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Influence of onion skin waste on growth performance, carcass characteristics, physiological responses, and histological indices of broiler chickens

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Abstract

This study investigated the effects of dietary inclusion of onion peel waste (*Allium cepa* L.) on the growth performance, nutrient digestibility, carcass traits, hematology, biochemistry, and intestinal histology of broiler chickens. A total of 200 day-old broiler chicks were randomly assigned to five dietary treatments (0.0, 2.5, 5.0, 7.5, and 10.0 g of onion peel per 25 kg of feed) using a completely randomized design for 56 days. Results showed that moderate inclusion levels (2.5–5.0 g) significantly enhanced growth performance, weight gain, and carcass yield, while higher levels (7.5–10.0 g) reduced performance but improved feed conversion ratios. Nutrient digestibility, especially crude protein and ether extract, was positively influenced by onion peel supplementation. Histological examination revealed no adverse effects on intestinal morphology across treatments. Hematological parameters remained largely unaffected, while biochemical indices such as albumin, total protein, and globulin improved significantly at higher inclusion levels. Phytochemical analysis confirmed the presence of bioactive compounds such as saponins, flavonoids, and tannins. The study concludes that onion peel waste can serve as a sustainable, functional feed additive that enhances broiler productivity and carcass quality without detrimental health effects. Further studies are recommended to optimize the dosage for maximum benefit.

Keywords: Onion peel waste, Broiler chickens, Growth performance, Nutrient digestibility, Phytochemical feed additive

Introduction

The poultry industry is continually seeking sustainable and cost-effective strategies to enhance broiler chicken production while minimizing environmental impact (Mottet & Tempio, 2017; FAO, 2020). One promising approach involves the utilization of agro-industrial by-products, such as onion skin waste, as feed additives. Onion skins, a major by-product of onion processing, are rich in bioactive compounds including flavonoids, sulfur-containing compounds, and antioxidants, which have been reported to offer multiple health benefits for poultry (Suleria *et al.*, 2015; Sharma *et al.*, 2019). These benefits include improved blood circulation, enhanced immunity, natural deworming effects, better feed conversion, and increased stress resistance, among others (Goodarzi *et al.*, 2014)

Recent studies have explored the inclusion of onion extracts or peels in broiler diets, with mixed results regarding their influence on growth performance and carcass characteristics. For instance, research has shown that supplementing broiler diets with onion extracts did not significantly affect feed intake, body weight, or feed conversion ratio, but did improve certain aspects of bone morphology and meat shear force (Malematja *et al.,* 2023). Similarly, the addition of onion peel as a feed additive has been found to yield positive effects on feed conversion ratio and production index, although without significant changes in final body weight or mortality rates (Jannah & Sudjarwo 2024). These findings suggest that while onion skin waste may not dramatically alter growth metrics, it can contribute to improved production efficiency and product quality.

The incorporation of onion skin waste in broiler nutrition offers several potential advantages. The antioxidants present can mitigate oxidative stress, a common challenge in intensive poultry production that negatively affects growth, immune function, and meat quality (Alagawany *et al.,* 2018; Suleria *et al.,* 2015). By reducing oxidative damage, onion skin compounds may enhance metabolic efficiency and support the birds' physiological resilience against environmental and pathogenic stressors (Khan *et al.,* 2018). Furthermore, the antimicrobial properties of onion-derived compounds can contribute to gut health by modulating the intestinal microflora, potentially reducing the need for antibiotic growth promoters and aligning with consumer demands for antibiotic-free poultry products (Lee *et al.,* 2017; Sharma *et al.,* 2019).

Beyond growth and carcass traits, the physiological responses and histological indices of broiler chickens are critical indicators of animal health and welfare. The antioxidants and antimicrobial compounds present in onion skins may help reduce oxidative stress, enhance metabolic functions, and prevent infections, thereby supporting overall physiological stability and tissue integrity in broilers (Alagawany *et al.,* 2018; Lee *et al.,* 2017). However, comprehensive evaluations encompassing these parameters are limited, and further research is warranted to elucidate the full spectrum of effects exerted by onion skin waste supplementation.

Given the dual benefits of waste valorization and potential improvements in poultry health and productivity, investigating the influence of onion skin waste on growth performance, carcass characteristics, physiological responses, and histological indices of broiler chickens.

Material and method

Experimental site

The experiment was conducted at National Veterinary Research Institute (NVRI) Vom, Plateau State. Vom is a quite Rocky village in Jos South Local Government Area situated 1,285meters above sea level. It has an annual rainfall of about 1,300_ 1,500mm lasting between April to October with the month of July recording the lowest temperature of 20C^{o} - 28C^{o} with the month of July recording the lowest temperature 16C^{o} - 18C^{o}. Vom has a great vegetation growth and it is however retarded during the dry season (November-March).

Experimental material

Onion peels (*Alliium cepa* L.) Were collected from local market (Kugiya and building materials markets Jos South Local Government of Plateau State). It was washed and air dried in order to be free from sand and contaminants grated by mixer (LID feed mill) and collected in a clean sack.

Experimental birds, Design and Management

A total number of two hundred (200), one day-old broiler birds were used for the experiment. A Completely Randomized Design (CRD) was used for this experiment. The chicks were randomly assigned to five (5) treatment groups having 40 birds per group. Each treatment group was replicated into four (R1, R2, R3, R4) times with a total number of 10 birds per replicate. The five treatment groups were designated as T1, T2, T3 and T4 and T5 containing (control 0.0g, 2.5g, 5g, 7.5g, 10g onion waste inclusion levels). The chicks were housed on rice husks on the floor in a deep litter pen with 23/1 light/dark cycle throughout the experimental period for 56 days. The diet was compounded locally and

milled at Livestock Investigation Division feed mill. The chicks were allowed to have free access to feed and water al libium.

Data Collection

Growth Performance of Broiler Chickens

Average daily gain (ADG) (g/bird/day) = final weigh gain – initial weight/(number of birds x number of days).

Average daily feed intake (ADFI) (g/bird/day) = cumulative feed intake/(number of birds x number of days).

Feed conversion ratio was assessed and calculated as FCR=feed intake (g)/weight (g)

Blood Sample Collection

Blood samples was collected into labeled Ethylene-deamine-tetra-acetic acid (EDTA) treated tubes for haematological analysis and into tubes without anticoagulant for serum biochemical evaluation. Evaluations was conducted according to the method already described by Bitto and Gemade (2001).

Hematological Parameters

At the end of the 60 days, blood samples were collected from three birds per treatment, one bird from each replicate and transferred into labeled and sterilized dry test tubes or bottles containing Ethylene Diamine Tetracetic Acid (EDTA) anticoagulant for haematological analysis which includes Packed Cell Volume (PCV), Red Blood Cell (RBC), White Blood Cell (WBC), Lymphocytes Neutrophils, Haemoglobin (Hb) and other blood indices (MCV, MCH, MCHC).

Serum Biochemical Analysis

The total protein, albumin, globulin, alkaline phosphates, aspartate transaminase, alanin transferase, in the serum were analyzed using a comolete automated procedure.

Measurements of chicken digestibility

Five chickens from each experimental unit separated randomly into a metabolic cage to measure energy digestibility. The metabolic cage was provided with plastic pads to accommodate chicken excreta. Each onion skin treatment was given to 15 chickens divided into (4) four replication groups. Before treatment, chickens were adapted for three days without onion skin administration and fed to spend ± 30 g/head for 24 hours then fast from feed for 24 hours, while water were provided ad libitum. Each onion waste was given according to the administration of additive dose (1% of feed consumption). Excreta from chickens is accommodated to ensure there is no feed in the digestive tract. Excreta was carried out for 36 hours since the onion waste treatment was stopped. Collected excreta immediately sprayed with H_2SO_4 0.01 N to bind the nitrogen and avoid evaporation. Excreta samples dried at 50 °C oven for 48 hours, then milled and analyzed for moisture content, crude protein, and gross energy. The value of energy retention consists of energy consumption and energy excretion, while nitrogen retention includes nitrogen consumption, excretion nitrogen.

Histological analysis

At the age of 8 weeks, three chickens per replicate were randomly selected for intestinal histology. Each chicken was weighed and humanely slaughtered according to the rules and regulations of the Animal Research Ethics Committee. They were then hanged upside down to completely bleed out, intestine were taken to Central Diagnostics Laboratory for histopathological analysis

Paraffin Wax Method of Tissue Processing

Conventional Method (Avwioro, 2011)

Tissues were harvested and fixed in 10% formalin for 3 days, cut into thin slices of 5mmX 2mm X 1mm thick and then processed in the following order using The SPIN tissue processor, STP 120 (Thermo scientific):

10% buffered formalin

70% Alcohol---------- 2hours

80% Alcohol---------- 2 hours
90% Alcohol ---------- 2 hours
95% Alcohol ---------- 2 hours
Absoloute Alcohol I ---------- 2 hours
Absolute Alcohol II ---------- 2 hours
Absolute Alcohol III ---------- 2 hours
Xylene I ---------- 2 hours
Xylene II ---------- 2 hours
Paraffin Wax Oven I ---------- 2 hours
Paraffin Wax Oven II ----------2 hours
EMBEDDING: Tissues were embedded in molten paraffin wax using embedding moulds. The tissues were embedded using embedding cassettes on a tissue Tek Embedding Centre (SLEE MPS/P2), and cooled rapidly on the cooling component.

Sectioning: Tissues were sectioned using a rotary microtome (MICROM HM340E Thermo-Scientific) set at 4micromes, picked on slides and ready for staining.
Haematoxylin and Eosin Staining Technique
Sections were dewaxed and hydrated by passing through two changes of xylene and through descending grades of alcohol (100%, 80%, 70%) for three minutes each and then into water, stained in Harris' haematoxylin solution for 5 minutes and washed in running water. They were differentiated in 1% acid-alcohol and then washed well in water, blued in Scott's tap water substitute for 5 minutes and rinsed briefly in distilled water, counterstained in 1% aqueous eosin for 2 minutes, washed well in water, dehydrated in descending grades of alcohol, cleared in xylene and mounted in DPX (Destrene, plasticiser and xylene). Sections were then placed in slide carriers and placed in a 40^0C oven to dry overnight.
They were read microscopically.
The onion peels sample was taken to biochemistry laboratory of NVRI Vom for qualitative and quantitative analysis, on day 60, six birds (i.e 2 per replicate) from each treatment, with an average body weight that corresponded to the respective treatment, selected for the carcass evaluation. They were allowed to fast for 12 h and then weighed, slaughtered until they completely bled out, de-feathered, eviscerated, and finally weigh to determine the dressing percentage. The weights of the dressed carcass, viscera, intestine, liver, heart, and spleen was determined and be expressed as a percentage of live body weight.
Carcass Evaluation
At the end of the 60 days experimental period, two birds from each replicate group (a total of 8 birds per treatment) were randomly selected and slaughtered for carcass evaluation. The following parameters were assessed:
Live weight: Recorded just before slaughter.
Carcass yield: The carcass was weighed after defeathering and evisceration, and the carcass yield was calculated as a percentage of the live weight.
Dressing percentage: Calculated using the formula:

$$\text{Dressing Percentage} = \left(\frac{Carcass\ Weight}{Live\ Weight}\right) \text{X } 100$$

Edible parts: The weight of the breast, thigh, wings, and drumsticks were recorded.
Non-edible parts: The weight of the feathers, head, feet, and internal organs
(gizzard, liver, heart) were recorded. vi. Carcass parts percentage: Each edible and non-edible part was expressed as a percentage of the total live weight.
vii. Fat content: The amount of fat in the abdominal region was measured by extracting and weighing the fat after careful dissection.

Data Analysis

The obtained data was analyzed using one-way Analysis of Variance (ANOVA). Where significant treatment effect was detected, means were separated using Ducan's multiple range test (DMRT) using the Statistical Package for Social Sciences (SPSS) software.

Results

Table 1 shows the phytochemical screening and quantity of several bioactive compounds. Saponins were highest at 19.6%, followed by flavonoids (2.5%), alkaloids (2.1%), steroids (1.1%), and tannins (1.65 mg/100 g). Cardiac glycosides and anthraquinones were detected, though their amounts were not specified.

Table 1: Qualitative and quantitative phytochemicals of onion peels

Parameters		Amount
Saponins	+	19.6%
Tannins	+	1.65mg/100g
Steroids	+	1.1%
Alkaloids	+	2.1%
Flavonoids	+	2.5%
Cardiac glycosides	+	
Anthraquinone	+	

+ Detected, - Non detected

Table 2 shows the effect of dietary onion waste levels on the growth performance of broiler chickens. The inclusion of onion peel meal in broiler diets significantly influenced growth performance parameters. While initial weights were consistent across all groups (244.53 g), final body weights were significantly higher ($p < 0.05$) in birds fed 2.5 g and 5.0 g per 25 kg feed compared to those on higher inclusion levels (7.5 g and 10.0 g), which showed reduced weights. Similarly, total weight gain followed the same pattern, with optimal gains observed at 2.5 g and 5.0 g inclusion. Feed intake increased with higher inclusion levels up to 7.5 g but dropped sharply at 10.0 g. Interestingly, feed conversion ratio (FCR) was best (lowest) at 10.0 g (2.07), indicating improved efficiency, though this group had the lowest weight gain, suggesting a trade-off between feed efficiency and growth performance. The poorest FCR was seen at 7.5 g (2.91). Values marked with different superscripts (a, b, c) differ significantly.

Table 2: Effect of dietary onion waste levels on the growth performance of broiler chickens

	Levels of onion peel meal inclusion (g/25kg)					
Parameters	0.0	2.5	5.0	7.5	10.0	S E M
Initial weights (g)	244.53	244.53	244.53	244.53	244.53	0.00^{NS}
Final weights (g)	2042.33^{ab}	2150.00^{a}	2174.07^{a}	1921.29^{b}	1851.85^{b}	32.64*
Total weight gains (g)	1797.80^{ab}	1905.47^{a}	1926.54^{a}	1676.63^{b}	1607.32^{b}	32.64*
Total feed intake (g)	4137.24^{b}	4377.97^{bc}	4669.67^{ab}	4874.67^{a}	3324.76^{c}	107.43*

Feed Conversion Ratio	2.38[b]	2.31[b]	2.44[b]	2.91[a]	2.07[c]	0.06*

[a, b] Means in the same row with different superscripts are significantly different (P<0.05)
S E M = Standard Error of Mean, N S = Not Significant (P>0.05)

Table 3 showed the proximate composition of experimental diets with graded levels of onions peel meal. The nutrient composition of diets with graded onion peel levels showed minimal variation. Moisture, crude protein, and crude fibre remained relatively stable across treatments. Lipid and ME values increased slightly with higher inclusion, suggesting improved energy content. Ash decreased slightly, while NFE increased with more onion peel. Calcium and phosphorus levels showed minor fluctuations but stayed within a normal range. Overall, onion peel inclusion had little adverse effect on the proximate composition of the diets.

Table 3: Proximate composition of experimental diets with graded levels of onions peel meal

	TREATMENT GROUPS MEANS				
PARAMETERS	Control (0g)	2.5g	5.0g	7.5g	10.0g
MOISTURE	6.26	6.16	6.10	6.24	6.04
CRUDE PROTEIN	17.59	17.33	17.63	17.24	17.52
CRUDE FIBRE	5.32	5.52	5.43	5.52	5.05
LIPIDS	2.64	2.51	3.04	2.99	3.03
ASH	6.99	6.44	6.33	6.06	6.12
NFE	61.20	62.05	61.47	61.95	62.24
M.E	338.92	340.11	343.78	343.70	346.29
CALCIUM	0.92	0.98	0.88	0.75	0.94
PHOSPHORUS	0.06	0.10	0.10	0.07	0.10

Means along each raw that do not share at least a superscript are statistically significant at 5% level. NS: Not significant, S: Significant

Table 4 showed the apparent nutrients digestibility of a broilers chickens fed graded levels of onion peel meals. Apparent nutrient digestibility varied with onion peel meal levels. Crude protein digestibility ranged from 10.81% (control) to 13.70% (7.5g/kg), with groups 2 with 2.5g/kg (12.81%) and 5 (12.77%) also showing high values. Crude fibre digestibility was highest in control (7.83%) and decreased to 5.60% in feed from 10g/kg. Ether extract digestibility increased from 13.50% (control) to a peak of 18.99% (2.5g/kg), then dropped to 14.18% in 5.0g/kg feed, and rose again slightly in 7.5g/kg (18.39%) and 5 (16.98%). Nitrogen-free extract digestibility was highest in group 2 (75.43%) and lowest in group 4 (47.83%), with group 1 at 69.63%, group 3 at 52.78%, and group 5 at 54.67%. Ash (mineral) digestibility peaked in group 3 (19.87%) and was lowest in groups 2 (10.99%) and 4 (10.73%).

Table 4: Apparent nutrients digestibility of a broilers chickens fed graded levels of onion peel meals

Parameter	Control	2.5g	5.0g	7.5g	10.0g	SEM

	(0g)					
Crude Protein	10.81[b]	12.81[a]	11.81[b]	13.70[a]	12.77[a]	0.42
Crude Fibre	7.83[a]	7.65[ab]	6.12[c]	7.51[b]	5.60[d]	0.11
Ether extract	13.50	18.99[a]	14,18[d]	18.39[b]	16.98[c]	0.13
Nitrogen free extract	69.63[b]	75.43[a]	52.78[c]	47.83	54.67[c]	0.06
Ash (minerals)	17.71[b]	10.99[d]	19.87[a]	10.73[d]	16.23[c]	0.15

Means along each raw that do not share at least a superscript are statistically significant at 5% level

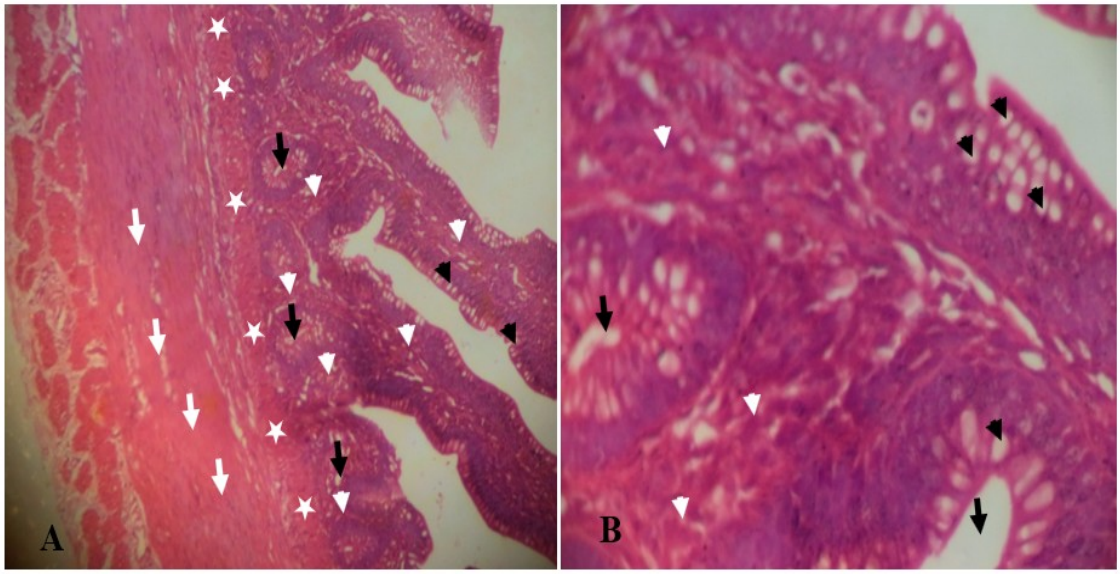


Plate 1 (T1): Intestine of a chicken exposed to normal environmental and nutritional conditions, showing normal morphology. The mucosa presents with its characteristic epethilium interspersed by Goblet cells (black arrowheads). White stars= muscularis mucosae, White arrows= muscularis externa, Black arrows= intestinal crypt, white arrow heads= Lamina propria. H&E A: X100 B: X400

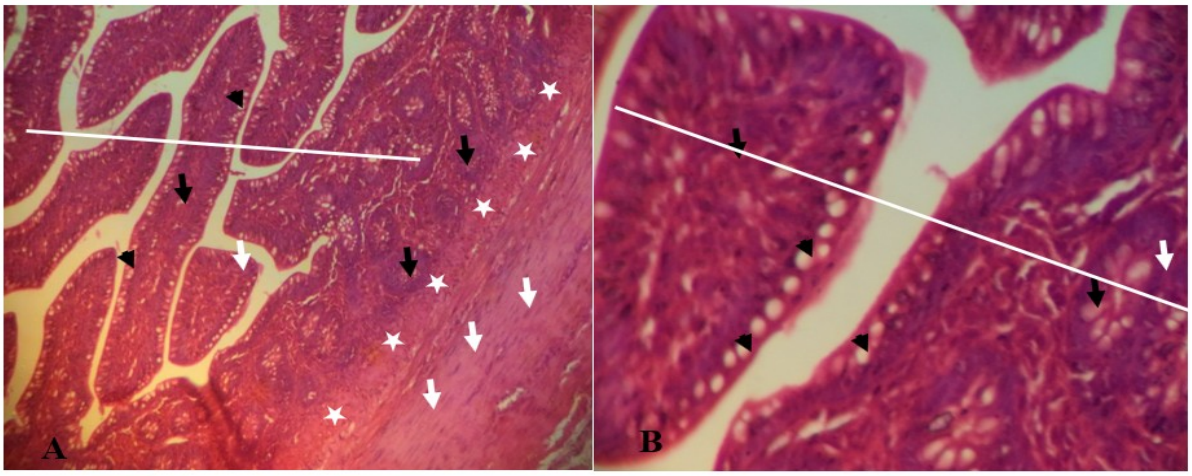


Plate 2 (T2): Intestine of a chicken given 2.5mg of dry onion back powder/ 50kg of feed, showing normal morphology with the mucosa (white line) showing its characteristic epithelium with Goblet cells (Black arrowheads). White stars= muscularis mucosae, White arrows= muscularis externa, Black arrows= intestinal crypt, white arrowheads= Lamina propria. H&E A: X100 B: X400

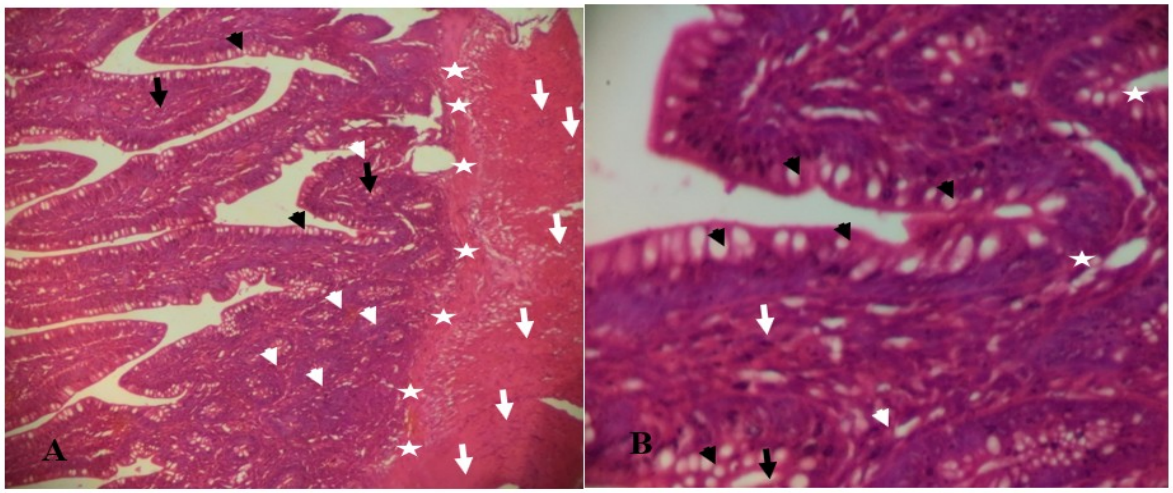


Plate 3 (T3): Intestine of a chicken given 5mg of dry onion back powder/ 50kg of feed, showing normal morphology. White stars= muscularis mucosae, white arrows= muscularis externa, Black arrows= intestinal crypt, white arrowheads= Lamina propria. Black arrowheads: Goblet cells. H&E A: X100 B: X400

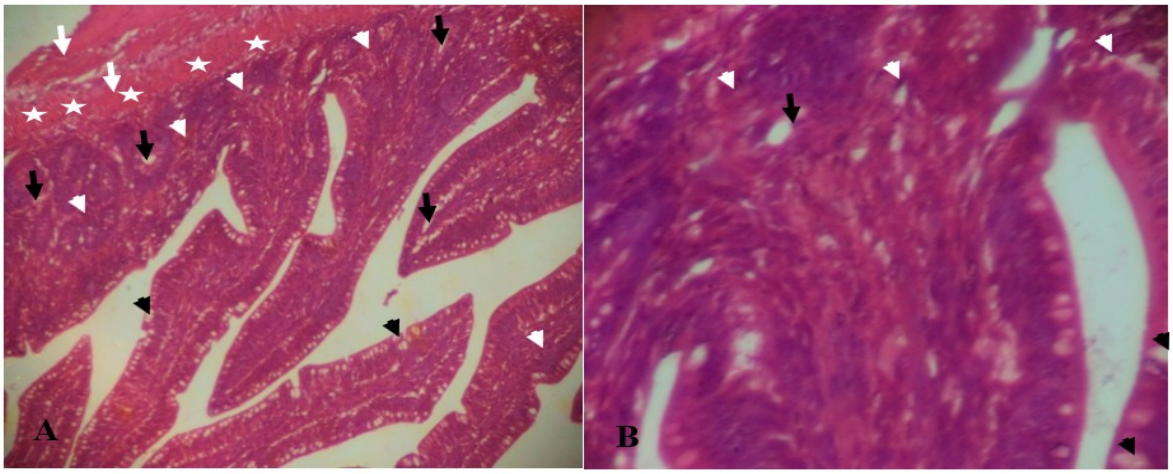


Plate 4 (T4): Intestine of a chicken given 7.5mg of dry onion back powder/ 50kg of feed, showing normal morphology. White stars= muscularis mucosae, White arrows= muscularis externa, Black arrows= intestinal crypt, white arrowheads= Lamina propria. Black arrowheads= Goblet cells. H&E A: X100 B: X400

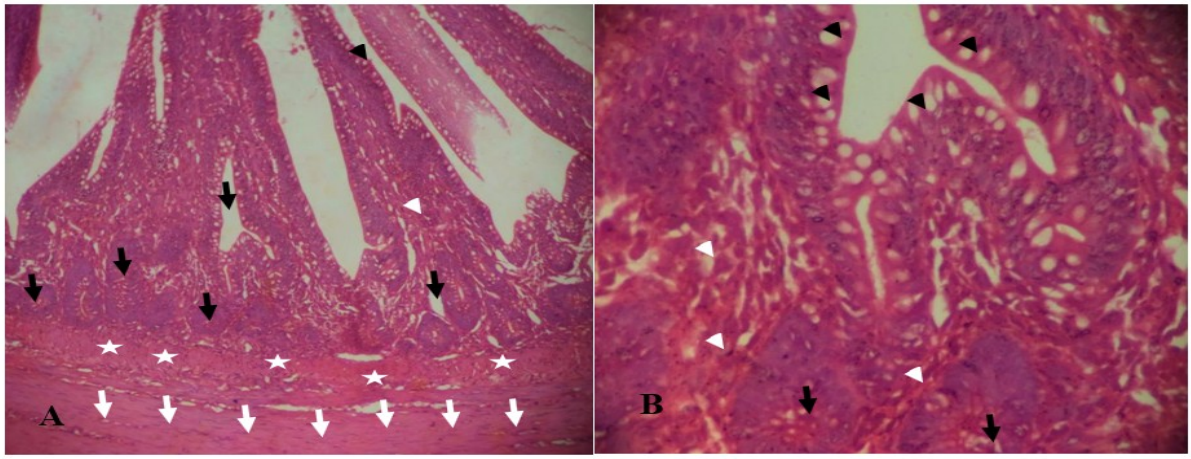


Plate 5 (T5): Intestine of a chicken given 10mg of dry onion back powder/ 50kg of feed, showing normal morphology. White stars= muscularis mucosae, White arrows= muscularis externa, Black arrows= intestinal crypt, white arrowheads= Lamina propria, Black arrowheads= Goblet cells. H&E A: X100 B: X400

4.1: Effect of varying levels of onion skin waste additives (*Allium cepa*) on intestinal histology of broiler chickens

Table 1 represents the effect of varying levels of onion skin waste additives (Allium cepa) on the intestinal histology of broiler chickens.

The study indicates no significant difference ($p<0.05$) between treatments on Villi Height (µm). villi height across all treatments is 124.99 µm, with treatment 5 showing the highest value (129.2 µm) and treatment 1 the lowest (120.4 µm).

Villi Width (µm) shows no significant differences ($p<0.05$) among the treatments, with with treatment 2 having the widest villi (18.8 µm) and treatment 4 the narrowest (15.5 µm).

Villi area among treatments shows no statistically significant ($p<0.05$). Treatment 5 had the largest area (7907.9 µm²), while treatment 4 had the smallest (6383.0 µm²).

The study indicate no significant differences between treatments across Crypt depth (µm), with treatment 4 having the greatest depth (26.6 µm) and treatment 1 the smallest (20.4 µm).

Crypt width (µm) shows no significant differences ($p<0.05$) across the treatments, with treatments 2 and 5 showing the largest crypt width (4.8 µm and 4.7 µm, respectively) and treatment 1 the smallest (4.3 µm).

The study indicates no significant difference ($p<0.05$) between treatments in crypt area, with treatment 4 showing the largest crypt area (417.8 µm²) and treatment 1 the smallest (311.8 µm²).

Table 5: Effect of varying levels of onion skin waste additives (*Allium cepa*) on intestinal histology of broiler chickens

TRTs	Villi Height (µm)	Villi width (µm)	Villi area $(\mu m)^2$	Crypt depth (µm)	Crypt width (µm)	Crypt area $(\mu m)^2$
1	120.4	17.4	7060.0	20.4	4.3	311.8
2	122.3	18.8	7781.6	21.8	4.8	365.1
3	124.6	16.9	7108.7	24.2	4.4	365.1
4	122.5	15.5	6383.0	26.6	4.6	417.8

5	129.2	18.1	7907.9	21.9	4.7	366.6
Mean	124.99	17.21	7268.05	23.50	4.60	376.10
S D	3.27	1.23	645.16	2.21	0.16	29.46
Chi-sq	0.504	0.504	0.504	0.504	0.504	0.413
LOS	NS	NS	NS	NS	NS	NS

N S = Not Significant (P>0.05)
Key: Metrics examined include villi height, villi width, villi area, crypt depth, crypt width, and crypt area, across five treatments (TRTs).

Table 6 shows the carcass analysis of broiler chicken fed diet with onion waste as additives. Dietary inclusion of onion waste influenced carcass characteristics in broilers. Live weights were highest in the 5.0 g group (2543.33 g) and lowest in the 10.0 g group (2256.67 g). Bled weights increased across treatments, peaking at 7.5 g (97.33%) and lowest in the control (93.47%). Defeathered weights also improved, with the highest value at 5.0 g (91.30%), compared to 84.13% in the control. Dressing percentage significantly increased in all supplemented groups (except 10.0 g) compared to the control, with the highest at 7.5 g (72.27%) and the lowest in the 10.0 g group (48.90%).

Table 6: Carcass analysis of broiler chicken fed diet with onion waste as additives

	Control (0g)	2.5g	5.0g	7.5g	10.0g	SEM
Live weights (g)	2333.33 ^{b}	2426.67 ^{a} ^{b}	2543.33 ^{a}	2326.67 ^{a} ^{b}	2256.67 ^{b}	33.39 *
Bled weights (%)	93.47 ^{c}	94.00 ^{b}	96.83 ^{ab}	97.33 ^{a}	94.60 ^{ab}	0.42*
Defeathered Weights (%)	84.13 ^{c}	86.39 ^{b}	91.30 ^{a}	88.84 ^{ab}	89.57 ^{ab}	0.61*
Dressing percentages	59.37 ^{b}	71.80 ^{a}	67.47 ^{a}	72.27 ^{a}	48.90 ^{a}	3.07*

Means along each raw that do not share at least a superscript are statistically significant at 5% level. NS: Not significant, S: Significant

Table 7 shows the percentage of broiler chicken organs and body parts fed diet with graded level of onion. The dietary inclusion of onion peel affected various organ and body part percentages in broiler chickens. Head percentage decreased significantly from 2.97% (control) to 2.20% at 10.0 g. Shank weight increased with inclusion, peaking at 6.27% (7.5 g). Breast meat remained stable in lower inclusion groups (~26%) but dropped sharply to 14.90% at 10.0 g. Thigh and drumstick weights were significantly higher at 7.5 g (12.47% and 8.87%, respectively). Abdominal fat was highest at 7.5 g (11.33%), suggesting increased fat deposition at this level. Heart and liver weights increased with higher inclusion, with the liver peaking at 3.17% (10.0 g). Spleen and gall bladder showed minor variations, while gizzard weight decreased with onion inclusion but increased again at 10.0 g. Intestinal weight and length were highest in 7.5 g and 10.0 g groups, with weights around 7.23–7.03% and lengths up to 7.80 cm.
Table 7: Percentage of broiler chicken organs and body parts fed diet with graded level of onion

Parameters	Control (0g)	2.5g	5.0g	7.5g	10.0g	SEM
Heads	2.97[a]	2.60[b]	2.53[b]	2.87[a]	2.20[c]	0.05*
Necks	5.4	5.67	6.07	6.13	5.73	0.06[NS]
Shanks	5.43[b]	5.80[ab]	5.93[a]	6.27[a]	5.90[ab]	0.07*
Backs	9.57	9.43	9.43	9.5	10.4	0.15[NS]
Breasts	26.00[a]	25.73[a]	24.87[a]	26.67[a]	14.90[b]	0.91*
Wings	9.57	9.43	9.43	9.5	10.4	0.15[NS]
Thighs	8.67[b]	9.03[b]	9.60[b]	12.47[a]	10.40[ab]	0.41*
Drumsticks	5.67[b]	6.03[b]	5.90[b]	8.87[a]	6.17[b]	0.12*
Abdominal fat	9.57[b]	9.20[b]	8.97[b]	11.33[a]	9.93[b]	0.20*
Hearts	0.77[a]	0.70[b]	0.70[b]	0.76[ab]	0.80[a]	0.01*
Liver	2.43[b]	2.06[c]	2.26[ab]	2.23[ab]	3.17[a]	0.08*
Spleen	0.10[a]	0.09[ab]	0.07c	0.08[b]	0.90[ab]	0.00*
Gall bladder	0.09[a]	0.08[ab]	0.07[b]	0.08[ab]	0.09[a]	0.00*
Full Gizzard	4.40[a]	3.77[b]	3.73[b]	4.03[ab]	4.27[a]	0.06*
Empty Gizzard	2.87[a]	2.17[ab]	1.90[b]	2.33[b]	2.33[b]	0.05*
Intestinal Weights	6.87[a]	4.80[c]	5.83[b]	7.23[a]	7.03[a]	0.17*
Intestinal lengths (cm)	7.80[a]	7.47[ab]	6.87[b]	7.57[ab]	7.77[a]	0.11*

Means along each raw that do not share at least a superscript are statistically significant at 5% level. NS: Not significant, S: Significant

Table 8 shows the hematological parameter. Onion peel inclusion had no significant effect (NS) on the hematological parameters measured. White blood cell counts ranged from 4,200 to 11,533 cells/µL, with the highest in the 2.5 g group. Neutrophils were also highest at 10.0 g (42.70) and lowest at 5.0 g (14.67). Lymphocyte counts peaked at 5.0 g (84.33) and were lowest at 2.5 g (30.00). Red blood cells and hemoglobin levels were generally stable, with average values of 1.49 million/µL and 7.51 g/dL, respectively. Haematocrit remained around 31.47%, while MCV and MCH varied widely due to inconsistent values across groups. MCHC ranged from 19.67 to 42.30 g/dL, with no significant trend.

Table 8: Hematological parameter

PARAMETERS	TREATMENT GROUPS MEANS					MEAN±SEM
	Control (0g)	TRT 2 (2.5g)	TRT 3 (5.0g)	TRT 4 (7.5g)	TRT 5 (10.0g)	

White blood cell (cells/µL)	6833	11533	7407	8933	4200	7793±1245^{NS}
Neutrophils (cells/µL)	24.30	11533	14.67	24.00	42.70	27.13±4.63^{NS}
Lymphocytes (cells/µL)	74.00	30.00	84.33	75.33	57.00	71.53±4.83^{NS}
Red blood cell (cells/µL)	1.50	67.00	1.33	1.50	1.43	1.49±0.10^{NS}
Haemoglobin (g/dL)	10.67	1.67	7.06	6.46	7.01	7.51±0.79^{NS}
Haematocrit (%)	29.67	6.34	32.33	33.67	31.67	31.47±0.71^{NS}
Mean cell volume (fL)	199.30	30.00	256.30	240.00	231.70	225.10±15.90^{NS}
Mean cell Haemoglobin (pg)	71.87	198.00	53.30	41.13	54.30	52.58±6.05^{NS}
Mean cell H. concentration (g/dL)	36.00^{NS}	42.30^{NS}	21.67^{NS}	19.67^{NS}	23.00^{NS}	24.27±2.61^{NS}

Means along each raw that do not share at least a superscript are statistically significant at 5% level. NS: Not significant, S: Significant

Table 9 shows the biochemistry parameters. Onion peel inclusion had significant effects (S) on some biochemical parameters. Albumin levels were highest at 10.0 g (31.00 g/L) and lowest in the control (25.00 g/L). Total protein also peaked at 10.0 g (41.00 g/L) and was lowest at 7.5 g (31.33 g/L). Globulin values were slightly varied, highest in the control (1.47 g/L) and lowest in the 2.5 g group (1.23 g/L), with significant but small differences. In contrast, alkaline phosphatase, aspartate transaminase (AST), and alanine transaminase (ALT) levels showed no significant differences (NS) across treatments, with average values of 30.53, 48.47, and 33.33, respectively.

Table 9: Biochemistry parameters

	TREATMENT GROUPS MEANS					
PARAMETERS	Control (0g)	TRT 2 (2.5g)	TRT 3 (5.0g)	TRT 4 (7.5g)	TRT 5 (10.0g)	MEAN±SEM
Albumin	25.00^{b}	27.67^{ab}	26.67^{b}	25.33^{b}	31.00^{a}	27.13±0.73^{S}
Total protein	36.33^{b}	33.33^{c}	38.00^{b}	31.33^{c}	41.00^{a}	36.00±0.96^{S}
Globulin	1.47^{a}	1.23^{c}	1.40^{ab}	1.27^{bc}	1.30^{bc}	1.33±0.03^{S}
Alkaline phosphate	35.00	26.67	32.67	32.00	26.33	30.53±1.48^{NS}
Aspartate Transaminase	53.33	42.67	51.33	51.33	43.67	48.47±1.97^{NS}
Alanine Transferase	34.67	26.67	36.33	37.33	31.67	33.33±2.05^{NS}

Means along each raw that do not share at least a superscript are statistically significant at 5% level. NS: Not significant, S: Significant

Discussion

Phytochemical Composition of Onion Peel Waste

The phytochemical screening (Table 1) revealed that onion peel waste contains a diverse array of bioactive compounds, with saponins being the most abundant (19.6%), followed by flavonoids (2.5%),

alkaloids (2.1%), tannins (1.65 mg/100 g), steroids (1.1%), and detectable levels of cardiac glycosides and anthraquinones. These findings are consistent with previous reports highlighting onion skins as a rich source of secondary metabolites, particularly flavonoids like quercetin, which possess strong antioxidant and antimicrobial properties (Suleria *et al.,* 2015; Alagawany *et al.,* 2018). The high saponin content is notable, as saponins have been documented to exhibit cholesterol-lowering, immune-stimulating, and antimicrobial effects in poultry (Khan *et al.,* 2018). The presence of tannins and alkaloids, although in lower quantities, may also contribute to the modulation of gut microflora and antioxidant defense mechanisms (Sharma *et al.,* 2019).

Growth Performance

Table 2 shows that dietary inclusion of onion peel meal at 2.5 g and 5.0 g per 25 kg feed significantly improved final body weights and total weight gains compared to control and higher inclusion levels. This suggests an optimal inclusion threshold beyond which growth performance declines, possibly due to the presence of anti-nutritional factors or reduced palatability at higher doses. Similar trends have been reported by Lee et al. (2017), where moderate supplementation of onion extract enhanced growth performance, while excessive levels led to diminished gains. The increased feed intake observed at 7.5 g inclusion, followed by a sharp decline at 10.0 g, may reflect feed acceptance and palatability issues at higher onion peel concentrations.

Interestingly, the feed conversion ratio (FCR) was lowest (best) at the highest inclusion level (10.0 g), despite this group having the lowest weight gain. This paradox suggests that while birds consumed less feed and gained less weight, the feed they consumed was utilized more efficiently. This could be due to metabolic adaptations or shifts in nutrient utilization efficiency induced by bioactive compounds in onion peel (Alagawany *et al.,* 2018). However, the poorest FCR at 7.5 g inclusion indicates that intermediate high levels may negatively affect nutrient assimilation or metabolism, a phenomenon also observed in other phytogenic feed additive studies (Khan *et al.,* 2018).

Proximate Composition of Diets

The proximate analysis of experimental diets (Table 3) showed minimal variation across treatments, indicating that graded inclusion of onion peel meal did not significantly alter the basic nutrient profile. Slight increases in lipid content and metabolizable energy (ME) at higher inclusion levels suggest that onion peel may contribute additional energy, possibly from residual oils or carbohydrates in the peel (Suleria *et al.,* 2015). The relatively stable protein, fiber, calcium, and phosphorus contents confirm that the diets remained nutritionally balanced, supporting the validity of observed performance effects being attributable to bioactive compounds rather than gross nutrient differences.

Nutrient Digestibility

Apparent nutrient digestibility (Table 4) varied with onion peel inclusion. Crude protein digestibility improved significantly at 2.5 g and 7.5 g levels, indicating enhanced protein utilization potentially due to improved gut health or enzyme activity stimulated by onion phytochemicals (Lee *et al.,* 2017). The decrease in crude fiber digestibility at higher inclusion levels, especially 10.0 g, may reflect the indigestible fibrous nature of onion peel, which could limit nutrient absorption at excessive doses (Sharma *et al.,* 2019).

Ether extract digestibility peaked at 2.5 g inclusion, suggesting that moderate onion peel levels may enhance lipid metabolism or absorption. The nitrogen-free extract (NFE) digestibility was highest at 2.5 g and lowest at 7.5 g, reinforcing the notion that moderate supplementation optimizes carbohydrate utilization, while higher levels may impair it, possibly due to anti-nutritional factors or altered gut microbiota (Khan *et al.,* 2018).

Ash (mineral) digestibility showed inconsistent patterns but was highest at 5.0 g inclusion, which may indicate improved mineral bioavailability at moderate levels of onion peel supplementation, potentially due to phytochemicals enhancing mineral absorption (Alagawany *et al.,* 2018).

The results of this study align with previous investigations demonstrating that moderate inclusion of onion by-products in poultry diets can improve growth performance, feed efficiency, and nutrient

digestibility, primarily through the action of antioxidant and antimicrobial phytochemicals (Lee *et al.,* 2017; Alagawany *et al.,* 2018). However, excessive inclusion may introduce anti-nutritional effects, reduce palatability, and impair nutrient utilization, as observed in this and other studies (Sharma *et al.,* 2019).

The observed improvements in feed conversion at the highest inclusion level, despite reduced growth, suggest complex physiological interactions that merit further investigation, such as effects on gut morphology, enzyme secretion, and metabolic rate. Moreover, the stable proximate composition across diets confirms that the benefits are likely due to bioactive compounds rather than macronutrient changes, highlighting the functional role of onion peel phytochemicals in broiler nutrition.

Intestinal Histology

The inclusion of varying levels of onion skin waste in broiler diets did not significantly affect intestinal histological parameters such as villi height, villi width, villi area, crypt depth, crypt width, or crypt area ($P > 0.05$). Although there were slight numerical increases in villi height and area at the 10.0 g inclusion level, these changes were not statistically significant. Intestinal morphology is a critical indicator of nutrient absorption capacity and gut health; taller villi and shallower crypts generally suggest improved absorptive efficiency and epithelial turnover (Awad *et al.,* 2009). The lack of significant histological changes suggests that onion peel inclusion at the tested levels does not adversely affect gut structure, supporting its safety as a feed additive. This aligns with findings by Lee et al. (2017), who reported no detrimental effects on intestinal morphology in broilers fed onion extracts, although some studies have noted improvements at moderate inclusion levels due to antioxidant and antimicrobial effects improving gut microenvironment (Alagawany *et al.,* 2018). The study examined the impact of varying levels of **onion skin waste (Allium cepa)** as a dietary additive on the intestinal histology of broiler chickens. The parameters analyzed included villi height, villi width, villi area, crypt depth, crypt width, and crypt area. The results showed **no significant differences** ($p<0.05$) between treatments for any of the histological parameters. The results of the study are in line with the findings made by (Ann-alle *et al.* 2019) who reported that adding different levels of onion skin extracts did not affect growth performance and intestinal histology of broiler chickens. Similarly, Farahani et al (2020) observed no effect on the gross and histopathological (morphology) analysis of broiler chickens fed basal diet containing 10 g/kg onion extracts. This suggests that adding onion skin extracts in diets did not alter the histological morphology parameters of the diet and thus did not affect its functional properties.

Across the treatments, the villi height averaged 124.99 µm, with treatment 5 showing the highest value (129.2 µm) and treatment 1 the lowest (120.4 µm). These results are consistent with findings from a study by **Al-Ghamdi *et al.* (2020)**, where onion skin waste as a dietary additive did not significantly alter villi height but showed slight improvements in nutrient absorption in broilers due to better gut health. Similarly, **Hernández *et al.* (2019)** reported no significant changes in villi height when onion by-products were included in the diet of broiler chickens.

The results indicated no significant difference ($p<0.05$) in villi width, with treatment 2 having the widest villi (18.8 µm) and treatment 4 the narrowest (15.5 µm). This is consistent with findings by **Qureshi *et al.* (2021),** who found that the addition of onion waste did not cause significant changes in the villi width of broilers, suggesting that the intestinal architecture may remain stable despite the dietary intervention.

Although there were no statistically significant differences ($p<0.05$) in villi area, treatment 5 had the largest villi area (7907.9 µm²), while treatment 4 had the smallest (6383.0 µm²). This supports the study by Elkomy *et al.* (2022), who found that the inclusion of onion skin extract did not significantly influence villi area in broilers but noted that higher villi area correlated with better nutrient absorption when other prebiotics were used.

Crypt depth showed no significant differences between treatments, with treatment 4 having the greatest depth (26.6 µm) and treatment 1 the smallest (20.4 µm). Similar findings were reported by **Mohamed *et***

***al.* (2019)**, who showed that dietary onion additives did not alter crypt depth significantly but enhanced gut health over time. This suggests that onion skin waste may not affect intestinal morphology directly, but could contribute to overall gut health improvements.

Both crypt width and crypt area exhibited no significant differences ($p<0.05$) among treatments. Treatment 4 had the largest crypt area (417.8 μm^2) and treatment 1 the smallest (311.8 μm^2), with no significant differences observed in crypt width. These results align with studies by **Ahsan *et al.* (2020),** who reported that dietary onion by-products did not significantly affect crypt morphology in broilers, but improved the balance of gut microbiota, leading to enhanced digestion.

The lack of significant differences in the villi and crypt histology parameters suggests that dietary onion skin waste does not drastically alter intestinal morphology. Güler *et al.* (2021) found similar outcomes when they incorporated onion skin into the diet of broilers, noting that the benefits of onion skin waste were more related to its antioxidant properties and gut microbiota modulation rather than direct changes in gut architecture. Moreover, Qureshi *et al.* (2021) also highlighted that onion waste products, rich in flavonoids and antioxidants, promote gut health through indirect pathways, such as enhancing immune response and preventing oxidative stress, without causing notable structural changes to the intestinal lining.

The slight, non-significant variations observed in the present study may be attributed to the concentration and bioavailability of the active compounds in onion skin, such as quercetin. Alonso-Pinero *et al.* (2018) suggested that the bioactive components of onion skin might have a dose-dependent effect on intestinal histology, which could explain why the higher concentration in treatment 5 showed slightly improved villi and crypt characteristics. Nonetheless, most of the evidence supports the conclusion that onion skin waste improves gut health through functional and microbiological improvements, rather than direct changes in intestinal structure.

Carcass Characteristics

Dietary onion waste significantly influenced carcass traits. The highest live weight was recorded at 5.0 g inclusion, with a decline at 10.0 g, mirroring growth performance trends. Bled and defeathered weights improved with onion peel supplementation, peaking at 7.5 g and 5.0 g respectively, indicating better processing yields. Dressing percentage was significantly higher in all supplemented groups except the 10.0 g group, which showed a marked decrease. The improved dressing percentages at moderate inclusion levels may be attributed to enhanced nutrient utilization and metabolic efficiency induced by bioactive compounds such as flavonoids and saponins (Khan *et al.,* 2018). The drop at 10.0 g could be linked to reduced growth performance and possible anti-nutritional effects at higher doses. Similar improvements in carcass yield with phytogenic additives have been documented in broilers (Alagawany *et al.,* 2018; Lee *et al.,* 2017).

Organ and Body Part Percentages

Onion peel inclusion affected several organ and body part proportions. The significant decrease in head percentage at 10.0 g may reflect overall reduced growth or altered body composition. Shank, thigh, and drumstick weights increased notably at 7.5 g, suggesting enhanced muscle development in these parts. Breast meat percentage remained stable at lower inclusion levels but dropped sharply at 10.0 g, consistent with reduced overall growth. The increase in abdominal fat at 7.5 g indicates possible shifts in energy metabolism or fat deposition patterns, a phenomenon previously observed with certain phytogenic additives (Khan *et al.,* 2018). Heart and liver weights increased with higher onion peel levels, which may reflect enhanced metabolic activity or detoxification processes stimulated by onion bioactives (Alagawany *et al.,* 2018). The variation in spleen, gall bladder, and gizzard weights was minor, though

the decrease in gizzard weight at intermediate levels may relate to altered digestive dynamics. Increased intestinal weight and length at higher inclusion levels could indicate adaptive responses to dietary fiber or phytochemicals, potentially enhancing nutrient absorption (Awad *et al.*, 2009).

Hematological Parameters

Onion peel supplementation had no significant effect on hematological indices, including white blood cell counts, neutrophils, lymphocytes, red blood cells, hemoglobin, hematocrit, and red blood cell indices (MCV, MCH, MCHC). The stability of these parameters suggests that onion peel inclusion does not induce hematotoxicity or immunosuppression, supporting its safety (Alagawany *et al.*, 2018). Although some numerical variations were noted, they were within physiological ranges and not statistically significant, consistent with other studies where phytogenic feed additives did not adversely affect blood profiles (Lee *et al.*, 2017).Biochemical Parameters (Table 9)

Significant effects of onion peel inclusion were observed on serum albumin, total protein, and globulin levels. Albumin and total protein peaked at the highest inclusion level (10.0 g), indicating enhanced protein metabolism or improved liver function. Globulin levels showed minor but significant variation, which may reflect modulation of immune-related proteins, as globulins include immunoglobulins (Khan *et al.*, 2018). The lack of significant changes in liver enzymes—alkaline phosphatase, aspartate transaminase (AST), and alanine transaminase (ALT)—suggests no hepatocellular damage, corroborating the safety of onion peel as a dietary additive. These findings align with previous reports that antioxidant-rich onion compounds can support liver health and protein metabolism without causing toxicity (Alagawany *et al.*, 2018; Sharma *et al.*, 2019).

Overall, the results indicate that onion skin waste can be included in broiler diets at moderate levels (2.5–7.5 g per 25 kg feed) without adverse effects on intestinal morphology, hematology, or liver function, while improving carcass traits and protein metabolism. The lack of significant histological and hematological changes supports the safety of onion peel supplementation. Improvements in carcass yield and organ development suggest enhanced nutrient utilization and metabolic benefits, likely mediated by the bioactive phytochemicals identified in the peel (flavonoids, saponins, alkaloids).

However, the decline in growth performance and breast meat percentage at the highest inclusion level (10.0 g) indicates that excessive onion peel may exert anti-nutritional effects or reduce feed palatability, consistent with previous findings (Lee *et al.*, 2017; Sharma *et al.*, 2019). The increase in abdominal fat at 7.5 g suggests a need to balance inclusion rates to optimize lean tissue deposition.

Conclusion

Onion peel waste is a valuable source of bioactive compounds that, when included at moderate levels (2.5–5.0 g per 25 kg feed), can enhance growth performance and nutrient digestibility in broiler chickens without adversely affecting diet composition. Higher inclusion levels may reduce growth but improve feed efficiency, indicating a trade-off that requires careful optimization. Also this study demonstrates that onion skin waste is a promising functional feed additive for broiler chickens, capable of enhancing carcass characteristics and protein metabolism without compromising gut health or hematological status at appropriate inclusion levels. Future research should focus on elucidating the mechanisms underlying metabolic modulation and determining the optimal inclusion rate to maximize growth and meat quality benefits. These findings support the potential of onion peel as a sustainable feed additive that adds value to agro-industrial waste while promoting poultry health and productivity.

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