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Review Article

Clove (*Syzygium aromaticum*): Alternative Antibiotic Growth Promoter for Broiler: A Review

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Abstract | Antibiotics Growth Promoter (AGP) is officially banned as a supplement for broiler feed due to an increase in harmful bacteria and causing antibiotic residues in meat which has implications for stunted growth performance and increased health problems in broiler farms. Herbal products have been proposed for use in broiler production in order to maintain health and maximize the growth potential of modern broilers. The performance of broiler chickens is focused on maximizing performance parameters, i.e., fast chicken growth with low feed consumption, and with optimal health status. This study provides an in-depth review of the use of cloves in feed to improve broiler chicken production performance and health. In conclusion, cloves contain bioactive substances that can be used to improve broiler chicken performance and health. Administration of appropriate dose is believed to replace the role of AGP, which is currently prohibited from its use in broiler chicken feed.

Keywords | AGP, Broiler, Cloves, Health status, Performance

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INTRODUCTION

Farmers commonly use antibiotic growth promoter (AGP) to improve feed utility (by chickens) as well as to maximize performance and health of broiler chickens. AGP has been shown to improve growth performance, control diseases caused by pathogenic bacteria, and improve feed conversion (Mehdi et al., 2018). According to recent research findings, the use of AGP can reduce the stress response in broiler chickens (Jeonga et al., 2020). However, the use of AGP in rations causes serious problems for consumers and has been prohibited. This is due to the fact that the use of AGP can result in residues in chicken products, which can be harmful to human health (Stefanello et al., 2020). Based on these circumstances, the poultry industry is expected to discontinue the use of AGP in broiler chickens and instead look for alternative methods of increasing livestock growth and chicken health, one of which is the use of herbal plants.

The use of herbal plants as natural additives in poultry feed has increased in recent years due to their high content of bioactive substances that can improve production performance, reduce pathogenic bacterial infections, and reduce antibiotic residues in meat and egg products (Reddy et al., 2018). The use of herbal plants in poultry feed has been shown to increase body weight gain, improve nutrient metabolism, and improve meat quality by lowering cholesterol levels and inhibiting peroxidation (Oloruntola et al., 2019; Sapsuha et al., 2021). Among the herbs that are believed to be used as a substitute for AGP is Clove (*Syzygium aromaticum*).

Clove (*Syzygium aromaticum*) is an Indonesian native plant that is widely used as a culinary spice. Clove is an aromatic tropical plant with a distinct aroma (Bhowmik et al., 2012) that has antioxidant, antimicrobial, analgesic, anti-obesity, and hepatoprotective properties in biological systems (Cortes-Rojas et al., 2014; Adu et al., 2020). The main bioactive substances found in cloves are eugenol, eugenol acetate, and β-caryophyllene (Jimoh et al., 2017). Eugenol is the primary active ingredient in the clove plant, accounting for up to 72-90% of its total content (Al-Shaikh and Perveen, 2017). It is a compound with pharmacological and antioxidant activity that helps to inhibit bacterial growth (Mohammadi et al., 2014). Cloves have traditionally been used to treat digestive disorders, parasitic infestations, and coughs (Bhowmik et al., 2012).

In general, the pharmacological benefits of cloves are associated with various bioactive components that can act as antimicrobial, antifungal, anti-inflammatory, hypoallergenic, and antioxidant (Jimoh et al., 2017; Al-Shaikh and Perveen, 2017; Asimi and Sahu, 2016). Overall, the phenolic compounds, flavonoids, and eugenol found in this clove plant allow it to function as an antibacterial, antifungal, and antioxidant agent, according to their findings. In terms of antibacterial capacity, Hemalatha et al. (2016) also found that the administration of cloves inhibited the growth of *Bacillus subtilis*, *Staphylococcus aureus*, *Klebsiela pneumonia*, and *Vibrio cholera* in their experiments. In addition, Sabdoningrum et al. (2017) showed that herbal plants were effective antibacterial agents against *Mycoplasma gallisepticum*, a pathogen that causes chronic respiratory disease in broilers. In another study, Uddin et al. (2017) assessed several bioactive compounds in clove plants. They discovered that cloves contain high levels of antioxidants such as phenols, flavonoids, saponins, alkaloids, phytosterols, and tannins. In line with this, Asimi et al. (2016) discovered the antioxidant content of clove plants. The clove plant also exhibits immune-boosting properties, which are important for host defense against pathogenic agents. Gandomani et al. (2014) concurred that the clove plant contains triterpenoids, saponins, and their derivatives, as well as mineral salts, all of which are important for increasing body resistance and enhancing the immune system. In addition, Rahman et al. (2017) revealed that the clove plant contains several active compounds that can function as immunomodulatory agents, i.e., deoxyandrographolide, andrographolide, neoandrographolide, 12-didehydroandrographolide, homoandrographolide, diterpenoids, and flavonoids. Many researchers have recently become interested in its diverse pharmacological properties, and many studies have been published with clove as the main subject. This current review focuses on the current state of knowledge regarding the effects of cloves and/or their main constituents on the performance and health of broiler chickens when used as a replacement for AGP.

To prepare for the current review, a literature search was conducted, with a focus on the use of cloves in broilers. Several criteria were used during the literature search, including the publication of peer-reviewed journals in both English and Indonesian, as well as seminar proceedings. During the literature search, the keywords broilers, cloves, and broiler performance and health were used. Scientific websites, including Elsevier, Science-Direct, Springer Link, E-Journal, and Google Scholar were used to select relevant papers.

Botanical composition and phytochemical characteristics

Syzygium aromaticum, also known as clove, is a medium-sized (8-20 m) tree from the Mirtaceae family native to the Maluku islands in eastern Indonesia. For centuries, the trade in cloves and the pursuit of this valuable spice fueled the Asian region's economic development. Clove trees are commonly grown along coastlines at a maximum elevation of 200 meters above sea level. After 4 years of planting, the production of flower buds, which is the commercial part of this tree, begins. Before flowering, flower buds are collected during the ripening phase. The top clove-producing countries are currently Indonesia, India, Malaysia, Sri Lanka, Madagascar, and Tanzania, particularly the island of Zanzibar (Kamatou et al., 2012). Cloves have been used as a cooking spice as well as a herbal medicine. In addition to the leaves, flowers, and fruit, clove oil is frequently used in aromatherapy and as a topical pain reliever.

This plant is rich in bioactive substances in the form of flavonoids, triterpenoids, phenolics, and tannins which are antibacterial compounds (Jimoh et al., 2017). Clove leaves are also known to contain compounds such as eucalyptol, caryophyllene, α-cardinol, and limonene (Mohammed et al., 2015). According to the results of Uddin et al. (2017), in addition to containing 3-Allyl-6-methoxyphenol-Eugenol compound, cloves also contain other compounds, including caryophyllene, 1, 4, 7-cycloundecatriene, 1, 5, 9, 9-tetramethyl, and eugenol acetate. These compounds are known to have benefits in the field of medicine, including antiseptic, anesthetic, analgesic, antioxidant, anti-inflammatory, and antimicrobial. The advantages of bioactive compounds found in clove plants are shown in Table 1.

In general, the pharmacological benefits of herbal plants are associated with various bioactive components that can function as antimicrobial, antifungal, anti-inflammatory, anti-allergic, and antioxidant agents. Clove essential oil produced from the distillation process contains compounds such as eugenol, tannin, caryophyllene, methyl salicylate, tannin, caryophyllene, methyl salicylate, and other compounds that have many health benefits because they have antiseptic, antimicrobial, and analgesic properties.

Table 1: Benefits of bioactive substances in clove plants (*Syzygium aromaticum*).

Bioactive substances	Benefits	References
Phenolic compounds such as eugenol, eugenol acetate and acetic acid	Beneficial in the fields of pharmacy, food, and agriculture	(Cortes-Rojas *et al.*, 2014)
eugenol, eugenol acetate, and β-caryophyllene	Having the ability of pharmacological and antioxidant activities and playing a role in inhibiting bacterial growth	(Jimoh *et al.*, 2017; Mohammadi *et al.*, 2014)
3-Allyl-6-methoxyphenol-eugenol, phenol, 2-methoxy-4-(2-propenyl), acetate, caryophyllene, 1, 4, 7,-cycloundecatriene, 1, 5, 9, 9-tetramethyl	Antibacterial agents against Bacillus subtillis, Staphylococcus aureus, Klebsiela pneumonia, Vibrio cholera. Having antioxidant activity	(Hemalatha *et al.*, 2016)
caryophyllene; 1, 4, 7,-cycloundecatriene; 1, 5, 9, 9-tetramethyl; and eugenol acetate	Beneficial in the field of medicine, including as an antiseptic, anesthetic, analgesic, antioxidant, anti-inflammatory, and antimicrobial agents.	(Uddin *et al.*, 2017)
flavonoids, triterpenoids, phenolics, and tannins	Antibacterial agents	(Jimoh *et al.*, 2017)
eucalyptol, caryophyllene, -cardinol, and limonene	Antibacterial agents	(Mohammed *et al.*, 2015)
3-allyl-6-methoxyphenol-eugenol, caryophyllene 1, 4, 7,-cycloundecatriene, 1, 5, 9, 9-tetramethyl, phenol, 2-methoxy-4-(2-propenyl), and eugenol acetate	Inhibit the growth of Streptococcus mutans bacteria that causes dental caries	(Suhendar and Sogandi, 2019)
Essential oil and eugenol	Inhibit the growth of fungi, including: Microsporum canis, Trichophyton mentagrophytes, Trichophyton rubrum, Epidermophyton floccosum, and Microsporum gypseum	(Rana *et al.*, 2011; Devi *et al.*, 2010; Park *et al.*, 2007)
phenolic compounds such as flavonoids, hydroxybenzoic acid, hydroxynamic acid, and hydroxyphenyl propens	As an anti-infection agent or food preservative	(Fu *et al.*, 2007)
polyphenols and antioxidant compounds	Free radical scavengers	(Pérez-Jiménez *et al.*, 2010; Shan *et al.*, 2005)
Eugenol	Inhibit the growth of *Escherichia coli* (*E. coli*), Staphylococcus aureus, and Bacillus cereus bacteria	(Sofia *et al.*, 2007; Pérez-Conesa *et al.*, 2006; Burt *et al.*, 2003)
eugenol and carvacrol	As antifungal medicines	(Hill *et al.*, 2013)
Eugeniin	Antiviral agent	(Kurokawa *et al.*, 1998))
Flavonoids	Antibacterial agents	(Sjafani *et al.*, 2022; Neveu *et al.*, 2010)
Essential oil	Relieves toothache and joint pain	(Jirovetz and Buchbauer, 2006)

The main bioactive compound in cloves is eugenol. Eugenol content in clove ranged from 9381-14650 mg/100 g. Clove flower buds can contain up to 18% essential oil. Approximately 89% of clove essential oil is eugenol, with the remaining 5% to 15% being eugenol acetate and β–cariofileno (Jirovetz and Buchbauer, 2006). It is also claimed that α-humulene is an important compound found in clove essential oil at concentrations of up to 2.1%. β-pinene, limonene, farnesol, benzaldehyde, 2-heptanone, and ethyl hexanoate are other volatile compounds found in low concentrations in clove essential oil.

Effect on broiler performance

As shown in Table 2, various studies have evaluated the effect of giving cloves in the form of flour, clove oil or aqueous extract on performance parameters of broiler chickens. Cloves contain natural bioactive compounds that can stimulate appetite, aid in endogenous secretion such as enzymes, and have antimicrobial activity, all of which can help improve livestock performance and health. Cloves can take the place of AGP as a growth promoter. This is due to the high concentration of active ingredients, which include antioxidants, immunostimulants, and antimicrobials (Adu et al., 2020; Wankhede, 2015; Kaur et al., 2019). Several bioactive compounds from plants have previously been identified as potential candidates that can stimulate the growth of beneficial bacteria such as lactobacilli and bifidobacteria while inhibiting the growth of pathogenic

Table 2: Effect of Clove (*Syzygium aromaticum*) and its preparations on performance parameters of broiler chickens.

Preparation	Optimum dose	Impact on broiler chickens	References
Clove essential oil	500 mg/kg feed	Eugenol in clove essential oil is very effective in increasing the growth performance of broilers.	(Mohammadi *et al.*, 2014)
Flour	10 g/kg feed	Increase the growth rate without affecting the health of the liver and intestines of broilers	(Al-Mufarrej *et al.*, 2019)
Clove essential oil	450 ppm/kg feed	Feed supplementation with 450 ppm clove essential oil increased feed intake (FI), weight gain (BBM), and improved feed conversion ratio (FCR)	(Azadegan *et al.*, 2014)
Clove bud flour	0.5 g/kg feed	Improve the performance of broiler chickens	(Mahrous *et al.*, 2017)
Clove essential oil	600 mg/kg feed	Chickens fed with clove oil 600mg/kg recorded more feed intake and body weight compared to the control group and antibiotics and the lowest mortality compared to the control group.	(Mukhtar, 2011)
Flour	2% in feed	Reducing feed costs and reducing the use of antibiotics in broiler rearing	(Sapsuha *et al.*, 2019)
Flour, oil and water extract	0.8% and 0.4% clove flour in feed, 0.8% clove oil in feed, and 0.4% clove water extract in drinking water	There was an increase in performance due to clove supplementation in the feed and drinking water of broiler chickens exposed to heat stress.	(Salman *et al.*, 2012)

bacteria (Fasina et al., 2015) and thus improve the performance of broiler chickens.

Al-Mufarrej et al. (2019) discovered that using 10 g of clove flour per kg of ration could increase growth rate without affecting the liver and intestine health of broilers. Another study found that broilers given 450 ppm clove essential oil had a significant increase in feed consumption and weight gain compared to the control group at 0-42 days of rearing (Azadegan et al., 2014). Because of the volatile oil content in cloves, an increase in feed consumption can lead to an increase in weight gain. Plants in the essential oil group have been shown to improve the taste and delicacy of feed, which can lead to increased feed consumption and weight gain (Sugiharto, 2016). Cloves contain approximately 18% essential oil, which is primarily composed of 89% eugenol, 5-15% eugenol acetate and β–cariofileno, 2.1% α-humulene, and trace amounts of β-pinene, limonene, farnesol, benzaldehyde, 2-heptanone, and ethyl hexanoate (Jirovetz and Buchbauer, 2006; Ali et al., 2014).

The mechanisms by which the clove can help improve performance broiler, because cloves contain natural bioactive compounds that can stimulate appetite, modulating the cellular membrane of microbes leading to membrane disruption of the pathogens, stimulating the growth of favourable bacteria such as lactobacilli and bifidobacteria of which can help improve performance broiler (Al-Mufarrej et al., 2019; Sjafani et al., 2022).

Effect on digestibility

Clove supplementation in feed has been associated with increased digestibility of broiler chickens (Agostini et al., 2012), which in turn increases nutrient availability and substrate availability for energy metabolism. Cloves have also been reported to improve the digestive tract (Chowdhury et al., 2018) and improve gut conditions, e.g., pH, digesta, and villi viscosity (Rahman et al., 2017; Ali et al., 2014). These conditions contribute to improved feed digestibility. In addition, the efficacy of clove preparations in restoring intestinal damage and digestive enzyme activity caused by stress and infection (Ghazanfari et al., 2014) may play a role in maintaining optimal digestive function of broiler intestines. Improved histomorphological (i.e., villous height, crypt depth, and villi height to crypt depth ratio) and ecological (e.g., increased lactic acid bacteria and decreased numbers of *Salmonella* sp. and *Escherichia coli*) gut health may also be linked to improved feed nutrient utilization in boiler chickens (Mohammadi et al., 2014; Gandomani et al., 2014; Mahrous et al., 2017; Chowdhury, 2018). Mohammadi et al. (2014) also observed a reduction in mortality in broiler chickens fed cloves in their feed. The above-mentioned bioactive compound content can play an important role in improving feed digestibility and improving broiler performance and health.

The mechanism related to clove can to improve the digestive tract in broiler chickens, i.e. the efficacy of clove preparations in restoring intestinal damage and digestive enzyme activity (Rahman et al., 2017) may play a role in maintaining optimal digestive function of broiler intestines and protect intestinal tissue from microbial attack (Suhendar and Sogandi, 2019; Ghazanfari et al., 2014). Eventually, optimal intestinal development can support the development digestive tract in broiler.

Effects on broiler health

Normal physiological conditions are required to ensure that broiler growth capacity is maximized. Herbal plant supplementation has been shown to maintain and improve broiler physiological condition. Previous studies found that cloves were beneficial to broiler health by inhibiting pathogenic bacteria, improving gut health, increasing antioxidant status, improving digestive function, and increasing chicken immunity (Al-Mufarrej et al., 2019; Mahrous et al., 2017). Su et al. (2021) investigated the effect of administering essential oil containing the active ingredients thymol 3.05%, carvacrol 2.3%, and cinnamaldehyde 0.26%, which demonstrated an increase in essential oil levels from 0 to 400 mg/kg and significantly increased superoxide dismutase (SOD) activity in broiler serum at 21 days old. The use of clove leaf flour as a phytobiotic can reduce feed costs and the use of antibiotics in broiler chicken production (Sapsuha et al., 2019).

Several bioactive components found in cloves have been shown to have immunomodulatory and anti-inflammatory properties. Bhowmik et al. (2012) discovered several bioactive compounds in clove leaf flour. They discovered that clove leaf flour contains a high concentration of bioactive compounds such as eugenol, flavonoids, and triterpenoids, all of which have antioxidant activity. In line with this, Adu et al. (2020) discovered that the antioxidant content in clove leaves has immune enhancing properties, which are important for host defense against pathogenic agents. Furthermore, Mohammed et al. (2015) discovered that clove leaves contain several active compounds that can act as immunomodulatory agents, including eucalyptol, karyophyllene, α-cardinol, and limonene, as well as diterpenoids and flavonoids. The presence of bioactive substances such as alkaloids, terpenoids, simple phenolic compounds, polysaccharides, peptides, glycoproteins, and nucleotides in most herbal plants, according to Chabib et al. (2018), may be responsible for the immune-stimulating effects of herbal plants.

Cloves have been shown to improve the health and function of the chicken digestive tract by having a positive impact on the microbial ecosystem in the digestive tract (Chowdhury et al., 2018). According to one recent study, using clove leaves improved gut health and function in broiler chickens. According to Ren et al. (2019), the administration of commercial phytogenics containing the active ingredients carvacrol, cinnamaldehyde, and eugenol may provide more energy for the growth of beneficial bacteria in the gut, such as bifidobacteria and *Lactobacillus* spp. Another study found that administering clove essential oil could reduce the number of pathogenic bacteria in the intestines of broiler chickens (Mohammadi et al., 2014). Meanwhile, Salman and Ibrahim (2012) reported that administration of clove flour, oil, and aqueous extract increased the concentration of short chain fatty acids (SCFA) in the cecum, promoted better gut development, increased the number of beneficial bacteria, and inhibited pathogenic bacteria in the gut of broiler chickens. Herbal plants have a greater impact because the bioactive substances contained in them can promote the growth of probiotic bacteria while also inhibiting pathogenic bacteria (Prakasita et al., 2019). Furthermore, the carbohydrate content, particularly oligosaccharides from herbal plants, can be a good substrate for the growth of probiotic microbes for improved gut health (Sjafani et al., 2022).

The mechanism related to clove can increase the health in broiler chickens, i.e. can increase the immune response in broiler chickens and can act as immunostimulant substances, and protect intestinal tissue from microbial attack (Ali et al 2014; Adu et al 2020; Sjafani et al., 2022). Eventually, optimal intestinal development can support the development of the immune system in the intestine. The increase in antioxidant status in broiler chickens due to the provision of the clove was due to bioactive substances in clove may act as an antioxidant which synergistically triggers antioxidant activity in the body of broilers (Gandomani et al., 2014; Mahrous et al., 2017).

CONCLUSIONS AND RECOMMENDATIONS

Cloves contain bioactive substances that can be used to improve the performance and health of broiler chickens. The administration of an appropriate dose is thought to replace the role of AGP, which is currently prohibited from use in broiler chicken feed.

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NOVELTY STATEMENT

Cloves (*Syzygium aromaticum*) contain bioactive substances that can be used to improve broiler chicken performance and health. Administration of appropriate dose is believed to replace the role of Antibiotics Growth Promoter (AGP), which is currently prohibited from its use in broiler chicken feed.

AUTHOR'S CONTRIBUTION

The manuscript was written by Yusri Sapsuha and Nur Sjafani, and edited by Suryati Djokrodiningrat. All authors read and approved the final manuscript.

Conflict of interest

The authors have declared no conflict of interest.

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