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Comparative Analysis of Floating Feed from Different Sources for Optimizing the Growth Performance of *Oreochromis Shiranus* Fingerlings

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ABSTRACT
The study evaluates the effects of floating feeds from different sources on the growth performance, feed utilization, nutrient digestibility and water quality for *Oreochromis shiranus* fingerlings cultured in hapa under pond systems in Malawi. Five diets were tested, two imported floating feed (Diets 1 and 4), one locally manufactured floating feed (Diet 5) and two on farm formulated floating feeds (Diets 2 and 3), each adjusted to 32% crude protein. Fish (initial mean weight: 8.45 ± 0.25g) were stocked at 25 fingerlings per hapa and fed twice daily at 3% body weight for 12 weeks, using a completely randomized design with three replicates per treatment. After 12 weeks, final mean weights were 21.608 ± 1.062g (Diet 1), 23.697 ± 1.347g (Diet 2), 26.225±1.413g (Diet 3), 25.970±1.959g (Diet 4), and 27.592±0.361g (Diet 5). There was a significant difference (P= 0.026) in final weights, with Diet 5 (locally manufactured floating feed) outperforming Diet 1 (imported floating feed). However, other growth parameters including mean weight gain, specific growth rate (SGR), average daily weight gain, apparent feed conversion ratio (AFCR) and protein efficiency ratio (PER) showed no significant differences (P> 0.05) among treatments. Survival rate was 100% across all treatments. Apparent digestibility coefficients (ADC) differed significantly among diets. Protein digestibility ranged from 78.33% (Diet 1) to 85.50% (Diet 5), with Diet 5 showing the highest value (P< 0.001). Fat digestibility followed a similar trend, the highest in Diet 5 (90.17%) and lowest in Diet 1 (83.30%). Fiber and ash digestibility were also significantly higher in diets 3 and 5 compared to the other treatments (P< 0.05). Water quality parameters remained within optimal ranges for *O. shiranus* culture and did not differ significantly across treatments (P> 0.05). In conclusion, the locally manufactured floating feed (Diet 5) demonstrated superior growth and nutrient digestibility compared to imported and on-farm formulated diets. It is recommended that smaller holder farmers use the locally manufactured floating feeds to optimize biological performance in *O. shiranus* fingerlings.

INTRODUCTION

Aquaculture plays a crucial role in meeting the growing global demand for fish protein (**Finegold, 2009; Subasinghe *et al*., 2009**). In Malawi, aquaculture is still at an early stage but has shown steady growth over the past two decades. National production increased from 813 metric tonnes in 2005 to 9,399 metric tonnes in 2020 (**Government**

of Malawi, 2021), with 10,007 ponds covering a total area of 251.6 ha now recorded (**GoM, 2021**). Despite this progress, production remains constrained by high input costs, particularly fish feed, which accounts for about 60% of total operating expenses **(Delgado & Minot, 2003; Munguti *et al.*, 2021)**.

Nutrition is a key driver of aquaculture productivity. Modern feeds are formulated to provide balanced amounts of protein, carbohydrates, lipids, vitamins and minerals, all essential for optimal growth, health and feed utilization efficiency in fish (**Gasco *et al.*, 2018; Mohammady *et al.*, 2023; Wang, 2023)**. Floating feeds are particularly advantageous, as they remain on the water surface, reducing waste, minimizing nutrient leaching and allowing farmers to monitor feeding behavior in real time **(Vanni *et al.*, 2013; Davis & Hardy, 2022; Hermawan *et al.*, 2023)**. However, feed availability and affordability remain pressing challenges in Malawi, where most floating feeds are imported from Zambia, raising costs for smallholder farmers **(Mwema *et al.*, 2021)**.

Locally manufactured floating feeds have been introduced in Malawi, offering potential cost savings and improved access. Alongside these, some farmers formulate their own on-farm diets using locally available ingredients such as blood meal and crop by-products, which can reduce reliance on expensive imported feeds **(Fagbenro, 1999; Makinde & Sonaiya, 2012)**. While on-farm feeds may enhance sustainability, their nutritional adequacy compared to commercial feeds has not been fully evaluated in *Oreochromis shiranus*, a key aquaculture species in Malawi.

Oreochromis shiranus (Makumba) is highly favored by smallholder farmers due to its tolerance to varied water quality and temperature conditions, fast growth, and adaptability **(Kassam & Sangazi, 2016; Limuwa *et al.*, 2018)**. Yet, little is known about how different floating feeds, imported, locally manufactured and on-farm formulated affect its growth, feed utilization, survival and environmental performance.

Therefore, this study evaluates the performance of different floating feeds for *O. shiranus* fingerlings, focusing on their effects on growth, feed utilization, nutrient digestibility, survival and water quality.

MATERIALS AND METHODS

Study area

The study was conducted at the Bunda Fish Farm of the Lilongwe University of Agriculture and Natural Resources (LUANAR). The site is located about 32.5Km south of Lilongwe City in the Central Region of Malawi (Fig.1)

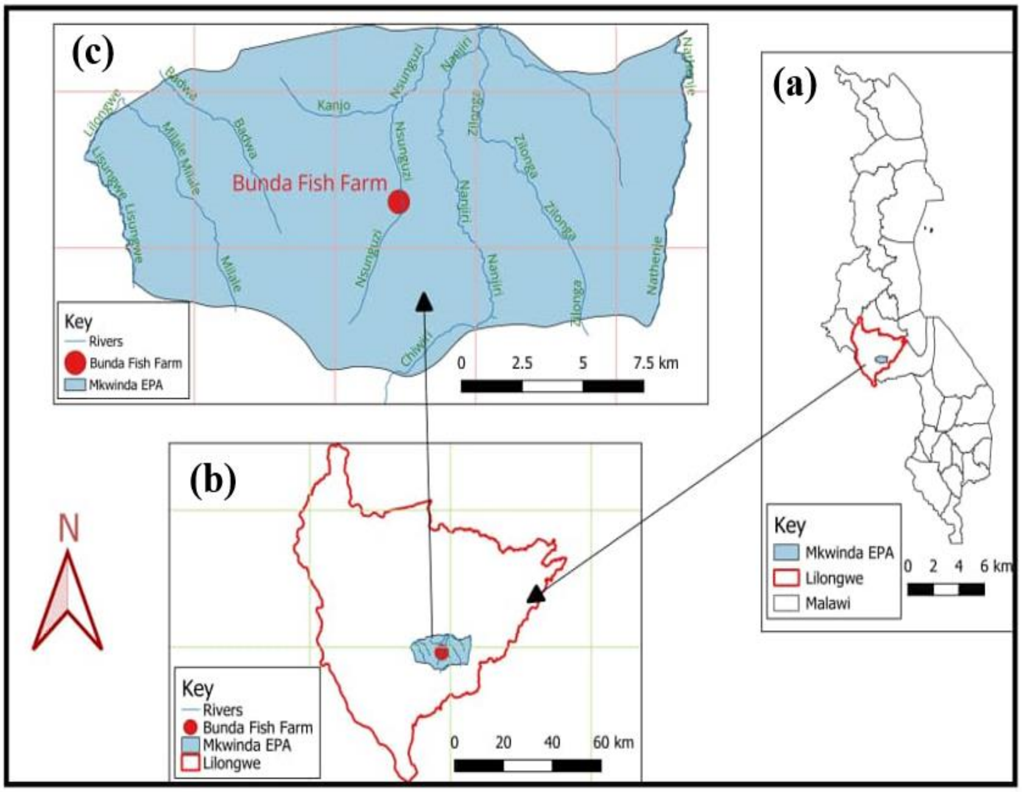

Fig. 1. Location of the study

Research design

Fish growth and feed utilization experiment

The study used a completely randomized design. There were five diets: one locally manufactured floating feed, two different imported floating feeds, and two different on-farm formulated floating feeds. Each diet was considered as a treatment, with each treatment replicated three times. A total of 15 hapas, each measuring 2m x 2m x 1.5m, were set up for the experiment. Each hapa was set as an individual experimental unit, containing 25 *Oreochromis shiranus* fingerlings. The fingerlings had an initial mean weight of 8.45 ± 0.25 g. This setup results in a stocking density of approximately 6.25 fish per square meter. The study was conducted over a period of 12 weeks.

Apparent digestibility experiment

The digestibility trial was conducted using plastic tanks (60 L) in the laboratory, each stocked with 15 *O. shiranus* fingerlings. Fish were first acclimatized for one week before the trial commenced. During the trial, they were fed experimental diets containing 10% chromium oxide (Cr_2O_3) as an inert marker. Faecal matter was collected over a two-week period and later analyzed for nutrient content using standard proximate analysis procedures, following **Kitagima and Fracalossi (2010)**.

Experimental diets

The following feed ingredients were used for the on farm formulated feed: Fish meal, soy bean, maize meal, vitamin premix, mineral premix and cassava (binder). The soy bean and fish meal were included in the on-farm formulated feed as protein sources, whereas maize and rice bran served as sources of energy. The first diet was the locally manufactured floating feed, the second and third diets was the imported floating feed purchased from two different companies. The fourth and fifth diets were formulated using a trial-and-error method **(Catacutan, 2002)**. This involved combining different quantities of fish meal, maize meal, rice bran, cassava (binder) and a mineral and vitamin premix in each diet to create a floating feed, as shown in Table(1).

Table 1. Ingredient composition (%) of the diets used at 32% CP

Ingredient	****Diet 1**	**Diet 2**	**Diet 3**	**Diet 4**	**Diet 5**
Fish meal	-	-	11.5	-	-
Soya bean	-	49.5	46.5	-	-
Blood meal	-	7.5	-	-	-
Maize	-	24.5	27.5	-	-
Rice bran	-	16.5	12.5	-	-
Vitamin premix	-	0.5	0.5	-	-
Mineral	-	0.5	0.5	-	-
Binder (cassava)	-	1	1.0	-	-
Total		100	100		

NB: Diets 1, 4 and 5 ingredient composition is not known since it is predetermined by the manufacturer. Synthetic vitamin and mineral premix contained (per kg of premix): Vitamin A, 15,000,000 i.u, Vitamin D_3, 4,000,000 i.u; Vitamin E, 200,000 i.u, Vitamin B_1 10,000 mg, Vitamin B_{12} 1,000 mg, Vitamin C 300 g, Phosphorus, 4,000 g, and Calcium 8,000 g. Chromic oxide (Cr_2O_3) was added at 0.5% of the diet as an inert digestibility marker.

Preparation of diets 2 and 3

The imported and locally manufactured feeds were purchased from the market, while ingredients for the on-farm formulated feed were sourced locally. The on-farm diet was processed into floating pellets following **Das (2017)**. The ingredients were ground, mixed with vitamins, minerals and binders, conditioned with steam and water and extruded into pellets. The pellets were then dried to reduce moisture, cooled to room temperature and packaged for use.

Proximate analysis of feed ingredients

The proximate analysis of the ingredients, including moisture content, crude protein, crude lipid, and energy, was determined following standard procedures of the Association of Official Analytical Chemists **(AOAC, 2005)**, as described by **Dawodu *et al*. (2012)** (Table 2).

Table 2. Proximate composition of feed ingredients used in diet formulation of the on-farm floating feed

Ingredient	Crude protein (%)	Crude Fat (%)	Moisture (%)	Ash (%)	Crude Fiber (%)
Fish meal	64.9 ± 0.04	2.0 ± 0.05	9.5 ± 0.03	17.5 ± 0.12	1.5 ± 0.09
Blood meal	79.8 ± 0.06	1.1 ± 0.04	10 ± 0.09	5.5 ± 0.03	1.1 ± 0.04
Soy bean	44.9 ± 0.91	3.0 ± 0.02	13.8 ± 0.10	7.2 ± 0.04	6.4 ± 0.05
Maize	9.3 ± 0.85	1.5 ± 0.06	12.48± 0.07	1.5 ± 0.01	2.1 ± 0.02
Rice bran	9.8 ± 0.06	11.5 ± 0.07	10.5 ± 0.06	8.5 ± 0.12	10.9 ± 0.03

NB: Values are expressed as mean ± standard deviations of three replicates (n = 3).

Data collection

Fish growth and feed utilization

Throughout the experimental period, growth parameters were monitored and recorded at two-week intervals. This included the measurement of body weight and standard length. A total of 8 *Oreochromis shiranus* fingerlings were sampled per hapa. The survival rates of fingerlings in each treatment group were also recorded. Apparent feed conversion ratio (AFCR) was calculated and recorded for each treatment group. The fish was weighed using an electronic scale (Yoshidal model HL-200) to record the body weight (g), and body length which was measured using a measuring board. The data collected were used in the following calculations (**Furukawa & Tsukahara, 1966)**:

(i) Percentage mean weight gain (%)

$$\textbf{PMWG} = \left(\frac{\text{Final Weight} - \text{Initial Weight}}{\text{Initial Weight}}\right) * 100$$

(ii) Average daily growth (ADG) (g/days)

$$\boldsymbol{ADG} = \frac{\text{Mean final weight} - \text{Mean initial weight}}{\text{Number of days}}$$

(iii)Specific growth rate (%/day)

$$\textbf{SGR} = \left(\frac{\text{In(Final Weight)} - \text{In(Initial Weight)}}{\text{Number of Days}}\right) \text{x100}$$

(iv)Survival rate (%)

$$\textbf{Survival rate}\ (\%) = \left(\frac{\text{Number of fish at the end of experiment}}{\text{Initial number of fingerlings stocked}}\right) \times 100$$

(v) Apparent feed conversion ratio (AFCR)

$$\textbf{AFCR} = \frac{\text{Amount of food given(g)}}{\text{Body weight gain (g)}}$$

(vi)The protein efficiency ratio (PER)

$$\textbf{PER} = \frac{\text{Weight gain(g)}}{\text{Protein intake (g)}}$$

Apparent digestibility

The digestibility trial was conducted to assess the nutrient efficiency of the experimental diets in *Oreochromis shiranus*, following established protocols for digestibility experiments in fish **(Kitagima & Fracalossi, 2010)**. The study involved one week acclimatization period, during which healthy fingerlings were transferred into experimental plastic tanks and fed a commercial maintenance diet to allow them to adjust to the new environment. Following this, the experimental fish were fed with five different experimental diets mixed with chromic oxide (Cr_2O_3) as an inert, indigestible marker. The digestibility trial was run for two weeks. The fish were fed twice a day and any uneaten feed was carefully removed 30min after feeding using a fine mesh scoop. Faecal matter was collected once daily by gentle siphoning from the tank bottom after feed removal to avoid contamination with uneaten feed or debris. Faecal material was the dried in an oven at 60°C for 24 hours and was then ground to fine powder using a clean mortar and pestle for subsequent chemical analysis.

Apparent digestibility coefficients were analyzed as follows **(Kitagima & Fracalossi, 2010)**:

ADC nutrient = 100- [100x ($\frac{\% \, Cr2O3diet}{\% \, Cr2O3 \, faeces}$) X ($\frac{\% \, nutrient \, or \, energy \, in \, faeces}{\% \, nutrient \, or \, Energy \, in \, diet}$)]

Where:

ADC = apparent digestibility coefficient (%)

% Cr_2O_3 diet = % chromic oxide percentage in diet;

% Cr_2O_3 faeces = % chromic oxide in faeces.

Water quality parameters

Monitoring of parameters such as temperature, dissolved oxygen, ammonia levels and pH levels were conducted throughout the study. Ammonia levels in rearing units were checked bi-weekly using the Phenate method. Temperature and pH of water in each hapa were recorded twice a day, at 8am and 2pm using a thermometer (OxyGuard Handy Therm, ±0.1°C accuracy) and a portable YSI Pro1020 meter (±0.01 pH units), respectively. Dissolved oxygen was measured using DO an OxyGuard Handy Polaris DO meter (±0.01 mg L^{-1}).

Data analysis

Collected data were analyzed using either one way analysis of variance (ANOVA) or the Kruskal Wallis test at an alpha level of 0.05, depending on whether the assumptions of parametric testing (normality and homogeneity of variances) were met **(Hsu, 2005)**. Specifically, the Kruskal Wallis test was applied to datasets that did not meet these assumptions, including water quality parameters, mean weight gain, specific growth rate (SGR), average daily growth rate (ADG), apparent feed conversion ratio (AFCR), protein efficiency ratio (PER) and benefit cost ratio (BCR). ANOVA was used for datasets meeting the parametric assumptions, such as initial and final weights, digestibility parameters (protein, fibre, ash and fat apparent digestibility coefficients), **(McDonald, 2014)**. When ANOVA indicated significant differences among treatment means, Tukey’s post hoc test was used for pairwise comparisons **(Zar, 2010)**. For non-parametric data, Dunn’s test was employed for pairwise comparisons following a significant Kruskal Wallis result **(Dunn, 1964; Dinno, 2015)**. The general linear model applied for ANOVA was:

$$Y_{ij} = \mu + \boldsymbol{\tau_i} + \boldsymbol{\varepsilon_{ij}}$$

Where, Y = *j*th observation on *i*th treatment

μ = overall treatment mean

τ_i = effect of the *i*th treatment

ε_{ij} = error

component association with *j*th unit on the *i*th treatment.

RESULTS

Growth performance, feed utilization and survival of *Oreochromis shiranus* fingerlings

The initial weight of *Oreochromis shiranus* fingerlings at the start of the experiment was not significantly different (P = 0.454) across the five diets (Table 3 & Fig. 2).

The final weight of *Oreochromis shiranus* fingerlings varied significantly (P= 0.0261) among the dietary treatments. The only significant pairwise difference was between fish fed Diet 5 and those fed Diet 1 (mean difference = 5.983 g, P= 0.0244).

All other pairwise comparisons were not statistically significant (P> 0.05). This suggests that while overall treatment differences existed, the clearest improvement in final weight was seen in fish receiving Diet 5 when compared to Diet 1. There were no significant differences (P> 0.05) in mean weight gain, specific growth rates, average daily gain, apparent feed conversation ratio, protein efficiency ratio and survival rates among fingerlings fed the five different diets. The growth curve of the fish over the experimental period is shown in Fig. (2).

Table 3. Growth performance and apparent feed conversion ratio of *Oreochromis shiranus* fingerlings fed diet (Mean ± SE)

Parameter	**Treatments**					
	Diet 1	**Diet 2**	**Diet 3**	**Diet 4**	**Diet 5**	***P*-value**
Initial weight (g)	7.675±0.829	8.512±0.766	8.183 ± 0.639	9.470 ± 0.304	9.233± 0.992	0.454
Final weight(g)	21.608±1.062^{b}	23.697±1.347^{ab}	26.225±1.413^{ab}	25.970±1.959^{ab}	27.592±0.361^{a}	0.026
Mean weight gain (%)	186.797±27.412	180.931±16.902	223.410±25.717	174.142±6.616	207.320±39.652	0.547
SGR(%/day)	1.244± 0.109	1.22.5± 0.071	1.390±0.009	1.200± 0.029	1.318± 0.146	0.547
ADG	0.166± 0.014	0.181± 0.018	0.215± 0.024	0.196± 0.022	0.219± 0.028	0.613
AFCR	5.812± 0.519	6.459± 0.702	6.954± 1.382	7.517± 1.364	6.690± 0.914	0.990
PER	0.645± 0.0.085	0.635± 0.085	0.704±0.109	0.627±0.083	0.669± 0.108	0.990

^{abc} *Means with different superscripts in the same row are significant at P< 0.05.*

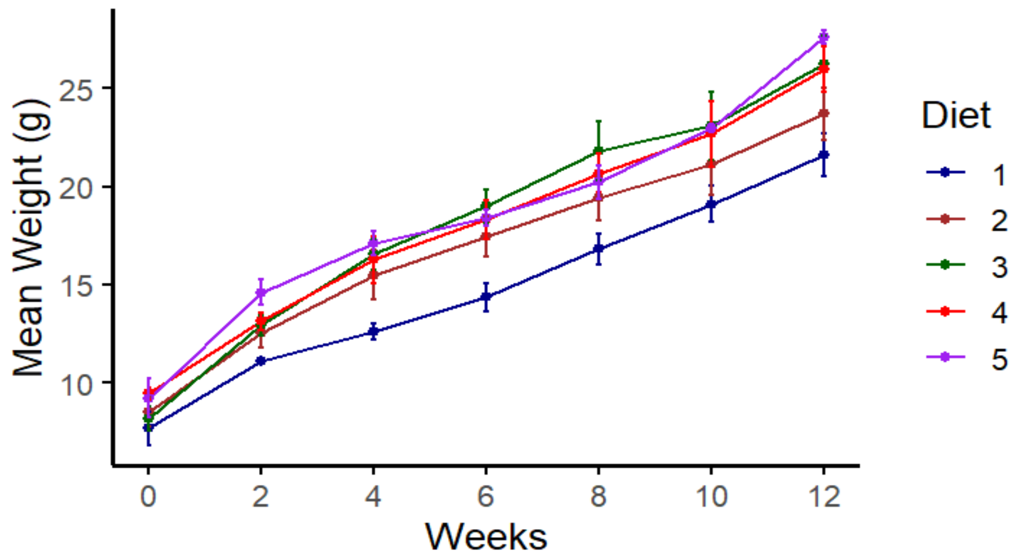

Fig. 2. Growth performance of *Oreochromis shiranus* fingerlings during experimental period

Apparent digestibility

The apparent digestibility coefficients (ADCs) for protein, fat, fiber and ash in *Oreochromis shiranus* fed five different diets are presented in Table (4). Statistically significant differences (P< 0.05) were observed among treatments for all the nutrients tested.

Table 4. Apparent digestibility coefficients (%) of nutrients in *Oreochromis shiranus* fed diets (Mean ± SE)

Parameter (%)	**Treatments**					
	Diet 1	**Diet 2**	**Diet 3**	**Diet 4**	**Diet 5**	***P*-value**
Protein	78.333±0.333^{d}	80.833±0.441^{c}	82.833 ± 0.167^{b}	80.833 ± 0.167^{c}	85.5± 0.289^{a}	< 0.001
Fat	83.300±0.473^{d}	84.867±0.186^{c}	87.700±0.351^{b}	86.033±0.033^{c}	90.167±0.167^{a}	< 0.001
Fiber	52.500±1.259^{b}	52.300±0.252^{b}	56.100±0.379^{a}	54.067±0.348^{ab}	56.±0.833^{a}	0.0021
Ash	27.500± 0.289^{c}	31.000±0.577^{b}	33.467±0.291^{ab}	30.833±0.291^{b}	35.867±0.441^{a}	< 0.001

****Values are presented as Mean ± Standard Error (SE) based on triplicate measurements (n= 3). ^{abc} Means with different superscripts in the same row are significant at P< 0.05.*

Protein ADC (%)

The apparent digestibility coefficient (ADC) for protein varied significantly ($P < 0.001$) among the experimental diets. The highest protein ADC was observed in fish fed Diet 5 (85.5 ± 0.29%), which was significantly higher than those fed Diet 1 (78.33 ± 0.33%), Diet 2 (80.83 ± 0.44%), Diet 3 (82.83 ± 0.17% and Diet 4 (80.83 ± 0.17%) ($P < 0.001$ in all cases). Fish fed Diet 3 (82.83 ± 0.17%) exhibited a significantly higher protein ADC than those fed Diet 1, Diet 2 and Diet 4. Diet 2 and Diet 4 were not significantly different from each other.

Fat ADC (%)

Fat ADC (%) varied significantly ($P = 0.000000110$) across the diets, ranging from 83.30 ± 0.47% in Diet 1 to 90.17 ± 0.17% in Diet 5. Tukey's test revealed that Diet 5 had a significantly higher Fat ADC than all other diets ($P < 0.001$). Diet 3 was significantly higher than diets 1 and 2 ($P < 0.001$), while Diet 4 was significantly different from Diet 1 ($P = 0.00038$) but not from Diet 2 ($P = 0.094$).

Fiber ADC (%)

There were significant differences in Fiber ADC (%) among the diets ($P = 0.0021$). Values ranged from 52.30 ± 0.25% in Diet 2 to 56.00 ± 0.83% in Diet 5. Tukey's pairwise comparisons indicated that Diet 5 had a significantly higher Fiber ADC (%) than Diet 1 ($P = 0.0074$) and Diet 2 ($P = 0.0054$). Diet 3 was also significantly different from Diet 1 ($P = 0.0236$) and Diet 2 ($P = 0.0171$).

Ash ADC (%)

Significant differences ($P < 0.001$ were observed for ash ADC (%) across diets, ranging from 27.50 ± 0.29% in Diet 1 to 35.87 ± 0.44% in Diet 5. According to Tukey's test, Diet 5 had a significantly higher ash ADC than all other diets ($P < 0.001$). Diet 3 also exhibited significantly higher ash ADC than Diet 1 ($P < 0.001$) and Diet, while differences between Diet 2 and Diet 4 were not statistically significant.

Water quality parameters

No significant differences ($P > 0.05$) were detected in temperature, dissolved oxygen and ammonia among the five treatments (Table 5). These findings suggest that the different feed treatments had no significant influence on the water quality parameters measured during the experimental period.

Table 5. Water quality parameters recorded in all treatments during the 12-week period of rearing *Oreochromis shiranus* fingerlings

Parameter	**Time**	**Treatments**					
		Diet 1	**Diet 2**	**Diet 3**	**Diet 4**	**Diet 5**	***P*-value**
Temperature	am	21.467±0.202	21.805±0.276	21.941±0.312	21.879±0.300	21.659±0.247	0.445
	pm	23.172 ±0.272	23.543 ±0.294	23.821±0.331	23. 686±0.354	23.494±0.287	0.571
Dissolved oxygen	am	3.978±0.045	4.110±0.044	4.140±0.044	4.114±0.045	3.998±0.037	0.574
	pm	3.919±0.06	4.058 ±0.048	4.113±0.051	4.094±0.057	4.020±0.049	0.123
pH	am	6.10-8.92	6.20-8.92	6.35-8.80	6.23-8.95	6.12-8.1	-
	pm	6.51-8.92	6.50-8.92	6.41-8.90	6.50-8.99	6.48-8.77	-
Ammonia		0.322±0.039	0.267±0.039	0.328±0.039	0.311±0.038	0.283±0.039	0.693

NB: Means are not significantly different (P> 0.05). Values are expressed as Mean ± Standard Error (SE), based on triplicate measurements (n = 3). A dash (-) in pH indicates parameters that were not statistically analyzed.

DISCUSSION

Growth of fish and feed utilization

The absence of significant differences in initial weight among treatments confirms effective randomization and uniform stocking **(M'balaka *et al*., 2012; M'balaka & Kassam, 2015)**. Growth performance indices (weight gain, ADG, SGR, AFCR, PER) also showed no significant variation across diets, consistent with studies reporting that isonitrogenous feeds often yield similar outcomes in tilapia when crude protein (CP) is standardized **(Liti *et al*. 2005; Loum *et al*., 2013; Muin *et al*., 2017)**. This suggests that once dietary CP requirements (~32% in this study) are met, ingredient differences exert limited influence on growth. From a management perspective, this indicates that alternative, cost-effective feed formulations can sustain fish performance when CP is maintained.

Final body weight, however, differed significantly, with Diet 5 (locally manufactured) outperforming Diet 1 (imported). Diets 2 and 3 (farm-formulated) produced intermediate results, statistically comparable to both commercial and local feeds, while Diet 4 (imported) also overlapped with these groups. Similar outcomes have been reported where local feeds matched or exceeded commercial diets when nutritional specifications were met **(Musiba *et al*., 2014; Limbu 2015)**. These findings highlight the potential of properly formulated local feeds to rival imported products, supporting the development of domestic aquaculture feed industries and reducing dependency on imports.

Survival rate

All five diets supported 100% survival of *Oreochromis shiranus* fingerlings during the 12-week trial. Similar high survival rate has been reported in other studies. **Manh *et al*. (2024)** reported high rates in snakehead fish fed black soldier fly larvae while **Nairuti *et al*. (2021)**, recorded a survival percentage exceeding 97 across treatments. These outcomes confirm that both formulated and commercial floating feeds met the nutritional and physiological needs of the fish. In addition, the consistency reflects effective husbandry and water quality management, aligning with broader findings that survival rates near 100% are achievable under proper culture conditions **(Simasiku *et al*., 2024)**.

Nutrient digestibility

Significant differences were observed in the apparent digestibility coefficients (ADCs) of protein, fat, fiber and ash among the five diets fed to *Oreochromis shiranus* fingerlings, reflecting differences in ingredient composition, feed quality and processing.

Protein digestibility was at its highest value in fish fed the locally manufactured feed (Diet 5), significantly exceeding the imported (Diets 1 and 4) and farm-formulated feeds (Diets 2 and 3). This aligns with findings in tilapia where balanced floating feeds yield protein digestibility values of 80–89% **(Tran-Ngoc *et al*., 2019)**. Diet 3, containing fishmeal and soybean meal, also recorded higher protein ADCs than diets 1 and 2, consistent with reports elucidating that fishmeal enhances digestibility due to its amino acid profile and low fiber content **(Muniasamy *et al*., 2024)**. The similarity between Diet 2 and Diet 4 suggests that properly processed plant-based proteins can match commercial formulations **(Estruch *et al*., 2018)**.

Fat digestibility was also the greatest in Diet 5, likely due to better lipid quality **(Sarker *et al*., 2016)**. Diet 3 outperformed diets 1 and 2, reflecting the positive effect of fishmeal-derived fatty acids **(Santiago & Lovell, 1988)**, while the lower values in Diet 2 may relate to plant oils and fiber interfering with lipid absorption **(El-Naggar *et al*., 2021)**.

Fiber digestibility followed a similar trend, with Diet 5 significantly higher than Diets 1 and 2. Although tilapia generally show limited fibre digestibility (30–60%; **Lupatsch *et al*., 1997)**, extrusion processing can enhance fiber utilization **(De Vries *et al*., 2012)**. The fiber levels in Diet 5 appeared within tolerable limits, supporting good digestibility and growth, unlike the negative effects reported in high-fiber diets **(Adamidou *et al.*, 2011)**.

Ash digestibility also varied, with Diet 5 again superior, likely due to better mineral sources and processing that reduce anti-nutritional factors **(Rousseau *et al*., 2020)**. Diet 3's higher ash ADC compared with diets 1 and 2 reflects the contribution of fishmeal and premixes, known to improve mineral bioavailability **(Santiago & Lovell, 1988)**.

Water quality parameters

Throughout the 12-week trial, water quality parameters, temperature, dissolved oxygen (DO), ammonia and pH remained stable across all treatments, with no significant differences. pH values (6.10–8.99) were within the optimal range for tilapia culture (6–9) **(Kassam & Sangazi 2016; Chipepe *et al*., 2021)**. Results are consistent with earlier *Oreochromis* studies **(M'balaka *et al*., 2012)**. DO levels indicated adequate aeration and stocking density, essential for growth and disease resistance **(Abdel Tawwab *et al*., 2015)**. Ammonia stayed well below the toxic threshold of 0.48mg L^{-1} **(López-Jiménez 2024)**, reflecting effective feed and water management. Water temperature also remained within the optimal growth range for tilapia **(Makori *et al*. 2017)**. The minimal variation in all parameters confirmed good husbandry and provided a stable environment for assessing dietary effects, without confounding stressors.

CONCLUSION

This study evaluated five floating diets. Two imported, two farm-formulated and one locally manufactured for their effects on the growth, survival, digestibility and water quality for *Oreochromis shiranus* fingerlings. All diets supported good survival, with significant variation in growth performance; the locally manufactured feed (Diet 5) achieved the highest final weight. Digestibility coefficients for protein, lipid, fiber and ash were also the highest in Diet 5, suggesting improved ingredient quality and processing. Water quality parameters remained within optimal ranges across treatments, indicating that differences in fish performance were caused by feed composition rather than environmental conditions. These findings demonstrate that locally produced feeds, when properly formulated, can perform better than imported diets in supporting growth and nutrient utilization of *O. shiranus* fingerlings.

Declaration of competing interest

The authors declare no conflict of interest.

Acknowledgement

Lilongwe University of Agriculture and Natural Resources, Bunda campus, department of Aquaculture and Fisheries Science facilities were used for the layout of the experiment and proximate analysis. The CEO of Apoche Farms for the facilities in floating fish feed processing. Aqua-fish (World bank Centre of Excellence in Aquaculture and Fisheries Science) for support.

Quality assurance and ethical compliance

All chemical analyses were performed in triplicate, and the UV–visible spectrophotometer was calibrated each day using verified chromic oxide standards to ensure accuracy. Diet preparation and processing followed Good Laboratory Practice (GLP) procedures to guarantee uniformity and repeatability. Ethical clearance for the use of fish and all experimental procedures was granted by the LUANAR Research Ethics Committee, in line with Malawi's National Research Ethics Guidelines.

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