

blood cell counts were significantly higher ($P < 0.05$) in fish fed garlic and neem diets than in the control and ginger-fed groups, indicating enhanced erythropoietic activity in these treatments.

White blood cell counts increased across all herbal-supplemented groups relative to the control treatment, with the highest count observed in fish fed the neem diet (6750 ± 469 cells μL^{-1}). Similarly, neutrophil percentages increased significantly from $41.20 \pm 0.58\%$ in the control group to $50.00 \pm 0.71\%$ in the neem-fed fish. These changes suggest enhanced cellular defence responses in fish receiving herbal supplementation.

Lymphocyte percentages ranged from $44.80 \pm 0.80\%$ to $50.80 \pm 1.74\%$ and did not differ significantly among treatments. Monocyte values were significantly lower in the supplemented groups than in the control treatment, while eosinophil counts were lowest in fish fed the garlic diet. Basophil values remained constant across all treatments.

4 Discussion

The proximate composition of the experimental diets showed that the inclusion of garlic, ginger, and neem modified the nutrient profile of the feeds. Compared with the control diet, the supplemented diets contained higher levels of crude protein, crude fibre, ash, and ether extract, while nitrogen-free extract decreased. These changes indicate that the herbal materials contributed additional nutrients alongside their phytochemical constituents. Since feed composition plays a major role in nutrient utilization and physiological processes, such variations may influence the overall health and performance of cultured fish. Similar observations have been reported for African catfish, where dietary nutrient composition has been shown to affect digestibility and metabolic efficiency (Langi et al., 2024; Oluyemi et al., 2024).

Among the diets, the neem-supplemented feed recorded the highest crude protein content (23.40%), whereas the garlic and ginger diets contained 22.00% crude protein. Protein is essential for tissue growth, enzyme synthesis, haemoglobin formation, and immune function. Previous studies have shown that adequate dietary protein improves nutrient utilization and physiological performance in African catfish (Fregene et al., 2024). The relatively higher protein content of the neem diet may have contributed to the favourable haematological responses observed in fish exposed to this treatment.

Mineral content, as reflected by ash values, was also higher in the herbal diets, particularly in the neem and ginger treatments. Ash represents the total mineral fraction of the feed and provides an indication of the availability of essential elements involved in cellular metabolism and blood formation. Earlier studies have shown that adequate mineral supply supports normal physiological activities and promotes efficient nutrient utilization in cultured fish (Oluyemi et al., 2024). Thus, the elevated ash content observed in the supplemented diets may have supported the maintenance of physiological stability throughout the feeding period.

Crude fibre increased with the inclusion of the herbal additives, with the highest value recorded in the ginger-supplemented diet. This increase was expected because plant materials naturally contain appreciable amounts of fibre. Although excessive dietary fibre may reduce digestibility in carnivorous fish species, moderate inclusion levels are generally tolerated. The absence of adverse changes in the measured blood parameters suggests that the 2% inclusion level used in the present study did not negatively affect fish health.

A decline in nitrogen-free extract was observed in the supplemented diets compared with the control. This reduction appears to be a consequence of the corresponding increases in protein, fibre, lipid, and mineral fractions. Since African catfish rely largely on protein and lipid metabolism for growth and maintenance, moderate changes in carbohydrate content are unlikely to compromise performance provided that energy requirements are adequately met. Similar observations have been reported by Langi et al. (2024), who emphasized the greater importance of protein quality in determining the performance of *Clarias gariepinus*.

The haematological responses observed in this study indicate that dietary supplementation with garlic, ginger, and neem influenced the physiological condition of the fish. Blood parameters are widely used in fish health assessment