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ABSTRACT
Antibiotics have been used in non-therapeutic fashion as growth promoter for about 50 years in many parts of the world. It has been proven that supplementation of antibiotics in the diets reduces morbidity and mortality, as well as improve feed efficiency and overall growth performance of broiler chickens. However, the routine use of these antimicrobial growth promoters (AGPs) is being curtailed in view of threat to public health occurring through microflora that are developing resistance to antibiotics. This risk has driven European Union and other countries to withdraw authorization of in-feed antibiotics since 1997. Removal of AGPs resulted in substantial increase infections in poultry. As a consequence, the poultry industry needs to find alternatives to antibiotics in order to stem the effects of infection. One comparable alternative is natural sources of herbs and medicinal plants, which later known as phytobiotics. For the last 15 years, these alternatives have been increasingly claimed to increase enteric health, stimulate digestive system, and enhance growth performance. It was reported that turmeric (Curcuma longa Linn.) belongs to such class of medicinal plant and may be an alternative to antibiotics in poultry production. In this review, the responses of poultry to diets supplemented with turmeric on growth performance, egg production, health status, and carcass characteristic were briefly discussed.

Keywords: Turmeric, non-antibiotic feed additive, poultry production

INTRODUCTION
Antibiotics have been used as antimicrobial growth promoters (AGPs) in animal feeds worldwide for many years to improve food safety by increasing animal health and reducing or removing certain exogenous pathogens. However, in order to avoid the possible risk of developing resistant pathogens, as well as to meet the public pressure for antibiotic-free animal products, the use of antibiotic in poultry diets was
totally banned in the European Community in January 2006. Nevertheless, apart from preventing the potential hazard, the absence of AGPs in the diet has resulted in health problems in poultry, including significant increase in infection (Casewell et al. 2003). Hofacre (2001) reported that the incidence of necrotic enteritis or Clostridial infection has engendered considerable complications related to animal welfare and resulted in severe economic losses in poultry industries. In order to reduce the disadvantages of sub- and clinical infections, the poultry and feed industries needs to find alternatives to AGPs. These alternatives are required to be generally recognized as safe for both animal and humans, environmentally friendly, applicable in the diets, and address organic livestock issue (Cabuk et al. 2006). Various alternatives of green additives have been studied in order to maximize the growth performance and product quality of poultry in the diets without antibiotics.

Turmeric (Curcuma longa Linn. or C. domestica Val.) is a rhizomatous herbaceous perennial herb of ginger family that is widely used and cultivated in the tropical and sub tropical regions of the world, such as in Pakistan, China, Indonesia, India, Malaysia, Jamaica, and Peru (Govindarajan and Stahl 1980). Linnaeus described turmeric as Curcuma longa and its taxonomic position is as follows:

- **Class**: Liliopsida
- **Subclass**: Commmelinids
- **Order**: Zingiberales
- **Family**: Zingiberaceae
- **Genus**: Curcuma
- **Species**: Curcuma longa

(Chattopadhyay et al. 2004)

Curcuma longa is the domesticated species of turmeric, while the wild one is called C. aromatic. It belongs to the family Zingiberaceae that consists of hundreds species of plants, along with other noteworthy members like curcuma, ginger, white-turmeric, black-turmeric, wild-turmeric, mango-ginger, cardamom, sian-tulip (hidden-ginger), zedoary, and galangal. This medicinal plant possesses rhizomes and underground root-like stems (Araújo and Leon 2001) that had been originally used as a food additive in curries to improve the storage condition, appearance, flavour, palatability, and preservation of food (Jayaprakasha et al. 2005).

**PHYTOCHEMICAL CONTENT OF TURMERIC**

Turmeric rhizome contains the highest active compounds (phytochemicals) than other parts in turmeric plant. Rhizome is the portion of the plant that used medicinally as human remedies and non-medicinally as food (spice) or feed additives. Extraction process of the rhizome results in a dry yellow polyphenol-rich powder that is oil-soluble in its natural state (Khan et al. 2012). When compared with the synthetic antibiotics, phytochemicals in turmeric are known to be natural, less toxic, residue free, and are thought to be ideal as feed additives in animal diets (Wang et al. 1998).

Turmeric contains 6.3% protein, 5.1% fat, 3.5% minerals, 69.4% carbohydrates, and 13.1% moisture (Chattopadhyay et al. 2004). The active ingredients of turmeric rhizomes consist of volatiles and non-volatiles constituents. The major active substances in non-volatile are the colouring agent and are a rich source of phenolic compounds, such as curcumin (Roughley and Whiting 1973), demethoxycurcumin, bisdemethoxy-curcumin, and colourless metabolites tetrahydro-curcumin (Huang et al. 1995). The major active substances in volatile oil are curcuminoids (Toenessen 1992), ar-turmerone (Ferreira et al. 1992), zingiberene (Smith and Robinson 1981), turmerone (Baik et al. 1993), and curlone (Kiso et al. 1983). Curcumin (diferuloylmethane) is the main yellow bioactive component that has a wide spectrum of biological actions, including antioxidant, antibacterial, antifungal, antiprotozoal, antiviral, antiinflammatory, anti-carcinogenic, antihypertensive, and hypo cholesteroleric activities (Bhavani Shankar and Sreenivas Murthy 1979; Govindarajan and Stahl 1980; Masuda et al. 2001; Chattopadhyay et al. 2004; Chen and Huang 2009). It is estimated that 2-5% of turmeric is curcumin (Agarwal et al. 2001). Curcumin and curcuminoids posses antinematocidal (Kiuchi et al. 1993), antiinflammatory (Ammon et al. 1993), antioxidative (Osawa et al. 1995), anticoagulants (Allen and Fetterer 2002; Abbas et al. 2010), and immunomodulatory (Kumari et al. 2007; Yarru et al. 2009) properties. Araújo and Leon (2001) summarized the biological properties of curcumin and other phytochemicals as curcumin (antibacterial, antiviral, antioxidant, antiinflammatory, antitumor), arturmerone (anti-snakkebite), methylcurcumin (antibacterial, antiprotozoal against *Leishmania amazonensis*), curcuminoids (antiprotozoal *Plasmodium falciparum* and *Leismania major*).

Volatile oil of turmeric has biological activities as antibacterial (Bhavani Shankar and Sreenivas Murthy, 1979), antifungal (Banerjee and Nigam, 1978), and anti-inflammatory agents (Chandra and Gupta, 1972). Other bioactive compounds also exhibit beneficial effects, such as demethoxy curcumin (antioxidant), bisdemethoxy curcumin (antioxidant), and sodium curcuminate (anti-inflammatory).
RESPONSES ON GROWTH PERFORMANCE OF BROILER

Numerous reports have been published, advocating the beneficial effects of turmeric meal supplementation on growth performance of broiler chickens. Kumari et al. (2007) reported that turmeric meal supplementation at the rate of 1.0 g/kg improved growth performance of 42-d old Vencob broiler chickens. Al-Sultan (2003) observed that addition of turmeric meal at the rate of 5.0 g/kg increased body weight and feed conversion ratio of broiler chickens. In other study, Durrani et al. (2006) found that supplementation of 5.0 g/kg turmeric meal in the diets resulted in a significant improvement on body weight gain and feed efficiency without any adverse effects on mortality. Allen et al. (1998), Abbas et al. (2010), and Lee et al. (2010a) noted that turmeric meal supplementation alleviated growth-depression effect of Eimeria infection. Similarly, Yarru et al. (2009) reported positive effects of 5.0 g/kg turmeric meal supplementation in birds exposed to aflatoxin. Gowda et al. (2009) reported that feeding broiler chickens with diets containing 74 ppm curcuminoids from turmeric meal ameliorated the growth-depression effect of aflatoxin B1. Zainali et al. (2008) reported that dietary supplementation of 10.0 g/kg turmeric meal increased the body weight gain of (Ross x Ross) broiler chickens reared under the heat stress condition. In a recent study using Arbor Acre broiler chickens, Rajput et al. (2012) showed that supplementation on 0.2 g/kg pure curcumin - phytochemicals derived from turmeric - increased the body weight gain and reduced the FCR of broiler chickens.

Some studies have reported that combinations of turmeric meal and other phytobiotics have beneficial effect to enhance the growth performance of broiler chickens. Al-Kassie et al. (2011) reported that supplementation of turmeric and cumin mixture in the diets at the rate of 5.0 g/kg resulted in a greater body weight gain and lower feed conversion ratio in 42-d old Arbor Acres broiler chickens. Other study (Sawale et al. 2009) have reported that dietary supplementation of layer diets with herbal-mineral mixture containing turmeric reduced the harmful effect of Ochratoxin A infection on body weight gain and feed efficiency. Improvement on the growth performance due to supplementation of turmeric meal in those studies might be attributed to the beneficial properties of phytochemicals in turmeric that posses antimicrobial, antifungal, and antioxidant activities in broiler chickens that may improve the bird utilisation of dietary nutrients (Osawa et al. 1995; Al-Sultan 2003; Radwan et al. 2008). On the other hand, there were reports to show that turmeric had the ability to stimulate the digestive system, such as stimulate the intestinal lipase, sucrase, and maltase activities (Platel and Srinivasan, 1996) as well as the secretion of pancreatic lipase, amylase, trypsin, and chymotrypsin enzymes (Platel and Srinivasan 2000). Recently, Rajput et al. (2012) showed that dietary supplementation of pure curcumin at the rate of 0.2 g/kg in a corn-soybean based diets increased villus length and width in the duodenum, jejunum, and caeca of 42 days old broiler chickens. Therefore, there is a possibility to suggest that improvement on the growth performance due to dietary turmeric meal in broiler chickens is attributed to the improved digestive system in the body.

However, some authors did not find beneficial effects on supplementing diets with turmeric meal at the rate of 0.5 g/kg (Akbarian et al. 2012), 1.0 g/kg (Rahmatnejad et al. 2009), 2.0 g/kg (Mehala and Moorthy 2008; El-Hakim et al. 2009), 5.0 g/kg (Gowda et al. 2008; Yarru et al. 2009), 10.0 g/kg (Al-Sultan 2003; Durrani et al. 2006; Abbas et al. 2010), or 30.0 g/kg (Abbas et al. 2010). In addition, supplementing drinking water with turmeric at the rate of 5.0 g per liter also did not influence body weight gain, daily feed intake, and feed conversion ratio of 21 d old Ross 308 broiler chickens (Sadeghi et al. 2012). The difference in responses of broiler chickens reported in those studies was due to the difference of the basal diets, rearing periods of the broiler or the other experimental details used in those studies, such as statistical design, dose supplementation, and breed of the birds.

RESPONSES ON EGG PRODUCTION AND QUALITY

There were evidences to show that dietary supplementation with turmeric meal stimulated egg production of laying hens. Supplementation of 5.0 g/kg turmeric meal in layer diets increased egg production, weight and mass, while supplementation of 10.0 g/kg increased the yolk weight and yolk index (Radwan et al. 2008). The authors suggested that supplementing layer diets with turmeric meal improved the environment in the uterus (specifically the site of calcium deposition) and consequently increased shell weight and thickness. In a study using a commercial product, supplementation of a herbo-mineral toxin binder product containing turmeric alleviated the adverse effect of Ochratoxin A infection on egg production (Sawale et al. 2009).

However, some studies found no effect of dietary supplementation with turmeric meal on egg production and quality. In a study using Single Comb White Leghorn layers, Moorthy et al. (2009) found that dietary supplementation of 1.0 g/kg turmeric meal did not influence hen house egg production as well as percent hen day egg production. Results in other studies showed that supplementation of turmeric meal
in the diets at 2.0 g/kg (Riasi et al. 2012) or 5.0 g/kg (Radwan et al. 2008) did not affect egg shell thickness or egg shell weight. In recent study, Malekizadeh et al. (2012) reported 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 dissimilarity results found in the egg traits may be caused by some differences in the experimental methods used in those studies.

RESPONSES ON HEALTH STATUS OF BROILERS

Turmeric also has beneficial effects on blood parameters in broiler chickens. Fat metabolism studies using male Wanjiang Yellow (Zhongze et al. 2008) and Arbor Acres (Zhongze et al. 2007; Zhongze 2009) broiler chickens showed that dietary supplementation of turmeric meal at the rate of 0.35 g/kg consistently stimulated the activity of hormone sensitive lipase (HSL) and increased the content of high-density lipoprotein (HDL) in the serum. Dietary supplementation of turmeric meal in the studies also reduced the total cholesterol concentration, total triglycerides, as well as the very low-density lipoprotein (VLDL) content in the blood serum. A study by Kermanshahi and Riasi (2006) showed that 0.5-1.5 g/kg turmeric meal supplementation decreased level of triglyceride, total cholesterol, HDL-cholesterol, and increased level of low-density lipoprotein-cholesterol (LDL-cholesterol) in the blood of Hy-Line W-36 laying hens. Riasi et al. (2012) reported that turmeric has a strong property to change the serum lipid profile in laying hens. Dietary supplementation of 0.5 g/kg turmeric meal in the study reduced the serum triglyceride, total and LDL-cholesterol and increased the serum HDL-cholesterol of Hy-Line W-38 laying hens. Emadi et al. (2007) reported that 2.5 g/kg turmeric meal supplementation in the diet 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 male Ross broiler chickens at 42 days of age. Malekizadeh et al. (2012) reported that 10.0-30.0 g/kg turmeric meal supplementation reduced total cholesterol in the blood serum of Single Comb White Leghorn (W-36) laying hen. Al-Sultan (2003) reported a significant improvement in both erythrocyte and leukocyte when the diets of broiler chicken was supplemented with 10.0 g/kg turmeric meal, while Sugiharto et al. (2011) reported a significant increased in erythrocyte following 600 mg/kg live body weight turmeric meal supplementation in the drinking water of broiler chickens. Antony et al. (1999) suggested that these improvements were attributed to the presence of curcumin in turmeric rhizome.

Other study using (Ross x Ross) male broiler chickens (Gowda et al. 2009) showed that dietary inclusion of 222 mg/kg curcuminoids from turmeric ameliorated the adverse effects of aflatoxin B1 on serum chemistry in terms of total protein, albumin and γ-glutamyl transferase activity. In that study, the depression in antioxidant functions caused by aflatoxin B1 was also mitigated by 222 mg/kg curcuminoids inclusion in the diets. In a study using cumin and turmeric mixture, Al-Kassie et al. (2011) reported that supplementation of 2.5 g/kg herbal mixture reduced blood cholesterol and mortality of Arbor Acres broiler chickens. The improvement in the serum lipid profile supports previous study by Chattopadhyay et al. (2004) and Srinivasan (2005) that turmeric has hypolipidemic and hypocholesterolemic properties.

Turmeric contains active compounds that beneficially stimulate bile secretion and bile flow which can support health of the liver. As noticed by Emadi and Kermanshahi (2007b), supplementation of turmeric meal in the diets at the rate of 2.5-7.5 g/kg reduced the concentrations of alkaline phosphatase (ALP), alanine aminotransferase (ALT), aspartate aminotransferase (AST), and lactate dehydrogenase (LDH) in the blood of broiler chickens. Reductions of these enzymes are important as the accumulation of these enzymes in the liver are related to toxicity. In more recent study, Malekizadeh et al. (2012) showed that supplementing diets with 10.0-30.0 g/kg turmeric meal reduced the ALT and AST in blood serum of single comb white leghorn (W-36) laying hens. In other studies using broiler chickens, dietary supplementation of turmeric meal reduced ALT (Akbarian et al. 2012) and alkaline phosphatase (ALP) activities in the blood serum (Emadi and Kermanshahi 2007a; Emadi and Kermanshahi 2007b), which can be indication of better function of liver. Curcumin has also been reported to be able to enhance the concentration of catalase (Pulla Reddy and Lokesh 1994), as well as the expression of hepatic superoxide dismutase (Cheng et al. 2005) and glutathione peroxidase (Yarru et al. 2009), the enzymes that known to have a close relationship with the antioxidant status of the body. These results were consistent with the result in Dias et al. (2006) study and showed beneficial properties of phytochemicals in turmeric as antioxidant and hepato-protective agents in poultry (Osawa et al. 1995; Araújo and Leon 2001; Maheshwari et al. 2006; Shukla and Singh 2007). These efficacies of phytochemicals in turmeric might be the reason why this additive supports the health status of poultry.
RESPONSES ON IMMUNOMODULATORY SYSTEM

Response of broiler chickens due to dietary turmeric supplementation on immunomodulatory system has been evaluated in some studies. Kurkure et al. (2000) reported that dietary supplementation of 0.5 g/kg turmeric ameliorated the harmful effect of aflatoxin B1 on the body immune system, showing the humoral immune-stimulatory potential in poultry. In this study, the authors demonstrated alleviation on the humoral response against Newcastle disease virus in cockerels induced aflatoxicosis. The number of lymphocytes in lymphoid organs was partially repaired following turmeric administration. Results in mycotoxicosis study (Sawale et al. 2009) showed that turmeric ameliorated the deleterious effects of ochratoxin A on haematobiochemical and body immune system of laying hens. The haemagglutination titre of the birds was increased when the diets were supplemented with 1.25 g/kg herbomineral toxin binder containing turmeric. In other study using (Ross x Ross) broiler chickens, Lee et al. (2010b) demonstrated immunomodulatory properties of turmeric against parasitic infection. Serum antibody level against a microneme protein 2 from Eimeria parasites. It has a putative function in parasite adhesion to the host cell and plays an important role in inhibiting sporozoite invasion of host cell (Sasai et al. 2008).

Turmeric has also been proven to have ability to stimulate the expression of genes which are involved in antioxidant and immune system of broiler chickens. Using a quantitative real-time PCR technique, Yarru et al. (2009) showed that 5.0 g/kg turmeric meal supplementation had beneficial effects on the stimulation of genes expression that involved in antioxidant function [cytochrome P450 1A1 and 2H1 (CYP1A1 and CYP2H1)] and genes expression that involved in the immune system [interleukins 6 and 2 (IL-6 and IL-2)] in broiler chickens. Lee et al. (2010b) reported that when compared to the control group, birds with turmeric administration had significantly higher level of transcripts encoding pro-inflammatory cytokine IL-1β in the duodenum. The levels of transcript encoding IL-6, IL-15 and IFN-γ in that study were also higher in turmeric treated birds. In a study with mice, Chuchill et al. (2000) showed that curcumin treatment increased the number of mucosal CD4 (+) T and B cells, suggesting that curcumin modulates lymphocyte-mediated immune functions. These improvements could be attributed to activity of curcumin as immunostimulant agent (Antony et al. 1999; Yadav et al. 2005; Gautam et al. 2007).

RESPONSES ON CARCASS TRAITS OF BROILERS

Dietary supplementation with turmeric may have beneficial effects on the carcass traits of broiler chickens as it contains beneficial phytochemicals, like curcumin, ar-turmerone, methylecurcumin, and other active compounds. Dietary supplementation of curcumin meal at the rate of 0.35 g/kg reduced the abdominal fat content, subcutaneous fat thickness, intermuscular fat width, and liver fatness of male Wanjian Yellow (Zhongze et al. 2008) chickens. In later study, Zhongze (2009) reported that percentage of abdominal and liver fat weight as well as subcutaneous fat thickness of Arbor Acres and Wangjiang Yellow broiler chickens were reduced following 0.25-0.35 g/kg curcumin supplementation. Samarasinghe et al. (2003) noted that 3.0 g/kg turmeric meal supplementation reduced the fat content and improved carcass quality of broiler chickens. Using a higher level of supplementation (5.0 g/kg), Durrani et al. (2006) showed beneficial effects of dietary turmeric meal supplementation to reduce fat content, increase carcass quality and dressing percentage, as well as to increase the breast, thigh, and giblet weight of broiler chickens. Dietary supplementation of turmeric meal in that study also had favourable effect to reduce the cost per chick ratio.

However, some studies did not find any significant effect of turmeric supplementation at the rate of 1.0 g/kg (Rahmatnejad et al. 2009) or 2.0 g/kg (El-Hakim et al. 2009) on carcass production. Al-Sultan (2003) reported no difference found in the crude protein content in breast and thigh muscles following turmeric meal supplementation in the broiler diets.

TOXICOLOGICAL EFFECTS OF TURMERIC

Turmeric is well known to have a property as a safe, natural, and residue free phytobiotics (Wang et al. 1998). The World Health Organization declared turmeric and its yellow coloring agent (curcumin) as safe to be used in human food and animal feed (WHO 1987). In human and animal studies so far turmeric is considered to have low toxicity (Alia et al. 2006), hence this yellow additive is secure and ideal for poultry. There is no publication as yet that have reported harmful effects of turmeric meal in poultry diets when used at low to moderate concentrations.

Consumption of excessive dosage of turmeric is not recommended because it may induce hepatotoxic effect as noted in studies using mice (Kandarkar et al. 2006). Wanneh et al. (2003) investigated the effect of dietary supplementation of 0.5 to 2.0% turmeric on the body weight and growth performance of broiler chickens. Their results showed that turmeric did not have any significant effect on body weight gain, feed intake, and feed conversion ratio. However, turmeric supplementation improved the dress percentage, abdominal fat content, and subcutaneous fat thickness of the birds. The results of this study suggested that turmeric meal had a positive effect on the carcass traits of broiler chickens.

The World Health Organization declared turmeric as a safe, natural, and residue-free phytobiotic. This natural pigment is considered to be free from any toxic effects. However, studies have shown that the consumption of excessive amounts of turmeric may lead to hepatotoxicity, which can be harmful to the liver. Therefore, it is recommended to use turmeric in moderation and at low to moderate concentrations to avoid any possible adverse effects on the poultry. It is also important to consider the source and quality of turmeric used, as different types may have varying levels of active compounds and may exhibit different effects in the body. Further research is needed to fully understand the impact of turmeric on the immune system and carcass traits of broiler chickens.
1998) and rats (Deshpande et al. 1998). In particular, Al-Sultan and Gameel (2004) recommended not supplementing broiler diets with more than 50.0 g/kg turmeric meal as it may contribute to induction of parenchymal and portal infiltration of mononuclear cells and hyperaemia of portal vessels.

**CONCLUSION**

Available literatures indicate that turmeric (*Curcuma longa*) may be a useful alternative to antibiotics in poultry production system due to its wide safety margin and its efficacies to promote growth performance. The enhancement in growth performance might be attributed to the improved enteric health status, digestive system, immunomodulatory system, and nutrient and energy utilization. However, so far little work has been done to suggest its mode of action in poultry. Therefore, to optimize the efficacy of turmeric meal supplementation in poultry diets, future researches should focus more on the mechanism of action, optimum dose of supplementation, as well as the duration of application.

**REFERENCES**


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.


