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SELECTED MEDICINAL HERBS AS IMMUNITY BOOSTERS AND GROWTH PROMOTERS IN AQUACULTURE-A SYSTEMATIC REVIEW

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ABSTRACT

Aquaculture is a rapidly growing field due to the increase in demand with a steadily rising population since they contribute a significant part to the protein diet in humans. Disease outbreak being a major concern, it is important to produce healthy fishes, which makes it mandate to make the fishes broad-spectrum disease resistant with strong immunity. The most common measure is the use of antibiotics. However, along with the positive effects, antibiotics threaten the environment and the human population. With the drawbacks of antibiotics, it becomes necessary to administer a much more eco-friendly means of immunity booster. Extracts from herbs or their parts, roots, leaves, and stems have positive effects against diseases caused by various pathogens like bacteria, viruses, parasites, and fungus with the least observed side effects. A review was conducted to understand the recent findings on the role of the herbal extract on various diseases and the potential use of herbal extracts as a feed supplement in aquaculture to improve the production output.

**Keywords: Aquaculture; Immunostimulant; Feed supplement; Medicinal herbs;
Disease resistant**

INTRODUCTION

Aquaculture is the most promising standard source of robust proteins for mankind [1]. Due to the increasing demand for fish and seafood by a gradually

booming population, various strategies for encouraged and advocated for an efficient fish farming [2]. In order to meet the demands, farmers most often increase the stock densities, which poses stress to fish and shellfish cultures [3]. Stress conditions have proven to weaken the immune system [4]. Disease outbreaks largely hamper the aquaculture expansion and development [5] causing a production loss of about 50% [6]. Hence, diagnosing and treating diseases plays a significant role in maintaining commercial aquaculture and preventing economic loss [7]. Antibiotics, chemotherapeutics, and disinfectants were used extensively to treat diseases in fish [8]. Recurrent chemical usage decreases the immunity of the animal [9], which can lead to environmental pollution as well as results in emergence of antibiotic-resistant strains as well as selection of more virulent strain, cytotoxicity, genotoxicity, and occurrence of residual antibiotics in various fish products [10].

Prohibiting the usage of the sub-therapeutic antibiotics in 2003 by the European Union (EU) forced scientists to venture into other possible environmentally friendly alternatives keeping in mind both the betterment of fish health as well as the safety of environment as well as the consumers [11]. Amidst the other possible approaches, the most eco-friendly immunomodulation can be achieved by the

administration of various functional feed additives, which are relatively inexpensive, eco-compatible, increase feeding efficiency, broad-spectrum activity and have shown to provide benefits on fish growth [12]. Outbreak of diseases are related more closely to the animal's physiological state hence during the last few decades, attention towards medicinal plants usage and probiotics as feed supplements to improve fish fitness and immune system has been growing rapidly [13].

Medicinal plants that cure diseases in humans have been supplemented in fish feed [14]. Pigments, flavonoids, essential oils, alkaloids, tannins, steroids, terpenoids, and phenolics are the major bioactive plant components [15] that are known for their ability to enhance fish growth, enhance immunity and help in disease resistance. Several researchers have assessed the potential uses of herbs in controlling bacterial, parasitic, or viral diseases, with an evident increase in disease control in these studies [16]. However, the exact mechanism that is involved in the enhancement of immune responses is poorly described. Few researches have proposed that plant extracts usage has the potential to activate Toll-like receptors, following which is the activation of many pathways taking part in cell signaling cascade activation, assisting a pro-

inflammatory response and eventually resulting in the modulation of both innate and adaptive immune responses [17]. In the present review paper, a systematic review of the present state of research regarding the use of medicinal herbs in increasing resistance against various diseases was carried out.

Overview of fish immunity

The immune system acts as a fantastic defensivesystem in all multi-cellular organisms. In fish, the natural immune system actively takes up its function in the defensive system against pathogens in various environmental conditions. The acquired immune system or adaptive immune system is not very significant in fighting against pathogens because the adaptive immune system is not evolved in the fishes. Since fishes are poikilothermic, the efficiency of antibodies and lymphocyte production, retention of memory cells does not occur efficiently. Therefore, the natural immune system is considered to be the primary defense mechanism [18]. First lines of defense system are the physical barriers for example skin, mucus secreted by fish, gills and alimentary tract which often come in direct contact with the pathogens. These organs contain macrophages, lymphocytes, granulocytes, dendrites and Natural Killer Cells (NKC's) [19]. The immune response time is less the second time when compared

to the first time in vertebrates. However, studies say that in fishes the type of immunoglobulins is less than that of higher vertebrates. Therefore, there is a delayed immune response to the parasites. By the time the immune system of fish reaches the peaks, the parasite acquires the body of the fish [20].

Inflammation is the first response given by the tissues which will help in making the blood capillaries more porous and bring in the defense cells to the region of infection. Recognition and attaching to the specific microorganisms (pathogen) is done by the antibodies, resulting in phagocytosis [21]. Some of the cellular components such as macrophages are found in the innermost layer (endothelial cells) of the blood vessels and they act like the scavengers during endocytosis. These kinds of endothelial cells are present in different regions of vertebrates: In agnatha and chondrichthyes they are present in gills, in osteichthyes they are present in kidney or heart [22]. Anti-inflammation is caused by the Cytokines, which are produced by types of leukocytes: Th1, Th2, and Th17 [23]. These cells produce different kinds of cytokines namely IL8, IL22, IL10. Especially IL10 is present in the many species of teleost ex: *Catla Catla* [24-26]. IL22 is expressed in trouts and helps in producing the recombinant gene called rIL22 and with E-coli this helps in

enhancing the expression and promotes the production of antimicrobial peptides in the spleen cells. Thereby increasing the innate immunity of the host to fight against microbes [27].

Use of Medicinal herbs in the treatment of various diseases

Diseases generated by microorganisms are the most serious problem in aquaculture cultivation. Due to the overuse of antibacterial and antifungal medications, these germs will eventually become resistant to these diseases [28]. The use of medicinal herbs in treatment of various diseases caused by bacteria, virus, fungus as well as parasites has been discussed below.

Medicinal herbs in treatment of bacterial diseases

Other organisms, besides fish, live in water, including many types of saprophyte bacteria that dwell in sediments and plants. A few them invade the skin, gills, and gastrointestinal system of fish, where they live as commensals, aiding digestion and boosting the immune systems of these animals [29]. The *Selaginella plana* species were tested and found to have the ability restrict three pathogenic diseases, i.e. *Streptococcus agalactiae*, *Flexibacter columnaris*, and *Edwardsiella ictaluri*, *Streptococcus agalactiae* and *Edwardsiella ictaluri* [28].

Studies showed that traditional Chinese medicine comprising of three different herbs, namely *Astragalus membranaceus*, *Angelica sinensis*, and *Crataegus upehensis*, has an impact on the increased growth rate and improved innate immune response, including increased lysozyme, superoxide dismutase, catalase and immunoglobulin levels against the bacteria, *Streptococcus agalactiae* in Nile Tilapia, *Oreochromis niloticus* [30]. *Aloe vera* and *salvia officinalis* contain an antimicrobial component called cineol that helps treat the gill and liver histopathological lesions of Rainbow trout caused by the bacteria, *Streptococcus iniae*. Previous studies also showed the synergistic effect of essential oils from various medicinal-aromatic plants like Greek oregano, savory and Spanish oregano has a potential for mitigating the pathogenic impact of the bacterium *Aeromonas veronii* [31].

Moreover, a study by [32] on various medicinal herbs against different bacterial species such as *Aeromonas hydrophila*, *Pseudomonas fluorescens*, and *Edwardsiella tarda* deduced the fact that extracts from the bulb of *Allium cepa* showed antibacterial effect against *Aeromonas hydrophila*, *Pseudomonas fluorescens* and the extracts of *Calotropis gigantea* is effective against *Edwardsiella tarda*. Studies also let out that extracts of

Tamarindus indica and *Emblica officinalis* leaves, *Allium sativum* bulb, and *Syzygium aromaticum* bud curbed the growth of *Enterococcus faecalis*, and in the same study, the consumption of methanol extracts of *A. sativum* and methanol and acetone extracts of *S. aromaticum* significantly lessened the mortality of fish artificially infected with *E. faecalis* [33]. In a study by Terzi [34] the extracts of thin-skinned plums can enhance the innate immunity of Rainbow trout (*Oncorhynchus mykiss*) and also showed that they can improve the survival rate against *Yersinia ruckeri*. Studies showed that goldfish fed with *Boesenbergia pandurata* extracts increased the growth of Goldfish at 2, 4, and 6 g/ kg, improved the quality value of feed, increased immunity, and resistance against infection by the bacteria *Aeromonas hydrophila*, *Pseudomonas fluorescens* [35]. It has been reported that Sea Bass, *Dicentrarchus labrax*, when bath immersed with ginger oil, had a high total protein in the serum, which is an index to determine the health status of fish [36]. Another study performed by [37] to find out the effect of dietary laurel-leaf cistus (*Cistus laurifolius*) ethanolic extract on growth performance and nonspecific immune responses in common carp (*Cyprinus carpio*) showed that there was an increase in growth and resistance against *Aeromonas hydrophila* at 0.1 g kg⁻¹ of dietary laurel-leaf cistus.

Medicinal herbs in treatment of viral diseases

As per Sivasankar *et al.*, [40] infectious hematopoietic necrosis virus, hiramé rhabdovirus, yellowtail ascites virus, striped jack nervous necrosis virus, and iridovirus. Studies have shown that neem leaves containing nimbin, azadirachtin, and meliantriol have been recorded to have a variety of effects dating back to ancient times, including insecticidal and antiviral [39]. Olive tree leaf (*Olea europaea*) suppressed viral haemorrhagic septicæmia rhabdovirus in vitro, according to Micol *et al.* [41]. To treat viral infections in fish, Harikrishnan *et al.* [42] and Novriadi and Haw [43] used extracts *Punica granatum* leaf extracts were administered intraperitoneally for 8 weeks and 72-hour immersion agnostic towards iridovirus in tiger grouper *Epinephelus fuscoguttatus* culture resulted indicated that this herbal extract produced protective immunity for the host. Direkbusarakom *et al.* [44] has given evidences against antiviral activity of 18 herbs against infectious hematopoietic necrosis virus, infectious pancreatic necrosis virus, and *Oncorhynchus masou* virus.

Medicinal herbs in treatment of parasitic diseases

Parasites rarely present challenges in the natural environment, but they can cause severe disease outbreaks in

aquaculture [45]. Parasites are one of nature's most efficient lifeforms [46], they can determine an ecosystem's overall health [47]. Protozoans make up the majority of common fish parasites. They are single-celled organisms that live in the aquatic environment in large numbers. These parasites cause inflammation of the epithelium, causing stressed fish to be agitated [48]. Diagnosis using medicinal plants with antimicrobial properties in aquaculture could be an effective solution. *Allium sativum* dry extract showed 95% higher efficacy than control group against *Gyrodactylus turnbulli* [49]. *Ichthyophthirius multifiliis* is one most common parasites ruling the aquaculture; in recent studies, several plants such as *Zingiber officinale* [50], *Lippia alba* [51], *Toddalia asiatica* [52], *Cynanchum atratum* [53] and *Sophora flavescens* [53] have shown anti-parasitic properties effectively decreasing its prevalence. Researches report parasites of various origins to prevail in a shared host; *Carassius auratus* (goldfish) is home to *Argulus spp.* [54], *Dactylogyrus spp.* [55], *Gyrodactylus kobayashii* [56] and *Ichthyophthirius multifiliis* [52] disrupt fish metabolisms. Although the organisms are affected, several findings show that treatments using Phyto-compounds efficiently work against the pathogen and maintain the health of the aquatic

organisms. The extract of *Ocimum gratissimum* and *Rosmarinus officinalis* belonging to the Lamiaceae showed significantly high control and prevention against *Cichlidogyrus tilapiae* and *Dactylogyrus minutus*, respectively [57, 58]. Similarly, *Zingiber officinale* extracted ethanolic ginger [59] and gingerol [50] decreased the intensity of prevalence against the parasites *Gyrodactylus turnbulli* and *Ichthyophthirius multifiliis*.

Medicinal herbs in treatment of fungal diseases

Another major organism hindering aquaculture is the fungi, with complex internal structures and true nuclei, the same as parasites. Fungus is one of the prevalent disease-causing organisms in aquatic organisms [62]. The cause of death of broodstocks in aquaculture is an opportunistic fungal infection [63]. The majority of fungi that may infect fish are opportunistic and are not alone fish parasites [62]. The antifungal properties of medicinal herb extracts in aquaculture inhibit fungal pathogen's functionalities, such as lysis of the fungal cell wall, disrupting cell permeability, altering metabolism, RNA, and protein synthesis, and ultimately causing the fungal pathogen's death. Herbal plants are effective antifungal agents, as reported in several investigations. Phytocompounds such as phenolics, flavonoids, saponins,

tannins, terpenoids, and sterols produced from the plants' ethanolic extracts were found to have strong antifungal properties [64, 65]. According to several researches *Saprolegnia* spp. affects a wide range of fishes; *Magnolia officinalis* [66], *Terminalia catappa* [67], *Thymus linearis* [68], *Aloe barbadensis* [69], *Kirganeliareticulata*, and *Pongamia pinnata* have antifungal properties against *Saprolegnia parasitica* in several studies. A survival rate of 88% in *Carassius gibelio* eggs against *Saprolegnia australis* infection with aqueous extract of *Radix sanguisorbae* [70]. *Saprolegnia ferax* inhibition was achieved with a low MIC value in *Ctenopharyngodon Idella* using *Magnolia officinalis* extract. Yao et al. [71] reported a 93.3% recovery of infections in *Ctenopharyngodon idella*, using *Rheum palmatum* phytochemicals. Researchers also showed egg survival efficiency, a higher rate of hatching after treatment with plant extract treated eggs, and significantly inhibited fungus growth [72, 73]. Sometimes plants also act on more than one fungal pathogen, *Aucklandia lappa* showed significantly high anti-*Saprolegnia* and anti-

Achlya activities [74]. Furthermore, the immune responses of various parasites and fungi toward Phyto-extracts in several pieces of research are specified in the Table 3.

CONCLUSION

The present review on the latest findings and scientific literature has put forth the importance of medicinal herbs in improving disease resistance amongst the aquatic organisms. Therefore, the medicinal herb extracts, which are environmental-friendly supplements, can be a promising alternative to the use of antibiotics in aquaculture. The optimum feed supplementation, duration and administration dose for each cultured organisms, including all the stages of development, has to be determined. The mode of action of these herbal extracts in enhancing the immunity with the application of proteomics and transcriptomics is highly recommended in future studies. It is believed that, herbal supplementation will definitely be a driving factor towards promoting sustainable aquaculture.

Table 1: Effect of various medicinal herbs against bacterial diseases

Family	Plant	Fish	Duration of treatment/Type of extract	Type of administration	Immune Parameters improved	Pathogen	References
<i>Fabaceae</i> + <i>Apiaceae</i> e+ <i>Rosaceae</i>	A mix of <i>Astragalus membranaceus</i> , <i>Angelica sinensis</i> , and	<i>Oreochromis niloticus</i>	4 weeks/Dry roots of <i>Astragalus membranaceus</i> , <i>Angelica sinensis</i> , and <i>Crataegus</i>	Oral	Enhanced lysozyme, superoxide dismutase, catalase, and immunoglobulin levels	<i>Streptococcus agalactiae</i>	(30)

	<i>Crataegusupehensis</i>		upehensis				
Asphodelaceae + Lamiceae	<i>Aloe vera</i> <i>Salvia officinalis</i>	Rainbow Trout (<i>Oncorhynchus mykiss</i>)	Ten days	Oral	Helpful in treating the gill and liver histopathological lesions.	<i>Streptococcus iniae</i>	(38)
Roceace	Thin-skinned plum (<i>Prunus domestica</i>)	Rainbow Trout (<i>Oncorhynchus mykiss</i>)	Twenty one days/ dried fruits of thin skinned plum.	Oral	Shows increased survival rate against the bacteria and improved the innate immunity	<i>Yersinia ruckeri</i>	(34)
Zingiberaceae	Boesenbergia pandurata	Gold fish (Cyprinus carpio).	Seven days	Oral	Boesenbergia pandurata extracts increased the growth of Gold fish at 2, 4, and 6 g/ kg, feed quality improvement, FCR, immunity, and resistance against infection by the bacteria <i>A. hydrophila</i> and <i>P. fluorescens</i> .	<i>Aeromonas hydrophila</i> and <i>Pseudomonas fluorescens</i>	(35)
Zingiberaceae	Ginger oil	Sea Bass (<i>Dicentrarchus labrax</i>)	Ninety six hours	Bath immersion	Increased fish serum Total protein (TP), an index to determine the health status of fish		(36)
Cistaceae	Dietary laurel-leaf cistus (<i>Cistus laurifolius</i>)	Common carp (Cyprinus carpio)	45 days	Oral	Enhanced Body weight and increased survival rate against <i>Aeromonas hydrophila</i> compared to control.	<i>Aeromonas hydrophila</i>	(37)
Asteraceae	<i>Eclipta alba</i> (Bhangra) leaf	tilapia fish (<i>Oreochromis mossambicus</i>)	Aqueous extract of <i>Eclipta alba</i> (Bhangra) leaf for 1, 2 or 3 weeks in 0, 0.01, 0.1 or 1% levels	oral	cellular and humoral responses, and disease resistance increased	<i>A. hydrophila</i>	(39)

Table 2: Effect of various medicinal herbs against parasitic diseases

Family	Plant	Fish	Duration of treatment/Type of extract	Immune Parameters improved	Pathogen	References
(53)	<i>Cynanchum atratum</i> and <i>Sophora flavescens</i>	<i>Ctenopharyngodon idellu</i>	6 mg/L ethanol extracts for 10 days	Cured the infected grass carp	<i>Ichthyophthirius multifiliis</i>	
Asteraceae	<i>Tridax procumbens</i>	<i>Oreochromis niloticus</i>	4–6 g/kg ethanol extract 3 times/day for 8 weeks	High fish activity, immunity, and resistance to <i>D. vastator</i> , antioxidant activities, intestinal morphometry	<i>Dactylogyrus vastator</i>	(60)
Melanthiaceae	<i>Paris polyphylla</i>	Goldfish (<i>Carassius</i>)	20 mg/L methanol extract for 48 hrs	Maximum anthelmintic activity against G.	<i>Gyrodactylus</i>	(56)

		<i>auratus</i>)		kobayashii, the therapeutic index (TI) reached 37.9	<i>kobayashii</i>	
Zingiberaceae	<i>Zingiber officinale</i>	Grass carp (Ctenopharyngodon idellus)	4 mg/L 10-gingerol for 15 days	Protected fish from <i>I. multifiliis</i> infection	<i>Ichthyophthirius multifiliis</i>	(50)
Lamiaceae	<i>Ocimum gratissimum</i>	<i>Oreochromis niloticus</i>	320 mg/L ethanol extract for 5 hrs	Effectively killed the <i>C. tilapiae</i>	<i>Cichlidogyrus tilapiae</i>	(57)
Fabaceae	<i>Copaifera duckei</i>	<i>Piaractus mesopotamicus</i>	50 mg/L Oleoresin for 7 days	Effective against monogeneans and no effect against <i>P. mesopotamicus</i> health	<i>Monogeneans spp.</i>	(61)
Lamiaceae	<i>Rosmarinus officinalis</i>	<i>Cyprinus carpio</i>	60-, 80-, and 100-ml aqueous extract for 30 days	Controlled and prevented monogenean infection	<i>Dactylogyrus minutus (monogenean)</i>	(58)
Verbenaceae	<i>Lippia alba</i>	<i>Tambaqui (Colossoma macropomum)</i>	100 and 150 mg/L of <i>L. alba</i> essential oil at 30 mins exposure	Reduced <i>I. multifiliis</i> abundance efficiently	<i>Ichthyophthirius multifiliis</i>	(51)
Zingiberaceae	<i>Zingiber officinale</i>	Guppy (<i>Poecilia reticulata</i>) (Pete)	5 and 7.5 ppt Ethanol extract of ginger for 90 and 30 min respectively	Significantly decreased intensity and prevalence of the infection.	<i>Gyrodactylus turnbulli</i>	(59)
Ginkgoaceae	<i>Ginkgo biloba</i>	Goldfish (<i>Carassius auratus</i>)	3.544 mg/L (EC50) Ethanol extract for 48 hrs	Showed high anthelmintic activity against <i>Dactylogyrus spp.</i>	<i>Dactylogyrus</i>	(55)
Rutaceae	<i>Toddalia asiatica</i>	Goldfish (<i>Carassius auratus</i>)	1.8 mg/L and 8 mg/L, chelerythrine and chloroxylinone respectively for 72 hrs	Parasite prevalence decreased compared to control (50 % and 60 %, respectively)	<i>Ichthyophthirius multifiliis</i>	(52)
Amaryllidaceae	<i>Allium sativum</i>	<i>Poecilia reticulata</i>	0.03 mg/L of dry extract	95% efficacy against <i>G. turnbulli</i> compared to control	<i>Gyrodactylus turnbulli</i>	(49)
Piperaceae	<i>Piper longum</i>	<i>Carassius auratus</i>	Piperine at 9.0 mg/L for 48 hrs	Showed 100% efficiency against the parasite compared to control	<i>Argulus spp.</i>	(54)

Table 3: Effect of various medicinal herbs against fungal diseases

Family	Plant	Fish	Duration of treatment/Type of extract	Immune Parameters improved	Pathogen	References
Combretaceae	<i>Terminalia catappa</i>	Angelfish (<i>Pterophyllum scalare</i>)	50 and 100 mg/L hot extract for 96 hrs	Higher percentage of viable eggs, total larvae and lower percentage of infected	<i>Saprolegnia parasitica</i>	(67)

				eggs was obtained		
Phyllanthaceae and Fabaceae	<i>Kirganelia reticulata</i> and <i>Pongamia pinnata</i>	<i>Carassius auratus</i> and <i>Cyprinus carpio</i>	150 µg/mL of both the plant ethanolic extract for 4-5 days	Inhibited the growth and the death of <i>S. parasitica</i>	<i>Saprolegnia parasitica</i>	(75)
Lamiaceae	<i>Thymus linearis</i>	Golden mahseer (<i>Tor putitora</i>)	0.32 mg ml ⁻¹ and 5.12 mg ml ⁻¹ ethanolic extract for 24 hrs	Inhibited hyphal growth to 54.45 ± 0.9% and completely inhibited at respective concentrations	<i>Saprolegnia parasitica</i>	(68)
Asphodelaceae	<i>Aloe barbadensis</i>	Rainbow trout (<i>Oncorhynchus mykiss</i>)	15 g/kg of dietary Aloe vera for 8 weeks	Increased innate immunity, growth, TNF-α (tumor necrosis factor-α) upregulation, gene expression, and boosted resistance against <i>S. parasitica</i>	<i>Saprolegnia parasitica</i>	(69)
Polygonaceae	<i>Rheum palmatum</i>	<i>Ctenopharyngodon idella</i>	20 mg/L rhein for 1 week	Prevented 93.3% of infections in <i>C. idella</i> , with 67.7% recovery rate compared to infected fish.	<i>Saprolegnia</i> spp.	(71)
Lamiaceae	<i>Zataria multiflora</i> Boiss.	rainbow trout (<i>Oncorhynchus mykiss</i>)	25 mg/L for 60 min daily (3 days)	Prevented fungal attack, increased the rates of hatching, eyed egg, and the final larvae.	<i>Fungus unspecified</i>	(73)
Magnoliaceae	<i>Magnolia officinalis</i>	grass carp (<i>Ctenopharyngodon idella</i>)	2 g/L herbal plant ethanol extract for 48 hrs	Showed enhanced growth inhibition with a 62.5 mg/L MIC value	<i>Saprolegnia ferax</i>	(66)
Rosaceae	<i>Radix sanguisorbae</i>	<i>Carassius gibelio</i> eggs	1280 mg/L aqueous extract in Single bath	88% survival (compared to 0.2 mg/L concn. of malachite green, 37% higher was achieved)	<i>Saprolegnia australis</i>	(70)
Myrtaceae	<i>Eucalyptus</i> spp.	<i>Rutilus frisii</i> eggs	100 mg/L Essential oil for 3 days (1 hr/day)	Higher rate of hatching (approx. 30% higher than control eggs) was observed in treated eggs and significantly inhibited fungus growth	<i>Fungus unspecified</i>	(72)
Costaceae	<i>Aucklandia lappa</i>	Organism unspecified	11.3 and 26.1 mg/L Petroleum ether extracts for 48 hrs	Anti- <i>Saprolegnia</i> and anti- <i>Achlya</i> activities was observed	<i>Saprolegnia</i> spp. and <i>Achlya</i> spp. activities	(74)

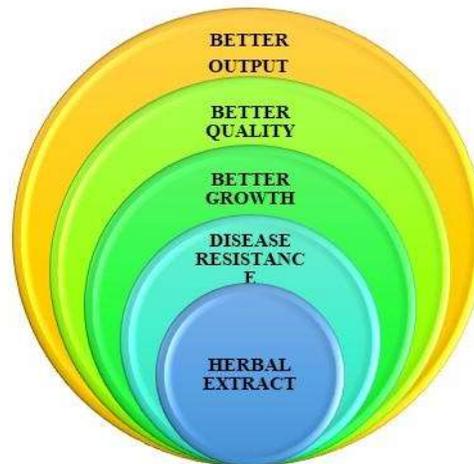


Figure 1: Herbal extract for better production output in aquaculture

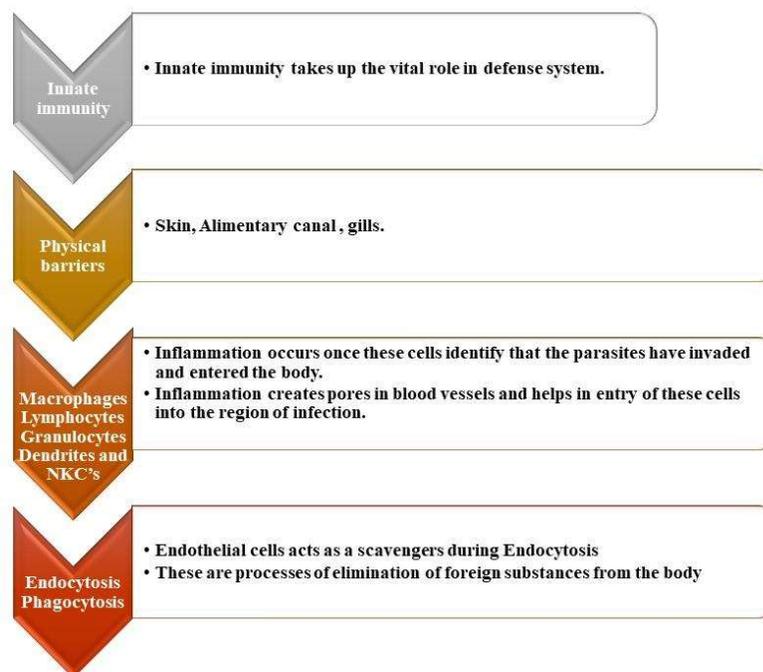


Figure 2: Process of Innate immune system in fishes

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