International Journal of Aquaculture, 2025, Vol.15, No.3, 155-164
http://www.aquapublisher.com/index.php/ija

Research Article Open Access

Evaluating the Growth Efficiency of *Oreochromis andersonii* Using Commercial and on Farm Formulated Feed in Controlled Indoor Tanks

Natasha Nyendwa [1], Sarah Ngandwe [1,2], Confred G. Musuka [1]
1 Department of Agriculture and Aquatic Sciences, Kapasa Makasa University, Chinsali, Zambia
2 Department of Environmental Science, Egerton University, Egerton, Kenya
Corresponding authors: shavshanyendwa@gmail.com; sarahngandwe3@gmail.com
International Journal of Aquaculture, 2025, Vol.15, No.3 doi: 10.5376/ija.2025.15.0015
Received: 14 Apr., 2025
Accepted: 19 Jun., 2025
Published: 07 Jul., 2025

Preferred citation for this article:
Nyendwa N., Ngandwe S., and Musuka C.G., 2025, Evaluating the growth efficiency of *Oreochromis andersonii* using commercial and on farm formulated feed in controlled indoor tanks, International Journal of Aquaculture, 15(3): 155-164 (doi: 10.5376/ija.2025.15.0015)

Abstract Feed quality plays a critical role in optimizing growth performance and carcass composition in aquaculture. In resource-limited settings, evaluating the potential of locally formulated feeds as alternatives to commercial diets is essential for sustainable fish production. This study assessed the effect of commercial and on-farm formulated feeds on the growth performance and carcass composition of *Oreochromis andersonii*. The experiment was conducted over a period of nine weeks at Kapasa Makasa University, using a Completely Randomised Design with two treatments: a commercial feed (T1, control) and an on-farm formulated feed (T2). A total of 60 fingerlings with an average initial weight of 3 g were stocked at a density of 10 fish per tank in six identical indoor plastic tanks. Fish were fed a 30% crude protein diet at 8% of the standing biomass, administered twice daily. Growth parameters (weight and length) were measured weekly after a 24-hour fasting period. Water quality parameters were monitored regularly to ensure optimal rearing conditions. The results revealed no significant differences in the final body weight between treatments, with 14.79 g (T1) and 13.74 g (T2), while there was a significant difference in the final mean lengths of 8.98 cm (T1) and 8.33 cm (T2). Survival rates remained at 100% in both treatments. Feed conversion ratio (FCR) was lower in T2 (1.5) compared to T1 (1.9), indicating better feed efficiency in the on-farm formulated diet. Additionally, carcass yield was higher in T2 (45.5%) than in T1 (37%). The findings suggest that on-farm formulated feed can serve as a cost-effective and nutritionally adequate alternative to commercial feed for O. andersonii, supporting its potential use in small-scale aquaculture systems.
Keywords *Oreochromis andersonii*; Growth performance; Carcass composition; On-farm feed; Commercial feed; Feed conversion ratio; Aquaculture

1 Introduction

Fish feed is a fundamental component in aquaculture, directly influencing the growth, health, survival, and reproductive performance of cultured fish (Chen et al., 2024). It is typically formulated into pellets or granules, which make it more digestible and efficient for the fish to consume, enabling them to reach their full growth potential (Ubina et al., 2021). In aquaculture systems, the formulation of nutritionally balanced commercial diets is essential for ensuring that fish receive the necessary nutrients and energy required for sustained growth and survival (El-Sayed and Izquierdo, 2022; Rusco et al., 2024).

Aquaculture in Zambia holds significant potential to enhance food security, thereby contributing to improved health and economic well-being for both citizens and the nation as a whole. Expansion of the aquaculture industry can also alleviate the pressure on Zambia's natural fisheries, promoting more sustainable resource use (Zhang et al., 2024; Amponsah et al., 2025). According to Overton et al. (2024) aquaculture is regarded as the most viable alternative for the development and conservation of fisheries resources, as well as for the restoration of degraded aquatic ecosystems. The success and sustainability of the aquaculture sector, however, are highly dependent on the availability of nutritionally balanced and cost-effective feed systems (Ubina et al., 2021).

Aquaculture in Zambia has experienced significant growth over the past decade, with production increasing fivefold. This expansion is expected to continue, positioning the sector as a key contributor to food and nutrition security in the country. In 2022, aquaculture production was estimated at 75 647 tons (FAO, 2023). Zambia has become one of the top ten aquaculture producers in Africa and the leading producer of farmed fish within the Southern African Development Community (SADC) (DoF, 2019) (MFL, 2023). These achievements reflect the nation's commitment to advancing its aquaculture sector, with significant investments in infrastructure, hatcheries, and feed production systems.

As global fish production continues to rise, the demand for more affordable and sustainable feed options becomes increasingly important (Geremia et al., 2024). For instance, *Oreochromis andersonii,* a key species in Zambian aquaculture, has shown great potential for marketability, particularly in both commercial and local fisheries (Kefi and Mwango, 2018). However, despite its high market demand, growth performance of this species remains suboptimal due to challenges in feed availability and formulation, particularly among small-scale farmers (Basiita et al., 2022). Many of these farmers, especially in rural areas, struggle to access affordable and quality feed, which severely impacts fish growth and overall farm productivity (Godfrey Musuka et al., 2023). The availability of quality feed remains one of the most significant barriers to aquaculture expansion, especially in rural communities (Hasimuna et al., 2023).

In addressing these challenges, studies have investigated the use of locally available ingredients in formulating fish feeds. A study by Musiba et al. (2014) evaluated the performance of two locally formulated feeds, TAF 1 and TAF 2, as replacements for commercial feeds in rearing African catfish in Tanzania. The results indicated that the locally formulated feed, TAF 1, outperformed the commercial feed in terms of weight gain, average daily gain, feed conversion ratio, and specific growth rate. This suggests that locally available ingredients can be effective alternatives to commercial feeds for African catfish farming. Another study by Opiyo et al. (2014) compared the growth performance, carcass composition, and profitability of Nile tilapia fed commercial and on-farm made fish feeds in earthen ponds. The study found significant differences in mean weights, specific growth rates, and feed conversion ratios between the different diets. Additionally, the carcass composition analysis revealed variations in moisture, crude protein, crude fat, fiber, and total ash content among the different diets. These findings highlight the impact of feed type on the growth and nutritional composition of Nile tilapia.

Building on these findings, the present study aims to compare the growth performance and carcass composition of *Oreochromis andersonii* raised on both commercial and farm-made feed in controlled plastic tank environments. By exploring the effectiveness of locally produced feeds against commercially available options, this study seeks to provide valuable insights into optimizing feed strategies for enhanced aquaculture productivity.

2 Methods

2.1 Description of study site

The experiment was carried out at Kapasa Makasa University in Muchinga province, Chinsali district (Figure 1). Chinsali lies approximately 15 kilometers west of the Great North Road and about 180 kilometers northeast of Mpika. Geographically, the area is situated between two major watersheds-the Chambeshi River of the Congo Basin and the Luangwa River of the Zambezi Basin. Positioned at an altitude of 1 600 meters above sea level, Chinsali experiences a mean annual temperature of 20.7 °C and receives approximately 1,114 mm of rainfall per year. The region falls within Zambia's Agro-Ecological Region III, which is characterized by a relatively cool climate and high rainfall, making it suitable for diverse agricultural and aquaculture activities.

2.2 Sampling procedure

A total of sixty *Oreochromis andersonii* fingerlings, of both sexes and of similar size and age, were sourced from the Kapasa Makasa University Campus in Chinsali, Zambia. The fingerlings were randomly distributed and stocked at a density of 10 fish per tank in six rectangular plastic tanks, ensuring uniform stocking conditions across all experimental units.

2.3 Experimental setup and design

A completely randomised design (CRD) was employed, incorporating two dietary treatments commercial feed and farm-made feed each with three replicates. The study was carried out over a period of nine weeks to evaluate the growth performance and carcass composition of *Oreochromis andersonii* under the two feeding regimes. Each week, a sample of 10 fish was collected from each treatment and replicate tank. The sampled fish were cleaned, and surface moisture was removed using a clean, dry cloth. Subsequently, each fish was measured for total weight and length to assess growth parameters. The indoor plastic tanks used as experimental units (Figure 2).

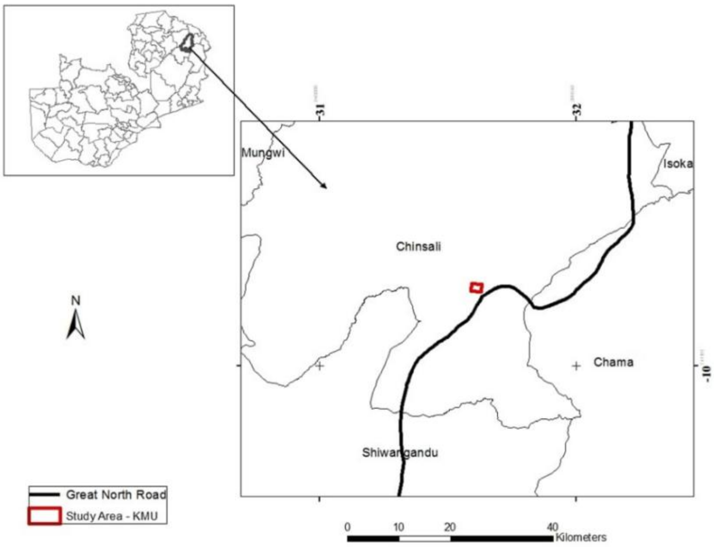

Figure 1 Showing the study site

Figure 2 Indoor experimental plastic tanks

2.4 Tank management

Tank preparation and management were carried out appropriately to ensure optimal conditions for fish culture. Prior to stocking, the tanks were thoroughly cleaned using a sponge and clean water to remove any debris or contaminants. During the experimental period, water in each tank was completely replaced four times per week to prevent algal growth, maintain water quality, and ensure adequate levels of dissolved oxygen for the fish.

2.5 Water quality monitoring

Water quality parameters including pH, dissolved oxygen, and temperature were monitored using a water quality meter, and the corresponding values were recorded regularly throughout the experiment.

2.6 Fish acclimatization and stocking

Fish were stocked in indoor tanks at a density of 10 fish per tank, with an initial average weight of 3 g. Prior to stocking in the experimental tanks, the fish were conditioned to the rearing environment for one week. This acclimatization period was intended to ensure uniform feed acceptability across all treatment groups. Sixty fish of similar size were selected from a larger population and distributed equally among six indoor tanks. Each tank measured 40 cm × 60 cm giving a surface area of 0.24 m^2 and a volume of 48 liters.

2.7 Feeding practice and feeding rate

In this experiment, fish were fed commercial feed and on farm-made feed to satiation. The feeding was done twice a day in the morning at 9 amand the afternoon at 3 pm. The fish were fed on the diet at the rate of 8% and the feeding took 9 weeks. Feed was administered by broadcasting across the tank surface to ensure even distribution and access for all fish.

2.8 Fish measurements

Fish growth was monitored on a weekly basis throughout the experiment. Body weights and lengths for all fish from each tank were recorded after 24 hours without feeding. Precautionary measures were taken to minimize stressing and injuring the fish during the weighing process by wearing gloves. Total lengths (TL) as well as wet weight (Wt.) of each fish were recorded. A measuring board and a ruler were used to measure the length (cm) of fish, while an electronic scale was used to measure the fish weight to 3 decimal units. At the conclusion of the experiment, all fish were individually harvested, weighed, and measured to determine final mean body weight and length. Survival rate was calculated using the following formula:

$$Survival = (Final\, number\, of\, fish\, per\, treatment\, /Initial\, number\, of\, fish\, per\, treatment) * 100$$

Specific growth rate:

Specific Growth Rate (SGR) expressed as a percentage of body weight per day was calculated using the equation shown by Westers (2001).

$$SGR\,(\%\, per\, day) = 100\,[\frac{(In\, Wt - In\, W1)}{t}]$$

where: ln (Wt.) is the natural logarithm of the weight at time t, and ln (W1) is the natural logarithm of the initial weight.

Mean weight gain (MWG):

Mean weight gain (MWG) was calculated using the formula:

$$MWG\, = (Final\, body\, weight - Initial\, body\, weight\, number\, of\, surviving\, fishes) * 100$$

Feed conversion ratio (FCR):

The feed conversion ratio (FCR) was calculated using the formula:

$$FCR\, = \,Total\, dry\, feed\, given\,(g)/Total\, weight\, gained\, by\, fish\,(g)$$

2.9 Carcass composition (meat yield)

Meat yield was carried out to assess carcass composition analysis. The fish samples were collected from all the different feed diets (3 from each), and then it was first scaled; thereafter, it was filleted to collect fillets (Figure 3). The fillets were used to assess the carcass composition. The equipment included a weighing scale to weigh the fish and fillets, buckets to clean the fish, a knife, and new razor blades to scale and fillet the fish.

2.10 Feed formulation

The diet 1 (Farm-made feed) was 40% crude protein level using the Trial and Error method from Sunflower meal, soybean meal, maize bran, Cassava meal, vegetable oil, vitamin and mineral premixes , while diet 2 (Commercial feed (Novatek) comprised of maize, maize bran, Wheat bran, Soybeans and Soycake, Fish meal, Vitamin and mineral premixes (NOVATEK, 2024). The diet was formulated in a way that essential nutrients meet the nutritional needs of the fish as required in culturing fish in tanks to have an improved growth rate with higher protein content.

Figure 3 Samples of collected fillets as meat yield for carcass composition

Diet preparation involved mixing the dry macro-ingredients: soybean meal, maize bran, sunflower meal, and cassava meal, before adding oil. Vegetable oil was included in the diets at 1% for all diets to provide n-6 fatty acids. Micro-ingredients, mineral and vitamin premixes were added each at 1.5% to the macro ingredients and finely mixed. Cassava meal was used as a binder to improve stability in water, increase pellet firmness and reduce the number of fines produced during processing (Confred and Rodney, 2015) (Table 1).

Table 1 Ingredients and compositions of experimental diet in percentage inclusion rates

Ingredients	On farm feed
Sunflower	38
Soybean meal	38
Maize bran	18.10
Cassava meal	2.00
Vitamin premix	1.50
Mineral premix	1.50
Vegetable oil	1.00

2.11 Data analysis

The data was collected based on weight, survival, and length. Every one week, fish from each tank was weighed and measured to assess growth performance and feed was adjusted to the increase in size. Survival was monitored on a daily basis and every week by counting the total number of fish in each tank. Feed intake was observed six days a week throughout the experimental period.

Data on body weight, total length, and water quality parameters collected during the feeding trials were analyzed using Minitab Statistical Software (Version 17). A one-way Analysis of Variance (ANOVA) was performed to determine whether there were statistically significant differences ($P < 0.05$) among the experimental groups. Microsoft Excel was used to generate all graphical representations of the results.

3 Results

3.1 Growth performance

Changes in the mean body weight of fish over the 9 week experimental period (Figure 4). Fish fed diets containing 30% crude protein showed significant growth across all water temperature levels. During the first three weeks, growth was relatively slow in both treatments, followed by a marked acceleration in growth from week four onward. In Treatment 1, no significant weight gain was observed between weeks 7 and 8, however, a sharp increase occurred between weeks 8 and 9. Despite both groups starting with an average initial weight of 3.0 g, the final mean body weight reached 14.78 g in Treatment 1 and 13.73 g in Treatment 2. The results showed no significance difference between treatments (P = 0.110, Figure 5).

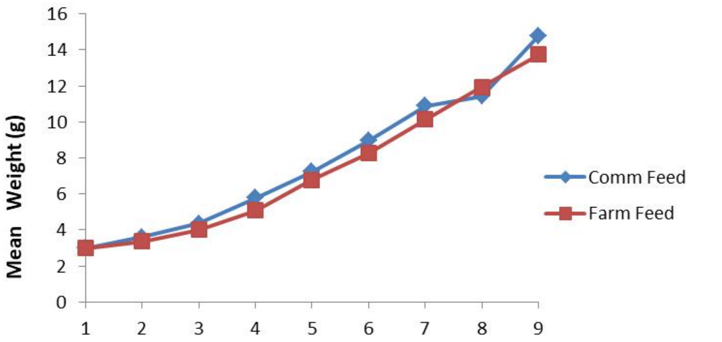

Figure 4 Mean body weights of *O. andersonii* reared in plastic tanks for 9 weeks

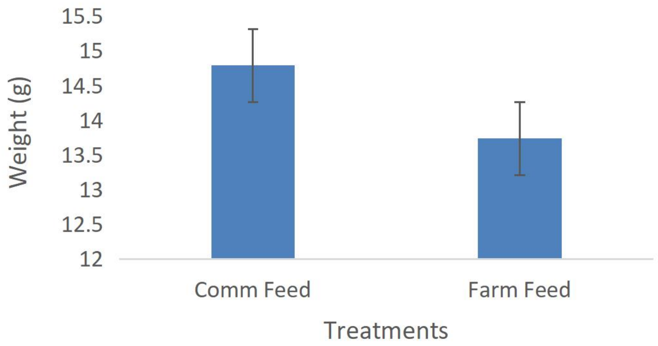

Figure 5 Comparison of final body weights between treatments

3.2 Size

At the start of the experiment, the smallest fish had a length of 3.8 cm while the biggest fish had a length of 7 cm. Therefore, the experimental fish for both treatments had different lengths ranging between 3.8 cm and 7 cm. At the end of the experiment, treatment 1 had a final mean length of 8.97 cm while treatment 2 had slow change in length in the first two weeks and in week five it had a fast change, therefore at the end of the experiment, treatment 2 had a final mean length of 8.36 cm (Figure 6). The diagram below shows the results of significance difference (P≤ 0.05) between the treatments, (P=0.007) (Figure7).

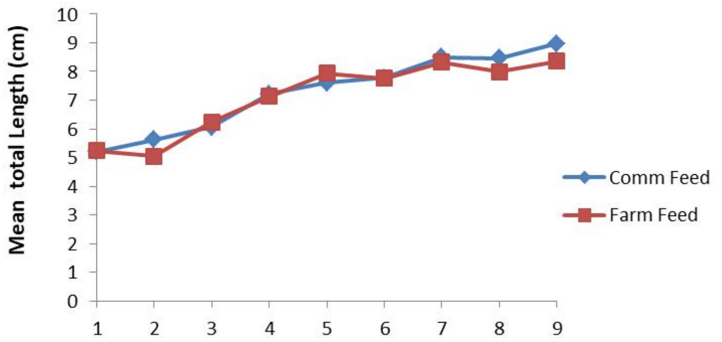

Figure 6 Final total length of *Oreochromis andersonii* at the end of the experiment

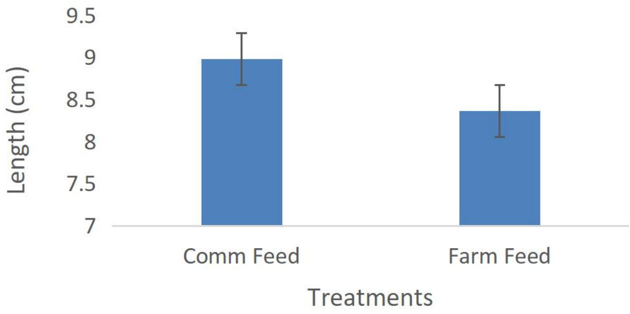

Figure 7 Comparison of final total length between treatments, carcass composition (Meat yield)

Carcass analysis revealed that Treatment 2 (on-farm-made feed) resulted in a higher meat yield (45.5%) compared to Treatment 1 (commercial feed, 37%) (Table 2).

Table 2 Carcass yield of *O. andersonii* reared on commercial and on-farm formulated diets

Treatment	Initial weight (plus the bones and offal) (%)	Final weight (meat yield) (%)
T1	62	37
T2	66	45.5

3.3 Feed conversion ratio

The analysis revealed significant differences ($P \leq 0.05$) between the two treatments, Treatment 1 had a better utilization of the feed (1.9) than treatment 2 (1.5).

3.4 Survival rates

$$Survival\ (\%) = Final\ number\ of\ fish\ per\ treatment/initial\ number\ of\ fish\ per\ treatment \times 100$$

In all the three (3) replicates for treatment 1, a total number of 30 had survived out of 30 fish, therefore, the survival rate was calculated as: Survival rate T1= (30÷30) ×100 = 100%.

In all the three (3) replicates for treatment 2, a total number of 30 had survived out of 30 fish, therefore, the survival rate was calculated as:Survival rate T2= (30÷30) ×100 = 100%.

3.5 Specific growth rate

SGR was calculated using the formula: SGR = (ln (Final weight (g) − ln (Initial weight (g) ×100) T (In days)

SGR for treatment one: SGR = (ln (458.4 (g) − ln (90(g) / 62 × 100 = 2.6.

SGR for treatment two: SGR = (ln (425.8(g) − ln (90(g) / 62 × 100 = 2.5.

3.6 Mean weight gain

MWG for treatment one was: = 425.8 g − 90g ÷ 30 × 100 = 1 120 g.

MWG for treatment two: = 458.4 g − 90g ÷ 30 × 100 = 1 228 g.

3.7 Water quality parameters

The mean water quality parameters during the entire experimental period (Table 3).

Table 3 Mean value (±SD) of water quality parameters sampled four times for each month

Months	Water temperature (°C)	Dissolved oxygen (mg/L)	pH
March	25.34±0.76	5.92±0.94	8.39±0.06
April	26.56±0.51	6.01±1.03	8.42±0.02
May	24.46±0.82	5.59±1.17	8.50±0.03

Note: the mean values (±SD) were recorded as constant across the two treatments

4 Discussion

At the onset of the experiment, the mean weight of *O. andersonii* was 3 g. Both treatments exhibited slow growth during the initial three weeks, likely due to acclimatization. Subsequently, growth rates increased, with Treatment 1 and Treatment 2 achieving final mean weights of 14.79 g and 13.74 g, respectively. Despite Treatment 1's numerically higher weight gain, the difference was not statistically significant ($P = 0.110$), indicating comparable performance between the commercial and on-farm-formulated feeds. This result is consistent with findings by Basiita et al. (2022), who reported similar growth patterns for *O. niloticus* under controlled conditions, with no significant differences in growth when fed either commercial or on-farm-made feeds.

While weight gain did not differ significantly between treatments, a notable difference was observed in fish length. Treatment 1 fish reached a mean length of 8.98 cm, whereas Treatment 2 fish averaged 8.33 cm ($P = 0.007$). This disparity suggests that factors beyond feed type, such as water quality parameters influenced by diet composition, may have impacted somatic growth. Environmental variables like temperature, pH, and dissolved oxygen are known to affect fish morphology and growth efficiency. A study by Abd El-Hack et al. (2022) found similar results, where variations in water quality, particularly temperature and oxygen levels, contributed to differences in fish length and growth efficiency, even under identical feeding conditions.

Despite Treatment 1's higher overall weight, its lower meat yield may be attributed to a greater proportion of non-edible components. These results align with a study by Opiyo et al. (2014), which observed that fish fed on-farm-formulated feeds often exhibited higher meat yield due to better nutrient utilization from locally sourced ingredients.

Feed conversion efficiency was better in Treatment 2, with an FCR of 1.5, compared to 1.9 in Treatment 1. Lower FCR values indicate more efficient feed utilization. Both treatments demonstrated acceptable FCRs, falling below the threshold reported in similar studies on tilapia species. For instance Mengistu et al. (2020) reported an FCR of 1.71 for tilapia fed in cage environments, emphasizing the efficiency of such diets in promoting optimal growth while minimizing feed wastage.

No mortality was observed in either treatment, indicating that the fish were reared under favorable conditions throughout the trial. The 100% survival rate underscores the effectiveness of the culture system and husbandry practices employed. This finding is consistent with studies on tilapia, such as those conducted by Ahir et al. (2023), who reported a 100% survival rate in tilapia on farm enriched feed, highlighting the effectiveness of optimized feeding and rearing practices.

The specific growth rate ranged from 2.5% in Treatment 2 to 2.6% in Treatment 1. Elevated SGRs are often associated with optimal environmental conditions, including suitable temperature and dissolved oxygen levels. Regular water changes and aeration likely contributed to these favorable conditions in the present study. Makori et al. (2017) found similar growth rates in tilapia when dissolved oxygen and temperature were maintained within optimal ranges, highlighting their importance in achieving high SGRs in aquaculture. Water temperature ranged from 24.46 ± 0.82 °C to 26.56 ± 0.51 °C, aligning with the optimal range for tilapia culture. Dissolved oxygen levels varied between 5.59 ± 1.17 mg/L and 6.01 ± 1.03 mg/L, exceeding the minimum threshold required for optimal growth. pH levels were within the recommended range, averaging between 8.39 ± 0.06 and 8.50 ± 0.03, further supporting healthy growth conditions. These results are consistent with findings from Makori et al. (2017), who recommended maintaining a temperature range of 25 °C~30 °C and dissolved oxygen levels above 5 mg/L for optimal tilapia growth.

5 Conclusions

In conclusion, the study highlights that on-farm-made feed can effectively support the growth performance and carcass composition of *Oreochromis andersonii* reared in indoor tanks. While there was no significant difference in growth performance or carcass composition between fish fed on commercial feed and those fed on the on-farm-made diet, the results suggest that on-farm-made feed can be a viable alternative in aquaculture, particularly in rural areas. The high percentage of carcass meat obtained from fish fed on the on-farm-made diet demonstrates its potential for successful aquaculture production. Additionally, using locally sourced ingredients, such as fishmeal substitutes with high protein content, makes on-farm-made feed both economically viable and beneficial for long-term sustainability in aquaculture. Given that commercial feed costs approximately ZMW 50 per kg, on-farm-made feed presents a more accessible and resource-efficient option for small-scale farmers.

Funding
The authors declare no funding for this research

Acknowledgments
The authors would like to thank Kapasa Makasa Univeristy for the lab analysis.

Conflict of interest
The authors declare no conflict of interest.

References
Abd El-Hack M.E., El-Saadony M.T., Nader M.M., Salem H.M., El-Tahan A.M., Soliman S.M., and Khafaga A.F., 2022, Effect of environmental factors on growth performance of Nile tilapia (*Oreochromis niloticus*), International Journal of Biometeorology, 66(11): 2183. https://doi.org/10.1007/s00484-022-02347-6

Ahir S.Y., Chaudhary R., Maraseni A., and Karki N.P., 2023, Comparative study of growth and survival of Nile tilapia (*Oreochromis niloticus*) on different feed types, Nepalese Veterinary Journal, 2023: 170-178. https://doi.org/10.3126/nvj.v38i1.55861

Amponsah S.K., Azumah D.D., Agyakwah S.K., Amponsah S.K., Azumah D.D., and Agyakwah S.K., 2025, Aquaculture in Africa: production systems, challenges, and opportunities, Emerging Trends in Fisheries - Sustainable Practices and New Perspectives, 2025.

Basiita R.K., Trinh T.Q., Sakala M.E., Chungu P., Malambo T., Hampuwo B., Mwema C., and Benzie J.A.H., 2022, Performance of *Oreochromis niloticus* and *Oreochromis andersonii* in controlled laboratory conditions in Zambia, Aquaculture Reports, 27: 101338. https://doi.org/10.1016/j.aqrep.2022.101338

Chen J.X., He S.L., Zhang Z.L., Li J.J., Zhang X.X., Li J.T., Xu J.R., Zheng P.H., Xian J.N., and Lu Y.P., 2024, Application of organic acid salts as feed additives in some aquatic organisms: potassium diformate, Fishes, 9(3): 85. https://doi.org/10.3390/fishes9030085

DoF, 2019, Department of fisheries, zambia. fisheries and aquaculture statistics: annual report; ministry of fisheries and livestock: Chilanga, Zambia.

El-Sayed A.F.M., and Izquierdo M., 2022, The importance of vitamin E for farmed fish-a review, Reviews in Aquaculture, 14(2): 688-703. https://doi.org/10.1111/raq.12619

FAO, 2023, Fisheries and aquaculture statistics: annual report (draft), Ministry of Fisheries and Livestock: Chilanga, Zambia.

Geremia E., Grande U., Tomajoli M.T.M., Petito A., Fasciolo G., and Napolitano G., 2024, Feed production for sustainable aquaculture: a bibliometric network analysis, Ecological Questions, 35(1): 1-17. https://doi.org/10.12775/EQ.2024.007

Godfrey Musuka C., Haambiya L., Kabati C.K., Anamunda A., Mulenga M., Banda E., and Moyo M., 2023, Commercial aquafeed production and usage in zambia: reviewing its current status, developmental constraints and opportunities, Journal of Agriculture and Aquaculture Research Article, 5(3): 1-20.

Hasimuna O.J., Maulu S., Nawanzi K., Lundu B., Mphande J., Phiri C.J., Kikamba E., Siankwilimba E., Siavwapa S., and Chibesa M., 2023, Integrated agriculture-aquaculture as an alternative to improving small-scale fish production in Zambia, Frontiers in Sustainable Food Systems, 7: 1161121. https://doi.org/10.3389/fsufs.2023.1161121

Kefi A.S., and Mwango J., 2018, Is the culture of exotic fish species the answer to low fish productivity, a case study on the use of *Oreochromis niloticus* in Zambia, International Journal of Fisheries and Aquaculture, 10(11): 129-139. https://doi.org/10.5897/IJFA2018.0703

Makori A.J., Abuom P.O., Kapiyo R., Anyona D.N., and Dida G.O., 2017, Effects of water physico-chemical parameters on tilapia (*Oreochromis niloticus*) growth in earthen ponds in Teso North Sub-County, Busia County, Fisheries and Aquatic Sciences, 20(1): 1-10. https://doi.org/10.1186/s41240-017-0075-7

Mengistu S.B., Mulder H.A., Benzie J.A.H., and Komen H., 2020, A systematic literature review of the major factors causing yield gap by affecting growth, feed conversion ratio and survival in Nile tilapia (*Oreochromis niloticus*), Reviews in Aquaculture, 12(2): 524-541.

MFL, 2023, Ministry of fisheries and livestock of the republic of Zambia, National Fisheries and Aquaculture Policy (NFAP), Ministry of Fisheries and Livestock: Lusaka, Zambia.

Musiba M.J., Ngupula G.W., Kashindye B.B., Elison M., Shoko A.P., Ndikumana J., Zziwa E., and Katunzi E.F.B., 2014, Performance of locally formulated feeds for rearing of African catfish in Tanzania, African Crop Science Journal, 22, 979-986.

Opiyo M.A., Githukia M.C., Munguti J.M., and Charo-Karisa H., 2014, Growth performance, carcass composition and profitability of Nile tilapia (*Oreochromis niloticus* L.) fed commercial and on-farm made fish feed in earthen ponds, International Journal of Fisheries and Aquatic Studies, 1(5): 12-17.

Overton K., Dempster T., Swearer S.E., Morris R.L., and Barrett L.T., 2024, Achieving conservation and restoration outcomes through ecologically beneficial aquaculture, Conservation Biology, 38(1): e14065.
https://doi.org/10.1111/cobi.14065

Rusco G., Roncarati A., Di Iorio M., Cariglia M., Longo C., and Iaffaldano N., 2024, Can IMTA system improve the productivity and quality traits of aquatic organisms produced at different trophic levels, the benefits of IMTA-not only for the ecosystem, Biology, 946: 13(11).
https://doi.org/10.3390/biology13110946

Ubina N., Cheng S.C., Chang C.C., and Chen H.Y., 2021, Evaluating fish feeding intensity in aquaculture with convolutional neural networks, Aquacultural Engineering, 94: 102178.
https://doi.org/10.1016/j.aquaeng.2021.102178

Zhang L., Maulu S., Hua F., Chama M.K.H., and Xu P., 2024, Aquaculture in Zambia: the current status, challenges, opportunities and adaptable lessons learnt from China, Fishes, 9(1): 14.
https://doi.org/10.3390/fishes9010014