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Sustainable Fish Farming through Plant-derived Feed Additives

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Abstract

Aquaculture is a rapidly expanding field. To reach global protein demand it needs sustainable and efficient methods to enhance fish growth and immunity. The use of synthetic hormones and antibiotics have raised a concern about residue, resistance and environmental impact and also to find natural alternatives. This review explains the use of medicinal plants and phytochemicals as natural growth hormone enhancers and immunostimulants in aquaculture. This study of peer-reviewed sources explains the use of natural sources and their impact on bioactive mechanisms, efficacy and species-specific response for integrating herbal feed additives into aquaculture.

Keywords*: Aquaculture, Medicinal plants, Growth.*

Introduction

Aquaculture is an essential field that supplies the world with protein-rich food, but the industry is under mounting pressure to adopt sustainable and environmentally friendly methods. Synthetic growth promoters and antibiotics are traditionally used to boost production. This raises a serious concern about chemical residues, the development of antimicrobial resistance, and harm to ecosystems. This leads to the necessity in natural alternatives, especially the medicinal plants, as feed additives. The bioactive constituents of medicinal plants reported to improve growth performance and immunity in fish via various biological pathways are saponins, flavonoids, tannins, and essential oils. They help to improve feed utilization, stimulation of digestive enzymes, modulation of endocrine pathways, especially growth hormone and insulin-like growth factor signaling, and enhancement of innate and adaptive immune responses. Based on an analysis of twenty-seven peer-reviewed studies, this paper highlights the potential of medicinal plants as natural growth promoters and immunostimulants for promoting sustainable aquaculture.

Medicinal Plants as Growth Promoters

Phytochemical-Based Growth Enhancement

Saponins, flavonoids, tannins, and essential oils are the major phytochemicals found in medicinal plants. They are very important for promoting fish growth by regulating physiological and hormonal pathways, particularly pathways associated with growth hormone (GH) and insulin-like growth factors (IGFs). They also exhibit anabolic effects by regulating the endocrine system (Chakraborty *et al.*, 2014; Faheem *et al.*, 2022). In a study, *Quillaja* saponins have been shown to significantly enhance growth in various fish species by improving protein synthesis and nutrient absorption (Francis *et al.*, 2005). Similarly, a study on *Oreochromis mossambicus* shows that the curcumin, a polyphenolic compound from *Curcuma longa*, stimulates the expression of GH, IGF-1, and IGF-2 genes. It leads to better digestion, improved feed conversion efficiency, and overall growth performance (Midhun *et al.*, 2016).

Hormonal and Reproductive Effects

Several medicinal plants have direct effect on hypothalamic-pituitary-gonadal (HPG) axis and reproduction. They influence and regulate the secretion of gonadotropins and sex steroids that affects fish growth. These hormonal effects influence both growth and reproductive physiology, making such plants valuable tools for selective breeding and sex reversal in aquaculture. A study on *Tribulus terrestris* is an Androgenic herb, showed that it is rich in steroidal saponins. The use of this stimulates testosterone production, leading to enhanced secondary sexual characteristics and gonadal development (Mansour *et al.*, 2018). Studies on supplements of *Tribulus terrestris* fed to *Oreochromis niloticus* showed elevated testosterone levels, increased sperm motility, and improved feed utilization efficiency an indication of endocrine modulation (Xu *et al.*, 2015; Mansour *et al.*, 2018). Furthermore, 17α-methyltestosterone, a synthetic androgen used for sex reversal in aquaculture, has alternative herbal extracts with capacity to induce male traits. A study on herbal formulations containing *Mucuna pruriens*, *Withania somnifera*, and *Tribulus terrestris* have been shown to increase sex reversal rates in tilapia and zebrafish,

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acts as an alternative for synthetic androgens like 17α-methyltestosterone (Chakraborty *et al*., 2014; Xu *et al*., 2015). These results focus on the potential of herbal sources as safe and environmentally friendly alternatives for promoting growth and regulating reproduction in aquaculture.

Immune Enhancement and Disease Resistance

Apart from their growth-promoting effects, medicinal plants contribute to the enhancement of fish immune defenses, including both innate and adaptive mechanisms. Medicinal plants have a great effect on the immune system of fish including both innate and adaptive mechanisms. They contribute to enhancing fish immune defences. Some plants contain diverse bioactive compounds such as allicin, cinnamaldehyde, and gingerols. They act as immunostimulants that implement antioxidant, anti-inflammatory, and antimicrobial activities (Van Hai, 2015; Dawood *et al*., 2018). The Cinnamaldehyde and Eugenol are bioactive compounds found in Cinnamon (*Cinnamomum verum*) introduced into the diets of *Ctenopharyngodon idella* and *Oreochromis niloticus* have been shown to enhance phagocytic activity, lysozyme levels, and serum immunoglobulin concentration. It has been reported to improve resistance to bacterial infections and reduce oxidative stress (Ghafoor, 2020). Allicin is a sulfur rich compound found in Garlic (*Allium sativum*), which is shown to stimulate macrophage activity, regulate cytokine expression, and promote leukocyte proliferation. It is responsible for enhancing the fish's ability to combat pathogens and recover from infections (Hassan *et al*., 2018). An antioxidant compound found in ginger (*Zingiber officinale*), neutralizes reactive oxygen species (ROS), involved in tissue repair and immune function during disease outbreaks. A study revealed that the ginger supplementation improves resistance against *Aeromonas hydrophila* and *Streptococcus* species in fish and increases survival rates (Dawood *et al*., 2022). These alternatives improve stress tolerance, enhance immunity and reduce disease risk supporting sustainable aquaculture health management.

Mechanisms of Action

Digestive and Metabolic Stimulation

Some medicinal plants are responsible for improving digestive and metabolic performance in fish. They enhance production of digestive enzyme secretions, promote nutrient absorption and improve feed uptake. These benefits directly increase the growth performance and overall health of the fish. In a study with dietary addition of *Malva parviflora* in *Oreochromis niloticus* showed significant increase in activity of amylase, lipase, and protease. It facilitates the digestion of carbohydrates, fats, and proteins (Abdel Rahman *et al*., 2024). This leads to higher feed conversion ratios (FCR) and enhances better nutrient uptake, supporting weight gain and growth. Similarly, some essential oils and polyphenolic compounds present in *Salvia officinalis* (sage) have been known to promote gastrointestinal health by stimulating bile secretion and enzyme production. The sage-supplemented diets lead to improved digestive performance. It is also responsible for enhancing gut morphology and increased nutrient uptake (Salomón *et al*., 2020). These herbs have antioxidant and anti-inflammatory properties. They help to maintain intestinal integrity. They minimize the oxidative damage caused to digestive tissues. They also support a healthy gut environment and increase metabolic capability (Tadese *et al*., 2022). The use of such herbs into fish diets not only improves digestion and growth but also reduces feed waste, contributing to both economic and environmental resilience in aquaculture.

Endocrine Modulation

Medicinal plants show significant effects on endocrine functions in fish by enhancing endogenous hormone activity, particularly within the growth hormone (GH)–insulin-like growth factor (IGF) axis, which plays a central role in balancing somatic growth, metabolism, and tissue development. Bioactive phytochemicals, including curcumin, saponins, and flavonoids, have been shown to interact with hormone receptors or control the expression of genes involved in endocrine pathways. A notable example is Curcumin, a compound from *Curcuma longa*, which has been reported to upregulate GH, IGF-1, and IGF-2 gene expression in *Oreochromis mossambicus*. This regulation improves growth performance and feed efficiency by enhancing protein synthesis and nutrient utilization (Midhun *et al*., 2016). Additionally, other phytogenic compounds can act as hormone stimulators or enhancers, binding to receptors or influencing signaling pathways related to growth promotion. For example, certain saponins affect endocrine function by stimulating the pituitary gland, leading to increased GH secretion (Francis *et al*., 2005; Chakraborty *et al*., 2014). Although these effects vary depending on species and dosage, plant-derived compounds present a promising and sustainable alternative to synthetic hormones for promoting growth in aquaculture.

Species-Specific Responses

The different species of fish exhibit unique physiological responses to the same phytochemicals. They have variations in metabolism, digestive systems, and receptor sensitivity. Therefore, it is very important to study that how bioactive compounds interact with the biology of specific species is crucial for optimizing feed formulations. For example, *Oreochromis niloticus* has demonstrated notable improvements in growth performance, immune function, and oxidative status when fed diets supplemented with cinnamon (*Cinnamomum verum*) and curcumin (*Curcuma longa*). These additives improved digestive enzyme activity, immune parameters, and resistance to bacterial infections (Midhun *et al*., 2016; Ghafoor, 2020). In contrast, *Sparus aurata* (gilthead seabream) responded more effectively to *Salvia officinalis* (sage) and *Lippia citriodora* (lemon verbena), showing improvements in feed intake, digestive function, and immune gene expression (Salomón et al., 2020). The study revealed the differences in herbal treatments based on species specific nutritional and physiological profiles. It is important to concentrate on the modified and optimal dosage and combination of herbs. Excessive use of certain phytochemicals may lead to reduced palatability, toxicity, or metabolic burden in sensitive species (Tadese *et al*., 2022). Therefore, more accurate and detailed research is needed for species-specific response and synergistic herb combinations. It is very important as they have a long term impact on health and productivity.

Comparative Effectiveness and Synergies

The medicinal plant species have some common and some rare bioactive compounds. Although they exhibit promising bioactivities, the more effective results are seen by combining multiple herbs. They show collaborative effects on growth and immune responses than single-herb supplements. Some combinations of diverse phytochemicals such as polyphenols, saponins, alkaloids, and essential oils can together target multiple physiological pathways. A study of dietary combination of turmeric (*Curcuma longa*), fenugreek (*Trigonella foenum-graecum*), and black cumin (*Nigella sativa*) demonstrated superior performance in fish compared to individual herbs. It leads to significant improvements in weight gain, feed conversion ratio (FCR). It also enhances antibacterial effect and antioxidant enzyme levels causing better growth (Barad *et al*., 2024). These results state that combining herbs has more effective multi-functional benefits. Altogether they enhance nutrient digestion, regulates and balances hormonal pathways, and interaction with receptors. Also responsible for improving innate immunity. The multi-herb formulations are more

effective at lower doses. They reduce the risk of inducing toxicity and improved palatability of feed (Sahoo *et al*., 2024). This strategy supports unified aquaculture by using natural additives to enhance fish welfare and reduce synthetic use.

Conclusion

Medicinal plants and their phytochemicals provide a sustainable and effective approach to enhance growth, immunity, and productivity in aquaculture. There are some challenges including standardization of extracts and dosages, variability in plant phytochemical composition based on origin and processing. While existing research is reliable and promising, more standardized, species-specific, and long-term studies are necessary to integrate these solutions into commercial systems. Advancements in omics technologies and precision aquaculture may help optimize herbal additive use.

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Conflicts of interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

References

1. **Abdel Rahman, A. N., Reyad, Y. A., Elshopakey, G. E., Younis, E. M., Abdelwarith, A. A., EL-Mageed, N. A., Kishta, A. A., Yaseen, A., Davies, S. J., & Ibrahim, R. E. (2024).** Efficacy of the dietary *Malva parviflora* leaves in modulating immune-antioxidant functions, resistance to *Candida albicans* and *Streptococcus agalactiae* infection, digestive/absorptive capacity, and growth of Nile tilapia (*Oreochromis niloticus*). *Aquaculture International*, *32*(6), 8229–8247.
2. **Asimi, O. A., & Sahu, N. P. (2013).** Herbs/spices as feed additive in aquaculture. *Scientific Journal of Pure and Applied Sciences*, *2*(8), 284–292.
3. **Barad, R. R., Verma, D. K., Yusufzai, S. I., Shrivastava, V., & Ram, A. R. (2024).** Herbal feed additives: Natural boost for aquatic health and growth. In *Sustainable Feed Ingredients and Additives for Aquaculture Farming: Perspectives from Africa and Asia* (pp. 405–431).
4. **Chakraborty, S. B., Horn, P., & Hancz, C. (2014).** Application of phytochemicals as growth-promoters and endocrine modulators in fish culture. *Reviews in Aquaculture*, *6*(1), 1–19.
5. **Dadras, F., Velisek, J., & Zuskova, E. (2023).** An update about beneficial effects of medicinal plants in aquaculture: A review. *Veterinární Medicína*, *68*(12), 449.
6. **Dawood, M. A. O.; El Basuini, M. F.; Yilmaz, S.; Abdel-Latif, H. M. R.; Alagawany, M.; Abdul Razab, M. K. A.; Hamid, N. K. A.; Moonmanee, T.; Van Doan, H. (2022).** Exploring the roles of dietary herbal essential oils in aquaculture: A review. *Animals*, *12*(7), 823.
7. **Dawood, M. A., Koshio, S., & Esteban, M. Á. (2018).** Beneficial roles of feed additives as immunostimulants in aquaculture: A review. *Reviews in Aquaculture*, *10*(4), 950–974.
8. **Emeka, U., Iloegbunam, N. G., Gbekele-Oluwa, A. R., & Bola, M. (2014).** Natural products and aquaculture development. *IOSR Journal of Pharmacy and Biological Sciences*, *9*(2), 70–82.
9. **Francis, G., Makkar, H. P., & Becker, K. (2005).** *Quillaja* saponins—A natural growth promoter for fish. *Animal Feed Science and Technology*, *121*(1–2), 147–157.
10. **Ghafoor, F. (2020).** Importance of herbs in aquaculture; Cinnamon a potent enhancer of growth and immunity in fish, *Ctenopharyngodon idella*. *Sustainable Aquaculture and Health Management Journal*, *6*(1), 78–92.
11. **Hassan, A. A. M., Yacout, M. H., Khalel, M. S., Hafsa, S. H. A., Ibrahim, M. A. R., Mocuta, D. N., & Dediu, L. (2018).** Effects of some herbal plant supplements on growth performance and the immune response in Nile tilapia (*Oreochromis niloticus*). *Sciendo*, *1*, 134–141.
12. **Hodar, A. R., Vasava, R. J., Mahavadiya, D. R., Joshi, N. H., Nandaniya, V. V., & Solanki, H. K. (2021).** Herbs and herbal medicines: A prominent source for sustainable aquaculture. *Journal of Experimental Zoology India*, *24*(1), 719–732.
13. **Immanuel, G., Uma, R. P., Iyapparaj, P., Citarasu, T., Peter, S. M. P., Babu, M. M., & Palavesam, A. (2009).** Dietary medicinal plant extracts improve growth, immune activity and survival of tilapia *Oreochromis mossambicus*. *Journal of Fish Biology*, *74*(7), 1462–1475.
14. **Makkar, H. P. S., Francis, G., & Becker, K. (2007).** Bioactivity of phytochemicals in some lesser-known plants and their effects and potential applications in livestock and aquaculture production systems. *Animal*, *1*(9), 1371–1391.
15. **Mansour, A. T., Omar, E. A., Srour, T. M., & Yousef, M. I. (2018).** Effect of three natural phytochemicals supplementation on growth performance, testosterone level and feed utilization of Nile tilapia (*Oreochromis niloticus*). *Aquaculture Nutrition*, *24*(1), 408–415.
16. **Mbokane, E. M., & Moyo, N. A. G. (2022).** Use of medicinal plants as feed additives in the diets of Mozambique tilapia (*Oreochromis mossambicus*) and the African sharptooth catfish (*Clarias gariepinus*) in Southern Africa. *Frontiers in Veterinary Science*, *9*, 1072369.
17. **Midhun, S. J., Arun, D., Edatt, L., Sruthi, M. V., Thushara, V. V., Oommen, O. V., Sameer Kumar, V. B.; Divya, L. (2016).** Modulation of digestive enzymes, GH, IGF-1 and IGF-2 genes in the teleost, tilapia (*Oreochromis mossambicus*) by dietary curcumin. *Aquaculture International*, *24*(5), 1277–1286.

18. **Ogunkalu, O. (2019).** Effects of feed additives in fish feed for improvement of aquaculture. *Eurasian Journal of Food Science and Technology*, *3*(2), 49–57.
19. **Orso, G., Imperatore, R., Coccia, E., Ashouri, G., & Paolucci, M. (2022).** Lamiaceae as feed additives in fish aquaculture. *Fishes*, *7*(6), 349.
20. **Reverter, M., Tapissier-Bontemps, N., Sasal, P., & Saulnier, D. (2017).** Use of medicinal plants in aquaculture. In *Diagnosis and Control of Diseases of Fish and Shellfish* (pp. 223–261).
21. **Sahoo, P., Samanta, S., Bhanja, A., Payra, P., Upadhyay, A. K., Gupta, S., & Kumar, P. (2024).** Exploring the potential of medicinal herbs in sustainable aquaculture practices (Chapter 8, pp. 105–124). In *Sustainable Aquaculture: A Step Towards a Green Future in Fish Farming*.
22. **Salomón, R., Firmino, J. P., Reyes-López, F. E., Andree, K. B., González-Silvera, D., Esteban, M. A., Tort, L., Quintela, J. C., Pinilla-Rosas, J. M., Vallejos-Vidal, E., & Gisbert, E. (2020).** The growth promoting and immunomodulatory effects of a medicinal plant leaf extract obtained from *Salvia officinalis* and *Lippia citriodora* in gilthead seabream (*Sparus aurata*). *Aquaculture*, *524*, 735291.
23. **Sumana, S. L., Xue, T., Hu, H., Abdullateef, M. M., Shui, Y., Ayana, G. U., Kayiira, J. C.; Zhang, C.; Samwel, B. J.; Zhu, J.; Su, S.; Ebenezer, A.; Simbo, E. B. S.; & Xiaojun, J. (2025).** Medicinal plants as ecological solutions for fish growth and immunostimulatory effects in aquaculture. *Aquaculture Research*, *2025*(1), 9778623.
24. **Tadese, D. A., Song, C., Sun, C., Liu, B., Zhou, Q.; Xu, P.; Ge, X.; Liu, M.; Xu, X.; Tamiru, M.; Zhou, Z.; Lakew, A.; & Ngoepe, T. K. (2022).**The role of currently used medicinal plants in aquaculture and their action mechanisms: A review. *Reviews in Aquaculture*, *14*(2), 816–847.
25. **Tonsy, H., Mahmoud, S., Labib, E., & Zaki, M. (2011).** Effect of some medicinal plants diets on the mono-sex Nile tilapia (*Oreochromis niloticus*), growth performance, feed utilization and some physiological parameters. *Egyptian Journal of Aquatic Biology and Fisheries*, *15*(2), 53–72.
26. **Van Hai, N. (2015).** The use of medicinal plants as immunostimulants in aquaculture: A review. *Aquaculture*, *446*, 88–96.
27. **Xu, P., Kpundeh, M. D., Qiang, J., & Gabriel, N. N. (2015).** Use of herbal extracts for controlling reproduction in tilapia culture: Trends and prospects—A review. *Israeli Journal of Aquaculture–Bamidgeh*, *67*.