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Growth Performance, Carcass Characteristics, Blood Parameters, Health Status and Economic Efficiency of Broiler Chicks Fed Diets Supplemented with Dried Orange Peel Powder

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Abstract

THIS study investigated how adding dried orange peel (DOP) to broiler diets affects growth performance, carcass characteristics, blood parameters, and economic efficiency. 120 Ross broiler chicks, aged one day, were randomly assigned to three treatment groups, each comprising four replicates of 10 chicks. The control group was fed a basal corn-soybean meal diet without additives, while the second and third groups were fed the same basal diet supplemented with 1 and 2% DOP, respectively. The growth performance traits, meat yield, blood parameters, and economic outcomes were evaluated. The results revealed that during the starter period, DOP supplementation significantly reduced live body weight (LBW), body weight gain (BWG), and feed consumption (FC) while improving the feed conversion ratio (FCR) compared to the control diet. Broiler chicks receiving 2% DOP had lower LBW, BWG, and FC, along with a better FCR than those in the other treatment groups. During the finisher period, broiler chicks fed 1% DOP exhibited the lowest BWG and the poorest FCR among the groups. The treated groups also showed the lowest final LBW, total BWG, and total FC relative to the control group. Dietary DOP supplementation significantly reduced serum levels of total cholesterol, high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), triglyceride, and abdominal fat percentage compared to the control diet. Also, adding 2% DOP greatly decreased the numbers of Salmonella and E. coli, and adding 1% DOP decreased the total number of bacteria in the cecal content compared to the control group. Furthermore, DOP supplementation significantly increased dressing carcass percentage and enhanced humoral immunity. In summary, although DOP negatively affected growth performance, it enhanced carcass quality by increasing the dressing percentage and decreasing the abdominal fat. Additionally, it improves broiler health status by lowering serum cholesterol, HDL, and triglyceride levels, suppressing pathogenic bacteria, and boosting humoral immunity.

Keywords: Orange peel, Broiler chicks, Growth performance, Carcass traits, Blood parameters.

Introduction

Feed additives are widely used across various animal species, including poultry, to supply essential nutrients, improve feed palatability and growth performance, and maximize feed utilization [1]. Phytogenic feed supplements, derived from plants, are natural alternatives to antibiotic growth promoters in animal and poultry feeding [2, 3, 4]. Phytogenic substances are categorized into four main types: herbs, which are non-woody blooming plants with therapeutic characteristics; spices, which are plant components other than leaves, such seeds, fruits, bark, or roots, that are prized for their strong flavour or fragrance; essential oils, which are aromatic oily liquids extracted from plant materials like flowers, leaves, fruits, and roots; and oleoresins, which are extracts obtained using non-aqueous solvents [5, 2, 6]. The primary bioactive compounds in photogenic plants include essential oils, polyphenols, terpenoids, and flavonoids [7]. Due to their antioxidant, antimicrobial, antistress, and anti-inflammatory properties, these compounds can enhance poultry growth performance, nutrient digestion, and intestinal integrity [6].

Oranges are the most widely produced citrus fruit globally, regarding yield and planted area [8]. In Egypt, the total area dedicated to orange cultivation reached 172,200 hectares during the 2022–2023 season, with a harvested area of 151,200 hectares yielding 3.6 million metric tons of oranges. Of this yield, 1.7 million metric tons were exported, 1.6 million metric tons were consumed fresh locally, and 300 thousand tons were processed [9]. The citrus

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manufacturing sector generates significant amounts of waste each year, primarily in peels, seeds, and pomace [10]. Citrus peel waste from juice extraction alone accounts for about 50–60% of the fruit's weight [11]. Often, this waste is discarded improperly, turning into environmental litter [12]. The improper disposal of these wastes can lead to environmental pollution, harm the health of humans and animals, and contribute to the production of greenhouse gases, exacerbating issues related to climate change [13, 14]

However, orange peel is a nutrient-rich byproduct, containing 9.73–13.20% crude protein, 2.64–8.70% crude fat, 12.54–15.3% crude fiber, 48.9–55.12% carbohydrates, 5.17–7.8% ash, 133.58–162.03 mg/100 g calcium, 50–52.12 mg/100 g phosphorus, 0.30–0.31 mg/100 g zinc, 9.37–19.95 mg/100 g iron, and 0.40–1.34 mg/100 g manganese [15, 16, 17]. In addition to its nutritional content, orange peel is an excellent source of bioactive compounds such as polyphenols, flavonoids, ascorbic acid, and carotenoids [18, 19, 10]. These compounds have antioxidant, antimicrobial, antistress, and anti-inflammatory properties, which, as previously mentioned, can enhance poultry growth performance, digestion, and intestinal integrity [6]. Therefore, incorporating orange peels into chicken feed could be an effective way to provide natural antioxidants and other essential nutrients to poultry.

The inclusion of dried orange peels in poultry diets has been investigated in several previous studies. For example, [20] found that adding 0.5%, 1.0%, 1.5%, and 2% dried orange residues to broiler diets significantly improved feed consumption and weight gain, while reducing liver and abdominal fat percentages, as well as serum triglyceride levels in broiler chickens. In another study, [21] reported that adding 0.8% dried orange peel (DOP) to broiler diets did not affect body weight gain (BWG), feed consumption (FC), feed conversion ratio (FCR), or carcass characteristics but significantly enhanced serum globulin and total antioxidant status while lowering serum glucose, HDL, LDL, very low-density lipoprotein (VLDL), and triglyceride levels. Additionally, [22] observed that dietary supplementation with orange peel extract at a level of 200 mg/kg improved growth performance and antioxidative status in growing male rabbits and decreased plasma total cholesterol and LDL levels. Therefore, this study aimed to assess the impact of dried orange peels as a feed additive on the growth performance, carcass characteristics, blood parameters, gut microbiota, bursa histology, and economic efficiency of broiler chicks.

Material and Methods

Birds, diets, experimental design, and managerial procedures.

A total of 120 Ross broiler chicks, aged one day, were randomly assigned to three treatment groups, each comprising four replicates of 10 chicks. Birds of each replicate were housed in floor pens lined with 10 cm thick sawdust litter. A basal corn-soybean meal diet with enough minerals, vitamins, and essential amino acids was formulated to cover all nutritional needs according to the NRC recommendations [23]. The ingredients and chemical compositions of the starter and grower diets are presented in Table 1. The control group was fed a basal diet without additives, while the second and third groups were fed the same basal diet supplemented with 1 and 2% DOP, respectively. The chicks were given free access to feed and fresh water throughout the experimental period. The vaccination program, hygienic procedures, and environmental conditions were established according to standard managerial procedures.

Orange peel preparation

Orange fruits purchased from the local market were peeled, and the peels were subsequently dried in the shade at room temperature for 15 days. The dried orange peels were ground using an electric blender to make the peel powder used in this study.

Data collection

Growth performance.

The live body weight (LBW) of the broiler chicks were individually weighted at 0, 21 and 42 days of age using a digital balance. Feed consumption (FC) during the starter phase (0-21 days), finisher phase (22-42 days), and the whole period from 0 to 42 days of age were estimated by subtracting the remaining feed at the end of each period from the total amount of feed offered during the period. Body weight gain (BWG) and the feed conversion ratio (FCR) during the starter and finisher phases and throughout the entire experimental period were calculated according to the following equations proposed by [24].

$$\text{BWG}=\text{Initial LBW} - \text{Final LBW}$$

$$\text{FCR}=\frac{\text{FC during the period}_n}{\text{BWG during the period}_n}$$

Where Final LBW= live body weight at 21 or 42 days of age, initial LBW= live body weight at 0 or 22 days of age, period n = from 0 to 21 days of age, from 22 to 42 days of age or from 0 to 42 days of age.

Sampling

At the end of the experimental period (42 days of age), six broiler chicks from each treatment, representing the average body weight of their treatment, were selected for sampling. Before slaughter, 6 blood samples from each treatment were drawn from the wing vein using a syringe needle, placed in nonheparinized tubes, and centrifuged at 3000 rpm for 15 min. The separated serum was withdrawn using a micropipette, placed in Eppendorf tubes, and kept at -20°C until subsequent biochemical analysis. All the selected chicks were

fasted for 12 hours and then slaughtered by cutting the jugular vein, carotid artery, and windpipe using a sharp knife. After complete bleeding, scalding, de-feathering, and evisceration, the cecal contents were squeezed into sterile tubes and kept in a refrigerator at -20°C until bacterial counts were performed. The bursa of Fabricius was dissected and prepared for microscopic histological examination.

Carcass criteria

The weights of the eviscerated carcass without a head or shank, the dressed carcass (eviscerated carcass + edible parts), the heart, the liver, the gizzard, the spleen, and the abdominal fat were measured using a digital balance to the nearest 0.1 g and are expressed as the percentage of live body weight [25].

Blood biochemical analysis

The concentrations of total serum protein, albumin, glucose, triglyceride, cholesterol, high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), and liver enzymes (ALT and AST) were assayed according to [26] using an enzymatic colorimetric method with reagent kits (Spectrum Diagnostics Company, Egypt) and a spectrophotometer. All assessment procedures for each parameter were performed according to the instructions of the manufacturer. The globulin concentration was calculated as the difference between the total protein concentration and the total albumin concentration.

Cecal microbial enumeration

One gram of each cecal content sample was thoroughly mixed with 9 ml of peptone water to create a homogenized mixture. Serial dilutions ranging from 10^{-2} to 10^{-7} were then prepared by mixing 1 ml of the homogenized sample with 9 ml of saline solution. To enumerate the total bacterial count, E. coli count, and Salmonella count, nutrient agar, EMB (eosin-methylene blue) agar, and SS (Salmonella Shigella) agar media were used, respectively. For determining the total bacterial count, 100 microliters of the 10^{-5} to 10^{-7} dilutions were inoculated onto nutrient agar media and incubated at 37°C for 24 hours. Similarly, Escherichia coli and Salmonella counts were determined by inoculating 100 µl from the 10^{-2} to 10^{-5} dilutions onto EMB and SS agar media, respectively, followed by incubation at 37°C for 24 hours. All microbial enumeration procedures were carried out according to [27].

Bursa Histomorphometry

Histological observations were conducted on tissue samples collected from various regions of the bursa of Fabricius, which were fixed in 10% neutral buffered formalin. Following complete fixation, the bursa was washed with tap water, dehydrated in a graded series of ethanol to absolute alcohol, cleared in methyl benzoate, embedded in paraffin, and sectioned into slices 5-7 µm thick. The sections were then stained with hematoxylin and eosin. The histological procedures were carried out following Romeis' protocols [28]. Morphometric parameters were measured using a Leica Q 500 MC image analyser.

Economic efficiency

The price of 1 kg of feed was calculated according to the following equation:

$$\mathrm{FP} = \frac{(FC1 \times FP2) + (FC2 \times FP2)}{TFC}$$

where FP is the price of 1 kg of feed; FC1 is the feed consumed (kg) during phase 1 (0 to 21 days of age); FC2 is the feed consumed (kg) during phase 2 (21 to 42 days of age); FP1 is the price of 1 kg of starter feed; FP2 is the price of 1 kg of finisher feed; and TFC is the total feed consumed during the whole period (0 to 42 days of age).

The feed cost per 1 kg of body weight gain or per 1 kg of dressed carcass was calculated according to the equation of [29] as follows:

$$\mathrm{Yi} = \frac{Qi \times Pi}{Gi}$$

where Yi is the feed cost per kg of body weight or dressed carcass weight of the I treatment, Pi is the price per kg feed fed in the I treatment, Qi is the amount of feed intake in the I treatment, and Gi is the weight gain or carcass weight obtained in the I treatment.

The net selling price was calculated as the difference between the selling price of 1 kg live body weight or 1 kg dressed carcass and the feed cost per 1 kg of body weight gain or 1 kg of dressed carcass.

Statistical analysis

The data from this study were analysed using a one-way analysis of variance (ANOVA) through the general linear model procedure in SAS software (SAS On Demand for Academics). Significant differences between group means were determined using Duncan's multiple range test [30].

Results and Discussion

Growth performance

The effects of DOP supplementation on LBW, BWG, FC, and FCR of broiler chicks are presented in Table 2. During the starter period, broiler chicks receiving DOP showed a significant reduction in LBW, BWG, FC, and FCR compared to the control group. Chicks supplemented with 2% DOP exhibited lower LBW, BWG, and FC, along with an improved FCR, than those receiving 1% DOP. In the finisher period, the treated groups demonstrated the lowest final LBW, BWG, and FC relative to the control group. Specifically, broiler chicks receiving 1% DOP

had the lowest LBW, BWG, and the poorest FCR compared to the other treatment groups. Furthermore, the treated groups consistently exhibited the lowest final LBW, total BWG, and total FC in comparison to the control group. No significant differences in feed consumption were observed among the treatments during the period from 21 to 42 days of age.

Citrus waste is an available source of bioactive substances, including essential oils (EOs), ascorbic acid, sugars, carotenoids, flavonoids, dietary fiber, polyphenols, and trace elements [10]. The primary flavonoids present in the Citrus species are hesperidin, narirutin, naringin, and eriocitrin [31]. Multiple studies have shown that hesperidin suppresses appetite by stimulating the secretion of cholecystokinin [32, 33]. Cholecystokinin, a peptide hormone secreted in the small intestine during and after food intake, acts as a satiety signal to regulate short-term food consumption [34, 35]. This mechanism could account for the reduced feed consumption observed in broiler chicks during the starter phase, which subsequently led to a decrease in growth rate in the treated groups compared to the control group. Similarly, cholecystokinin is the primary hormone responsible for stimulating pancreatic enzyme secretion and gallbladder contraction, slowing gastric emptying, and regulating intestinal motility [34]. These actions optimize digestion and absorption, which are crucial for the efficient assimilation of nutrients by organisms [36]. This may explain the improved feed conversion ratio observed in the treated groups compared to the control group.

These results are in agreement with those of [37], who found that adding DOP up to 3%. to the broiler diet decreased FI and BWG and increased the FCR during the starter and finisher periods. According to [20], adding 1% DOP to a broiler diet reduced the FI, BWG and instability of the FCR during the starter phase. Moreover, [38] reported that adding 2 or 4% DOP powder to a broiler diet significantly reduced BWG and cumulative FC. Also, [39] reported that the supplementation of citrus peel oils (orange, lemon, and bergamot) to a broiler diet reduced feed intake and improved the feed conversion rate. The authors observed that the lowest feed intake and the best feed conversion ratio were in broilers that were fed 3 mL/kg orange peel oil.

Carcass traits

The results presented in Table 3 indicate that dietary DOP supplementation did not affect the eviscerated carcass percentage but significantly increased the dressing carcass percentage. Broiler chicks that received 1% DOP had the highest relative weights of the heart, gizzard, and spleen, followed by those that received 2% DOP, while the control group exhibited the lowest relative weights of these organs. Additionally, the abdominal fat percentage in broiler chicks fed 1% or 2% DOP was significantly lower than that in the control group, by approximately 41.38% and 35.06%, respectively.

Our results are in full agreement with the findings of [40], who observed that supplementing broiler diets with banana or orange peel at levels of 1.5% and 2%, respectively, significantly increased the percentages of dressed carcasses, hearts, gizzards, and spleens compared to the control group. Similarly, [41] reported that adding DOP to broiler diets at levels of 160 and 240 g/kg feed improved the dressing percentage and reduced abdominal fat percentage relative to the control group. Furthermore, [20] found that incorporating dried sweet orange (Citrus sinensis) pulp into broiler diets at concentrations of 0.5%, 1%, 1.5%, and 2% significantly decreased the relative weights of the liver and abdominal fat compared to those of the control group.

Blood biochemical parameters

Table 4 demonstrates that dietary supplements did not significantly influence serum total protein, albumin, globulin, or glucose levels. However, they did have a significant effect on the lipid profile, as the addition of DOP to broiler diets at 1% and 2% reduced levels of cholesterol, HDL, LDL, and triglycerides compared to the control group. Hesperidin, the primary flavonoid in orange peel [42, 31], plays a key role in inhibiting both cholesterol absorption and synthesis by regulating enzymes or mRNAs associated with cholesterol metabolism [43]. Additionally, citrus peel is a rich source of pectin [44], which is known to lower blood cholesterol levels through its interaction with bile acid metabolism [45]. The presence of hesperidin and pectin in orange peel likely accounts for the observed reductions in cholesterol, HDL, LDL, and triglyceride levels compared to the control group. These findings align with those of [20], who reported that incorporating dried sweet orange pulp into broiler diets at concentrations of 0.5%, 1.0%, 1.5%, and 2% significantly lowered triglyceride, total cholesterol, LDL, HDL, and ALT levels compared to the control group, while glucose and AST levels remained unaffected. Furthermore, [21] found that supplementing broiler diets with 0.8% dried sweet orange (Citrus sinensis) peel significantly reduced serum glucose, total cholesterol, triglyceride, LDL, VLDL, and HDL levels compared to the control group.

Cecal bacterial count

Table 5 presents the statistical analysis of the cecal microbial count. The addition of 2% DOP to the broiler diet significantly reduced the total bacterial count in the cecal content, while 1% DOP supplementation notably decreased the Escherichia coli count. Both levels of dietary DOP

supplementation significantly lowered the Salmonella count compared to the control group. Orange peels contain bioactive compounds, such as flavonoids and polyphenols, which possess antibacterial properties. These compounds may be responsible for the reduction in Salmonella and Escherichia coli counts observed in the treated groups. Research has shown that polyphenols have beneficial effects on the gut microbiome by reducing pathogenic bacteria and promoting the growth of beneficial bacteria [31, 46, 47]. Additionally, [48] reported that various flavonoids, including naringin (a flavonoid compound abundant in orange peels) effectively inhibit bacterial and fungal growth. The observed decrease in total bacterial count in our study may be attributed to the inhibition of pathogenic microbes (Escherichia coli and Salmonella) in the treated groups.

Our findings are in agreement with those of [38], who reported that supplementing broiler diets with 2% DOP significantly reduced the E. coli count compared to the control group. Similarly, [39] found that adding orange peel oils to broiler diets significantly increased the lactic acid count and decreased the E. coli count in the jejunum. Furthermore, [49] observed that supplementing broiler diets with 2% orange or grapefruit peel reduced the growth of pathogenic Escherichia coli and Staphylococcus spp., while significantly enhancing the growth of beneficial Lactobacillus spp. Moreover, [50] reported that broiler chicks given drinking water supplemented with 2, 4, or 6 g DOP/L had the lowest total bacterial count in the ileal content compared to control chicks.

Histomorphometry of the bursa

Our histological data indicated that dietary supplementation with DOP at levels of 1 and 2% significantly increased the average follicle area compared with that in the control group. On the other hand, there was a significant increase in the number of follicles per plica in the group fed a 2% DOP-supplemented diet compared to the other groups, and there was a significant decrease in the number of follicles per plica in the group fed a 1% DOP-supplemented diet compared to the other groups. However, there was no significant difference in the area of plica between the two groups (Figure 1 and Table 6). The bursa, a primary lymphoid organ, is essential for the establishment and maintenance of B cells [51]. Dietary DOP supplementation significantly increased the follicle area and the number of follicles. Several authors have shown that increases in the bursal follicle's area are linked to the stimulation of humoral immunity and the production of B lymphocytes [52, 53, 54]. In this context, [55] reported that broiler chicks fed diets supplemented with DOP at levels of 1 or 2% had greater primary and secondary antibody responses to sheep red blood cells (SRBCs) and against phytohemagglutinin (PHA-P) antigen than did those in the control group. Additionally, [56] reported that adding the methanolic extract of DOP to broiler diets at levels of 0.5, 1, or 1.5 ml/kg significantly increased antibody titters against infectious bursal disease, Newcastle disease, and infectious bronchitis disease compared with those in the control group.

Economic efficiency

Regarding the feed cost and economic efficiency of broiler chick-fed diets supplemented with DOP (Table 7), the results revealed that the broiler chicks fed a diet supplemented with 1% DOP had the highest feed cost, 1 kg of live body weight or 1 kg of dressing carcass; the lowest net selling revenue, 1 kg of live body weight; and the lowest economic efficiency and relative economic efficiency compared with those of the other treatments. On the other hand, adding DOP to broilers at a level of 2% decreased the feed cost to produce 1 kg of dressing carcass and improved the net selling revenue for 1 kg of dressing carcass, economic efficiency and relative economic efficiency compared with the other treatments.

Conclusion

The findings of this study indicate that adding DOP to the broiler diet hurts growth performance but improves carcass traits by increasing the dressing percentage and decreasing the abdominal fat percentage and enhances broiler health status by decreasing the serum cholesterol, HDL, and triglyceride levels; suppressing pathogenic bacteria; and stimulating humoral immunity.

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Author contributions

Mohammed Younis was the major contributor to the experimental design, statistical analysis, writing of the manuscript and data interpretation. Mohammed Amer Abu El Makarem carried out the experiment, collected the data, performed the biochemical analysis, and determined the bacterial enumeration. Saber Gomaa Abdo reviewed and edited the draft of the manuscript. All the authors read and approved the final manuscript.

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Declaration of Conflict of Interest

The authors declare that there is no conflict of interest.

Ethical of approval

This study was conducted by the principles outlined in the Declaration of Helsinki. All procedures involving animals adhered to the European Community Council Directive of 24 November 1986. Ethical approval for the study was obtained from the Research Ethics Committee of the Faculty of Agriculture, Assiut University, Egypt (Reference number: 03-2024-0005).

TABLE 1. Composition and calculated analysis of stater and grower diets for broiler chicks.

Ingredients	Ingredients percentages	
	Starter	Grower
Yellow corn	56.5	60.1
Soybean meal 44%	30	23.4
Gluten 60%	7.54	8.54
Oil	1.8	3.9
Methionine	0.06	0.01
Lysine	0.1	0.1
Limestone	1	1
Dicalcium phosphate	2.35	2.30
Salt (NaCl)	0.35	0.35
Premix *	0.3	0.3
Total	100	100
Calculated analysis		
ME k.cal/kg diet	3000	3200
Cured protein	23	21
Cured fat	4.38	6.58
Cured fiber	3.53	3.14
Methionine	0.52	0.45
Lysin	1.19	1.02
Calcium	1.1	1
Available	0.52	0.50

***** Each kg premix contained: vitamin A (acetate), 6250000 I.U.; vitamin D3 (Cholecalciferol), 2500000 I.U.; vitamin E (α – tocopherol), 25000 mg; vitamin k,1750 mg; vitamin B1, 500 mg; vitamin B2, 2750mg; vitamin B6, 1250 mg; vitamin B12, 10 mg; nicotinic acid (niacin), 20000mg; Calcium pantothenate, 5000mg; folic acid , 500 mg; biotin 50mg; iron sulfate,22000 mg; manganese oxide,31000 mg; copper sulfate,2500 mg ; zinc oxide,37500 mg ; potassium iodide,650 mg; sodium selenite, 113 mg; cobaltous sulfate,50 mg; Ethoxyquin,250 mg; wheat bran (carrier), 120 gm; limestone (carrier), up to 1kg .

TABLE 2. Effect of dietary dried orange peel supplementation on live body weight, body weight gain, feed consumption and feed conversion ratio of broiler chicks.

Measurements	Treatments			P- value
	C	DOP1	DOP2	
Live body weight (g)				
0 day	41.77±0.26	41.70±0.34	41.80±0.38	0.9762
21 days	961.90±3.53[a]	775.90±1.35[b]	763.07±1.97[c]	<.0001
42 days	2662.30±8.71[a]	2366.87±11.09[c]	2482.10±6.34[b]	<.0001
Body weight gain				
0-21 days	920.13±3.30[a]	734.20±1.08[b]	721.27±1.71[c]	<.0001
21-42 days	1700.40±11.30[a]	1590.97±11.59[b]	1719.03±5.81[a]	<.0001
0 – 42 days	2620.53±8.86[a]	2325.17±11.14[c]	2440.30±6.15[b]	<.0001
Feed consumption				
0-21 days	1189.90±7.33[a]	927.60±13.29[b]	889.23±9.42[c]	<.0001
21-42 days	2495.03±12.50	2497.57±10.87	2513.43±29.08	0.7748
0 – 42 days	3684.93±19.79[a]	3425.17±23.54[b]	3402.67±37.97[b]	0.0007
Feed conversion ratio				
0-21 days	1.29±0.005[a]	1.26±0.005[b]	1.23±0.003[c]	<.0001
21-42 days	1.47±0.010[b]	1.57±0.012[a]	1.46±0.008[b]	<.0001
0 – 42 days	1.41±0.005[b]	1.47±0.008[a]	1.39±0.006[b]	<.0001

[a,b,c] means with different superscript letters within the same row are significant differences at probability level ($p \leq 0.05$). C) broiler chicks group fed basal diet without addition (control); DOP1) broiler chicks group fed basal diet supplemented with 1% dried orange peel; DOP2) broiler chicks group fed basal diet supplemented with 2 % dried orange peel.

TABLE 3. Effect of dietary dried orange peel supplementation on the carcass traits of broiler chicks.

Measurements	Treatments			p-value
	C	DOP1	DOP2	
LBW	2636.17±13.04	2336.67±15.77	2420.17±6.68	<.0001
Eviscerated carcass %	70.59±0.33	71.09±0.52	71.99±0.34	0.0779
Dressed carcass %	74.37±0.34[b]	75.89±0.47[a]	75.79±0.30[a]	0.0222
Liver%	2.10±0.010[a]	2.04±0.036[a]	1.88±0.017[b]	<.0001
Heart%	0.35±0.002[c]	0.66±0.054[a]	0.48±0.002[b]	<.0001
Gizzard%	1.33±0.006[c]	2.10±0.143[a]	1.71±0.007[b]	<.0001
Spleen%	0.12±0.001[c]	0.22±0.022[a]	0.17±0.002[b]	0.0002
Abdominal fat %	1.74±0.010[a]	1.02±0.133[b]	1.13±0.040[b]	<.0001

[a,b,c] means with different superscript letters within the same row are significant differences at probability level ($p \leq 0.05$). C) broiler chicks group fed basal diet without addition (control); DOP1) broiler chicks group fed basal diet supplemented with 1% dried orange peel; DOP2) broiler chicks group fed basal diet supplemented with 2 % dried orange peel.

TABLE 4. Effect of dietary dried orange peel supplementation on some blood parameters of broiler chicks.

Parameters	Treatments			P-value
	C	DOP1	DOP2	
Total protein (g/dl)	6.69±0.032	6.69±0.020	6.70±0.020	0.9713
Albumin (g/dl)	3.27±0.096	3.29±0.130	3.47±0.109	0.4373
Globulin (g/dl)	3.39±0.113	3.35±0.136	3.23±0.115	0.6209
AL/GL ratio	0.97±0.065	1.01±0.084	1.08±0.069	0.5485
Glucose (mg/dl)	233.76±6.143	220.23±6.610	239.93±10.46	0.2395
Lipid profile				
Cholesterol (mg/dl)	257.05±11.07^{a}	153.58±9.39^{b}	129.47±10.85^{b}	<.0001
HDL (mg/dl)	73.12±2.39^{a}	44.20±5.63^{b}	46.47±3.67^{b}	0.0002
LDL (mg/dl)	12.05±0.71^{a}	9.96±0.56^{b}	10.85±0.27^{ab}	0.0492
Triglyceride (mg/dl)	176.15±9.56^{a}	82.60±1.79^{b}	81.02±1.96^{b}	<.0001
Liver functions				
AST (IU/ml)	15.31±1.789	15.37±0.856	17.16±1.059	0.5327
ALT (IU/ml)	209.20±10.38^{a}	167.00±3.99^{b}	170.90±5.13^{b}	0.0023

^{a,b} means with different superscript letters within the same row are significant differences at probability level ($p \leq 0.05$). C) broiler chicks group fed basal diet without addition (control); DOP1) broiler chicks group fed basal diet supplemented with 1% dried orange peel; DOP2) broiler chicks group fed basal diet supplemented with 2 % dried orange peel.

TABLE 5. Effect of dietary orange peel supplementation on cecal microbiota of broiler chicks.

Bacteria species	Treatments			P-value
	C	DOP1	DOP2	
Total bacterial count (log10)	8.70±0.25^{a}	8.93±0.21^{a}	6.95±0.39^{b}	0.0004
Escherichia coli count (log10)	5.80±0.18^{a}	4.43±0.34^{b}	5.41±0.07^{a}	0.0022
Salmonella count (log10)	5.56±0.08^{a}	4.18±0.29^{b}	4.28±0.10^{b}	<.0001

^{a,b,c} means with different superscript letters within the same row are significant differences at probability level ($p \leq 0.05$). C) broiler chicks group fed basal diet without addition (control); DOP1) broiler chicks group fed basal diet supplemented with 1% dried orange peel; DOP2) broiler chicks group fed basal diet supplemented with 2 % dried orange peel.

TABLE 6. Effect of dietary dried orange peels on bursa histomorphometry of broiler chicks at 42 days old.

Measurements	Treatments		
	Control	DOP1	DOP2
Follicle area/um	427007.92±5491.33^{b}	457810.76±2583.79^{a}	457878.23±4852.256^{a}
No. of follicles/plica	39.80±0.73^{b}	35.67±1.45297^{c}	48.25±1.03^{a}
Area of plica/um	17568343.96±1638377.77^{a}	16879618.15±1883015.73^{a}	18850531.33±2275855.66^{a}

^{a,b,c} means with different superscript letters within the same row are significant differences at probability level ($p \leq 0.05$). C) broiler chicks group fed basal diet without addition (control); DOP1) broiler chicks group fed basal diet supplemented with 1% dried orange peel; DOP2) broiler chicks group fed basal diet supplemented with 2 % dried orange peel.

TABLE 7. Feed cost and economic efficiency of broiler chicks fed diets supplemented with dried orange peels at deferent levels.

Items	Treatments			p-value
	C	DOP1	DOP2	
Feed cost/ 1kg LBW (EGP)	33.61±0.12[b]	35.21±0.20[a]	33.30±0.14[b]	<.0001
Net revenue / 1 kg LBW (EGP)	27.39±0.12[a]	25.79±0.20[b]	27.70±0.14[a]	<.0001
Economic efficiency / LBW	81.54±0.65[a]	73.43±0.98[b]	83.26±0.78[a]	<.0001
Relative Economic efficiency	100	90.05	102.11	
Feed cost/ 1 kg DC (EGP)	44.49±0.16[b]	45.57±0.26[a]	43.20±0.18[c]	<.0001
Net revenue / 1 kg DC (EGP)	35.51±0.16[b]	34.43±0.26[c]	36.80±0.18[a]	<.0001
Economic efficiency / DC	79.88±0.62[b]	75.71±0.97[c]	85.28±0.79[a]	<.0001
Relative Economic efficiency	100	94.78	106.67	

[a,b,c] means with different superscript letters within the same row are significant differences at probability level ($p \leq 0.05$). C) broiler chicks group fed basal diet without addition (control); DOP1) broiler chicks group fed basal diet supplemented with 1% dried orange peel; DOP2) broiler chicks group fed basal diet supplemented with 2 % dried orange peel, LBW= live body weight, DC= dressed carcass, EGP= Egyptian pound.

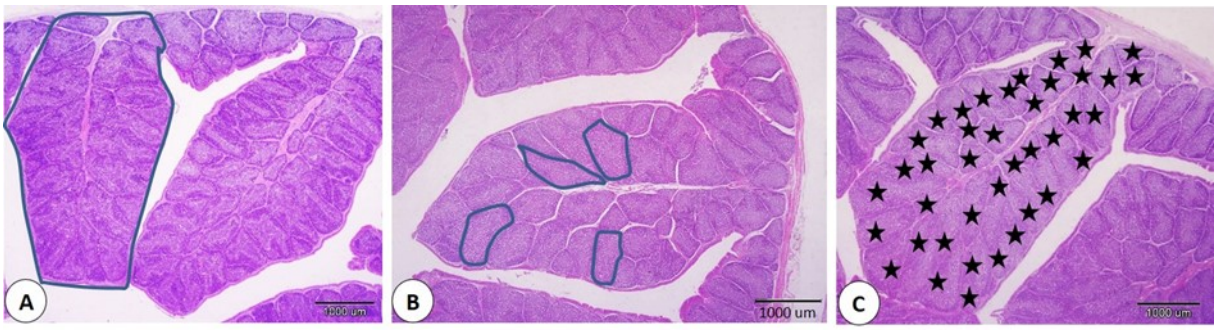

Fig. 1. Effect of dietary dried orange peel supplementation at different levels on the histomorphometry of the bursa of Fabricius. A) Control group. B) 1% DOP group. C) 2% DOP group. The bordered area in A showed Area of plica, the bordered area in B showed a follicle area, and the bordered area in C showed No.

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أداء النمو، خصائص الذبيحة، مؤشرات الدم، الحالة الصحية والكفاءة الاقتصادية لكتاكيت التسمين المغذاة على علائق مدعمة بمسحوق قشر البرتقال المجفف

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الملخص

بحثت هذه الدراسة في كيفية تأثير إضافة قشر البرتقال المجفف (DOP) إلى علائق دجاج التسمين على أداء النمو وخصائص الذبيحة ومعايير الدم والكفاءة الاقتصادية. تم توزيع 120 كتكوت دجاج تسمين روس، بعمر يوم واحد، بشكل عشوائي على ثلاث مجموعات علاجية، كل منها تضم أربع مكررات من 10 كتاكيت. تم تغذية المجموعة الضابطة على نظام غذائي أساسي من الذرة وفول الصويا بدون إضافات، بينما تم تغذية المجموعتين الثانية والثالثة على نفس النظام الغذائي الأساسي مضافًا إليه 1 و2٪ من قشر البرتقال المجفف على التوالي. تم تقييم سمات أداء النمو وإنتاجية اللحوم ومعايير الدم والنتائج الاقتصادية. كشفت النتائج أنه خلال فترة البادئ، قللت اضافة قشر البرتقال المجفف بشكل كبير من وزن الجسم الحي (LBW) وزيادة وزن الجسم (BWG) واستهلاك العلف (FC) مع تحسين نسبة تحويل العلف (FCR) مقارنة بالنظام الغذائي للتحكم. كان لدى كتاكيت دجاج التسمين التي تلقت 2٪ من قشر البرتقال المجفف أقل وزن جسم حي،زيادة في وزن جسم واستهلاكا للعلف ، إلى جانب نسبة تحويل العلف أفضل من تلك الموجودة في مجموعات العلاج الأخرى. خلال فترة الناهي، أظهرت فراخ الدجاج اللاحم التي تغذت على 1% DOP أدنى نسبة لنمو الجسم وأدنى نسبة تحويل غذائي بين المجموعات. كما أظهرت المجموعات المعالجة اقل وزن للجسم الحي عند النهاية وإجمالي نسبة تحويل غذائي مقارنة بمجموعة التحكم. أدت مكملات DOP الغذائية إلى تقليل مستويات الكوليسترول الكلي في المصل ولكوليسترول الحميد عالي الكثافة (HDL-C) والكوليسترول الضار منخفض الكثافة (LDL-C) والدهون الثلاثية ونسبة الدهون في البطن بشكل ملحوظ مقارنة بالمجموعة الضابطة. كما أدى إضافة 2% DOP إلى تقليل أعداد السالمونيلا والإشريكية القولونية بشكل كبير، كما أدى إضافة 1% DOP إلى تقليل العدد الإجمالي للبكتيريا في محتوى الأعور مقارنة بمجموعة التحكم. وعلاوة على ذلك، أدت مكملات DOP إلى زيادة نسبة التضميد بشكل ملحوظ وتعزيز المناعة الخلطية. باختصار، على الرغم من أن DOP أثر سلبًا على أداء النمو، إلا أنه عزز جودة الذبيحة من خلال زيادة نسبة التصافي وتقليل الدهون في البطن. بالإضافة إلى ذلك، فهو يحسن الحالة الصحية للدجاج اللاحم عن طريق خفض مستويات الكوليسترول في الدم، والكوليسترول الجيد، والدهون الثلاثية، وقمع البكتيريا المسببة للأمراض، وتعزيز المناعة الخلطية..

الكلمات الدالة: قشر البرتقال، كتاكيت التسمين، أداء النمو، صفات الذبيحة، مؤشرات الدم.