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PJBS

ISSN 1028-8880

Pakistan Journal of Biological Sciences

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

OPEN ACCESS Pakistan Journal of Biological Sciences

ISSN 1028-8880
DOI: 10.3923/pjbs.2025.131.137

Research Article
Impact of Diets Containing Olive Cake and Herbs on Growth Performance and Carcass Traits of Broiler Chicken Through Growing Stage

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Abstract

Background and Objective: Olive cake, a by-product of olive oil extraction, is a sustainable, protein-rich ingredient that enhances poultry growth and profitability. It is cost-effective and valuable in modern poultry nutrition programs. So, this study investigated the impact of the fermentation process of olive cake and its usage to replace yellow corn with or without adding herbal additives in broiler diets on growth performance, carcass characteristics and blood parameters. **Materials and Methods:** At 21 days of age, 600 unisex chicks of the Sasso breed were distributed among 60 groups of 10 birds each. Using an utterly randomized approach, five treatments with twelve replicates of ten birds each were dispersed in a 2×2×2 factorial arrangement. Two varieties of olive cake (fermented, with and without herbal mixture) and two olive cake levels (20 and 30% in diet substituted with yellow corn) are used as treatments. Growth performance, blood parameters, carcass characteristics and meat quality were measured at a significant level of 0.05 using a one-way ANOVA model. **Results:** The increasing olive cake (OC) in poultry diets reduced feed consumption, with the 30% OC herbal mixture showing the least intake ($p<0.05$). Significant variations were found in the feed conversion ratio (FCR) among treatments, but OC did not affect organ weights. While, liver percentage was significantly impacted, blood parameters like triglycerides and cholesterol showed no significant differences, except for reduced total cholesterol in OC-fed broilers. The OC addition in poultry rations presents a cost-effective alternative to traditional diets. **Conclusion:** Using unconsumed olive waste as poultry feed additives can reduce feed costs, improve broiler growth and decrease environmental pollution. This approach offers an economical and sustainable solution amid rising feed prices and competition.

Key words: Olive cake, broiler, fermented, herbal, yellow corn, carcass

Citation: Rahmy, H.A.F., S.M.M. Noureldin, F.M.M. Abosamra, A.E.M. Mahmoud, A.M.K. Elsaid and A.S.M. Korayem, 2025. Impact of diets containing olive cake and herbs on growth performance and carcass traits of broiler chicken through growing stage. Pak. J. Biol. Sci., 28: 131-137.

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

After the oil is extracted, the leftover olive skin, crushed pulp and kernel shell still contain some oil; this mixture includes roughly 25% water and is called olive cake. The simple olive cake is the term for the initial oil extracted from an olive that remains under pressure. Its contents are relatively rich in water (24%) and oil (9%). Due to the quick oxidation caused by air exposure, storing and disposing of it is not easy[1].

Innovation in agriculture achieves a "zero waste" economy, in which waste from raw materials is used to produce new goods and applications[2]. On the other hand, the fast-expanding chicken farming industry dramatically raises feed costs and consumption. Feed expenses account for over 70% of production costs in the chicken sector[3].

Numerous studies have been conducted to meet the growing demand for feed while lowering feed costs. Examining the possibilities for using alternate feed sources in poultry nutrition is one of the key topics highlighted in these studies. Feeding animals items suitable for human consumption is not advisable because this encourages competition between humans and animals. By-products from collecting and processing olives, which have long been a vital part of Egypt and the Mediterranean region's diets, may one day be used as substitute feed ingredients by the chicken industry. By-products, including olive leaves, olive, black water (wastewater) and olive pomace, are created when olives are processed to make oil. Prior research on the viability of utilizing these by-products in animal nutrition and the resulting outcomes has demonstrated the possibility for other feed sources and significant financial benefits[4]. Studies in the past have investigated the possibility that adding products from the olive industry to the diets of broilers could hurt growth performance metrics, but only up to a certain extent[5]. This research aimed to use the solid-state fermentation method to bio-transform and valorize olive cake, a by-product of the Egyptian olive industry, to add value to chicken feed. In this case, the challenge is to allow the complex fibers in the olive cake: Lignin, cellulose and hemicellulose to decompose and be ingested by birds and by supplementation of herbal and aromatic plants, also study the effects of production on the growth rate, feed intake, feed conversion ratio, blood parameters and carcass characteristic.

MATERIALS AND METHODS

Study location and time: This study was conducted in July, 2023 at the Faculty of Organic Agriculture at Heliopolis University for Sustainable Development, Cairo, Egypt.

Reagents: The ISIS and SEKEM Company (Agricultural Seeds, Herbs and Plants Mixed Spices, Belbis, Sharkia governorate, Egypt) provided the by-product (olive cake) and aromatic and herbal plants.

In this study, three kinds of fragrant herbs: Lemongrass, chamomile and mint, were combined and administered as feed additives to treatments 1 and 3 at a rate of 4%.

The nutritional value of the ingredients was measured by applying to the Association of Official Analytical Chemists Official Methods, AOAC[6].

Ethical approval: The Institutional Animal Care and Use Committee (CU-IACUC), Cairo University, Egypt, approved the Animal Housing and Handling Protocols. Feeding trials with The broilers were kept in floor pens with similar growing conditions.

Animals and treatments: Sixty groups of ten birds (Sasso strain purchased from https://www.doctorsayedzakaria.com/sasso-shaver/) each received 600 unisex chicks from the Sasso breed at 21 days of age. Five treatments consisting of twelve replicates of ten birds each were distributed in a $2\times2\times2$ factorial configuration using a completely randomized method. Treatments consist of two types of Olive cake (Fermented, with (WH) and without herbal mixture (WO)), two levels of olive Cake (20 and 30% in diet replaced with yellow corn) and with and without herbal mixture (Table 1).

Management procedures: Automatic nipple cup drinker water and pelleted feed were always accessible. Broilers were given growing diets comprising 21% crude protein. The 50 Association of Official Analytical Chemists' Procedures were followed in analyzing the olive cake and feed ingredient for moisture, crude protein, ether extract, crude fiber, ash and nitrogen-free extract, AOAC[6].

Each bird's weight was measured to the nearest gram. Each subject's body weight was measured on the 1st day of the experiment and then once a week until the trial ended. Body weight gain was calculated by subtracting the final body weight simultaneously from the average initial body weight across the relevant timeframe.

Each replicate's feed intake (FI) was recorded weekly until the end of the experiment[7]: Average feed intake/chick = Grams per week divided by the number of chicks during the same week.

Feed conversion ratio (FCR) was calculated weekly for each group, including the weight gain of the dead birds: FCR is feed intake in grams divided by body weight gain in grams. Following an overnight fast, eight birds representing

Table 1: Structure and chemical analysis of experimental diets

	Experimental diet				
Item	C, 0%	T1, 20% WH	T2, 20% WO	T3, 30% WH	T4, 30% WO
Yellow corn	580	464	464	406	406
Soybean meal, 44% CP	304	303	303	316	316
Corn gluten meal	48	48	48	48	48
Soybean oil	29	30	30	21	21
Olive cake	0	116	116	174	174
Herbal mixture	0	4	0	4	0
Calcium carbonate	12	10	12	10	12
Di-calcium phosphate	15	13	15	13	15
Common salt	3.5	3.5	3.5	3.5	3.5
Premix*	3	3	3	3	3
DL-Methionine	1.8	1.8	1.8	1.8	1.8
L-Lysine HCl	1.4	1.4	1.4	1.4	1.4
Toxin binder	2.3	2.3	2.3	2.3	2.3
Chemical composition					
GE (Kcal/kg)	3045	3040	3040	3041	3041
CP (%)	21.00	21.07	21.07	21.05	21.05
CF (%)	3.55	5.13	5.13	9.33	9.33
Ca (%)	0.896	0.894	0.894	0.894	0.894
Available phosphorus (%)	0.408	0.408	0.408	0.408	0.408

C, 0%: Control diet, T1, 20% WH: 20% olive cake inclusion with herbal mixture, T2, 20% WO: Olive cake inclusion without herbal mixture, T3, 30% WH: 30% olive cake inclusion with herbal mixture, T4, 30% WO: 30% olive cake inclusion without herbal mixture, herbal mixture: Lemongrass+Chamomile+Mint, *Premix: Each 2.5 kg contains vitamin A (10, 000000 IU), vitamin D3 (2, 000000 IU), vitamin E (10 g), vitamin k3 (1000 mg), vitamin B1 (1000 mg), vitamin B2 (5 g), vitamin B6 (1.5 g), pantothenic acid (10 g), vitamin B12 (10 mg), niacin (30 g), folic acid (1000 mg), biotin (50 g), Fe (30 g), Mn (60 g), Cu (4 g), I (300 mg), Co (100 mg), Se (100 mg) and Zn (50 g)

each treatment replicate were randomly selected and killed after the experiment. It was determined how much the internal organs and carcass weighed relative to the weight of the living body.

Blood samples were collected from the birds during the slaughter for each treatment. The samples were placed in 2 mL sterile vials and coagulated for 4 hrs. The serum was stored at -20°C until analysis after being centrifuged for 10 min at 2000 rpm. The blood plasma lipid profiles of total cholesterol according to Watson[7], Low-Density Lipoprotein (LDL) according to Wieland and Seidel[8], High-Density Lipoprotein (HDL) as explained by Lopez-Virella *et al.*[9] and triglycerides by Fossati and Prencipe[10] were assessed using commercial diagnostic kits.

Carcass traits: Samples were analyzed at Cairo University Research Park (CURP)/Faculty of Agriculture for the following traits: Chemical analysis of two birds from each replication (six per group) was performed using the Food Scan™ Pro meat analyzer (Foss Analytical A/S, Model 78810, Denmark). Meat color was measured by a Chroma meter (Konica Minolta, model CR 410, Japan) calibrated with a white plate and light trap supplied by the manufacturer. Color was expressed using the CIE L, a and b color system. Three spectral readings were taken for each sample at different locations of the LD muscle. Lightness (L*) (dark to light), the redness (a*) values (reddish to greenish). The yellowness (b*) values (yellowish to bluish) were estimated.

Statistical analysis: SAS software's 9.4 general linear model was used to do a one-way analysis of variance in the data gathered from this experiment[11]. The olive cake inclusion level with and without herbal mixture was the key determinant. When there were substantial discrepancies, Duncan's New Multiple Range test, according to Duncan[12], was used to compare means. The analysis's fixed effects model was:

$$Yij = \mu+Ti+eij$$

Where:

Yij = Observing the J_{th} chick in the i_{th} treatment
μ = Overall mean
Ti = Effect of the ith treatment (i = 1, 2, 3,)
eij = Experimental random error effect

The significance level was set at ($\alpha = 0.05$).

RESULTS AND DISCUSSION

Regardless of the amount of olive cake (OC), herbal and aromatic plant administration significantly boosted the growth rate and enhanced the output index. Moreover,

Table 2: Feed intake, feed conversion ratio (FCR, feed (g)/gain (g)) and body weight gain (BWG) of broiler chickens fed diets with varying amounts of olive cake from 21 to 48 days of age

	Experimental diet						
Item	C, 0%	T1, 20% WH	T2, 20% WO	T3, 30% WH	T4, 30% WO	±SE	p-value
Feed intake (g)	2062	2075	2010	2077	2066	23.6	0.040
BWG 21-48 days of age (g)	1356[a]	1330[a]	1262[ab]	1226[b]	1221[b]	34.7	0.035
Feed conversion rate	1.52[b]	1.58[b]	1.59[b]	1.69[a]	1.69[a]	0.04	0.048

[a,b]Means that different superscripts within each row are significantly different (p<0.05). C, 0%: Control diet, T1, 20% WH: 20% olive cake inclusion with herbal mixture, T2, 20% WO: Olive cake inclusion without herbal mixture, T3, 30% WH: 30% olive cake inclusion with herbal mixture, T4, 30% WO: 30% olive cake inclusion without herbal mixture, herbal mixture: Lemongrass+Chamomile+Mint and SE: Standard error

Table 3: Effect of olive cake with and without herbal mixture on carcass and inner organs (%) ratios of 21-48 days old

Item	Dressing	Abdominal fat	Liver	Heart	Pancreas	Gizzard	Intestines	Caecum
C, 0%	68.08	0.35	2.20[ab]	0.62	0.30	1.77	4.24	0.57
T1, 20% WH	70.28	0.54	2.11[c]	0.76	0.31	1.79	4.20	0.45
T2, 20% WO	68.82	0.51	2.20[ab]	0.69	0.28	1.70	4.12	0.50
T3, 30% WH	69.90	0.50	2.11[c]	0.70	0.32	2.11	3.82	0.65
T4, 30% WO	69.78	0.51	2.25[a]	0.62	0.31	2.16	3.64	0.70
±SE	4.52	0.23	0.22	0.10	0.04	0.18	0.45	0.13
p-value	0.13	0.28	0.04	0.17	0.27	0.27	0.26	0.18

[a,b]Means that different superscripts within each row are significantly different (p<0.05), C, 0%: Control diet, T1, 20% WH: 20% olive cake inclusion with herbal mixture, T2, 20% WO: Olive cake inclusion without herbal mixture, T3, 30% WH: 30% olive cake inclusion with herbal mixture, T4, 30% WO: 30% olive cake inclusion without herbal mixture, herbal mixture: Lemongrass+Chamomile+Mint and SE: Standard error

adding OC at 20 and 30% to broiler diets had no discernible effect on feed intake, growth rate or feed conversion ratio. Table 2 displays the body weight gain (BWG) and average daily feed intake (ADFI) throughout the trial. Significant variations ($p<0.05$) in the feed conversion ratio and between the experimental treatments ranged between 1.52-1.69. The experimental treatments' levels of olive cake gradually dropped concerning feed intake to 2010 g in treatment 2, according to the results. The birds fed 30% of OC with a herbal mixture consumed more feed, 2077 g, than the other experimental treatments ($p<0.05$). A substantial difference ($p<0.05$) was found in the feed conversion ratio (FCR) between the experimental treatments.

The feed conversion ratio of the birds given a control diet without being supplemented with OC with a herbal mixture was lower than that of the other treatments.

Essential oils or their extracts, as well as phytochemicals isolated from herbals rich in bioactive ingredients with anti-inflammatory, antimicrobial and antioxidant effects, are promising alternatives to antibiotics in a global strategy to decrease the use of drugs to enhance the productivity of broilers under intensive production[13,14].

Olive cake (5%) and yeast (0.4 g/kg) significantly enhanced the broiler's body weight gain (BWG), feed conversion ratio (FCR) and Euro pean production efficiency index (EPEI)[15].

On the other hand, Zhang *et al.*[16] found that the broiler diets with high levels of OL (5%) significantly decreased the growth indices. However, according to other studies, adding olive cake to the diet (with the addition of phytase enzyme) had no appreciable (10-15%) impact on grill growth indicators[17]. Al-Harthi[15] and Saleh *et al.*[18] claim that broiler feeding involves an olive cake meal. These writers made use of isocaloric and isonitrogenous diets.

Carcass characteristics and relative organ: The effects of OC with and without herbal mixture on the relative weights of the inner organs and carcass of 48 days old broilers are shown in Table 3. The relative weights of the carcass, abdominal fat, heart, pancreas, gizzard, gut and caecum were unaffected by OC substitution. However, OC with and without an herbal mixture had a considerable impact on the liver percentage. Compared to the control groups, it was observed that taking OC with herbal supplementation caused a decrease in relative liver weight. The inclusion of olive cake with or without a herbal mixture significantly influenced the liver percentage ($p = 0.04$), with T4 (30% olive cake without a herbal mixture) showing the highest liver ratio (2.25%). No significant differences were observed in other parameters, including dressing percentage, abdominal fat, heart, pancreas, gizzard, intestines and caecum ($p>0.05$). Overall, dietary treatments demonstrated some effect on liver weight but did not significantly alter other carcass and inner organ ratios in 21-48 days old birds in Table 3.

The reduction in the relative liver weight seen in all groups given OC may be attributed to the presence of antioxidant chemicals and unsaturated fatty acids, including polyunsaturated and monounsaturated fatty acids[19,20].

Table 4: Chemical analysis of carcass (breast meat only) using olive cake with and without herbal mixture on carcass ratios of 21-48 days old

Item	Collagen	Protein	Fat	Moisture
C, 0%	0.99	24.72[a]	0.91[b]	73.29
T1, 20% WH	1.22	22.18[b]	0.99[b]	75.96
T2, 20% WO	0.98	22.05[b]	1.26[a]	75.58
T3, 30% WH	1.19	22.82[b]	0.99[b]	75.17
T4, 30% WO	1.23	22.02[b]	0.89[b]	76.58
±SE	-	0.39	0.02	0.90
p-value	-	0.023	0.034	0.175

[a,b]Means with different superscripts within each row significantly differ (p<0.05), C, 0%: Control diet, T1, 20% WH: 20% olive cake inclusion with herbal mixture, T2, 20% WO: Olive cake inclusion without herbal mixture, T3, 30% WH: 30% olive cake inclusion with herbal mixture, T4, 30% WO: 30% olive cake inclusion without herbal mixture, herbal blend: Lemongrass+Chamomile+Mint and SE: Standard error

Table 5: Colour of carcass using olive cake with and without herbal mixture on carcass ratios of 21-48 days old

Item	Lightness (L*)	Redness (a*)	Yellowness (b*)
C, 0%	53.53[c]	8.79[a]	7.84
T1, 20% WH	58.47[a]	6.49[c]	6.84
T2, 20% WO	57.21[b]	7.76[b]	6.1
T3, 30% WH	56.26[b]	7.67[b]	6.06
T4, 30% WO	58.12[a]	7.51[b]	6.91
±SE	0.345	0.93	0.81
p-value	0.001	0.024	0.278

[a,b]Means with different superscripts within each row significantly differ (p<0.05), lightness (L*) (dark to light), redness (a*) values (reddish to greenish) and yellowness (b*) values (yellowish to bluish) were estimated, C, 0%: Control diet, T1, 20% WH: 20% olive cake inclusion with herbal mixture, T2, 20% WO: Olive cake inclusion without herbal mixture, T3, 30% WH: 30% olive cake inclusion with herbal mixture, T4, 30% WO: 30% olive cake inclusion without herbal mixture, herbal blend: Lemongrass+Chamomile+Mint and SE: Standard error

However, it was clear that the diet's high fiber content had a detrimental impact on the body's ability to use fat. Anti-nutritional elements found in fiber raise viscosity and lower bile salt and lipase release, reducing dietary fat breakdown; the positive impact of herbals on enhancing gut ecology and digestion by decreasing the colonization of pathogenic bacteria.

Various studies show that grill diets counting OL (3-6%) decrease abdominal fat percentages[16]. When dietary OL is added, meat quality is enhanced, lean tissue deposition is encouraged, lipid synthesis is inhibited and fatty acid oxidation is increased[21].

Carcass characteristics: Chemical analysis of the breast shown in Table 4 and 5 was lower in T1, 2, 3 and four compared to control (C). The dietary interventions did not affect color qualities other than brightness (L*) and redness (a*). The T2 and T3 broiler chickens had higher L* of breast meat than C ($p = 0.001$) and T1 and T4 ($p = 0.012$). The T2 grill chickens had lower a* values than T1 and T3, 4 ($p = 0.048$).

The study revealed significant protein and fat content differences among the treatments ($p<0.05$), while collagen and moisture levels remained statistically similar. The highest protein content was observed in the control group (24.72%), followed by T3 (22.82%), with other treatments showing lower values. Fat content was significantly higher in T2 (1.26%) compared to different groups. Moisture content increased with treatments containing olive cake and herbal mixtures, though differences were not statistically significant ($p>0.05$). These results suggest that incorporating olive cake, with or without a herbal mixture, influences the chemical composition of breast meat, particularly protein and fat levels in Table 4.

According to de-Cara *et al.*[22], using phytobiotics derived from olive derivatives (leaves) improved several aspects of meat quality, including color and drip losses. The potential protective action of olive by-products against oxidative stress may account for the stability of meat under oxidative stress[23].

These properties could explain why the carcass's fat content was decreased via dietary OC at level 30%. Adding olive pulp (25 or 50 mg/kg diet) significantly increased the levels of 18:1n-9 and MUFAs in the breast muscle of the broiler[24]. Furthermore, in boiler-fed fermented olive pomace, breast meat's fat-to-cholesterol ratio and cholesterol content dramatically dropped by about 16.7 and 13.7%, respectively[21]. The same study concluded that adding more fermented olive pomace to frozen meat could increase its oxidative stability, improve quality and lengthen its shelf life[23].

The findings indicate that including an olive cake with and without a herbal mixture significantly influenced the carcass's lightness (L*) and redness (a*). At the same time, yellowness (b*) remained unaffected ($p = 0.278$). Treatments with 20 and 30% olive cake without the herbal mixture (T4 and T2) yielded the highest lightness values, significantly surpassing the control group ($p = 0.001$). Redness was highest

Table 6: Effect of diets containing olive cake with and without herbal mixture on blood parameters of broiler chickens

	Experimental diet						
Item	C, 0%	T1, 20% WH	T2, 20% WO	T3, 30% WH	T4, 30% WO	±SE	p-value
Albumin (g/dL)	1.7	1.2	1.4	1.6	1.5	0.142	0.282
Creatinine (mg/dL)	0.5	0.4	0.6	0.5	0.5	0.287	0.258
Total protein (g/dL)	5.9	4.3	4.2	4.0	4.3	0.098	0.206
Triglycerides (mg/dL)	49.2	41.0	55.3	41.0	40.0	0.135	0.549
Total cholesterol (mg/dL)	116.3[b]	135.0[a]	136.0[a]	132.3[a]	137.0[a]	9.27	0.001
HDL (mg/dL)	38.3	51.7	52.3	34.0	34.0	0.272	0.556
LDL (mg/dL)	71.3	75.3	72.7	70.0	75.0	0.345	0.123

[a,b]Means with different superscripts within each row significantly differ ($p<0.05$), C, 0%: Control diet, T1, 20% WH: 20% olive cake inclusion with herbal mixture, T2, 20% WO: Olive cake inclusion without herbal mixture, T3, 30% WH: 30% olive cake inclusion with herbal mixture, T4, 30% WO: 30% olive cake inclusion without herbal mixture, herbal blend: Lemongrass+Chamomile+Mint and SE: Standard error

in the control group and lowest in T1 ($p = 0.024$). These results suggest that olive cake inclusion, particularly without the herbal mixture, enhances carcass lightness while slightly reducing redness in Table 5.

Blood plasma analysis: Variations in blood components reveal an animal's well-being and general health. Living things can effectively control their physiological processes within the typical blood attribute ranges. Otherwise, various managerial stressors alter the blood components of broilers housed in extensive production systems, impairing their growth, health and well-being. During the growth phase, nutritional measures may help birds become healthier. On day 48, broilers fed the experimental diet without the additional OC and herbal had lower circulation total cholesterol ($p<0.05$) than broilers fed different levels of OC and herbal mixture (Table 6). Including olive cake with or without herbal mixtures in broiler chicken diets significantly affected total cholesterol levels ($p = 0.001$), with diets containing olive cake showing higher cholesterol than the control. However, no significant differences were observed among the experimental diets in other blood parameters such as albumin, creatinine, total protein, triglycerides, HDL and LDL levels ($p>0.05$). These findings suggest that while olive cake with or without herbal mixtures impacts cholesterol, it does not markedly affect other blood parameters in broiler chickens in Table 6.

However, across treatment groups, blood triglycerides, total protein, albumin, glucose, HDL and LDL cholesterol did not differ ($p>0.05$). Furthermore, broilers fed OL (1%) had a higher protein percentage and a lower lipid profile than the broiler group[25]. Furthermore, rabbits fed diets with olive cake (10 or 15%) and phytase enzyme showed lower cholesterol and triglycerides[17]. Furthermore, Al-Harthi[15] discovered that the lipid content of grill-given diets containing 5% olive cake combined with yeast (0.4 g/kg) was lower than that of free olive cake.

CONCLUSION

This study found that fermented olive cake with and without herbal plants results in slower body weight gain in broilers compared to those with control diets. Broilers fed fermented OC substitution did not affect the relative weights of the inner organs or carcass, indicating that it creates healthy broilers. This study stated that carcass fat content was decreased via dietary OC at a level of 30%. The level of inclusion of OC was not affected by analyzing blood for bird health.

SIGNIFICANCE STATEMENT

This study provides valuable insights into the potential use of olive cake as a sustainable component in broiler feed. The findings highlight that fermented olive cake, with or without the addition of herbs, could serve as a viable alternative feedstuff, promoting the circular economy by transforming food waste into secondary resources for poultry. By leveraging by-products from the local food industry, the study aims to reduce production costs and environmental impact, contributing to the sustainability of Mediterranean poultry farming. Additionally, it paves the way for future research into incorporating olive cake in the diets of high-performance broiler strains such as Ross 308 and Cobb 500.

ACKNOWLEDGMENTS

The research that led to these results received funding from the European Union's PRIMA Program for Research, Technological Development and Demonstration under grant agreement n°2013 and the Basque Country government through the FEADER funds (Grant agreement number 2013-PRIMA Funding Projects-Call 2020 Section 1 Farming IA).

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