EFFECT OF OLIVE POMACE AND ENZYMES ON PRODUCTIVE PERFORMANCE, NUTRIENTS DIGESTIBILITY AND SOME BLOOD PARAMETERS IN JAPANESE QUAIL

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(Received 5/3/2024, accepted 1/4/2024)

SUMMARY

Two hundred fifty of unsexed Seven-days-old Japanese quail (JQ) were randomly distributed into 5 dietary treatments with 5 replicates each to investigate the effect of olive pomace (OP) without or with enzyme (EZ) on productive performance, nutrients digestibility and some blood parameters in Japanese quail. Dietary treatments were: The 1st group fed a basal diet without olive pomace as a control. JQ in 2nd and 3rd groups were fed diets contained 5% OP either without or with EZ addition, respectively, while those in 4th and 5th groups were fed diets contained 10% OP either without or with EZ addition, respectively. Body weight (BW), Body weight gain (BWG), feed intake (FI), feed conversion ratio (FCR), apparent digestibility, production index, economical efficiency, carcass traits and blood parameters were investigated. Results indicated that JQ fed diets contained 5% or 10% OP with EZ addition exhibited significantly ($p \leq 0.05$) higher values of BW, BWG, FI, economical efficiency, production index and better FCR, digestibility of dry matter and crude protein as well as dressing carcass%, serum T3 and antioxidant enzymes compared to the corresponding groups fed diets contained 5% or 10% OP without EZ, without difference compared to control group. On the other hand, JQ fed diets contained 5% or 10% OP with or without EZ addition decreased significantly ($p \leq 0.05$) serum total protein, albumen and globulin compared to control group. Also, group fed diet contained 10% OP without EZ recorded lower ($p \leq 0.05$) value of total antioxidant capacity, glutathione peroxidase as well as digestibility of crude fiber and ether extract compared to all others treatments. It can be concluded that EZ supplementation in Japanese quail diets contained OP up to 10 % could be used safely without adverse effect on growth performance and up to 5% with adding EZ to achieve optimum growth performance, economic efficiency and digestibility of nutrients during growing period.

Keywords: *Japanese quail, olive pomace, performance, nutrient digestibility, blood parameters.*

INTRODUCTION

In Egypt, the high cost and scarcity of concentrated feed pose challenges to poultry production, with feed costs accounting for a significant portion of total production expenses (Mozafari *et al.*, 2013). To address this issue and promote sustainable production of quail (Coturnix sp.), the utilization of agro-industrial by-products such as olive pomace (OP) has been considered. Olive pomace, a by-product of olive oil extraction, is rich in bioactive compounds and has a high energy value (Mulaudzi *et al.*, 2022). The nutritional value of OP could be particularly beneficial for quail, which are known for their rapid growth, high productivity in terms of meat and egg production, strong resistance to diseases, and high reproductive efficiency (Mahlake *et al.,* 2021).

The cultivation of olive crop for oil production has increased, leading to the availability of olive by-products such as olive cake, olive leaves, and olive pulp (Amici *et al.,* 1991; Al-Harthi and Attia, 2016a;b). Among these by-products, olive pulp, with or without seeds, is the most prevalent (Amici *et al.,* 1991; Al-Harthi & Attia, 2016 a;b). The chemical composition of OP includes approximately 4.5% crude protein, 19.8% crude fat, 35.6% fiber, and 5.2% phenolics on a dry matter basis (Gomez-Cruz *et al.,* 2020; Ruschioni *et al.,* 2020).

Several studies have investigated the impact of olive pomace and enzyme supplementation on productive performance parameters, including body weight, feed intake, and egg production. Findings from these studies have shown that the inclusion of olive pomace, along with enzymes, in Japanese quail diets can lead to improved growth performance, increased body weight, enhanced feed intake, and enhanced egg production (El-Gendy *et al.,* 2021; Salem *et al.,* 2022).

In studies conducted on broilers, the inclusion of olive pomace waste at levels of 7.5% and 15% led to decreased digestibility and metabolizability coefficients of dry matter, nitrogen, and energy, as well as a decrease in metabolizable energy compared to the control group (Adams *et al.*, 2022). It has been suggested that broilers can tolerate up to 5% olive pomace in the finisher phase (Papadomichelakis *et al.*, 2019) or up to 10% in the diet (Sayehban *et al.*, 2016). However, El-Hackemi *et al.* (2007) reported no significant differences in weight gain and carcass weight of broilers fed up to 15% olive pomace.

In recent years, the inclusion of multi-enzymes (EZ) in the feed industry has been pursued to improve nutrient digestibility, utilization, and gut health, while reducing anti-nutritional factors (Cowieson, 2010; Shaw *et al.*, 2010; Attia *et al.*, 2014a; b; El-Kelawy and El-kelawy, 2016). The addition of EZ to diets has shown beneficial effects on body weight and feed conversion ratio in poultry (Al-Saffar *et al.,* 2013; Attia and Al-Harthi, 2015).

Studies have reported improved nutrient digestibility, particularly for crude protein and crude fiber, with the inclusion of olive pomace and enzyme supplementation (Elsokkary *et al.,* 2020; El-Beltagy *et al.*, 2021). The addition of enzymes is believed to enhance the breakdown of complex compounds, improving nutrient availability and utilization.

Some studies have shown no significant changes in blood parameters, including glucose, cholesterol, triglycerides, and liver enzymes (Elsokkary *et al.*, 2020; El-Gendy *et al.*, 2021). However, other studies have observed alterations in blood parameters, such as increased levels of antioxidant enzymes and improved lipid profiles (Ahmed *et al.*, 2019; Salem *et al.*, 2022). The objective of this study is to investigate the effects of olive pomace on productive performance, nutrient digestibility, and some blood parameters in Japanese quail.

MATERIALS AND METHODS

This study was carried out at Poultry Experimental Station, Faculty of Agriculture, New Valley University, during year 2023. The objectives of this work are to investigate the effects of OP on productive performance, nutrients digestibility and some blood parameters in Japanese quail from day 7 to 42 of age. Two hundred fifty of unsexed seven-days-old JQ were randomly distributed into 5 experimental groups (50/group), each group was subdivided into five replicates (10/ replicate). The 1st group fed a basal diet without OP as a control. JQ in the 2nd and 3rd groups were fed diets included 5% OP either without or with enzyme (Natuzyme) addition, respectively, while those in the 4th and 5th groups were fed diets included 10% OP either without or with EZ addition, respectively. The obtained olive pomace waste was prepared and analyzed according to the Association of Official Analytical Chemists (AOAC, 2004). The experimental diets were fortified with adequate vitamins and minerals mixtures and formulated to meet all nutrients requirements according to NRC (1994) (Table 1).

Chicks in all treatment groups were reared under similar managerial and hygienic conditions of animal welfare. All birds were wing banded and housed in wire cages (40×50×25 cm). The indoor temperature was kept at 33 °C for the first 3 days of age then declined gradually by 2.8 degree weekly till constant at 24 °C during the rest of the experiment. Artificial lighting was provided continuously for 24 hour / day. Cleaned water was available all the time and feed were offered *ad libtum* as mash. Data of growth performance including body weight (BW) and feed intake were recorded for each replicate (g/bird) between 7 and 42 d of age. Besides, body weight gain BWG (g/bird) as well as feed conversion ratio (FCR) (g feed/g gain) were calculated. Economic efficiency for all experimental diets were calculated as described by Zeweil (1996). Production index expressed as European Production Efficiency Index (EPEI) was calculated as listed by Attia *et al*. (2012) as follows: -

$$EPEI = \frac{BW\ (Kg) \times SR}{PP \times FCR} \times 100$$

BW = Body Weight (kg), SR = Survival Rate (100% - mortality) PP = Production Period (days), FCR = Feed Conversion Ratio.

Apparent digestibility of dry matter (DM), organic matter (OM), crude protein (CP), ether extract (EE) and crude fiber (CF) was done according to (Aggoor *et al.,* 2000).

At 42 d of age, fifteen birds around average body weight of treatment were obtained from each treatment then fasted for 12 hours and individually weighed then slaughtered and feathered. Records of dressing%, liver%, heart%, gizzard%, heart%, stomach%, intestine% and thymus% were individually separated, weighed and calculated for each organ relative to pre-slaughtered weight.

Table (1): Ingredients and chemical composition of the experimental basal diets fed during the experiment stage.

Ingredient	Starter Diets				
	Control	5% OP	5% OP+Enz	10% OP	10% OP+Enz
Corn, Grain	50.5	46.5	46.5	42.5	42.5
Soybean Meal -44%	40.5	38	38	35	35
Soybean Oil	3	3	3	3	3
Gluten Meal	2.35	3.85	3.85	5.85	5.85
Dical. Phos.	1.65	1.65	1.65	1.65	1.65
Olive Pulp*	0	5	5	10	10
Vit + Min. Premix**	0.3	0.3	0.3	0.3	0.3
Limestone	1.2	1.2	1.2	1.2	1.2
Common Salt	0.3	0.3	0.3	0.3	0.3
DL-Methionine	0.07	0.07	0.07	0.07	0.07
L-Lysine HCl	0.13	0.13	0.13	0.13	0.13
Enzyme***	0.0	0.0	0.05	0.0	0.05
TOTAL	100	100	100	100	100
Determined[1] and calculated[2] composition (% as fed basis)					
Dry matter[1]	86.48	86.65	86.65	86.83	86.83
Dry matter[2]	86.48	86.65	86.65	86.83	86.83
ME (kcal/kg)[2]	2960	2957	2957	2961	2961
Crude protein[1]	23.63	23.59	23.59	23.60	23.60
Crude protein[2]	23.88	23.83	23.83	23.87	23.87
Ether extract[1]	5.38	5.81	5.81	6.25	6.25
Ether extract[2]	5.30	5.78	5.78	6.27	6.27
Crude fiber[1]	3.91	4.89	4.89	6.03	6.03
Crude fiber[2]	4.06	5.14	5.14	6.20	6.20
Calcium2	0.97	1.01	1.01	1.04	1.04
Total phosphorus2	0.72	0.71	0.71	0.69	0.69
Available phosphorus[2]	0.46	0.46	0.46	0.45	0.45
Lysine[2]	1.34	1.29	1.29	1.24	1.24
Methionine[2]	0.46	0.47	0.47	0.49	0.49

**contained 92.7% dry matter, 9.4% crude protein, 26.7%crude fiber, 12.3% ether extract, 8.3% Ash.*

***Vit+Min mix. provides per kilogram of the diet: Vit. A, 12000 IU, vit. E (dl-α-tocopheryl acetate) 20 mg, menadione 2.3 mg, Vit. D3, 2200 ICU, riboflavin 5.5 mg, calcium pantothenate 12 mg, nicotinic acid 50 mg, Choline 250 mg, Vit. B_{12} 10 μg , Vit. B_6 3 mg, thiamine 3 mg, folic acid 1 mg, d-biotin 0.05 mg. Trace mineral (mg/ kg of diet): Mn 80 Zn 60, Fe 35, Cu 8, Selenium 0.1 mg.*

****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.*

Fifteen blood samples in heparin tubes were collected at 42 d of age from each treatment to determine number of red blood cells (RBC), white blood cells (WBC) and different types of leukocytes according to Hepler (1966). Packed cell volume (PCV %), Hemoglobin (Hgb) concentration and red cell indices (MCH and MCHC) were determined as described by Jain (1986) :

Mean Corpuscular Hemoglobin (MCH) (Pg) = HbX10/ RBC's

Mean Corpuscular Hemoglobin Concentration (MCHC) (g/dl) = HbX100/PCV

An Additional fifteen samples in non-heparinized tubes were obtained also from each treatment at 42 d of age for biochemical analysis using commercial kits. The collected blood samples were centrifuged at 3000 rpm for 15 minutes, and kept at -20°C until used for analysis. Blood serum was analyzed for determination of glucose levels (mg/dl), total protein (g/dl), albumin (g/dl) and globulin (g/dl) which were measured according to Trinder (1969), Henry et al. (1974), Doumas (1971) and Coles (1974), respectively. In addition, creatinine, urea-N, total lipids, triglycerides and total cholesterol were determined according to (Fabiny and Ertingshausen, 1971), (Sampson *et al.*, 1980), (Chabrol and Charonnat, 1973), (Fossati and Prencipe, 1982), (Stein, 1986), (Lopez-Virella *et al.*, 1977) and (Friedewald *et al.*, 1972), respectively. Thyroid hormones (T_3 and T_4) were analyzed by using radioimmunoassay kits as described by Sharp et al. (1987). The activities of aspartate amino transferase (AST), and alanine amino transferase (ALT), were estimated according to Reitman and Frankle (1957). Total antioxidant capacity (TAC), superoxide dismutase (SOD) activity, glutathione peroxidase (GPX) activity and glutathione (GSH) activity were determined according to Koracevic et al. (2001), Misra and Fridovich (1972), Paglia and Valentine (1967) and (Ellman, 1959), respectively.

Data obtained were analyzed using the GLM procedure of the Statistical Analysis System (SAS, 2002), using one-way ANOVA as in the following model: $Yik= \mu + Ti + eik$

Where, Y is the dependent variable; μ is the general mean; T is the effect of experimental treatments; and e is the experimental random error. Before analysis, all percentages were subjected to logarithmic transformation (log10x+1) to normalize data distribution. The differences among treatment means were determined using Duncan's new multiple range test (Duncan, 1955).

RESULTS AND DISCUSSION

Growth performance:

The results from the study examining the effects of olive pomace (OP) with or without enzymes on the growth performance and economic efficiency of Japanese quail chicks are summarized in Table (3). Quails that were fed diets containing 5% and 10% OP with enzyme supplementation exhibited significantly higher body weight at 42 days and body weight gain from days 7 to 42 (P<0.05) compared to the corresponding groups fed the same diets without enzymes (220, 218 vs 195, 186, respectively); (191, 191 vs 168, 158, respectively). However, these values did not significantly differ from the control group. Additionally, there was a significant difference in feed intake (FI) (P<0.05), which was higher in the groups fed diets containing 5% and 10% OP with enzyme supplementation compared to those fed diets containing 5% and 10% OP without enzymes.

Table (3): Effect of olive pomace with or without enzymes on growth performance and economic efficiency of Japanese quail chicks.

Items	Control	5%OP	5%OP +Enz	10%OP	10%OP +Enz	Sig.	SEM
BW 7 d , g	28.6	27.6	28.8	28.2	27.2	0.844	1.14
BW 42 d , g	231a	195b	220a	186b	218a	0.004	6.37
BWG 7 – 42 d , g	202a	168b	191a	158b	191a	0.002	5.89
FI 7 – 42 d , g	617a	556b	606a	553b	588ab	0.003	11.67
FCR 7 – 42 d, g	3.05b	3.33ab	3.17b	3.53a	3.08b	0.006	0.087
Production index, %	18.00a	14.09b	16.54a	12.76b	16.81a	0.001	0.734
Economic efficiency*	62.43a	47.15bc	56.85ab	37.96c	57.62ab	0.003	3.63

BW= Body weight, BWG= Body weight gain, FI= Feed intake, FCR= Feed Conversion ratio, SEM=Standard error of means
a,b Values within a row with different superscripts differ significantly at P<0.05.
** Economic efficiency= Net Revenue/ Total cost*

Conversely, the poorest feed conversion ratio (FCR) from days 7 to 42 was observed in the groups fed diets containing 5% and 10% OP without enzymes compared to all other treatment groups.

Furthermore, quails fed diets containing 5% and 10% OP with enzyme supplementation showed significantly improved production index and economic efficiency (P<0.05) compared to those fed diets containing 5% and 10% OP without enzymes.

The present date demonstrates that enzyme supplementation to diets contained 5% or 10% OP had the greatest BW, BWG and FI. This finding agree with Ibrahim *et al.* (2021) who found that broiler fed diet contained enzymatically fermented OP at 7.5 and 15% had higher body weight and body weight gain, improved economic efficiency and better feed conversion ratio. Also, Constantina *et al.* (2018) found that broiler fed diets contained 5 and 7.5% recorded higher BW, BWG and better FCR. On the other hand, El Hachemi., *et al.* (2007); Sayehban *et al.,* (2016); Al-Harthi., (2017) and Adams *et al.* (2022) found that inclusion of dietary dried olive pulp up to 10% had no negative effects on growth performance of broilers. Similarly, dietary OP inclusion up to 100 g/kg in broiler diets had no effect on weight gain (Sayehban *et al.,* 2016; Sateri *et al.,* 2017). Also, the dietary inclusion of OP between 50 and 100 g/ kg in the diets of broiler chicks reduced growth performance, which was linked to the high fiber content of OP (Sayehban *et al.,*2020). Itumeleng *et al.* (2023) showed that jumbo quail fed OP at 250 g/kg had reduced body weight and feed intake. Moreover, Saleh, and Alzawqari, (2021) found lower feed intake when 200 g/kg olive cake meal was used to replace corn in broiler diets. Improvement in bird performance due to feeding olive pomace supplemented with enzymes can be attributed to several factors. Firstly, enzymes play a crucial role in breaking down complex nutrients present in olive pomace, such as fibers and non-starch polysaccharides, into simpler forms that are more easily digestible by the birds (Cowieson, 2010; Attia *et al.,* 2014a). This enhanced nutrient digestibility which leads to better utilization of dietary components, resulting in improved growth performance. Moreover, enzymes can help overcome the antinutritional factors present in olive pomace, such as lignin and tannins, which may interfere with nutrient absorption and utilization (Shaw *et al.,* 2010). By degrading these antinutritional factors, enzymes facilitate the availability of nutrients for absorption in the gastrointestinal tract, thereby promoting growth and efficiency in birds. Furthermore, the inclusion of enzymes in the diet can enhance the overall gut health of the birds (El-Kelawy and El-Kelawy, 2016). Enzymes aid in maintaining a balanced gut microbiota by promoting the growth of beneficial bacteria and inhibiting the proliferation of harmful pathogens (Attia *et al.,* 2014b). A healthier gut environment enhances nutrient absorption and immune function, contributing to improved performance and disease resistance in birds.

Digestibility of nutrients:

Results of the apparent nutrients digestibility conducted on Japanese quail chicks, fed diets containing olive pomace (OP) with or without enzyme supplementation, are presented in Table (4). It was observed that the digestibility percentages of dry matter and crude protein were significantly higher (P<0.05) in the groups of quails fed diets containing 5% and 10% OP supplemented with enzymes compared to those fed diets containing the same percentages of OP without enzyme supplementation. However, these values did not differ significantly from the control group. Conversely, the digestibility percentages of ether extract and fiber were significantly lower (P<0.05) in the quail groups fed diets containing 10% OP without enzyme supplementation. Additionally, there were no significant differences observed between treatment groups regarding ash digestibility.

Table (4): Apparent nutrients digestibility of Japanese quail chicks fed diet contains olive pomace with or without enzymes.

Items	Control	5%OP	5%OP +Enz	10%OP	10%OP +Enz	Sig.	SEM
Dry matter %	77.82a	73.36ab	77.06a	70.66b	74.85ab	0.049	1.70
Protein %	74.76a	67.54bc	73.53a	65.19c	71.70ab	0.004	1.76
Ether Extract %	84.15a	81.00a	81.74a	76.01b	82.28a	0.002	1.21
Fiber %	39.66a	38.11a	37.47a	32.01b	35.97a	0.003	1.20
Ash	51.67	52.55	52.17	51.17	52.19	0.933	1.18

SEM=Standard error of means

a,b Values within a row with different superscripts differ significantly at P<0.05.

The current findings demonstrate that the addition of enzymes to diets containing 5% and 10% olive pomace (OP) led to enhanced digestibility of dry matter and crude protein. This observation is consistent with the findings of Ibrahim *et al.* (2021), who reported improved digestibility of dry matter and crude protein in broilers fed diets containing enzymatically fermented OP at levels of 7.5% and 15%. The improvement in bird digestion due to feeding olive cake supplemented with enzymes can be attributed to several factors. Olive cake, a byproduct of olive oil extraction, is rich in fiber and protein but contains anti-nutritional factors such as phenolic compounds, tannins, and lignin, which can hinder nutrient absorption and utilization by birds (Ravindran, 2013). These anti-nutritional factors can adversely affect the activity of digestive enzymes and impair nutrient digestion and absorption in birds (Nalle *et al.,* 2014). The beneficial effects of enzymes can be attributed to their role in disrupting the integrity of plant cell walls, leading to the release of encapsulated nutrients (Shaw *et al.,* 2010). Furthermore, the inclusion of exogenous enzymes in the diet facilitates the hydrolysis of non-starch polysaccharides (NSP) and reduces intestinal viscosity, resulting in improved nutrient digestibility and growth performance in birds (Amerah, 2015). Also, supplementing olive cake with enzymes helps in breaking down these anti-nutritional factors, enhancing the availability of nutrients for digestion and absorption in birds (Brenes *et al.,* 2016). Enzymes such as cellulase, xylanase, and phytase can degrade complex polysaccharides, such as cellulose and hemicellulose, present in olive cake, into simpler sugars, which are more readily fermentable by gut microflora and absorbable by birds (Yaghoubi *et al.,* 2014). Furthermore, enzymes like phytase can hydrolyze phytic acid, reducing its anti-nutritional effects and improving phosphorus availability (Selle and Ravindran, 2007). Additionally, supplementation with enzymes may enhance the activity of endogenous digestive enzymes in birds, thereby improving overall digestive efficiency (Bedford, 2018). This synergy between exogenous and endogenous enzymes can lead to better nutrient utilization, improved growth performance, and enhanced feed conversion efficiency in birds fed olive cake-based diets (Hassan *et al.,* 2019).

Carcass characteristics:

The results of carcass characteristics and the relative weights of organs in Japanese quail chicks fed diets containing olive pomace (OP), with or without enzymes, are presented in Table (5). It was observed that the dressing percentage was higher in the quail groups fed diets containing 5% and 10% OP supplemented with enzymes ($P<0.05$) compared to those groups fed diets containing 5% and 10% OP without enzymes. Nevertheless, this difference was not statistically significant compared to the control group. However, there were no significant differences between the treatment groups regarding the relative weights of organs such as the liver, gizzard, heart, stomach, intestine, spleen, and thymus.

Table(5): Carcass characteristics and relative organs weight of Japanese quail chicks fed diet contains olive pomace with or without enzymes.

Items	Control	5%OP	5%OP+Enz	10%OP	10%OP+Enz	Sig.	SEM
Dressing%	74.20a	68.93b	73.48a	67.28b	72.55a	0.001	1.131
liver%	2.51	2.49	2.48	2.31	2.38	0.581	0.100
Spleen%	0.05	0.05	0.05	0.05	0.04	0.65	0.004
gizzard%	2.48	2.24	2.32	2.41	2.19	0.301	0.103
heart%	0.9	0.86	0.89	0.88	0.88	0.864	0.030
stomach%	0.39	0.37	0.36	0.39	0.36	0.168	0.011
intestine %	3.23	3.11	3.24	3.27	3.25	0.372	0.059
thymus%	0.04	0.03	0.04	0.03	0.03	0.501	0.004

SEM, Standard error of means
a,b Values within a row with different superscripts differ significantly at $P<0.05$.

The current data indicates that there is an increase in dressing percentage by supplementing EZ to diets containing 5% or 10% OP. This increase is attributed to the improved nutrient utilization facilitated by the addition of EZ in the diet, as suggested by Cowieson (2010), and Shaw et al. (2010). Higher body weight and improved feed conversion ratio also contribute to the observed increase in dressing percentage, as noted by Attia and Al-Harthi (2015). However, there were no significant differences observed between treatments concerning carcass characteristics. This finding is consistent with the results of Saleh and Alzawqari (2021) and Pappas et al. (2019), who reported no significant differences in carcass characteristics of broilers when fed diets containing 80 and 100 g/kg of OP instead of maize. Similarly, Itumeleng et al. (2023) demonstrated that jumbo quails fed on OP at a level of 250 g/kg had no impact on carcass yield. Additionally, Al-Harthi (2017) observed no effect on carcass traits in broilers fed diets containing 5% and 10% olive cake with phytase enzyme. Likewise, Sateri et al. (2017) found that broilers fed diets containing 2%, 4%, 6%, and 8% olive meal with enzyme did not exhibit any significant changes in carcass traits.

Blood parameters:

The results regarding the effect of olive pomace (OP) with or without enzymes on blood biochemical parameters are summarized in Table 6. Significant differences were observed in blood serum levels of T3, total protein, albumin, and globulin. Specifically, blood serum T3 levels were higher in groups fed diets containing 5% OP+Enz (P<0.05) compared to the group fed diets containing 10% OP without enzymes. However, these levels did not significantly differ from those in any other treatment groups.

Conversely, serum levels of total protein, albumin, and globulin were decreased (P<0.05) in all groups fed diets containing OP with or without enzymes compared to the group fed the control diet. However, there were no significant differences in blood serum glucose, T4, renal and liver function parameters among the treatment groups. Additionally, no significant differences were observed in serum lipid profile parameters including total lipids and triglycerides between the treatment groups. Furthermore, serum cholesterol significantly increased in the group fed diets containing 10% OP without enzymes compared to all other treatment groups. Significant differences were also noted in serum antioxidant enzyme levels. Specifically, lower values of total antioxidant capacity and glutathione peroxidase were observed in the group fed 10% OP compared to all other treatment groups. However, glutathione levels were significantly higher in the groups fed diets containing 10% OP+Enz and the control diet compared to all other treatment groups. No significant differences were found in superoxide dismutase levels among the treatment groups.

Table (6): Effect of olive pomace with or without enzymes on blood serum biochemical parameters at 42 days of age of Japanese quails.

Items	Control	5%OP	5%OP +Enz	10%OP	10%OP +Enz	Sig.	SEM
Serum biochemical parameters							
Glucose (mg/dl)	267	242	258	232	249	0.386	12.980
T3 (ng / ml)	1.97a	1.93ab	1.98a	1.77b	1.88ab	0.054	0.050
T4 (ng / ml)	9.96	9.92	10.06	9.50	9.66	0.800	0.360
Total protein (mg/dl)	5.35a	4.40cd	4.81b	4.09d	4.55bc	0.010	0.107
Albumin (mg/dl)	2.67a	2.35b	2.37b	0.05c	2.38b	0.017	0.078
Globulin (mg/dl)	2.68a	2.04c	2.44ab	0.36d	2.18bc	0.005	0.117
Renal and Liver functional							
Urea (mg/dl)	20.34	19.36	21.02	21.42	20.9	0.630	0.980
Creatinine (mg/dl)	0.74	0.75	0.76	0.78	0.80	0.686	0.040
Urea/Creatinine	27.68	25.98	27.96	27.58	26.0	0.578	1.130
AST, U/L	70.23	75.54	69.21	73.05	70.43	0.351	2.370
ALT, U/L	34.13	33.35	33.41	34.70	33.73	0.687	0.740
ALT/AST	0.49	0.44	0.48	0.48	0.48	0.525	0.020
Serum Lipid Profile							
Total lipids (mg/dl)	439	417	427	446	414	0.556	15.882
Triglycerides (mg/dl)	316	350	321	370	338	0.317	19.537
Cholesterol (mg/dl)	170b	187ab	173b	201a	175b	0.008	5.862
Serum antioxidants enzymes							
TAOC (mg/dl)	512a	492a	506a	446b	500a	0.012	12.66
GPX (mg/dl)	0.524a	0.481ab	0.493a	0.432b	0.496a	0.048	0.02
GSH (mg/dl)	852a	814bc	824b	793c	836ab	0.004	7.79
SOD (mg/dl)	229	227	227	220	228	0.712	4.73

a,b,c Means in the same row followed by different letters are significantly different at (P ≤ 0.05); Sig.= significantly SEM= Standard error of mean; AST=aspartate amino transferase; ALT=alanine amino transferase; HDL=high-density lipoprotein; LDL=low-density lipoprotein; TAOC=total antioxidant capacity; GPX =glutathione peroxidase; GSH= glutathione; SOD=superoxide dismutase

Evaluation of blood parameters provides insights into the physiological status and health of Japanese quail. Studies examining the effects of OP and enzyme supplementation on blood parameters have reported varying results. The current data demonstrates significant differences among treatments in plasma biochemical parameters. This observation is consistent with findings by Al-Harthi (2017), who noted a decrease in serum cholesterol levels in broilers fed diets containing 5% and 10% olive cake with phytase enzyme. Similarly, Saleh and Alzawqari (2021) reported lower serum cholesterol levels when olive cake meal replaced maize at 100 g/kg in broiler diets. In contrast, Sateri *et al.* (2017) found no effect on blood triglycerides, total protein, albumin, glucose, and uric acid in broilers fed diets containing 2%, 4%, 6%, and 8% olive meal with enzymes. Likewise, Itumeleng *et al.* (2023) observed no impact on plasma biochemical parameters in jumbo quails fed on OP at levels of 200 and 250 g/kg. Furthermore, the data presented indicates higher levels of plasma antioxidant enzymes when olive pomace is included in the diet. This finding aligns with research by Ibrahim et al. (2021), who found increased total antioxidant capacity, total superoxide dismutase, and glutathione peroxidase in broilers fed diets containing enzymatically fermented olive pomace at levels of 15% and 30%. The elevated serum antioxidants attributed to olive pomace are due to its phenolic compounds with antioxidant activities, such as oleuropein, oleacein, oleocanthal, tyrosol, and hydroxytyrosol, which can reduce alpha-tocopherol radicals (Rigacci and Stefani, 2016; and Constantina *et al.*, 2018).

Results of effect of OP with or without enzymes on hematological criteria are presented in Table (7). There was no significant difference on hematological criteria between treatments groups. The study examined the impact of olive pomace (OP) supplementation, with or without enzymes, on hematological parameters, as detailed in Table 7. Interestingly, the analysis revealed no significant variances in hematological criteria across the treatment groups. This suggests that the inclusion of olive pomace, regardless of enzyme supplementation, did not elicit discernible effects on hematological parameters. These findings are consistent with several previous studies that have reported similar results regarding the hematological effects of olive pomace supplementation. For instance, Estévez *et al.* (2005) observed no significant alterations in hematological parameters in broiler chickens fed diets containing olive by-products. Additionally, Moyo *et al.* (2013) found no significant differences in blood parameters when evaluating the nutritional characterization of Moringa leaves in poultry. The absence of significant differences in hematological criteria between the treatment groups in our study may be attributed to various factors such as dosage, duration of treatment, or specific characteristics of the study population. Further investigation with larger sample sizes, different dosages, or longer intervention periods may provide deeper insights into the potential hematological effects of olive pomace and enzymes.

Table (7): Effect of olive pomace with or without enzymes on blood hematological criteria at 42 days of age of Japanese quails.

Items	Control	5%OP	5%OP +Enz	10%OP	10%OP +Enz	Sig.	SEM
Hematological criteria							
RBC's (10^6/cmm3)	1.56	1.58	1.56	1.5	1.52	0.942	0.08
Hemoglobin (g/100ml)	12.58	12.76	13.76	13.1	12.26	0.778	0.86
PCV, %	33.44	35.32	33.28	31	31.64	0.796	2.63
MCH (Ug)	84.92	80.78	89.2	87.68	81.14	0.94	8.63
MCHC, %	38.38	37.7	42	43.28	41	0.894	4.57
MCV	219	223	214	208	207	0.961	17.51
WBC's (103/cmm3)	23.26	22.02	23.08	24.26	22.42	0.464	0.89

a,b,c Means in the same row followed by different letters are significantly different at($p \leq 0.05$); Sig.= significantly; SEM= Standard error of mean; RBC's = red blood cells; PCV= packed cell volume; MCH= mean corpuscular hemoglobin; MCV= Mean cell volume; MCHC= Mean Corpuscular Hemoglobin Concentration; WBC's= white blood cells.

CONCLUSION

It could be concluded that enzyme supplementation in Japanese quail diets contained olive pomace up to 10 % could be used safely without adverse effect on growth performance and up to 5% with adding EZ to achieve optimum growth performance, economic efficiency and digestibility of nutrients during growing period.

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تأثير تفل الزيتون والإنزيمات على الأداء الإنتاجي وهضم المركبات الغذائية وبعض قياسات الدم للسمان الياباني

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أجريت هذه الدراسة في وحدة بحوث الدواجن بمزرعة كلية الزراعة جامعة الوادي الجديد. هدفت هذه الدراسة إلى دراسة تأثير تفل الزيتون على الاداء الانتاجي، وهضم المركبات الغذائية وبعض قياسات الدم للسمان الياباني. تم استخدام عدد 250 طائر سمان ياباني غير مجنس عمر 7 ايام وقسمت عشوائيا الي 5 معاملات غذائية كل منها فى خمس مكررات. غذيت المجموعة الاولي على العليقة الاساسية الخالية من تفل الزيتون لتمثل عليقة المقارنة (الكنترول). غذيت المجموعة الثانية والثالثة من السمان على علائق تحتوي على 5% من تفل الزيتون اما بدون او مع اضافة الانزيمات علي التوالي، وغذيت المجموعة الرابعة والخامسة من السمان على علائق تحتوي على 10% من تفل الزيتون اما بدون او مع اضافة الانزيمات على التوالي. تم تقدير كلا من وزن الجسم، الزيادة في وزن الجسم، استهلاك العلف، معدل التحويل الغذائي، معامل هضم المركبات الغذائية، معدل الانتاج، الكفاءة الاقتصادية، صفات الذبيحة وبعض قياسات الدم. اظهرت النتائج ان السمان الذي تغذى علي علائق تحتوي علي 5% أو10% من تفل الزيتون مع اضافة الانزيمات سجل زيادة معنوية في كلا من وزن الجسم، الزيادة في وزن الجسم، استهلاك العلف، افضل معدل تحويل غذائي، وكفاءة اقتصادية، ومعدل انتاج، ومعامل هضم المادة الجافة والبروتين بالإضافة الي نسبة الذبيحة المجهزة، وهرمون الثيروكسين وإنزيمات الأكسدة مقارنة بمجموعة السمان التي تغذت علي 5% أو10% من تفل الزيتون بدون اضافة انزيمات مع عدم وجود اختلاف مع مجموعة الكنترول. علي الجانب الاخر مجموعة السمان التي تغذت علي 5% أو10% من تفل الزيتون مع او بدون اضافة الانزيمات اظهرت انخفاض معنوي في محتوى سيرم الدم من للبروتين الكلي، الالبيومين، والجلوبيولين مقارنة بمجموعة الكنترول. ايضا مجموعة السمان التي تغذت علي 10% من تفل الزيتون بدون اضافة الانزيمات سجلت اقل قيمة لإنزيمات الأكسدة بالإضافة الي معامل هضم الالياف ومستخلص الاثير مقارنة بجميع المعاملات الأخرى. نستنتج من ذلك أن إضافة الإنزيمات في علائق للسمان الياباني مع استخدام تفل الزيتون حتى 10% لا تؤثر سلبًا على أداء النمو، بينما استخدام مستوى 5% من تفل الزيتون مع إضافة الإنزيمات يحقق اعلي معدل نمو، وكفاءة اقتصادية ومعدل هضم المركبات الغذائية خلال فترة النمو.