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The Effect of Onion Skin Meal on Ileum Histology in Broiler Chickens

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ABSTRACT

For many years, plant-based feed additives have served as alternatives to antibiotics, improving feed efficiency and ensuring livestock safety. The present study aimed to investigate the effects of garlic skin, shallot skin, and onion skin on the ileum in broiler chickens. A total of 189 broiler chickens were used in the present study and randomly assigned to nine treatment groups with three replicates, each consisting of seven chickens. The chickens were fed a basal diet supplemented with no onion skin (T0), 0.1% bacitracin (T1), 0.5% garlic skin (T2), 0.5% shallot skin (T3), 0.5% onion skin (T4), a basal diet supplemented with 0.25% garlic and 0.25% shallot skins (T5), a basal diet supplemented with 0.25% garlic and 0.25% onion skins (T6), a basal diet supplemented with 0.25% shallot and 0.25% onion skins (T7), and a basal diet supplemented with 0.167% garlic, shallot, and onion skins each (T8) for 35 days. The current results indicated that adding garlic skin meal, shallot skin meal, and onion skin meal did not affect ileal histology, villi number, villi length, villi width, villi surface area, and crypt depth in broiler chickens. The absence of adverse histological alterations indicated that onion skin meal is safe for utilization as a feed additive.

Keywords: Broiler chicken, Garlic skin, Ileum, Onion skin, Shallot skin

INTRODUCTION

The use of antibiotics as feed additives in broiler nutrition has caused several adverse effects, including drug residues in livestock products and the development of bacterial resistance, which may pose significant human health risks (Mehdi et al., 2018). Several countries have banned antibiotics in livestock feed because of concerns about drug residues and antimicrobial resistance (Castanon, 2007). Since January 1, 2006, the European Union has formally prohibited antibiotic use in livestock feed under Regulation No. 1831/2003 (Castanon, 2007). A similar policy was implemented in Indonesia through Minister of Agriculture Regulation No. 14/2017, which banned the use of antibiotics as feed additives since January 2018 (Azizah et al., 2024). Following the prohibition on using antibiotics as feed additives in livestock production, numerous alternatives, including probiotics, prebiotics, phytobiotics, and organic acids, have been explored (El-Hack et al., 2022; Anyigor et al., 2026).

One promising alternative is phytobiotics: plant-derived feed additives containing bioactive compounds with diverse biological effects, such as antioxidant, antibacterial, anti-inflammatory, antiviral, antifungal, and immunomodulatory activities (Ivanova et al., 2024). The plant-based feed additives are known to increase productivity, improve feed utilization efficiency, and enhance gut morphofunctional properties (Selionova et al., 2025). Garlic skin, shallot skin, and onion skin are different types of phytobiotic feed additives (Kothari et al., 2019). Garlic skin possesses flavonoids, tannins, phenolics, and anthocyanins (Dos Santos et al., 2022). Shallot skin has phenolic and flavonoid compounds (Moldovan et al., 2024). Onion skin is a food waste that can cause environmental pollution when not properly managed. Onion skin contains bioactive compounds beneficial for poultry health, including flavonoids,

phenolics, anthocyanins, tannins, saponins, phenols, and quercetin (Benitez et al., 2011; Shabir et al., 2022). Bioactive compounds in onion skins have antibacterial, antioxidant, and immunomodulatory properties (Adeyemi et al., 2021) that may enhance gut health and improve poultry productivity (Obianwuna et al., 2024). The antibacterial properties of onion skins can inhibit the growth of pathogenic bacteria in the gut (Kumar et al., 2022). Reducing the pathogenic bacterial population may help maintain intestinal health, thereby supporting optimal gut function. This mechanism can improve villus morphology, which plays an important role in nutrient absorption (Heak et al., 2017). No scientific reports have addressed the impacts of dietary onion skin on poultry intestines. Therefore, the present study aimed to investigate the effects of garlic skin, shallot skin, and onion skin meals on the histological structure of the ileum in broiler chickens.

MATERIALS AND METHODS

Ethical approval

The Animal Care and Use Committee of the University of Brawijaya, Malang, Indonesia, approved all procedures performed in the present study.

Study design

A total of 189 unsexed Lohmann MB 202 broiler chickens with an average body weight of 44.78 g/chicken were randomly divided into nine treatment groups with three replicates, and each replicate consisted of seven chickens. The first group received only the basal feed without any feed additives (T0), and the second group received the basal feed supplemented with 0.1% bacitracin (T1; Widodo et.al., 2022). The third, fourth, and fifth groups received the basal feed supplemented with 0.5% garlic skin (T2), 0.5% shallot skin (T3), and 0.5% onion skin (T4), respectively. The sixth group was fed the basal feed supplemented with 0.25% each of garlic skin and shallot skin (T5), the seventh group received the basal feed supplemented with 0.25% each of garlic skin and onion skin (T6), and the eighth group received the basal feed supplemented with 0.25% each of shallot skin and onion skin (T7). The last group received the basal feed supplemented with 0.167% each of garlic, shallot, and onion skins (T8). Before the chickens arrived, the pens were cleaned and disinfected. The chickens were raised for 35 days in 27 floor pens measuring 100 × 100 × 80 cm, which were lined with rice husks. The ambient temperature was maintained at approximately 32°C during the first three days and gradually reduced to 23°C by the end of the rearing period, while relative humidity was maintained between 50 and 70% (EFSA AHAW Panel et al., 2023). The chickens were fed a basal feed manufactured by PT New Hope, Indonesia, using a mash-form starter feed from 1 to 21 days of age and a crumble-form finisher feed from 22 to 35 days of age, including soybean meal, corn, fish meal, meat and bone meal, corn gluten, palm kernel meal, oil, and calcium phosphate (Table 1). Drinking water was provided *ad libitum*. Chickens were vaccinated with Newcastle disease and infectious bronchitis vaccines (PT Vaksindo Satwa Nusantara, Indonesia) at 1 day of age via eye drops. The Gumboro vaccine (PT Medion Ardhika Bhakti, Indonesia) was administered at 10 days of age via drinking water. Each vaccine was administered once during the rearing period. There were no mortality rates in the present study.

Table 1. Nutrient content of the basal feed for broiler chickens at starter and finisher phases

Nutrient content	Starter (1-21 days)	Finisher (22-35 days)
Water content (%)	Max 14	Max 14
Crude protein (%)	Min 22	Min 20
Crude fat (%)	Min 5	Min 5
Crude fiber (%)	Max 5	Max 5
Ash (%)	Max 8	Max 8
Calcium (%)	0.8-1.1	0.8-1.1
Total phosphorus (with phytase enzyme, %)	Min 0.5	Min 0.5
Total aflatoxin (µg/kg)	Max 50	Max 50
Lysine (%)	Min 1.2	Min 1.2
Methionine (%)	Min 0.45	Min 0.45
Methionine + cystine (%)	Min 0.8	Min 0.8
Tryptophan (%)	Min 0.19	Min 0.19
Threonine (%)	Min 0.75	Min 0.75

Source: PT New Hope East Java, Max: Maximum, Min: Minimum.

Onion skin meal

Garlic skins, shallot skins, and onion skins were obtained from traditional markets in Malang City, Indonesia, and collected on the same day. A total of 1.2 kg of garlic skins, 3 kg of shallot skins, and 1.8 kg of onion skins were collected in dry and intact condition. The skins were washed with clean water, then oven-dried at 50°C for 24 hours. After the drying process, the skins were ground into a 100-mesh meal. The resulting meals were stored in airtight glass jars and kept in a dry place away from direct sunlight. The meals were then added to the basal feed according to treatment doses.

Ileum histology

Ileum samples were obtained at 35 days of age by slaughtering one chicken from each experimental unit, resulting in a total of 27 chickens. The chickens were slaughtered with a sharp knife by cutting the neck to sever the carotid arteries, jugular veins, trachea, and esophagus (Salwani et al., 2016). The small intestine was then removed. Samples were taken by cutting the ileum of the small intestine along 1 cm, then cleaned with distilled water and fixed in 10% neutral buffered formalin. Histological examination was performed by cutting the ileum into 4 µm sections using a microtome, then mounting them on slides for staining with Harris Hematoxylin and Eosin (Tejeda and Kim, 2021). Examinations were performed using a light microscope (Nikon, Japan) equipped with an Optilab camera connected to a computer, and analyzed using Image Raster software (version 4.0.5). The number of villi (per transverse cut**)**, villi length, villi width, and crypt depth were measured. In addition, the villi surface area was calculated using Formula 1 (Iji et al., 2001).

Villi surface area = (b + c) / c × a (Formula 1)

where a is the villi length, b is the basal width of villi, and c is the apical width of villi.

Statistical analysis

One-way analysis of variance (ANOVA) was used to analyze the data with SPSS software version 27. Significant differences between mean values were tested using Duncan's Multiple-Range Test (DMRT), with the significance level set at P value less than 0.05.

RESULTS AND DISCUSSION

Histological examination of the ileum demonstrated that adding garlic, shallot, and onion skin meal to the feed did not produce statistically significant changes in the measured parameters across all treatment groups ($p > 0.05$; Table 2). Histological findings of the ileum sampled from broiler chickens across different treatment groups are illustratedin Figure 1.

Table 2. Effects of onion skin meal on ileum histology in 35-day-old broiler chickens

Treatment	Villi amount (per transverse cut)	Villi length (µm)	Villi width (µm)	Villi surface area (µm^2)	Crypt depth (µm)
T0	4.80	377.20	41.83	1,054.60	110.70
T1	5.73	374.43	46.78	1,248.10	78.40
T2	7.33	399.87	34.90	1,119.27	100.17
T3	5.27	376.07	37.33	1,135.93	95.20
T4	4.80	336.20	40.60	862.30	81.30
T5	5.53	333.90	37.67	931.23	76.37
T6	5.00	338.43	42.05	893.37	83.47
T7	6.60	445.27	31.70	1,330.13	84.57
T8	5.13	353.43	37.13	961.57	86.83
SEM	0.28	9.42	1.45	53.44	3.38

T0: Basal feed (control), T1: Basal feed + 0.1% bacitracin, T2: Basal feed + 0.5% garlic skin, T3: Basal feed + 0.5% shallot skin, T4: Basal feed + 0.5% onion skin, T5: Basal feed + 0.25% each of garlic skin and shallot skin, T6: Basal feed + 0.25% each of garlic skin and onion skin, T7: Basal feed + 0.25% each of shallot skin and onion skin, T8: Basal feed + 0.167% each of garlic, shallot, and onion skins. SEM: Standard error of the mean

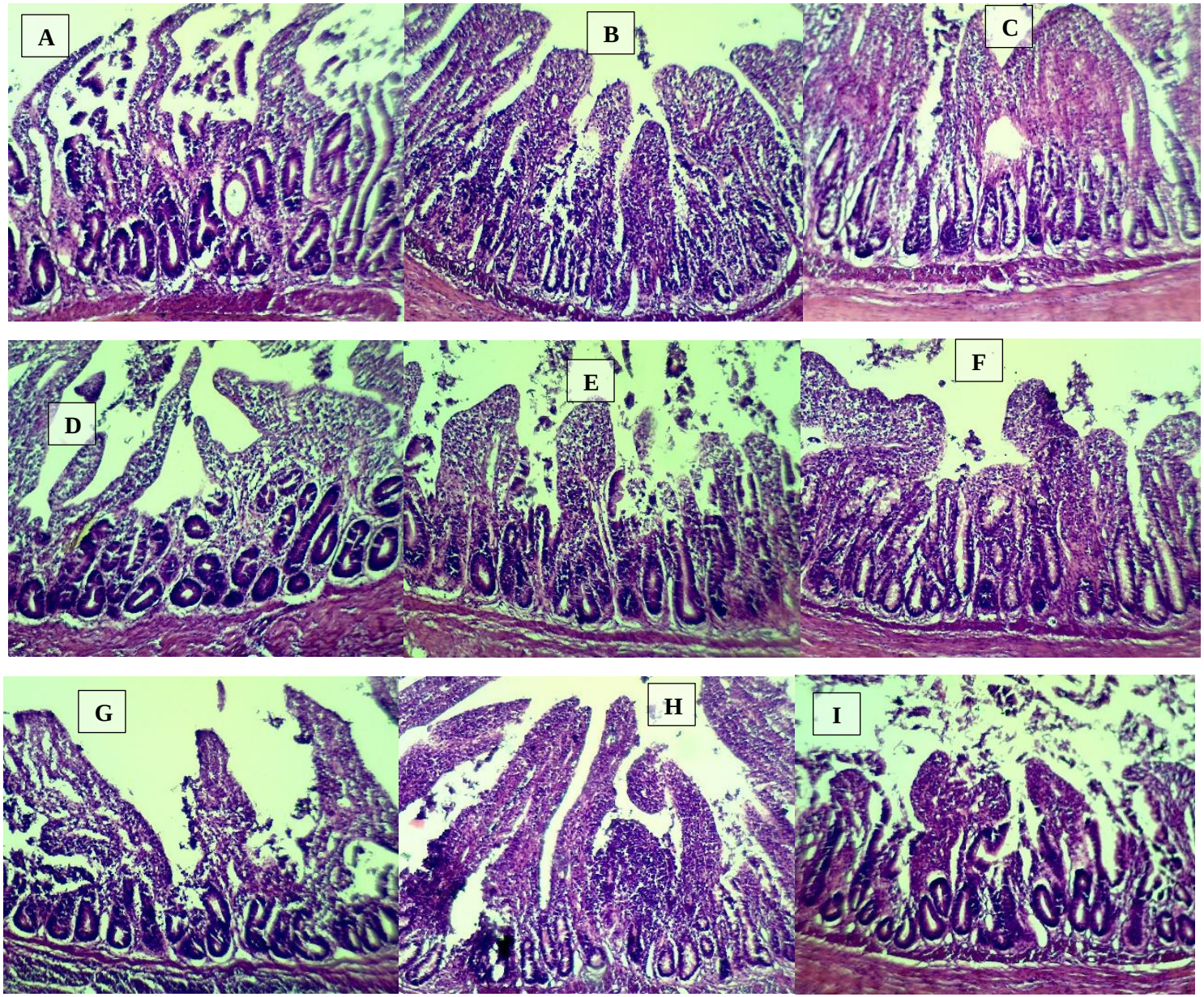

Figure 1. Ileal histology of 35-day-old broiler chickens fed diets supplemented with garlic, shallot, and onion skin meals. **A:** Without onion skin (T0), **B:** 0.1% bacitracin (T1), **C:** 0.5% garlic skin (T2), **D:** 0.5% shallot skin (T3), **E:** 0.5% onion skin (T4), **F:** 0.25% each of garlic skin and shallot skin (T5), **G:** 0.25% each of garlic skin and onion skin (T6), **H:** 0.25% each of shallot skin and onion skin (T7), **I:** 0.167% each of garlic skin, shallot skin, and onion skin (T8)**.**

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Garlic skins, shallot skins, and onion skins are agricultural byproducts rich in bioactive compounds and can be used as natural feed additives to support the digestive health of broiler chickens (Dulia et al., 2026). Onion skins contain different bioactive compounds, including flavonoids, alkaloids, terpenoids, tannins, saponins, phenols, anthocyanins, and quercetin, which have been reported to possess antibacterial activity (Shabir et al., 2022). However, the level of onion skins used in the current study was not sufficient to produce significant changes in the ileum of broiler chickens. The absence of significant effects in the present study was likely due to the low level of onion skin meal added. Mozin et al. (2015) reported that adding shallot by-products at levels ranging from 0.5% to 2% had no remarkable effects on small intestinal characteristics in broiler chickens, including villi height and crypt depth. These findings indicated that these levels of bioactive compounds were insufficient to optimally stimulate intestinal villi development.

Intestinal morphology is related to the intestine's capacity to absorb nutrients (Awad et al., 2009). Longer, wider villi provide a larger surface area for nutrient absorption, making the process more efficient (Prakatur et al., 2019). Feed additives can support intestinal development and optimize nutrient absorption (Oni and Oke, 2025). One method for assessing the effects of feed additives on the digestive tract involves histological examination of intestinal morphology (Alsafy et al., 2024). The current results demonstrated that the onion skin meal had no notable effects on the ileum in broiler chickens, indicating that the bioactive compounds in onion skin meal could not enhance villi growth, so the surface area for nutrient absorption did not increase notably (Hossain and Amin, 2026). Onion skins contain bioactive compounds with antibacterial properties, such as flavonoids and phenols (Albandary, 2023). Flavonoids act as antibacterial agents by targeting key bacterial processes such as nucleic acid replication, membrane functionality, and energy production (Shamsudin et al., 2022). Moreover, flavonoids may also reduce adhesion and biofilm formation, porin expression on cell membranes, membrane permeability, and pathogenicity, all of which are critical mechanisms for bacterial growth (Shamsudin et al., 2022). Furthermore, phenol demonstrates its antibacterial efficacy by disrupting cell membranes (Dembinska et al., 2025). Specifically, phenolic compounds interact with the lipid layer, increasing membrane permeability and triggering leakage of intracellular components, eventually resulting in cell lysis (Dembinska et al., 2025). Such bioactive compounds can suppress the population of pathogenic bacteria in the digestive tract and create a healthier gut environment (Gilani et al., 2021).

According to Li et al. (2024), lactic acid bacteria such as *Lactobacillus* sp. and *Enterococcus* sp. are beneficial microorganisms found in the chicken gut, whereas pathogenic bacteria such as *Escherichia coli* and *Salmonella* sp. can disrupt gut health. Active compounds in onion skins can modulate the composition of the gut microbiota by promoting the growth of beneficial bacteria while suppressing pathogenic bacteria (Adeyemi et al., 2021). However, when onion skins were included in the diet at low levels, the resulting antibacterial activity did not demonstrate sufficient potency to influence the composition of the gut microbiota and, ultimately, the villi morphology.

CONCLUSION

The addition of garlic skin, shallot skin, and onion skin meal did not negatively affect ileal histology in broiler chickens. However, the inclusion levels used in the present study were too low to induce significant histological changes. Therefore, further studies at higher levels of garlic, shallot, and onion skin meal are recommended to achieve significant histological improvements.

DECLARATIONS

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Authors' contributions

Salsabila Fyrda Maharani conducted the research and wrote the manuscript. Edhy Sudjarwo contributed to designing the study and proofreading the manuscript. Osfar Sjofjan participated in designing the study, proofreading the manuscript, and analyzing the data for publication. All authors approved the final edition of the manuscript prior to publication in the present journal.

Availability of data and materials

The data and materials are available from the corresponding author upon reasonable request.

Competing interests

The authors declare no competing interests.

Ethical considerations

All authors have affirmed that this study is free of plagiarism, misconduct, data fabrication and/or

falsification, duplicate publication and submission, and redundancy, and have provided their consent for publication. The authors declare that they did not use any artificial intelligence tools for the composition and preparation of this study. Additionally, the authors state that they are responsible for the accuracy, originality, and integrity of the final content before submission, during the revision process, and upon final publication of the article.

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REFERENCES

Adeyemi KD, Oseni AI, and Asogwa TN (2021). Onionskin waste versus synthetic additives in broiler diet: Influence on production indices, oxidative status, caecal bacteria, immune indices, blood chemistry, and meat quality. Italian Journal of Animal Science, 20(1): 587-599. DOI: https://www.doi.org/10.1080/1828051X.2021.1892545

Albandary NA (2023). Phenolic compounds content, antioxidant, antibacterial and antifungal activities of red onions skin. Iraqi Journal of Agricultural Sciences, 54(4): 1050-1057. DOI: https://www.doi.org/10.36103/ijas.v54i4.1794

Alsafy MAM, Abdellatif IA, EL-Gendy SAA, Abumandour MMA, Noreldin A, and Bassuoni NF (2024). Analyzing the morphology and *avian β-defensins* genes (*AvβD*) expression in the small intestine of Cobb500 broiler chicks fed with sodium butyrate. BMC Veterinary Research, 20: 1-13. DOI: https://www.doi.org/10.1186/s12917-024-04253-y

Anyigor EA, Jecinta EO, Ogbuewu IP, and Etuk EB (2026). Nutritional intervention: Impacts on gut microbiome, health, and productivity of laying hens. Journal of World's Poultry Science, 5(1): 9-16. DOI: https://www.doi.org/10.58803/jwps.v5i1.116

Awad WA, Ghareeb K, Abdel-Raheem S, and Bohm J (2009). Effects of dietary inclusion of probiotic and synbiotic on growth performance, organ weights, and intestinal histomorphology of broiler chickens. Poultry Science, 88(1): 49-56. DOI: https://www.doi.org/10.3382/ps.2008-00244

Azizah FL, Sjofjan O, and Widodo E (2024). Assessing the impact of black soldier fly oil (*Hermetia illucens*) from various phases as feed additive on the growth performance and histomorphology of broiler chickens. Advances in Animal and Veterinary Sciences, 12(3): 509-514. DOI: https://www.doi.org/10.17582/journal.aavs/2024/12.3.509.514

Benitez V, Molla E, Cabrejas MAM, Aguilera Y, Andreu FJL, Cools K, Terry LA, and Esteban RM (2011). Characterization of industrial onion wastes (*Allium cepa* L.): Dietary fibre and bioactive compounds. Plant Foods for Human Nutrition, 66(1): 48-55. DOI: https://www.doi.org/10.1007/s11130-011-0212-x

Castanon JIR (2007). History of the use of antibiotic as growth promoters in European poultry feeds. Poultry Science, 86(11): 2466-2471. DOI: https://www.doi.org/10.3382/ps.2007-00249

Dembinska K, Shinde AH, Pejchalova M, Richert A, and Brzezinska MS (2025). The application of natural phenolic substances as antimicrobial agents in agriculture and food industry. Foods, 14(11): 1-21. DOI: https://www.doi.org/10.3390/foods14111893

Dos Santos PCM, Da Silva LMR, Magalhaes FEA, Cunha FET, Ferreira MJG, and De Figueiredo (2022). Garlic (*Allium sativum L.*) peel extracts: From industrial by-product to food additive. Applied Food Research, 2(2): 1-7. DOI: https://www.doi.org/10.1016/j.afres.2022.100186

Dulia DAP, Sudjarwo E, and Sjofjan O (2026). Effect of dietary onion peel powder (*Allium cepa* L.) as a feed additive on production performance in broiler. Journal of Animal Science Padjadjaran University, 26(2): 142-146. DOI: https://www.doi.org/10.24198/jit.v26i2.1447

EFSA AHAW Panel, Nielsen SS, Alvarez J, Bicout DJ, Calistri P, Canali E, Drewe JA, Garin-Bastuji B, Gonzales Rojas JL, Schmidt CG et al. (2023). Scientific opinion on the welfare of broilers on farm. EFSA Journal, 21(2): 1-236. DOI: https://www.doi.org/10.2903/j.efsa.2023.7788

El-Hack MEA, El-Saadony MT, Salem HM, El-Tahan AM, Soliman MM, Youssef GBA, Taha AE, Soliman SM, Ahmed AE, El-kott AF et al. (2022). Alternatives to antibiotics for organic poultry production: Types, modes of action and impacts on bird's health and production. Poultry Science, 101(4): 101696. DOI: https://www.doi.org/10.1016/j.psj.2022.101696

Gilani SMH, Rashid Z, Galani S, Ilyas S, Sahar S, Hasan Z, Al-Ghanim K, Zehra S, Azhar A, Al-Misned F et al. (2021). Growth performance, intestinal histomorphology, gut microflora and ghrelin gene expression analysis of broiler by supplementing natural growth promoters: A nutrigenomics approach. Saudi Journal of Biological Sciences, 28(6): 3438-3447. DOI: https://www.doi.org/10.1016/j.sjbs.2021.03.008

Heak C, Sukon P, Kongpechr S, Tengjaroenkul B, and Chuachan K (2017). Effect of direct-fed microbals on intestinal villus height in broiler chickens: A systematic review and meta-analysis of controlled trials. International Journal of Poultry Science, 16(10): 403-414. DOI: https://www.doi.org/10.3923/ijps.2017.403.414

Hossain ME and Amin NB (2026). Proliferation dynamics of enterocytes: Implications for intestinal barrier function, performance, health, and welfare in broiler chickens. Poultry Science, 105(9): 107128. DOI: https://www.doi.org/10.1016/j.psj.2026.107128.

Iji PA, Hughes RJ, Choct M, and Tivey DR (2001). Intestinal structure and function of broiler chickens on wheatbased diets supplemented with a microbial enzyme. Animal Bioscience, 14(1): 54-60. DOI: http://www.doi.org/10.5713/ajas.2001.54

Ivanova S, Sukhikh S, Popov A, Shishko O, Nikonov I, Kapitonova E, Krol O, Larina V, Noskova S, and Babich O (2024). Medicinal plants: A source of phytobiotics for the feed additives. Journal of Agriculture and Food Research, 16: 101172. DOI: https://www.doi.org/10.1016/j.jafr.2024.101172

Kothari D, Lee WD, Niu KM, and Kim SK (2019). The genus *Allium* as poultry feed additive: A review. Animals, 9(12): 1-21. DOI: https://www.doi.org/10.3390/ani9121032

Kumar M, Barbhai MD, Hasan M, Punia S, Dhumal S, Radha, Rais N, Chandran D, Pandiselvam R, Kothakota A et al. (2022). Onion (*Allium cepa* L.) peels: A review on bioactive compounds and biomedical activities. Biomedicine & Pharmacotherapy, 146: 112498. DOI: https://www.doi.org/10.1016/j.biopha.2021.112498

Li X, Li W, Zhao L, Li Y, He W, Ding K, and Cao P (2024). Characterization and assessment of native lactic acid bacteria from broiler intestines for potential probiotic properties. Microorganisms, 12(4): 749. DOI: https://www.doi.org/10.3390/microorganisms12040749

Mehdi Y, Montminy MPL, Gaucher ML, Chorfi Y, Suresh G, Rouissi T, Brar SK, Cote C, Ramirez AA, and Godbout S (2018). Use of antibiotics in broiler production: Global impacts and alternatives. Animal Nutrition, 4(2): 170-178. DOI: https://www.doi.org/10.1016/j.aninu.2018.03.002

Moldovan C, Nicolescu A, Frumuzachi O, Rocchetti G, Lucini L, Mocan A, and Crisan G (2024). Ultrasound-assisted sustainable extraction of bioactive phytochemicals in shallot (*Allium ascalonicum* L.) peel: A DoE and metabolomics combined approach. Sustainable Chemistry and Pharmacy, 41: 101729. DOI: https://www.doi.org/10.1016/j.scp.2024.101729

Mozin S, Rosyidi D, and Sjofjan O (2015). The effect of shallot (*Allium ascalonicum* L.) by-product as an antibacterial and alternative phytobiotic on characteristics of small intestine of broiler.

Livestock Research for Rural Development, 27(4): 78. Available at: http://www.lrrd.org/lrrd27/4/mozi27078.htm

Obianwuna UE, Chang X, Okoleh VUO, Onu PN, Zhang H, Qiu K, and Wu S (2024). Phytobiotics in poultry: Revolutionizing broiler chicken nutrition with plant-derived gut health enhancers. Journal of Animal Science and Biotechnology, 15: 169. DOI: https://www.doi.org/10.1186/s40104-024-01101-9

Oni AI and Oke OE (2025). Gut health modulation through phytogenics in poultry: Mechanisms, benefits, and applications. Frontiers in Veterinary Science, 12: 1616734. DOI: https://www.doi.org/10.3389/fvets.2025.1616734

Prakatur I, Miskulin M, Pavic M, Marjanovic K, Blazicevic V, Miskulin I, and Domacinovic M (2019). Intestinal morphology in broiler chickens supplemented with propolis and bee pollen. Animals, 9(6): 301. DOI: https://www.doi.org/10.3390/ani9060301

Salwani MS, Adeyemi KD, Sarah SA, Vejayan J, Zulkifli I, and Sazili AQ (2016). Skeletal muscle proteome and meat quality of broiler chickens subjected to gas stunning prior slaughter or slaughtered without stunning. CyTA – Journal of Food, 14(3): 375-381. DOI: https://www.doi.org/10.1080/19476337.2015.1112838

Selionova MI, Trukhachev VI, Zagarin AY, Kulikov EI, and Belyaeva NP (2025). Effects of dietary supplementation using phytobiotics with different functional properties on expression of immunity genes, intestinal histology, growth, and meat productivity of broiler chickens. Veterinary Science, 12(4): 302. DOI: https://www.doi.org/10.3390/vetsci12040302

Shabir I, Pandey VK, Dar AH, Pandiselvam R, Manzoor S, Mir SA, Shams R, Dash KK, Fayaz U, Khan SA et al. (2022). Nutritional profile, phytochemical compounds, biological activities, and utilisation of onion peel for food applications: A review. Sustainability, 14(19): 1-15. DOI: https://www.doi.org/10.3390/su141911958

Shamsudin NF, Ahmed QU, Mahmood S, Shah SAA, Khatib A, Mukhtar S, Alsharif MA, Parveen H, and Zakaria ZA (2022). Antibacterial effects of flavonoids and their structure-activity relationship study: A comparative interpretation. Molecules, 27(4): 1-43. DOI: https://www.doi.org/10.3390/molecules27041149

Tejeda OJ and Kim WK (2021). Effects of fiber type, particle size, and inclusion level on the growth performance, digestive organ growth, intestinal morphology, intestinal viscosity, and gene expression of broilers. Poultry Science, 100(10): 101397. DOI: https://www.doi.org/10.1016/j.psj.2021.101397

Widodo E, Leke JR, Pangestu KT, Hidayatul A, Purnomo DR, and Farhan M (2022). Effect of addition level of *Pandanus amaryllifolius* Roxb. on broiler performances at starter period. E3S Web of Conferences, 335: 00033. DOI: https://www.doi.org/10.1051/e3sconf/202233500033

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