doi:10.1017/S004393391200030X

Potential applications of ginger (*Zingiber officinale*) in poultry diets

R.U. KHAN[1]*, S. NAZ[2], Z. NIKOUSEFAT[3], V. TUFARELLI[4], M. JAVDANI[3], M.S. QURESHI[5] and V. LAUDADIO[4]

[1]Department of Animal Health, Faculty of Animal Husbandry and Veterinary Sciences, KPK Agricultural University, Peshawar, Pakistan; [2]Department of Wildlife and Fisheries, GC University, Faisalabad, Pakistan; [3]Department of Clinical Science, Faculty of Veterinary Medicine, Razi University, Iran; [4]Department of Animal Production, Faculty of Veterinary Medicine, University of Bari Aldo Moro, 700100 Valenzano, Bari, Italy; [5]Department of Livestock Management, Faculty of Animal Husbandry and Veterinary Sciences, KPK Agricultural University, Peshawar, Pakistan
***Corresponding author: rifatullahkhhan@gmail.com**

In the last decade, there has been growing interest in the use of natural herbs and medicinal plants as feed additives in poultry diets to maximise their potential output. Ginger is one such potential rhizome with a wide range of medicinal effects. In broilers and layers, this plant has been used in different forms, doses and durations. In this review, documented effects of ginger in poultry feed on feed intake and feed conversion ratio, growth and weight gain, carcass yield, egg production and quality, antioxidants and blood biochemistry, with their possible mechanisms of action, are discussed.

Keywords: ginger; broilers; layers; production; blood metabolites

Introduction

Various feed additives are used in poultry to maximize net returns and carcass quality. In the past, growth-promoting antibiotics were used as feed additives; however, these were associated with residues in the meat and eggs by consumers, and have been banned or limited in many countries (Diarra *et al.*, 2011). As a result, natural alternatives to antibiotics, such as herbs and medicinal plants, have attracted attention due to their wide range of potential beneficial effects (Manesh *et al.*, 2012).

Ginger (*Zingiber officinale*, Rosc.) is a major crop, grown primarily in Central Asia, China, India and Pakistan and exported worldwide. Ginger is a well-known plant and is widely used as a spice and medical treatment for certain ailments in traditional medicine (Larsen *et al.*, 1999; Mohd-Yusof *et al.*, 2002; Tapsell *et al.*, 2006; Zhang *et al.*, 2009). Ginger root contains several compounds which have biological activities such as

World's Poultry Science Journal, Vol. 68, June 2012
Received for publication September 29, 2011
Accepted for publication November 23, 2011

antioxidation, antimicrobial and pharmacological effects (Akoachere *et al.*, 2002; Rabadah *et al.*, 2004; Ali *et al.*, 2008). Ginger contains several active compounds including gingerol, shogaols, gingerdiol, and gingerdione (Kikuzaki and Nakatani, 1996; Zhang *et al.*, 2009; Zhao *et al.*, 2011).

Feed intake and efficiency

Opinion in the literature is divided regarding the influence of ginger on feed intake. Tekeli *et al.* (2011) reported that 240 ppm of *Z. officinale* had a positive effect on feed consumption with respect to negative control broilers. Nasiroleslami and Torki (2010) showed that the addition of the essential oil of ginger did not affect feed intake or feed conversion in laying hens. Zhang *et al.* (2009) did not find any significant difference in daily feed intake by feeding ginger at the rate of 5 g/kg when processed to different particle sizes (300, 149, 74, 37, and 8.4 μm) although numerically the feed intake was higher than the control. Zhao *et al.* (2011) found that daily feed intake and feed conversion ratio (FCR) did not differ between laying hens fed ginger in the diet (5, 10, 15 and 20 g/kg), and Akbarian *et al.* (2011) found that feeding ginger at different levels (0.25, 0.5 and 0.75%) had no effect on feed intake and FCR in laying hens.

Incharoen and Yamauchi (2009) fed dried fermented ginger (1 and 5%) to White Leghorn laying hens and found that feed consumption and FCR tended to increase in ginger fed groups. Likewise, the use of 2% red ginger in the ration of broiler chickens has resulted in higher feed intakes and FCRs (Herawati, 2010). Onu (2010) reported that the addition of ginger (0.25%) in the basal diet of broiler chicks resulted in improved FCR although feed intake did not change.

In some cases ginger has been applied via drinking water in poultry. In their report, Javed *et al.* (2009) reported that broiler chicks dosed with aqueous extract (15 ml/l of drinking) of a mixture of plants containing ginger improved feed intake and FCR. However, Kausar *et al.* (1999) showed that a carminative mixture containing ginger at the dose rate of 2 and 4 ml/l of drinking water increased FCR.

Some researchers have combined plant products, including ginger, in trials. Moorthy *et al.* (2009) found that feed intake did not differ at six week of age, although FCR was significantly higher in birds fed a combination of 0.2% ginger and 0.2% curry leaf powder.

The differences in these reported findings may be due to the different varieties of ginger used, their processing, dose and the duration of the experiments.

Most of the researchers attributed the better performance of the broiler birds fed ginger to an improvement in palatability and the quick digestive effect of this natural product. They further postulated that due to the effect of this natural product, the digestive tract would have been emptied earlier and feed consumption will have been promoted. Ginger has been found to increase secretion of gastrointestinal enzymes including lipase, disaccharidase and maltase (Zhang *et al.*, 2009). According to Herawati (2010) the improved performance may be attributed to the two types of digestive enzymes in ginger; protease and lipase, which are present as part of the plants natural protective mechanisms (Zhang *et al.*, 2009). Zhao *et al.* (2011) reported that ginger enhances animals' nutrient digestion and absorption because of its positive effect on gastric secretion, enterokinesia and digestive enzyme activities.

Growth performance and body weight gain

Tekeli *et al.* (2011) stated that *Z. officinale* improved body weight gain in broiler chickens at the rate of 120, 240 and 360 ppm, however Zhang *et al.* (2009) did not find any significant difference for average daily gain in broilers by feeding ginger at the rate of 5 g/kg. Herawati (2010) found that the use of 2% red ginger in the ration of broiler chickens produced higher body weights. Onu (2010) reported that the addition of ginger (0.25%) to the basal diet of broiler chicks resulted in higher body weights. In their work, Kausar *et al.* (1999) showed that carminative mixture containing ginger at the dose rate of 2 and 4 ml/l of drinking water increased body weight on the 5th week of the experiment. Javed *et al.* (2009) reported that broiler chicks dosed with aqueous extract of a mixture of plants containing ginger improved body weight gain. El-Deek *et al.* (2002) observed that a diet containing 1 g/kg of ginger did not affect growth performance, whereas Farinu *et al.* (2004) reported that supplementation of ginger at the levels of 5, 10, or 15 g/kg slightly improved growth in broilers. In contrast, Al-Homidan (2005) observed reduced growth rate in starter broilers (1 to 4 wk) when ginger was fed at the rate of 60 g/kg body weight at the 6th week of age (Moorthy *et al.*, 2009) which may be due to the toxic effect of this compound (Zhang *et al.*, 2009). The different results on growth performance of broilers may be ascribed to the different doses used in the experiments.

Carcass traits

In a recent study, Zhang *et al.* (2009) observed that birds fed ginger produced higher carcass weights compared to untreated birds. Dressing percentage, breast weight and leg weights increased significantly in response to an aqueous extract of a plant mixture containing ginger (Javed *et al.*, 2009). Zhang *et al.* (2009) suggested that improved carcass quality of broilers may be associated with the antioxidant effect of ginger which enhances protein and fat metabolism. Conversely, Moorthy *et al.* (2009) reported no effect of ginger supplementation on carcass characteristics including New York dressed percentage, eviscerated weight, ready to cook percentage, abdominal fat pad and giblet weight. El-Deek *et al.* (2002) found that the dressing percentage did not differ between control and ginger treated broilers up to sixth week of age. Likewise, Onu (2010) affirmed that the addition of ginger (0.25%) in the basal diet of broiler chicks did not result in significant differences in carcass characteristics.

Egg production and quality

Nasiroleslami and Torki (2010) found that the addition of the essential oil of ginger increased egg shell weight and egg shell thickness in laying hens. However, feeding ginger essential oil did not affect egg index, yolk index and Haugh unit. However, other researchers have not always seen the same benefits. Zhao *et al.* (2011) reported that laying hens fed with ginger at the rates of 5, 10, 15 and 20 g/kg of feed had no effect on laying rate and average egg weight, however egg mass increased significantly in supplemented groups. Akbarian *et al.* (2011) showed that feeding ginger at the rates of 0.5 and 0.75% improved egg production although egg weight did not differ between the control and treated groups. Previous work (Incharoen and Yamauchi, 2009) showed that White Leghorn laying hens fed dried fermented ginger (1 and 5%) showed better egg production and mass in comparison to those of control birds. However, there were no

significant differences in shell breaking strength, shell thickness, shell ratio, albumin ratio, yolk ratio, yolk colour and Haugh unit among the dietary treatments.

The exact mechanism through which egg laying performance is enhanced is not known. 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.

Antioxidant effects

Free radicals are constantly generated inside the body and cause oxidative damage to the cells. Therefore, neutralising entities must be present in order to alleviate such peroxidative damage. The antioxidant defence system includes natural and synthetic antioxidants and antioxidant enzymes present in the biological system (Sies, 1991; Zhang *et al.*, 2009). Free radicals are constantly produced in the body and certain amounts of these components are necessary for normal physiological functions. When their production exceeds normal levels however, they cause peroxidative 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 (Zhang *et al.*, 2009; Zhao *et al.*, 2011). Therefore, an increase in the level of these enzymes would enhance the scavenging capacity of these deleterious substances. Malondialdehyde (MDA) is the end product of lipid peroxidation, therefore, monitoring MDA is a useful indicator of the extent of lipid peroxidation in the cell (Sumida *et al.*, 1989).

Zhang *et al.* (2009) showed that supplementation of ginger at the rate of 5 g/kg significantly increased the activities of SOD and GSHPx and reduced MDA in broilers at the age of 21 and 42 days. The reduced level of MDA indicated that the addition of ginger alleviated the lipid peroxidative damage to the cell. According to these authors, the antioxidant effect of ginger increased linearly with decreasing the size of the ginger particle from 300 to 37 μm. It appears that the effect of the particle size on improving the antioxidant status is likely due to an alteration to the availability of the effective compounds in ginger. However, very low particle size (8 μm) may negate antioxidant activity due to mechanical damage and exposure to ambient air, thereby reducing the usefulness of the effective compounds in the ginger. Zhao *et al.* (2011) reported that supplementation of ginger in laying hens improved serum and egg yolk enzymatic antioxidant activity measured at 35 and 70 days of laying period. Moreover, it has been reported that feeding ginger at the rate of 0.5 and 0.75% significantly increased the activities of GSHPx and reduced MDA concentration in plasma (Akbarian *et al.*, 2011).

Although increased levels of these antioxidant enzymes and a reduction in MDA concentration may be due to the presence of ginger in the feed, the mechanism involved is not yet known. Literature has shown that polyphenolic flavonoids in the plants are some of the major sources of the antioxidant compounds (Huang and Frankel, 1997; Singh *et al.*, 2005). The potential active ingredients in ginger are gingerols, shogaols, gingerdiol, gingerdione and some related phenolic ketone derivatives (Kikuzaki and Nakatani, 1996; Fuhrman *et al.*, 2000; Zhang *et al.*, 2009; Zhao *et al.*, 2011). Some studies have also shown that raw ginger plant materials and single constituents like [6]- gingerol have the ability to protect against lipid peroxidation (Aeschbach *et al.*, 1994; Kuo *et al.*, 1999). Furthermore, Zhao *et al.* (2011) reported that ginger contains several compounds such as gingerol, shogaols, gingerdiol,

gingerdione, and some relating phenolic ketone derivatives that possess antioxidant activities. They concluded that the enhanced serum antioxidants may be partially attributed to the slowing of the process of oxidation of the feed by ginger powder.

Blood biochemistry

Saeid *et al.* (2010) found that serum glucose, total cholesterol, LDL-cholesterol and VLDL-cholesterol decreased significantly in broilers fed with 0.4 and 0.6% aqueous ginger extract, however, HDL-cholesterol concentration increased in these birds. Onu (2010) reported that supplementation of ginger (0.25%) in the basal diet of broiler chicks did not result in any significance difference in terms of total protein, albumin, globulin, urea and creatine. Recently, Rehman *et al.* (2011) studied the effect of dosing broilers (10 ml/l of drinking water) with an aqueous extract of a mixture of medicinal plants (garlic, berberine and aloe vera) along with ginger, which resulted in a significant decrease in serum glucose, ALT (alanine aminotransferase), AST (aspartate aminotransferase) and ALP (alkaline phosphatase) concentration, however, serum protein increased significantly in the treated group. In the same experiment, the cholesterol profile including total cholesterol, triglyceride, LDL, VLDL decreased significantly in the treated group, while HDL cholesterol concentration increased. Zhang *et al.* (2009) found that total protein concentration was higher at 21 day and 42 days of sampling in broilers treated with ginger powder but cholesterol concentration was reduced at these intervals. Kausar *et al.* (1999) reported that carminative mixture containing ginger at the dose rate of 2 and 4 ml/L of drinking water did not affect serum albumin, globulin and total protein in broilers. Al-Homidan (2005) observed reduced total protein and globulin in the plasma of broiler chicks due to dietary supplementation of 60 g/kg which may be due to a toxic effect of the ginger. Farinu *et al.* (2004) reported that supplementation of ginger at the rate of 5, 10 and 15 g/kg did not affect total protein and albumin in the serum of broiler chickens. The discrepancies in these results may be due to the difference in doses used as well as experimental conditions.

The exact mechanisms through which blood metabolites are altered are not known. It was postulated that (E)-8 beta, 17-epoxyllabed-12-ene-15, 16-dial, a compound isolated from ginger, interferes with cholesterol biosynthesis in liver homogenates of hypercholesterolaemic mice causing its reduction (Tanabe *et al.*, 1993). Srinivasan and Sambaiah (1991) reported that feeding rats with ginger significantly elevated the activity of hepatic cholesterol 7-alpha-hydroxylase which is a rate limiting enzyme in the biosynthesis of bile acids and stimulates the conversion of cholesterol to bile acids leading to the excretion of cholesterol from the body.

Toxicological effects

Studies concerning the toxicological effects of using ginger as a feed supplement in poultry feed are rare. However, Herawati (2010) reported that broilers fed diets containing 0.5, 1.0 and 1.5% red ginger showed oedema, necrosis and inflammation in muscles. Ginger contains atsiri sescuiterpen oil which is potentially toxic in animals. All phytobiotics have toxic characteristics and the intensity of their toxicity is determined by the dose and duration of the feeding period (Herawati, 2010). Feeding such substances at higher doses causes symptoms of congestion, oedema, inflammation and necrosis (Ganiswarna, 1995).

Other effects

The surface of the gastrointestinal tract in chickens responds very quickly to alterations in nutrient intake (Dou *et al.*, 2002). The histology of the intestinal villi and epithelial cells on the apical surface is commonly affected by dietary feed components (Yamauchi *et al.*, 2006). It has been suggested that longer villi absorb a greater amount of available nutrients due to an increased surface area (Caspary, 1992). Greater villi height and more mitosis in the gut indicate that the function of intestinal villi is stimulated as a result of enhanced absorption (Langhout *et al.*, 1999; Yasar and Forbes, 1999). Incharoen and Yamauchi (2009) showed that the villus height, surface area, cell area and cell mitosis in the intestinal segment had higher values in ginger-fed laying hens compared to the control birds. Moreover, they also found an increased number of filamentous bacteria which have been found to have strong immunomodulating effects due to high levels of IgA in the intestine and may have protective roles against infection with *Salmonella enteritidis* and *Escherichia coli* O103 (Garland *et al.*, 1982; Heczko *et al.*, 2000). Kausar *et al.* (1999) reported that carminative mixture containing ginger at the dose rate of 4 ml/l of drinking water increased means titre in primary and secondary responses against Newcastle disease, suggesting immunomodulating effects of ginger. Sudrashan *et al.* (2010) reported that essential oil isolated from ginger resulted in a significant reduction in the bacterial counts of Staphylococcus, *E. coli* and Salmonella when applied as a decontaminating agent in the ratio of 1:150, 1:250 and 1:500 to chicken meat. Zhao *et al.* (2011) found that ginger reduced the oxidation of stored feed which may be partially responsible for the improved laying performance and for the serum and egg yolk antioxidant contents.

Conclusions

Whilst reports regarding the efficacy of ginger in poultry diets vary, there are indications that feeding this plant material can promote growth performance in broilers, egg and laying characteristics in hens and may be involved in enhancing gut function and antioxidation in poultry. However, the doses, application (via feed or water) and extraction processes for ginger need to be standardised in order for firm conclusions regarding efficacy to be drawn. Future research should concentrate on this standardisation, which will allow optimal use of this material in feed or water for the benefit of poultry producers.

References

AESCHBACH, R., LOLIGER, J., SCOTT, B.C., MURCIA, A., BUTLER, J., HALLIWELL, B. and ARUOMA, O.I. (1994) Antioxidant actions of thymol, carvacrol, 6-gingerol, zingerone and hydroxytyrosol. *Food Chemistry and Toxicology* **32**: 31–36.

AKBARIAN, A., ABOLGHASEM, G., AHMADI, S. and HOSSEIN, M. (2011) Effects of ginger root (Zingiber officinale) on egg yolk cholesterol, antioxidant status and performance of laying hens. *Journal of Applied Animal Science* **39**: 19-21.

AKOACHERE, J.F.T.K., NDIP, R.N., CHENWI, E.B., NDIP, L.M., NJOCK, T.E. and ANONG, D.N. (2002) Antibacterial effect of Zingiber officinale and Garcinia kola on respiratory tract pathogens. *East African Medical Journal* **79**: 588–592.

AL-HOMIDAN, A.A. (2005) Efficacy of using different sources and levels of Allium sativum and Zingiber officinale on broiler chicks performance. *Saudi Journal of Biological Sciences* **12**: 96–102.

ALI, B.H., BLUNDEN, G., TANIRA, M.O. and NEMMAR, A. (2008) Some phytochemical, pharmacological and toxicological properties of ginger (Zingiber officinale Roscoe): A review of recent research. *Food Chemistry and Toxicology* **46**: 409-420.

CASPARY, W.F. (1992) Physiology and pathophysiology of intestinal absorption. *American Journal of Clinical Nutrition* **55**: 299s-308s.

DIARRA, S.S., KWARI, I.D., GIRGIRI, Y.A., SALEH, B. and IGWEBUIKE, J.U. (2011) The use of sorrel (*Hibiscuss sabdariffa*) seed as a feed ingredient for poultry: A review. *Research Opinions in Animal & Veterinary Sciences* **1**: 573-577.

DOU, Y., GREGERSEN, S., ZHAO, J., ZHUANG, F. and GREGERSEEN, H. (2002) Morphometric and biochemical intestinal remodeling induced by fasting in rats. *Digestive Diseases Science* **47**: 1158-1168.

EL-DEEK, A.A., ATTIA, Y.A., MAYSA, M. and HANNFY, M. (2002) Effect of anise (Pimpinella anisum), ginger(Zingiber officinale Roscoe) and fennel (Foeniculum vulgare) and their mixture on performance of broilers. *Archiv für Geflügelkunde* **67**: 92–96.

FARINU, G.O., ADEMOLA, S.G., AJAYI, A.O. and BABATUNDE, G.M. (2004) Growth, haematological and biochemical studies on garlic and ginger-fed broiler chickens. *Moor Journal of Agriculture Research* **5**: 122–128.

FUHRMAN, B., ROSENBLAT, M., HAYEK, T., COLEMAN, R. and AVIRAM, M. (2000) Ginger extract consumption reduces plasma cholesterol, inhibits LDL oxidation and attenuates development of atherosclerosis in atherosclerotic, apolipoprotein E-deficient mice. *Journal of Nutrition* **130**: 1124–1131.

GANISWARNA, S.G. (1995) Farmakologi dan Terapi (Pharmacology and Teraphy). Medical Faculty, Indonesia University, Gaya Baru Jakarta, pp: 471.

GARLAND, C.D., LEE, A. and DICKSON, M.R. (1982) Segmented filamentous bacteria in the rodent small intestine: their colonization of growing animals and possible role in host resistance to Salmonella. *Microbial Ecology* **8**: 181-190.

HECZKO, U., ABE, A. and FINLAY, B.B. (2000) In vivo interactions of rabbit enteropathogenic Escherichia coli O103 with its host: an electron microscopic and histopathologic study. *Microbes Infection* **2**: 5-16.

HERAWATI (2010) The Effect of Feeding Red Ginger as Phytobiotic on Body Weight Gain, Feed Conversion and Internal Organs Condition of Broiler. *International Journal of Poultry Science* **9 (10)**: 963-967.

HUANG, S.W. and FRANKEL, E.N. (1997) Antioxidant activity of tea catechins in different lipid systems. *Journal of Agriculture and Food Chemistry* **45**: 3033–3038.

INCHAROEN, T. and YAMAUCHI, K. (2009) Production performance, egg quality and intestinal histology in laying hens fed dietary dried fermented ginger. *International Journal of Poultry Science* **8**: 1078-1085.

JAVED, M., DURRANI, F., HAFEEZ, A., KHAN, R.U. and AHMAD, I. (2009) Effect of aqueous extract of plant mixture on carcass quality of broiler chicks. *ARPN Journal of Agricultural and Biological Science* **4**: 37-40.

KAUSAR, R., RIZVI, F. and ANJUM, A.D. (1999) Effect of Carminative mixture on health of broiler chicks. *Pakistan Journal of Biological Sciences* **2**: 1074-1077.

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

KIKUZAKI, H. and NAKATANI, N. (1996) Cyclic diarylheptanoids from rhizomes of Zingiber officinale. *Phytochemistry* **43**: 273–277.

KUO, J.M., YEH, D.B. and PAN, B.S. (1999) Rapid photometric assay evaluating antioxidative activity in edible plant material. *Journal of Agriculture and Food Chemistry* **47**: 3206-3209.

LANGHOUT, D.J., SCHUTTE, J.B., VAN LEEUWEN, P., WIEBENGA, J. and TAMMINGA, S. (1999) Effect of dietary high and low methyllated citrus pectin on the activity of the ileal microflora and morphology of the small intestinal wall of broiler chickens. *British Poultry Science* **40**: 340-347.

LARSEN, K., IBRAHIM, H., KHAW, S.H. and SAW, L.G. (1999) Gingers of Peninsular Malaysia and Singapore. Natural History Publications (Borneo), Kota Kinabalu, Malaysia.

MANESH, M.K. (2012) Influence of poly germander (Teucrium polium) and watercress (Nasturtium officinale) extract on performance, carcass quality and blood metabolites of male broilers. *Research Opinions in Animal & Veterinary Sciences* 2: 69-71.

MOHD-YUSOF, Y.A., SIEH, S., MURAD, N.A. and WAN-NGAH, W.Z. (2002) Anticancer effect of ginger extract (Zingiber officinale) on liver cancer cell lines. *Journal of Biochemical and Molecular Biology* **7**: 38–42.

MOORTHY, M., RAVI, S., RAVIKUMAR, M., VISWANATHAN, K. and EDWIN, S.C. (2009) Ginger, Pepper and Curry Leaf Powder as Feed Additives in Broiler Diet. *International Journal of Poultry Science* **8**: 779-782.

NASIROLESLAMI, M. and TORKI, M. (2010) Including Essential Oils of Fennel (*Foeniculum Vulgare*) and Ginger *(Zingiber Officinale*) to Diet and Evaluating Performance of Laying Hens, White Blood Cell Count and Egg Quality Characteristics. *Advances in Environmental Biology* **4**: 341-345.

ONU, P.N. (2010) Evaluation of two herbal spices as feed additives for finisher broilers. *Biotechnology in Animal Husbandry* **26**: 383-392.

RABABAH, T.M., HETTIARACHCHY, N.S. and HORAX, R. (2004) Total phenolics and antioxidant activities of fenugreek, green tea, black tea, grape seed, ginger, rosemary, gotu kola, and ginkgo extracts, vitamin E, and tert-butylhydroquinone. *Journal of Agriculture and Food Chemistry* **52**: 5183-5186.

REHMAN, S., DURRANI, F.R., CHAND, N., KHAN, R.U and FAWAD UR REHMAN (2011) Comparative efficacy of different schedules of administration of medicinal plants infusion on hematology and serum biochemistry of broiler chicks. *Research Opinions in Animal & Veterinary Sciences* **1**: 8-14.

SAEID, J.M., ARKAN, B.M. and AL-BADDY, M.A. (2010) Effect of Aqueous Extract of Ginger (*Zingiber officinale*) on Blood Biochemistry Parameters of Broiler. *International Journal of Poultry Science* **9**: 944-947.

SIES, H. (1991) Oxidative stress: From basic research to clinical application. *American Journal of Medicine* **91**: 31-38.

SINGH, G., MARIMUTHU, P., DE-HELUANI, C.S. and CATALAN, C. (2005) Antimicrobial and antioxidant potentials of essential oil and acetone extract of Myristica fragrans Houtt. (aril part). *Journal of Food Science* **70**: 141-148.

SRINIVASAN, K. and SAMBAIAH, K. (1991) The effect of spices on cholesterol 7-alpha hydroxylase activity and on serum and hepatic cholesterol levels in the rat. *International Journal of Vitamins and Nutrition Research* **61**: 364-369.

SUDRASHAN, S., FAIROZE, N., WILDFRED, S. and SHEKAR, R. (2010) Effect of aqueous extract and essential oils of ginger and garlic as immunostimulant in chicken meat. *Research Journal of Poultry Science* **3**: 58-61.

SUMIDA, S., TANAKA, K., KITAO, H. and NAKADOMO, F. (1989) Exercise induced lipid peroxidation and leakage of enzyme before and after vitamin E supplementation. *International Journal of Biochemistry* **21**: 835-838.

TANABE, M., CHEN, Y.D., SAITO, K. and KANO, Y. (1993) Cholesterol biosynthesis inhibitory component from *Zingiber officinale* Roscoe. *Chemical and Pharmaceutical Bulletin*, *(Tokyo)* **41**: 710-713.

TAPSELL, L.C., HEMPHILL, I., COBIAC, L., PATCH, C.S., SULLIVAN, D.R., FENECH, M., ROODENRYS, S., KEOGH, J.B., CLIFTON, P.M., WILLIAMS, P.G., FAZIO, V.A. and INGE, K. E. (2006) Health benefits of herbs and spices: The past, the present, the future. *Medical Journal of Australia* **185**: 4-24.

TEKELI, A., KUTLU, H.R. and CELIK, L. (2011) Effect of Z. offincinale and propalis extracts on the performance, carcass and some blood parameters of broiler chicks. *Current Research in Poultry Science* **1**: 12-23.

YAMAUCHI, K., BUWJOOM, T., KOGE, K. and EBASHI, T. (2006) Histological intestinal recovery in chickens re-fed dietary sugar cane extract. *Poultry Science* **85**: 645-651.

YASAR, S. and FORBES, J.M. (1999) Performance and gastro-intestinal response of broiler chicks fed on cereal gain-based foods soaked in water. *British Poultry Science* **40**: 65-76.

ZHANG, G.F., YANG, Z.B., WANG, Y., YANG, W.R., JIANG, S.Z. and 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.

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.