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Fenugreek as a phytogenic feed additive in poultry feed- A review

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Abstract
Antibiotics are known as health care miracle. In poultry farming, for reducing the incidence of diseases caused by pathogens and for performance enhancement, they are extensively used. Antibiotic have a certain dated as withdrawal time. If an antibiotics are not restricted from the poultry feed prior of slaughtering, it will be cause to a precipitation of antibiotic residues in broiler meats, this will be detrimental for human life by consumption this meats, (Halfhide, 2003) [29] so, the European Union has banned the use of antibiotics in animal production since 2006 that led the researchers to look for other alternatives. One of the potential alternatives reported in poultry production are phytogenic additives, among the various phytogenic one such medicinal herb known as Fenugreek (*Trigonella foenum graecum)*,has many physiological utilization such as antibacterial, anticancer, antiulcer, anthelmintic, hypocholesterolemic, hypoglycaemic, antioxidant and antidiabetic agent and has beneficial influence on digestion and absorption. It is rich in protein, fat, total carbohydrates and minerals such as calcium, phosphorus, iron, zinc, magnesium (Gupta *et al.*, 1996) [28], fatty acids predominantly linoleic, linolenic, oleic and palmitic (Schryver, 2002) [53].

Keywords: Fenugreek, phytogenic feed, feed, Poultry feed

Introduction
During the last decade, the growing concerns about the bleak outcome of antibacterial growth promoters has triggered researches into the use of phytogenic feed additives in poultry production in order to establish better performance of birds as well as security of consumers. Phytogenic feed additives are compound derived from varieties of plants, its parts, extracts and essential oils which possess active substances that are of significant importance. In contrast, with synthetic antibiotics or inorganic chemicals, these plant-derived products have proven to be safe, residue free, less toxic and are thought to be perfect feed additives in food animal production. They are incorporated in the diet of animal feed in order to enhance productivity by improvement of digestibility, nutrient absorption and elimination of pathogens residents in the gut (Athanasiadou *et al.*, 2007) [12]. Among the various phytogenics available, this review will focus on one such herb known as Fenugreek (*Trigonella foenum graecum)*, locally known as Methi. It is a well known medicinal plant that grows in nature and chiefly cultivated in India, Pakistan and China (Alloui *et al.*, 2012) [11]. It is used in functional food, traditional food, and nutraceuticals as well as in physiological utilization such as anti-inflammatory, antibacterial, anthelmintic, hypocholesterolemic, hypoglycaemic, antioxidant and antidiabetic agent and has beneficial impact on digestion and ability to manipulate the food quality (Murlidhar and Goswami, 2012) [44]. Some of the valuable effects of fenugreek in human health include upgrading of respiratory, stomach and intestinal health, kidney and liver functions, purification of blood and boosting of immune system. Fuller and Stephen (2015) discussed the mechanisms of actions 4-hydroxyisoleucine and fiber from Fenugreek on metabolic syndrome. This review summarizes current knowledge regarding the positive effect of fenugreek supplementation in livestock animals specially poultry.

Composition of fenugreek seed
Fenugreek seeds contain crude protein (28.4%), crude fiber (9.30%), ether extract (7.14%), total ash (3.28%) and moisture (6.87%). It contains 35% alkaloids, primarily trigonelline (Mullaicharam *et al.*, 2013) [43]. Moreover, fenugreek seeds are rich in protein, fat, total carbohydrates and minerals *viz.* calcium, phosphorus, iron, zinc, magnesium (Gupta *et al.*, 1996) [28], fatty acids predominantly linoleic, linolenic, oleic and palmitic (Schryver, 2002) [53].

Stimulation of appetite is due to neurin, biotin, trimethylamine by their action on the nervous system (Michael and Kumawat, 2003) [40] and stimulate growth by increasing the cholesterolemic effects in the body by the active principles. Taylor *et al.,* (2002) [57] reported levels of diosgenin in fenugreek seed successions ranging from 0.24% to 0.92% depending on the accession and the year and location of cultivation. Saponins levels in fenugreek seed as high as 6% have been reported (Sauvaire *et al.,* 1996).

Effect on feed intake

Gaikwad *et al.,* (2020) concluded that with highest level of fenugreek seed powder had highest feed consumption rate in the broiler birds. Yasin *et al.,* (2020) [64] also indicated that supplementation of FSP in broiler diets improved feed consumption, which can be due to the improvement of palatability of the feed containing FSP. In harmony of these above findings Qureshi *et al.,* (2015) [48] noted that the cumulative feed consumption was significantly improved (P<0.05) in fenugreek seeds supplemented groups than compared with the control group. Bhale (2015) [17] also noticed similar that inclusion of 1% germinated fenugreek seed powder in broiler ration improved feed intake and that resulted into better weight than without germinated fenugreek seed powder. Tariq *et al.,* (2014) also reported that the birds fed on diet containing 1, 2 and 3% fenugreek seed significantly (P<0.05) increased the feed intake. Alloui *et al.,* (2012) [11] who reported that the palatability of feedstuffs containing fenugreek seeds are improved because of the presence of high levels of the carbohydrate fraction, galactomannan, in the fenugreek seeds. Moreover, Hind *et al.,* (2013) [32] reported increased daily gain and feed intake due to the stimulative effect of FSP on the digestive system of broilers. These results were contradictory to Duru *et al.,* (2013) [20] and Weerasingha and Atapattu (2013) [60] who reported that the birds fed with 5% fenugreek seed powder consumed significantly (P<0.01) less amount of feed compared to control group. Abo El- Nor (1999) recommended that inclusion of fenugreek seed in the basal diet may have an effect on hypothalamus gland to stimulate hungur center in the brain and increase appetite.

Effect on production performance

Ali *et al.,* (2021) [10] showed that 0.5%, 1% and 1.5% fenugreek seed supplementation of broiler diets resulted in increase in live weight than 0% fenugreek seed in broiler seeds. The broiler of 1.5 and 1% fenugreek supplemental group was significantly (P<0.05) higher in average of weekly live weight gain compared to 0.5% and non-supplemented groups. Significant difference (P<0.05) were found at 14 days, 21 days and 28 days of age. The highest body weight gain was observed in 1.5% FGS treatment group, followed by 1, 0.5 and 0% supplemental groups, respectively. Yassin *et al.,* (2020) [64] reported that the average daily gain (ADG) for T4 (3%) and T3 (2%) was higher (P<0.05) than those fed T1 (0%) diets while T2 (1%) had an intermediate value during the growing phase. During the finisher and the entire period the highest (P<0.05) ADG was for T4 groups fed 3% FSP while the lowest (P<0.05) was for T1. Rahimian *et al.,* (2018) [49] showed that supplementation of various levels of fenugreek seed powder improved significantly (P<0.05) body weight and Pre–slaughter weight of broiler chicks. This may be due to the presence of the fatty acids, or due to stimulating effect on the digestive system of broilers. Gaikwad *et al.,* (2019) [25] showed that 1.5% Fenugreek seed powder supplemented feed diet increases cumulative weight (P<0.05) over control and other supplemental groups. Weerasingha and Atapattu (2013) [60] and Mamoun *et al.,* (2014) [38] reported 1% level and 1.5% Magda (2012) [36] inclusion levels useful for improving live body weight, body weight gain, feed conversion ratio, protein efficiency ratio, feed consumption and efficiency of energy utilization. Hind *et al.,* (2013) [32] reported increased daily gain and feed intake due to the stimulative effect of FSP on the digestive system of broilers. Alloui *et al.,* (2012) [11] who found that addition of fenugreek seed in broiler diets increased average daily gain. Wahab *et al.* 2019 [59] revealed that fenugreek seeds supplementation at the rate of 0.5% decreased feed intake and improved egg production of spent layers by 10% without affecting egg quality traits. The high percentage of egg production in group FS-0.5 may be due to phytoestrogen which may have stimulatory effect on egg production (Awadein *et al.,* 2010) [14] while lower egg production in high levels of fenugreek supplemented groups may be due to reduced feed intake in these groups.

Effect on feed conversion ratio

Yasin *et al.,* (2020) [64] concluded that fenugreek seed powder addition at various levels in broiler diets improved the feed conversion efficiency which is in agreement with the findings of Hamden *et al.,* (2010) [30] who reported that inclusion of FSP improved feed conversion efficiency of broiler chicks. Rahimian *et al.,* (2018) [49] showed that the body weight and feed conversion ratio were significantly highest ($P \leq 0.05$) in treatment group that fed on fenugreek supplemented feed compared to control group. Qureshi *et al.,* (2015) [48] reported that feed conversion ratio was significantly (P<0.05) improved in the birds fed diets containing either raw or enzyme treated fenugreek seeds, alone or in combination, when compared with the control group. Among the different treatment groups, best FCR of 1.88±0.008 was observed in the group fed combination of enzyme treated fenugreek seeds, followed by enzyme treated fenugreek group. Alloui *et al.,* (2012) [11] showed that fenugreek seeds significantly (P<0.05) affect Feed Conversion Ratio during the 42 days of age due to the development of the broiler chicks' gut and progressive morphological changes in gastrointestinal tissues that can be induced by differences in gut load of microbial content including their metabolites. Weerasingha and Atapattu (2013) [60] reported that a 13.8% improvement in FCR value in comparison to control group, the birds fed 1% fenugreek reported the best FCR.

Effect on carcass traits

Yesuf *et al.,* (2017) stated that a significant difference ($P \leq 0.05$) in commercial carcass yield and its percentage, edible carcass yield and its percentage, breast meat weight and its percentage, giblet percentage and back weight among the supplemented groups. Chicks fed on 1% and 2% FSP have significantly ($P < 0.05$) high dressing percentage compared to control group and also gizzard weights decreased significantly ($P > 0.05$) with the addition of FSP in the diets (Mamoun *et al.,* 2014) [38]. Abd Elgadir *et al.,* (2019) [2] stated that the sensory evaluation of breast meat of broiler chickens fed on diet containing 2.5% GC improved meat color, flavor, juiciness, and overall acceptability. Delimaris (2013) [18] also concluded that improvement in the dressing percentage of broilers supplemented with fenugreek seed powder up to 3%

of their diet due to higher dry matter and crude protein intake. Guo *et al.,* (2004) and Alloui *et al.,* (2012) [11] found that the dressing percentages of chicks fed on 1% and 2% FSP showed significantly (p<0.05) highest weights compared to unsupplemented group. Due to the inclusion of fenugreek seeds in diet, a major impact on the digestive parts seen, increase in weight and length of intestines has been reported (Duru *et al.*, 2013) [20]. These results are in line with Toaha *et al.,* (2016) [63], who also revealed that broiler chickens fed on diet containing 2% Fenugreek supplemented feed yielded the greatest meat in the breast and the lowest fat in the abdomen. The improvement in muscle weight may be attributed to the antioxidative properties of FN and GC, which enhances the digestive enzymes, diminishing the bacterial activities and lean mass (Dixit *et al.*, 2005; Khan *et al.*, 2011) [19, 34].

Effect on nutrients metabolizability

Latif and Toson (2021) [35] recorded the greatest value of crude protein digestibility for birds fed diet containing 1.0% fenugreek seeds powder which can be result of long contact between the digesta and mucosal epithelium due to its positive impact on intestinal morphology, which may be more effective for digestion and absorption of nutrients. Similarly, Yasin *et al.,* (2020) [64] showed that as the supplementation of fenugreek seed powder increased in the dietary regimen of broiler the CP (g/d) and ME (kcal/d) intake increased significantly (P<0.05) over control diet during both grower and finisher phases. Park and Kim (2016) also reported that total tract digestibility of dry matter and nitrogen of broilers fed with 0.1% Fenugreek seed extract (FSE) were significantly (P<0.05) higher than that of control group with no FSE treatments, in addition to decreasing excreta ammonia gas emission of broilers. Weerasingha and Atapattu (2013) [60] found that N retention (g/100g body weight) in broiler chicks improved from 0.48 in control to 0.60 in 5% Fenugreek (*Trigonella foenum-graecum* L.) Seed Powder supplemented diet, but were not altered significantly. Magda (2012) [36] also concluded that supplementation of fenugreek to broiler chicks significantly (p< 0.05) improve protein efficiency ratio values in contrast with the un-supplemented diets. Moreover significant (p< 0.05) improvements in efficiency of energy utilization for chicks fed diets containing 0.5 and 1.5% of fenugreek seed powder.

Effect on gut Histomorphology

Qureshi *et al.,* (2015) [48] revealed the antimicrobial action of Fenugreek seeds has beneficial effect on intestinal histomorphology by might be due to decrease in the inflammatory reactions at the mucosa level, thereby increasing the villus height that effects performance. Similarly, Mahmood *et al.,* (2015) [37] and Abdel-Rahman *et al.,* (2014) [3] also reported that the incorporation of fenugreek seeds at 5.33 kg per ton of broiler ration begot a significant (p < 0.05) increase in the villus height and width, crypt depth and surface area of the intestine that will help to enhance the absorptive surface area for better usage of nutrients. Adil *et al.,* (2010) [8], Awadein *et al.,* (2010) [14] investigated that incorporation of fenugreek at 0.5% level in the diet of laying hens reduced total lipid content in liver. The hepato-protective role of Fenugreek seeds have been attributed to the bioactive ingredients present in it, which enhance hepatic function and improve the gut health. Khan *et al.,* (2011) [34] reported that fenugreek seed extract had no impact on visceral organs (liver, heart, gizzard, and intestines) of broiler chicks. There was a significant linear increase in relative length of the small intestine with increasing dietary fenugreek levels.

Effect on immunity

Verma *et al.,* (2010) [58] concluded that Fenugreek seed oil and aqueous extract have a potent antibacterial activity against Salmonella typhi, Escherichia coli, and Staphylococcus aureus where aqueous extract is prepared by boiling of fenugreek seed in water. Qureshi *et al.,* (2015) [48] reported that the *in vitro* antibacterial activity of Fenugreek and found the 2.1 mm of zone of inhibition for the concentration of 0.05 mg/ml of extract against *E. coli* on the Mueller Hinton agar. Similarly, Dash *et al.,* (2011) reported that *in vitro* antibacterial activity of methanolic extract of fenugreek against *E. coli* and attributed to the flavonoids, saponins and phenols present in it (Schryver, 2002) [53]. Yarnell and Abascal (2009) attributed the antibacterial action of dandelion to the presence of phenylpropanoids, triterpenoid, saponins and many other components present in it. Fenugreek reported to have anti-diabetic, anti-fertility, anti-cancer, anti-microbial, anti-parasitic, hypo-cholesterolaemic effects and has been reported to have antimicrobial hypoglycemic, hypolipidemic, and antioxidant effect on animals (Basch *et al.*, 2003) [15]. Abid *et al.* (2011) [6] demonstrated that the fenugreek increasing the immunity of birds at 24 and 34 day and because fenugreek increases the cellular ties of thymus gland and bone marrow. Awad *et al.* (2015) [13] results suggest that the fenugreek seed, specially the highest dosage used in the present work could be considered a good food supplement to improve the immune status and increase the production of gilthead sea bream. As (Abed *et al.,* 2014) [5] showed supplemented with 1% fenugreek recorded high anti-body titter against Newcastle disease virus and Gumboro disease virus.

Effect of fenugreek seed on blood and serum parameters

El-Hack *et al.* (2015) [21] reveald that a decrease in laying hens serum total cholesterol concentration and an increase in high-density lipoprotein cholesterol concentration duo to fenugreek seed extract supplementation. Trigonelline showed anti-diabetic activity by improvement of insulin signaling pathway (Aldakinah *et al.* 2017) [9], attenuation of endoplasmic reticulum stress and oxidative stress in type 2 diabetic rats (Mayakrishnan *et al.* 2015) [39], affecting the regeneration of pancreatic islet b-cells, the secretion of insulin, and glucose metabolizing enzymes (Zhou *et al.* 2012) [66]. Bhaisare and Thyagarajan (2014) [16] reported the positive effect on haemopoietic process in the body due to certain bioactive principles in fenugreek seeds which results in haemoglobin content rise significantly (p<0.05) high when fenugreek seeds were used in turkey poults. Mamoun *et al.* (2014) [38] reported in reduction in the serum cholesterol level could be due to the presence of saponins and resins in fenugreek seeds which might have render the bile acid and cholesterol absorption from intestine. Weerasingha *et al.* (2013) [60] indicated that fenugreek contains bioactive components such as minerals, vitamins, lecithin and choline that help to dissolve cholesterol and fatty substances. Abdul-Rahman (2012) [4] investigated that significant (p < 0.05) improvement the RBC count, PCV percentage and Hb concentration in Fenugreek supplementation group at level of 10 g/kg of diet in broiler breeder chicken, due to the improvement of antioxidant activity in RBCs which check the production of free radicals that destroy Hb and cause hemolysis of RBCs. It may be

concluded that repeated treatment for 6 weeks with fenugreek extract in rats can lower kidney/body weight ratio and blood glucose and also improves hemorheological properties (Xue *et al.*, 2007) [61]. Roberts (2011) [50] suggested that the hypoglycemic effect may be mediated through stimulating insulin synthesis and/or secretion from the beta pancreatic cells. Also, El-Kaiaty *et al.* (2002) [23] indicated that fenugreek seeds extract contains steroid saponins and reduce serum cholesterol. Dixit *et al.* has also indicated that fenugreek seed and its extract can reduce blood glucose levels.

Effect on egg yolk composition

Nasra *et al.*, (2010) [14] who reported a small but significant reduction in egg yolk cholesterol by feeding hens of local *Mandarah* strain diets containing 0.1 or 0.5% ground fenugreek seeds. Also, Safaa (2007) [51] found that fenugreek at 2% level fed to 35-wk old *Lohmann Brown* laying hens reduced egg yolk cholesterol concentrations from 18.5 to 17.2 mg/g egg yolk. Moustafa (2006) [41] observed a reduction in yolk total cholesterol concentration when *Hy-Line White* laying hens fed diets supplemented with 0.05, 0.1 or 0.15% fenugreek from 40 to 59 weeks of age. In regard to fenugreek seed genotype, Ozan *et al.*, (2011) [46] found fenugreek seed genotypes that contents of lipids ranged from 5.8 to 15.2%, total sterol varied from 14,203 to 18,833 mg/kg of lipids and cholesterol ranged from 270 to 1,281 mg/kg lipid and suggested that the amounts of cholesterol in fenugreek seeds were low and their absorption would be minimized by the excessive amounts of phytosterols. Shafey *et al.* (1992) [54] found differences between strains of pullets in weight gain, food consumption, rate of lay, egg weight and yolk cholesterol. Thus, some hens genotypes seem particularly resistant to having their yolk cholesterol level changed. Fenugreek seeds used at low dietary levels (0.1 to 2%) reportedly showed egg yolk cholesterol reduction around 7% (Nasra *et al.* 2010; Safaa 2007) [45, 51].

Effect on economics

Mukhtar *et al.* (2013) [42], who reported that supplementation of fenugreek seed powder to broiler diet resulted in economic benefits. Mamoun *et al.* (2014) [38] also recorded profit for the broilers fed on diets containing 1% FGS compared to 3% FGS group. Increase in the profitability of broilers fed rations containing herbal growth promoters may be attributed to the better efficiency of feed utilization, which resulted in more growth and better conversion feed to live weight gain. Gerson *et al.* (2009) [26] reported that use of the phytogenic feed additive in broiler chicken diets had a good economic advantage when feed cost is considered. Abaza *et al.* (2008) [1], El-Latif *et al.* (2002) [23], Jahan (2012) [33] reported that the inclusion levels of herbal feed additives in diets recorded the least cost/kg gain and the highest percent of economic efficiency compared with that of the un-supplemented diet.

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