Chapter 04

Herbal Treatment Options for Salmonellosis in Poultry Flock

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ABSTRACT

One of the challenging issues especially in the poultry industry of developing countries is the rise in salmonella infections. Salmonella bacteria have a pathologic impact on the gastro-intestinal system of its host hence reducing their gut health. It is commonly known as "food poisoning". Reduction in gut health lowers the capability to absorb nutrients which ultimately leads to lower production and sub-optimal immune response. Factors like lack of hygiene practices and insufficient disease control measures lead to increased salmonellosis incidence that in turn increases the economic losses of poultry farmers. Besides affecting poultry, salmonellosis is also a serious health concern for public health and biosecurity. Being a serious concern for the researchers, salmonella was treated effectively with antibiotics in the past. Azithromycin was the drug of choice against this disease. However, since the rise in antibiotic resistance researchers have now turned their attention towards formulation of other medicinal alternatives that have less side effects and chances of antibiotic resistance development. In case of salmonella in poultry many herbal items have been used but some of them give very effective results for example Green tea, Ginger extracts, Onion peel extracts, Guava leaf extracts, and Essential oils.

KEYWORDS
Salmonella, Gut health, Herbal medicine, Poultry

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INTRODUCTION

Over the recent several years, the poultry industry has grown tremendously and become an important sector of the livestock industry. This also brings a lot of hurdles to be faced by the poultry industry, especially antimicrobial resistance and colonization of pathogens. Salmonella is an important disease of poultry birds which also affects human health. Growth promoters in poultry are banned in several countries, essentially antibiotic growth promoters; this is due to the development of resistance in bacteria against antibiotics. Salmonella destroys the gut integrity in poultry birds leading to the loss in production, performance, and eventually death. This alarming situation led to the discovery of alternative ways to antibiotics in poultry industries such as probiotics and herbal medications. These herbal products are safe to use as they don't exhibit any side effects and also treat many infections (Bajpai et al., 2012). These herbal medications have been used in many countries for their beneficial effects on the health of birds. They don't exhibit any adverse side effects. Also the risk of antibiotic residual is no longer the concern of farmers as the herbal products don't have residual substances to be left in the body of birds. Herbal products are known to exhibit antioxidants actions, antimicrobial activities, and immunomodulatory functions. Herbal products stimulate feed consumption in birds so increase the production and performance of poultry birds (Karadas et al., 2014).

Salmonellosis

Salmonella, which causes systemic infections, is an intracellular bacterium that has the capability to significantly affect both farmers and consumers. It has the ability to cause infections that affect the health as well as the safety of the host (Orimaye et al., 2024). The prevalence of salmonellosis is significantly high and it has deleterious impacts on the production rate of commercial poultry. It also presents serious public health risks. Morphologically, salmonella is a rod-shaped, Gram-negative bacteria and is able to survive in both the presence and absence of oxygen. The pathogenicity of salmonella is very high, causing inflammation of the intestinal tract which results in gastroenteritis (Figure1). *Salmonella enterica*, sub-species *serovar typhimurium*, is the major cause of gastroenteritis in both humans and animals, the leading cause of acute gastroenteritis and bacteremia (Kim et al., 2013). At a young age, chicks are more prone to the infection of salmonella due to the weak immune system at this very young age (Wilson et al., 2016). The source of infections of salmonella in chicks includes hatchery and poultry houses. If a chick gets infected with salmonella, the bacteria enters the body and starts multiplication and making colonies in the intestinal tract. The infection occurs at a high rate at a young age (the starter phase) and then decreases over time. Salmonella can transfer to the human population through contaminated food for example meat and results in serious cases of food poisoning (Bajpai et al., 2012).

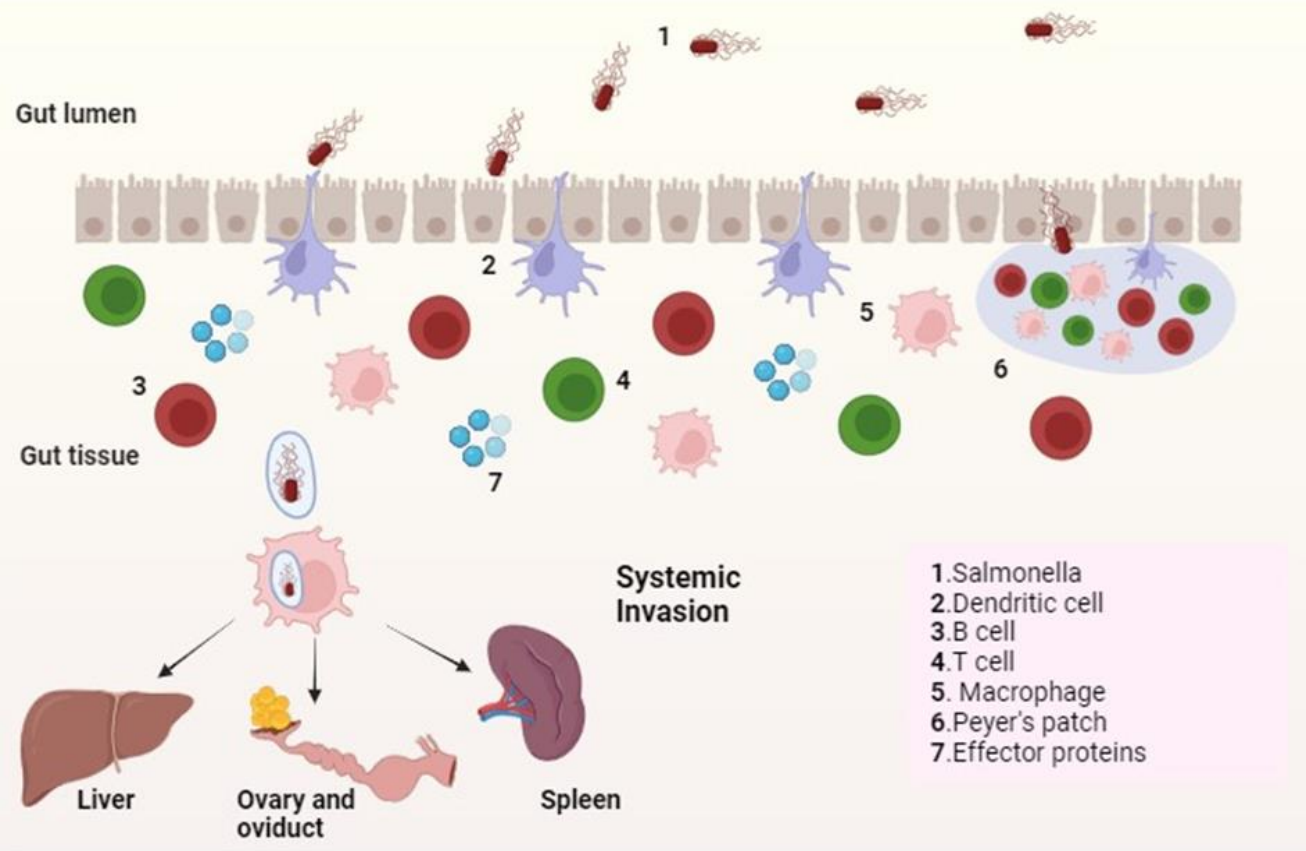

Fig. 1: Pathogenesis of *Salmonella* in poultry

Herbal Treatment Options

The escalation of resistance of antibiotics in bacteria is the result of excessive use of these antibiotics against microbes in poultry, especially meat-type, and livestock. This situation of antibiotic resistance in poultry and livestock leads to the urgent need for some alternatives of antibiotics (Kerek et al., 2023). Nature has gifted to humanity, a gift in the form of various plant-based antimicrobial substances (Fig. 2) which have many therapeutic benefits (Burt, 2004). There are potentially high sources of bioactive compounds of plant origin (Bajpai et al., 2008). It has been proved by both in vivo usage and in vitro studies that the bioactive compounds of plant origin can work against pathogenic actions of various types of bacteria, especially in controlling Salmonella infections in poultry to increase the production and performance of poultry (Ibrahim et al., 2021). The feed additives of plant origin have been used for their therapeutic capacities to enhance the production of poultry. The pharmacology properties of these plant-based products increase the production through stimulating feed consumption, enhancing the antioxidant properties, and preventing antibiotic resistance threats (Juskiewicz et al., 2011). Some other studies show that the use of plants derived products for example polyphenol and oils enhance the production of broilers in many ways including increased absorption of nutrients, improved antioxidant status, and immune response (Khan et al., 2012; Tehseen et al., 2016).

Green Tea

The use of herbal extracts in poultry enhances the production rate and decreases the rate of mortality (Khan, 2014). *Camellia sinensis* locally known as green tea is a natural herb with no toxic side effects. It has a wide variety of bioactive substances for example polyphenols, volatile oils, alkaloids, and polysaccharides (Banerjee and Chatterjee, 2015). Green tea contains high amounts of amino acids with L-theanine as the major element making up to 50% of its amino acid structure, this makes the nutritional value of green tea very high (Abd El-Hack et al., 2020). Catechins polyphenols are also a major component of green tea (Samynathan et al., 2016; Mohammadpour et al., 2021). The medical qualities attributed to green tea include antioxidant activity, antibacterial activity, and immunomodulatory activity which makes green tea a powerful tool against many poultry diseases (Angga et al., 2018). Green tea helps to control the level of cholesterol, especially the LDL cholesterol and decreases the level of lipoprotein lipase and the level of adipose triglyceride lipase. These functions are controlled by polyphenols, as they increase the reverse cholesterol transport. This function is done when polyphenol removes the cholesterol from peripheral tissues. This cholesterol is then transferred to the liver which lowers cholesterol uptake (Huang et al., 2013). Study shows that the leaf of green tea meal polyphenols shows antimicrobial activities against fungi, viruses, and bacteria in the intestine (Zhao et al., 2013). Green tea contains compounds that help in the growth and development of good microbes and inhibit the production of infectious microbes (Pérez-Burillo et al., 2021). This action ends in the low production of harmful microbes which in turn reduces the microbial competition and provides room for good microbes to thrive. *Camellia sinensis* (L.) is widely in use all around the world especially in China, Japan, and Taiwan. Green tea is one of the oldest beverages and is consumed all over the world. The classification of green tea is based on different aspects including the way of processing green tea leaves, the location of its location, and the type of soil in which green tea grows. During the fermentation process of green tea, the capacity of antioxidant activity is impacted. This is due to the increased production of catechins which is the result of catechins oxidation to aflavins (Hinojosa-Nogueira et al., 2021). According to the chemical composition of green tea, there are almost ten different types of compounds present in green tea which primarily include phenolic acids, and polyphenolic chemicals for example catechins, proteins, fats, and amino acids (Zhang et al., 2018). Green tea contains amino acids which include l-theanine, tyrosine, and tryptophan. The trace elements for example magnesium, chromium, manganese, calcium, copper, zinc, iron, selenium, sodium, cobalt, and nickel also present in green tea. Glucose, cellulose, and sucrose are the types of carbohydrates present in green tea (Ye et al., 2018).

Fig. 2: Various herbal remedies against *Salmonella*.

Ginger Extract

Zingiber officinale locally named Ginger is a semi-woody perennial plant belonging to the family *Zingiberaceae*. It is widely used as a spice as well as a medicinal plant. According to the chemical composition of ginger, its rhizomes contain

carbohydrates, lipids, terpenes, and phenolic substances (Zhang et al., 2023). Ginger has been known as a medicinal agent as it contains different active biochemical substances which include gingerol, shogaols, gingerdiol, and gingerdione (George et al., 2015). Studies show that the administration of ginger root extracts in broiler chicks was found to be reducing the population of intestinal microbes specially Salmonella sp., Lactobacillus sp., and E. coli (Ofongo-Abule and Ohimain, 2015). This action provides the evidence of antibacterial activities of ginger root extracts, but there is also a risk to the good microbial population in the GIT, so it is suggested that the dosage should be critically considered. Ginger extracts are also widely used for its antioxidant potential and anti-inflammatory activities. Gas-chromatography-mass spectrometry technique shows the chemical composition of ginger, the main compounds found include zingiberene, curcumene, and sesquiphellandrene (Tao et al., 2009). In-vitro activity shows that ginger extracts decrease the peroxidation of tissue lipids and this is done by absorbing the free radicals for example superoxide, hydroxyl, and DPPH (Srinivasan, 2014). It is found that the oral administration of ginger oil for 30 days enhances the levels of glutathione reductase, glutathione, and superoxide dismutase. On the other hand ginger extracts were found to decrease the levels of phospholipids, total cholesterol, triglycerides, and cholesterol (VLDL or LDL) in the blood and aortic tissue (Al-Tahtawy et al., 2011). Ginger root extracts increase the antioxidant activity and boost the digestive enzyme in the birds. Ginger oil is widely used all over the world for medical activities (Shahrajabian et al., 2019).

Guava Leaf Extract

Guava (*Psidium guajava*) is well known for its high nutritional value and as a medicinal plant (Scholar, 2022). *Psidium guajava* is found all over the world and belongs to the family Myrtaceae. *P. guajava* is a phytotherapeutic plant used to manage different diseases in folk medicine for a long time and results are considered satisfactory. Different parts of the plant are used traditionally to treat different medical conditions, mostly malaria, cough, wounds, vomiting, ulcers, dysentery, gastroenteritis, and inflamed gums (Abdel-Hafez et al., 2015). Phytochemical analysis of *P. guajava* shows that this plant extract contains almost 20 compounds with tannins and P-sitosterol known to be the best elements. Leaf extracts of guava found to be very effective for antibacterial activity, especially against *Salmonella enterica, Serovars typhimurium*, *Staphylococcus. aureus*, *Escherichia coli*, *Bacillus subtilis*, and *Pseudomonas aeruginosa* (Mahfuzul Hoque et al., 2007). The chemical compounds found in guava leaves are glycosides, saponins, flavonoids, terpenoids, and phenol. Different studies show that the antibacterial activity of *P. guajava* is attributed to the bioactive compounds present in guava leaves (Adeyemi et al., 2022). Some other researchers show that the antimicrobial action of guava is due to the presence of phytochemical compounds in it which have been studied for their effect on bacteria (Biswas et al., 2013). A 5% concentration of guava leaf extracts is widely used against salmonella which inhibits the growth of salmonella. Guava is used for its natural potential against the pathogen and for control and management of the pathogen.

Onion Peel Extracts

Recent investigations show that onion peel can be used as a nutritional fiber and a source of bioactive compounds for livestock and also in food industries. Another amazing quality attributed to onion is that it is used as a source of biomolecules, a component of fertilizers made up of organic matter, and also used as a source of renewable energy (Stoica et al., 2023). Onion peel is found to contain a variety of chemicals that exhibit biological activities and used as pharmaceutical agents and also in the food industry. Phenolic compounds are present in onion, with higher volume in the outer as compared to the central layers. The main component of the phenolic chemicals is polyphenolic flavonoids (Pérez-Gregorio et al., 2014). A sun-induced chemical named quercetin formed by the deglucosidation of onion's glycosides (Joković et al., 2024) is thought to be present in high amounts in the peel of onion. It. The antimicrobial activities of onion peel have been proven to be more effective against Gram-positive bacteria as compared to Gram-negative bacteria (Fredotović et al., 2021). Onion peel extracts have been studied and evaluated to check their activity to improve the health, productivity, performance, and growth of poultry (Olugbemi-Adesipe, 2019; Malematja et al., 2022). Onion peel extracts contain phytochemical substances that not only work against pathogenic bacteria but also improve the digestion and absorption of nutrients without affecting the total weight gain and feed intake of birds. Onion peel extracts have been used in the poultry industry as it does not have any adverse effects on the carcass yield of poultry meat (Kothari et al., 2019). Onion peel extracts have no negative effects on poultry production so they could be used as an alternative to antibiotics in poultry.

Essential Oils

Essential oils are naturally present non-toxic, volatile, and aromatic substances. They extract from a large variety of plants and different parts of plants and are known to have the ability to work as growth promoters, immunostimulants, antioxidants, antibacterial, antifungal, and antiparasitic in the poultry industry (Zhai et al., 2018). Essential oils have environment-friendly properties which are beneficial to use against the food borne microbes, especially *Salmonella*, *Campylobacter*, and *E. coli* O157:H7 (Burt, 2004; Johny et al., 2008; Nair et al., 2014; Nair et al., 2015; Nair et al., 2016a; Nair et al., 2016b). Some important essential oils have been drawn from different plants are discussed below. The extracts of *Cymbopogon citratus* locally named lemongrass can work as an antibacterial agent against some bacteria mostly *S. enterica* and *S. typhimurium*. Traditionally lemongrass is used as a flavoring agent in Asian cuisine (Singh et al., 2011). LGEO (lemongrass essential oil) which is extracted from the lemongrass (Tajidin et al., 2012) is standardized by the U. S. Food and

Drug Administration and is known as GRAS (generally recognized as safe). The bioactive compound of essential oil is present as a combination of isomeric forms for example geranial (α-citral) and neral (β-citral) whereas citral is the main bioactive component of essential oils (Tajidin et al., 2012). Other than citral, several other chemical compounds are also present in essential oils at a low concentration, for example, limonene, citronellal, b-myrcene, and gerniol (Schaneberg and Khan, 2002; Tajidin et al., 2012). The antimicrobial activities of LGEO against food-borne bacteria, especially Salmonella have been discussed in some old studies (Shin, 2005; Naik et al., 2010; Shah et al., 2011; Moore-Neibel et al., 2013). The combined action of citral and LGEO has been found to enhance the antibiotic sensitivity of streptomycin against *S. typhimurium* (Shin, 2005). Thyme and oregano-based essential oils are also used to administer in chickens which prevents the colonization of various species of Salmonella in the gastrointestinal tract (Johny et al., 2008). These essential oils are known to be used as a stimulant to feed intake in poultry which ultimately leads to weight gain (Bolukbasi et al., 2006; Cross et al., 2007; Khattak et al., 2014). The antibacterial activities of these essential oils improve the performance of poultry by maintaining beneficial gut microbes and inhibiting the growth of pathogenic bacteria. The antibacterial activities of essential oils are attributed to Carvacrol, thymol, eugenol, and cinnamaldehyde (Mathlouthi et al., 2009; Al-Shuwaili et al., 2015; Moukette et al., 2015). The antibacterial activity is done by destroying the genetic material, changing the permeability of the cell membrane, and disrupting the enzymatic system of bacteria (Hulin et al., 1998; Krishan and Narang, 2014). These oils stimulate feed intake and secretion of the enzymes of the digestive system in poultry birds (Bento et al., 2013), and immunomodulatory actions (Brenes and Roura, 2010; Tiihonen et al., 2010; Amerah et al., 2011; Hosseini et al., 2013; Karadas et al., 2014; Khattak et al., 2014). Cinnamaldehyde present in the bark of cinnamon plants is used for its antibacterial, antifungal, and anti-inflammatory activities (Johny et al., 2010). Cinnamaldehyde shows its antibacterial activities by different mechanics including change of membrane permeability and by stopping the consumption of glucose. 10mM of cinnamaldehyde is found to reduce the colonization of S. enteritidis. Daily feed supplementation of cinnamaldehyde in poultry chickens was found to decrease the colonization of cecal *S. enteritidis*.

Conclusion

Salmonellosis is a bacterial disease that mainly affects the digestive system in both poultry and humans. This disease not only affects birds but it may also be transmitted to humans through consumption of infested undercooked meat. Hence besides being disruptive for the poultry industry this disease is also a serious concern for the health of humans that come in regular contact with chicken and chicken products. The severity of this disease and recent increase in its incidence rate has raised an alarm among the researchers. Although it was easily controlled in the past by using antibiotics like azithromycin, the escalation of antibiotic resistance among bacteria has rendered this drug useless against Salmonella. Such trends call for development of alternative medicinal options to battle salmonella. Many of the alternative options are now being researched to develop commercial products that can be used to control salmonellosis with least side effects. For instance, herbal products like essential oils, ginger, guava leaf and onion peel extracts and green tea are some of the best options that have been reported to be substantially useful against the attack of Salmonella.

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