

supplementation resulted in higher white blood cell and neutrophil counts, indicating a stronger stimulation of innate immune responses. Although the effects of ginger were less pronounced, the blood parameters remained within normal physiological ranges, suggesting that the additive supported normal body functions without adverse effects.

An important finding of this study is that the three phyto-genic supplements did not produce identical responses. Garlic showed greater influence on erythrocytic parameters, whereas neem exerted stronger effects on immune-related indices. These differences highlight the diverse biological roles of herbal feed additives and suggest that their use can be tailored to specific production goals, whether improving physiological performance, enhancing immunity, or promoting overall fish health.

The results also emphasize the importance of evaluating dietary interventions beyond growth performance alone. The relationship observed between dietary quality and haematological responses suggests that nutritional status and physiological wellbeing are closely linked. Consequently, blood-based indicators provide additional information that complements conventional growth measurements and contributes to a more comprehensive assessment of fish welfare.

Overall, the findings indicate that garlic, ginger, and neem have considerable potential as functional feed additives in African catfish culture. Their ability to support physiological condition and immune function without reliance on synthetic chemotherapeutic agents highlights their value in sustainable and environmentally responsible aquaculture practices.

The findings demonstrate the complementary physiological roles of garlic, ginger, and neem as phyto-genic feed additives, supporting their application in sustainable African catfish production. Future research should optimise dietary inclusion levels, evaluate combined herbal formulations, and integrate biochemical, molecular, and commercial performance indicators under long-term farming conditions to strengthen evidence-based nutritional strategies for aquaculture.

Conflict of Interest Disclosure

The author affirms that this research was conducted without any commercial or financial relationships that could be construed as a potential conflict of interest.

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