



REVIEW ON USAGE OF MEDICINAL PLANTS IN FISH DISEASES

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ABSTRACT

The purpose of present review is to enlighten the present and future prospective on importance of medicinal plants on fish diseases. Now a day, the parasitic outbreak acts as an important limiting factor for fish culture. The infection of *Trichodina* parasites and *Aeromonas hydrophila* bacterium has lead to great economic loss for fish culture business. These fast antibiotics from plants are frequently used to control fish diseases. The current review article provides an account of phytochemicals, immunostimulants, phytobiotics, fermented Vegetable product (FVP) and other plant extract in fish disease control and management.

KEYWORDS : Fish pathogens, herbs, medicinal plants (herbal drugs), treatment of fish diseases.



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INTRODUCTION

Globally fish and shellfish culture are subjected to many diseases that lead to great losses and decrease in fish production. The lack of effective disease control has the potential of being the chief limiting factor of the realization of highly stable fish production. The use of immunostimulants in aquaculture for prevention of diseases is a promising new development. Immunostimulants may be defined as the agent, which stimulate the non-specific immune mechanisms on their own or specific immune mechanism when coupled with an antigen. In general, immunostimulants comprise a group of biological and synthetic compounds that enhance the non-specific defense mechanisms in animals, thereby imparting generalized protection. This protection may be particularly important for fish that are raised in or released into environments where the nature of pathogen is unknown and immunization by specific vaccine may be futile. Immunostimulants promote a greater and more effective sustained immune response to those infectious agents (Viruses, Bacteria, Fungi, and Parasites), producing subclinical disease without risks of toxicity, carcinogenicity or tissue residues¹. They help to hastening the maturation of non-specific and specific immunity in young susceptible animals¹.

Although herbal remedies have been with us for human therapy for millennia, there has been relatively little research on the medicinal plants to be used against fish diseases. Herbal drugs can be used not only as remedies but even more so, as growth promoters, stress resistance boosters and preventatives of infections. Hence, herbal drugs in disease management are gaining success, because they are cost effective, eco-friendly and have minimal side effects². A large portion of the world population, especially in developing countries depends on the traditional system of medicine for a variety of diseases. Several hundred genera are used medicinally and plants are vital sources for potent and powerful drugs. Plants are rich in a wide variety of secondary

metabolites of phytochemical constituents such as tannins, alkaloids and flavonoids, which act against different diseases³⁻⁵.

Medicinal plants acting against Fish diseases

To preserve and protect the environment as well as human health as a best alternative, different parts of *Azadirachta indica* (Neem) tree have been studied by Chitmanat *et al.*⁶. Neem leaves containing nimbin, azadirachtin and meliantril have been reported to possess a variety of properties, including insecticidal and antiviral from ancient times. Indian almond (*Terminalia catappa*) and garlic (*Allium sativum*) have been said as an alternative to chemicals to treat fish ectoparasites, *Trichodina* sp. infections in tilapia (*O. niloticus*) fingerlings. Both Indian almond and garlic had low acute toxicity to tilapia fingerlings, treating the trichodiniasis caused by *Trichodina*⁵. The immunostimulant effects of the dietary intake of 3 plants (*viz.*, *Viscum album*, *Urtica dioica* and *Zingiber officinale*)-extracts on rainbow trout (*Oncorhynchus mykiss*) have also been confirmed by the authors. Christyapita *et al.*⁷ observed the immunostimulatory effect of aqueous extract (AqE) of *Eclipta alba* (Bhangra) leaf (oral administration as feed supplement) in tilapia fish, *Oreochromis mossambicus*. It was noted that the *Eclipta alba* extract enhances non-specific immune responses and disease resistance of *O. mossambicus* against *Aeromonas hydrophilia* infection. According to Winkaler *et al.*⁸ *A. indica* extract can be used successfully in aquaculture to control fish predators.

Castro *et al.*⁹ screened the methanolic extracts of 46 Brazilian plants and found only 31 to have the antibacterial activities against fish pathogenic bacteria, *viz.*, *Streptococcus agalactiae*, *Flavobacterium columnare* and *A. hydrophila*. Yin *et al.*¹⁰ added the extracts of 2 Chinese herbs (*viz.*, *Lonicera japonica* and *Ganoderma lucidum*) in diets of tilapia fish (*O. niloticus*) and found that these herbs act as

immunostimulants and appear to improve the immune status and disease resistance. Both herbs when used alone or in combination increased the survival of fish after challenge with *A. hydrophila*. Yin *et al.*¹⁰ reported that oral administration of ginger (*Zingiber officinale*) extract increases the phagocytic capability of cells in rainbow trout (fish), while the extracts of 4 Chinese herbs (*Rheum officinale*, *Andrographis paniculata*, *Isatis indigotica* and *Lonicera japonica*) increased the phagocytosis of white blood cells of carp. Turker *et al.*¹¹ reported that the alcoholic and aqueous extracts of *Nuphar lutea*, *Nymphaea alba*, *Stachys annua*, *Genista lydia*, *Vinca minor*, *Fragaria vesca*, *Filipendula ulmaria* and *Helichrysum plicatum* herbs of Bold (Turkey) have antibacterial activity against *A. hydrophila*, *Yersinia ruckeri*, *Lactococcus garvieae*, and *Enterococcus faecalis* Bacteria isolated from fish. This observation provides the aquaculturists with a promising management tool for control or treatment of fish diseases. Nya and Austin¹² observed the control of *A. hydrophila* infection after feeding with *A. sativum* (0.5 and 1 g/100 g of feed for 14 days) to rainbow trout (fish), *Oreochromis mykiss* (Walbaum). Ahilan *et al.*² observed that the addition of *Phyllanthus niruri* and *Aloe vera* (Aloe) as herbal additives can positively enhance the growth performance of goldfish, *Carassius auratus* as well as its resistance to *A. hydrophila* infections. The authors further reported that the herbal additives in diets often provide cooperative action to various physiological functions. The synergistic effect of herbs has been reported in other fishes, including Japanese flounder and *Clarias gariepinus*. The growth increase in *Labeo rohita* fish fed with herbal supplemented diet was due to improved food utilization and high protein synthesis. The benefit of herbal growth promoters as an additive in the carp feed has also been found. Furthermore, the medicinal plants, viz., ginger, nettle and mistletoe as an adjuvant therapy in rainbow trout through feed enhanced phagocytosis and cellular and humoral defense mechanisms against pathogens. The traditional Chinese medicines in

yellow croaker elevated the non specific defense mechanism and increased the disease resistance of fish against bacterial pathogens. The disease resistant of *Catla catla* fish was produced through immersion treatment of 3 herbs, viz., *A. sativum*, *A. indica* and *Curcuma longa* (Haldi rhizome, turmeric) in spawn. *Aloe vera* has been found to a disease suppressing agent and showed antibacterial effect in juvenile rock fish².

Harikrishnan *et al.*¹³ reported that mixed herbal extracts supplementation diets restored the altered haematological parameters and triggered the innate immune system of goldfish (*Carassius auratus*) against *A. hydrophila* infection. Ravikumar *et al.*⁴ observed that the chloroform extract of *Datura metel* plant has wide range of antimicrobial activity against many fish pathogens. *Datura metel* which collected from the Kanyakumari coast can be used as a putative antimicrobial drug in the aquaculture maintenance. The chloroform extract of *D. metel* can be effectively used as a potential antimicrobial agent to overcome the problem of mass mortality of ornamental fish in aquarium so as to enable to enhance the market revenue throughout the world. These authors also told the antimicrobial activity of 5 Chinese herb extracts against 13 bacterial and 2 viral fish pathogens. Sharma *et al.*¹⁴ observed the stimulatory effect of dietary doses of *Withania somnifera* (Ashwagandha) root on immunity and disease resistance against *A. hydrophila* infection in Indian major carp, *L. rohita* fingerlings. Abdul Kader Mydeen and Haniffa¹⁵ cited that *A. indica* leaf aqueous extract could effectively control the *A. hydrophila* infection in common carp (a freshwater fish usually bred in ponds), *Cyprinus carpio*.

Abdul Kader Mydeen and Haniffa¹⁵ evaluated the antimicrobial potency of aqueous extract of three common medicinal herbs, *Azadirachta indica* (Neem leaves), *Solanum torvum* (Sundakai fruit coat) and *Curcuma longa* (Turmeric, rhizome) against the in vitro growth of pathogenic bacterium *Aeromonas hydrophila* isolated from infected freshwater fish, *Channa striatus* was assessed by disc diffusion assay.

Determination of minimum inhibitory concentration (MIC) for each aqueous herbal extract was done on Muller Hinton agar swabbed with 0.5 ml of overnight culture of *A. hydrophila* (10^6 cfu/ml). After incubation period, zones of inhibition around herbal extracts incorporated discs were measured. The strongest antibacterial activities among all plant species were obtained by the aqueous extract of *A. indica* with inhibition zone of 18 mm against *A. hydrophila*, *S. torvum* demonstrated moderate (11 mm) and *C. longa* marked weak (8 mm) inhibiting activity against *A. hydrophila*. The antimicrobial activity of aqueous extract of 3 medicinal plants, viz., *A. indica* (leaf), *Solanum torvum* (Sundakai fruit coat) and *C.*

longa (rhizome) against the *in vitro* growth of *A. hydrophila*, isolated from infected fresh-water fish, *Channa striatus* was noticed by Abdul Kader Mydeen and Haniffa¹⁵. Kolkovski and Kolkovski¹⁶ reported that some herbal extracts are very effective against gills and skin flukes like *Benedenia seriola*. Nargis *et al.*¹⁷ seen the immunostimulant effects of the dietary intake of *A.sativum* and *Vitex negundo* extracts on fingerlings of *Labeo rohita* fish. Ravikumar *et al.*¹⁸ studied that among 15 coastal medicinal plants/ parts of plants, *A. indica*, *Cinnamomum verum* and *Eupatorium odoratum* exhibited excellent antibacterial activity against 10 Bacterial pathogens from diseased ornamental fishes.



Figure 1
Fishes infected with pathogens

Ichthyophonosis disease is recognized to be of economic significance in both fish cultured and wild fishes¹⁹. Its causative agent is *Ichthyophonus hoferi*, that has a very broad host spectrum and is known to infect marine and cultured fish, causing granulomatous systemic disease in vascularized organs such as heart, spleen, liver and kidneys²⁰. The variability in clinical signs is undoubtedly related to the site of the fungal invasion, including abnormal swimming patterns, some fish develop a dark colour. Also, it is the cause of many unidentified deaths in fishes^{21,22}. Diagnosis of Ichthyophonosis depends on external and internal alterations. Isolation of infective fungus which needs special condition, nutrients and histopathology of the infected

organs. More recently, the application of medicinal herbs in disease management is gaining momentum because herbal treatment is cost –effective and has minimal side effect²². *Azadirachta indica* (neem) is one of the most widely tropical plants and its leaves contain several chemical and biological active ingredients²³, about ten herbs are most commonly used in China to treat fish diseases such as gill rot, white mouth disease, *Aeromonas hydrophila* in Carp and fungal pathogen as *Aphanomyces invadans*^{22,24,25}. *Fucus vesiculosus* is marine algae sulfated polysaccharide with a wide variety of biological activities, that revealed anti-inflammatory and antiviral²⁶ antibacterial²⁷ antifungal²⁸

anticoagulant and immunomodulating²⁹
antitumor effects³⁰ and antioxidant^{22,31}.

Antimicrobial herbs against Fish pathogens

The antimicrobial activity of 5 Chinese herb extracts against 13 Bacterial and 2 Viral fish pathogens has been reported couple of decade back³². The aqueous extract of *Azadirachta indica* leaf has been tested against *A. hydrophila* infection in common carp *Cyprinus carpio* and the results showed that this plant could effectively control *A. hydrophila* infection³³. In a study of methanolic extracts of 46 Brazilian plants, 31 extracts were found to exhibit the antibacterial activity against fish pathogenic bacteria, viz., *Streptococcus agalactiae*, *Flavobacterium columnare* and *A. hydrophila*. The microorganism, *F. columnare* was most susceptible to many tested extracts. In contrast to its high virulence to young fish, this bacterium is sensible to the main disinfectants used in fish farms, such as potassium permanganate, hydrogen peroxide, chloramines and salt. Despite of their common use, these compounds may be dangerous to fish fry and aquatic environment. The plant extracts can be applied as an alternative to prevent and control outbreaks of columnaris, mainly in hatchery. Since these substances are natural, their hazardous potential is lower when compared with other products. The results show that the analyzed plants presented a high potential as alternative therapy of bacterial fish diseases⁹. The alcoholic extract of *Vinca minor* and the alcoholic and aqueous extract of *Nuphar lutea* displayed a broad antibacterial spectrum¹¹. *Enterobacter* species and *Escherichia coli* isolated from marine fish *Amphiprion sebae* caused 15 mm zone of inhibition against *A. indica* extract³⁴. *In vitro* antibacterial & antifungal activity of the chloroform extracts of the 17 different coastal medicinal plants were screened against ornamental fish pathogens, e.g., different gram positive & gram negative Bacteria. *Datura metel* Linn (Thorn-apple) showed wide range of antimicrobial activity against many of the fish pathogens. *D. metel* showed maximum sensitivity (19 mm diameter) against *Penicillium*

restrictum fungal species and *Lantana camara* showed maximum sensitivity (13 mm diameter) against *Vibrio* bacteria species³⁵.

The strong antimicrobial activity of *Datura metel* might be due to the presence of various phytoconstituents, such as alkaloids flavonoids, phenols, tannins, saponins and sterols. It has been concluded from this study that the *D. metel* which collected from the Kanyakumari coast can be used as a putative antimicrobial drug in the aquaculture maintenance⁴. The antimicrobial potency of aqueous extract of 3 medicinal plants, viz., *A. indicia* (leaf) *Solanum torvum* (fruit coat) and *Curcuma longa* (Rhizome) against the *in vitro* growth of pathogenic bacterium *A. hydrophila* isolated from infected fresh-water fish *Channa striatus*. The strongest antibacterial activities among all plants were obtained by the aqueous extract of *Azadirachta indica* with inhibition zone of 18 mm against *A. hydrophila*. The *S. torvum* demonstrated moderate (11 mm) and *C. longa* (8 mm) marked weak inhibiting activity against *A. hydrophila*. From this study, it is proved that among the 3 herbs, extract of *A. indica* is very effective against *A. hydrophila*¹⁵. Fifteen coastal medicinal plants/parts were investigated to evaluate the antibacterial activity against bacterial fish pathogens. Among the plants *A. indica*, *Cinnamomum verum* and *Eupatorium odoratum* exhibited excellent antibacterial activity against 10 bacterial pathogens from diseased ornamental fishes under captivity. *Eupatorium odoratum* inhibited the growth of *Vibrio* species (14 mm). It is concluded from the present study that the coastal medicinal plants from the Kanyakumari coast has the potential antimicrobial compounds to cure the ornamental fish bacterial diseases^{18,35}.

An experiment was conducted by Rahman *et al.*³⁶ to compare the efficacies of some selected antibiotics and medicinal plants against common bacterial fish pathogens viz., *Aeromonas hydrophila*, *Pseudomonas fluorescens* and *Edwardsiella tarda*. Four different antibiotics viz., CFCIN (Ciprofloxacin), Renamycin (oxytetracycline), DT-10

(doxycycline) and Sulfatrim (sulphadiazine + trimethoprim) were exposed in different doses (100, 75, 50 and 25 ppm) to the culture of freshly isolated bacteria under the *in vitro* condition for sensitivity test and minimum inhibitory dose (MID) was tested. Based on *in vitro* results, antibiotics were applied to the experimental infection of Thai silver barb, *Barbonymus gonionotus*. CFCIN showed the best result with 100% recoveries of challenged fish in prolonged bath treatment. Medicinal plants with extracts were prepared from various parts (leaves and bulb) of garlic, turmeric and neem and four different doses were applied to the fresh culture of pathogenic isolates under the *in-vitro* condition to determine minimum inhibitory dose (MID). However, garlic offered the best result with $90.00 \pm 2.89\%$ recoveries of challenged fish in aquarium trial. Akand + neem, turmeric and akand showed moderate to weak recovery rates with the same dose. Their study showed that medicinal plants would be an effective control measure along with antibiotics against bacterial fish diseases³⁵. Turker *et al.*¹¹ prepared alcoholic and aqueous extracts from 22 species of herbs from Bolu (Turkey) were screened for antibacterial activity against *Aeromonas hydrophila*, *Yersinia ruckeri*, *Lactococcus garvieae*, *Streptococcus agalactiae* and *Enterococcus faecalis*. Extracts with various solvent of *Nuphar lutea*, *Nymphaea alba*, *Stachys annua*, *Genista lydia*, *Vinca minor*, *Fragaria vesca*, *Filipendula ulmaria*, *Helichrysum plicatum* showed the highest inhibitory activity. The ethanolic extract of *Vinca minor* and the alcoholic and aqueous extract of *N. lutea* displayed a broad antibacterial spectrum against the target organisms.

Amal *et al.*³⁷ evaluated the antimicrobial activity of indigenous Jordanian plant extracts of *Hypericum triquetrifolium*, *Ballota undulata*, *Ruta chalepensis*, *Ononis natrix*, *Paronychia argentea* and *Marrubium vulgare* against pathogenic bacteria, *Bacillus subtilis*, *Staphylococcus aureus*, *Escherichia coli* and *Pseudomonas aeruginosa* are reported that all these extracts had shown promising antimicrobial activity on all isolates. From this study, it was proved that among the three

herbs, extract of *A. indica* was very effective against *A. hydrophila*. Heavy antibiotics used in aquaculture need to be reduced and replaced with alternative processes for treating fish diseases to avoid the emergence of antibiotic resistance in pathogenic and environmental bacteria^{38,39}. The herbal plants may be used as potential and promising source of pharmaceutical agents against fish pathogens in the organic aquaculture¹⁵.

Plant originated immunostimulants

Plant product promote various activities such as Antistress, growth promotion, appetite stimulation, immunostimulation, aphrodisiac and antimicrobial properties due to the active principles such as alkaloids, flavanoids pigments, phenolics, terpenoids, steroids and essential oils¹. Leaves of *Ocimum sanctum* contain water-soluble phenolic compounds and various other constituents, such as eugenol, methyl eugenol and caryophyllene that may act as an immunostimulant. In tilapia (*Oreochromis mossambicus*), the acetone extract of *O. sanctum* was found to enhance the anti-sheep red blood cell (SRBC; sheep erythrocytes) antibody response. Leaves extract of *Ocimum sanctum* affected both specific and non-specific immune responses and disease resistance against *Aeromonas hydrophila*. It stimulated both antibody response and neutrophil activity. *Phyllanthus emblica* has antioxidant activity, antimicrobial activity and anti-inflammatory activity. Amla fruit pulp contains large proportion of vitamin C, which has also been identified as an immunostimulant. An acetone extract of *P. emblica* enhanced the anti-SRBC antibody response in tilapia⁴⁰. *Azadirachta indica* is a highly esteemed "wonder" tree of India that is widely dispersed throughout the country. Biomedical research has revealed that neem possesses anti-human immunodeficiency virus, anti-tumor and antimicrobial activities. Azadirachtin, a triterpenoid derived from *A. indica*, enhanced respiratory burst activities, the leukocyte count and the primary and secondary antibody response against SRBC in tilapia^{1,41,42}. The herbal extract of *Solanum trilobatum* contains compound like Sobatum, b-solamarine,

solaine, solasodine, glycoalkaloid, diosgenin and tomatidine⁴³. *Solanum trilobatum* possesses a broad spectrum of antibiotic, antibacterial and anticancer activity. A study aimed at assessing the effects of the water- and hexane-soluble fractions of *S. trilobatum* on the nonspecific immune mechanisms and disease resistance of tilapia found that all doses of the water soluble fraction significantly enhanced the production of reactive oxygen and decreased the percentage mortality following a challenge with *Aeromonas hydrophila*^{1,12}. *Eclipta alba* has been reported to possess several medicinal properties. The methanol extracts of the whole plant of *E. alba* significantly increased the phagocytic index, antibody titer and WBC count in mice⁴⁴. Oral administration of *E. alba* leaf aqueous extract to *Oreochromis mossambicus* indicate that dietary intake of *E. alba* aqueous leaf extract enhances the non-specific immune responses and disease resistance of *O. mossambicus* against *A. hydrophilai*⁷. Root extracts of *Zingiber officinale* contain polyphenol compounds (6-gingerol and its derivatives), which have a high antioxidant activity. The use of Ginger at 0.5g/110g of feed reduced mortalities to 00% compared with the controls (64%). Moreover, there was a significant increase in growth, feed conversion and protein efficiency. There was proliferation in the number of neutrophils, macrophages and lymphocytes, and enhanced phagocytic, respiratory burst, lysozyme, bactericidal and anti-protease activities compared with the controls⁴⁵. *Allium sativum* improve the gain in body weight, survival rate and resistance against challenge infection of *Aeromonas hydrophila*. Both compounds showed extended effects after withdrawal and improved resistance to cold stress during the winter season^{1,46}.

Green tea (GT) extracts contain a unique set of catechins that possess biological activity in antioxidant, antiangiogenesis, and antiproliferative assays that are potentially relevant to the prevention and treatment of various forms of cancer. The inclusion of green tea in fish diet up to 0.5 g/kg diet enhanced the protein contents in fish body, while the lowest lipid contents were obtained at 0.0–0.5 g GT/kg

diet. Hematological and biochemical parameters were improved in fish fed 0.25–2.0 g GT/kg diet, while the lowest values were obtained in the control. The survival of fish challenged with *A. hydrophila* increased with increasing GT level in fish diets. These results indicate that GT supplement is promising immunostimulant, which could improve fish performance, health^{1,47}. The antiviral activity of a large scale produced plant extract of *Cynodon dactylon* was examined on white spot syndrome virus (WSSV) in black tiger shrimp *Penaeus monodon* by *in vivo* testing after administration through oral route. The results of the study showed that the plant extract of *C. dactylon* was found to be highly effective in preventing WSSV infection with no mortality and no signs of WSD (White spot disease) at 2% and 40% mortality at 1% in *P. monodo*, respectively⁴⁸. When *Catla catla* was fed with *Achyranthes aspera* (0.5%), both specific and non-specific immunity were enhanced compared with the control fish fed with the normal diet⁴⁹. This was revealed by higher serum antibody levels and higher serum anti-proteases in the test group fish than control groups. Serum globulin level and RNA/DNA ratio of the spleen were also significantly enhanced in the fish fed with the *A. aspera* containing diet.

Nyctanthes arbortristis (L) is widely used plant in the traditional medicinal systems of India. It possesses hepatoprotective, antileishmanial, antiviral and antifungal activities. Feeding tilapia for 2 weeks with selected doses of chloroform extract of *Nyctanthes arbortristis* seeds significantly enhanced serum lysozyme, alternate complement activities and cellular ROS (Reactive Oxygen Species), RNI (Reactive Nitrogen Intermediate) and MPO production. It was evident from the disease resistance test that feed supplemented with *Nyctanthes arbortristis* seed extract at 0.1% or 1% level significantly reduced the mortality of *O. mossambicus* and a 3-week feeding with 0.1% extract-supplemented diet appears to be the optimal regimen for maximal disease resistance^{1,50}.

Fermented Vegetable product (FVP) and other plant extract

The phagocytic activities and superoxide generation of peritoneal induced leukocytes were significantly higher in fish Japanese flounder (*Paralichthys olivaceus*) fed the FVP supplemented diet than fish fed the control diet. FVP feeding in fish had a significantly higher ($P < 0.05$) activity of lysozyme than in the control fish⁵¹. Plant extract of *Cyanodon dactylon*, *Aegle marmelos*, *Tinospora cordifolia*, *Picrorhiza kurooa* and *Eclipta alba* were used to increase the immunity of shrimps against the WSSV. The mixed methanolic extracts of above plants were supplemented with various concentrations viz. 100(A), 200(B), 400(C), and 800(D) mg kg⁻¹ through artificial diets individually⁵². The shrimps fed on diet D (800 mg kg⁻¹) significantly ($P < 0.0001$) had more survival (74%) and reduction in the viral load compare to other diet. It also showed better performance of haematological, biochemical and immunological parameters.

Phytobiotics in Fish diseases

The main cause of the decrease fish production is the occurrence of diseases caused by different pathogens. The need for enhanced

disease resistance, feed efficiency, and growth performance of cultured organisms is substantial for various sectors of this industry. It is preferable that, in the case of commercial aquaculture, the costs production to be reduced. Because the cost of antibiotics used for prevention and treatment of disease and hormones used for growth performance is high and from the desire to search for new options, several studies have been carried out to test new compounds, from which the aquaculture industry has developed the concept of functional additives². This category includes also phytobiotics. Thus, it was proved that their use in fish diet led to improvement of the innate immune system for infection with various Bacteria (*Aeromonas hydrophila* in particular) in different species of fish⁵³. Phytobiotics are plant-derived, natural compounds embedded into diets which enhanced animal productivity. The phytobiotics have a wide variety of properties such as antioxidant, antimicrobial, anticarcinogenic, analgesic, insecticidal, antiparasitic, anticoccidial, growth promoters, appetite enhancement, stimulant of secretion of bile and digestive enzyme activity, laxatives and antidiarrhoea, hepatoprotection⁵³(Table 1).

Table 1
Herbal plant families & their multiple therapeutic properties in aquaculture

Sl. No.	Scientific name	Family	Therapeutic Properties	Source
1	<i>Myristica fragrans</i>	Myristicaceae	Digestion, Stimulant & Antidiarrhoic	Coutteau <i>et al.</i> , 2011 ⁵⁴
2	<i>Eclipta alba</i>	Asteraceae	Immunostimulatory effect	Pandy Govind <i>et al.</i> , 2012 ⁵
3	<i>Datura metal</i>	Solanaceae	Antimicrobial effect	Ravikumar <i>et al.</i> , 2010 ⁴
4	<i>Allium sativum</i>	Amaryllidaceae	Immunostimulant	Nargis <i>et al.</i> , 2011 ¹⁷
5	<i>Nymphaea alba</i>	Nymphaeaceae	Antibacterial	Turker <i>et al.</i> , 2009 ¹¹
6	<i>Zingiber officinale</i>	Zingiberaceae	Phagocytosis of WBC	Yin <i>et al.</i> , 2008 ¹⁰
7	<i>Vitex negundo</i>	Lamiaceae	Antibacterial agent	Prabhu Narayan Marimuthu <i>et al.</i> , 2012 ⁵⁵
8	<i>Solanum nigrum</i>	Solanaceae	Anticarcinogenic	Patel <i>et al.</i> , 2009 ⁵⁶
9	<i>Azadirachta indica</i>	Meliaceae	Antiviral, antiseptic, fungicidal	Cristea <i>et al.</i> , 2012 ⁵³
10	<i>Curcuma longa</i>	Zingiberaceae	Anti-inflammatory, antifungal, anti-venom, Anticoagulant, Antifertility	Chattopadhyay <i>et al.</i> , 2004 ⁵⁷

CONCLUSION

Herbal product have a potential application as an immunostimulant in fish culture, primarily because they can be easily obtained, are not expensive and act against a broad spectrum of

pathogens. Most of the herbs and herbal extracts can be given orally, which is the most convenient method of immunostimulation. However, the effect is dose-dependent and

there is always a potential for overdosing consequently, dosage optimization is strongly recommended. The use of such plant products as immunostimulants in fish culture systems may also be of environmental value because of their biodegradability. Due to their beneficiary

attributes we conclude that herbal extracts can be used in fish culture as alternatives to vaccines, antibiotics or chemotherapeutic agents.

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