

**Curcumin effects on biological properties of
freshwater catfish *Heteropneustes fossilis*
(Bloch 1794)**

A Summary of the Thesis Submitted to the
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SUMMARY

Aquaculture, or the farming of fish and other aquatic organisms, is an important industry that provides food, income, and employment opportunities to millions of people worldwide. However, human activities may have a significant impact on fish and other aquatic organisms in aquaculture systems.

One major side effect of human activities on fish in aquaculture is the degradation of water quality. Pollution from agricultural runoff, industrial discharges, and municipal sewages can result in an increased level of chemicals and other contaminants in the water, which can allow the growth of harmful algae and other organisms. This makes fish stressed, leading to decreased growth rates, increased susceptibility to disease, and even death. The concept of replacing drugs with herbs and their metabolites to treat and prevent diseases. This approach has been used for thousands of years in traditional medicine systems such as Ayurveda, Chinese medicine, and Native American medicine. Herbs have been found to contain bioactive compounds that have medicinal properties, and they may be used as an alternative to synthetic drugs in the management of various conditions such as pain, inflammation, anxiety, depression, and hypertension.

The use of herbs as a replacement for drugs has gained popularity in recent times due to concerns about the safety and side effects of pharmaceutical drugs, as well as the high cost of healthcare. Turmeric, a tropical herb belonging to the Zingiberaceae family, has been used for its medicinal properties for centuries. Curcumin, a polyphenolic compound found in the turmeric plant, has been shown to have various beneficial effects on both humans and animals, including promoting growth,

stimulating the immune system, and reducing inflammation. Similarly, pyrimidine has a special position as a pharmaceutical compound and is used to heal so many diseases. But these medicinally important bio-compounds have their restrictions and limitations. Sometimes hybrid synthesis of valuable bio-compounds bypasses their limitations due to changes in their structural and chemical properties and may show additive effects. But this is a matter of invention, exploration, and screening in the target groups.

In aquaculture, *Heteropneustes fossilis* is highly valued for its flavour, nutrients, and medicinal benefits and is ideal for aquaculture due to its ability to breathe air and survive in low-oxygen water. Despite extensive research on *H. fossilis*, the bioremediation of curcumin in fish by the effects of environmental pollutants is still being explored. This study aims to address this gap by proposing strategies for reducing the harmful effects of pollutants and developing hybrid compounds using curcumin and pyrimidine derivatives to overcome the physical and chemical limitations of curcumin. This research is presented in thesis form with an introduction, three chapters, and a summary, with references provided at the end to avoid repetition.

Chapter1

Effect of curcumin medium in freshwater catfish, *Heteropneustes fossilis*

To support sustainability and resilience, there is a rising trend toward the use of safe, alternative components in aqua feed. One such compound being studied for its nutritional value, immune-stimulating, anti-oxidant, and growth-promoting qualities is curcumin. An experiment was conducted using different concentrations of curcumin to determine the optimal concentration for improving fish health, stress condition, nutritional value, and immunity in adult *H. fossilis*. The results showed that a mild

dose of curcumin (10 µg/mL) was the most beneficial concentration; after that, the experiment was conducted for short (1, 5 days) and long (21 days) duration study, as well as a post-treatment clearance effect for a 7-day recovery period. The results showed that a mild dose of curcumin (10 µg/mL) with a durational study led to the greatest improvement in their overall health. Curcumin acted on stress management by controlling catalase, peroxides, and lipid peroxidase activities, and improved internal tissue helped in maximum nutrient assimilation. Some haematological indices increased while others decreased significantly after curcumin treatment, and immunity parameters showed mixed results, with one-week post-treatment suggesting poor maintenance of the curcumin response towards health and immunity. In conclusion, using curcumin medium in catfish can help reduce poor water quality hazards and improve the fish's nutrient value for consumers, considering anthropological activities that have compromised natural water body conditions.

Chapter 2

Bio-screening of pyrimidine in freshwater catfish, *Heteropneustes fossilis*

Pyrimidine is a distinctive heterocyclic compound that plays a crucial role as a genetic biomolecule in cells and exhibits a diverse range of biological activities, making it a promising tool for environmentally friendly disease treatment and economic efficiency in aquaculture. One such compound, 4,6-dimethyl-2-hydroxypyrimidine hydrochloride, was studied for its effects on the immune parameters of a freshwater catfish, *H. fossilis*. Adult fish were administered various doses (10 fg/mL - 1 mg/mL) and durations (1, 5, and 21 days), along with a control group. Their blood parameters were examined. The results showed that 4,6-dimethyl-2-hydroxypyrimidine hydrochloride (10 pg/mL) enhanced fish health by regulating their immune response, as evidenced by higher levels of red blood cells and haemoglobin. The ideal

concentration of the compound was found to have a positive effect during a one-day treatment period. Further research indicates that the compound significantly increases antioxidant activity (catalase, peroxidase, and lipid peroxidase levels), enhances tissue health (histotexture of vital organs), and improves the internal structure of the fish in a time-dependent manner. Internal tissue strengthening enhanced nutrition absorption (proteins, carbohydrates, and lipids). This suggests that treatment with 4, 6-dimethyl-2-hydroxypyrimidine hydrochloride can help enhance fish health and improve their nutritional value indirectly.

Chapter 3

Bio-screening of curcuminoid hybrid compound in freshwater catfish, *Heteropneustes fossilis*

Anthropogenic activity has caused natural water sources to deteriorate, which is harming aquatic organisms. Pyrimidine and curcumin have the potential to be cost-effective and environmentally friendly disease treatments. In this study, arylvinylpyrimidine was tested on catfish at different concentrations (1 pg/mL - 1 mg/mL) to determine the most effective concentration. An effective concentration of arylvinylpyrimidine (0.1 µg/mL) was then tested for various durations (1, 5, and 21 days), followed by a one-week recovery period, along with the control media. Treatment with arylvinylpyrimidine improved tissue health, increased oxidative activity, and increased nutrient uptake. Certain haematological parameters also increased, while MPO activity and NBT were reduced. Overall, treatment with arylvinylpyrimidine could help mitigate the risks associated with poor water quality and improve the health of aquatic species.

Overall summary of all chapters

- Organic compounds are extremely beneficial, but they may have their limitations.
- Limitations can be overcome by searching for effective combinations of biomolecules.
- Green hybrid molecules will provide an eco-friendly, metabolizable, nonlethal biomolecule as a curcuminoid hybrid compound of current study immersed as nutraceuticals and an immunity booster for catfish, *H. fossilis*.

Thus, the present research aims to understand how curcumin and pyrimidine benefit *H. fossilis*. The amounts of anti-oxidant enzymes, the biochemical composition, and the histo-architecture of tissues were shown to change in *H. fossilis* in response to monomolecule. These are the important parameters to assess the level of general defence mechanisms and metabolic rate of fish. Fish are an excellent bio-indicator for determining the state of aquatic ecosystem health. Nevertheless, the use of antioxidants such as curcumin and the pyrimidine derivative chemical (4,6-dimethyl-2-hydroxypyrimidine hydrochloride) might lessen the damaging effects of the pollutant. In the last chapter, a novel hybrid arylvinylpyrimidine molecule (a hybrid of curcumin and a pyrimidine derivative) was determined to have the most potent antioxidant action in fish and to improve fish health by having a synergistic impact. Results encourage organic hybrid synthesis to overcome monomer limitations and also support their synergic effects. That may be the eco-friendly, economic, and metabolizable approach to fighting several environmental threats.