diet without reduction in broiler WG. These authors argue that the observed performance losses are related to the high fiber content of this byproduct. Despite these arguments, the inclusion of OP at the level of 100g/kg in the present experiment did not cause any performance losses no problems. This supports the hypothesis that in regions where there is a large supply of this byproduct, it may be used as raw material in poultry diets.

The xyloglucan content of OP did not affect the performance of the broilers fed 100g/kg of OP, as its level was within the safe limits for diets based on corn and soybean meal. The presence of other antinutritional factors in OP, such as pectic polysaccharides (Cardoso *et al*., 2007), did not negatively affect the performance at this level of inclusion.

The beneficial substances in OP include oleuropeosides, flavonoids, flavanols, and simple phenolic compounds (Ryan *et al*, 2002), but the broilers fed the diets containing this byproduct was not improved. The presence of hydrophilic phenols in virgin olive oil is strictly related to the activities of various endogenous enzymes of olive fruits, as their concentrations in the oil are strongly affected by extraction conditions. Crushing and malaxation are the most important critical points of the oil mechanical extraction process (Servili, 2002; Yorulmaz *et al*., 2012). Therefore, at this level of OP addition, the levels of these substances may too low or they may have been inactivated by the crushing process (Clodoveo, 2012).

Afsari *et al*. (2013) added enzymes to diets containing 100g/kg of OP and did not find any performance gains in laying hens. Zangeneh and Torki (2011) did not observe any improvements in egg production, egg mass, or FE when adding β-mannanase to diets containing up to 90g/kg OP. The use of commercial exogenous enzymes in poultry diets as digestibility enhancers of various substrates is now a common practice (Choct, 2006). Experimental designs that include enzymes generally focus on the addition of enzymes while discounting their nutritional value in the diets (Choct, 2006). The experimental diet m*et al*l nutritional requirements of the evaluated broiler strain, independently of the ENZ inclusion. Therefore, the nutrients provided by enzymes exceeded the requirements of the birds. Araújo *et al*. (2014), studying other fibrous byproducts of the oil industry such as sunflower meal, found a positive interaction between the inclusion of an enzyme blend and increasing levels of this feedstuff. In his experimental design, the nutritional values that would have been provided by increasing the digestibility of that feedstuff due to the inclusion of the enzyme belnd were discounted. Due to the experimental design that was used in the present experiment, it was not possible to observe any benefits of the addition of ENZ at levels of up to 100g/kg OP in terms of improvement of the nutritional value of the diets.

Behnke and Beyer (2002) evaluated the benefits of processing feed for the performance of broilers. Feed processing increases nutrient levels, particularly energy (Moritz *et al*., 2005). Olive seeds are highly lignified and have a low fat content (García-Ayuso & Luque de Castro, 1999). When OP is processed by partially destoning, its nutritional value increases, indicating that it may be included at high levels in non-ruminant feeds. In this study, a maximum level of 100 g/kg was included in the diet, but no interaction between processing (destoning) and dietary inclusion levels were detected. This interaction may be perhaps observed when higher inclusion levels of OP in future studies. The increase in FI was related to the lower fiber content of the feed including processed OP. Fiber is bulky and physical limits intake, which explains the observed values. The higher intake observed in treatments with processed OP together with even greater WG values explains the greater FE of birds fed processed OP compared with those fed non-processed OP. The increase in EE and PE may be attributed to the lower fiber content of the processed material, as there was a decrease in the digesta rate of passage, improving FE as a whole.

An another explanation the better results obtained with processed OP is that the removal of the enzymes contained in the olive seeds (stones) of olives resulted in higher content of antioxidant factors (Table 3). Lavelli and Bondesan (2005) observed an increase in total secoiridoid polyphenol (with antioxidant, antimicrobial and anti-inflammatory activities) content and in the antioxidant activity of extra virgin olive oils produced from pre-destoned fruits. Those researchers concluded that further knowledge on the reactions that occur during olive processing, particularly with regards to the involvement of endogenous pulp and stone enzymes, is essential for predicting the effect of destoning on extra virgin olive oil quality. The olive oil residue contributes with most of the energy provided by the OP in broiler diets, where the oil and those beneficial dietary factors are present. Therefore, the presence of these antioxidant, antimicrobial, and anti-inflammatory compounds (not inactivated by seed enzymes) may have contributed to the superior poultry performance in the broilers fed the processed OP.

No significant interaction (p>0.05, Table 7) between olive pulp (OP) levels and enzyme supplementation, OP levels and pulp processing, or enzyme supplementation and pulp processing were detected for economic parameters. The inclusion of OP increased (p≤0.04, Table 7) FC at the 100g/kg level, but did not affect (p>0.05, Table 7) PEI. The inclusion of ENZ did not improve (p> 0.05, Table 5) PEI or reduce FC. OP processing did not interfere (p>0.05, Table 7) with PEI or FC during the experiment. Other researchers found conflicting economic performance results. Araújo *et al*. (2014), working with sunflower meal (FG, another byproduct of the oil industry) in broiler diets, found better economic efficiency index (EEI) by adding 80 g/kg of FG to broiler feeds. The byproducts of the oil industry are gaining importance as feedstuffs worldwide (Porto *et al*., 2008). In some regions and countries, the cost of OP may limit its use in poultry diets, while in others, OP inclusion in poultry diets may reduce production costs. The cost of OP greatly varies from region to region due to factors such as shipping from production to processing, shipping from processing to consumer, general production costs, and regional economic policies (agricultural subsidies, etc.). In regions and countries that produce olive oil,

Table 4 – Performance of 1- to 21-day-old broilers fed diets containing the different levels of olive pulp (processed and non-processed), and supplemented or not with enzymes*

Treatment \ Trait		Feed intake (g/day)	Weight gain (g/day)	Feed Efficiency	Energy Intake (kcal/day)	Energy Efficiency (kcal/g)	Protein Intake (g/day)	Protein Efficiency (g/g)
		Starter period age (1st-21st days of age)						
ENZ	No	57.13±0.19	44.97±0.52	1.32±0.01	172.83±0.59	4.00±0.03	13.14±0.04	0.30±0.001
	Yes	57.51±0.19	44.81±0.52	1.33±0.01	173.98±0.59	4.03±0.03	13.22±0.04	0.30±0.001
p value		0.242	0.147	0.130	0.694	0.120	0.223	0.051
OP	50	57.04±0.19	45.21±0.52	1.31±0.01	172.55±0.59	3.99±0.03	13.12±0.04	0.30±0.001
	100	57.60±0.19	44.57±0.52	1.33±0.01	174.26±0.59	4.04±0.03	13.25±0.04	0.30±0.001
p value		0.950	0.362	0.519	0.890	0.323	0.392	0.595
OP	p	57.43±0.19	44.10^{b}±0.52	1.36^{b}±0.01	173.74±0.59	4.11^{b}±0.03	13.21±0.04	0.31^{b}±0.001
	u	57.21±0.19	45.68^{a}±0.52	1.29^{a}±0.01	173.07±0.59	3.92^{a}±0.03	13.15±0.04	0.29^{a}±0.001
p value		0.910	<0.001	0.019	0.515	0.0120	0.662	0.035
50 p		57.11±0.39	44.69±0.96	1.33±0.02	172.76±1.19	4.04±0.07	13.13±0.09	0.30±0.002
50 p+ENZ		56.94±0.39	43.79±0.96	1.35±0.02	172.27±1.19	4.11±0.07	13.09±0.09	0.31±0.002
100 p		57.56±0.39	43.27±0.96	1.39±0.02	174.13±1.19	4.20±0.07	13.24±0.09	0.31±0.002
100 p+ENZ		58.11±0.39	44.64±0.96	1.36±0.02	175.80±1.19	4.11±0.07	13.36±0.09	0.31±0.002
50 u		58.05±0.39	47.48±0.96	1.27±0.02	172.60±1.19	3.85±0.07	13.12±0.09	0.29±0.002
50 u+ENZ		57.04±0.39	44.87±0.96	1.31±0.02	172.56±1.19	3.96±0.07	13.12±0.09	0.30±0.002
100 u		56.80±0.39	44.44±0.96	1.29±0.02	171.83±1.19	3.92±0.07	13.06±0.09	0.29±0.002
100 u+ENZ		57.94±0.39	45.93±0.96	1.30±0.02	175.27±1.19	3.93±0.07	13.32±0.09	0.29±0.002
Ctrl		57.19±0.39	46.23±0.96	1.29±0.02	173.02±1.19	3.91±0.07	13.15±0.09	0.29±0.002
Ctrl+ENZ		57.77±0.39	46.33±0.96	1.30±0.02	174.76±1.19	3.93±0.07	13.28±0.09	0.29±0.002
p value		0.323	0.253	0.145	0.144	0.089	0.456	0.399

*Means (± standard error) within each column (dietary treatments) with no common superscript significantly differ at $p \leq 0.05$. Means (± standard error) within each column of dietary treatments with no different superscript do significantly not differ at $p > 0.05$. ENZ= enzyme blend supplementation; OP= olive pulp; p=processed; u= non-processed; Ctrl=Control diet with no olive pulp inclusion.

such costs are lower, and therefore may contribute to reduce poultry production costs. It was expected that the inclusion of OP would not interfere with PEI values, as it did not influence performance results (FI, WG, FE, IE, EE, PE, and PI). The PEI is calculated using performance and livability (PEI = [(ABW * livability) / MA * FCR] * 100). Since the dietary inclusion of OP did not affect broiler performance, PEI values could be influenced only by mortality differences among the treatments, which was not the case, as evidenced by the PEI results.

Dietary ENZ inclusion did not affect PEI or FC, and consequently did not affect mortality, as previously discussed for OP inclusion. Araújo *et al*. (2014) also did not find improvements in PEI when adding an enzyme blend to diets containing increasing sunflower levels. However, the addition of enzymes to diets with fibrous oil industry byproducts may have a positive effect on economic efficiency (Araújo *et al*., 2014). Enzymes are used worldwide to reduce the feed costs associated with poultry production (Choct, 2006). Again, these results may be explained by the experimental design that is used. Commonly, the studies with enzymes apply diets that consider the nutritional matrix of the enzyme products when formulation the experimental diets (Choct, 2006), differently from the present study, where the enzyme blend was added "on top" of the broiler requirements.

Although OP processing (partial destoning) improved broiler performance, such effect was not observed for PEI and FC. These results are more difficult to understand, as we did expect better PEI values due to the better performance results. The cost of OP processing was low cost, since there were no differences in FC between the inclusion of processed and non-processed OP. Due to the better performance of broilers obtained with the same FC, OP processing would be very interesting for the poultry industry from an economic point of view. However, PEI is more important than performance in modern broiler production. PEI is widely used today when evaluating the production of broiler chickens of various current commercial strains (Zlatica el al., 2009). According to Zlatica *et al*. (2009), the success of a poultry flock can be measured by this index. Therefore, it may be inferred that including OP in the feed, either processed or not, provides similar results to the poultry production chain.

Table 5 – Performance of 22- to 42-day-old broilers fed diets containing the different levels of olive pulp (processed and non-processed), and supplemented or not with enzymes*

Treatment		Feed intake (g/day)	Weight gain (g/day)	Feed Efficiency	Energy Intake (kcal/day)	Energy Efficiency (kcal/g)	Protein Intake (g/day)	Protein Efficiency (g/g)
Finishing period age (22nd-42nd days of age)								
ENZ	No	175.21±2.28	82.97±1.70	2.19±0.05	551.92±7.18	6.91±0.16	36.79±0.47	0.46±0.01
	Yes	170.81±2.28	79.82±1.70	2.26±0.05	538.05±7.18	7.13±0.16	35.87±0.47	0.47±0.01
p value		0.535	0.067	0.572	0.534	0.058	0.165	0.321
OP	50	171.86±2.28	81.95±1.70	2.20±0.05	541.38±7.18	6.94±0.16	36.09±0.47	0.46±0.01
	100	174.15±2.28	80.84±1.70	2.25±0.05	548.59±7.18	7.10±0.16	36.57±0.47	0.47±0.01
p value		0.589	0.756	0.345	0.147	0.453	0.789	0.351
OP	p	174.01±2.28	79.38±1.70	2.30^{b}±0.05	548.15±7.18	7.26^{b}±0.16	36.54±0.47	0.48^{b}±0.01
	u	172.00±2.28	83.41±1.70	2.15^{a}±0.05	541.82±7.18	6.78^{a}±0.16	36.12±0.47	0.45^{a}±0.01
p value		0.423	0.534	0.005	0.165	0.012	0.416	0.017
50 p		172.11±4.35	80.69±3.27	2.22±0.09	542.15±13.72	7.00±0.29	36.14±0.91	0.46±0.02
50 p+ENZ		171.13±4.35	79.86±3.27	2.29±0.09	539.07±13.72	7.23±0.29	35.93±0.91	0.48±0.02
100 p		178.87±4.35	81.13±3.27	2.27±0.09	563.44±13.72	7.16±0.29	37.56±0.91	0.47±0.02
100 p+ENZ		173.95±4.35	75.83±3.27	2.43±0.09	547.96±13.72	7.66±0.29	36.53±0.91	0.51±0.02
50 u		177.23±4.35	85.94±3.27	2.14±0.09	558.29±13.72	6.76±0.29	37.22±0.91	0.45±0.02
50 u+ENZ		166.99±4.35	81.33±3.27	2.14±0.09	526.02±13.72	6.75±0.29	35.06±0.91	0.45±0.02
100 u		172.63±4.35	84.12±3.27	2.13±0.09	543.79±13.72	6.71±0.29	36.25±0.91	0.44±0.02
100 u+ENZ		171.16±4.35	82.27±3.27	2.18±0.09	539.17±13.72	6.88±0.29	35.94±0.91	0.45±0.02
Ctrl		175.16±4.35	86.42±3.27	2.04±0.09	551.76±13.72	6.43±0.29	36.78±0.91	0.42±0.02
Ctrl+ENZ		171.78±4.35	83.06±3.27	2.10±0.09	541.13±13.72	6.62±0.29	36.07±0.91	0.44±0.02
p value		0.498	0.214	0.239	0.321	0.145	0.321	0.149

*Means (± standard error) within each column (dietary treatments) with no common superscript significantly differ at $p \leq 0.05$. Means (± standard error) within each column of dietary treatments with no different superscript do significantly not differ at $p > 0.05$. ENZ= enzyme blend supplementation; OP= olive pulp; p=processed; u= non-processed; Ctrl=Control diet with no olive pulp inclusion.

Table 6 – Performance of 1- to 42-day-old broilers fed diets containing the different levels of olive pulp (processed and non-processed), and supplemented or not with enzymes*

Treatment		Feed intake (g/day)	Weight gain (g/day)	Feed Efficiency	Energy Intake (kcal/day)	Energy Efficiency (kcal/g)
ENZ	No	116.17±1.17	63.97±0.81	1.76±0.02	362.37±3.70	5.46±0.08
	Yes	114.16±1.17	62.31±0.81	1.79±0.02	356.02±3.70	5.58±0.08
p value		0.129	0.328	0.140	0.328	0.453
OP	50	114.45±1.17	63.58±0.81	1.76±0.02	356.96±3.70	5.46±0.08
	100	115.88±1.17	62.70±0.81	1.79±0.02	361.42±3.70	5.57±0.08
p value		0.566	0.132	0.146	0.081	0.121
OP	p	115.72±1.17	61.74^{b}±0.81	1.83^{b}±0.02	360.95±3.70	5.69^{b}±0.08
	u	114.61±1.17	64.55^{a}±0.81	1.72^{a}±0.02	357.44±3.70	5.35^{a}±0.08
p value		0.431	0.005	0.008	0.273	0.002
50 p		114.61±2.25	62.69±1.57	1.78±0.04	357.45±7.10	5.52±0.15
50 p+ENZ		114.04±2.25	61.82±1.57	1.82±0.04	355.67±7.10	5.67±0.15
100 p		118.21±2.25	62.20±1.57	1.83±0.04	368.78±7.10	5.68±0.15
100 p+ENZ		116.03±2.25	60.23±1.57	1.89±0.04	361.88±7.10	5.89±0.15
50 u		117.14±2.25	66.71±1.57	1.71±0.04	365.45±7.10	5.31±0.15
50 u+ENZ		112.02±2.25	63.10±1.57	1.72±0.04	349.29±7.10	5.35±0.15
100 u		114.72±2.25	64.28±1.57	1.71±0.04	357.81±7.10	5.32±0.15
100 u+ENZ		114.55±2.25	64.10±1.57	1.74±0.04	357.22±7.10	5.41±0.15
Ctrl		116.18±2.25	66.33±1.57	1.66±0.04	362.39±7.10	5.17±0.15
Ctrl+ENZ		114.78±2.25	64.69±1.57	1.70±0.04	357.94±7.10	5.28±0.15
p value		0.312	0.089	0.145	0.113	0.174

*Means (± standard error) within each column (dietary treatments) with no common superscript significantly differ at $p \leq 0.05$. Means (± standard error) within each column of dietary treatments with no different superscript do significantly not differ at $p > 0.05$. ENZ= enzyme blend supplementation; OP= olive pulp; p=processed; u= non-processed; Ctrl=Control diet with no olive pulp inclusion.

Table 7 – Performance and economic parameters of 1- to 42-day-old broilers fed diets containing the different levels of olive pulp (processed and non-processed), and supplemented or not with enzymes*

Treatment	Trait	Protein Intake (g/day)	Protein Efficiency (g/g)	Final weight (g)	Feed cost (Rial/kg)	Production index
ENZ	No	24.96±0.24	0.38±0.009	2,735±34	24,436±222	371.13±9.08
	Yes	24.54±0.24	0.39±0.009	2,666±34	24,661±222	355.07±9.08
p value		0.455	0.112	0.078	0.156	0.056
OP	50	24.60±0.24	0.38±0.009	2,719±34	24,053[a]±222	369.00±9.08
	100	24.91±0.24	0.39±0.009	2,682±34	25,043[b]±222	357.20±9.08
p value		0.145	0.798	0.354	0.035	0.233
OP	p	24.87±0.24	0.39[b]±0.009	2,642±34	24,709±222	344.28±9.08
	u	24.64±0.24	0.37[a]±0.009	2,759±34	24,388±222	381.92±9.08
p value		0.127	0.018	0.141	0.162	0.410
50 p		24.64±0.47	0.38±0.10	2,683±66	24,060[ab]±412	359.36±17.41
50 p+ENZ		24.51±0.47	0.39±0.10	2,646±66	24,299[ab]±412	346.06±17.41
100 p		25.40±0.47	0.39±0.10	2,660±66	25,054[ab]±412	345.83±17.41
100 p+ENZ		24.94±0.47	0.41±0.10	2,578±66	25,423[b]±412	325.88±17.41
50 u		25.17±0.47	0.37±0.10	2,850±66	23,801[ab]±412	397.71±17.41
50 u+ENZ		24.09±0.47	0.37±0.10	2,698±66	24,054[ab]±412	372.87±17.41
100 u		24.66±0.47	0.37±0.10	2,748±66	24,829[ab]±412	381.63±17.41
100 u+ENZ		24.63±0.47	0.37±0.10	2,742±66	24,867[ab]±412	375.46±17.41
Ctrl		24.97±0.47	0.36±0.10	2,836±66	23,059[a]±412	404.91±17.41
Ctrl+ENZ		24.68±0.47	0.37±0.10	2,766±66	23,378[ab]±412	387.46±17.41
p value		0.356	0.412	0.335	0.045	0.137

*Means (± standard error) within each column (dietary treatments) with no common superscript significantly differ at $p \leq 0.05$. Means (± standard error) within each column of dietary treatments with no different superscript do significantly not differ at $p > 0.05$. ENZ= enzyme blend supplementation; OP= olive pulp; p=processed; u= non-processed; Ctrl=Control diet with no olive pulp inclusion.

Table 8 – Interaction between the variables (*p* values)*

Starter period (1-21 days of age)							
Interaction	Feed intake	Weight gain	Feed Efficiency	Energy Intake	Energy Efficiency	Protein Intake	Protein Efficiency
OP x ENZ	0.27	0.36	0.15	0.74	0.55	0.64	0.17
OP x PROC	0.08	0.89	0.18	0.91	0.56	0.85	0.19
ENZ x PROC	0.07	0.73	0.69	0.38	0.71	0.36	0.64
OP x ENZ x PROC	0.65	0.48	0.36	0.28	0.45	0.74	0.56
Finisher period (22-42 days of age)							
	Feed intake	Weight gain	Feed Efficiency	Energy Intake	Energy Efficiency	Protein Intake	Protein Efficiency
OP x ENZ	0.14	0.52	0.44	0.56	0.45	0.43	0.09
OP x PROC	0.12	0.63	0.36	0.45	0.25	0.18	0.45
ENZ x PROC	0.72	0.36	0.34	0.36	0.32	0.24	0.32
OP x ENZ x PROC	0.44	0.45	0.48	0.33	0.65	0.26	0.22

Total period (1-42 days of age)										
	Feed intake	Weight gain	Feed Efficiency	Energy Intake	Energy Efficiency	Protein Intake	Protein Efficiency	Final weight	Feed cost	Production index
OP x ENZ	0.18	0.19	0.10	0.78	0.77	0.36	0.56	0.34	0.63	0.65
OP x PROC	0.16	0.44	0.25	0.56	0.14	0.35	0.45	0.15	0.14	0.78
ENZ x PROC	0.45	0.39	0.36	0.42	0.09	0.34	0.65	0.22	0.23	0.45
OP x ENZ x PROC	0.43	0.11	0.34	0.32	0.25	0.21	0.61	0.14	0.44	0.66

*p values ≤0.05 presents positive interaction. ENZ= enzyme blend inclusion; OP= olive pulp and PROC=processing.

CONCLUSION

The dietary inclusion of processed olive pulp improved broiler feed efficiency and energy efficiency during the experimental period. The dietary supplementation of the enzyme blend did not influence any of the studied variables. The dietary inclusion of olive pulp at levels of up to 100g/kg does not have deleterious effects on broiler productive performance.

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