

Unconventional plants as a source of phytochemicals for broiler chicken

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ABSTRACT

Objective: To carry out a review to know the modes of action and the commercial application of unconventional plants as growth promoters in broiler chicken production.

Design/Methodology/Approach: A bibliographic review of unconventional and commonly used plants was carried out, which have shown efficacy as growth promoters on broiler chickens.

Results: Numerous reports have demonstrated the efficacy of phytochemicals present in plants as antioxidants, antimicrobials, and immune-stimulants.

Limitations of the study/Implications: Alternative use of unconventional plants can help to develop sustainable production systems and the production of innocuous meat products.

Findings/Conclusions: The use of additives of natural origin in poultry feed represents a viable option to replace or reduce the use of antibiotics and growth promoters on broiler chickens.

Keywords: Phytochemicals, secondary metabolites.

INTRODUCTION

Bacterial resistance by the use of antibiotics as growth promoters has caused the search for alternatives to develop sustainable production systems for meat products that consider the welfare of the consumers of those products and the animals from which products are obtained (Lillehoj and Lee, 2012). The use of herbal products is an antimicrobial alternative and promoter of animal growth due to their contents of secondary metabolites (Dhama *et al.*, 2015).

The herbs begin to be used in the poultry industry as promoters of growth in the fight against various infections for their potential as alternatives to antibiotics and their content of bioactive substances that could improve production parameters attributed to some phytochemicals which may favorably modify the metabolism of the animal (Dhama



et al., 2015; Vinus *et al.*, 2018). However, additional complications arise because herbal additives for animal feed can vary widely by agro-climatic origin, processing and composition, when the additive is an extract or an essential oil (Hashemi and Davoodi, 2010). The objective of this review was to provide an overview of recent knowledge about the use of some unconventional plants as a source of phytochemicals for feeding broiler chickens, excluding the use of extracts and essential oils.

Unconventional plants as sources of phytochemicals

Sweet wormwood (*Artemisia annual*). Active compounds: artemisinin, flavonoids, phenols, purines and lipids (Brisibe *et al.*, 2009). Effect: 2 to 4% of the diet as anti-parasite, antioxidant (Cherian *et al.*, 2013), coccidiostats (Brisibe *et al.*, 2009), reduces the count of enterobacteria and increases the content of lactobacilli in the intestine (Panaite *et al.*, 2018; 2%).

Garlic (*Allium sativum*). Active compounds: ajoene, allyl cysteine, diallyl sulfide and allicin. Effect: the inclusion of up to 3% garlic improves weight gain, feed conversion, decreases the mortality rate (Makwana *et al.*, 2015; Karangiya *et al.*, 2016; Patel *et al.*, 2017; Belal *et al.*, 2018). It has antimicrobial properties, increases the quantity of antibodies, decreases the concentration of triglycerides, cholesterol, low-density lipoproteins and increases the levels of high-density lipoproteins (Toghyani *et al.*, 2011; Faghani *et al.*, 2014).

Anise (*Pimpinella anisum*). Active components: The seed contains trans-anethole eugenol, methyl-chavicol, anisaldehyde, estragole, coumarins, scopoletin, umbelliferone, estroles, terpene hydrocarbons, polyenes and polyacetylenes (Barakat *et al.*, 2016). Effect: the inclusion of anise seed in the feed improves weight gain, feed consumption and feed conversion (Yazdi *et al.*, 2014; Mahmood *et al.*, 2014a; Barakat *et al.*, 2016), increases the quantity of antibodies against avian influenza virus (10 g kg⁻¹ of feed; Yazdi *et al.*, 2014), Gumboro and Newcastle (1 g kg⁻¹ of feed; Mahmood *et al.*, 2014b) and increases the amount of immunoglobulins [(5-15 g kg⁻¹ of feed; Barakat *et al.*, 2016); (0.5-1 g L⁻¹ of water; Al-Shammari *et al.*, 2017)].

Cinnamon (*Cinnamomum zeylanicum*). Active compounds: cinnamaldehyde, 2-hydroxycinnamaldehyde, cinnamyl acetate, coumarin, eugenol and caryophyllin (Saeed *et al.*, 2018). Effects: improves

weight gain, feeding efficiency, digestion, intestinal microflora activity and immune response (Toghyani *et al.*, 2011; Singh *et al.*, 2014; Faghani *et al.*, 2014; Saeed *et al.*, 2018). It decreases the plasma concentration of cholesterol, triglycerides, low-density lipoproteins and increases high-density lipoproteins (Faghani *et al.*, 2014). Antioxidant and anti-inflammatory activity (Bansode, 2012). Dose: 0.02 to 7%.

Coriander (*Coriandrum sativum*). Active components: essential oil, tannins, terpenoids, reducing sugars, alkaloids, phenolic compounds, flavonoids, fatty acids, sterols and glycosides (Hosseinzadeh *et al.*, 2014). Effect: coriander seeds (1 to 3% in the diet) improve weight gain, feed conversion (Al-Jaff, 2011; Saeid and Al-Nasry, 2010; Abou-Elkhair *et al.*, 2014), stimulate the immune system (Hosseinzadeh *et al.*, 2014), decreases cholesterol, glucose, low-density lipoproteins and high-density lipoproteins (Al-Jaff, 2011).

Chile (*Capsicum annum*). Active compounds: capsaicin, capsinin and capsanthin. Effects: antioxidant capacity (Thiamhirunsopit *et al.*, 2014), increases weight gain, feed consumption and reduces feed conversion, information obtained by evaluating doses between 0.25-1.7% (Al-Kassie *et al.*, 2011a; Thiamhirunsopit *et al.*, 2014; Puvaca *et al.*, 2015). It strengthens the immune system of poultry (Al-Kassie *et al.*, 2011a; 0.25-1.00%) and is effective against Salmonella infection (Alaa, 2010; 1-2%). Chili pepper decreases the blood concentration of cholesterol (Alaa, 2010; Al-Kassie *et al.*, 2011a; Puvaca *et al.*, 2015), triglycerides, low-density lipoproteins, increases the concentration of high-density lipoproteins (Puvaca *et al.*, 2015), and total serum protein (Alaa, 2010).

Black cumin (*Nigella sativa*). Active compounds: alkaloids, essential oils, imoquinone, dithymoquinone, thymol, carvacrol, nigelycine, nigelidin and hedrin (Azeem *et al.*, 2014). Effects: viable alternative to replace the use of antibiotics, growth promoter, antioxidant and immune-regulator (Azeem *et al.*, 2014; Kumar and Patra, 2017). Black cumin increases the quantity of antibodies against Newcastle, Gumboro and Bronchitis (Durrani *et al.*, 2007; Kumar and Patra, 2017). The addition of cumin seeds to the diet causes greater weight gain, feed consumption and better feed conversion [Durrani *et al.*, 2007 (4%); Kumar and Patra, 2017 (0.5-2.0%)]. In addition, adding 0.4% to the diet reduces the concentration of triglycerides and cholesterol (Kumar and Patra, 2017).

Turmeric (*Curcuma longa*). Active compounds: curcumin, cinnamic acid, curcylone and niacin (Guil-Guerrero et al., 2017). Effects: antioxidant (Guil-Guerrero et al., 2017), improves the immune response (Nayaka et al., 2012) of chickens infected with Newcastle (Guil-Guerrero et al., 2017) and Eimeria (Lee et al., 2010). Turmeric powder supplementation improves weight gain and feed conversion (0.5%) (Al-Sultan, 2003; Abou-Elkhair et al., 2014), and decreases blood triglycerides (Nouzarian et al., 2011).

Eucalyptus (*Eucalyptus globulus*). Active component: terpene-eucalyptol and tannins (Farhadi et al., 2017). Effects: *Eucalyptus* leaves improved productive behavior, it is also associated with the manipulation of the intestinal microbiota and better immunity (Hassan et al., 2011; Farhadi et al., 2017).

Ginger (*Zingiber officinale*). Active compounds: gingerdiol, gingerol, gingerdione and phenolic compounds. Effects: antioxidant properties (Zhang et al., 2009). The addition of 0.02 to 1.5% to the feed improves weight gain, feed conversion, reduces mortality in chickens (Oleforuh-Okoleh et al., 2014; Youssef et al., 2016; Belal et al., 2018) and stimulates the immune system (Valiollahi et al., 2014).

Laurel (*Laurus nobilis*). Active compounds: cineol, eugenol, acetyl and methyl eugenol, α - and β -pinene, felandrene, linalool, geraniol and terpineol (Zekovic et al., 2009). Effect: by using 2 to 6 g kg⁻¹ of bay leaves in feed, the total of bacteria and aerobic bacteria in the colon is inhibited (Nafea et al., 2018).

Moringa (*Moringa oleifera*). Active compounds: polyphenols, vanillic-, ferulic-, melilotic- acids, vitamins A, E, C and complex B. Effects: alternative source of protein in diets at levels of 50 to 140 g kg⁻¹ of leaves in the diet replacing the soybean meal (*Glycine max* L.), finding as a result greater weight gain and feed conversion (Melesse et al., 2013). The inclusion of moringa leaves (1, 2, 5, 10 and 15%) in the diet reduced abdominal fat, increased omega 3 and 6 fatty acids, improving meat color, attributed to greater oxidative stability (Cui et al., 2018).

Neem (*Azadirachta indica*). Active compounds: triterpenoids (azadirachtin, nimbine, salanine, meliacin). Effects: by supplementing 0.25% of Neem leaves, weight gain increase, and it improves feed conversion; it also

has antimicrobial, antiviral and antifungal action (Ansari et al., 2012).

Black pepper (*Piper nigrum*). Active compounds: glutathione peroxidase, glucose-6-phosphate dehydrogenase, vitamin C, curcumin and piperine (Khalaf et al., 2008). Effects: the addition in the diet (0.02 to 1.0%) improves weight gain, feed intake and feed conversion (Al-Kassie et al., 2011b; Shahverdi et al., 2013; Valiollahi et al., 2014; Abou-Elkhair et al., 2014). Black pepper improves the immune system through increasing the concentration of immunoglobulins in serum (Al-Kassie et al., 2011b; Abou-Elkhair et al., 2014; Valiollahi et al., 2014); also, it decreases the blood concentration of cholesterol, triglycerides, low-density lipoproteins and increases the concentration of high-density lipoproteins (Al-Kassie et al., 2011b; Shahverdi et al., 2013; Puvaca et al., 2015; Singh et al., 2018).

Green tea (*Camellia sinensis*). Active compounds: catechins, flavonoids with antioxidant activity (Farahat et al., 2016). Effect: the addition of green tea leaves (0.5 to 2% in the diet) decreases the plasma cholesterol level (Yang et al., 2003), improves the immune response (Wang et al., 2018) to coccidiosis (Jang et al., 2007) and to H9N2 influenza (Lee et al., 2012) and Newcastle (Farahat et al., 2016) viruses.

CONCLUSION

There are several products of herbal origin that can be used in the production of broiler chickens as growth promoters, natural antibiotics and antivirals, as well as alternative sources of antioxidants, all of which offers a viable alternative to partially or totally replace antibiotics in the diet.

REFERENCES

- Abou-Elkhair, R., Ahmed, H.A., & 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-Australasian Journal of Animal Sciences*, 27(6): 847.
- Al-Kassie, G.A., Al-Nasrawi, M.A., & Ajeena, S. J. (2011a). The effects of using hot red pepper as a diet supplement on some performance traits in broiler. *Pakistan Journal of Nutrition*, 10(9): 842-845.
- Al-Kassie, G.A., Al-Nasrawi, M.A., & Ajeena, S.J. (2011b). Use of black pepper (*Piper nigrum*) as feed additive in broilers diet. *Research Opinions in Animal and Veterinary Sciences*, 1: 169-173.
- Alaa, A.A. (2010). The effect of the *Capsicum annum* in the diet of broilers on the isolation and shedding rate of *Salmonella*



- paratyphoid*. Kufa Journal for Veterinary Medical Sciences. 1: 28-38.
- Al-Jaff, F. K. (2011). Effect of coriander seeds as diet ingredient on blood parameters of broiler chicks raised under high ambient temperature. *International Journal of Poultry Science*. 10(2): 82-86.
- Al-Shammari, K.I.A., Batkowska, J., & Gryzinska, M.M. (2017). Effect of various concentrations of an anise seed powder (*Pimpinella Anisum* L.) supplement on selected hematological and biochemical parameters of broiler chickens. *Revista Brasileira de Ciencia Avícola*. 19: 41-46.
- Al-Sultan, S.I. (2003). The effect of *Curcuma longa* (turmeric) on overall performance of broiler chickens. *International Journal of Poultry Science*. 2: 345-353.
- Ansari, J., Khan, S. H., Haq, A. U., & Yousaf, M. (2012). Effect of the levels of *Azadirachta indica* dried leaf meal as phyto-genic feed additive on the growth performance and haemato-biochemical parameters in broiler chicks. *Journal of Applied Animal Research*. 40: 336-345.
- Azeem, T., Zaib-Ur-Rehman, U.S., Asif, M., Arif, M., & Rahman, A. (2014). Effect of *Nigella sativa* on poultry health and production. *Science Letter 2(2)*: 76-82.
- Bansode, V. (2012). A review on pharmacological activities of *Cinnamomum cassia* Blume. *International Journal of Green Pharmacy*. 6(2): 102-108.
- Barakat, D., El-Far, A., Sadek, K., Mahrous, U., Ellakany, H., & Abdel-Latif, M. (2016). Anise (*Pimpinella anisum*) enhances the growth performance, immunity and antioxidant activities in broilers. *International Journal of Pharmaceutical Sciences Review and Research*. 37(24): 134-140.
- Belal, S.A., Uddin, M.N., Hasan, M.K., Islam, M.S., & Islam M.A. (2018). Effect of ginger (*Zingiber officinale*) and garlic (*Allium sativum*) on productive performance and hematological parameters of broiler. *International Journal of Agriculture and Environmental Research*. 4(1): 12-23.
- Brisibe, E.A., Umoren, U.E., Brisibe, F., Magalhaes, P.M., Ferreira, J.F., Luthria, D., Wu, X., & Prior, R.L. (2009). Nutritional characterisation and antioxidant capacity of different tissues of *Artemisia annua* L. *Food Chemistry*. 115: 1240-1246.
- Cherian, G., Orr, A., Burke, I.C., & Pan, W. (2013). Feeding *Artemisia annua* alters digesta pH and muscle lipid oxidation products in broiler chickens. *Poultry Science*. 92:1085-1090.
- Cui, Y.M., Wang, J., Lu, W., Zhang, H.J., Wu, S.G., & Qi, G.H. (2018). Effect of dietary supplementation with *Moringa oleifera* leaf on performance, meat quality, and oxidative stability of meat in broilers. *Poultry Science*. 97(8): 2836-2844.
- Dhama, K., Latheef, S. K., Mani, S., Samad, H.A., Karthik, K., Tiwari, R., Khan, R.U., Alagawany, M., Farag, M.R., Alam, G.M., Laudadio, V., & Tufarelli, V. (2015). Multiple beneficial applications and modes of action of herbs in poultry health and production- A review. *International Journal of Pharmacology*. 11: 152-176.
- Durrani, F.R., Chand, N., Zaka, K., Sultan, A., Khattak, F.M., & Durrani, Z. (2007). Effect of different levels of feed added black seed (*Nigella sativa* L.) on the performance of broiler chicks. *Pakistan Journal of Biological Sciences*. 10: 4164-4167.
- Faghani, M., Rahimian, Y., Rafiee, A., & Namjoo, A.R. (2014). Effect of garlic and cinnamon in comparison to virginiamycin on performance and some haematological parameters in broiler chicks. *Research Opinions in Animal and Veterinary Sciences*. 4(9): 504-507.
- Farahat, M., Abdallah, F., Abdel-Hamid, T., & Hernandez-Santana, A. (2016). Effect of supplementing broiler chicken diets with green tea extract on the growth performance, lipid profile, antioxidant status and immune response. *British Poultry Science*. 57:714-722
- Farhadi, D., Karimi, A., Sadeghi, G., Sheikahmadi, A., Habibian, M., Raei, A., & Sobhani, K. (2017). Effects of using eucalyptus (*Eucalyptus globulus* L.) leaf powder and its essential oil on growth performance and immune response of broiler chickens. *Iranian Journal of Veterinary Research*. 18(1): 60.
- Guil-Guerrero, J.L., Ramos, L., Paredes, J.Z., Carlosama-Yépez, M., Moreno, C., & Ruales, P. (2017). Effects of turmeric rhizome powder and curcumin in poultry production. *Journal of Animal and Feed Sciences*. 26(4): 293-302.
- Hassan, M.S.H., El Sanhoury, M.H., Ali, W.A.H., & Ahmed, A.M.H. (2011). Effect of using eucalyptus leaves as natural additives on productive, physiological, immunological and histological performance of laying Japanese quail. *Egyptian Poultry Science*. 31:305-329.
- Hashemi, S. R., & Davoodi, H. (2010). Phyto-genics as new class of feed additive in poultry industry. *Journal of Animal and Veterinary Advances*. 9(17): 2295-2304.
- Hosseinzadeh, H., Qotbi, A., Ahmad, A., Seidavi, A., Norris, D., & Brown, D. (2014). Effects of different levels of coriander (*Coriandrum sativum*) seed powder and extract on serum biochemical parameters, microbiota, and immunity in broiler chicks. *The Scientific World Journal*. 2014: 1-11.
- Jang, S.I., Jun, M.H., Lillehoj, H.S., Dalloul, R.A., Kong, I.K., Kim, S., & Min, W. (2007). Anticoccidial effect of green tea-based diets against *Eimeria maxima*. *Veterinary Parasitology*. 144:172-175.
- Khalaf, A.N., Shakya, A.K., Al-Othman, A., El-Agbar, Z., & Farah, H. (2008). Antioxidant activity of some common plants. *Turkish Journal of Biology*. 32: 51-55.
- Karangiya, V.K., Savsani, H.H., Patil, S.S., Garg, D.D., Murthy, K.S., Ribadiya, N.K., & Vekariya, S.J. (2016). Effect of dietary supplementation of garlic, ginger and their combination on feed intake, growth performance and economics in commercial broilers. *Veterinary World*. 9(3):245-250.
- Kumar, P., & Patra, A. K. (2017). Beneficial uses of black cumin (*Nigella sativa* L.) seeds as a feed additive in poultry nutrition. *World's Poultry Science Journal*. 73(4): 872-885.
- Lee, S.H., Lillehoj, H.S., Jang, S.I., Kim, D.K., Ionescu, C., & Bravo, D. (2010). Effect of dietary curcuma, capsicum and lentinus on enhancing immunity against *Eimeria acervulina*. *Journal of Poultry Science*. 47: 89-95.
- Lee, H.J., Lee, Y.N., Youn, H.N., Lee, D.H., Kwak, J.H., Seong, B.L., Lee, J.B., Park, S.Y., Choi, I.S., & Song, C.S. (2012). Anti-influenza virus activity of green tea by-products *in vitro* and efficacy against influenza virus infection in chickens. *Poultry Science*. 91:66-73.
- Lillehoj, H. S., & Lee, K. W. (2012). Immune modulation of innate immunity as alternatives-to-antibiotics strategies to mitigate the use of drugs in poultry production. *Poultry Science*. 91: 1286-1291.
- Mahmood, M.S., Ahmad, M.F., Hussain, I., Abbas, R.Z., Khan, A., & Rafiq, A. (2014a). Growth promoting effect of *Pimpinella anisum*

- (aniseed) in broiler chickens. *Boletín Latinoamericano y del Caribe de Plantas Medicinales y Aromáticas*. 13(3).
- Mahmood, M.S., Hussain, I., Ahmad, M.F., Khan, A., Abbas, R.Z., & Rafiq, A. (2014b). Immunomodulatory effects of *Pimpinella anisum* L. (aniseed) in broiler chicks against Newcastle disease and infectious bursal disease viruses. *Boletín Latinoamericano y del Caribe de Plantas Medicinales y Aromáticas*. 13(5).
- Makwana, R.B., Raval, A.P., Chauhan, H.D., Kulkarni, R.C., Srivastava, A.K., Bhagwat, S.R., & Rajgor B.B. (2015). Effects of garlic (*Allium sativum*) supplementation on growth performance, carcass characteristics and economics of broilers. *Journal of Animal Research*. 5(4):843-848.
- Melesse, A., Getye, Y., Berihun, K., & Banerjee, S. (2013). Effect of feeding graded levels of *Moringa stenopetala* leaf meal on growth performance, carcass traits and serum biochemical parameters of chickens. *Livestock Science*. 157: 498-505.
- Nafea, H.H., Hamid, B.I., & Mousa, B.H. (2018). Effect of dietary *Melissa officinalis* and *Laurus nobilis* on some microbial traits of broiler. *The Eurasia Proceedings of Science, Technology, Engineering and Mathematics*. 3: 121-125.
- Nayaka, H.B., Umakantha, B., Wilfred, S., Murthy, H.N.N., & Naravanaswamy H. (2012). Effect of neem, turmeric, vitamin E and their combinations on immune response in broiler. *Global Veterinaria*. 9: 486-489.
- Nouzarian, R., Tabeidian, S.A., Toghyani, M., Ghalamkari, G., & Toghyani, M. (2011). Effect of turmeric powder on performance, humoral immune responses and serum metabolites in broiler. *Journal of Animal and Feed Sciences*. 20: 389-400.
- Oleforuh-Okoleh, V.U., Chukwu, G.C., & Adeolu, A.I. (2014). Effect of ground ginger and garlic on the growth performance, carcass quality and economics of production of broiler. *Global Journal of Bioscience and Biotechnology*. 3(3): 225-229.
- Panaite, T.D., Criste, R.D., Saracila, M., Tabuc, C., Turcu, R.P., & Olteanu, M. (2018). The use of ascorbic acid and *Artemisia annua* powder in diets for broilers reared under heat stress. *Romanian Biotechnological Letters*. 23(5): 13976.
- Patel, R.M., Garg, D.D., Patel, V.R., Vahora, S.G., Raval, A.P., & Choubey, M. (2017). Effect of dietary supplementation of garlic (*Allium sativum*) and fenugreek (*Trigonella foenumgraecum* L.) seed powder on growth performance, carcass characteristics and economics of feeding in broilers. *Journal of Animal Research*. 7(2):313-318.
- Puvaca, N., Kostadinovic, L., Ljubojevic, D., Lukac, D., Levic, J., Popovic, S., & Duragic, O. (2015). Effect of garlic, black pepper and hot red pepper on productive performances and blood lipid profile of chickens. *European Poultry Science*. 79: 1-13.
- Saeid, J.M., & Al-Nasry, A.S. (2010). Effect of dietary coriander seeds supplementation on growth performance, carcass traits and some blood parameters of broiler chickens. *International Journal of Poultry Science*. 9:867-870.
- Saeed, M., Kamboh, A.A., Syed, S.F., Babazadeh, D., Suheryani, I., Shah, Q.A., & Alagawany, M. (2018). Phytochemistry and beneficial impacts of cinnamon (*Cinnamomum zeylanicum*) as a dietary supplement in poultry diets. *World's Poultry Science Journal*. 74(2): 331-346.
- Shahverdi, A., Kheiri, F., Faghani, M., Rahimian, Y., & Rafiee, A. (2013). The effect of use red pepper (*Capsicum annum* L.) and black pepper (*Piper nigrum* L.) on performance and hematological parameters of broiler chicks. *European Journal of Zoological Research*. 2(6): 44-48.
- Singh, J., Sethi, A.P.S., Sikka, S.S., Chatli, M.K., & Kumar, P. (2014). Effect of cinnamon (*Cinnamomum cassia*) powder as a phytobiotic growth promoter in commercial broiler chickens. *Animal Nutrition and Feed Technology*. 14: 471-479.
- Singh, J., Sharma, M., Mehta, N., Singh, N.D., Kaur, P., Sethi, A.P.S., & Sikka, S.S. (2018). Influence of supplementation of black pepper powder through feed in broiler chickens on growth performance, blood profile, meat sensory qualities and duodenum morphology. *Indian Journal of Animal Sciences*. 88(2): 215-221.
- Thiamhirunsopit, K., Phisalaphong, C., Boonkird, S., & Kijparkorn, S. (2014). Effect of chili meal (*Capsicum frutescens* LINN.) on growth performance, stress index, lipid peroxidation and ileal nutrient digestibility in broilers reared under high stocking density condition. *Animal Feed Science and Technology*. 192: 90-100.
- Toghyani, M., Toghyani, M., Gheisari, A., Ghalamkari, G., & Eghbalsaid, S. (2011). Evaluation of cinnamon and garlic as antibiotic growth promoter substitutions on performance, immune responses, serum biochemical and haematological parameters in broiler chicks. *Livestock Science*. 138: 167-173.
- Valiollahi, M.R., Rahimian, Y., Miri, Y., Asgarian, F., & Rafiee, A. (2014). Effect of ginger (*Zingiber officinale*) and black pepper (*Piper nigrum* L.) powder on performance, haematological parameters and antibody titre in broiler chicks. *Research Opinions in Animal and Veterinary Sciences*. 4(3):128-132.
- Vinus, R.D., Sheoran, N., Maan, N.S., & Tewatia, B.S. (2018). Potential benefits of herbal supplements in poultry feed. *The Pharma Innovation Journal*. 7(6): 651-656
- Wang, Y., Yin, C., Wang, D., Huang, J., Ho, C. T., Zhou, Y., & Wan, X. (2018). Supplemental summer-autumn tea leaf (*Camellia sinensis*) improve the immune status of broilers. *Journal of Applied Animal Research*. 46: 1260-1267.
- Yang, C.J., Yang, I.Y., Oh, D.H., Bae, I.H., Cho, S.G., Kong, I.G., Uganbayar, D., Nou, I.S., & Choi, K.S. (2003). Effect of green tea by-product on performance and body composition in broiler chicks. *Asian-Australasian Journal of Animal Sciences*. 16:867-872.
- Yazdi, F.F., Ghalamkari, G., Toghyani, M., Modaresi, M., & Landy, N. (2014). Anise seed (*Pimpinella anisum* L.) as an alternative to antibiotic growth promoters on performance, carcass traits and immune responses in broiler chicks. *Asian Pacific Journal of Tropical Disease*. 4(6): 447-451.
- Youssef, S.F., Selim, N.A., Abdel-Salam, A.F., & Nada, S.A. (2016). Evaluations of some natural antioxidant sources in broiler diets: effect of different ginger extract forms and levels on broiler performance, immune response and quality of chilled and frozen meat. *Egyptian Poultry Science*. 36:299-317.
- Zekovic, Z.P., Lepojevic, Z.D., & Mujic, I.O. (2009). Laurel extracts obtained by steam distillation, supercritical fluid and solvent extraction. *Journal of Natural Products*. 2: 104-109.
- Zhang, G.F., Yang, Z.B., Wang, Y., Yang, W.R., Jiang S.Z., & Gai G.S. (2009). Effects of ginger root (*Zingiber officinale*) processed to different particle sizes on growth performance, antioxidant status and serum metabolites of broiler chickens. *Poultry Science*. 88: 2159-2166.