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Review Article

Potentials Application of Black Pepper (*Piper Nigrum L.*) in Poultry Nutrition

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ABSTRACT

The possibility of using natural growth promoters or non-anti-biotic growth promoters as feed additives derived from herbs and spices or other plants in poultry nutrition to maximize their potential output has been extensively researched for the past three decades. Black pepper is one of such potential spices with a wide range of medicinal effects. In poultry birds, this spice has been used in different forms, dosages as well as period of time. This review, documented potentials application of black pepper in poultry nutrition on feed intake and efficiency, growth performance, body weight gain, carcass yield, egg production and quality, gut function, antioxidants and blood biochemistry with their possible mechanism of actions is discussed.

Keywords: Black pepper, King of spices, Gut micro-biota, Herbs and medicinal plant, Metabolism.

INTRODUCTION

Different feed additives are added in poultry nutrition to up-grade the quality of the final products (Puvača *et al.,* 2013). A while back, growth-promoting antibiotics were used as feed additives; however, these were associated with alteration of natural gut micro-biota and drugs resistance in bacteria and human (Rehman and Haq, 2014). For that reason, natural alternatives to antibiotics, such as herbs and medicinal plants, have

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attracted attention due to their wide range of potential beneficial effects (Alagawany *et al.,* 2016).

Black pepper (Family – *Piperaceae*) is a perennial climbing vine that is used in folklore medicine to manage several diseases like fever, cold, muscular pains, dysentery, cough, worm among others; black pepper belongs to the genus Piper and species *nigrum*. It originated in India but is now cultivated in several tropical and sub-tropical countries, including Sri Lanka, Nigeria, Thailand, Malaysia, Ghana, China, Madagascar, Brazil, and Indonesia, among others due to its ability to withstand harsh tropical conditions. Black pepper (*Piper nigrum L.*) which is referred to as "king of spices" (Damanhouri and Ahmad, 2014) contains an impressive list of plant derived chemical compounds that are known to have disease preventing and health promoting properties (Ahmad *et al.,* 2012). Ahmed *et al.,* (2013) explained that, black pepper has been proven to be rich in certain active enzymes (glutathione peroxidase and glucose-6-phosphate dehydrogenese) which manifest benefits for metabolism and the inhibition of oxidation. *Peperine* (1-piperoyl-piperidine) which is an active substance in black pepper, it can increase absorption of selenium, vitamin B complex, bête carotene and *curcumin* as well as other nutrients (El-Tazi *et al.,* 2014).

Effect on Feed Intake and Efficiency

Feed consumption is one of the important and influential gauges in determining the performance of broiler chickens. Therefore, it is essential to determine the effect of feed ingredients on the animal's feed intake. Published studies regarding black pepper impact on feed intake of broilers vary from one experiment to another. Ufele *et al.,* (2020) indicated that, inclusion of black pepper at 5g/kg feed had a beneficial influence on feed intake and body weight gain in broiler chickens. Ramon *et al.,* (2016) showed that, there was no statistical differences ($P>0.05$) between the means of production performance variables with the inclusion of black pepper in the feed in laying hens. Safa *et al.,* (2014) indicated that, group supplemented with (1%) black pepper had significant differences ($P<0.05$) on feed intake and feed conversion ratio. Navjot *et al.,* (2017) found that, black pepper supplementation decreased feed intake at 2nd and 3rd week of age but there were no significant differences in feed conversion ratio, and Galib *et al.,* (2011) found that, feeding black pepper at different levels (0.25, 0.50, 0.75, and 1%) had no significant differences among treatment group during 2nd, 4th, and 6th weeks. Al-Kassie *et al.,* (2011) and Abou-Elkhair *et al.,* (2014) mentioned that, black pepper powder in chicken nutrition did not record positive significant influence on feed conversion ratio. Nikola *et al.,* (2014) reported that, the adding of black pepper powder at (1.0g/100g) in the basal diet of broiler chickens resulted to low feed conversion ratio in treatments T_2 and T_5 (1.8 kg/kg) and the highest in control treatment T_1 (2.1 kg/kg), without statistically significant ($p>0.05$) differences.

Al-kassie *et al.,* (2011) reported that, feed intake in the experimental group during the growth period (0-2 and 2-4 weeks) showed a significant effect (P<0.05) as compared with control. Similarly, the use of 0.5 % (5g/1kg) black pepper in the ratio of broiler chickens in average total feed intake by the control treatment was numerically least and significant different (P<0.05) from the other treatments (Garlic and Black pepper) with a value of 4420.71g (Aikpitanyi *et al.,* 2018). Ghaedi *et al.,* (2013); Abou-Elkhair *et al.,* (2014); and El Tazi *et al.,* (2014) stated that, addition of black pepper significantly improved feed efficiency of broilers.

Occasionally black pepper has been applied via drinking water in poultry. In their report, Egena *et al.,* (2023), reported the effects of three breed (Cobb500, Ross308, and Arbor acre) of broiler chicken as affected by the administering of varying doses of aqueous pepper (0-28 days). The results revealed a significant (P<0.05) influence of the level of administration on the final body weight, body weight gain, and feed conversion ratio. Final body weight, and body weight gain were similar (P>0.05) in birds dosed with 3 and 3-5ml of pepper, but they were significantly (P<0.05) better compared with those on the control (0 pepper). In the same experiment, birds on the aqueous pepper extract were observed better feed conversion ratio than those in the control group.

Effect on Growth Performance and Body Weight Gain

Abundant studies investigated the effect of black pepper powder on the growth performance of broiler chicken. The differences among the studies might be due to several factors such as basal diets, growing duration, statistical design, breeds of broiler, dosage of black pepper powder, and variation of the amount of active components. Ndelekwute *et al.,* (2015) observed comparable body weight gain in starter (1–21 days) and finisher (22–49 days) broiler chickens fed 2.5, and 5.0 g black pepper seeds/kg feed respectively. However, this did not concur with the findings of Abou-Elkhair *et al.,* (2014) and El Tazi *et al.,* (2014) at inclusion levels of 0.5g and 1g ground black pepper per kg of commercial ration, respectively. Ghaedi *et al.,* (2013) found that, the inclusion of black pepper (2ml per liter) of drinking water resulted to higher birds' weight (P<0.05) compared with the control. In their work, Rahimian *et al.,* (2016) recorded a 6% increase in body weight gain in Cobb 500 broiler chickens fed with 20 g black pepper/kg feed, which they ascribed to the ability of bioactive compounds present in black pepper to encourage the proliferation of beneficial gut-microbes. Ghaedi *et al.,* (2014) observed that a diet containing 2mg/ml black pepper and 200 g/ton virginiamycin had numerically higher body weight gain and lower feed conversion ratio on Ross 308 broiler chickens than those offered diet without black pepper supplementation. In contrast, Navjot *et al.,* (2017) mentioned a decrease in body weight gain in boilers when fed black pepper (0.5%) but significantly decrease in average body weight was observed during 2nd week in groups fed with 0.5% black pepper. Singh (2015) documented gain in average body weight in groups fed with 0.5% black pepper as compare to groups fed control. The different results on growth performance of broilers may be ascribed to the different doses used in the experiments. Akinwumi *et al.,* (2022) found improved egg quality in layers fed with black pepper at 0.1–0.5 g/kg feed when compared with the layers fed with a diet without black pepper supplementation. Similarly, Kelvin and James (2023) who wrote on production performance and egg quality of commercial laying hens fed black pepper and red pepper documented, treatment (T_6) recorded the highest Roche color fan score of 9.89 followed by 9.67 obtained from treatment (T_2) (1% black pepper), both were significantly different from the color score of 8.44 recorded in the control. According to Zhao *et al.,* (2011) the higher performance of the laying hens may be due to antioxidant, antimicrobial and other activities such as increased blood circulation and secretion of digestive enzymes and reduction in the oxidation of feed. Al-Kassie *et al.,* (2011) showed that, inclusion of black pepper at the levels of 0.50%, 0.75% and 1% in the diet improved body weight gain. Ndelekwute *et al.,* (2015) indicated that, adding black pepper at the starter phase 0.25 and 0.50% improved live weight significantly ($P<0.05$). Mehdipour *et al.,* (2013) affirmed that, dietary supplementation of essential oil like capsaicin, garlic powder, thymol powder, black pepper powder among others, improve the performance of broilers and carcass yields. Aikpitanyi *et al.,* (2019) documented ginger, black pepper and their combination diets were significantly different ($P<0.05$) in weight gain from the control diet. In their work, Akinwumi, *et al* (2022) noticed that, the result of the bled weight of noiler chicken fed on black pepper was significantly ($P<0.05$) highest across the treatment groups. In the same experiment, Akinwumi *et al.,* (2022) established a significant difference on noiler chicken fed with black pepper, roselle and green tea at 1.0g/kg inclusion level improved ($P<0.05$) the carcass characteristics better than the control.

Effect on Gut Function

Several studies indicated that, black pepper in different concentrations had positive effects on the digestion and absorption of many materials with an improvement in the morphology of the gastrointestinal tract in broiler (Upadhaya *et al.,* 2016). Sugiharto *et al.,* (2021) affirmed that, the histology of the intestinal villi and epithelial cells on the apical surface is commonly affected by feed administered with 1% lactic fermented black pepper. Sabour *et al.,* (2019) documented that, feeding organic acid increased the jejunal villi height of broiler chickens. In the same experiment, Sabour *et al.,* (2019), noticed that acidic condition may favor the increased LAB population and hence improve the intestinal ecology and villi development. Oso *et al.,* (2019) suggested that black pepper may reduce the pathogenic bacterial load and thus improve the intestinal morphology of broilers. The minimum pathogen load could be attributed to the less tissue damage and inflation, which thereby, maintain the intestinal integrity of chicks (Rajput *et al.,* 2013). In their work, Jang *et al.,* (2007) mentioned that, the positive effect of medicinal plants can be attributed to improving nutrient absorption as a result of stimulating saliva and bile secretion and increasing the effectiveness of digestive enzymes, leads to an improvement in the health of the bird in general. In addition, Pearlin *et al.,* (2020) discovered that the pH of the GIT is influenced by a number of factors, one of which is dietary composition. Evidently, it has been discovered that black pepper promotes the growth of healthy gut microbes like Lactobacillus (Ghaedi *et al.,* 2014; and Kishawy *et al.,* 2022). In their study result Naidu *et al.,* (1999) found that, black pepper inhibited the proliferation of pathogenic microbes in chicken gut. Black pepper-based diets may have accomplished this by increasing the production and release of mucus in the digestive tract of chicken, which in turn inhibits the adhesion of pathogens and aid in stabilization of intestinal microbial eubiosis in chickens (Windisch *et al.,* 2008). Rahman *et al.,* (2015) documented that administration of alcoholic extracts of black pepper at 9 ml/kg body weight reduced oocyst counts in coccidiosis- challenged chickens. The author postulated that, this may be linked to the bioactive agents in black pepper, specifically anti-inflammatory, anti-oxidant, and anti-microbial.

Antioxidant Effects

In this day and age, there has been growing interest for natural anti-oxidants in food due to its health against oxidative stress and many diseases. This was further supported by Christaki, (2012) who affirmed that, plant derived anti-oxidants are gaining more interest on poultry nutrition because their meat has high content of polyunsaturated fatty acids and susceptible to lipid oxidation. Antioxidant is natural or synthetic constituents that can be used for inhibition of free radical formation by scavenging and suppression of degenerative and chronic diseases (Halliwell, 2000). The objective of antioxidant protects cells against free radicals, which may play a role in heart disease, cancer and other diseases. Free radicals are constantly produced in the body and certain amounts of these components are necessary for normal physiological functions. When the production of free radicals exceeds normal levels however, they cause per-oxidative damage to the cell membrane and organelles (Khan, 2011). Generally, the body has three major antioxidant enzymes namely superoxide dismutase (SOD), glutathione peroxidase (GSHPx) and catalase which are involved in scavenging reactive oxygen species (Zhao *et al.,* 2011). Therefore, an increase in the level of these enzymes would enhance the scavenging capacity of these deleterious substances. Many plants have been identified as excellent poultry antioxidants, important among which is black pepper. Insane *et al.,* (2017) showed that, ethanol extract of *piper nigrum L.* leaves had the highest antioxidant activity with an IC50 value of 57.72µg/mL, and according to the antioxidant activity classification, the ethanol extract of *piper nigrum L.* leaves had vigorous antioxidant activity. In another study, Sapam *et al.,* (2018) proven that *pipper nigrum L.* provides antioxidant effects using the cold extract of *piper nigrum L.* and even methanol PPPH. The result was obtained on the antioxidant activity of 78.81% with 200µg/mL. According to Damanhouri and Ahmed, (2014); and Sapam *et al.,* (2018), *piper nigrum L.* has antioxidant potential due to flavonoids and phenolic content. Nikola *et al.,* (2014) established that, adding of black pepper in the amount of 1.0g/100kg (T5), significantly ($P<0.05$) decreased the concentration of triglycerides (14.4mg/dl) in blood serum. According to the author, this can be explained by the possible inhibition of the Acetyl CoA syntheses enzymes that is necessary for the biosynthesis of fatty acids. In the same experiment, the lowest concentration of the total cholesterol was recorded in treatment T4 ($P<0.05$) while the highest concentration of HDL (35.6mg/dl) was recorded in treatment T4 with addition of 0.5g/100g of black pepper powder. Both levels of black pepper in the study decreased LDL levels compared to the levels in chickens of the control treatment. This effect can be explained by the possible mechanism of antioxidant and anti-peroxide lowering action on LDL or the decrease in hepatic production of very low-density lipoprotein (VLDL) which serves as the precursor of LDL in the blood circulation (Kim *et al.,* 2009). In their investigation, Ghaedi *et al.,* (2014), addition of black pepper decreased triglycerides and the total cholesterol while the concentration of HDL was increased.

Blood Biochemistry

Abou-Elkhair *et al.,* (2014) found that, blood characteristics of broiler chickens fed with 5 g black pepper/kg feed had comparable blood values when compared to the control. Similarly, Al-Kassie *et al.,* (2011) had comparable white blood cells (WBC) in broiler chickens fed with 0 and 5 g black pepper/kg feed. In contrast, Shahverdi *et al.,* (2013) showed that chickens fed with black pepper-based diets had significantly lower Hb, PCV, RBC, heterophils (H)/lymphocyte (L) ratios, and cholesterol relative to the control group. The disparity in the significant differences in these findings may be due the rate of application of the black pepper and/or experimental condition. Tajodini *et al.,* (2015) stated that, the mechanism by which high doses of black pepper reduced PCV and RBC in broiler chickens is not well known; however, it was postulated that, the action of bioactive constituents on estrogen, which reduces the levels of RBC and PCV in the blood. Furthermore, Al-kassie *et al.,* (2011); and Sugiharto *et al.,* (2021) added that, inclusion of black pepper to animal feed reduced RBC counts in broiler chickens, implying that black pepper had an adverse influence on erythropoiesis. This also suggests that the inclusion of high levels of black pepper in chicken diets may not be well-utilized by broilers for best blood values. Kishawy *et al.,* (2022) mentioned that, the inclusion of 0.5 g black pepper oil/kg feed in the diet of broiler chickens increased plasma proteins, suggesting that the quality of protein in the diet was not compromised by black pepper supplementation. This may be linked to the strong agonistic effect of bioactive agents in black pepper, specifically *piperine* on β adrenergic receptors (Atal *et al.,* 2012). Akinwumi *et al.,* (2022) noted that, the inclusion of black pepper into noiler chicken feed does not have significant ($P<0.05$) on protein metabolism at the rate of 1.0g/kg. Abou-Elkhair *et al.,* (2014); Kishawy, *et al* (2022); and Sugiharto *et al.,* (2021) found no significant effect of black pepper on plasma ALT and AST levels in broiler chickens, indicating the hepatoprotective effect of black pepper in broiler chickens. Damanhouri and Ahmad, (2014) opined that, the non-significant increase in ALT and AST levels of broilers fed with black pepper essential oils could in part be attributed to the hepatoprotective activity of black pepper, as it improved the liver function. Kishawy *et al.,* (2022) affirmed that, adding black pepper oil/kg feed at the rate of 0.25 and 0.5 g to broiler diet increased plasma immune traits, as evidenced by increased lysozyme activity, immunoglobulin levels, and phagocytic indices when compared to birds fed with a diet without black pepper oil supplementation. The inclusion of black pepper into broiler chicken diet would significantly increase blood HDL cholesterol concentration significantly. This was further supported by Ramesh *et al.,* (1996) who linked the active agents in black pepper-based diets on the activities of lipoprotein lipase (LPL) and cholesterol acyl transferase (LCAT) as earlier research has shown that increased activity of blood LPL and LCAT results in an increase in HDL biosynthesis and a decrease in LDL levels.

CONFLICT OF INTEREST

The author declares that there was absence of any potential conflict of interest.

REFERENCES

Abou-Elkhair, R., Ahmed, H.A. and Selim, S. (2014), "Effects of Black pepper (*Piper nigrum*), Turmeric Powder (*Curcuma longa*) and Coriander Seeds (*Coriandrum sativum*) and their Combinations as Feed Additives on Growth Performance, Carcass traits, Some Blood Parameters and Humoral Immune Response of Broiler Chickens", *Asian-Australas J Anim Sci., 27(6): 847–854.*

Ahmad, N., Fazal, H., Abroasi, B.H., Farooq, S. and Ali, M. (2012), "Biological role of *Piper nigrum L*. (Black pepper)", A review. *Asian Pacific J. Trop. Biomed*., S1945-S1953.

Ahmed, S.A., Abood, N.H. and Al-Janabi, A.A. (2013), "Anti-microbial Effect of Pomegranate Peel Extract on Some Pathogenic Micro-organisms", *Eng. Technol., J*., 31: 316-324.

Aikpitanyi, K.U., Igwe, R.O. and Egweh, N.O. (2019), "Assessment of Ginger and Black Pepper as Feed Additives on Growth Performance and Carcass Traits of Broiler Chickens", *International Journal of Veterinary Science and Animal Husbandry*, 5(1): 033-038.

Akinwumi,A.O., Oshodi, O.A., Atande, R.A., Ogunsola, O.M., Ayoola, S.J., Ajani, R.A. and Odeleye, B.D. (2022), "Meat Quality of Noiler Chickens as Influenced by Dietary

Natural Antioxidant Supplementations", *Journal of Applied Sciences International*, 25(5): 46-62.

Al-Kassie G.A.M., Al-Nasrawi, M.A.M. and Ajeena, S.J. (2-011), "Use of Black pepper (*Piper nigrum*) as Feed Additive in Broilers Diet", *Res. Opin. Anim. Vet. Sci*., 1:169–173.

Alagawany, M., Ashour, E.A.and Reda, F.M. (2016), "Effect of Dietary Supplementation of Garlic (*Allium sativum*) and Turmeric (*Curcama longa*) on Growth Performance, Carcass traits, Blood profile and Oxidative status in Growing Rabbits", *Annals of Animal Science*, 16(2): 489-505.

Atal, S., Agrawal, R.P., Vyas, S., Phadnis, P. and Rai, N. (2012), "Evaluation of the Effect of *Piperine* per se on Blood Glucose Level in Alloxan-induced Diabetic Mice", *Acta Pol Pharm - Drug Res*., 69: 965–969.

Christaki, K. (2012), "Naturally derived Antioxidants in Poultry Nutrition", *Res. J. Biotechnol*., 7: 109-112.

Damanhouri, Z.A. and Ahmad, A. (2014), "A Review on Therapeutic Potential of *Piper nigrum L.* (Black pepper). The king of Spices." *Medicinal and Aromatic Plants*, 3(3): 3-6.

Egena, A., Alabi, O., Ocheme, O., Sikiru, A., Adegbola, M. and Oche, O. (2023), "Administering Aqueous Pepper Extract Influence the Growth Performance, Nutrient Utilization and selected Haematological and Serum Characteristics of Three Breeds of Broiler Chickens", *Genet, Biodiv. J.*, 7(2): 39-50.

El-Tazi, S.M.E., Mukhtar, M.A., Mohammed, K. and Tabidi, M.H. (2014), "Effect of using Black pepper as Natural Feed Additive on Performance and Carcass quality of Broiler Chicks", *International Journal of Pharmaceutical Research and Analysis*, 14, 108-113.

Ghaedi, H., Nasr, J., Kheir, F., Miri, Y. and Rahimian, Y. (2013), "Effect of use Virginiamycin as Probiotic, Black pepper Extract as Phytogenic Feed Additive on Performance of Broiler Chicks. *J. of Agric. Sci*., 3(12): 521-525.

Ghaedi, H., Nasr, J., Kheiri, F., Rahimian, Y. and Miri, Y. (2014), "The Effect of Virginiamycin and Black pepper (*Piper nigrum L.*) Extract on Performance of Broiler Chicks", *Res. Opin. Anim. Vet. Sci*., 4: 91–5.

Halliwell, B. (2000), "The antioxidant paradox", *Lancet*, 355: 1179-1180.

Isane, M., Marliani, L. and Dinilah, N.P. (2017), "Comparison of Antioxidant Activities from Four Spices of Piper", *Pharmacia*, 7(2): 305-312.

Jang, I.S., Ko, J.H., Kang, S.Y. and Lee, C.Y. (2007), "Effect of Commercial Essential oils on Growth Performance, Digestive Enzyme activity and Intestinal Micro-flora Population in Broiler Chickens", *Animal Feed Science Technology*, 134: 304-315.

Kelvin, U.A. and James, A.I. (2023), "Assessment of Production Performance and Egg quality of Commercial Laying Hens Fed Black pepper and Red pepper Additives", European Journal of Veterinary Medicine, 3(3):

Khan, R.U. (2011), "Antioxidants and poultry semen quality", *World's Poultry Science Journal*, 67: 297-308.

Kim, Y.J., Jim, S.K., Yang, H.S. (2009), "Effect of Dietary Garlic Bulb and Husk on the Physicochemical Properties of Chicken Meat", *Poultry Sci*., 88, 398-405.

Kishawy, A.T.Y., Al-Khalaifah, H.S., Nada, H.S., Roushdy, E.M., Zaglool, A.W. and Ahmed, I.T. (2022), "Black pepper or Radish Seed Oils in a new Combination of Essential oils Modulated Broiler Chickens' Performance and Expression of Digestive Enzymes, Lipogenesis, Immunity, and Autophagy-related Genes", *Vet. Sci*., 9: 43.

Mehdipour, Z., Afsharmanesh, M. and Sami, M. (2013), "Effects of Dietary Symbiotic and Cinnamon (*Cinnamomum verum*) Supplementation on Growth Performance and Meat Quality in Japanese Quails", *Livestock Sciences*, 154: 152-157.

Naidu, A.S., Bidlack, W.R. and Clemens, R.A. (1999), "Probiotic spectra of Lactic Acid Bacteria (LAB)", *Crit. Rev. Food Sci. Nutr*., 39: 13–26.

Navjot, S.S., Udeybir, S., Sethi, A.P.S., Hundal, J.S., Lamba, J.S. and Amit, S. (2017). Effect of Black pepper and Jaggery Supplementation with or without Feed Restriction on Broilers Performance. Journal of Animal Research, 7(5): 903-912.

Ndelekwute, E.K., Afolabi, K.D., Uzegbu, H.O., Unah, U.L. and Amaefule, K.U. (2015), "Effect of Dietary Black pepper (*Piper nigrum*) on the Performance of Broiler", *Bangladesh Journal Animal Sciences,* 44: 120–127.

Nikola, P., Ljiljana, K., Dragana, L., Diagomir, L. and Sanja, P. (2014), "Influence of Black pepper (*Piper nigrum L.*) On Productive Performances and Blood Lipid Profile of Broiler Chickens", *Annals of Biological Research*, 5(12): 29-33.

Oso, A.O., Suganthi, R.U., Reddy, G.B.M., Malik, P.K. Thirumalaisamy, G., Awachat, V.B., Selvaraju, S., Arangasamy, A. and Bhatta, R. (2019), "Effect of Dietary Supplementation with Morphology and Cecal Microflora of Broiler Chickens", *Poultry Sciences*, 98(10): 4755-4766.

Pearlin, B.V., Muthuvel, S., Govidasamy, P., Villavan, M., Alagawany, M. and Ragab, F.M, (2020), "Role of Acidifiers in Livestock Nutrition and Health: A review", *J. Anim. Physiol. Anim. Nut.,* 104: 558–69.

Puvača, N., Stanaćev, V., Glamočić, D., Lević, J., Perić, L., Stanaćev, V.Ž. and Milić, D. (2013), "Beneficial effects of Phytoadditives in Broiler Nutrition", *World's Poultry Science Journal,* 69(1): 27-34.

Rahimian, Y., Faghani, M., Davoodi, S.M. and Rafiee, A., Davoodpoor, A. and Nezhad, M.H.G. (2016), "Potential use of Protexin Probiotic and Black pepper Powder on Cobb 500 Broiler Chicks", *Azarian J. Agric*., 3:129–34.

Rahman, B., Begum, T., Sarker, Y.A., Hassan, M.Q., Saha, S. and Sikder, M.H. (2015), "Comparative Efficacy of Alcoholic Extracts of Black peppers (*Piper nigrum*) and Chutra Leaves (*Urtica dioica*) with ESB3 against *coccidiosis* in Chickens", *Res. Agric. Livest. Fish*, 2: 117–24.

Rajput, N., Muhammad, N., Yan, R., Zhong, X, and Wang, T. (2023), "Effect of Dietary Supplementation of *Curcumin* on Growth Performance, Intestinal Morphology and Nutrients Utilization of Broiler Chicks", *Journal of Poultry Science*, 50(1): 44-52.

Ramesh, C., Kannan, A.K. and Kapoor, N.K. (1996), "Lipid lowering Activity of Guggulsterone from Commiphora mukul in Hyperlipidemic Rats", *Phytother Res*., 10: 508‑511.

Ramon, D.M., Frank, G.G.C., Julmar, D.F., João, P.F.R., Lucas, D.M. and Jessica, L.D. (2016), “Black pepper (Piper nigrum) in Diets for Laying Hens on Performance, Egg Quality and Blood Biochemical Parameters. Acta Sci. Anim. Sci., 38(4):

Rehman, Z., and Haq, A. (2014), “Effect of Garlic and Ginger Supplementation on Broiler Performance”, Lambert Publishing Company.

Sabour, S., Tabeidian, S.A. and Sadeghi, G. (2019), “Dietary Organic acid and Fibre source affect Performance, Intestinal morphology, Immune responses, and Gut mocroflora in Broilers. *Animal Nutrition*, 5: 156-162.

Safa, M.A. and Wahab, E.T. (2014), “Response of Broiler Chicken to Diets Containing Different Mixture Powder Levels of Red Pepper and Black Pepper as Natural Feed Additive”, *Animal and Veterinary Sciences*, 2(3): 81-86.

Sapam, R., Kalita, P.P., Sarma, M.P., Talukdar, N. and Das, H. (2018), “Screening of Phytochemicals and Determination of Total Phenolic content, Antioxidant and Antimicrobial Activity of Methanolic Extract of *Piper nigrum* Leaves”, *Indo Am. J. Pharm. Reg*., 8(2): 1354-1360.

Shahverdi, A., Kheiri, F., Faghani, M., Rahimian, Y. and Rafiee, A. (2013), “The Effect of Use Red Pepper (*Capsicum annum L.*) And Black pepper (*Piper nigrum L.*) On Performance and Haematological Parameters of Broiler Chicks”, *Eur. J. Zool. Res.,* 2: 44–8.

Sugiharto, S., Widiastuti, E., Pratama, A.R., Wahyuni, H.I., Yudiarti, T. and Sartono, T.A. (2021), “Haematological and Intestinal Responses of Broilers to Dietary Supplementations of Lactic fermented Turmeric, Black pepper or a Mixture of Both”, *Acta Univ. Agric. Silvic. Mendelianae Brun*, 69: 101–10.

Tajodini, M., Saeedi, H.R. and Moghbeli, P. (2015), “Use of Black pepper, Cinnamon and Turmeric as Feed Additives in the Poultry Industry”, *World’s Poult. Sci. J.*, 71: 175–83.

Ufele, A.N., Ofordile, S. and Aghalu, U. (2020), “The Effects of *Allium sativum* and *Piper nigrum* on the Growth Performance and Packed Cell volume of Broiler Chicks”, *Int. J. Anim. Sci. Tech*., 4: 1–5.

Upadhaya, S.D., Kim, S.J. and Kim, I.H. (2016), “Effects of Gel-based phytogenic Feed Supplement on Growth Performance, Nutrient Digestibility, Blood Characteristics and Intestinal Morphology in Weanling Pigs”, *Journal Applied Animal Research*, 44: 384-389.

Windisch, W., Schedle, K., Plitzner, C. and Kroismayr, A. (2008), “Use of Phytogenic Products as Feed Additives for Swine and Poultry”, *J. Anim. Sci*., 86(S14): E140–148.

Zhao, X., Yang, Z.B., Yang, W.R., Wang, Y., Jiang, S.Z. and Zhang, G.G. (2011), “Effects of Ginger Root (*Zingiber officinale*) on Laying Performance and Antioxidant Status of Laying Hens and on Dietary Oxidation Stability”, *Poultry Science*, 90: 1720-1727.