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Saponin in Poultry and Monogastric Animals: A Review

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A B S T R A C T

Due to awareness of consumers towards clean and safe meat availability, plant secondary metabolites (PSMs) such as essential oils, organic acids, saponins and flavonoids *etc*. are rapidly gaining attention since last few decades. PSMs are the secondary compounds that are produced by plants and they don't have primary role as nutrients. These can be the effective alternative to antibiotics because of their promising effects on overall performance of poultry and monogastric animals. Saponins are high molecular weight glycosides which are able to form foam in aqueous solution. They are credited with several pharmacological and biological activities like hypocholesterolaemic, anti-carcinogenic, anti-microbial, anti-inflammatory, anti-oxidant and immunomodulatory effects on both poultry and animals. Saponins can be obtained from various parts of plants such as seed, stem, root, pericarp, shell and bark. Optimum level of saponin is being used as feed supplement in poultry and monogastric animal's nutrition and has shown many beneficial effects. In the present review an attempt was made to summarize these promising effects of saponin in poultry and monogastric animal's nutrition.

Introduction

Phytobiotics or phytogenic feed additives (PFAs) in poultry nutrition had shown many promising effects on overall production as well as welfare of the birds. Feed constitutes major production cost for these enterprises. The shortage of quality feed as well as rapid growth rate of poultry industry had made poultry enterprise more challengeable.

The phytogenic feed additives mainly comprise of organic acids, essential oils, saponins and flavonoids *etc*. and inorganic substances like antibiotics, growth promoters, *etc*. But there is increasing public concerns towards presence of chemical residues in poultry products and microbial resistance to antibiotics. Therefore, use of phytogenic feed additives against antibiotics as performance enhancer is becoming very popular practice now days (Wallace *et al.*, 2002). Thus, the present review had made an attempt compile the information's on one of the important PSMs, saponin in poultry production.

Saponin

Saponins are diverse group of high molecular weight plant secondary metabolites (PSMs), containing either a tetracyclic steroidal or a pentacyclic triterpenoid aglycone and one or more sugar chains. The name is presumed from the Latin word sapo (soap) reflecting their wide spread ability to form stable soap-like foams in aqueous solutions (Vincken *et al.,* 2007).

Chemistry of saponins

Sugar moieties (pentoses, hexoses or uronic acid) of saponin is glycosidically linked to a hydrophobic aglycone (sapogenin) which may be either triterpenoid or steroid in nature (Francis *et al.,* 2002). Triperpenes are the most widely, naturally occurring saponins. The skeleton of triterpenoid and steroid saponins are oleanane and spirostane or furostane, respectively (Sparg *et al.,* 2004; Siegler, 1998). The biological property of saponins varies according to the ring structure of aglycone moieties and number of sugars attached to it.

Effects of saponins

Effect on feed intake, growth and litter quality

Optimum dietary level of saponin from different sources, favored higher growth rate, better feed efficiency (Yejuman *et al.,* 1998), as well as reduced the emission of noxious ammonia from excreta (Al-Bar *et al.,* 1993) thereby improving the health and welfare of poultry and pigs (Anthony *et al.,* 1994). Addition of Chlorophytum root @ 0.015% in broilers has shown improvement in nitrogen utilization and profitability (Gaurav, 2015). Gaurav (2015) reported a higher growth rate in Camellia seed saponin supplemented (@ 600 mg/kg) group. Miah *et al.,* (2004) reported that diet containing 75 mg saponin/kg had improved body weight gain at all stages of growth with better feed efficiency and performance index as well as improved carcass quality. Saponins increase the permeability of intestinal mucosal cells *in-vitro,* inhibit active mucosal transport and facilitate uptake of substances that are normally not absorbed (Johnson *et al.,* 1986). In optimum levels, it would increase nutrient absorption from the intestine by increasing villi diameter by 40-50A^{o} thereby making those permeable to large molecules like ferritin; this fact may be responsible for better growth rate (Seeman *et al.,* 1973).

Ammonia, a bacterial breakdown product of uric acid is the most noxious gas in poultry houses. Poor management practices and wet litter are the predisposing factors, favoring the continual release of ammonia from the litter. Excessive levels of ammonia are detrimental for broiler health (Yeo and Kim, 1997). *Yucca schidigera* extract has been reported to reduce atmospheric ammonia in poultry farms by inhibiting urease enzyme activity (Ayasan *et al.,* 2005). Chaudhary (2017) reported that supplementation of soapnut shell powder @ 150 ppm had significantly reduced excreta moisture content, thus, helped in reducing pollution as well as improved welfare of broiler breeders.

Effect on serum and meat cholesterol levels

A number of studies had shown that saponins from different sources lowered serum cholesterol levels (Matsuura, 2001; Gaurav, 2015, Chaudhary, 2017). Saponin and bile acids interaction in the gut leads to formation of large mixed micelles which promotes increased cholesterol excretion (Oakenfull, 1986) and finally results in reduction of serum cholesterol level. It has been found that the ethanolic extract of de-fatted fenugreek seeds inhibits taurocholate and deoxycholate absorption *in-vitro,* in a dose-dependent manner in everted intestinal sacs (Stark and

Madar, 1993). The hypocholesterolemic activity of saponins is also due to delaying of intestinal absorption of dietary fat by inhibiting pancreatic lipase activity (Han *et al.*, 2000). Saponins are also reported to reduce the harmful LDL-cholesterol selectively in the serum of rats, gerbils as well as in poultry (Matsuura, 2001; Gaurav, 2015; Chaudhary, 2017).

Gaurav (2015) and Chaudhary (2017) reported that serum total cholesterol level was significantly decreased and the HDL-cholesterol was significantly increased following supplementation of saponin rich feed additives. Researchers reported that saponins from different sources had lowered serum cholesterol level in broiler chickens (Matsuura, 2001; Afrose *et al.*, 2010; Owolabi *et al.*, 2010).

Age of the broilers and presence of saponin in feed or both, influences the total cholesterol content in breast meat. Ponte *et al.*, (2004) in their study found that Alfalafa saponin lowered the total cholesterol in the meat without affecting the *in-vivo* biosynthesis of cholesterol.

Effect on haemato-biochemical parameters

Gupta *et al.*, (2005); Gaurav (2015) and Chaudhary (2017) did not find any significant change in haemato-biochemical parameters (Hb, PCV, Glucose, creatinine, total protein, albumin, globulin, A: G ratio, calcium, inorganic-phosphorus, SGOT, SGPT and ALP) in rats, chickens and broiler breeders following supplementation with saponin from different sources. Kaya *et al.*, (2004) reported that dietary supplementation of Yucca powder @ 100 ppm to quails did not affected serum total protein concentration but albumin level was decreased.

Effect on antioxidant activity

Antioxidants are the compounds which inhibits the oxidation of other molecules. Oxidation is a chemical reaction produces free radicals that damages the cells and manifest as adverse biological effects. Superoxide dismutase (SOD), glutathione peroxidase (GPx) and catalase (CAT) are the main antioxidant enzymes in the body, contributing to the antioxidant activity. Shi *et al.*, (2014) reported that activity of these antioxidant enzymes was increased significantly following supplementation of alfalfa saponin extract @ 15 g/kg in weaned piglets. Malondialdehyde (MDA) is one of the most frequently used indicators of lipid peroxidation.

Increased MDA can be interpreted as cellular membrane damage (Niedernhofer *et al.*, 2003). MDA content in the serum, liver, spleen and muscle was decreased following alfalfa saponin extract supplementation in weaned piglets (Shi *et al.*, 2014).

Group-B soyasaponins from legumes (kidney beans, peanuts, chickpeas, clover, and Japanese bush clover etc.), contains an antioxidant moiety at C23, DDMP (2,3-dihydro-2,5-dihydroxy-6-methyl-4*H*-pyran-4-one) which allows saponins to scavenge superoxide's by forming hydroperoxide intermediates, and thus preventing bio-molecular damage by free radicals (Hu *et al.*, 2002).

The administration of saponin from *Solanum anguivi* fruit significantly increased both CAT and SOD activities in heart, whereas, concentration of MDA was decreased (Elekofehinti *et al.*, 2012). Diosgenin (a steroidal sponin of *Dioscorea spp.*) supplementation (0.5%) caused a 27% and 13% increase in GPx and CAT activities in erythrocytes of rats (Son *et al.*, 2007).

Effect on immune system

Saponins are capable of stimulating immune system and thereby enhancing resistance to the diseases (Cheeke, 2001). Saponins can stimulate secretion of cytokines and trigger innate immunity (Song and Hu, 2009), as well as enhance humoral and cellular immune responses (Palatnik *et al.,* 2004). Significant immune-stimulation and protection to diseased are achieved by immunization of chickens with immune-stimulating complexes contained purified saponins (Berezin *et al.,* 2010). Zhai *et al.,* (2014) reported that administration of saponins isolated from ginseng stems and leaves through drinking water of chickens significantly enhanced the immune responses to vaccination against Newcastle disease, avian influenza and infectious bursal disease. Sahoo *et al.,* (2015) reported that antibody titre against Newcastle disease virus in broiler chicks on 7^{th} and 14^{th} day post-vaccination was significantly higher in the *Yucca schidigera* extract group. Supplementation of Yucca up to 100 or 150 mg/kg diet improved immunity in layers (Alagawany *et al.,* 2016). Chaudhary (2017) reported that soapnut shell powder saponin @ 75 and 150 ppm had significantly improved both cell mediated and humoral immune response in broiler breeders.

Effect on egg production and egg quality

Yucca supplementation up to 100 mg/kg in diet is effective in improving egg production, egg mass and shell thickness in laying hens (Alagawany *et al.,* 2016). Ayasan *et al.,* (2005); Gurbuz *et al.,* (2011) and Alagawany *et al.,* (2016) observed that Yucca supplementation to layer's diet had no effect on egg weight, shape index and shell weight compared to non-supplemented groups. Guclu (2003) and Kutlu *et al.,* (2001) reported that Yucca extract supplementation to the layers did not affect egg production, albumin and yolk index, shape index, Haugh unit and shell thickness but reduced egg's specific gravity and number of cracked eggs. Egg yolk cholesterol and triglycerides were significantly reduced by dietary Karaya saponin supplementation (Afrose *et al.,* 2010). Chaudhary (2017) reported that broiler breeders supplemented with graded level of soapnut shell powder saponin did not manifest any significant difference in quality of egg lay.

Effect on semen quality and sex hormones

Miah *et al.,* 2004 reported that supplementation of saponin resulted in an increased testis size in male broiler birds s. An increase in seminiferous tubule diameter in cockerels receiving a diet containing 100 mg/kg saponin was reported by Hong *et al.,* (1976). SFTT (Saponin rich fraction of *Tribulus terrestris*) had a beneficial effect on male reproductive functions in rats. It altered reproductive functions in males and improved the quality of spermatozoa. SFTT (Saponin rich fraction of *Tribulus terrestris*) treated rats had significantly higher sperm concentration compared to control (Hemalatha and Hari, 2015).

Rats fed with 5% *Panax ginseng* have shown significant increase in blood testosterone levels (Fahim *et al.,* 1982). Ginsenosides are triterpenoid saponins found in *Panax ginseng* that structurally resemble the steroid hormones. Ginsenoside Rg1, the major active constituent in *Panax ginseng*, is responsible for the increased serum testosterone levels and improvement in the copulatory behavior (Wang *et al.,* 2010). Ginsenoside Rb1, a key ginsenoside found in American ginseng, is found to increase the secretion of LH by acting directly on the anterior pituitary gland (Tsai *et al.,* 2003). Oyeyemi *et al.,* (2015) reported an increased sperm motility and count with increasing dose of saponin from *Vernonia amygdalina* treatment to male wistar

rats resulted in an increased fertilizing capacity of the spermatozoa. Balazi *et al.*, (2013) reported that *Yucca schidigera* administration increased the spermatozoa concentration and motility of rabbit buck. Chaudhary (2017) reported that soapnut shell powder supplementation to broiler breeders had significantly improved the semen quality as well as serum and seminal plasma testosterone levels.

Effect on fertility, hatchability and embryonic mortality

Fertility, hatchability and embryo mortality are the major parameters of reproductive performance of a breeding flock. *Yucca schidigera* supplementation @ 120 ppm in diet did not affect hatchability of total eggs set, hatchability of fertile eggs set and fertile egg percent in quails (Ayasan, 2013). Enaiat *et al.*, (2011) found that cocks supplemented with *Yucca schidigera* and *Yucca schidigera* in combination with aluminum chloride had recorded significantly higher fertility percent than control. Chaudhary (2017) reported that supplementation of soapnut shell powder saponin @ 75 ppm in diet to broiler breeders had significantly improved fertility, hatchability of total eggs set and hatchability of fertile eggs set as well as decreased total embryonic mortality.

It is concluded from above information that saponins reduces total cholesterol and LDL-cholesterol levels in serum and meat. Also it improves semen quality as well as testosterone level in serum and seminal plasma of both poultry and mono-gastric animals *vis a vis* improves fertility and hatchability of eggs.

Saponins helps in overall improvement in production, immunity, litter quality, gut health, meat quality and welfare of poultry as well as monogastric animals without affecting cost economics. So, it can be used as an alternative to antibiotics for production of clean and green meat which ultimately helps us to achieve one health concept.

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