



Studies on Digestive Anatomy and Digestibility Influenced by Cassia Fistula Powder in *Gallus Domesticus*

Sarfraz Ali Depar¹, Sumayya Farman Chandio^{1,2}, Hina Ali Ahmed³, Muhammad Sumair Arain¹, Mussawar Hussain¹, Zainab Lanjar^{1,4}, Ambreen Leghari^{4*}, Muhammad Bilawal Arain^{1,2}

¹Sindh Agriculture University, Tandojam, Pakistan

²Livestock and Fisheries Department, Government of Sindh, Pakistan

³Department of Zoology, Sardar Bhaduar Khan Women's University, Balochistan, Pakistan.

⁴Shaheed Benazir Bhutto University of Veterinary and Animal Sciences, Sakrand, Pakistan

* **Correspondence:** drambreen.leghari@gmail.com

Citation | Depar. S. A, Chandio. S. F, Ahmed H. A, Arain. M. S, Hussain. M, Lanjar. Z, Leghari. A, Arain. M. B, "Studies on Digestive Anatomy and Digestibility Influenced by Cassia Fistula Powder in *Gallus Domesticus*", IJASD, Vol. 08, Issue. 01 pp 85-93, January 2026

Received | December 23, 2025 **Revised |** January 15, 2026 **Accepted |** January 18, 2026

Published | January 21, 2026.

The present study was conducted to evaluate the effects of Cassia fistula (CF) powder as a phytogenic feed additive on nutrient digestibility, intestinal morphology, and liver histology in broiler chickens, with particular emphasis on the starter phase. A total of 80 one-day-old broiler chicks were randomly allocated to six experimental groups under a completely randomized design. Group G1 (commercial diet) and G2 (basal diet) served as control groups. Groups G3 and G4 received basal diets supplemented with CF powder at 250 mg/kg during the starter and finisher phases, respectively, while groups G5 and G6 received commercial diets supplemented with CF powder at the same dose during the starter and finisher phases, respectively. Parameters evaluated included nutrient digestibility (crude protein, fat, and metabolizable energy), relative organ weights, intestinal histomorphology, and liver histology.

Dietary supplementation of CF powder, particularly in group G5, resulted in a significant ($p < 0.05$) improvement in crude protein, fat, and metabolizable energy utilization compared to control and other treated groups. Relative weights of digestive organs (proventriculus, liver, and gizzard) did not differ significantly ($p > 0.05$) among groups, indicating the absence of adverse effects. Intestinal histomorphology revealed a significant ($p < 0.05$) increase in villus height in CF-supplemented groups, suggesting enhanced absorptive capacity. Liver histological examination showed normal hepatic architecture across all treatment groups, with no evidence of pathological alterations, supporting the safety of CF supplementation at the tested dose.

In conclusion, dietary inclusion of Cassia fistula powder at 250 mg/kg, particularly when supplemented during the starter phase with a commercial diet, improved nutrient utilization and intestinal morphology without inducing hepatic toxicity. These findings suggest that Cassia fistula has potential as a natural, safe phytogenic feed additive to improve digestive efficiency in broiler production, although further studies incorporating biochemical and dose-response evaluations are warranted.

Keywords: Cassia Fistula, Digestive Anatomy, Digestibility, *Gallus Domesticus*.

Introduction:

Cassia fistula, a member of the Fabaceae family, is an ornamental plant commonly known as the golden raintree. It originates from Southeast Asia and is widely cultivated in tropical and subtropical regions, including southern Pakistan. The plant is rich in naturally

occurring bioactive compounds, predominantly secondary metabolites, which have been widely utilized in traditional medicine, nutraceuticals, and various commercial products [1]. Numerous studies have reported the therapeutic potential of *Cassia fistula* in the management of dermal disorders such as eczema, and its metabolites exhibit diverse biological activities, including antibacterial, antifungal, hepatoprotective, antioxidant, and muscle-relaxant properties [2].

Different parts of *Cassia fistula*, particularly the fruits, leaves, flowers, and pulp, have been traditionally used to treat diabetes, inflammation, fever, liver disorders, pulmonary congestion, gastrointestinal complaints, and eye diseases [3][4]. Additionally, the plant has demonstrated antibacterial activity against several Gram-positive and Gram-negative bacteria, including *Escherichia coli*, *Bacillus subtilis*, *Proteus vulgaris*, *Klebsiella aerogenes*, and *Pseudomonas aeruginosa* [5]. These findings highlight the broad pharmacological potential of *Cassia fistula*.

Despite extensive documentation of its medicinal and antioxidant properties in human and experimental models, there is a clear lack of scientific evidence regarding the use of *Cassia fistula* as a phyto-genic feed additive in poultry nutrition. Its effects on intestinal health, feed efficiency, gut development, and liver function in broilers remain insufficiently explored. This gap is especially important in the context of modern poultry production, where restrictions on antibiotic growth promoters have increased interest in safe, plant-based alternatives.

Herbs and medicinal plants are known to contain biologically active compounds that enhance nutrient digestion, improve gut health, and increase nutrient availability. *Cassia fistula* contains appreciable levels of amino acids, crude protein, and essential minerals, comparable to those found in other legumes and oilseeds [6], suggesting its potential suitability as a feed ingredient. Early nutrition plays a critical role in broiler performance, particularly during the starter phase, when the digestive system of newly hatched chicks is still immature, and nutrient digestibility is limited [7]. During this period, highly digestible feed ingredients are required to support optimal intestinal development and growth.

The intestinal microbial population also plays a crucial role in broiler health and productivity. Beneficial microorganisms, such as lactic acid bacteria, contribute to intestinal integrity and inhibit pathogenic colonization [8]. Plant-derived bioactive compounds may favorably modulate gut microflora, thereby enhancing intestinal health and feed efficiency. Moreover, the liver, as an accessory organ of the gastrointestinal tract, is essential for metabolism, detoxification, and nutrient utilization. Oxidative stress and free radical production can impair liver function, negatively affecting growth performance and feed efficiency in broilers [9][10].

Previous studies have demonstrated the hepatoprotective effects of *Cassia fistula*, attributed to its high levels of polyphenols and flavonoids. Extracts from its seeds and pulp have been shown to reduce serum levels of liver enzymes, including SGOT, SGPT, SALP, and bilirubin, indicating improved liver function [11][12]. However, these hepatoprotective effects have not been adequately investigated in broilers under nutritional and production conditions.

Furthermore, *Cassia fistula* has been reported to possess purgative, antihelminthic, and gastrointestinal regulatory properties, which may aid in preventing intestinal disorders, improving waste expulsion, and enhancing nutrient absorption in young chicks [13][14][15][16][17][18]. Such properties may be particularly beneficial during the early post-hatch period, when intestinal development and nutrient utilization are critical for long-term growth performance.

Therefore, the present study was designed to address this research gap by evaluating the effects of dietary supplementation of *Cassia fistula* powder on intestinal health, feed efficiency, and hepatoprotective activity in broilers, with particular emphasis on the starter

phase. This study aims to provide scientific evidence supporting the potential use of Cassia fistula as a natural, safe, and functional phytogetic feed additive in poultry production systems.

Materials and Methods:

Location of the Experiment:

The experimental trial was conducted at the Poultry Research Station of Sindh Agriculture University, Tandojam, Sindh.

Experimental Birds and Management:

From the commercial hatchery, one-day-old broiler (n=80) chicks were purchased. Housing management and vaccination protocols were followed. Cassia fistula powder was purchased from an herbal medicine store in Hyderabad.

Birds were distributed into six groups with three replicates; each replicate had 10 chicks. However, groups G1 and G2 were fed with commercial and basal diet, respectively, and considered as control groups. Group G3 (starter phase) and group G4 (finisher phase) were both supplemented with Cassia fistula powder at a dose of 250 mg/kg in the basal diet, respectively. Group G5 (starter phase) and group G6 (finisher phase) were supplemented with Cassia fistula powder at a dose of 250 mg/kg in the commercial diet. Moreover, the fresh water was provided ad libitum, and the feeding program consisted of a two-phase starter diet (0-21 days) and a finisher diet (22-42 days).

Parameters to be studied:

The parameters studied were digestibility, hepatoprotective effect (liver histology), and intestinal morphology in commercial broilers.

Digestibility:

The feces of birds from each group were collected, dried, weighed, and later milled to pass through a 1.0 mm sieve, and proximate analysis (crude protein) was performed by the method of the Association of Official Analytical Chemists [19].

Determination of crude protein (%):

A one-gram fecal sample and a five-gram digestion mixture containing potassium sulfate, copper sulfate, and ferrous sulfate was added to a digestion flask along with 30 mL of hydrochloric acid. Samples were shaken and mixed well in a digestion flask, then heated for 3 hours until a light green color appeared. Then, they were kept at room temperature for 30 minutes to cool the digestion samples. The sample was diluted in distilled water. 10 mL NaOH (40%) and 10 mL diluted sample were placed in the Kjeldahl apparatus for distillation, and the ammonia was trapped in 10 mL boric acid (2%) in a beaker at the other end. The volume was made up to 50 mL in the beaker. Finally, H₂SO₄ was used for titration to capture ammonia until a yellowish color changed to light pink, and crude protein percentage was calculated.

Nitrogen (%)	$\frac{1.4 (V1-V2) \times \text{Normality of HCl} \times 100}{250}$
=	wt. of sample

Protein (%) = N% x conversion factor (6.25)

Determination of ether extract (%):

Ether extraction was performed using a Soxhlet extraction unit as described by [19]. Briefly, the apparatus, condenser, and distillation flask were dried. Two grams of dried sample were taken into a fat-free extraction thimble and placed in the extraction apparatus, and 250 mL of diethyl ether was added as the solvent for 5-6 hours at 55–60°C in the Soxhlet apparatus. The condenser was attached, and the apparatus was placed on an electric heater with running water through the condenser. Extraction was carried out for 6 hours. The sample was removed and the diethyl ether was allowed to evaporate., The extracted fat was dried and then weighed.

W2 – W1

Fat (%) = x 100

W3

Where,

W1 = weight of empty distillation flask

W2 = weight of distillation flask + fat

W3 = weight of sample taken

Weight of non-edible and edible organs:

At the end of the experiment, three birds from each group were slaughtered, and the following organs were removed: gizzard, proventriculus, and liver with the help of scissors and a scalpel, and then weighed using an electronic weighing machine.

Intestinal histology:

After slaughtering, the bird’s entire intestinal tract was removed for histological examination, and approximately 1.5–2 cm segments of the jejunum were collected. The segments were fixed in 10% neutral buffered formaldehyde for 48 hours, then processed for dehydration with 75% ethanol for one hour and clearing with pure xylene for 30 minutes, and then embedded in paraffin wax. Histological examination was performed on 4 μm-thick transverse sections mounted on slides and stained with hematoxylin and eosin (H&E).

Liver histology:

The liver tissue was dewaxed, rehydrated, dipped in Hematoxylin, differentiated, washed, blued, dehydrated, and stained with Eosin Y. Different quantities and qualities of H&E were used.

Statistical analysis:

The final data were tabulated in Microsoft Excel, and then analyzed using one-way analysis of variance (ANOVA) at a significance level of P = 0.05 using the SPSS 8.1 statistical package.

Results:

Crude protein, fat, metabolizable energy (%):

Table 2 shows the mean crude protein (%) values for birds in different groups supplemented with *Cassia fistula*.; the highest values were observed in group G5 compared to G2, G3, G4, and G6. The lowest crude protein value was observed in group G1. Significant (p < 0.05) variation in crude protein percentage was noticed between groups (G1, G5, and G6). While groups (G2, G3, and G4) were not significantly (p > 0.05) different from one another. Fat (%) in the birds recorded the highest values in group G5 than in G3, G4, and G1, respectively. The lowest fat values were observed in the G2 group. A significant (p < 0.05) variation in fat percentage was recorded between all groups. The highest metabolizable energy values were calculated in birds reared in group G5. than in G3, G6, G4, and G1, respectively. The lowest fat values were recorded in the G2 group. A significant (p < 0.05) variation in metabolizable energy was noticed between groups (G1, G2, G4, and G5). While groups (G3 and G6) were not significantly (p > 0.05) different from one another.

Table 1. Effects of *Cassia fistula* supplementation on nutrient retention in broiler chickens.

Nutrients	Group G1	Group G2	Group G3	Group G4	Group G5	Group G6	P-value
Crude protein (%)	56±0.02c	62±0.88ab	61±1.24ab	60±1.00ab	63±0.91a	59±1.58bc	0.0104
Fat (%)	40±1.64cd	38±4.95d	55±4.07ab	44±5.25bcd	59±2.60a	54±6.2abc	0.0254
Metabolized energy (%)	73±3.66bc	63±2.67c	83±4.30ab	78±5.44b	89±1.73a	82±2.60ab	0.0037

^{abcd} superscripts showed a significant difference at (p < 0.05)

Relative weight of organs in broiler chickens:

Table 3 presents the relative organ weights, including the proventriculus (%) of birds supplemented with *Cassia fistula* in different groups. The highest proventriculus weight was observed in birds reared in group G1., followed by G3, G2, and G4, respectively. The lowest

proventriculus weight was equally observed in groups G5 and G6. Statistically non-significant ($p > 0.05$) variation was observed among all groups. The highest relative weight of the gizzard was observed in group G1, followed by G2, G6, G3, and G5, respectively. The lowest value was noted in the G3 group. A significant ($p < 0.05$) variation was noticed between groups (G1, G2, G3, and G5). While groups (G4 and G6) were not significantly ($p > 0.05$) different from one another. The liver weight (%) of birds supplemented with *Cassia fistula* showed that the highest values were recorded in group G1. compared with groups G2, G3, G4, and G6. The lowest liver weight was observed in the G5 group. Significant variation was observed between groups (G1, G2, and G3), while groups G4 and G5 were not significantly different. Small intestinal villi (jejunum) of birds supplemented with *Cassia fistula* in different groups were examined. The highest villus heights were recorded in groups G5, G3, G4, G6, and G1, respectively. Additionally, the villus height was lowest in group G2. Significant ($p < 0.05$) variation was observed among all groups.

Table 2. Effects of *Cassia fistula* supplementation on the relative weight of organs in broiler chickens.

Relative organs	Group G1	Group G2	Group G3	Group G4	Group G5	Group G6	P-values
Proventriculus (%)	0.30±0.02 ns	0.29±4.7 6ns	0.29±6.59 ns	0.28±0.0 1ns	0.28±0.0 1ns	0.27±9.4 3ns	0.4411
Gizzard (%)	2.31±0.07a	2.20±0.0 6ab	1.98±0.06 bc	1.98±0.0 6bc	1.97±0.1 1c	2.11±0.0 1abc	0.0277
Liver (%)	2.20±0.06a	2.11±0.0 1ab	2.09±0.01 abc	2.07±0.0 2bc	1.98±0.0 6c	2.05±0.0 3bc	0.0429
Villi height (µm)	1198±50.8 0ab	1077±36 .09c	1110±45. 21bc	1095±15 .58bc	1280±28 .93a	1246±47 .03 a	0.0126

^{ns} = Nonsignificant

^{abcd} superscripts showed a significant difference at ($P < 0.05$)

Histomorphology of liver as influenced by *Cassia fistula* powder:

The photomicrograph shown in **Fig. 2** of chicken liver sections under 20× magnification treated with *Cassia fistula* did not show any abnormalities in any group. The hepatocytes were well organized and showed normal arrangement around the portal tract and central vein. Groups A and B showed photomicrographs with mild liver changes while maintaining normal hepatocyte architecture., but no other abnormalities were observed. Note G1=Group, G2=Group, G3=Group, G4=Group, G5=Group and G6=Group.

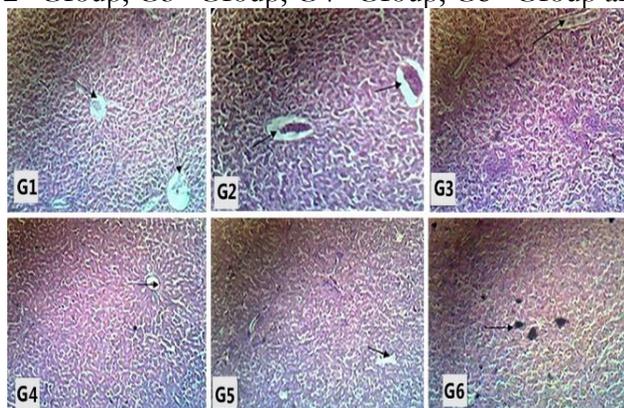


Figure 1. Histomorphology of liver as influenced by *Cassia fistula* powder

Intestinal morphology as influenced by *Cassia fistula* powder:

Fig. 2 shows the villus height measured from the tip of the villus to the base. The tissue section was examined at 20× magnification with a microcomputer-integrated digital imaging analysis system.

G1= Group, G2= Group, G3= Group, G4= Group, G5= Group and G6= Group

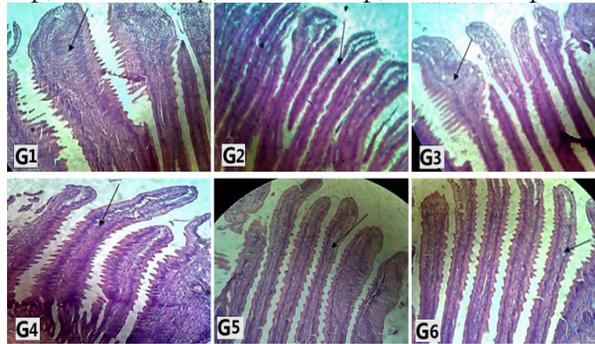


Figure 2. Histomorphology of the villi height of the small intestine, Cassia fistula powder
Discussion:

The present study demonstrates that dietary supplementation of Cassia fistula powder during the starter phase positively influenced growth performance, nutrient utilization, intestinal morphology, and liver health in broilers. Rather than simply reflecting numerical improvements, these effects can be explained through the biological and physiological properties of Cassia fistula and its bioactive constituents.

The enhanced weight gain observed in broilers fed Cassia fistula-supplemented diets may be attributed to the presence of phytochemicals, such as flavonoids, polyphenols, and metabolites already bioactive, which stimulate appetite, improve gut function, and enhance metabolic efficiency. Medicinal herbs are known to act as natural growth promoters by modulating digestive physiology and reducing metabolic stress, thereby improving nutrient assimilation and overall growth performance [20]. The appreciable levels of carbohydrates, proteins, lipids, and free amino acids present in *Cassia fistula* further support its role as a functional feed additive contributing to improved energy availability and protein deposition.

The improvement in crude protein, fat, and metabolizable energy utilization observed in the supplemented groups can be mechanistically linked to enhanced digestive enzyme activity and improved nutrient digestibility. Herbal feed additives have been reported to stimulate the secretion of endogenous digestive enzymes, enhance bile flow, and promote the breakdown of complex feed components, thereby increasing nutrient absorption [21]. Additionally, bioactive compounds in Cassia fistula may reduce intestinal inflammation and oxidative stress, thereby preserving intestinal epithelial integrity and facilitating more efficient nutrient transport across the gut epithelium.

The lack of adverse effects on liver and gizzard weights, along with normal histological architecture of the liver, indicates that Cassia fistula supplementation did not exert any toxic or hypertrophic effects on vital organs. This finding is consistent with its reported hepatoprotective properties, which are primarily mediated through antioxidant mechanisms. Flavonoids and phenolic compounds present in Cassia fistula scavenge free radicals and inhibit lipid peroxidation, thereby protecting hepatocytes from oxidative damage [22]. The preservation of normal hepatocyte organization, central vein diameter, and portal tract structure suggests that the liver maintained its physiological detoxification and metabolic functions despite dietary intervention.

The observed changes in heart and spleen weights may reflect improved immune and circulatory function rather than pathological alterations. The spleen, a key immune organ, may respond to phytochemicals by enhancing lymphoid activity, while the absence of liver hypertrophy further confirms the safety of Cassia fistula supplementation [23][24][25]. These findings collectively indicate that Cassia fistula supports physiological organ development without inducing stress or toxicity.

Improvements in intestinal morphology, particularly increased villus height and surface area, provide a clear mechanistic explanation for the enhanced feed efficiency observed

in the treated groups. Taller villi and deeper crypts increase the absorptive surface area of the intestine, leading to improved nutrient uptake and feed conversion efficiency [26][27][28]. Herbal supplements, including *Cassia fistula*, possess antimicrobial properties that reduce pathogenic microbial load in the intestine, thereby minimizing toxin production and inflammation that can otherwise impair villus integrity [21][29]. A healthier intestinal microenvironment promotes epithelial cell proliferation and maturation, ultimately supporting optimal growth performance.

Overall, the findings suggest that *Cassia fistula* exerts its beneficial effects through a combination of antioxidant activity, modulation of gut microbiota, enhanced digestive efficiency, and protection of intestinal and hepatic tissues. These mechanisms collectively improve growth performance and feed utilization in broilers, particularly during the nutritionally critical starter phase.

Conclusions:

It was concluded from the present study that supplementation of *Cassia fistula* in the broiler diet improved the digestibility of crude protein, fat, and metabolizable energy, as well as digestive organ development in broilers.

Conflict of Interest: We confirm that there is no conflict of interest for this paper.

Data Availability: Available data can be shared on demand.

References:

- [1] A. K. Mondal, S. Parui, and S. Mandal, "Biochemical analysis of four species of *Cassia* L. pollen," *Aerobiol.* 1998 141, vol. 14, no. 1, pp. 45–50, Mar. 1998, doi: 10.1007/BF02694594.
- [2] C. B. Andrea Ciorba, "The impact of hearing loss on the quality of life of elderly adults," *Clin. Interv. Aging*, vol. 7, p. 159, 2022, [Online]. Available: <https://pmc.ncbi.nlm.nih.gov/articles/PMC3393360/#:~:text=Especially in the elderly%2C hearing,as well as communication disorders>.
- [3] A. D. Kinghorn, "Quality Standards of Indian Medicinal Plants," *J. Nat. Prod.*, vol. 67, no. 4, pp. 739–740, Apr. 2004, doi: 10.1021/NP030714Y.
- [4] Sarfiraz Ali Depar, "To investigate the effect of *Cassia fistula* powder on the growth performance and health of broiler," *Pure Appl. Biol.*, vol. 10, no. 4, 2021, [Online]. Available: <https://www.thepab.org/index.php/journal/article/view/1868>
- [5] M. A. R. M. Irshad, Man Singh, "Assessment of Anthelmintic Activity of *Cassia fistula* L.," *Middle-East J. Sci. Res.*, vol. 5, no. 5, pp. 346–349, 2010, [Online]. Available: [https://www.idosi.org/mejsr/mejsr5\(5\)/5.pdf](https://www.idosi.org/mejsr/mejsr5(5)/5.pdf)
- [6] N. B. Chaudhari, K. Chittam, and V. Patil, "Hepatoprotective Activity of *Cassia fistula* Seeds against Paracetamol-Induced Hepatic Injury in rats.," 2009.
- [7] Z. U. A. Geyra, "Enterocyte dynamics and mucosal development in the posthatch chick," *Poult Sci*, vol. 80, no. 6, 2001, [Online]. Available: <https://pubmed.ncbi.nlm.nih.gov/11441845/>
- [8] H. R. Juul-Madsen, G. Su, and P. Sørensen, "Influence of early or late start of first feeding on growth and immune phenotype of broilers," *Br. Poult. Sci.*, vol. 45, no. 2, pp. 210–222, Apr. 2004, doi: 10.1080/00071660410001715812.
- [9] S. K. Das A. Bali, "A Comparative Study on the Antioxidant and Antimicrobial Properties of Garlic and Coriander on Chicken Sausage," *Int. J. Meat Sci.*, vol. 1, no. 2, pp. 108–116, 2011, [Online]. Available: https://www.researchgate.net/publication/273995674_A_Comparative_Study_on_the_Antioxidant_and_Antimicrobial_Properties_of_Garlic_and_Coriander_on_Chicken_Sausage
- [10] Muthusamy Senthil Kumar, Ramasamy Sripriya, "Wound healing potential of *Cassia fistula* on infected albino rat model," *J Surg Res*, vol. 131, no. 2, 2006, [Online].

- Available: <https://pubmed.ncbi.nlm.nih.gov/16242721/>
- [11] “Antipyretic activity of *Cassia fistula* Linn. pods.” Accessed: Jan. 21, 2026. [Online]. Available: https://www.researchgate.net/publication/247158554_Antipyretic_activity_of_Cassia_fistula_Linn_pods
- [12] M. G. A. Arain Muhammad Usman, “In vivo activity of different feeding levels of Greater Celandine (*Chelidonium Majus*) extract on the growth performance and digestibility in broilers,” *Int. J. Vet. Sci. Res.*, 2021, [Online]. Available: https://www.researchgate.net/publication/355163379_In_vivo_activity_of_different_feeding_levels_of_Greater_Celandine_Chelidonium_Majus_extract_on_the_growth_performance_and_digestibility_in_broilers
- [13] T. Bhakta, S. Banerjee, “Hepatoprotective activity of *Cassia fistula* leaf extract,” *Phytomedicine*, vol. 8, no. 3, pp. 220–224, 2001, [Online]. Available: <https://www.sciencedirect.com/science/article/abs/pii/S094471130470032X>
- [14] A. B. B. A. R. Garcia, “A comparison of methods to determine amino acid digestibility of feed ingredients for chickens,” *Poult Sci*, vol. 86, no. 1, pp. 94–101, 2007, [Online]. Available: <https://pubmed.ncbi.nlm.nih.gov/17179421/>
- [15] K. R. . B. Kirtikar, “Indian medicinal plants Vol_2,” Internet Archive. Accessed: Jan. 21, 2026. [Online]. Available: <https://archive.org/details/in.gov.ignca.2047>
- [16] D. S. Fabricant and N. R. Farnsworth, “The value of plants used in traditional medicine for drug discovery,” *Environ. Health Perspect.*, vol. 109, no. Suppl 1, p. 69, 2001, doi: 10.1289/EHP.01109S169.
- [17] W. Z. Wendy L. Frankel, “Mediation of the trophic effects of short-chain fatty acids on the rat jejunum and colon,” *Gastroenterology*, vol. 106, no. 2, 1994, [Online]. Available: <https://pubmed.ncbi.nlm.nih.gov/8299904/>
- [18] “Growth Performance, Blood Components, Immune Response, and Carcass Traits in Broiler Chickens Fed with *Eucalyptus globulus*.” Accessed: Jan. 21, 2026. [Online]. Available: https://www.researchgate.net/publication/371695020_Growth_Performance_Blood_Components_Immune_Response_and_Carcass_Traits_in_Broiler_Chickens_Fed_with_Eucalyptus_globulus
- [19] AOAC, “Official Methods of Analysis Volume 1,” Association of Official Analytical Chemists, Arlington, VA. Accessed: Jan. 21, 2026. [Online]. Available: https://archive.org/stream/gov.law.aoc.methods.1.1990/aoc.methods.1.1990_djvu.txt
- [20] F. C. Guo, R. P. Kwakkel, and M. W. A. Verstegen, “The use of Chinese herbs as alternative for growth promoters in broiler diets,” 2000. Accessed: Jan. 21, 2026. [Online]. Available: <https://research.wur.nl/en/publications/the-use-of-chinese-herbs-as-alternative-for-growth-promoters-in-b/>
- [21] C. H. H. Z. R. Xu, “Effects of dietary fructooligosaccharide on digestive enzyme activities, intestinal microflora and morphology of male broilers,” *Poult Sci*, vol. 82, no. 6, 2003, [Online]. Available: <https://pubmed.ncbi.nlm.nih.gov/12817461/>
- [22] “Gross Anatomical and Histological Studies on the Liver of Broiler.” Accessed: Jan. 21, 2026. [Online]. Available: https://www.researchgate.net/publication/273777803_Gross_Anatomical_and_Histological_Studies_on_the_Liver_of_Broiler
- [23] Holy Kwabla Zanu, “Possibilities of using *Moringa (Moringa oleifera)* leaf meal as a partial substitute for fishmeal in broiler chickens diets,” *Online Journal of Animal and Feed Research*. Accessed: Jan. 21, 2026. [Online]. Available: https://www.researchgate.net/publication/267366892_Possibilities_of_using_Moringa

ga_Moringa_oleifera_leaf_meal_as_a_partial_substitute_for_fishmeal_in_broiler_chickens_diets

- [24] P. S. M. P. Siddhuraju, "Studies on the antioxidant activity of Indian Laburnum (*Cassia fistula* L.): a preliminary assessment of crude extracts from stem bark, leaves, flowers and fruit pulp," *Food Chem.*, vol. 79, no. 1, pp. 61–67, 2002, [Online]. Available: <https://www.sciencedirect.com/science/article/abs/pii/S0308814602001796>
- [25] C. V. R. M. Kannampalli Pradeep, "Effect of *Cassia fistula* Linn. leaf extract on diethylnitrosamine induced hepatic injury in rats," *Chem Biol Interact*, vol. 167, no. 1, 2007, [Online]. Available: <https://pubmed.ncbi.nlm.nih.gov/17289008/>
- [26] K. Y. J. Ruttanavut, "Effects of Dietary Bamboo Charcoal Powder Including Vinegar Liquid on Growth Performance and Histological Intestinal Change in Aigamo Ducks," *Int. J. Poult. Sci.*, vol. 8, no. 3, 2009, [Online]. Available: <https://scialert.net/abstract/?doi=ijps.2009.229.236>
- [27] J. R. P. L. Montagne, "A review of interactions between dietary fibre and the intestinal mucosa, and their consequences on digestive health in young non-ruminant animals," *Anim. Feed Sci. Technol.*, vol. 108, no. 1–4, pp. 95–117, 2003, [Online]. Available: <https://www.sciencedirect.com/science/article/abs/pii/S0377840103001639>
- [28] Muhammad Sumair Arain., "Influence of clove powder and choline on performance, digestibility and weight of internal organs of Japanese quail," *Pure Appl. Biol.*, vol. 12, no. 1, 2003, [Online]. Available: <https://thepab.org/index.php/journal/article/view/2544>
- [29] S. A. Soomro *et al.*, "Improving the Growth Performance and Nutrient Utilization in Broilers Fed Low Protein Diet: The Effect of *Bacillus pumilus* on Digestibility and Microflora Dynamics," *Pak. J. Zool.*, vol. 57, no. 6, 2025, doi: <https://dx.doi.org/10.17582/journal.pjz/20240525073941>.



Copyright © by authors and 50Sea. This work is licensed under the Creative Commons Attribution 4.0 International License.