HARNESSING THE POTENTIAL OF HERBAL BIOMEDICINES IN AQUACULTURE

Abstract

Aquaculture a driving force in enhancing global prosperity and providing cheap source of protein. This has put pressure in the field resulting in use and abuse of antibiotics to counteract diseases caused due to intensification. Growing awareness of the adverse impacts of antibiotics has spurred a widespread shift towards natural products. The potentiality of various extracts from plants and animals as immunomodulators, appetite stimulants, anti-stress agents, antioxidants, antibacterial, antifungal, and antiviral agents is emphasised and proven with better results. These biomedicines also play a role in stimulating development while mitigating the risk of infections that pose threats to both the ecosystem and the health of fish. Herbal compounds, including phenolics, polyphenols, alkaloids, quinones, terpenoids, lectins, and polypeptides, emerge as highly effective alternatives to antibiotics and synthetic compounds. This chapter reviews into the potential of herbal biomedicines in aquaculture, offering sustainable alternatives for fostering growth and ensuring the health of aquatic ecosystems.

Keywords: Antioxidant, Anti stress, Antiviral, Appetite Stimulants, Growth promoter, Immunostimulants

Authors

Jayashri Mahadev Swamy
Karnataka Veterinary Animal and Fisheries Science, University, Bidar Karnataka.

Amogha K.R
College of Fisheries Science, Mangalore.

Preeti
Karnataka Veterinary Animal and Fisheries Science, University, Bidar Karnataka.

Somnath R. Yadav
Maharashtra Animal and Fishery Sciences University, Nagpur, Maharashtra, India.

Junaid Sidiq
Central Institute of Fisheries Education Mumbai.

Ganapathi Naik. M
College of Fisheries Science, Mangalore.
Email: jayashriswamy22@gmail.com

1. Introduction

Capture fisheries is declining year by year resulting in aquaculture sector as a more sustainable alternative. With the intensification in aquaculture to produce more and more, which inturn has resulted in diseases, common practices for disease control involve the use of antibiotics and chemotherapeutics. Unfortunately, the widespread application of these preventive measures has detrimental effects on the water environment, resulting in development of antibiotic-resistant bacterial strains (Done *et al.*, 2015). This has forced mankind to look into alternatives like herbal medicines (Bruce, Brown, 2017)

Medicinal plants hold particular promise due to their rich content of biological compounds, including alkaloids, terpenoids, saponins, and flavonoids. These plant-derived elements find widespread use in aquaculture to enhance growth performance, fortify the immune system, and provide antioxidant effects (Reverter *et al.*, 2017). Incorporation of plant products into the diet is seen as a strategic approach to mitigate risks associated with antibiotic and chemotherapeutic use (Nayak, 2010). This shift towards medicinal plants is a positive shift towards more sustainable aquaculture practices.

2. Significance of Biomedicines in Aquaculture

Biomedicines play an important role in aquaculture due to the rapid growth and intensification, leading to a stressful environment and disease challenges (Kennedy *et al.*, 2016). Medicinal plants, recognized as immunostimulants for centuries (Tan and Vanitha, 2004), offer a natural and safe alternative to traditional antibiotics and immune prophylactics. These plants, used as feed additives and chemotherapeutics, contain beneficial compounds like phenolics, polyphenolics, alkaloids, quinones, terpenoids, lectins, and polypeptides, serving as effective substitutes for synthetic substances (Harikrishnan *et al.*, 2011).

Several studies highlighted the impact of herbal components in fish diets, presenting cost-effective and eco-friendly alternatives with fewer adverse effects. Plant extracts exhibit antipathogenic, stress-relieving, appetite-stimulating, tonicity- and immunostimulation-enhancing, maturation-facilitating, and maturation-promoting effects on fish (Reverter *et al.*, 2014). Herbal fish diets are associated with improved immune system efficiency (Dügenci and Candan, 2003), heightened stress tolerance (Ji *et al.*, 2009) and enhanced growth performance (Ji *et al.*, 2007; Dada, 2012).

Enhancing Immune System with the help of Immunostimulants

Immunostimulants, encompassing chemicals, medications, or activities, fortify the immune system in animals, bolstering their innate defenses against pathogens. Dietary supplementation elevates critical markers such as myeloperoxidase, phagocytic activity, serum lysozyme, and NBT, offering insights into non-specific defense mechanisms in fish. *Astragalus radix* and Lonicera extracts revealed heightened phagocytic and lysozyme activities in tilapia Yin *et al.* (2006). Black cumin, garden cress, dill, and clove basil supplementation resulted in increased lysozyme activity induction in rainbow trout, common carp, and tilapia Celik *et al.* (2017). Feeding gilthead sea bream with fenugreek seeds and leaf extracts elevated fish serine peroxidase activity (Beltrán *et al.*, 2018; Guardiola *et al.*, 2018). Significantly, dietary administration of gotu kola powder (Naphakorn Srichaiyo *et al.*,

2020), and coriander seed extract (Farsani *et al.*, 2019), induced heightened phagocytic ability and respiratory burst in various fish species. All these studies throw greater light in the usage of herbal medicines for better health.

Herbal Medicines as Growth Promoters and Increased Appetizer

Research on herbal medicines has shown its effectiveness in influencing the growth parameters of fishes (Ali *et al.*, 2008). Studies on common carp (*Cyprinus carpio*) and tilapia (*Oreochromis niloticus*) revealed that incorporating Quillaja saponin plant in the feed enhances specific growth rate, protein efficiency ratio, lipid utilization, and energy utilization, while reducing feed conversion ratio. Several herbs, including *Coriandrum sativum, Curcuma longa, Zingiber officinale, Rosmarinus officinale,* and *Allium cepa,* has been employed in aquaculture studies.

Nile tilapia fed diets containing 400, 800, and 1200 mg of vegetable choline per kilogram of feed showed increased weight gain, corporal length, and feed intake, as reported by Matheus *et al.* (2019). In a study by Luo *et al.* (2016), supplementing yellow catfish (*Pelteobagrus fulvidraco*) with vegetable choline resulted in enhanced weight gain, specific growth rate, and feed intake. Diets containing 0.5%, 1%, and 2% argan oil a study by Esin Baba *et al.* (2017) demonstrated that argan oil stimulated certain aspects of the non-specific immune system in Nile tilapia during both the pre- and post-challenge periods.

According to Hassan *et al.* (2018), supplementing Nile tilapia (*O. niloticus*) with 1% rosemary increased weight gain, SGR and protein efficiency ratio significantly but had no effect on carcass composition. According to Safari *et al.* (2019), a diet containing 20–25 g/kg of ferula powder could enhance the growth performance of Koi carp (*C. carpio koi*). According to Hien *et al.* (2019) adding 5 g kg^{-1}*Elephantopus scaber* to the diet considerably increased the WG and SGR of Nile tilapia while simultaneously lowering FCR. Clove basil inclusion in Nile tilapia Aline Brum *et al.* (2017), has improved the feeding conversion ratio and weight gain. These results give us better picture in the usage do medicinal herbs its effectiveness not only in terms of health but also growth.

Herbal Drugs as an Antioxidant in Relieving Stress in Fish

Antioxidant properties of herbal drugs play a crucial role in helping living organisms manage oxidative stress caused by free radicals. Numerous chemical compounds present in plants exhibit antioxidative properties, assisting organisms in dealing with oxidative stress induced by damage from free radicals. This process contributes to enhancing the overall physiological well-being of fish (Chakraborty and Hancz, 2011).

According to Hiam Elabd *et al.* (2016) after a week of starvation of *Astragalus membranaceus* and liquorice in yellow perch (*Perca flavescens*), the activities of glutathione peroxidase (GPx) and lipid peroxidase (LPx) were significantly elevated while those of superoxide dismutase (SOD) and catalase (CAT) were significantly decreased. According to Zahran *et al.* (2014), feeding *O. niloticus* Astragalus polysaccharides as a dietary supplement decreased the activities of SOD and GPx. In Nile tilapia, *O. niloticus* fed diets enriched with cinnamon nanoparticles, Mohsen Abdel *et al.* (2018) reported that the dietary particles evoked antioxidant activity wherein MDA level and activities of SOD and CAT increased

significantly, whereas GPx decreased significantly. In Nile tilapia fed diets enriched with cinnamon nanoparticles, Al-Sagheer *et al.* (2017) found that supplementing Nile tilapia with 200 mg lemongrass and 400 mg geranium/kg−1 diet led to a notable increase in both enzymatic (CAT) and reduced glutathione nonenzymatic (GSH) antioxidants, as well as a notable decrease in MDA levels. Wang *et al.* (2018) showed that supplementing Chinese herbal medicines mixtures increased the antioxidant capacity of Japanese seabass, *L. japonicus*, as evidenced by higher activities of total antioxidant capacity (T-AOC), SOD and CAT. According to Nazeri *et al.* (2017) *O. mykiss* exhibited the highest CAT enzyme activity when fed a diet containing rutin.

Herbal Extracts: Alleviating Stress in Aquatic Organisms through Antistress Activity

Herbal drugs play a pivotal role in counteracting stress in aquatic organisms by scavenging free radicals and inhibiting the production of oxygen anions. Various herbs, such as *Piper longum, Emblica officinalis, Asparagus racemosus, Ocimum sanctum, Withania somnifera*, and *Tribulus terrestris*, are recognized for their adaptogenic and anabolic properties, along with the ability to boost vital energy. *Picrorhiza kurro*a is employed in shrimp stress treatment, exhibiting similarities to xanthine oxidase inhibitors, metal-ion chelators, and superoxide dismutase (Citarasu *et al.*, 2010). Further, the bioflavonoid rutin, derived from *Toona sinensis*, demonstrates robust antistress and antioxidant properties in crustaceans. Rutin was known to enhances biochemical, immunological, and hematological responses in *Litopenaeus vannamei* under stress induced by *Vibrio alginolyticus* Hsieh *et al.* (2008). Wu *et al.*(2007) found that feeding common carp (*C. carpio*) a diet containing 0.3 g/kg Qompsell extract decreased stress and stimulated immunological parameters like serum lysozyme activity, nitric oxide synthase (NOS), superoxide dismutase (SOD) and levels of albumin, globulin and total serum protein. Chinese medicinal herbs *A. membranaceus* and *L. japonica*, at 0.1% each and in combination with and without boron 0.05% in diet, enhanced the non-specific immune response in Nile tilapia (*O. niloticus*) (Ardo *et al.*, 2008). *Tinospora cordifolia*, also known as Guduchi, is a well-known anti-stress herb (Mittal *et al.*, 2014). Several studies by Castro *et al.*, 2008; clove oil is a proven way to lessen stress during handling, transport and confinement.

Harnessing Herbal Power: Antiviral Properties against Fish and Shrimp Viruses

Herbal drugs emerge as potent antiviral agents combating fish and shrimp viruses. Methanol extracts from five medicinal plants,*C. dactylon, A. marmelos, Tinospora cordifolia, Picrorhiza kurroa, and Eclipta alba*were integrated into the diet of WSSV-infected shrimp, showcasing significant antiviral activity. Notably, *P. monodon* treated with an aqueous Bermuda grass (*C. dactylon*) extract, either orally or intramuscularly, exhibited zero mortality against WSSV (Balasubramanian *et al.*, 2007). Traditional Indian medicinal plants, including *A. marmelos, C. dactylon, L. camara, M. charantia, and P. amarus,* displayed robust antiviral activity against WSSV in *P. monodon*.

The active compounds found in herbs have the potential to inhibit or block the transcription of the virus, thereby reducing its replication in host cells and boosting non-specific immunity. They boost the host immune system's capacity. Numerous bioactive compounds found in various ethanolic and methanolic herbal extracts have the ability to inhibit or block the synthesis of viral mRNA, thereby reducing viral replication in host cells and enhancing

non-specific immunity. Harikrishnan *et al.* (2010) showed that the herbal leaf extract of *Punica granatum* improved innate immune responses and disease resistance against lymphocystis viruses in Olive flounder.

Herbal Guardians: Unleashing Antifungal Powers

Herbal drugs exhibit remarkable antifungal activity, disrupting fungal cell walls, modifying membrane permeability, influencing metabolism, and inhibiting protein synthesis, ultimately leading to fungal cell death. Hashemi *et al.* (2011) highlighted the inhibitory effect of ethanol extracts from common rue (*Ruta graveolens*) on Saprolegnia sp., showing its potent antifungal properties. Ali (2013) explored essential oils from *Glycyrrhiza glabra* and *Matricaria chamomilla* ten traditional Chinese medicinal plants, including *Cnidium monnieri, Magnolia officinalis, and Aucklandia lappa*, exhibited robust inhibitory effects on fungal species, particularly Saprolegnia and *Achlya klebsiana*. Noteworthy antifungal activity was observed in petroleum ether extracts from *Cnidium monnieri, Magnolia officinalis, and Aucklandia lappa* bark (Wu *et al.*, 2011). Red algae *Asparagopsis taxiformis* demonstrated antifungal prowess against Aspergillus species (Wu *et al.*, 2011).

Unveiling Nature's Elixir: Herbal Aphrodisiacs for Enhanced Reproduction

Herbal drugs, recognized for their diverse therapeutic properties, also wield the power to act as potent aphrodisiacs, influencing reproductive processes and hormonal balance. Babu (1999) discovered that a maturation diet enriched with extracts from *W. somnifera, Mucuna pruita, Ferula asafoetida,* and *Piper longum* significantly increased fecundity and gonadal weight in black tiger shrimp. *Asparagus racemosus, i*n conjunction with 5% rice bran, was observed to promote reproduction and enhance sexual parameters in *A. franciscana* (Devi 1995). Furthermore, Lin-Cabello *et al.* (2004) reported accelerated maturation in crayfish (*Cherax quadrucarinatus*) when fed a diet containing plant carotenoids, vegetable oils, and vitamin A.

Citarasu T. (2010) showed the efficacy of an herbal product, reprotism, in enhancing reproductive performance in *Artemia franciscana*. The addition of retinol palmitate exhibited a profound inductive effect on the primary vitellogenic phase and indicators of ontogenic oocyte development. These findings show the potential of herbal interventions in fostering reproductive vitality across various aquatic species.

Empowering Aquaculture through Indigenous Wisdom

Harnessing the potential of herbal biomedicines in aquaculture emphasizes the incorporation of indigenous technical knowledge from local communities. Collaborative research with these communities to document traditional practices and remedies is the need of the hour. Integrating indigenous knowledge ensures a better understanding of the environment, species, and practices, offering valuable insights into effective herbal solutions. Collaborative research projects should engage local practitioners, combining their wisdom with scientific methodologies to identify, validate, and optimize herbal interventions. This approach not only respects cultural diversity but also promotes sustainable practices rooted in local traditions. By embracing indigenous technical knowledge, research can bridge the gap between traditional wisdom and modern aquaculture, fostering a harmonious coexistence that

benefits both ecosystems and local communities. This inclusive approach holds the key to unlocking the full potential of herbal biomedicines while fostering community-led sustainable aquaculture practices.

3. Conclusion

The vast majority of active ingredients found in herbal biomedicines, encompassing alkaloids, flavonoids, pigments, phenolics, terpenoids, starch, steroids, and essential oils, embodies a rich source of biomedical properties that significantly benefit aquaculture. These properties, including growth promotion, immune system tonicity, appetite stimulation, and antistress effects, present a holistic approach to enhance the overall health and performance of aquatic species. Harnessing the potential of herbal biomedicines in aquaculture not only addresses concerns related to the cost and adverse effects associated with synthetic compounds but also contributes to the broader goal of fostering environmental sustainability. Beyond their therapeutic potential, herbal extracts play a pivotal role in disease prevention and growth optimization. The multifaceted benefits offered by herbal biomedicines underscore their significance in promoting a balanced and resilient aquaculture ecosystem.

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