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Utilizing Medicinal Plants for Disease Treatment in Aquaculture: An Approach to Improve Fish Health

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ABSTRACT

Botanicals were being used more and more in aquaculture to promote fish health as well as for disease prevention. In this review, we discuss the efficacy of botanicals in aquaculture worldwide and go through their modes of action that might play a key role in these activities. Similarly, some plants with well documented broad-spectrum antimicrobial, immunomodulatory activity, and antioxidant properties. These can be advantageous as supplements in fish feed to stimulate the immune function of fish. Plant extracts may exert positive effects on animal health through different modes rather than relying solely on a single mode. Using herbs as dietary additives has been shown to enhance immunity defense mechanisms. Recently, botanical treatments have been incorporated into aquaculture, resulting in increased growth rates and disease resistance, thus giving rise to more sustainable practices. Work was still being done in this area to find new bioactive compounds, understand how they work, and identify delivery systems that will ensure the compound reaches cells where needed. They can be incorporated with sustainable approaches, such as the aquaponics system, and possibly remain organic accredited, all while decreasing chemical residue on food products and sustaining environmental wellness. These emerging botanical approaches promise environmentally sustainable strategies for disease management in aquaculture, supporting the consumer shift to demand safe and sustainably produced seafood. The advantages that botanical treatments offer indicate them as essential tools for the development of a sustainable and eco-friendly aquaculture industry.

INTRODUCTION

Aquaculture is the farming of fish and aquatic plants as a crop that contributes to meeting global needs for seafood while also presenting an attractive alternative in response to overfishing. Medicinal plants that offer natural and environmentally sound ways to enhance fish health and manage diseases [1]. The use of medicinal plants to maintain the health of fish is a practice with firm cultural traditions spanning all five continents of the globe. Astragalus was used in traditional Chinese medicine, and neem and turmeric in India as a part of Ayurveda. Plants like *Vernonia amygdalina* and *Moringa oleifera* were employed for their antibacterial properties in Africa. Tribes of the South American Amazon used cat's claw and Lapacho for immune-enhancing and antimicrobial activities. Even in Medieval Europe, natural remedies like garlic and thyme were used for fish disease. All these old traditional practices have had significant contributions to the definition of modern botanical approaches in aquaculture research [2]. The use of medicinal plants in aquaculture has gradually grown from conventional practices through a systematic process into scientifically supported applications. In the early 20th century, research started

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identifying bioactive compounds in these plants as being antimicrobial, anti-inflammatory, and even immune-boosting. Since then, ethnobotanical surveys and phytochemical analyses have proved that such traditional methods are effective and have initiated the development of commercial botanical products tailored for use in aquaculture [3]. Common Diseases in Aquaculture: Bacterial Infections In Aquaculture: Bacterial infections constitute the major bottleneck in the fish farming enterprise, resulting in significant economic losses and adversely affecting fish production and fish health. Since the disease is highly transmissible, early detection and management are crucial. Aeromonas infections, caused mainly by *Aeromonas hydrophila*, affect several freshwater fish species, such as catfish, carp, and tilapia ulceration and abdominal distension are among the symptoms [4]. The *Vibrio* causes serious infections in marine fish like salmon, shrimp, and groupers, leading to skin lesions, ulcers, and high mortality rates. Therefore, despite the increased use of many antibiotics, including florfenicol, plant-derived alternatives to antibiotics are considered in bacterial diseases because of their antibacterial activities and hence offer sustainable options [5]. Columnaris disease is caused by *Flavobacterium columnare* and affects mostly catfish, carp, and tilapia. The symptoms include white or yellow lesions on the skin that ultimately lead to mortality. Traditional treatments include antibiotics such as potassium permanganate and oxytetracycline, although Indian almond leaves containing antibacterial tannins are a natural treatment to prevent bacteria from multiplying and assist in promoting fish health [6]. Streptococcosis, due to bacteria like *Streptococcus iniae* and *Streptococcus agalactiae,* afflicts warm-water fish, including tilapia and rainbow trout. Meningitis, exophthalmia, and erratic swimming are evident signs of the infection, which may be lethal if treated late. The use of medicinal plants, particularly thyme with potent antibacterial properties, is now being explored for such uses [7]. Infections with *Pseudomonas* and more specifically *Pseudomonas fluorescens* in freshwater fish, including trout, catfish, and carp, may lead to various symptoms, including lesions and fin rot. The control measure is that plant-based alternatives such as ginger extract is being valued for their antibacterial properties [8]. Botanicals in aquaculture consist of plant extracts and essential oils that possess antimicrobial properties to control bacterial infections, greatly reducing reliance on antibiotics and minimizing the risk of antibiotic-resistant strains. Moreover, numerous immunostimulants exist in medicinal plants that promote fish health and their disease resistance [9]. Parasitic Infestations in Aquaculture: The common health problems in fish, related to parasites, include slow growth rates and high mortality rates, which create a substantial impact on aquaculture. Organisms responsible for these diseases include protozoans, helminths, and crustaceans [10]. Ichthyophthiriasis, the disease produces white spots on the skin, gills, and fins labored respiration, and increased mucus production. Nevertheless, natural drugs that include garlic and neem extracts are currently being tested for eco-friendlier approaches in decreasing the intensity of this parasitic disease, therefore reducing synthetic chemical applications [11]. Trichodina species infect freshwater as well as marine fish, triggering copious amounts of mucus secretion with inflamed gills, frayed fins, and rapid respiration. Indian almond extracts, betel leaf extract, etc. Right now, oral use may start appearing as an alternative effective sustainable treatment in the years to come [12]. Monogenean parasites are often seen in freshwater fish such as carp goldfish and tilapia, causing gill rot, excessive production of mucus over the surface body wall along with flared opercula (gills), and erratic swimming behavior that could ultimately lead to death. Chemical treatments such as natural botanical solutions like pomegranate or garlic also have antiparasitic properties that can be used to maintain fish health [13]. The application of botanical treatments in aquaculture has a potential future as an environmentally friendly replacement for current practices used with other fish species [4]. Symptoms of nematode infestation include a swollen abdomen and visible worms in fish. Treatments include Anthelmintics like natural approaches are being investigated through garlic and wormwood [14]. It causes copepod infestations due to parasites such as *Argulus* and *Lernaea* species that live by eating the skin of fish like salmon, trout, and carp, resulting in sores on their skin and according to thin shed tissue with lots of mucus touching environmental substances. Nevertheless, natural extracts such as neem and turmeric are promoted for sustainable aquaculture management with less reliance on synthetic chemicals in controlling parasitic diseases [15]. Bioactive compounds reduce the use of synthetic chemicals for minor skin lesions and parasites, protecting. The environment is biodegradable and contributes to the health of fish. The use of these natural alternatives for fish health management is still on its way to being optimized, and ongoing against parasitic infestations that persistently trouble the aquaculture industry [16]. Fungal Infections in Aquaculture: Fungal infections are not ordinarily transmitted from fish to fish, but they can also be severely devastating. These infections should be called secondary; as primary effects are almost certainly necessary to cause sufficient damage for most bacterial pathogens [17]. Saprolegniasis, caused by fungi is mostly a problem in cool-water fish but occasionally can be associated with warm-water species as well. Affected fish show lesions and malaise a white plaque on the skin signifies infection. Treatment may be possible with botanical solutions for their anti-fungal properties [18]. Branchiomycosis,

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commonly known as Gill rot in fish is caused by *Branchiomyces parasitic* fungi. The infection can cause death, respiratory distress, and gill necrosis. Ways to reduce infection involve more benign uses, such as maintaining a proper balance of water quality, reducing organic matter, and treating the pond with copper sulfate. Recently, medicinal agents having antifungal action utilizing botanical spices like turmeric and neem extracts are being employed against infections in the infected fish [18]. The utilization of medicinal plants involved in these treatments could enhance the immune responses of fish and provide an earth-friendly alternative to chemical strategies for fungal conidia control [19]. Viral Diseases in Aquaculture: Viral diseases have a devastating impact on the aquaculture industry, leading to mortality and financial loss. Once viruses are established, they become some of the most elusive infections to cure, making prevention more crucial than ever [19]. Infectious Hematopoietic Necrosis is a potentially catastrophic disease caused by IHNV, most commonly affecting salmonids like salmon and trout. Affected fish exhibit white gills, a swollen abdomen, and high mortality rates, particularly in young fish. Although there are no successful antiviral treatments, prevention relies mainly on vaccination and good husbandry biosecurity practices. The efficacy of botanical drugs against viral infections, such as garlic and echinacea extracts [20, 21]. Infectious Pancreatic Necrosis (IPN) is caused by the IPNV virus, this disease affects salmonids, particularly juvenile fish. Symptoms include abdominal enlargement, darkened body coloration, and 100 percent mortality. As with IHN, there are no effective antiviral treatments, so prevention focuses on vaccination, biosecurity, and water quality management. Botanical treatments, possibly with immunostimulant properties to augment fish health, such as extracts from *Astragalus* or licorice, are under investigation [22]. Viral Hemorrhagic Septicemia (VHS) is caused by the VHSV virus, this disease can infect several species of freshwater, brackish water, and marine fish. Common signs of ill health include hemorrhages, bulging eyes, anemia, and high mortality. Because there are no commercially available effective antiviral treatments, control of VHS relies on biosecurity and more passive measures, including green tea and ginseng are two plant extracts that have been studied for their antiviral properties against VHSV [23]. Spring Viremia of Carp [SVC], with interference from the SVCV Virus, most commonly affects juvenile carp. Symptoms of infected fish include abdominal swelling, changes in skin color, high mortality, overall poor condition, and pop-eye. Similar to most viral diseases, control involves biosecurity, vaccination, and good management as there are no antivirals available that have demonstrated efficacy [24]. These treatments through botanicals may play a role in improving fish health and providing viral disease control. Further research is needed to fully investigate and utilize medicinal plants in the aquaculture industry [25].

Table 1: Plant Extracts Were Increasingly Being Used to Naturally Treat Bacterial, Fungal, and Parasitic Infections in Fish

S.No.	Plant Name	Constituents	Fish Disease Name	Type of Disease	Effect on Fish Body Part	Signs and Symptoms	Plant-Based Treatment	References
1	Garlic	Allicin, Sulfur Compounds	Aeromonas Infection	Bacterial	Skin and gills	Lesions, hemorrhages	Immersion baths with garlic extract	[26, 27]
2	Echinacea	Alkamides, Polysaccharides	Ichthyophthiriasis (Ich)	Parasitic	Skin, fins	White spots, lethargy	Feed supplementation with Echinacea powder	[28, 29]
3	Neem	Azadirachtin, Limonoids	Columnaris Disease	Bacterial	Skin, Mouth	Cottony Growth, Ulcers	Addition of neem leaf extract to fish feed	[30]
4	Turmeric	Curcuminoids	Aeromonas Infection	Bacterial	Skin, Internal Organs	Hemorrhages, Inflammation	Dietary Inclusion of Turmeric Powder	[31]
5	Ginger	Gingerol, Shogaol	Vibrio Infection	Bacterial	Digestive Tract	Bloating, Loss of Appetite	Immersion Baths with Ginger Extract	[32]
6	Aloe Vera	Polysaccharides, Anthraquinones	Flavobacterium Infection	Bacterial	Skin, Scales	Fin rot, Reddened Skin	Topical Application of Aloe Vera gel	[33]
7	Licorice	Glycyrrhizin, Flavonoids	Saprolegnia Infection	Fungal	Skin, Gills	White Cotton-like Growth, Lethargy	Bath Treatment with Licorice Extract	[34]
8	Basil	Eugenol, Linalool	Aeromonas Infection	Bacterial	Skin, Respiratory System	Lesions, Respiratory Distress	Feed Supplementation with Basil Powder	[35, 36]
9	Chamomile	Apigenin, Chamazulene	Trichodiniasis	Parasitic	Gills, Skin	Excess Mucus, Erratic Swimming	Immersion Baths with Chamomile tea	[37, 38]
10	Lemon Balm	Citronellal, Rosmarinic Acid	Ichthyophthiriasis (Ich)	Parasitic	Skin, Scales	White Spots, Rubbing Against Objects	Feed Incorporation of Lemon Balm Extract	[39]
11	Papaya	Papain, Chymopapain	Gill Flukes	Parasitic	Gills	Respiratory Distress, Excess Mucus	Bath Treatment with Papaya Leaf Extract	[40]
12	Thyme	Thymol, Carvacrol	Aeromonas Infection	Bacterial	Skin, Digestive Tract	Lesions, Bloating	Feed Supplementation with Thyme Oil	[41]
13	Sage	Rosmarinic acid, Thujone	Aeromonas Infection	Bacterial	Skin, Digestive Tract	Lesions, Digestive Issues	Feed Supplementation with Sage Extract	[42]
14	Rosemary	Rosmarinic Acid, Camphor	Vibrio Infection	Bacterial	Digestive Tract	Loss of Appetite, Internal Inflammation	Immersion Baths with Rosemary Extract	[42, 43]

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15	Peppermint	Menthol, Menthone	Ichthyophthiriasis (Ich)	Parasitic	Skin, Gills	White Spots, Irritation	Feed Incorporation of Peppermint Oil	[44, 45]
16	Ginseng	Ginsenosides, Polysaccharides	Saprolegnia Infection	Fungal	Skin, Scales	Cottony Growth, Lethargy	Topical Application of Ginseng Extract	[46, 47]
17	Oregano	Carvacrol, Thymol	Aeromonas Infection	Bacterial	Skin, Digestive Tract	Lesions, Digestive Issues	Feed Supplementation with Oregano Oil	[48]
18	Cinnamon	Cinnamaldehyde, Eugenol	Vibrio Infection	Bacterial	Digestive Tract	Loss of Appetite, Internal Inflammation	Immersion Baths with Cinnamon Extract	[49]
19	Dandelion	Taraxasterol, Flavonoids	Flavobacterium Infection	Bacterial	Skin, Gills	Fin Rot, Reddened Skin	Feed Supplementation with Dandelion Extract	[50]
20	Marigold	Lutein, Zeaxanthin	Ichthyophthiriasis (Ich)	Parasitic	Skin, Scales	White Spots, Irritation	Bath Treatment with Marigold Extract	[51]
21	Yarrow	Sesquiterpene Lactones, Flavonoids	Ichthyophthiriasis (Ich)	Parasitic	Skin, Gills	White Spots, Irritation	Immersion Baths with Yarrow Extract	[52, 53]
22	Wormwood	Artemisinin, Sesquiterpenes	Gill Flukes	Parasitic	Gills	Respiratory Distr-ess,Excess Mucus	Bath Treatment with Wormwood Extract	[54]

Medicinal Plants and Their Properties

Anti-Bacterial Plants in Aquaculture: Plant extracts can inhibit bacterial growth with strength similar to synthetic antibiotics and offer an environmentally friendly option as a natural antibacterial for aquaculture purposes [55]. Garlic has proven to possess potent antibacterial qualities largely because of its abundant influx of bioactive compounds such as allicin, ajoene, and diallyl sulfides. The production of allicin when garlic was crushed can suppress the growth and reduce mortality rates due to disease by bacteria such as Aeromonads hydrophilic and Vibrio species in fish [56]. Turmeric was rich in curcuminoids, while allicin and sulfur compounds present in garlic indicate a high antibacterial effect [57]. These natural ingredients can also be supplemented as nutraceuticals in fish feed or used as water-soluble extracts for improving immunity and other metabolic functions in fish [58]. Antiparasitic Plants in Aquaculture: In inference, plant-derived antiparasitic extracts offer a promising and safe new alternative to chemical treatments in aquaculture. This natural approach can reduce parasite burdens and increase fish health status as well as survival rates without environmental damage because they were not chemically synthesized [59]. Neem water extraction can be applied or mixed with fish feed and directly applied to the affected areas. Organic fungicide neem also has bacteriostatic and antifungal activity. Papaya seeds, particularly those containing papain and chymopapain, were highly regarded as anti-parasitic treatments for aquacultured livestock, especially against nematodes and tapeworms [60, 61]. Anti-Fungal Plants in Aquaculture: These plants not only work as a defense mechanism against fungus but also provide better conditions to increase fish health and productivity [62]. Ginger can be administered either as a liquid or mixed with fish feed. Regarding its advantages as an aquaculture feeding regime, it has broad-spectrum anti-inflammatory action and digestive properties. The essential oils, including eugenol and linalool, have given basil a reputation as an antifungal plant. These were strong fungicides against saprolegnia species' fish and egg pathogens [63]. Antiviral Plants in Aquaculture: The use of antiviral plants in aquaculture echinacea boosts the immune system, especially against cat herpes virus, and prevents viral replication. It can be administered as an extract or blended into fish feed, delivering benefits such as enhancing innate immunity and adaptation and reducing inflammation [64]. Licorice, another powerful medicinal herb, contains glycyrrhizin and flavonoids, which have effective antiviral properties such as herpes and influenza. It can be taken orally or diluted to inhibit virus replication and stimulate the defense mechanism [65].

CONCLUSIONS

Aquaculture, when combined with plant-based techniques, provides a unique and sustainable way to improve fish health, improve productivity, and reduce environmental impact. Research continues to show the therapeutic potential of plants was effective in the removal of pollutants and chemical stressors that clean up aquatic ecosystems, improving their overall health. Whether in salmon farming in Europe, or tilapia farming in Africa, these techniques continue to offer benefits such as increased disease resistance, improved growth, and reduced reliance on antibiotics. Aquaculture practices incorporating plant-derived products were more sustainable and resilient disease control strategies. As research expands and practices that can support the profession evolve, phytotherapy was poised to reshape the future of aquaculture worldwide.

Authors Contribution

Conceptualization: US
Methodology: TI
Formal analysis: TK
Writing, review and editing: TI, MU, HI, A, TK, SH, MMJ, MUG

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Conflicts of Interest

The authors declare no conflict of interest.

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