Chapter 05

Herbal Remedies for Treating *E. coli* in Poultry Flock

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ABSTRACT

Due to the high consumption of poultry meat, poultry industry also gained major place in the economy of world. To enhance the rate of production of meat, many antibiotic feed additives are used in the feed and water of birds. But the increased use of antibiotics results in the resistance of antibiotics in the bacteria. To inhibit the emergence of resistance, many other products introduce to use as feed additives in bird. Plants and herbs are the potential source of naturally occurring compounds to use in poultry which possesses less side effects and in poultry and human as well. For the antibacterial, antiviral, anti-parasitic, and antioxidant activities of these herbs and spices, they are widely used in poultry to enhance the body weight and production rate. These plants also used for their therapeutic activities in the poultry against many bacterial and viral infections.

KEYWORDS
Poultry, Antibiotics, Feed additives, Herbs, Infection

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INTRODUCTION

Since the last four decades, the poultry industry has reached a milestone in production but there are still many hurdles in the way of achieving a high rate of production. The main problem includes high feed cost and improper use of antibiotics in birds (Kudoh et al., 1998; Alagbe et al., 2019). The indiscriminate use of antibiotics in poultry is a major health concern as the residue present in several end products present serious health issues in humans due to the resistance developed in bacteria against these antibiotics. These health concerns led to the ban on the use of antibiotic feed additives in poultry in 2006 by the European Union (Vicente et al., 2007). The most popular and potential alternative of antibiotic feed additives are phytobiotics, phytogenics and probiotics. These medicinal plants contain one or more beneficial bacteria or yeast which help in promoting gut health of the bird and also protect from the condition called as dysbiosis which probably results in stress, water deprivation, fasting infections which may result in disturbance of the normal gut microflora and number of infectious microorganisms increase (Vicente et al., 2007; Alagbe, 2020). Gut is considered as the most important organ as processes of digestion, absorption of nutrients, integrity of intestine, metabolism of nutrients and fermentation take place there (Al-Mashhadani, 2015). The exposure of the intestinal tract to the infectious agents such as *Escherichia coli*, *Clostridium*, *Pseudomonas*, *Blastomyces* and *Salmonella* result in imbalance of gut microflora, loss of productivity and immunosuppression (Kudoh et al., 1998).

E. coli Infections in Poultry

Avian pathogenic *Escherichia coli* (APEC) which is basically an extra-intestinal pathogenic *E. coli* (ExPEC) has the potential to cause local and systemic severe infections in chicken, ducks, turkeys, and many other poultry birds (Figure 1)

(Dho-Moulin and Fairbrother, 1999). APEC cause serious infections in poultry bird which collectively called as avian colibacillosis. In avian colibacillosis various systems of body faced serious infections for example in liver it cause perihepatitis, in air sacs it results in airsacculitis, also cause pericarditis, damage egg production by causing egg peritonitis, and various other infections such as salphingitis, coligranuloma, omphalitis, cellulitis, and osteomyelitis/arthritis (Dziva and Stevens, 2008). Swollen head syndrome in chickens and osteomyelitis complex in turkeys also caused by APEC (Guabiraba and Schouler, 2015).

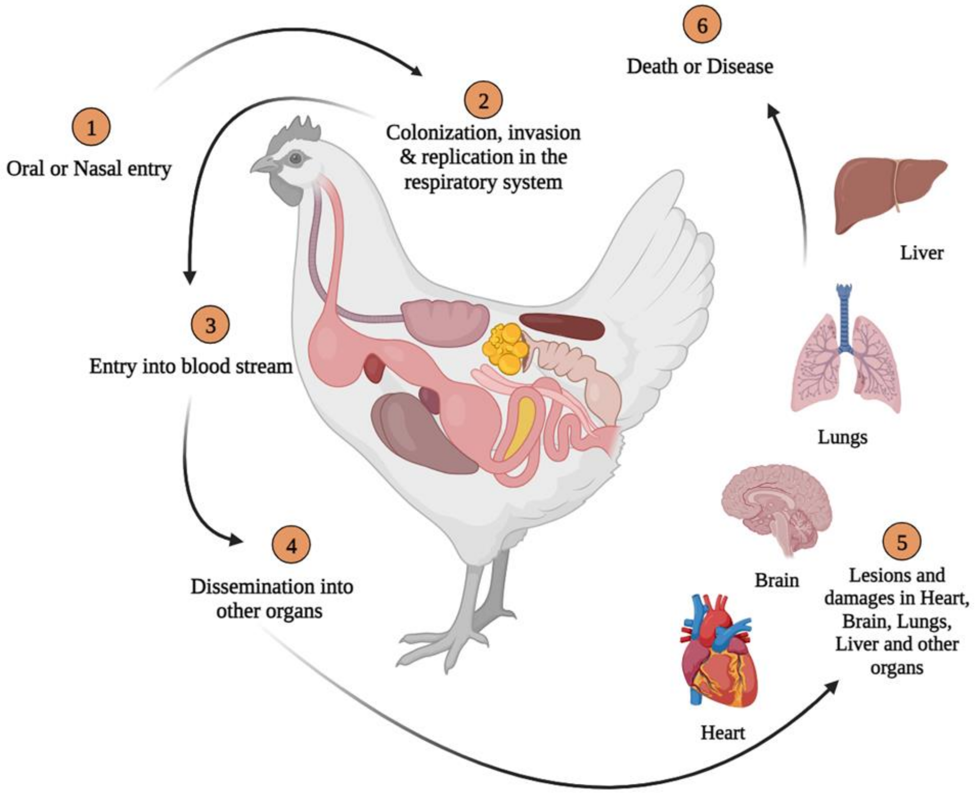

Fig. 1: Pathology of Avian Pathogenic *E. coli* (APEC)

The rate causes major harmful health outcomes in poultry due to colibacillosis include mortality (up to 20%) and morbidity, decrease in meat production (decrease in live weight 2%, 2.7% decrease in feed conversion ratio) and rate of egg production (up to 20%) decline in hatching rate, at slaughter high rate of condemnation of carcass (up to 43%) (Dho-Moulin and Fairbrother, 1999; Dziva and Stevens, 2008; Guabiraba and Schouler, 2015). While in young chickens the rate of mortality exceeds up to 53.3% (Mellata, 2013). Due to the high cost of treatment and preventive measures, the poultry industry faces hundreds of millions of dollars of losses due to APEC around the world (Ghunaim et al., 2014). The estimated loss due to APEC in broilers is $40 million which is only due to carcass condemnation in the United States (US) (de Brito et al., 2003). All types of poultry species raised in all types of production systems are under the threat of APEC (Dziva and Stevens, 2008). It is also noticed that APEC attacks (9.52% to 36.73%) all age groups of chickens (Lutful Kabir, 2010).

The age at which the attack of APEC is most prevalent in broilers is 4 and 6 weeks of age while in the layers the most susceptible age is throughout the grow and lay periods especially at the peak of egg production rate and late lay periods (Lutful Kabir, 2010). In the US it is noted that almost 30% poultry flocks are susceptible to APEC at any point of age (Johnson et al., 2008). A number of APEC serotypes causes colibacillosis in poultry especially in field outbreaks but most commonly found serotypes are O78, O2 and O1 which causes the majority of cases (80%) in poultry (Dho-Moulin and Fairbrother, 1999; Ghunaim et al., 2014). APEC causes systemic infections in poultry both as a primary pathogen or as a secondary pathogen to viral infections such as infectious bronchitis (IBV), Newcastle disease (NDV), avian influenza (AIV)) and Mycoplasma (*Mycoplasma gallisepticum* (MG)) infections, immunosuppressive disease, infectious bursal disease (IBD).

The age at which broiler chickens are at risk of getting APEC infections is at 4 and 6 weeks old but in case of layer, the chickens are more vulnerable at the peak of egg production and almost throughout the growth period (Dho-Moulin and Fairbrother, 1999). In the United States, it has been noticed that almost 30% of the population of poultry has been threatened by APEC at any time (Johnson et al., 2008). The three major serotypes used to cause almost 80% infection in birds are O78, O2 and O1 but many other serotypes have also been seen in field outbreaks (Dho-Moulin and Fairbrother, 1999; Ghunaim et al., 2014). APEC causes infection in poultry both as primary agent and secondary agent (Figure 2) (as a result of viral infections such as (infectious bronchitis (IBV), Newcastle disease (NDV), avian influenza (AIV)) and Mycoplasma (*Mycoplasma gallisepticum* (MG)) infections, immunosuppressive disease (infectious bursal disease (IBD)), and as a result of stress from overcrowding in poultry shed and high levels of ammonia as the pathogen can enters in the body of bird through oral and respiratory routes (Dho-Moulin and Fairbrother, 1999; Guabiraba and Schouler, 2015).

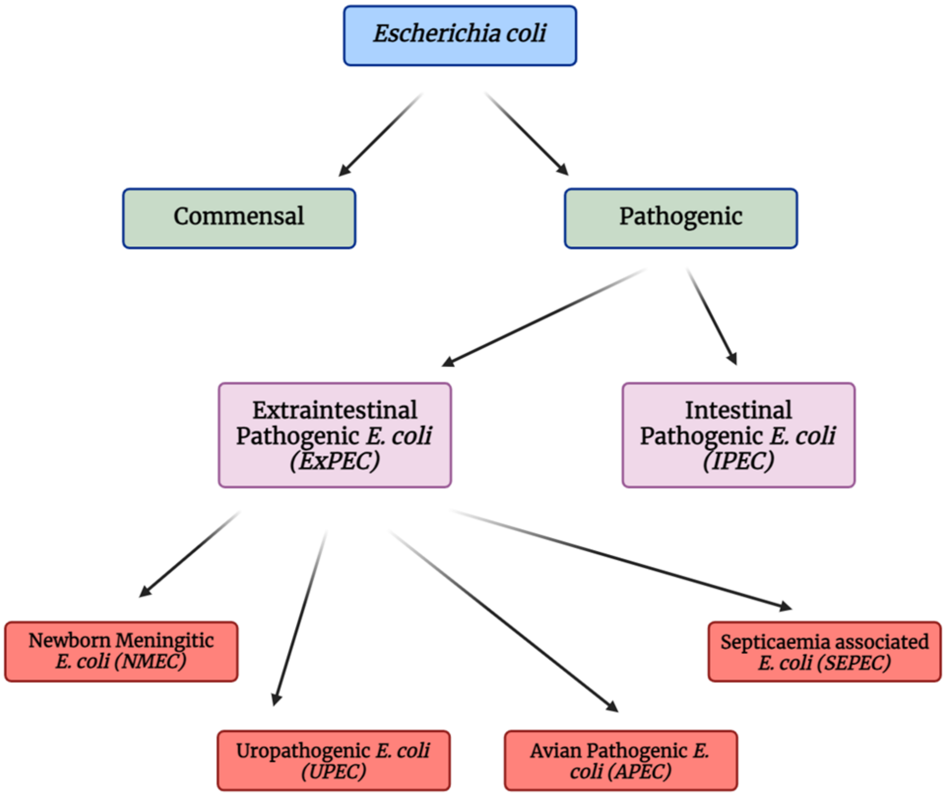

Fig. 2: Classification of *E. coli* based on origin and pathogenicity.

It has been seen that APEC didn't harm its host and colonize in the body of host at different places including intestinal and respiratory tracts but in the presence of any stress indicators for example production stress, immunosuppression or in any other infections (Dziva and Stevens, 2008; Collingwood et al., 2014). APEC enters in the body in the presence of any stress indicator and reaches in the intestinal or respiratory tract through the lacerations in the epithelial tissue of intestine and trachea through which it reaches the bloodstream and other internal organs of the host body (Dho-Moulin and Fairbrother, 1999; Dziva and Stevens, 2008; Guabiraba and Schouler, 2015). Contaminated feed and water are the major vectors of spreading infection in poultry birds and can be transferred to the other healthy birds through feco-oral and aerosol routes (Dho-Moulin and Fairbrother, 1999; Dziva and Stevens, 2008; Guabiraba and Schouler, 2015). Vertically, APEC transferred through contaminated eggs due to infected breeders (Dho-Moulin and Fairbrother, 1999; Dziva and Stevens, 2008; Guabiraba and Schouler, 2015). APEC acts as an opportunistic pathogen and remains in the intestinal and respiratory tract of the host without causing any infection but in the presence of any stressor such as immunosuppression, it causes infections (Dziva and Stevens, 2008; Collingwood et al., 2014).

APEC has many different virulence factors including adhesins, invasins, protectins, iron acquisition systems, and toxins to cause infection in the chickens (Dho-Moulin and Fairbrother, 1999; Guabiraba and Schouler, 2015). These virulence factors help APEC in various functions such as adhesion, invasion and evasion from the host different immune responses and also facilitate the proliferation, colonization and dissemination of APEC in different systems of host which result in serious infections in chickens (Dziva and Stevens, 2008; Collingwood et al., 2014). There are several other bacterial factors present for example secretion systems (type III and VI), quorum sensing systems, transcriptional regulators, two-component systems, and metabolism-associated genes also responsible for APEC infections in chickens (Palaniyandi et al., 2013; Ma et al., 2014; de Paiva et al., 2015; Jiang et al., 2015; Zhuge et al., 2016; Barbieri et al., 2017; Wang et al., 2017; Guerra et al., 2018; Li et al., 2020). To develop effective treatment methods and preventive measures, a detailed understanding of these factors will be very helpful.

Herbal Remedies for *E. coli* Infections of Poultry

Antibiotic-resistant bacteria are proliferating, endangering the safety of food products like chicken as well as people who use them. Numerous researches emphasize the antimicrobial qualities of medicinal plants, which are just as significant as those of current synthetic medications. The prospect is the driving force behind the growing interest in using medicinal herbs instead of conventional treatment for chickens (Table 1). Powdered Amla (*Phyllanthus emblica*) fruit contains tannin (Rose et al., 2018) has ability to destroy bacteria by their engulfing properties (Sai Ram et al., 2003). Consuming amla causes the gut's lactic acid bacteria to produce more lactic acid, which lowers the pH of the colon and keeps organisms from integrating into the intestinal mucosa, preventing harm to tissues from failed toxin synthesis (Dalal et al., 2018). Supplementing the broiler feed with *Salvia rosmarinus* can boost *Lactobacilli* numbers and lower *E. coli* levels (Norouzi et al., 2015). Likewise, another researcher (Al-Mashhadani, 2015) found as rise in Lactobacilli count had an impact on weight growth, supplementing with *Curcuma longa* (turmeric) reduced the viability of *E. coli* in the cecum. Lannaon (Lannaon,

2009) discovered, broiler chicks responded more positively to herbal mixtures of avocado leaves, guava, duhat, eucalyptus, or tam arind trees than to currently available medicines. Studies by Mapatac (Mapatac, 2015) revealed that giving broiler infusion of guava enhanced efficiency in addition to other vegetation, such as leaves of malunggay (*Moringa oleifera*) and avocado (*Persea americana*). Further research, yet, suggests that eating different avocado segments may have strong antimicrobial qualities.

Table 1: Effective antibacterial herbs against *E. coli* infection in poultry flock.

No.	Herb spp.	Botanical name	Effective part of plant	Effective against	References
1.	*Salvia rosmarinus*	Rosemary	Leaves	*E. coli*	(Norouzi et al., 2015)
2.	*Curcuma longa*	Turmeric	Rhizome	*E. coli*	(Al-Mashhadani, 2015)
3.	*Persea americana*	Avocado	Leaves and bark	*E. coli, S. aureus*	(Ogundare and Oladejo, 2014)
4.	*Persea americana*	Avocado	Fruit	*E. coli, S. aureus*	(Guzmán-Rodríguez et al., 2013)
5.	*Persea americana*	Avocado	Seed	*E. coli, S. aureus, S. agalactiae*	(Cardoso et al., 2016)
6.	*Psidium guajava*	Guava	Fruit	*E. coli, S. Typhimurium*	(Ibrahim et al., 2011)
7.	*Syzygium cumini*	Duhat	Stem	*B. amyloliquefaciens, S. aureus, E. coli, P. aeruginosa*	(Sharma, 2017)
8.	*Tamarindus indica*	Tamarind	Fruit	*E. coli, K. pneumoniae, S. paratyphi A., P. aeruginosa.*	(Daniyan and Muhammad, 2008)
9.	*Thymus vulgaris*	Thyme	Leaves	*E. coli, S. Typhimurium*	(Aktuğ and Karapinar, 1986; Marino et al., 1999)
10.	*Cinnamomum zeylanicum*	Cinnamon	Inner bark	*Klebsiella spp., E. coli, L. monocytogenes, and Bacillus spp.*	(Griggs and Jacob, 2005; Gupta et al., 2008; Abd El-Hack et al., 2020)
11.	*Allium sativum*	Garlic	Bulbs	*E. coli*	(Ziarlarimi et al., 2011)

Use of Herbal Extracts in Poultry

The extracts of leaves and stems work well in opposition to *Staphylococcus aureus* and *E. coli* because they include terpenoids, tannins, flavonoids, and saponins (Table 2) (Ogundare and Oladejo, 2014). Additionally, the fruit has a raised-phenolic component that is work well towards *Streptococcus agalactiae, S. aureus*, and *E. coli* (Cardoso et al., 2016), and the seed has defensin PaDef, that is powerful in killing these pathogens (Guzmán-Rodríguez et al., 2013; Cardoso et al., 2016). The aerial parts of duhat (*Syzygium cumini*) consist of bioactive compounds, like flavonoids, tannins, terpenoids, and alkaloids, which restrict different bacteria such as *Bacillus amyloliquefaciens*, also *S. aureus*, with *E. coli*, and *Pseudomonas aeruginosa* to grow further. Guava (*Psidium guajava*) also have the ability to limit the growth of *Salmonella Typhimurium* (Ibrahim et al., 2011) and *E. coli* (Sharma, 2017). The foliage of Eucalyptus (*Eucalyptus globulus L.*) are rich in naturally occurring compounds that reduce the activity of *Salmonella, Klebsiella spp., S. Streptococcus A., Proteus spp.*, and *S. aureus*. These components include tannins, flavonoids, volatile oils, and terpenoids (Sallam et al., 2009). The ripe fruit of the tamarind tree, Tamarindus indica, also includes bioactive substances that prevent the growth of *Salmonella paratyphi A, P. aeruginosa, Klebsiella pneumoniae,* and *E. coli*. These components include alkaloids, flavonoids, saponins, and tannins (Daniyan and Muhammad, 2008). Additionally, thyme inhibited the in situ development of *S. Typhimurium* (Aktuğ and Karapinar, 1986) and *E. coli* (Marino et al., 1999). Enhanced antibacterial qualities versus pathogenic bacteria such *Klebsiella spp., E. coli, Listeria monocytogenes*, and *Bacillus spp.* were seen in the vital oil of cinnamon (*Cinnamomum zeylanicum*) (Gupta et al., 2008; Abd El-Hack et al., 2020). Furthermore, cinnamon (*C. zeylanicum*) essential oil may have inherent antibacterial qualities in chickens, according to Griggs and Jacob (Griggs and Jacob, 2005). Furthermore, *Menthe spp.*, *Allium sativum*, and *Allium cepa* may all successfully stop E. coli from growing (Ziarlarimi et al., 2011).

Table 2: Various herb preparations that are effective against *E. coli* infection in poultry.

No.	Plant Spp.	Effective extract	Zone of inhibition (mm)	References
1.	*Achillea wilhelmsii*	Methanol	9	(Amjad et al., 2011)
2.	*Allium sativum*	Methanol	21.5	(Garba et al., 2013)
3.	*Artimesia scoparia*	Methanol	24	(Moghaddam and Sani, 2015)
4.	*Artimesia scoparia*	Essential oil	26	(Moghaddam and Sani, 2015)
5.	*Coriandrum sativum*	Ethyl acetate	7	(Keskin and Toroglu, 2011)
6.	*Coriandrum sativum*	Ethanol	14.5	(Shaheen et al., 2015)
7.	*Cuminum cyminum*	Methanol	8	(Keskin and Toroglu, 2011)
8.	*Withania coagulans*	Methanol	10	(Peerzade et al., 2018)

Cumin was shown to be greater in effectiveness against *E. coli* and *Enterobacter aerogens* than against other types of bacteria in a research that used the technique of disc diffusion to examine the antibacterial properties of cumin (Chaudhry and Tariq, 2008). Cassia angustifolia was found to be incredibly effective in opposition to methicillin-resistant *Staphylococcus aureus*, *Salmonella*, *E. coli*, and *Shigella shinga*, as well as *K. pneumoniae*. Bameri et al. (Bameri et al., 2013) demonstrated this effectiveness, which may have implications for the digestive system, where certain pathogenic bacteria rely on the binding of microbes to intestinal mucosal cells, a process that is strongly regulated by the hydrophobic surface characteristics of these microorganisms. According to Jamroz et al. (Jamroz et al., 2003), a combination of plant extraction decreased the number of *C. perfringens* and *E. coli* in intestinal materials in a way that was equivalent to the effects of the drug avilamycin. According to reports, the addition of a volatile oil (EO) blend including carvacrol, trans-cinnamaldehyde, and capsaicin at 49.5, 29.7, and 19.8 g/kg, each, significantly reduced the amount of *E. coli*. (Jamroz et al., 2005). According to Yasar et al. (Yasar et al., 2011), adding 1.5% of cumin to the diet dramatically lowered the counts of lactic acid bacteria, enterobacteriae, psychrophilic aerobic bacteria, and *E. coli*. Four herbs—cumin, peppermint, yarrow, and poley—as well as an antibiotic—flavomycin—were added to the feed of young chicken by Sharifi et al. (Sharifi et al., 2013). They discovered that the middle part of intestine Lactobacilli and Coliform bacterial populations remained unchanged after supplementation. Intestinal *Bifidobacterium* and *Clostridium* counts were lowered in broiler chicken feed upon the incorporation of flavomycin, peppermint, yarrow, and poley. There was no discernible effect of cumin on Bifidobacterium. Hosseinzadeh et al. (Hosseinzadeh et al., 2014) use different amount of coriander powder and its extract in the water amd feed of the bird and found no discernible impact on *Lactobacillus* bacteria. In contrast, the use of 1.5% coriander seed powder and 1250 ppm extract considerably decreased the *E. coli* count. Ten or one gram per kilogram was fed to meat birds' basal with black cumin seed and/or seed extraction. According to the findings, the addition inhibited the number of Coliform bacteria in the intestine's caecal region, improving health in conjunction with promoting development-related features (Erener et al., 2010). Additionally, the possible advantages of supplying a botanical cocktail containing coriander, cumin, black pepper, and turmeric included the capacity to reduce the overall *Coliform* count in the quail ileum (Khosravifar et al., 2014). Similar to what was previously said, several studies have shown that eating carwey, turmeric, and cumin inhibited the formation of *E. coli* and coliform and increased the health of the digestive tract, which in turn enhanced consumption and processing (Samarasinghe et al., 2003; Iacobellis et al., 2005).

Conclusion

Many plants contain some naturally occurring compounds in them which work as medicine for poultry birds to treat many bacterial, viral, antiparasitic and antifungal infections. These plants offer many advantages but major advantages of the use of these plant includes less side effects, harmless for use in birds, human and environment, decrease the risks of antimicrobial resistance and almost no residue present in chicken meat and eggs and their products for human consumption. Many plant species have been used as therapeutic agents in poultry and many are under research to find out their potential benefits on the health of poultry birds. Near future, many natural products with less risk of side effects will be used in birds to fight against diseases.

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