Turkish Journal of Agriculture - Food Science and Technology, 6(1):102-106, 2018

Turkish Journal of Agriculture - Food Science and Technology

Available online, ISSN: 2148-127X
www.agrifoodscience.com,
Turkish Science and Technology

Turmeric (*Curcuma Longa*): An Underutilized Phytogenic Additive in Poultry Nutrition

Olumuyiwa Joseph Olarotimi*

Department of Animal Production and Health, The Federal University of Technology Akure, P.M.B 704, Akure, Ondo State, Nigeria

ARTICLEINFO

Review Article

Received 21 September 2017
Accepted 22 November 2017

Keywords:

Broilers
Curcumin
Ginger
Haematology
Hen
Phytotoxicity

ABSTRACT

The aim of this review paper is to explore the available information from research findings on the use of Turmeric (*Curcuma longa*) as a reliable phytogenic antibiotic for poultry production in the tropics especially in Nigeria and other countries. A wide range of phytogenic additives has found a growing interest in fortification of poultry diets. Supplementation of natural alternatives to antibiotic growth promoters in order to maintain both birds' performance and health in the tropics will be a welcome development. Turmeric has reportedly been widely supplemented in poultry diets as natural alternative antibiotics in several studies with outstanding performances. The nutritional, medicinal, haematological and phyto-toxicological effects of turmeric were reviewed in this paper. Hence, turmeric supplementation at recommended inclusion rate in poultry feeds without posing any deleterious effects to the birds' performances as well as the consumers of the products, and ultimately, leading to better profitability on the part of the farmers, will be a nutritional breakthrough for the farmers in the tropics.

*Corresponding Author:
E-mail: joemuyi@gmail.com

DOI: https://doi.org/10.24925/turjaf.v6i1.102-106.1572

Introduction

The sublime aim of poultry production in the developing countries of the world is to achieve optimum production at least costs possible in meeting animal protein requirements of the populace in such a practice that transcends the religious and/or social restriction perceptions of every individual. In poultry production, the source of additive in feed is very important as this will have a resultant effect on the quality of the products to be consumed by entire populace. For decades, the use of antibiotics as a growth promoter in commercial poultry production has been the usual practice. The inclusion of such as an additive in poultry diet was remarkable for reducing morbidity and mortality; increasing feed efficiency and growth performance of broiler chickens. Intestinal pathogens tend to reduce the growth rate of poultry. The use of antibiotics, Antimicrobial Growth Promoters (AGP), in combating these pathogens has been severally stressed. The main challenge with the use of AGP in poultry production is that of the residual effects it always leaves in the bird's tissues. This poses a great health risk to the consumer of such products. When passed on to humans through the food chain, it results in the breakdown of the immune system (Basak, 2015). This has, therefore, paved the way for the use of natural products especially the phytogenic additives as potential replacement for antibiotics. Natural products from herbs and spices have been reportedly used as feed additives for several farm animals (Khan et al., 2012). Their inherent advantages as compared with synthetic antibiotics or inorganic chemicals are that they are natural, less toxic and residue free. These characteristics have rightly positioned them to be ideal feed additives in animal production (Wang et al., 1998).

Turmeric (*Curcuma longa*) is one of the numerous phytogenic additives of importance in poultry feed production. Turmeric and its extracts have been reported to be an effective alternative to AGP's in poultry production (Bask, 2015). Turmeric is a rhizome of the herbaceous perennial plant of the ginger family, Zingiberaceae. Though it is known to be native to the tropical South Asia, it is also widely grown in Nigeria and other tropical and sub-tropical Africa since it requires temperature between 20 and 30℃ and a considerable amount of annual rainfall for growth (Khan et al., 2012).

Nutritional Benefits of Turmeric as Poultry Feed Additive

Several authors have reported the proximate composition of turmeric rhizome (Table 1). Chattopadahyay et al. (2004) reported 6.3% proteins, 5.1% fat, 3.5% minerals, 69.4% Carbohydrates and 13.1%Moisture. Ikpeama et al. (2014) reported that turmeric contains 8.92% moisture, 2.85% ash, 4.60% crude fibre, 6.85% fat, 9.40% crude protein and 67.38% carbohydrate. Another report outlined the composition of turmeric as having carbohydrates (67.91%), low contents of fat (2.46%), fiber (4.02%) and protein (9.34%) (Youssef et al., 2014). The fibre (4.60%) content is also indicative that turmeric will help maintain the digestive tract integrity of the birds fed. Turmeric is also noted to be rich in minerals and vitamins (Table 2). The leaves are equally great source of vitamin and minerals (Chattopadhyan et al., 2004). Ikpeama et al. (2014) opined that the fact the ash content of turmeric was 2.85% shows that turmeric will contain reasonable amount of minerals. The amino acid content of tumeric is also high (Table 2). Ikpeama et al. (2014) had shown that turmeric contains 0.89% thiamine, 0.16% riboflavin, 2.30% naicine, 0.20% calcium, 0.63% phosphorus, 0.46% potassium and 0.05% iron. Curcumin powder made from turmeric was reported to be a rich source of minerals and antioxidants such as Ca, P, K and Mg as well as total phenols, flavonoids and vitamin C (Youssef et al., 2014).

It has been reported that turmeric supplemented at 1.0 g/kg diet improved growth performance of broiler chickens (Kumari et al., 2007). In another study, 0.75% and 1% inclusion of turmeric in the diets of broiler chickens were recorded to bring about an improved body weight gain, feed intake and feed conversion ratio (Al-Kassie et al., 2011). He further opined that dietary feeding of essential oils extracted from turmeric potentially improve the secretion of digestive enzymes and consequently improve the digestibility of the feeds and enhance the performance of broilers. Another study also supported that turmeric has the ability to stimulate the digestive system, increase the secretion of intestinal lipases, amylase, trypsin and Chymotrypsin enzymes hence enhancing digestibility (Rajput et al., 2012). Furthermore, increased weight gain and feed conversion ratio (FCR) with significant reduction in feed intake were recorded by Durrani et al. (2006) when broilers were fed turmeric at 0.5% inclusion rate as against that of the control group.

Nanung (2013) reported that dietary supplementation of poultry diets with turmeric may have beneficial effects on the carcass traits of broiler chickens as it contains beneficial phytochemicals, like curcumin, ar-turmerone, methylcurcumin, and other active compounds. Wang et al. (2015) also documented that dietary turmeric supplementation at 100 – 300 mg/kg diet significantly increased the breast muscle weight and breast muscle weight ratio ($P<0.05$), but significantly reduced abdominal fat ratio ($P<0.05$) as compared to the control group. They further explained the decrease in abdominal fat might be due to the influence of curcumin on adipocyte apoptosis or glucose withdrawn from blood as by Sugiharto et al. (2011). Curcumin had been reportedly mentioned in significantly decreasing total cholesterol, which might be due to inhibition of hepatic 3-hydroxyl-3-methyglutaryl CoA reductase, which is responsible for cholesterol synthesis in the liver (Al-Kassie et al., 2011, Gandhi et al., 2011 and Kumari et al., 2007).

Away from broiler chickens, several reports have equally highlighted the beneficial effects of turmeric on laying hens. Supplementation of layer diets with turmeric meal at 5 g/Kg had been reported to increase percentage hen day production (%HDP) while the internal and external egg qualities such as egg weight, egg mass, yolk weight and yolk index were significantly increased at the group fed 10 g/kg (Radwan et al., 2008). They further suggested that turmeric may have positive effect on the site of calcium deposition in the uterus and hence increase shell weight and thickness.

However, some other authors reported findings contrary to the beneficial effects of turmeric earlier highlighted. Akbarian et al. (2012) did not find beneficial effects on supplementing diets with turmeric meal at the rate of 0.5 g/kg while Rahmatnejad et al. (2009) at 1.0 g/kg. There have been negative findings as well when 2.0 g/kg (El-Hakim et al., 2009), 5.0 g/kg (Yarru et al., 2009), 10.0 g/kg and 30.0 g/kg (Abbas et al., 2010) of turmeric was supplemented in poultry diets. Emadi and Kermanshahi (2007) reported that supplementation of Turmeric has no significant effect on feed intake, weight gain and feed conversion ratio of broiler chicks. Moorthy et al. (2009) reported no significant effect of feeding 0.1% turmeric on laying birds and percent hen day egg production of Single Comb White Leghorn layers.

Riasi et al. (2008) reported that feeding different levels (0.0, 0.5, 1.0, 1.5 and 2.0 g/kg of feed) of turmeric to the laying hens had no significant effect on specific gravity, egg shell thickness, egg shell weight and eggs shell weight to egg weight ratio. Malekizadeh et al. (2012) further supported that supplementation of turmeric meal in the diet at the rate of 10.0 or 30.0 g/kg did not influence egg production, egg weight, and egg mass of single comb White Leghorn (W-36) laying hens. The dissimilarities in these results found in the egg traits may be caused by some differences in the experimental methods used in those studies or may be a dose-dependent issue.

Haematological and Serum Biochemical Effects

Apart from the nutritional benefits that turmeric has been found to confer on poultry birds, it also has various physiological effects. A lot of studies have reported some of the haematological effects turmeric has on poultry production. It has been widely reported that turmeric supplementation has beneficial effects on the blood physiology in poultry chickens. Turmeric meal inclusion in broiler diets at 0.35 g/Kg has been found to stimulate the production of Serum High-density lipoproteins (HDL), thereby reducing the total cholesterol, LDL (Low-density lipoproteins) and VLDL (very low density lipoprotein) concentrations in serum (Zhongze et al., 2008). Kermanshahi and Riasi (2006) and Riasi et al. (2012) were also in agreement with this finding by showing that 0.5-1.5 g/kg turmeric meal supplementation in layers diets decreased the level of triglyceride, total

cholesterol, LDL-cholesterol, and increased the level of HDL-cholesterol in the blood of the laying hens.

Further study by Emadi and Kermanshahi (2007) posited that 2.5 g/kg turmeric meal supplementation in the diet of broiler chickens increased the total cholesterol and HDL-cholesterol, while 5.0 g/kg supplementation increased haemoglobin and reduced LDL-cholesterol, very low-density lipoprotein cholesterol (VLDL-cholesterol), and red blood cells of the broiler chickens at 42 days of age.

Al-Sultan (2003) observed a significant increase in both serum red and white blood cells concentrations upon inclusion of 10 g/Kg turmeric meal in the diet of broiler chickens. Also, Sugiharto et al. (2011) supported a significant increase in serum erythrocyte counts when 600 mg/kg live body weight turmeric meal supplementation in the drinking water of broiler chickens was administered. Naderi et al. (2014) observed that turmeric powder at the rate of 2.5 g/Kg and 7.5 g/Kg of the diet significantly increased lymphocytes percentage compared with the control group ($P<0.05$). Also, the percentage of heterophils significantly was reduced by turmeric powder at the level of 2.5 g/Kg of the diet ($P<0.05$). In addition, supplementation of the diet with turmeric powder (2.5 g/Kg and 7.5 g/Kg) significantly reduced the ratio of heterophils/lymphocytes compared with the control group ($P<0.05$).

The presence of curcumin in turmeric rhizome has been suggested to be responsible for this improvement (Antony et al., 1999). More so, Gowda et al., 2009 reported that dietary supplementation of 222mg/Kg curcuminoids had amelioration impact on the adverse effects of Aflatoxin B1 on serum total protein, albumin and γ – Glutamyl transferase activity.

Turmeric also has profound beneficial effects on the serum enzymes. Another study has shown that supplementation of turmeric meal in poultry diets at the rate of 2.5 to 7.5 g/Kg potentially reduced the concentrations of alkaline phosphatase (ALP), Alanine aminotransferase (AST) and Lactate dehydrogenase (LDH) in the blood of broiler chickens (Emadi and Kermanshahi, 2007). Accumulation of these enzymes in the liver will result in hepatotoxicity. Curcumin also has enhancement effects on the concentration of Catalase and Super oxide dismutase (SOD) and glutathione peroxidase which in turn have an effect on the antioxidant status of the body of the birds. (Yarru et al., 2009).

Medicinal

Turmeric has also been reported to confer herbal-therapeutic effect on poultry. Dietary inclusion of 0.5 g/Kg turmeric was noted to have shown humoral immune stimulatory potential in poultry by causing ameliorative effect on the harmful effect of Aflatoxin B1 on the body's immune system (Kurkure et al., 2000). Turmeric supplemented in layers diets was reported to enhance the body immune system of the birds against the harmful effects of Ochratoxin A infection on body weight gain and feed efficiency (Sawale et al., 2009). Turmeric supplementation at 3% levels in the poultry diets was reported to have conferred coccidiostatic effects on the treated birds as the peak excretion of oocysts was reportedly delayed about 1 or 2 days relative to the control infected group (Abbas et al., 2010). This was also buttressed by Lee et al. (2010) which reported that fecal oocyst shedding from birds infected with E. acervulina was significantly decreased when broiler chickens were fed with a diet containing turmeric. Churchill et al. (2000) reported that curcumin treatment increased the number of mucosal CD4 (+) T and B cells, suggesting that curcumin modulates lymphocyte-mediated immune functions. Curcumin at concentrations of 25, 50, 100, 200 and 400 μM had also been reported to show considerable effects on Emeria tenella sporozoite morphology and viability in a dose-dependent manner after incubation over 3, 6, 18 and 24 hours (Khalafalla et al., 2011). The report further showed that the sporozoite infectivity was reduced at curcumin concentrations of 100 and 200 μM by 41.6% and 72.8%, respectively when compared with that of the control group. The anticoccidial activity of turmeric was explained to be due to its antioxidant properties (Allen et al., 1998).

Table 1 Proximate and amino acids profile of turmeric*

Parameters	Composition
Proximate	(%)
Moisture	8.92-13.1
Crude Protein	9.34-9.40
Dry Matter	87-91
Ash	2.85-9.67
Fibre	4.02-4.60
Fat	2.46-6.85
Carbohydrate	67.38-6.91
Amino Acids (Essential)	(%)
Ariginine	2.48
Histidine	1.8
Isoleucine	7.58
Leucine	2.53
Lysine	12.73
Methionine	3.28
Threonine	2.87
Valine	1.53
Non-Essential	(%)
Alanine	2.55
Aspartic acid	5.05
Glutamic acid	8.75
Glycine	3.42
Serine	2.29
Tyrosine	3.68

*References: Ikpeama et al (2014), Chattopadhyay et al. (2011), Youssef et al. (2014), Ashish et al. (2014)

Phyto-toxicological Effects

Turmeric is reported as a safe, natural, and residue free phytogenic antibiotics and the curcumin has been widely reported safe for human and animal consumption (WHO 1987; Wang et al., 1998). There is no documented publication till date that have reported harmful effects of turmeric meal in poultry diets when used at low to moderate concentrations (Nanung et al., 2013). However, excessive consumption of turmeric is not recommended because it may induce hepatotoxic effect as observed in experimental mice and rats (Kandarkar et al., 1998; Deshpande et al., 1998). In broiler ration, an inclusion

rate of not more than 50 g/kg turmeric meal is recommended to avoid induction of parenchymal and portal infiltration of mononuclear cells and hyperaemia of portal vessels (Al-Sultan and Gameel, 2004). There are no other current studies on toxicological effects in birds which can be found in the literature.

Table 2 Vitamins, minerals and antioxidant profile of turmeric*

Parameters	Composition
Vitamins	(%)
Riboflavin	0.59
Thiamine	0.16
Niacin	2.3
Ascorbic acid	2.59
Vitamin A	0
Minerals	mg/kg
Ca	2288
P	5439
K	5513
Fe	110
Mn	23
Cu	6
Mg	1795
Na	947
Antioxidant	g/100g
Total Phenols	6.487
Flavonoids	4.509
Lycopene	0.0173
Vit C	2.59
Vit E	0.31

*References: Ikpeama et al (2014), Chattopadhyay et al (2011),Youssef et al (2014), Ashish et al (2014)

Conclusion

From the available reports, apart from the fact that turmeric could be a veritable source of protein and carbohydrate, improvements recorded on the growth and hen day production performances in birds fed turmeric meal supplemented diets in all the studies could be attributed to the beneficial properties of phytochemicals in turmeric that presented it as viable antimicrobial, antifungal, and antioxidant phytogenic feed additives capable of improving the utilization of dietary nutrients in birds and hence bringing about safer products and better profitability.

References

Abbas RZ, Iqbal Z, Khan MN, Zafar MA, Zia MA. 2010. Anticoccidial activity of *Curcuma longa* L. in broilers. Braz. Arch. Biol. & Tech. 53: 63-67.

Akbarian A, Golian A, Kermanshahi H, Gilani A, Moradi S. 2012. Influence of turmeric rhizome and black pepper on blood constituents and performance of broiler chickens. Afri. J. Biotech. 11: 8606-8611.

Al-Kassie GAM, Mohseen AM, Abd-ALJaleel RA. 2011. Modification of productive performance and physiological aspects of broilers on the addition of a mixture of cumin and turmeric to the diet. Res. Opin. Anim. & Vet. Sci. 1: 31-34.

Allen PC, Danforth HD, Augustine PC. 1998. Dietary modulation of avian coccidiosis. Int'l. J. Parasitol. 28: 1131-1140.

Al-Sultan SI, Gameel AA. 2004. Histopathological changes in the Livers of Broiler Chicken Supplemented with Turmeric (*Curcuma longa).* Int'l. J. Poult. Sci. 3: 333-336.

Al-Sultan SI. 2003. The Effect of Curcuma longa (Turmeric) on Overall Performance of Broiler Chickens. Int'l. J. Poult. Sci. 2: 351-353.

Antony S, Kuttan R, Kuttan G. 1999. Immunomodulatory activity of curcumin. Immuno. Invest. 28: 291-303.

Ashish KS, Rajib CD, Asaduz Z, Muhammed YM. 2014. Amino acids composition and pepsin digestibility of protein isolated from turmeric *(curcuma longa* l.*)* produced in Bangladesh. W. J. Pharma. Res. 3: 1634-1641

Basak S. 2015. Turmeric oil – functional feed additive for poultry nutrition. Available from: https://www.linkedin.com/ pulse/turmeric-oil-functional-feed-additive-poultry-nutrition-basak. Accessed 28th August 2017

Chattopadhyay I, Biswas K, Bandyopadhyay U, Banerjee RK. 2004. Turmeric and curcumin: Biological actions and medicinal applications. Curr. Sci. 87: 44-53.

Chattopadhyay I, Kaushik B, Bandyopadhyay U, Ranajit K. 2011. Turmeric and curcumin: Biological actions. Indust. Toxicol. Res. 78: 2081-2087.

Churchill M, Chadburn A, Bilinski RT, Bertagnolli MM. 2000. Inhibition of intestinal tumors by curcumin is associated with changes in the intestinal immune cell profile. J. Surgic. Res. 89: 169-175.

Deshpande SS, Lalitha VS, Ingle AD, Raste AS, Garde SG, Maru GB. 1998. Subchronic oral toxicity of Turmeric and ethanolic Turmeric extract in female mice and rats. Toxicol. Lett. 95: 183-193.

Durrani FR, Mohammed I, Asal S, Shhail SM, Naila C, Durrani, Z. 2006. Effect of different levels of feed added turmeric (*Curcuma longa*) on the performance of broiler chicks. J. Agric. & Biol. Sci. 1: 9-11.

El-Hakim ASA, Cherian G, Ali MN. 2009. Use of organic acid, herbs and their combination to improve the utilization of commercial low protein broiler diets. Int'l. J. Poult. Sci. 8: 14-20.

Emadi M, Kermanshahi H. 2007. Effect of turmeric rhizome powder on the activity of some blood enzymes in broiler chickens. Int'l. J. Poult. Sci. 6: 48-51.

Gandhi P, Khan K, Chakraverty N. 2011. Soluble curcumin: a promising oral supplement for health management. J. Appl. Pharma. Sci. 1: 1-7.

Gowda NKS, Ledoux DR, Rottinghaus GE, Bermudez AJ, Chen YC. 2008. Efficacy of turmeric (*Curcuma longa*), containing a known level of curcumin, and a hydrated sodium calcium aluminosilicate to ameliorate the adverse effects of aflatoxin in broiler chicks. Poult. Sci. 87: 1125-1130.

Ikpeama A, Onwuka GI, Nwankwo C. 2014. Nutritional Composition of Tumeric (*Curcuma longa*) and its Antimicrobial Properties. Int'l J. Sci. & Engin. Res. 5: 1085-1089

Kandarkar SV, Sharda SS, Ingle AD, Deshpande SS, Maru GB. 1998. Subchronic oral hepatotoxicity of Turmeric in mice–histopathological and ultrastructural studies. Ind. J. Exp. Biol. 36: 675-679.

Kermanshahi, H, Riasi A. 2006. Effect of turmeric rhizome powder (*Curcuma longa*) and soluble NSP degrading enzyme on some blood parameters of laying hens. Int'l. J. Poult. Sci. 5: 494-498.

Khalafalla RE, Müller U, Shahiduzzaman M, Dyachenko V, Desouky AY, Alber G, Daugschies A. 2011. Effects of curcumin (diferuloylmethane) on Eimeria tenella sporozoites in vitro. Parasitol. Res. 108: 879-886.

Khan RU, Naz S, Javdani M, Nikousefat Z, Selvaggi M, Tufarelli V, Laudadio V. 2012. The use of Turmeric (*Curcuma longa*) in poultry feed. W. Poult. Sci. J. 68: 67-103

Kumari P, Gupta MK, Ranjan R, Singh KK, Yadav R. 2007. *Curcuma longa* as feed additive in broiler birds and its pathophysiology effect. Ind. J. Exp. Biol. 45: 272-277.

Kurkure NV, Pawar SP, Kognole SM, Bhandarkar AG, Ganorkar AG, Kalorey DR. 2000. Ameliorative effect of turmeric (*Curcuma longa*) in induced aflatoxicosis in cockerels. Ind. J. Vet. Pathol. 24: 26-28.

Lee SH, Lillehoj HS, Jang SI, Kim DK, Ionescu C, Bravo D. 2010. Effect of dietary curcuma, capsicum, and lentinus on enhancing local immunity against Eimeria acervulina infection. J. Poult. Sci. 47, 89-95.

Malekizadeh M, Moeini MM, Ghazi S. 2012. The effects of different levels of ginger (Zingiber officinale Rosc) and turmeric (*Curcuma longa* Linn) rhizomes powder on some blood metabolites and production performance characteristics of laying hens. J. Agric. Sci. & Tech. 14: 127-134.

Moorthy M, Saravanan S, Mehala C, Ravi S, Ravikumar M, Viswanathan K, Edwin SC. 2009. Performance of single comb white leghorn layers fed with Aloe vera, *Curcuma longa* (turmeric) and probiotic. Int'l. J. Poult. Sci. 8: 775-778.

Naderi M, Akbari MR, Asadi-Khoshoei E, Khaksar K, Khajali F. 2014. Effects of dietary inclusion of turmeric (*curcuma longa*) and cinnamon (*cinnamomum verum*) powders on performance, organs relative weight and some immune system parameters in broiler chickens. Poult. Sci. J. 2: 153-163

Nanung DD. 2013. Turmeric (*curcuma longa* linn.) supplementation as an alternative to antibiotics in poultry diets. WARTAZOA Indo. Bulle. Anim. & Vet. Sci. 23: 41-49

Radwan N, Hassan RA, Qota EM, Fayek HM. 2008. Effect of natural antioxidant on oxidative stability of eggs and productive and reproductive performance of laying hens. Int'l. J. Poult. Sci. 7, 134-150.

Rahmatnejad E, Roshanfekr H, Ashayerizadeh O, Mamooee M, Ashayerizadeh A. 2009. Evaluation the effect of several non-antibiotic additives on growth performance of broiler chickens. J. Anim. & Vet. Adv. 8: 1670-1673.

Rajput N, Muhammad N, Yan R, Zhong X, Wang T. 2012. Effect of dietary supplementation of curcumin on growth performance, intestinal morphology and nutrients utilization of broiler chicks. J. Poult. Sci. 50: 44-52

Riasi A, Kermanshahi H, Fathi MH. 2008. Effect of Turmeric rhizome powder (*Curcuma longa*) on performance, egg quality and some blood serum parameters of laying hens. Pages 297 - 300 in Proc. 1st Mediterr. Summ. World Poult. Sci. Asso. Greece.

Riasi A, Kermanshahi H, Mahdavi AH. 2012. Production performance, egg quality and some serum metabolites of older commercial laying hens fed different levels of turmeric rhizome (*Curcuma longa*) powder. *J. Medic. Plts Res.* 6: 2141-2145.

Sawale GK, Gosh RC, Ravikanth K, Maini S, Rekhe DS. 2009. Experimental mycotoxicosis in layer induced by ochratoxin A and its amelioration with herbomineral toxin binder 'Toxiroak'. Int'l J. Poult. Sci. 8: 798-803.

Sugiharto I, Widiastuti E, Prabowo NS. 2011. Effect of turmeric extract on blood parameters, feed efficiency and abdominal fat content in broilers. J. Indo. Trop. Anim. Agric. 36: 21-26.

Wang D, Huang H, Zhou L, Li W, Zhou H, Hou G, Liu J, Hu L. 2015. Effects of Dietary Supplementation with Turmeric Rhizome Extract on Growth Performance, Carcass Characteristics, Antioxidant Capability, and Meat Quality of Wenchang Broiler Chickens. Itali. J. Anim. Sci. 14: 344-349.

Wang R, Li D, Bourne S. 1998. Can 2000 years of herbal medicine history help us solve problems in the year 2000? Biotechnology in the Feed Industry. Pages 273 – 291 in Proc. Alltech`s 14th Annual Symp. Kentucky, USA.

WHO. 1987. Principles for the safety assessment of food additives and contaminants in food. World Health Organization (WHO), International Programme on Chemical Safety (IPCS), in cooperation with the Joint WHO/FAO Expert Committee on Food Additives (JECFA). Geneva, Switzerland. World Health Organization No. 70.

Yarru LP, Settivari RS, Gowda NKS, Antoniou E, Ledoux DR, Rottinghaus GE. 2009. Effects of turmeric (*Curcuma longa*) on the expression of hepatic genes associated with biotransformation, antioxidant, and immune systems in broiler chicks fed aflatoxin. Poult. Sci. 88: 2620-2627.

Youssef MKE, El-Newihi AM, Omar SM, Ahmed ZS. 2014. Assessment of Proximate Chemical Composition, Nutritional Status, Fatty Acid Composition and Antioxidants of Curcumin (Zingiberaceae) and Mustard Seeds Powders (Brassicaceae). Food & Publ. Health. 4: 286-292

Zhongze H, Like W, Aiyou W. 2008. Effect of curcumin on fat metabolism in Wanjiang Yellow chickens. Cerl. Feed Ind. 4: 12.