Original Article

Growth Performance and Carcass Quality Index of Broiler Chickens Fed Diets Supplemented with Different Pomegranate Pomace Levels

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Abstract

Different levels of pomegranate pomace (PP) were added to the diets of broiler chickens to evaluate their performance and the quality of their carcasses and meat. In the experiment, 400 one-day old unsexed Ross 308 chicks weighing an average 38.85 ± 0.07 g were randomly assigned into five treatment groups. Birds in the first group (Control; T1) were fed a standard diet (SD) without any additives, T2 birds received SD + 0.02% butylhydroxytoluene (BHT), and the T3, T4, and T5 treatment groups received a SD + 0.25%, 0.50%, and 0.75% PP, respectively. Each treatment included four replicates of 20 birds. The treatments had no significant impact on their growth performance index and carcass yield. T4 produced enhanced characteristics in meat quality, such as reduced cooking loss and increased water-holding capacity. There were no noticeable variations in shear force. By increasing HDL and decreasing LDL, total cholesterol, and triglycerides, T5 significantly enhanced serum lipid profiles. Antioxidant status was also improved with increased glutathione peroxidase (GPx) and decreased malondialdehyde (MDA) concentrations in the PP-treated groups, specifically T4 and T5. In conclusion, PP supplementation at 0.50% or 0.75% concentrations can be used in the diets of broiler chickens as antioxidants and for improving their meat quality without affecting growth performance.

Keywords: Antioxidants, Broiler Chickens, carcass quality, Growth, Pomegranate pomace

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Introduction

To prevent the oxidative deterioration of feed and poultry meat, poultry nutrition has traditionally used synthetic antioxidants such as butylated hydroxytoluene (BHT) (16). However, safer natural alternatives in poultry nutrition have grown in importance due to concerns over potential toxicities and residue deposition of synthetic antioxidants like BHT (16). Utilizing agricultural byproducts in poultry diets is an increasingly favored approach for reducing feed costs and environmental waste. Several byproducts, including pomegranate pomace (PP), are high in nutrients and physiologically active substances that can satisfy the nutritional requirements of poultry and improve their production (27, 9).

Pomegranate (*Punica granatum* L.) byproducts, especially pomegranate pomace, are rich in polyphenolic compounds with potent antibacterial and antioxidant properties, including anthocyanins, ellagic acid, and punicalagin (24, 20). Given these properties, researchers are investigating the use of PP as a functional feed additive in poultry diets. Studies show that the natural antioxidants present in pomegranate peel and pomace improve gut health, increase antioxidant capacity, and enhance broiler performance (27, 9).

However, the effects of PP on broiler performance remain uncertain. According to (22), PP supplementation had a negative impact on growth parameters including feed intake, body weight gain, and feed efficiency. They stated that anti-nutritional components, such as tannins, which may delay nutrient absorption and metabolism, may cause these adverse effects. The endogenous antioxidant system reduces reactive oxygen species (ROS), but under stressful conditions, oxidative damage can occur, necessitating the use of antioxidant supplements (28). Earlier studies, however, showed that antioxidants, both natural and synthetic, may enhance immune responses, reduce oxidative stress, and improve broiler performance when subjected to nutritional stress (14, 13). Additionally, PP inclusion has been shown to enhance growth, carcass characteristics, and meat quality by some researchers (25, 10), but other researchers have found insignificant results (6, 7). Therefore, this study aimed to evaluate the effect of dietary supplementation with various levels of PP (0.25%, 0.50%, and 0.75%) compared with butylhydroxytoluene (BHT, 0.02%) on growth performance, carcass characteristics, meat quality, serum lipid profile, and antioxidant status in broiler chickens.

Materials and Methods

Location and managing of the experiment

The experiment took place on October 8, 2024, at the Gerdarasha farm, which is part of the College of Agricultural Engineering Sciences at the Salahaddin University-Erbil, Iraq. A total of 400 unsexed one-day old Ross 308 chicks, with average body weight of 38.85 ± 0.07 g, were obtained from the Sardam private hatchery in Erbil-Qushtapa. They were divided into five experimental treatments, each with four replicates (20 birds per replicate). The treatments were as follows: Control treatment (standard diet (SD) with no additives; T1), SD + 0.02% butylated hydroxytoluene (BHT; T2), SD + 0.25% pomegranate pomace (T3), SD + 0.50% pomegranate pomace (T4) and SD + 0.75% pomegranate pomace (T5).

Pomegranate pomace preparation

Pomegranate pomace was obtained from a farm in Shqlawa in Erbil-Iraq and kept away from direct sunlight for seven days. The PP was processed in a hammer mill (Model HM-200, Retsch GmbH, Germany) for 5 min/kg to a final particle size of approximately 1 mm. The chemicals in the PP were analyzed in a laboratory of the Kosar Company following the procedure described by AOAC (Table 1).

Table 1. Nutrient analysis of dried pomegranate pomace

Contents	%
Moisture	5.91
Crude protein	2.53
Fat	2.1
Crude fiber	17.72
Ash	4.49
Non-fiber carbohydrate	67.25
Metabolizable energy kcal/kg DM	3119

Nutritional Needs of Broilers

Two basal diets were formulated to meet the nutritional requirements of the broiler chickens, namely starter and grower. The starter diet was provided for the first three weeks, and the finisher for the last two weeks of the experimental period. The compositions of the basal starter and grower diets are shown in Table 2.

Table 2. Composition and nutritional levels of experimental starter and grower diets (1-35 days)

Ingredients	Starter (%)	Grower (%)
Corn	43.71	51.35
Soya bean meal 44%	38	30.51
Wheat	11	11
Fish meal 56%	2	1.6
Toxin binder	0.15	0.15
Mono dicalcium phosphate 21%	1.2	1.2
Soybean oil	1.5	2.1
DL-Methionine	0.2	0.2
L-Lysine	0.14	0.14
Salt	0.3	0.3
Enzyme	0.05	0.05
Calcium Ca %	1.7	1.35
Anticoccidial	0.05	0.05
Total	100	100
Calculated Chemical Analysis		
Metabolic energy kcal/kg	2875	3004
Crude protein %	22.93	20.3
Fat %	3.837	4.591
Fiber	4.024	3.687
Available P for poultry	0.377	0.359
Calcium %	1.099	0.919
Total phosphorus %	0.664	0.623
Salt	0.349	0.341
Arginine	1.03	1.263
Lysine	1.2	1.12
Methionine + Cystine	0.88	0.777
Methionine	0.5	0.496
Threonine	0.75	0.719
Tryptophan	0.22	0.238

Growth Performance

A digital sorting device balance with a sensitivity of 0.01 g was used to record the body weights (BW) of broiler chickens on days 7, 21, and 35. Using the following formula, body weight gain (BWG) and feed conversion ratio (FCR) were calculated as follows (26):

BWG (g) = BW (g) at the week ending - BW (g) at the week beginning

FCR = Feed intake through a period (g)/Weight gain during the same period (g)

Carcass Traits

On day 35, two birds from each replicate were randomly selected, fasted for 12 hours, and their slaughtered live body weights were recorded. The slaughtering was done according to Islamic (halal) slaughter procedures. After bleeding, the birds were de-feathered, eviscerated, washed with clean cold water, and their carcasses were cut open. The internal organs (liver, heart, gizzard, spleen, and bursa of Fabricius) and carcass parts (leg and breast) were individually weighed. The results of organ weights and cut yields were reported as percentage-to-carcass weight as follows:

Cut yield % = [weight of cut/carcass body weight] ×100

Dressing percentage was calculated following the equation reported by (26):

Dressing percentage = [Carcass weight (g)/Live body weight (g)] ×100

Blood Sampling

During slaughtering, 5 ml of sticky blood was extracted via jugular venipuncture, placed in blood tubes with ethylenediaminetetraacetic acid (EDTA) as an anticoagulant (BD Franklin Lakes, NJ, USA), and kept in an icebox. The plasma sections were stored at -20 °C after the blood samples were centrifuged at 3000 × g for 15 min at 4 °C until further analysis.

Lipid Profiles Determination

Commercial ELISA kits from BioAssay Systems (EnzyFluo™ Custom Cell-Based ELISA Kit, USA) were used to measure the serum concentrations of triglycerides (TG), total cholesterol (TCH), high-density lipoprotein (HDL), low-density lipoprotein (LDL), and very low-density lipoprotein (VLDL). The EnzyChrom™ Cholesterol Assay Kit (Catalogue No. ECCH-100) was used to measure total cholesterol according to the manufacturer's instructions. The Buyer's Guide for Life Science (BioCompare) quality and performance comparisons were used for selecting the kits. All data was expressed in mg /dl.

Oxidant and Antioxidant Enzyme Activity Determination

Glutathione peroxidase (GSH-Px) (Enzo Life Sciences, USA) and malondialdehyde (MDA) (Randox Laboratories Ltd., UK), pair biomarkers of oxidative stress, were measured in the serum samples using commercial ELISA-based kits in accordance with the manufacturer's instructions.

Meat Quality Assessment

After 24 h of chilling at 4 °C, the breast muscle (*pectoralis major*) was removed from each carcass, vacuum packaged, individually labelled, and stored at -20 °C until further meat quality parameters analysis.

pH Measurement

The pH of muscle breast samples was examined in accordance with (33). After homogenizing a 10 g sample of muscle in 90 ml of distilled water, the pH was determined using pre-celebration probe pH meter (EZDO PP-203, Taiwan).

Water Holding Capacity

Using the technique proposed by (29), the water holding capacity (WHC) of breast muscle samples was evaluated. Briefly, about 8 g of muscle samples were placed in a centrifuge tube along with 12 ml of 0.6 M NaCl solution. The supernatant was decanted and measured after centrifuging for 15 minutes at 10.000 rpm. WHC was calculated using the following formula:

WHC (%) = [(Weight of sample before centrifuging - Weight of sample after centrifuging)/ Weight of sample before centrifuging] × 100

Cooking Loss

For each treatment, the individual weight of the muscle samples was recorded as the initial weight (W1). The samples were placed in plastic bags and cooked in a water bath (HAAKE C10, UK) at 80 °C for 20 minutes. After cooling, the samples were re-weighed and recorded as W2. The percentage of cooking loss was determined as follows (11):

Cooking loss (%) = [W1 - W2] / W1 ×100, where W1= weight before cooking, and W2 = weight after cooking

Meat Shear Force Measurement

Cooked muscle samples were sliced into uniform blocks measuring 1cm × 1cm × 2cm to evaluate the meat's tenderness. Texture analyzer (CT3™, USA) filled by a Volodkevich bite jaw was used to test each block. The shear force was determined through averaging the peak force needed to shear through the sample (23).

Color Measurement

The color of muscle samples was determined according to (21) using a ColorFlex spectrophotometer (Shenzhen 3nh Technology Co., Ltd, China). The color of the meat's surface was measured by its redness (a*), lightness (L*), and yellowness (b*). The samples were left to bloom for 30 minutes at room temperature. Before using the device, a calibration tile was done against white and black colors. The values of L*, a*, and b* for each sample were noted in triplicate to ensure accuracy and repeatability.

Statistical Analysis

The experiments were conducted in a completely randomized manner. The data on growth performance, carcass characteristics, meat quality, and blood parameters were analyzed using a generalized linear model of SAS (SAS, 2004). With a threshold for significance of P<0.05, Duncan's multiple range test was used to evaluate significant differences between treatment means. The following mathematical model was used:

Yijk = μ + tij + eijk

where, Yijk = dependent variable,

μ = overall mean,

tij = effect of dietary treatment, and

eijk = experimental error.

Results and Discussion

Growth Performance

The impact of pomegranate pomace (PP) on broiler chicken developmental performance is shown in **Table 3**. Body weight (BW) on day 7 did not change significantly (P>0.05) by the treatments, indicating uniform initial body weight. While T1 (1011.68 g) remained statistically similar in all groups, broilers in group T5 (987.26 g) had a significantly lower BW at day 21 compared to groups T2 (1027.65 g), T3 (1013.00 g), and T4 (1021.76 g). T5 birds also showed a significantly lower body weight gain (801.79 g) at days 7 and 21, while the BHT group (T2) showed higher weight gains (840.70 g), indicating that high levels of PP may have an adverse effect on growth owing to its polyphenolic anti-nutritional effects such as tannins (**22**).

Table 3. Impact of various levels of pomegranate pomace additives on the broiler chickens' growth performance

Treatment	Days	T1	T2	T3	T4	T5	SEM#
Body weight (g)	7	188.50 a	187.25 a	190.00 a	185.25 a	185.75 a	1.43
	21	1011.68ab	1027.65 a	1013.00ab	1021.76ab	987.26 b	5.68
	35	2303.88 a	2346.61 a	2356.00 a	2374.25 a	2295.57 a	11.85
Body weight gain (g)	(7-21)	823.36 ab	840.70 a	823.18 ab	836.71 ab	801.79 b	5.44
	(21-35)	1292.21 a	1318.96 a	1343.00 a	1352.49 a	1308.30 a	11.6
	(7-35)	2115.57 a	2159.66 a	2166.18 a	2189.20 a	2110.09 a	11.87
Feed intake (g)	(7-21)	1043.80ab	1037.62ab	1043.92ab	1044.75 a	1030.20 b	2.14
	(21-35)	1885.29 a	1861.11 a	1910.85 a	1872.00 a	1834.86 a	13.11
	(7-35)	2929.21 a	2898.74 a	2954.65 a	2916.75 a	2865.06 a	13.99
FCR (kg feed/ kg weight)	(7-21)	1.26 a	1.23 a	1.27 a	1.25 a	1.28 a	0.01
	(21-35)	1.46 a	1.41 a	1.42 a	1.38 a	1.40 a	0.01
	(7-35)	1.38 a	1.34 a	1.36 a	1.33 a	1.36 a	0.01

$^{a-b}$ means within the same row with distinct superscripts differ considerably (P<0.05).

T1: Standard diet=SD (control); T2: SD + 0.02% BHT; T3, T4, and T5: SD + 0.25%, 0.50%, and 0.75% PP, respectively. SEM: standard error of mean.

Feed conversion ratios (FCR) and feed intake did not change across treatments, with all groups showing identical patterns for the variables during the later growth phase (days 21-35) with no significant difference (P<0.05). However, T3 and T4 showed numerically higher body weight gain. The T4 group (0.50% PP) had the highest final body weight (2374.25 g) while the T5 (2295.57 g) had the lowest. This suggests that broiler performance can be improved with moderate PP supplementation. These findings are inconsistent with (**25**), who noted that pomegranate peel extract improves feed efficiency and growth at trace levels. Improved nutrient utilization, antioxidant activity, and gut health may explain the positive effects of polypropylene on performance at low incorporation rates (**18**). However, because polyphenols and tannins impede protein digestion, high incorporation levels may reduce feed efficiency (**7**).

These results are also consistent with those of (**31**), who found that low levels of PP did not significantly change body weights or feed conversion rates. However, (**6**) found that PP supplements significantly increased body weight and feed efficiency, suggesting differences in results based on the pomegranate cultivar, extraction method, or dosage applied.

Carcass Traits

Table 4 shows the impact of various pomegranate pomace (PP) levels on percentage of broiler chickens' edible parts. Dressing percentages and internal organs were not significantly affected by PP supplementation, which is in line with the findings of (30, 4). Significant variations were observed in breast yield, with T2 (BHT) achieving the highest yield (43.19%) followed by T1 (41.74) and T4 (42.05) while T3 and T5 showed significantly lower values at 41.26% and 41.17%, respectively. Additionally, leg yield in T2 (28.76%) was significantly greater than both T1 (26.05%) and T3 (26.48%).

Table 4. Impact of various levels of pomegranate pomace additives on dressing percentage and the internal organs of the broiler chickens

Trait (%)	T1	T2	T3	T4	T5	SEM#
Dressing	75.017	75.860	75.657	75.803	76.213	0.1726
Breast	41.745 ab	43.190 a	41.268 b	42.056 ab	41.170 b	0.2809
Leg	26.058 b	28.765 a	26.486 b	26.891 b	27.303 ab	0.2975
Gizzard	1.398	1.647	1.392	1.408	1.533	0.0393
Heart	0.641	0.612	0.605	0.583	0.508	0.0131
Liver	3.223	3.197	3.328	3.141	3.141	0.0645
Fabricius	0.197	0.232	0.206	0.226	0.222	0.0095
Spleen	0.167	0.173	0.175	0.160	0.128	0.0082

[a-b] means within the same row with distinct superscripts differ considerably (P<0.05).

T1: Standard diet=SD (control); T2: SD + 0.02% BHT; T3, T4, and T5: SD + 0.25%, 0.50%, and 0.75% PP, respectively. SEM: standard error of mean.

Based on these results, low doses of PP could have similar benefits without the use of synthetic additives. Owing to their anti-nutritional effects, high levels of PP (0.75%) did not further enhance carcass characteristics. A study by (7) hypothesized that polyphenols-rich supplements would reduce the absorption of nutrients. (32) reported that average broiler breast yields ranged from 16.5% to 18.6%, less than for the percentages determined in this study.

Meat Quality Traits of Broiler Chicken Breasts

Key meat quality parameters, including shear force, water holding capacity (WHC), and cooking loss affected by different levels of PP are presented in Table 5. T4 exhibited higher moisture retention, showing a WHC of 76.275% compared to the other treatments (P<0.05). On the other hand, lower WHC values were recorded for T1 (70.81%) and T5 (69.68%). The significant decrease in cooking loss in T4 (19.83%) compared to T1 (23.237%) and T5 (23.048%) further indicates the beneficial effects of PP levels on the ability of meat to hold water. These results agree with (3), who found that adding dried pomegranate peel improves water retention and reduces cooking loss. The absence of significant differences in shear force value (P<0.05) suggests that different concentrations of PP had no effect on tenderness. This outcome is supported by (17), who noted that tenderness remained unchanged despite an improvement in water retention. Antioxidant compounds present in PP may have a role in preserving muscle damage through reducing lipid and protein oxidation during cooking, and could be responsible for increased WHC and decreased cooking losses (15).

Table 5. Impact of various levels of pomegranate pomace additives on meat quality of broiler breast meat muscle

Trait	T1	T2	T3	T4	T5	SEM#
WHC %	70.811 c	72.976 b	71.326 bc	76.275 a	69.683 c	0.6216
Cooking loss %	23.237 a	21.451 b	22.381 ab	19.830 c	23.048 a	0.2842
Shear force kg	1.410	1.383	1.386	1.368 a	1.401	0.0186
Lightness	51.720 a	52.529 a	52.646 a	50.459 a	47.556 b	0.4959
Redness	10.035	11.205	10.999	10.173	11.048	0.3269
Yellowness	12.350	12.215	12.093	11.158	12.696	0.237
pH	6.241 cb	6.223 cb	6.123 c	6.337 ab	6.412 a	0.0236

[a-c] means within the same row with distinct superscripts differ considerably (P<0.05).

T1: Standard diet=SD (control); T2: SD + 0.02% BHT; T3, T4, and T5: SD + 0.25%, 0.50%, and 0.75% PP, respectively. SEM: standard error of mean.

Table 5 shows (P<0.05) the significant effects of dietary treatments on the pH and color of the breast meat. Samples in T5 (0.075%) showed the highest pH (6.41), followed by T4 (6.33), and T3 (6.12). The antioxidant properties of polyphenols, which maintain mitochondrial integrity and enzyme function while preventing postmortem glycolysis and lactic acid accumulation, may be the cause of an increase in meat pH in the higher PP level groups (25, 2). Antioxidants may affect postmortem pH by delaying the breakdown of glycogen into lactic acid. The lightness in T5 was the lowest (47.556), which showed a darker meat color and was substantially different than for the other treatments (P<0.05). This could be caused by the phenolic pigments in PP, which have an impact on myoglobin's redox status and light reflectance (19). Higher visual redness scores were displayed by T2 and T5, indicating that by maintaining myoglobin, antioxidants, both natural and synthetic, may enhance the redness of meat, while the results showed non-significant differences (P>0.05) in yellowness. The resulting pattern might be due to the deposition of flavonoid compounds or natural carotenoids found in PP, which can change the meat's yellow color (22).

Serum Lipid Profiles

The serum lipid profiles of the broiler chickens supplemented with various levels of pomegranate pomace (PP) including high-density lipoprotein (HDL), low-density lipoprotein (LDL), total cholesterol (TCH), and triglycerides (TG) are displayed in **Table 6**. All lipid parameters showed significant differences (P<0.05) at higher PP levels. The highest HDL concentrations were observed in T5 at 45.13 mg/dL, followed by T4 (44.19 mg/dL) and T3 (39.50 mg/dL). These results were all significantly higher compared to those of the BHT (T2) and control groups at 28.40 mg/dL and 25.68 mg/dL, respectively. On the other hand, all PP-supplemented groups showed a significant decrease in LDL concentrations with the T5 group recording the largest decrease (61.37 mg/dL) compared to the 147.42 mg/dL for the T1 control group and 115.60 mg/dL for the BHT group (T2).

Table 6. Impact of various levels of pomegranate pomace additives on the serum lipid profiles (mg/dL) of broiler chickens

Trait	T1	T2	T3	T4	T5	SEM#
HDL	25.68 [d]	28.40 [c]	39.50 [b]	44.19 [a]	45.13 [a]	3.07
LDL	147.42 [a]	115.60 [b]	89.70 [c]	66.51 [d]	61.37 [e]	4.58
TCH	173.1 [a]	144.0 [b]	129.2 [c]	110.7 [d]	106.5 [d]	6.3
TG	289.0 [a]	251.3 [b]	179.8 [c]	170.1 [c]	168.9 [c]	10.2

[a-c] means within the same row with distinct superscripts differ considerably (P<0.05). T1: Standard diet=SD (control); T2: SD + 0.02% BHT; T3, T4, and T5: SD + 0.25%, 0.50%, and 0.75% PP, respectively. SEM: standard error of mean.

Similar results were observed for total cholesterol with T5 (106.5 mg/dL) and T4 (110.7 mg/dL) recording the largest decreases and significantly lower than for the T1 (173.1 mg/dL) and T2 (144.0 mg/dL) groups. All PP-treated groups also showed a significant decrease in triglyceride levels. T5 and T4 birds had the lowest concentrations at 168.9 and 170.1 mg/dL, respectively, while T1 and T2 had the highest at 289.0 mg/dL and

251.3 mg/dL, respectively. Pomegranate pomace has a potent hypolipidemic effect, as demonstrated by a significant reduction in total and LDL cholesterol, and triglycerides, as well as an increase in HDL cholesterol. These positive effects are likely attributable to pomegranate's high concentration of bioactive components, such as punicalagin, ellagic acid, and various polyphenols, which are known to enhance antioxidant defenses, inhibit lipid peroxidation, and modulate lipid metabolism (**24**). (**5**) found that adding 7.5 - 10 g/kg of pomegranate peel to broiler feed significantly reduced serum triglyceride and cholesterol levels. According to them, this effect was caused by a decrease in the expression of the PP receptor, a vital gene involved in hepatic lipid synthesis.

The results of this study are also supported by (**19**), who found that increasing the dosage of pomegranate pulp by 4 - 10% in poultry diets improved HDL levels and reduced LDL levels. Through such results, (**30**) showed that adding 0.05 - 0.1% pomegranate peel powder significantly improved lipid levels. The antioxidant and anti-inflammatory prosperity of the polyphenols in pomegranate may regulate these effects by improving lipoprotein metabolism, inhibiting fat absorption, and enhancing bile acid secretion (**27**, **20**). The potential of PP as a more effective and safer natural substitute for synthetic antioxidants in poultry diets has been proven by the fact that BHT (T2) only slightly decreased lipid parameters. Consequently, pomegranate pomace can be a useful natural feed additive to enhance the health and serum lipid profile of broilers, especially when added at a ratio rate of 0.50 to 0.75%.

Antioxidant Status of the Serum of Broiler Chickens

The effects of dietary pomegranate pomace (PP) supplementation on the blood levels of malondialdehyde (MDA) and glutathione peroxidase (GPx) in the broiler chickens are illustrated in **Table 7**. Differences ($P<0.05$) were significantly seen between the treatments for each studied parameter. In contrast to the T1 (119.4 U/ml), T5 (157.0 U/ml) and T4 (155.3 U/ml) showed significantly higher GPx activity, indicating that birds fed higher levels of PP had a better antioxidant defense system. The mean values of glutathione peroxidase in T3 (149.0 U/ml) and T2 (149.7 U/ml; BHT) were significantly higher than those in the control group. The natural antioxidant enzyme activity can be enhanced using both synthetic and natural antioxidants, with 0.50 and 0.75% PP showing somewhat greater effects.

Table 7. Impact of various levels of pomegranate pomace additives on antioxidant status (nmol/ml) in broiler chickens

Trait	T1	T2	T3	T4	T5	SEM#
GPx	119.4 ^{c}	149.7 ^{b}	149.0 ^{b}	155.3 ^{a}	157.0 ^{a}	8.03
MDA	10.09 ^{a}	7.15 ^{b}	6.78 ^{b}	6.02 ^{c}	6.19 ^{c}	0.31

$^{a-c}$ means within the same row with distinct superscripts differ considerably ($P<0.05$). T1: Standard diet=SD (control); T2: SD + 0.02% BHT; T3, T4, and T5: SD + 0.25%, 0.50%, and 0.75% PP, respectively. SEM: standard error of mean.

The PP-supplemented groups had considerably lower levels of malondialdehyde (MDA), which is an indicator of oxidative stress and lipid peroxidation. T4 (6.02 nmol/mL) and T5 (6.19 nmol/mL) experienced the lowest MDA values, followed by T3 (6.78 nmol/mL) and T2 (7.15 nmol/mL). The effectiveness of PP and BHT in reducing oxidative damage was confirmed by the control group (T1), which had the highest MDA concentration (10.09 nmol/mL). The largest decrease was observed with natural PP supplementation. The significant increase in GPx and decrease in MDA concentrations in this study indicate the potent antioxidant activity of pomegranate pomace, especially at levels between 0.50% and 0.75%. These effects likely come from the high concentration of bioactive components in PP. These compounds include punicalagins, ellagic acid, and flavonoids, especially polyphenols, which enhance enzymatic antioxidant activity and reduce oxidative stress (**24**, **1**).

Previous studies indicate that pomegranate peel and pomace positively affect the oxidative status of poultry. (**8**) reported that pomegranate peel extract reduced lipid peroxidation and increased glutathione (GSH) and catalase levels in broiler liver tissues. According to (**7**), food supplementation with 4% pomegranate peel or 10 g/kg PP can significantly decrease serum MDA concentrations while increasing GPx activity. Similarly, fermentation of PP at 10 g/kg concentration reduced MDA levels in breast meat by 18% compared to the control group, according to (**9**). These antioxidant effects are dose-dependent, whereby moderate doses (4–5%) enhance the antioxidant defense system without negatively impacting growth or health, while high doses

(8–10%) can affect intestinal morphology or nutrient absorption (7). Further, a study by (1) supports the protective effect of PP against oxidative cellular damage, indicating that a decrease in oxidative stress markers, including MDA, is typically accompanied by an increase in the activity of antioxidant enzymes, including SOD and GPx. Since oxidative stability affects post-slaughter tissue integrity, these improvements may indirectly lead to improved lipid metabolism and meat quality.

Conclusion

This study showed that the cut carcass yield and meat quality attributes of broilers can be enhanced without negative effects on performance by supplementing their diets with 0.50 - 0.75% of pomegranate pomace. The potential of PP as a natural alternative to synthetic antioxidants like BHT is further supported by these findings, offering broiler nutrition both practical and financial benefits.

Supplementary Materials: None.

Author Contributions: Author 1: assisted in all broiler chicken procedures for the experiment and contributed to the measurement of all carcass quality parameters. Author 2: contributed to the idea, design and execution of the study and for the statistical analysis. Both authors contributed equally to the write-up of the final manuscript.

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Tables:

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مقالة أصيلة

أداء النمو وصفات الذبيحة النوعية لفروج اللحم المغذات على عليقة مضاف إليها مستويات مختلفة من تفل الرمان

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الخلاصة

هدفت هذه الدراسة إلى تقيم تأثير مستويات مختلفة من إضافة تفل الرمان على أداء دجاج التسمين، وخصائص ذبائحها النوعية. في هذه التجربة، وُزّع 400 فروج لحم الغير مُجَنّس من سلالة روس 308 (بمتوسط وزن 38.85 ± 0.07 غرام، بعمر يوم واحد) عشوائيًا على خمس معاملات تجريبية. غذيت الطيور في المعاملة الأولى عليقة قياسية بدون أي إضافات (معاملة السيطرة) بينما غذيت الطيور في المعاملة الثانية عليقة قياسية مع إضافة 0.02% بوتيل هيدروكسي تولوين. غذيت الطيور في المعاملة الثالثة، الرابعة والخامسة طيور على عليقة قياسية مع إضافة 0.25%، 0.50% و 0.75 % تفل الرمان على التوالي. تضمنت كل معاملة أربع مكررات بعشرين طائر. لم يكن للمعاملات تأثير معنوياً على معايير أداء النمو نسبة التصافي للذبيحة. حسّنت المعاملة الرابعة خصائص جودة اللحوم، مثل تقليل الفقد أثناء الطهي وزيادة القدرة على الاحتفاظ بالماء. لم تُلاحظ أي اختلافات في صفة الطراوة بين المعاملات. من خلال زيادة HDL وخفض LDL والكوليسترول الكلي والدهون الثلاثية، حسّنت إضافة 0.75 % تفل الرمان معنوياُ مستويات الدهون في مصل الدم. إعتماداُ على تركيز الجلوتاثيون بيروكسيديز (GPx) تركيزات المالونديالدهيد (MDA) في المعاملات التي استخدمت تفل الرمان، حسنت المعاملتين الرابعة والخامسة من مضادات الأكسدة. في الختام، يمكن استخدم تفل الرمان في تغذية فروج اللحم كمضاد للاكسدة وتحسين الصفات النوعية للذبيحة من دون اي ناثير على النمو

الكلمات المفتاحية: النمو، فروج اللحم، صفات النوعية للذبيحة، مضادات الأكسدة، ثفل الرمان