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Overview of herbal biomedicines with special reference to coriander (*Coriandrum sativum*) as new alternative trend for the development of aquaculture

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ABSTRACT

In several countries of the world, particularly in developing countries, the aquaculture industry is a significant pillar in meeting the human need for essential protein since it is considered the cheapest source of animal protein, which has led to an intensification of fish farming. This intensification has led to the spread of several diseases that lead to significant economic losses. Accordingly, farm owners resorted to the misuse of antimicrobials resulting in hazard effects on public health. The use of herbal medicinal plants is an environmentally sustainable method to improve the growth rate, immunity, and disease resistance of fish. Coriander is recognized as one of the most popular herbal medicinal plants. This review will throw the light on the main hazardous effects of chemical and antibiotic misuse in aquaculture, Coriander (*Coriandrum sativum*) as a medicinal herbal plant alternative to antibiotics and its mode of action to enhance the aquaculture production development.

INTRODUCTION

Fish farming has been quickly increased with intensification over the past four decades to satisfy the increasing global demand for animal protein (Hardy, 2002). Fish intensification leading fish exposure to crowding stress in addition to the environmental stressors as deterioration of water quality, hypoxia. Also, the intensification often weakens the immune system of fish and increases their exposure to infection by the opportunistic bacteria, which leads to greater economic losses **(Oliva- Teles, 2012)**. In the basis of the above, those responsible for the fish industry have recourse to the unnecessary use of antibiotics, whether preventive or medicinal, to minimize these casualties, resulting in a variety of harmful and dangerous consequences **(Cabello *et al.*, 2013)**. The degree of antibiotic danger effect depends on its ability to enter the cell, its cytoplasm and organelle concentration and metabolism and its effect on the biological function of the cell **(Donowitz, 1994).** The hazard effects of chemical and antibiotic misuse in aquaculture can be outlined in the following points:

Impairment of the physiological and immunological parameters

Although the use of antibiotics leads to improved production and development in the aquaculture industry, it has a negative impact on human and environmental health **(Rico *et al.*, 2012; Lulijwa *et al.*, 2020)**. Exposure to antibiotics, even minor doses, but continuously, leads to disturbance of physiological activities, metabolism, and immune system **(Limbu *et al.*, 2018)**.

The antibiotic misuse induces the suppression of lipogenesis and fatty acid β-oxidation, prohibition of aerobic glycolysis and in opposite, it enhances the anaerobic glycolysis and gluconeogenesis **(Limbu *et al.*, 2020).** Overuse of antibiotics on fish farms may also lead to hematopoiesis, leukocytosis, lymphocytosis, hepatotoxicity, nephrotoxicity **(Limbu, 2020).**

The antibiotic medicated diets were reported to cause impairment of liver function as a result of cell damage **(Dobšíková *et al.*, 2013; Reda *et al.*, 2013)** with alteration to some enzymes such as hepatic CYP1A and CYP3A enzymes **(Topic Popovic *et al.*, 2012).** While the findings of previous studies varied between the increase **(Reda *et al.*, 2013)** and the decrease **(Shalaby *et al.*, 2006; Saravanan *et al.*, 2012)** in the effect of antibiotics on alanine aminotransferase (ALT) and aspartate aminotransferase (AST). **Reda *et al.* (2013)** recorded increase of urea value and significant decrease in the value of creatinine of *Oreochromis niloticus* treated with oxytetracycline (OTC) as a result to kidney pathological alteration.

The effect of antibiotics on hematological parameters depends on the concentration and duration of antibiotic exposure. Chloramphenicol medicated diet does not affect some hematological parameters of *O. niloticus* and *Clarias gariepinus* **(Shalaby *et al.*, 2006; Nwani *et al.*, 2014).** While, RBC swelling, the release of immature erythrocytes, anemia caused by tissue injury, impaired RBC, reduced erythrocyte life span، and suppressive effects of antibiotics on erythropoietic tissues are responsible for the decreased RBC counts following exposure to antibiotics **(Nwani *et al.*, 2014)**.

The misuse of antibiotic in aquaculture is leading to the oxidative stress, which negatively affect fish immune system with cellular damage **(Limbu *et al.*, 2020).** The adverse effect of antibiotics on immunity could be attributed to several factors. The first possibility of the antibiotic effect on fish immunity may be due to its inhibition effect on humoral immunity and C3 gene expression in the gut with an increase in the cell parameters as recorded in *Sparus aurata* treated with Oxytetracycline **(Guardiola *et al.*, 2012).** In addition to the compromising effect of oxytetracycline and doxycycline on the mitogenic and allogeneic response of carp leukocytes **(Grondel *et al.*, 1985).** The second possibility that the treatment with antibiotic has a counteract effect on the fish antioxidant capacity due to increase the free radicals as hydrogen peroxide and superoxide anion **(Oliveira *et al.*, 2013)**. Besides, reduction in some antioxidant enzymes such as reduced glutathione S transferase (GST), superoxide dismutase (SOD) with elevation of lipid peroxidation as a results to increase in malondialdehyde (MDA) levels as recorded in *C. gariepinus* exposed to tetracycline **(Olaniran *et al.,* 2019).**

Some studies have demonstrated that use of bacteriostatic antibiotics could improve bacterial virulence by its impair to AMP or complement function resulting in bacteria may survive longer until the innate immune responses are called for **(Kristian *et al.,* 2007).** On contrary, florfenicol did not display major variations in overall levels of immunoglobulin M (IgM) and phagocytic activity when contrasted with the control fish **(Reda *et al.,* 2013).**

Promotion of antibacterial gene resistance

The global misuse of antibiotics is the foundation of antimicrobial resistance (AMR) growth and propagation in aquaculture **(Léger *et al.,* 2021).** The multiplicity of AMR bacteria, whether from sewage water, hospital effluents, industrial and agricultural runoff, makes the aquatic ecology a complicated environment that is difficult to disentangle, especially in low- and middle-income countries (LMICs) that use significant amounts of unknown antimicrobials **(Marti *et al.,* 2014; Reverter *et al.,* 2020).** In addition, what makes matters more difficult is that after wastewater treatment, antibiotics are not entirely eliminated, and so aquatic ecosystems are constantly subjected to antibiotics **(Sinthuchai *et al.,* 2016).** Moreover, AMR is increased by other causes, such as the use of chemicals other than antibiotics as a disinfectant or climatic change that raise the hazard of AMR **(Pal *et al.,* 2015; MacFadden *et al.,* 2018).** Therefore, the regulating of use antibiotics in aquaculture is very significant, especially because the World Health Organization (WHO) has listed 40 of the 60 categories of antimicrobial drugs used in aquaculture as critically important **(Bondad-Reantaso *et al.,* 2012; Liu *et al.,* 2017).**

Every year, there are 700,000 deaths globally, and by 2050 the number of deaths could exceed 10 million because of the AMR **(de Kraker *et al.,* 2016).** The biggest concern of AMR is that it occurs even in the presence of low concentrations of antibiotics in the aquatic environment, which has a very dangerous impact on the health of humans and other animals **(Carvalho and Santos, 2016; Sun *et al.,* 2020).**

Impairment the beneficial effect of gut microbiota

Antibiotics are used in aquaculture operations to eliminate bacterial infections that directly absorbed into the fish intestine, which necessarily affects the intestinal microbiota of fish leading to impairment of fish growth performance and immunity **(Limbu *et al.,* 2019; Wang *et al.,* 2020)**. In addition, the impairment of the intestinal barrier function, which is the first line of protection, resulting in increased permeability and further impacts fish health **(Vancamelbeke and Vermeire, 2017)**.

Drug residues in fish products

Though the very low concentration of antibiotics, long-term exposure may contribute to biocondensation of antibiotics in living species, such as plants, molluscs, fish, shrimps, and waterfowl, via the food chain **(Chen *et al.,* 2020).** The presence of these antibiotic residues can be responsible for adverse effects on human health, allergic reactions and increase the chance of cancer and aplastic anemia **(Ibrahim *et al.*, 2020).**

Therefore, a strict policy and legislation for the use of antimicrobials in food and aquaculture species must be developed and implemented. Prevention of their adverse effects on humans, food, animals, aquaculture, and the environment are critical. Also, finding environmentally friendly natural alternatives to raise the immunity of aquatic organisms and increase their growth rates and their resistance to diseases has become an urgent necessity.

Coriander (*Coriandrum sativum*) as a medicinal herbal plant alternative to antibiotics

Coriander (*Coriandrum sativum* L.) is a very common, taxonomically classified medicinal plant belonging to the Apiaceae family, commonly used as a spice as well as in the pharmaceutical and food industries. The plant used in folk medicine, especially in Egypt **(Önder, 2018)**. Essential oil and fatty oil, especially petroselinic acid, linoleic acid, oleic acid, and palmitic acid, are the most essential constituents of coriander **(Coşkuner and Karababa, 2007; Mandal and Mandal, 2015)**. In addition, coriander is rich in vitamins, particularly vitamin A/β-carotene and vitamin C, minerals and fiber and iron, like other green vegetables **(Girenko, 1982)**. Previous studies have proven the effective medicinal role of coriander plant because of its effect as neuroprotective, blood pressure lowering effects, hypoglycemic, hypolipidemic, hypocholesterolemia, anticonvulsant, antioxidant, anticancer, anxiolytic, anticonvulsant, relieving migraine, and analgesic **(Chithra and Leelamma, 1997; Hosseinzadeh and Madanifard, 2000; Prachayasittikul *et al.*, 2018)**. In addition, to its reported antimicrobial, anthelmintic and antifungal effects **(Basilico and Basilico, 1999; Singh *et al.*, 2002; Eguale *et al.*, 2007).** The beneficial role of medicinal plants in general and *Coriandrum sativum* in the enhancement of aquaculture production can be summarized in the following:

The growth promoting effect

The herbal plants, which were used in aquaculture studies, are a lot and several such as *Coriandrum sativum* **(Ahmed *et al.*, 2020)**, *Curcuma longa* **(Kumari and Paul, 2020)**, *Zingiber officinale* **(Fazelan *et al.*, 2020)**, *Rosmarinus officinale* **(Naiel *et al.*, 2020)**, and *Allium cepa* **(Akrami *et al.*, 2015)**. There is a several recorded study of the effect of herbal plants in the improvement of the digestion and absorption. The role of herbal plants in the digestion improvements could be related to different reasons such as enhancement of digestive enzyme activity and increase bile secretion, which very important for fatty acids digestion and absorption **(Srinivasan, 2016).** Besides, herbal plants could be enhancing fish growth performance by stimulate the appetite and improvement the gut microbiota **(Citarasu, 2010).**

Farsani *et al.* (2019) recorded a significant increase in specific growth rate and final weight of *Oncorhynchus mykiss* fed for 8 weeks on diets supplemented with 2% coriander seed extract (CSE). They returned these results to the bactericidal effects of CSE, which protect the nutrient from the pathogenic bacteria of the intestine.

Effect on hematological and biochemical parameters

The results of previous studies differed on the effect of using herbal plants as a feed additive in fish on hematological parameters. Some studies recorded significant improvement in hematological parameters **(Yılmaz *et al.*, 2015; Güllü *et al.*, 2016; del Rocío Quezada-Rodríguez and Fajer-Ávila, 2017)**, while other studies recorded that the herbal plants had no effects on hematological parameters. About the impact of coriander on the hematological parameters, Farsani *et al.* (2019) recorded significant increase in the levels of hematocrit value, hemoglobin content, white blood cells, red blood cells in *Oncorhynchus mykiss* fed on diet supplemented with 2% coriander seed extract after 8 weeks of feeding.

The immunostimulant effect

Many previous studies have proven that herbal plants have a stimulating effect on different types of immune cells, where they stimulate the general immune state in different types of fish. The proper amount of dietary herbal medicine can promote the non-specific immunity of fish to resist invasion by viruses and bacteria **(Citarasu, 2010; Zhang *et al.*, 2020).** From the ingredients in the herbal medicinal plants that have beneficial effects on the fish immune system as polysaccharides, saponins, flavonoids, alkaloids, anthracene, essential oils, and organic acids. These ingredients have significant improvement effects on some nonspecific immune parameters such as serum protein, lysozyme activity, antioxidant activity **(Pu *et al.*, 2017).** Several components such as phenolic compounds, flavonoids, alkaloids, phospholipids, phytosterols, pyrogallic tannins and coumarins, which has antioxidative activity, are found in the coriander ethanol extract **(Wangensteen *et al.*, 2004).** While the aqueous extract of *Coriandrum sativum* L. seed is inducing both innate and adaptive immunities as a result of macrophage activation, which may contribute to triggering host defense against pathogens **(Ishida *et al.*, 2017)**. **Innocent (2011)** reported significant increase in the total erythrocytic, leucocytic counts, and hemoglobin content of *Catla catla* fed on diet supplemented with *C. sativum* powder at 2 g kg^{-1} diet for 14 days, which suggesting that *C. sativum* could be used as a potent immune stimulant. Similarly, **Farsani *et al.* (2019)** reported that *O. mykiss* fed on a diet supplemented with 2% coriander seed extract for 8 weeks have significant stimulation to serum total immunoglobulin (IgM), total serum protein, and globulin, which possesses a wide spectrum of biological functions in fish. Also, the zebrafish fed 20 g/kg coriander powder showed remarkably increased mucosal immune parameters (the total immunoglobulin, protease and lysozyme activity) and significant higher expression gene for lysozyme, interleukin-1-beta (*IL- 1B*), insulin-like growth factor-1 (*IGF- 1*) and tumor Necrosis Factor alpha (*TNF- α*) **(Safari *et al.*, 2019).**

Antioxidant effect

The antioxidant effect of medicinal plants in quenching of the reactive oxygen species (ROS) as superoxide anion, hydroxyl radical, and lipid peroxides were returned to its phenolic components, such as flavonoids, phenolic acids, and phenolic diterpenes **(Pietta *et al.*, 1998)**. The coriander extraction technique has an impact on the yields of phenolics and flavonoids, where water extraction is better than ultrasonic and microwave-assisted extraction **(Önder, 2018).** In comparison to black cumin and niger seed oils, coriander seed oil and its fractions demonstrated the highest radical scavenging activity (RSA) **(Ramadan *et al.*, 2003).**

Antibacterial and disease resistance effect

The herbal medicinal plant has recently considered as useful alternatives to traditional drugs and/or chemicals for aquaculture disease control and prophylaxis because of their antimicrobial activity **(Chanu *et al.*, 2012)**. Many phenolics, polysaccharides, proteoglycans, and flavonoids in the medicinal plant can play has a main role in preventing or controlling infectious microbes **(Chakraborty and Hancz, 2011).**

Some studies proved that Gram-positive bacteria were more susceptible to coriander oil (Delaquis *et al.*, 2002)**.** On the other hand, other studies revealed a high activity of coriander oil against Gram-negative bacteria **(Rattanachaikunsopon and Phumkhachorn, 2010).** Antimicrobial activities of coriander are related with phenolic compounds followed by alcohols, aldehydes, ketones, ethers, and hydrocarbons **(Ferdeş and Ungureanu, 2012)**.

Heavy metals chelating effect

The chelating activity of coriander in aquatic environment has been studied independently or in conjunction with other compounds. *Oncorhynchus mykiss* diet supplementation with 2 % coriander powder lowers liver and kidney cadmium concentration by 20 -30 % **(Ren *et al.*, 2006)**. Also, **Ren *et al.* (2009)** proved that coriander assists in the removal of cadmium chloride from rainbow trout. **Ahmed *et al.* (2020)** have proven that dietary supplementation with coriander, particularly with alcoholic extract at a diet of 30 mg kg^{-1}, counteracts the immunotoxic effects of lead exposure by improving *O. niloticus* immune response. The addition of 2% of each of coriander, garlic, and Chlorella algae in *Carassius gibelio* diet has protected from kidney damage of cadmium exposure (10 mg L^{-1}) **(Nicula *et al.*, 2016)**. The concentration of heavy metals in carcasses of *Huso huso* fed 10 or 15 g kg^{-1} of coriander powder was substantially decreased **(Bahrekazemi *et al.*, 2020).**

CONCLUSION

The application of herbal medicinal plant in general and coriander in particular will be an eco-friendly alternative to antibiotics in aquaculture industry, where it is distinguished by several beneficial characters such as: its immunostimulant, growth promoting, antibacterial, antiviral, anthelminthic, and antioxidant activities, as well as its role in heavy metals chelation.

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