ISSN No:-2456-2165

Potency of Phytobiotics in Herbal Spices as an Antimicrobial Growth Promoter in Broiler Chicken Diets: A Review

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Abstract:- In this study, the significance of herbs and spices as antimicrobial growth promoter (AGP) and as replacement for synthetic antibiotics in poultry diets, has paved the way. The herbal spices investigated were Garlic (Allium sativum L.), Turmeric (Curcuma longa L.), Oregano (Origanum vulgare L.), and Malunggay (Moringa oleifera Lam.). The effective supplementation levels were found to be 5kg/ton garlic, 0.75% turmeric, 0.40g/kg oregano powder, and 0.75-1.0% malunggay leaf meal supplementation. In garlic, turmeric, oregano, and malunggay respectively, the active compounds allicin, curcumin, thymol and carvacrol, and cryptochlorogenic acid, isoquercetin, and astragalin were established. For more efficient use of herbal powder and meals, effort should focus in obtaining the best processing technique such as air drying and 50-60^{0}C hot air oven for a maximum of 6 hours. Given this, the present studies highlighted an overview of the experimental uses of common spices in broilers on growth efficiency, carcass quality, and health status, supported by past findings to the present. The spices' phytogenic content may be the explanation for their potency as an AGP. Finally, the findings have inspired further analysis of spices in broiler rations to ascertain the most active ingredients and their optimal doses.

Keywords:- *Phytobiotics, Allium Sativum, Curcuma Longa, Origanum Vulgare, Moringa Oleifera.*

I. INTRODUCTION

Food additives have been commonly used as a method for the animal productivity in poultry nutrition (Lee *et al.*, 2001) to enhance the performance and safety of broiler chickens (Kostadinovic, 2013). Many plants have proven to have antibacterial, antifungal, antiparasitic, antiviral, antihypertensive, anti-inflammatory, hypoglycemic, antithrombotic, antihyperlipidemic, and antioxidant functions. It has been practiced for decades to use antibiotics as a growth inducer in commercial poultry production. The use of such as an additive in poultry diet was remarkable in reducing morbidity and mortality; increasing the feed efficiency and broiler chickens ' growth output. Intestinal pathogenic agents tend to lower poultry growth rates. The utilization of an antimicrobial growth promoters (AGP), has been severely stressed in combating these pathogens. However, by reasons of potential health hazards and environmental issues caused by the improper use of synthetic pharmaceuticals, including feed AGP's and growth hormones, besides public demand for organically prepared food, has gradually shifted the attitude towards these chemical antibiotics (Greathead 2003; Rochfort *et al.* 2008). Research has led to increased concern about the incidence of microbial resistance in human pathogen due to the continued use of AGP's in animals leading to a ban on the use of synthetic antibiotics in poultry and livestock feeding in advanced countries in the early 2000s.

The main challenge of using AGP in raising poultry is that of the residual effects that it always leaves in tissues of the bird. It poses a major health danger for such goods to the customer. It results in a deterioration of the immune system when consumed by humans as food (Basak, 2015). This suggested for the use of natural products, in particular phytogenic additives, as a potential replacement for antibiotics. Natural herbal and spice products have reportedly been used as additive to feeds for several farmed animals (Khan *et al.*, 2012). Compared to synthetic chemical antibiotics, their inherent advantages show that they are residue-free, natural, and less toxic. These features rightly positioned them as ideal feed additives for poultry (Wang *et al.*, 2015).

Phytobiotics have gained interest in the past decades as natural growth promotes feed additives in broiler production. They have several medicinal properties with no residual side effects and are the best alternatives to promoting antibiotic growth (Rahman *et al.* 2014). These substances are beneficial in poultry nutrition because of their active pharmacological compounds that stimulate appetite and feed intake, improve endogenous digestive secretion and activate immune responses (Abdelnour *et al.*, 2018; Toghyani *et al.*, 2010).

Phytobiotics such as essential oils, spices, and oleoresins are plant derived products, (Pirgozliev *et al.*, 2018; Mohammadi Gheisar & Kim, 2018). They are usually added in the diet or in water to poultry animals to enhance their productivity by improving feed properties, promoting the performance of animals in production, and to improve the quality of the products obtained from these animals, (Mohammadi Gheisar & Kim, 2018).

Herbs and spices are considered part of the human diet and used as traditional medicine for thousands of years, as well as improving food color, taste, and aroma (Andradea & Salvador Ferreira, 2013). For over 30 years, the active compounds in spices have shown to have some vitamins, flavonoids, terpenoids, carotenoids, phytoestrogens, and minerals, and have demonstrated their therapeutic properties (Shan *et al.,* 2005; Srivastava *et al.,* 2010; Rahaiee *et al.,* 2015; Mallick *et al.,* 2016).

Spices are known food additives commonly used as seasoning, coloring, flavoring agents and food preservatives with recognized medicinal properties such as antioxidant, antimicrobial, anti-inflammatory, anticarcinogenic potential, digestive stimulant action, hypolipidemic, antimutagenic, etc. The production of phenolic antioxidants and antimicrobials in spices gives food-conserving properties (Zarai *et al.*, 2013).

Therefore, the paper aims to assess the progress and ability of phytobiotics in commonly used herbal spices and to articulate the various active compounds and the methods of preparation, primarily for the advancement of the poultry sector.

➢ *Garlic (Allium sativum L.)*

Garlic (*Allium sativum*), a member of the Allium family (Liliaceae), has been used for many years to treat human diseases, including respiratory infections, ulcers, diarrhea and skin infections, lower serum and cholesterol in the liver (Qureshi *et al.,* 1983; Fenwick *et al.,* 1985; Hassan *et al.,* 2019). Reuter, (1995) reported the effects of garlic as an antibiotic, anticancer, antioxidant, immunomodulatory, hypoglycemic and cardiovascular-protective plant.

In poultry, positive effects of herbal garlic powder supplements on meat broiler output, carcass quality, and quality characteristics were reported by Schleicher *et al.,* (1998) as it was found to have significant antioxidant actions (Gardzielewska *et al.,* 2003). Also, garlic is very rich in aromatic oils that enhance digestion and positively influence the inhalation of the respiratory system into the birds ' air sacs and lungs. To improve the health of chicken and to meet consumer expectations regarding food quality, poultry raisers are increasingly using natural feed supplements (Gardzielewska *et al.,* 2003; Fadlalla *et al.,* 2010).

Allicin, ajoene, S-allyl cysteine are the main active ingredients in garlic. Garlics have shown antimicrobial function (Adibmoradi *et al.,* (2006) and improve broiler chicks ' productive performance. However, some studies indicated that commercial garlic oil, garlic powder and commercially available garlic extract could be hypocholesterolemic (Songsang *et al.,* 2008). Besides its antimicrobial activities, garlic increases the palatability of feed and therefore feed intake. Garlic supplementation of broiler chicken diets has improvement in weight gain (P > 0.05) and increased supplementation levels (5000 vs. 500 mg/kg diet) improved. Compared to raw garlic powder dietary supplementation in terms of bird's results, no consistent effect was obtained from boiled garlic (Onibi *et al.*, 2009). Additional garlic in broiler diets did not have a significant influence on carcass and organ characteristics but abdominal fat weights were reduced numerically non-significantly increased dietary supplementation with garlic enhanced palatability scores and significantly increased scores of aroma. The oxidative stability of refrigerated broiler chicken meat was enhanced in the diets by additional garlic and was better at higher supplementation levels *(*Penko *et al.,* 2015).

Garlic in the feed of broiler chicks has a significant positive impact on the growth output and carcass yield of broiler chicks (Fadlalla *et al.,* 2010). The optimal inclusion rate for growth efficiency and carcass yield was 0.3 percent. Recently, the introduction of garlic to the broiler chick diet has increased weight gain and has been better at low supplementation rates (500 mg/kg diet) that can be useful for economic and effective broiler development (Pagrut *et al.,* 2018). Furthermore, (Al-Massad *et al*., 2018; Al-Ramamnehinc 2018) incorporating garlic powder as a feed additive in the broiler diet significantly enhanced broiler chicks ' growth, economic and productive performance. The body weight, weight gain, feed consumption, feed conversion ratio, carcass weight and internal organs showed better chicken feed characteristics under the same care when compared to untreated group. The result showed lower mortality rates, lower disease susceptibility and treatment for medicinal products using garlic powder. Characteristics of meat and blood have shown lower levels of cholesterol, triglyceride, LDL, HDL than the control group. Adding garlic as a growth promoter results in lower production costs by increasing the feed conversion ratio, weight gain and feed efficiency of treated groups compared to untreated groups. For poultry feed, garlic can be used effectively to substitute the antibiotic growth promoter, this was substantiated on Table 1.

➢ *Turmeric (Curcuma longa L.)*

Turmeric is a spice extracted from Curcuma longa plant rhizomes, a component of the family of Zingiberaceae (Sawant & Godghate, 2013; Chanda & Ramachandra, 2019). Curcumin has antioxidant properties (Kunchandy & Rao, 1990; Masuda *et al.,* 1993; Unnikrishnan & Rao, 1995; Cohly *et al.,* 1998) anti-inflammatory (Chainani-Wu, 2003) anticarcinogenic (Frank *et al.,* 2003). Tumeric elements are called curcuminoids, often curcumin (diferuloylmethane), demethoxycurcumin, and bisdemethoxycurcumin (Chainani-Wu, 2003). Turmeric is made up of curcuminoids of 3-5 percent. Curcumin's melting point, C2H20O6, is 184^{o}C. For ethanol and acetone, it is soluble, but insoluble for oil (Weber *et al.,* 2006). Besides these, curcumin has a range of potential therapeutic effects, including antineoplastic, antiapoptotic, antiangiogenic, cytotoxic, immunomodulatory properties (Strimpakos & Sharma, 2008).

One of the numerous phytogenic additives of importance in the production of poultry feed is the bioavailability in turmeric (*Curcuma longa*). Bask (2015) established turmeric and its extracts as an effective alternative to the antibiotic growth promoter (AGP) in poultry development. As feed supplement, *Wang et al.,* (2015) documented a remarkable increase in breast muscle weight and breast muscle weight ratio but a significant decrease in the abdominal fat ratio (P < 0.05) compared to the control group. The body weight gain, daily weight gain, feed conversion ratio and daily feed intake did not increase significantly compared to the positive and negative control groups with the addition of turmeric powder. Qasem *et al.*, (2015) found that body weight, daily weight gain and daily intake of food at 21 and 42 days of age were significantly higher in both positive and negative control groups over the other dietary treatment groups. Although no significant differences in the FCR between the treated and the control groups, the FCR was higher across the study period in all treated groups than in the control groups.

The diet with turmeric powder has a negative effect: lower growth rate and bird feed consumption. The turmeric powder may have decreased the consumption of the supplemented diets due to an adverse effect on the feed's palatability and therefore the daily intake of the treated groups was significantly lower than the control groups (Qasem *et al.*, 2015). Apart from the fact that turmeric could be a true source of protein and carbohydrate, improvements reported in growth and the success of hen day development in birds fed turmeric meal supplemented diets in all studies could be attributed to the beneficial properties of turmeric phytochemicals as a viable antimicrobial, antifungal and antioxidant (Olarotimi, 2018). Moreover, Choudhury *et al.* (2018) revealed that body weight, improved FCR, highest BPEI and higher gross profit per bird provided 0.75% turmeric powder in feed were increased. It may, therefore, be recommended that turmeric powder be used as a natural feed additive in feed at a level of 0.75% to improve the overall performance of broiler chicken as emphasized under Table 2.

- *Oregano (Origanum vulgare L.)*

Oregano (*Origanum vulgare* L.) is a wide distribution aromatic plant throughout the Mediterranean region and Asia (Vokou *et al.*, 1993). The essential oil from *the O. vulgare* subspecies hirtum plant consists of more than 20 ingredients through a steam distillation process, most of which are phenolic antioxidants (Vekiari *et al.*, 1993). Roofchaee *et al*, (2011) suggested that the oil extracted from oregano may be able to grow to promote effects on broiler chickens. Supplementation of broiler diets with 600 and 1200 mg/kg oregano extract oil significantly improved the FCR in either grower or overall experimental periods compared with control. Such results can be due to improved feed usage efficiency. Besides, this essential oil had a strong antibacterial effect and significantly reduced cecal populations of E. coli. Also, the oregano extract oil tended to increase dose-dependent serum antioxidant activity. However, to achieve significant antioxidant properties in the serum, higher levels of this essential oil in the diet may be needed. Oregano extract oil supplementation showed a significantly positive effect on broiler growth efficiency, carcass characteristics, and intestinal health, suggesting that oregano extract oil could be a promising alternative to antibiotic AGP (Peng *et al.*, 2016).

Badiri & sabre, (2016) showed that the introduction of oregano oil in the diet of quails had a major effect on the final body weight of quail ($P > 0.05$). The addition of various levels of oregano oil might have different effects on quails ' thighs and neck weights ($P < 0.05$). The tests for oregano oil had no variations in quail blood levels of triglyceride, cholesterol, HDL, and LDL ($P < 0.05$). Recently, Silva-Vázquez *et al.*, (2018) exhibited positive effects on broiler performance, blood profiles, carcass traits, and meat composition with the addition of 0.40 g/kg in the broiler chicken diet from the two sources of Mexican oregano oils as presented in Table 3.

- *Malunggay (Moringa oleifera Lam.)*

Moringa oleifera is a plant under the Moringaceae family abundantly grown in the tropics. Multiple advantages are present in the plant because different parts of the tree (leaves, fruit, immature pods and flowers) are edible and are part of traditional diets in many countries located tropical and subtropical. Olugbemi *et al*, (2010) have reported Moringa oleifera leaf's antimicrobial effects and are a good source of fats, proteins, and minerals. Without impacting productivity or hematological indices, the inclusion of *Moringa oleifera* in cassava-based broiler diets can be up to 5 percent.

II. PHYTOBIOTICS IN DIFFERENT HERBAL SPICES

- *Allicin*

Allicin (ally 2-propenethiosulfinate), an antibacterial principle of garlic, has attracted much attention as it has potent antimicrobial property against a wide range of microorganisms, including Staphylococcus aureus immune to methicillin (Fujisawa *et al.*, 2009). The allyl thiosulfinates, of which allicin (diallyl thiosulfinate) is the most abundant and most studied are alliin, S (+)-allyl-L-cysteine sulfoxide, and alliinase enzymatic products are pharmacologically activity of crushed raw garlic cloves. Moreover, the allicin are likewise actively involved for the antibacterial activity of garlic and that the removal of allicin also removed all activity (Cavallito & Bailey, 1944). Considerable evidence indicates that allyl polysulfides or their common metabolite (allyl methyl sulfide) of whole garlic are in-charge of the lipid-lowering, antioxidant, anti-atherosclerotic, and anticancer effects in animals and humans (Lawson, 1998; Lawson & Hunsaker, 2018).

- *Curcumin*

It belongs to the family of curcuminoids and has been used traditionally as medicines for centuries (Amalraj *et al.*, 2017). As a spice, with its typical color and flavor, it offers curry. It has known to cure respiratory problems like bronchial hyperactivity, asthma, allergy andother health problems including hepatic diseases, coryza, anorexia, cough, and sinusitis. Traditional Indian medicine has found curcumin an important medication (Rahman *et al.*, 2006; Tirkey *et al.*, 2005; Prasad *et al.*, 2014). Over the few decades, extensive research has shown its significant role in treatment and prevention of numerous chronic inflammatory diseases, including neurodegenerative,

ISSN No:-2456-2165

neurological, respiratory, metabolic, autoimmune and malignant diseases (Prasad *et al.*, 2014).

➢ *Thymol and Carvacrol*

The essential oil that *O. vulgare* has acquired from subspecies hirtum plant comprises more than 20 ingredients through a steam distillation process are mostly phenolic antioxidants (Vekiari *et al.*, 1993). Oregano oil and its main phenolic components, carvacrol [2-methyl-5-(1-methyl) phenol] and thymol

Parameters	**Dietary treatment (kg/ton)**			
	0	**2.5**	**5**	**7.5**
Bodyweight	2053.70^{a}	2115.70^{be}	2277.70^{bc}	2213.80^{bd}
Feed intake	1082.80^{a}	1078.80^{ae}	1223.00^{bc}	1180.5^{bd}
Total feed conversion ratio	1.23^{a}	1.25^{a}	1.22^{a}	1.23^{a}
Live weight	2053.80^{a}	2115.00^{be}	2277.80^{bc}	2213.60^{bd}
Carcass weight	1503.30^{a}	1575.00^{be}	1715.30^{bc}	1655.80^{bd}
Chest weight	523.90^{a}	562.40^{be}	632.10^{bc}	595.70^{bd}
Thigh weight	485.50^{a}	496.20be	514.10^{bc}	510.00^{bd}
Back weight	202.90^{a}	217.40^{be}	224.70^{bc}	218.60^{bd}
Wings weight	163.40^{a}	175.50^{be}	199.004^{bc}	187.10^{bd}
Neck weight	85.80^{a}	93.40^{be}	99.60^{bd}	101.31^{bc}

Table 1:- This table shows average growth and carcass yield (gram/bird) when supplementary powder garlic (0, 2.5, 5, and 7.5 kg/ ton) is added to broiler diets.
Source: Al-Massad, et al., (2018)

Parameters	**Dietary treatment (%/kg)**			
	T_0 (Control)	**T_1 (TP-0.25%)**	**T_2 (TP- 0.50%)**	**T_3 (TP- 0.75%)**
Total feed intake	3587.06	3561.11	3585.4	3659.02
Total body weight gain	1900.28^{c}	1963.97^{ac}	2049.36^{ab}	2134.56^{b}
Total FCR	1.88	1.81	1.75	1.71
BPEI	101.08	108.5	117.09	124.82
Livability (%)	100	100	100	100
Chick cost (A) = 1.05 x cost of day-old chick	33.6	33.6	33.6	33.6
Feed cost (B) = Live weight in Kg x FCR x Cost per	116.09	115.28	116.59	118.37
Miscellaneous expenditure (C) = Add 15% of (A+B)	22.45	22.33	22.52	22.79
Additional cost of Turmeric powder (D)	--	0.88	1.79	2.74
Production cost per broiler (A+B+C+D)	172.14	172.09	174.5	177.5
Sale of one live broiler @ 100 per Kg	190	196.39	204.94	213.46
Gross profit per broiler	17.86	24.3	30.44	35.96

Table 2:- This table shows growth, performance indices, and economics of production of dietary treatment of turmeric powder in broiler diets.
Source: Choudhury, et al., (2018).

Parameters	Dietary treatment (g/kg)		
	CTR	Control diet + 0.25g Oxytetracycline/kg	Control diet + 0.40g Oregano powder/kg
Body weight (g)	2,604.31[a]	2,651.73[b]	2,763.42[b]
Feed intake (g)	4,287.40[a]	4,103.43[b]	4,9011.49[b]
Weight gain (g)	437.03	441.95	460.57
Feed efficiency	2.10[a]	1.85[ab]	1.66[b]
Slaughter weight	2,552.22	2,718.64	2,771.78
Hot carcass weight	2,080.36	2,112.52	2,252.21
Cold carcass weight	2,109.48	2,136.48	2,274.62
Hot carcass yield	2,163.27	2,188.76	2,332.52
Cold carcass yield	2,163.27	2,188.76	2,332.52

Table 3:- This table shows growth and carcass characteristics of broiler chicken under oxytetracycline and oregano powder on broiler diets.
Source: Méndez Zamora et al., 2017)

Parameters	Moringa oleifera leaf meal (%)				
	0.00	0.25	0.50	0.75	1.00
Initial live weight (g)	148.33	148.67	150	154.67	150.67
Final body weight (g)	2497.00[b]	2641.00[a]	2671.00[a]	2720.00[a]	2750.00[a]
Body weight gain(g)	2349.00[b]	2492.00[a]	2521.00[a]	2565.00[a]	2599.00[a]
Growth ratio	56.75[b]	60.03[a]	60.71[a]	61.81[a]	62.50[a]
Feed intake	4284	4156	4256	4081	4300
Feed efficiency	1.82[b]	1.67[a]	1.69[a]	1.59[a]	1.65[a]
EPEF	326.27[b]	377.76[a]	377.77[a]	406.77[a]	395.73[a]
Mortality	0	0	0	0	0
Carcass weight (g)	1735.30[d]	1751.27[cd]	1874.70[bc]	1916.50[b]	2069.43[a]

Table 4:- this table shows growth performance and yield performance of broiler chicken treated with varying levels of Moringa oleifera leaf meal of broiler diets.
Source: Alshukri, et al., (2018

(2-isopropyl-5-methyl phenol), are known for their wide range of in vitro Lambert *et al.*, (2001) and in vivo antimicrobial activity (Adam *et al.*, 1998). These have several biomedical properties such as anti-inflammatory, anti-leishmanial, antioxidant, hepatoprotective and anti-tumor activity (Aeschbach *et al.*, 1994). Oregano extract oil's main active components are thymol and carvacrol, which, due to positive effects on nutrient digestibility, can improve feed digestibility (Jamroz *et al.*, 2003), and induce higher bile acid secretion (Hashemipour *et al.*, 2016). In their in vitro study, Penalver *et al.* (2005) showed that essential oregano oil had an incredible antibacterial effect on E strains of poultry origin. They also suggested that this strong antibacterial activity could be largely attributed to the existence of two main OEO active components, thymol, and carvacrol. Helander *et al.*, (1998) studied the antibacterial function of two main OEO, carvacrol and thymol components on E. Coli in a similar mechanism and reported both carvacrol and thymol; disintegrate bacterial membrane, leading to the release of membrane related materials into the external medium. They also suggested that thymol and carvacrol can penetrate the bacteria and thus influence their growth.

- *Crypto-chlorogenic Acid, Isoquercetin, and Astragalin*

Moringa oleifera Lamarck (Moringaceae) is a multi-purpose medicinal plant use to treat various diseases previously found to have significant active components in this plant's leaves. Phenolics and flavonoids in M's leaves are active antioxidants (Chumark et al., 2008; Verma et al., 2009). The main compounds have been isolated and classified as cryptochlorogenic acid, isoquercetin and astragalin, which in many studies have shown exceptionally strong antioxidant activity in the ethanolic extracts of Moringa oleifera, the content of cryptochlorogenic acid, isoquercetin and astragalin (Nakatani et al., 2000; Olszewska & Michel, 2012; Jung et al.,2010). Oleifera leaves ranged from 0.015% to 0.150% (average 0.081%), 0.067% to 0.145% (average 0.120%) and 0.056% to 0.290% (average 0.153%), respectively. However, the quality of these components in dry powdered leaves ranged from 0.006% to 0.057% (average 0.032%), 0.028% to 0.057% (average 0.047%) and 0.023% to 0.110% (average 0.060%), respectively.

ISSN No:-2456-2165

III. METHODS OF PREPARATION OF HERBAL FEED SUPPLEMENT

The garlic powder (old and fresh garlic) will be prepared wherein garlic bulbs will be air-dried in the shade for one day, and chopped finely followed by drying at 60ºC for 6h to prepare powder by milling (Sasaki *et al.*, 1999).

Every variety of fresh turmeric root will be washed, steamed for 7 minutes and crushed finely before drying at 50°C for about 6 hours in a hot air oven. Using a high-speed blender, dry turmeric will be collected and ponded into a fine powder (Surojanametakul *et al.*, 2010).

Oregano's leaves and stems will be collected and dried out in the shade for a month at room temperature, and then polished with a drill. Until further use, the powdered oregano was kept at 4°C (Park *et al.*, 2015).

The harvested leaves, while retaining their greenish color, will be dried in shade under a shed until they will be crispy to touch. Using a hammer mill, the dried leaves will then be milled to produce (MOLM) available for mixture into broiler diets (Onu & Aniebo, 2011).

IV. CONCLUSION

The phytobiotics of the commonly used herbal spices were tested as feed additives to poultry in several studies. Based on the literatures, it lead to the conclusion that spice antioxidant activities were high enough to make the spices recognized as fresh and natural sources of antimicrobial growth promoter substances for use as natural feed supplements in broiler. The amount of phytobiotic content in the herbal spices may be substantial for its potent antioxidant activity, while other spices have considerable amount of phenolic and flavonoids which guarantee their antioxidant properties.

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