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Exploring the Benefits of Phytochemicals in Aquaculture: A Comprehensive Review

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Abstract: ***The rapid expansion of aquaculture necessitates the exploration of cost-effective and nutritionally rich feed alternatives. This review focuses on the potential of phytochemicals as a viable solution. The use of herbal plants in fish feed not only offers a cost-effective approach but also provides nutritional benefits, contributing to the growth and health of fish. The paper discusses various herbal plants and their impact on fish growth, immunity, and overall health. It also highlights the potential of these plant-based feeds in reducing the adverse effects of commercial feed additives. The review emphasizes the need for further research to understand the nutritional, physiological, and ecological impacts of plant-derived substances in fish feeds. The paper concludes with the assertion that plant-based feeds, enriched with phytochemicals, can contribute significantly to sustainable aquaculture practices. The plants that are especially known for their therapeutic properties, such as Moringa oleifera, Phyllanthus niruri, Phyllanthus emblica, and Azadirachta indica, are given greater consideration, bearing in mind the nutrition and immunity that a fish needs from its primary feed.***

Keywords: Fish feed, Aquaculture, Plant-based feed, Growth rate & fortified feed

1. Introduction

Many herbs and herbal products are used in aquaculture techniques to treat ailments, increase growth, relieve stress, stimulate hunger, enhance immunity, and prevent infections in order to produce healthy fish (1-5). Herbal plant sources are being examined as a feasible option to be used in fish feed without sacrificing the nutritional content (6, 7). The use of nutritionally deficient diets can result in reduced development and output in fish due to stress, but it can also result in fish loss due to nutritional deficiency syndromes and death caused by increased vulnerability of nutritionally weakened fish to infectious illnesses. Fish feeds are the most expensive in aquaculture (8), owing to the utilization of animal protein sources such as fish meal, shrimp meal, and so on (9). If plant sources can be employed as a complement to animal protein sources, not only will production costs be reduced, but fish growth and production will also increase (10).

The World Health Organisation (WHO) supports the use of medicinal herbs and plants to replace or lessen the use of chemicals as part of the worldwide movement towards returning to nature. For a number of factors, such as sustainability, availability, cost-effectiveness, and environmental friendliness, herbal plant protein sources have been utilised for a very long time as feed. Fish consumption has also grown, making it the food source that is expanding the quickest in the developing globe.

Many studies show that including herbs in a fish diet has a positive effect on growth and disease-free fish in commercial fish farming (11, 12). Excessive use of synthetic medicines, antibiotics, and hormones in aquaculture to control illnesses and enhance fish development. However, the end product can be detrimental to the environment and human health (13), as well as decrease immunity in the host (14). The WHO promotes supplemented diets that include therapeutic herbs or plants to reduce the need of pesticides in fish meals (15). Herbs and herbal items can be utilised in the fish diet to help the fish grow faster in captivity (16).

The demand for premium fish feed will continue to rise. Despite being essential to production and yield outcomes, fish feed only makes up around half of aquaculture production costs (17). The price of feed will grow in tandem with a rise in the demand for fish. The demand for organic is both increasing and decreasing due to static marine catches and alternative applications of organic for livestock and human consumption (18). It became imperative to find substitute sources of protein to replace (complete/partial) organic in the diet as a result (19).By increasing saliva secretion, different digestive enzymes, bile, pancreatic enzyme activity, and fish mucus, herbs and herbal products added to fish diets changed feeding habits, increased feed consumption, and faster digestion (20, 21). As a consequence, the information in this review concerning fish development using herbal feed additives is helpful.

Impact of Plant-based feed on Fish Health:

Fish growth enhancers are helpful when medicinal plants are used (22-24). The extract of thyme (*Origanum heracleoticum L.*) was found to increase weight gain and offer a favourable feed conversion ratio in a different investigation (25). According to Shalaby *et al.* garlic added to tilapia meal increased the specific growth ratio and protein efficiency ratio (26). According to research by Turan *et al.*, adding purple clover to tilapia (*Oreochromis aureus*) diet increases the feed conversion ratio, specific rate of growth, protein efficiency ratio, and apparent protein utilisation (27). Indifferent research, the feed for *Labeorohita* was supplemented with a combination of *Trigonella foenum graecum L., M. fragrens, P. betel, P.*

Carylifolia, and *Camheria sp* (28). The quantity of protein efficiency ratio significantly increased while the feed conversion ratio stayed the same (29).

According to research by Ahmad *et al.* (30), cumin-containing meals significantly increased the specific growth ratio, protein efficiency ratio, apparent protein intake, and apparent energy utilisation of tilapia (*O.niloticus)* fish. Herbal sources might provide adverse side effects if they are used excessively and contain harmful components. However, when administered and applied properly, there are no problems (31). Aquacultural operations will be carried out securely and any possible financial losses due to sickness or developmental issues may be prevented in advance thanks to the preliminary analysis of the impacts of herbal sources to be utilised in fish farming.

Fish immune systems and overall health have been improved by using a variety of therapeutic herbs, including olive leaf extract (32). The medicinal herbs utilised in this study have a variety of therapeutic benefits. For example, *Withania coagulans* extract is widely known for its numerous medicinal benefits. Its extraction has demonstrated several miracles over time, including wound healing, the prevention of excessive blood sugar (antihyperglycemic), the prevention of cancer, and boosting the species' resistance to various illnesses (33). Additionally, it lessens oxidative stress and inflammation (34).

Herbal feed Supplements used in Aquaculture

***Moringa oleifera* (Murungai):**
The plant known as *M.oleifera*, sometimes referred to as "drumstick, " is a highly nutritious addition to the diet of fish that consume plants, such as tilapia, barbs, and carps. Even at the level of 25 Russell's bodies, adding moringa leaf to the diet of *Tilapia rendalli* was costly and had a negative impact on development and health, which may have been caused by the tannins and polyphenols found in the leaves. 10% of the dietary protein in Nile tilapia fry may be replaced with steam-heated moringa leaf meal without affecting development (35).

Over a long period of time fish meal has been an important concern for the aquaculture industry. However, the quest for an alternate protein source is necessary due to the low availability and high cost. More and more, biological components are being partially or entirely replaced with supplies from plants. Practically the focus on fish feed has recently been the primary research on aquaculture nutrition (36). The majority of research in recent years has focused on the substitution of uncommon feedstuffs such *M. oleifera* for fish meal in fish diets (37). Fish diets using moringa leaf as an alternate protein source have been evaluated, and it seems to be an unequalled supply of protein. *O.niloticus's* growth performance may be partially replaced by moringa leaf meal in traditional diets without suffering (38). These results are analogous to those of others who found that feeding fish a moringa-based diet at 10% replacement level resulted in favourable growth effects (39).

***Aloe barbadensis* (Aloe vera):**
It is a lily (Liliaceae) or Aloeaceae family perennial plant (57). It's a cactus-like perennial succulent that thrives in hot, dry regions. Vital nutrients such as proteins, essential fatty acids, Vit. C and E, carbohydrates (sugars) and minerals are important in fish to support appropriate immunological responses (40). Aside from the high cost of fish feeds and poor seed, disease outbreak is a key concern in fish farming (41). Herbal treatment has been enhanced to control the most harmful parasite diseases that affect humans, animals, and fish. The purpose of this study was to see how common carp (*Cyprinus carpio*) grew after being given three doses of ethanolic Aloe vera extract. This study found that ethanolic Aloe vera extract had a positive impact on growth performance. Aloe vera extract in the diet can help fish develop faster by increasing the efficacy by stimulating growth, appetite and acts as an immunostimulant, as well as reducing stress, reducing food losses, and protecting them from predators (42).

***Phyllanthus niruri L* (Keezhanelli):**
Fish growth promoters are made from the plant *Phyllanthus niruri L*. Food composition, quality, and quantity are all important factors in fish growth (43, 44), and numerous feed formulations have been explored to replace natural food for both edible and decorative fishes (58). In contrast to a control group, the experimental groups' growth was observed to be boosted by a diet supplemented with *P. niruri* in the current study. Due to *P. niruri*'s less stressful, more enjoyable, and digestible nature-that is, its growth-promoting effect-the result shows the quickest rate of growth in terms of fish length and weight. When administered *Andrographis paniculata,* the fish *O.mossambicus* had comparable outcomes (45). The challenge test results indicate that fish fed a 2 percent *P. niruri* diet exhibited higher immunostimulatory activity. As a result, *P. niruri* is a growth promoter as well as an immunostimulatory.

***Psidiumguajava L.* (Guava):**
The growth and nutrient usage of *O. niloticus* fingerlings were adversely affected by the guava aqueous extract. The ultimate increase in the physiological growth of the experimental fish was significantly greater in *P. guajava* treated fish when compared to the commercial feed fed groups. In groups of fish fed guava-treated diets, feed consumption was noticeably greater, indicating that more feed was eaten. The proportion of fish that survived ranged from 90% to 95%, according to the weight increase and feed consumption statistics, indicating that groups had a better feed conversion ratio. According to the results, fish performance and development have both enhanced (46).

***Phyllanthus emblica* (Amla):**
The current study focused on *P.emblica*.to assess the immunostimulatory capability of feeding in fish. The specific rate of growth and feed conversion rate of the fish fed an Amla extract integrated diet improved. Better palatability, digestion, and nutrient absorption may be required to incorporate Amla into the diet, resulting in improved SGR and FCR. A substantial increase in specific growth rate was seen in *O.niloticus* fed an *Echinacea purpurea* and *Allium sativum* supplemented diet and

infected with *Aeromonas hydrophila* (47, 59). As a result, it's clear that including Amla in one's diet has a significant impact on growth.

***Ocimum basilicum* (Basil):**

Ocimum basilicum is added to the diet of sea bream (*Sparus aurata*). In the current study, an increase in sea bream growth and feed utilisation was noted. Basil seeds are more effective at promoting growth than leaves because they contain active ingredients like planteose, mucilage, polysaccharides, and glued oil, which contain linoleic acid, linolenic acid, oleic acid, and unsaturated fatty acids. List *et al.* and Amirkhani *et al.*(60, 75) found that adding basil leaf extract to fish diets at inclusion levels of 4% and 8% increased the growth and specific growth rate and decreased feed conservation ratio (FCR) of *Cyprinus carpio*. Diets with basil as a supplement showed no impact on survival. Incorporating dried basil leaves into diets for Hybrid Tilapia, *O.niloticus* X *O. aureus* fingerlings considerably increased growth rate when compared to the control diet, especially at the easiest inclusion level of 2 percent dry basil leaves (28).

***Azadirachta indica* (Neem):**

The Neem tree (*A.indica*), also known as the Nim tree or Margosa tree, is a non-leguminous multi-purpose tree in the Meliaceae family (48). It has been claimed that humans, as well as many other animals and fish species, benefit from it (49-51). The Neem plant has been shown to have antibacterial, antifungal, antiviral, and pesticide qualities (52) and additionally, it enhances general health and performance while having no detrimental effects on essential organs. Contrary to Gowda's (53), findings, the fish's average feed intake was not impacted by the neem leaf's bitterness, demonstrating that catfish do not require detoxification of neem for enhanced palatability and acceptance in feed (54) and the feed intake and weight increase are reported similarly by many other studies (55). The outcomes of this study supported the findings of Talpur *et al.* (56) for Lates calcarifer fingerlings, showing that Neem leaf inclusion had a positive substantial effect on both weight increase and feed conversion efficiency in *Clarias gariepinus* juveniles. Neem leaves added to feed significantly improve growth performance overall growth parameters and prevent bacterial development. Neem leaf extracts in the management of diseases in animal health should be promoted due to its growth enhancing and anti-microbial ability.

***Cassia auriculata* (Avaram):**

A number of human illnesses are treated using linn, a potential herbal. Dried flowers include terpenoids, tannin, flavonoids, saponin, cardiac glycosides, and steroids. Triterpene, diterpene alcohols, and phytol, all of which are used in medicinal therapies, are abundant in this plant's leaves. According to earlier studies (61-66), the plant's aerial parts have historically been used to treat acute toxicity, conjunctivitis, fever, diabetes, ulcers, and other conditions. Therefore, the goal of this study was to ascertain the immunomodulatory action of powdered avaram leaf in young milkfish. A meal containing Cassia auriculata leaf powder (CAL) had a good effect on milkfish growth in the current study. Higher levels of CAL in the diet led to efficient growth rates and protein conversion ratio. The results of Priyadarshini *et al.* (67), who fed common carp a polyherbal immunomodulator that increased weight gain and specific growth rate, were consistent whereas *O.niloticus*, grew faster when fed *S. cumini* seed powder (68). If milkfish juveniles were provided a CAL integrated diet, there may have been better feed utilisation, as evidenced by improved digestion, nutritional absorption, and subsequent carcass accretion and weight increase.

***Zingiber officinale* (Ginger):**

In addition, the Zingiberaceae family includes ginger. They are often accessible throughout Southern and Eastern Asia. There are 1300 species in 49 genera that make up this family. Numerous phenolic substances that are present in *Z. officinale*. Flavonoids, paradols, sesquiterpenes, minerals, and vitamins are also found in addition to these phenolic chemicals. Ginger has traditionally been used to cure a variety of ailments, including cramps, sore throats, fever, nausea, stomach discomfort, and dementia. Additionally, the various medicinal qualities, that helps to fight against free radical, inflammation, apoptosis, hyperglycaemia, pyrectics, diabetes (68). The current study sought to assess the potential value of these two magical herbs in aquaculture as an immune stimulant since although having many medicinal characteristics, their usage in aquaculture is quite restricted.

2. Discussion

Subsequently, aquaculture is one of the divisions that is expanding the quickest worldwide because of the increased stipulation for fish, aquaculture has intensified more quickly. A nutritional imbalance or poor feed quality in such a high-intensity system might hinder growth and output. As availability has diminished, the cost of fish meal, which has traditionally been the main source of protein in feed composition, has increased. Research into unusual plant sources as an alternative protein source has become crucial since total replacement of fishmeal with animal protein sources is difficult, expensive, and neither sustainable nor cost-effective. It thinks that providing milkfish juveniles with a diet that contains CALs with plant protein sources might boost feed availability and reduce feed expenditures. The drawbacks of using feedstuffs made from plants, such as the presence of anti-nutritional factors and varying amino acid contents, have been minimised through the use of a variety of techniques. Numerous research has examined the efficacy of herbal supplements in fish feed for preventing fish diseases and producing healthy fish. The research supports the use of herbs and herbal supplements as food additives for well-nourished fish.

Plant bioactive compounds may be a potential source of sex reversal agents, innovative pharmaceuticals, and pharmacological substances for enhancing fish production, health, and food safety and quality (70). The majority of phytochemicals, according to Ghosal *et al.*, (71), are redox active substances that can operate as H^+ donors, reducing agents, OH^- radical or superoxide radical scavengers, metallic chelators, lipid peroxidation modulators, and reducers of H_2O_2/$FeCl_2$-induced DNA damage. Such antioxidant activities may enhance immunological factors, indirectly raise tolerance to various stressors, improve

overall physiological health, and provide fish with the greatest potential health and nutritional outcomes (73, 74).According to Egerton *et al.*, significant problem for the aquaculture sector is developing cost-effective, sustainable diets that enhance fish welfare and growth potential. Furthermore, it is acknowledged that fish must be taken into account when making dietary modifications since fish gut microbiota has a substantial influence on fish health and growth. Some promising recent research suggests that future diets with extremely little or no fishmeal inclusion may be viable with proper design. However, it has been suggested that a minimum of 5% fishmeal is required to provide yet-to-be-identified growth factors, which are thought to include naturally occurring trace and ultra-trace chemicals such amines and steroids. (75).

Monosex growth and immunological health after being fed solvent extracts of the four plants *Basella alba*, *Tribulus terrestris*, *Mucuna pruriens*, and *Asparagus racemosus*, Nile tilapia were observed for 30 days. The feeds considerably outperformed the control in terms of growth rate. Higher levels of Growth Hormone, Insulin like Growth Factor-1, and 11-Ketotestosterone, immunostimulatory action, haematological, anti-oxidant, and hepato-protective activity. The abundance of secondary metabolites in plant extracts may be responsible for their capacity to promote growth, good health, and immune stimulation. In comparison to the other two plant materials, they were more powerful in promoting growth, immune-stimulation, and adaptogenic capacity (74).

Hence, Herbal feed additives promote fish development, lower stress, strengthen immunity, and guard against infections, all of which help to produce healthy fish fit for human consumption. In comparison to the control group, supplementation with medicinal herbs considerably boosted weight gain, specific growth rates, and protein efficiency ratio. The therapeutic plant additions had little effect on the carcass composition, and some of them barely registered. Based on current findings, as well as the cheap cost and growth effect of fish fed with herbal plants, it is advised that herbal plants be utilised in fish feed to reduce pathogen-related mortality.

3. Conclusion

As a result, various plant leaves are employed as protein sources in fish feed formulations, with the majority of them serving as a partial replacement for fish meal. Plant protein sources are sustainable, environmentally benign, and cost-effective in the feed sector.

4. Future Scope

Such study will be a pioneer to various researchers to understand the alternatives to prepare various fish feed formulations incorporating plant materials that in turn will have nil adverse effects on the fish body as well as humans who consume them rather than administration of various drugs to have a sustained aquacultural practice.

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