Lemongrass (Cymbopogon citratus) as a Phytogenic Feed Additive in Aquaculture: Effects on Growth Performance, Feed Utilization, Immunity, and Disease Resistance

Siddhartha Mehrotra[1], Dr. Gauri Saxena[2*]

[1]Research Scholar, Department of Botany, University of Lucknow, siddharthamehrotra10@gmail.com, 0009-0009-1515-4495

[2*]Professor, Department of Botany, University of Lucknow, gaurigupta72@yahoo.com, 0000-0003-2235-2755

Abstract:
Intensive aquaculture systems have increased production but also raised concerns about disease pressure, stress, and the consequences of prolonged antibiotic and synthetic growth-promoter use. Plant-based feed additives offer one practical route toward more sustainable practices. Lemongrass (Cymbopogon citratus), long valued in traditional medicine and cuisine, contains citral and related compounds that display antimicrobial, antioxidant and immunomodulatory activity. This review draws together experimental findings published up to 2022 on the dietary use of lemongrass leaf powder, aqueous extracts and essential oil in cultured fish. Across tilapia, African catfish and tambaqui, moderate inclusion levels have frequently improved weight gain, specific growth rate and feed conversion, while supporting selected haematological and innate-immune parameters and, in several challenge trials, reducing mortality after bacterial infection. Effective doses generally fall in the range of 0.25–0.50 ml kg^{-1} for essential oil and 2–10 g kg^{-1} for leaf powder, although species and product form influence the optimum. Safety appears acceptable within the tested ranges. Remaining gaps include longer-term commercial trials, wider species coverage and clearer mechanistic understanding. Overall, the pre-2023 literature indicates that lemongrass is a low-cost candidate phytogenic additive capable of contributing to growth, health and reduced reliance on conventional chemotherapeutic agents.

Key words: Cymbopogon citratus, lemongrass, phytogenic additive, aquaculture nutrition, growth, immunity, tilapia, Clarias gariepinus

Introduction

Aquaculture now supplies a substantial share of the world's aquatic food. Expansion has brought denser stocking, formulated feeds and greater control over the rearing environment, yet these changes have also intensified physiological stress and the risk of infectious disease. For many years antibiotics and synthetic growth promoters were employed routinely; the resulting problems of resistance, tissue residues and environmental contamination have prompted both regulatory restrictions and a search for alternatives.

Phytogenic additives—preparations derived from herbs, spices or medicinal plants—have received increasing attention because they can influence growth, gut function, oxidative status and non-specific immunity through a variety of secondary metabolites. Among the plants examined, lemongrass (Cymbopogon citratus Stapf) stands out for its wide cultivation, modest cost and well-documented biological properties. The species is a perennial tropical grass whose leaves yield an essential oil rich in citral. Traditional uses for digestive and febrile conditions have been supplemented by modern studies confirming antibacterial, antifungal and antioxidant actions.

By the end of 2022 a series of controlled feeding trials had evaluated dried leaf material, aqueous extracts and essential oil in several warm-water fish. The present review summarises those findings with particular attention to growth, feed efficiency, haematology, immune markers and resistance to experimental infection. Practical dosage ranges and remaining research needs are also considered.

2.Botanical background and chemical constituents

Cymbopogon citratus belongs to the grass family Poaceae. It forms dense clumps of long, aromatic leaves and is harvested mainly for steam-distilled essential oil or for direct use of the dried foliage. Citral (the mixture of neral and geranial) normally accounts for the largest fraction of the oil, frequently 40–70 %, accompanied by geraniol, nerol, limonene and smaller amounts of other monoterpenes. Leaf powders and aqueous extracts contain residual volatiles together with flavonoids and other polar constituents.Citral disrupts bacterial membranes and interferes with energy metabolism, explaining much of the observed antimicrobial activity against aquaculture pathogens such as Aeromonas hydrophila. Antioxidant effects arise both from direct radical scavenging and from stimulation of endogenous enzyme systems. These properties provide a rational basis for exploring lemongrass as a functional feed ingredient.

3.Influence on growth performance and feed utilisation

Most trials conducted before 2023 reported positive growth responses when lemongrass was included at moderate levels. In Nile tilapia, dietary essential oil at 200 or 400 mg kg^{-1} for twelve weeks improved final weight, specific growth rate and feed utilisation relative to an unsupplemented control (Al-Sagheer et al., 2018). Similar trends appeared with higher oil inclusions in other tilapia studies (Brum et al., 2017; Saccol et al., 2018).African catfish (Clarias gariepinus) responded well to leaf meal or powder. Inclusion rates between 5 and 10 g kg^{-1} commonly increased weight gain and specific growth rate while lowering or maintaining feed conversion ratio (Dada, 2015; Adeniyi et al., 2017; Adebayo et al., 2018). One economic assessment indicated a more favourable benefit–cost ratio at the higher end of the effective range.In tambaqui (Colossoma macropomum), essential oil at 0.25 or 0.50 ml kg^{-1} produced measurable gains in weight over a 60-day period, accompanied by elevated intestinal protease activity (Copatti et al., 2022).

Improvements in feed efficiency have been linked to greater digestive-enzyme activity, modest changes in gut morphology and, in some cases, reduced metabolic stress. Dose–response curves frequently show an optimum beyond which further increases yield little additional benefit or even slight declines, underscoring the need for careful calibration.

4.Haematological, immune and antioxidant responses

Haematological values in lemongrass-fed fish have generally remained within normal ranges or shown modest positive shifts. Red-cell counts, haemoglobin and haematocrit tended to be stable or slightly elevated, indicating absence of toxicity and possible support of oxygen transport. White-cell responses varied; some trials recorded higher counts consistent with immune activation, while others observed lower values that authors interpreted as reduced infectious or stress burden.Innate immune markers frequently improved. Lysozyme activity and total immunoglobulin levels rose in tilapia receiving essential oil (Al-Sagheer et al., 2018). Antioxidant enzymes such as superoxide dismutase and catalase increased, while lipid-peroxidation markers declined in several studies (Brum et al., 2018; Saccol et al., 2018). These changes suggest that lemongrass can help maintain redox balance under the oxidative load typical of intensive culture.Collectively the pre-2023 data portray lemongrass as a mild immunomodulator and antioxidant rather than a potent pharmacological agent, a profile compatible with continuous dietary use.

5.Resistance to experimental infection

Challenge trials provide the most direct evidence of health benefit. Nile tilapia fed lemongrass essential oil or combinations containing the oil showed higher survival and fewer tissue lesions after Aeromonas hydrophila infection (Brum et al., 2017; Al-Sagheer et al., 2018). African catfish receiving leaf powder exhibited improved survival when subsequently challenged with Aeromonas salmonicida (Adebayo et al., 2018).In tambaqui the essential-oil treatments improved pre-challenge health indicators, although post-challenge survival differences were not always statistically significant (Copatti et al., 2022).

In-vitro assays have confirmed inhibitory activity of lemongrass oil and extracts against several fish-pathogenic bacteria, reinforcing the biological plausibility of the in-vivo results. Protection appears more consistent when the additive is supplied prophylactically at growth-promoting doses than when it is used as a sole therapeutic measure during acute outbreaks.

6.Practical dosage ranges and formulation notes

Synthesis of the available trials suggests the following approximate working ranges (subject to product composition and species):

- **Essential oil:** 0.25–0.50 ml kg^{-1} diet for tambaqui; 200–400 mg kg^{-1} for tilapia.
- **Leaf powder or meal**: 5–10 g kg^{-1} for African catfish, with some benefit recorded at lower levels.

Essential-oil components are volatile; losses during pelleting can be reduced by encapsulation or late-stage addition. Leaf powders are simpler to prepare in regions where the plant grows abundantly and may therefore suit small- and medium-scale producers. Palatability remains acceptable at the effective doses reported.

7.Safety considerations

Within the inclusion levels tested up to 2022, survival, organ indices and routine haematology showed no consistent adverse trends. Occasional improvements in these parameters further support safety. Residue data specific to fish were still limited by the end of 2022, yet the rapid metabolism of monoterpenes in vertebrates suggests low risk of accumulation in edible tissues under normal feeding periods.

8.Limitations and research needs

Most studies available by 2022 were short-term (4–12 weeks) and performed under controlled laboratory or semi-intensive conditions. Commercial-scale, long-duration trials remained scarce. Species diversity was narrow, with heavy emphasis on tilapia and African catfish. Standardisation of citral content and extraction methods was incomplete, complicating dose translation between laboratories. Mechanistic work on gut microbiota, precise molecular pathways and interactions with other feed components was only beginning.Future investigations should therefore prioritise multi-site

field trials, broader species coverage, product standardisation, economic analyses and combined use with probiotics or other phytogenics.

9.Conclusions

Experimental evidence published up to 2022 indicates that dietary lemongrass (Cymbopogon citratus), whether supplied as leaf powder, aqueous extract or essential oil, can improve growth performance and feed efficiency, support haematological and innate-immune parameters, enhance antioxidant status and contribute to greater resistance against bacterial challenge in several important aquaculture species. Effective doses are moderate and the safety margin appears adequate. Because the plant is inexpensive and widely available, it constitutes a realistic option for reducing dependence on antibiotics and synthetic growth promoters. Continued work to refine dosages, confirm long-term commercial performance and clarify mechanisms will strengthen the basis for routine use.

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