دراسة مقارنة لتأثيرات الأعلاف الطافية والغارقة على أداء النمو ونسبة التحويل الغذائي في أسماك البلطي النيلي (*Oreochromis niloticus*)تحت الظروف المخبرية

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الملخص:

استغرقت هذه الدراسة 60 يوماً لتقييم تأثير نوعين من النظام الغذائي التجاري (العائم والغاطس) على أداء النمو وكفاءة التحويل الغذائي لصغار أسماك البلطي النيلي (*Oreochromis niloticus*) التي تم تربيتها في خزانات بلاستيكية في ظل ظروف معملية خاضعة للرقابة. تم استخدام الأسماك الصغيرة بمتوسط وزن ابتدائي بلغ 13.53 ± 1.16 غ. أظهرت النتائج تفوقاً كبيراً للأعلاف العائمة على الأعلاف الغاطسة، حيث كشف التحليل الإحصائي عن اختلافات جوهرية (P<0.05) بين المعاملات A (الأعلاف الغاطسة) وB (الأعلاف العائمة) في معظم معايير النمو. سجلت المعاملة B أعلى وزن نهائي قدره 18.90 غ مقارنة بـ 16.80 غ في المعاملة A .كما حققت المعاملة B أعلى زيادة إجمالية في الوزن قدرها 5.36 غ، مقارنة بـ 3.28 غ في المعاملة A .وفيما يتعلق بمعدلات النمو، كانت أعلى القيم لمعدلات النمو النسبي والنوعي لصالح (الأعلاف العائمة) المعاملة B، مما يشير إلى كفاءتها في دعم النمو السريع. كما سجّلت المعاملة (B) أفضل معامل تحويل غذائي (FCR) بلغ 2.65، مما يدل على كفاءة استخدام أفضل للأعلاف العائمة. ويُعزى تفوق الأعلاف العائمة إلى محتواها العالي من البروتين وانخفاض فقدانه أثناء التغذية، مما ينعكس إيجابًا على أداء النمو وتحسين كفاءة التحويل الغذائي لصغار أسماك البلطي النيلي.

الكلمات المفتاحية: الأعلاف العائمة، الأعلاف الغاطسة، سمك البلطي النيلي، أداء النمو، معدل البقاء.

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A Comparative Study on the Effects of Floating and Sinking Feeds on Growth Performance and Feed Conversion Ratio in Juvenile Nile Tilapia (*Oreochromis niloticus*) Under Laboratory Conditions

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Abstract:

This 60-day study evaluated the effect of two commercial diet types (floating and sinking) on the growth performance and feed conversion efficiency of juvenile Nile tilapia (Oreochromis niloticus) reared in plastic tanks under controlled laboratory conditions. Juvenile fish were used with an average initial weight of 13.53 ± 1.16 g. The results demonstrated a significant superiority of the floating feeds over the sinking feeds, with statistical analysis revealing substantial differences ($P<0.05$) between treatments A (sinking feeds) and B (floating feeds) in most growth parameters. Treatment B recorded the highest final weight of 18.90 g, compared to 16.80 g in treatment A. Treatment B also achieved the highest total weight gain of 5.36 g, compared to 3.28 g in treatment A. Regarding growth rates, the highest values for relative and specific growth rates favored the floating feeds (Treatment B), indicating their efficiency in supporting rapid growth. Also, Treatment B recorded the best Feed Conversion Ratio (FCR) of 2.65, indicating better utilization efficiency of the floating feeds. The superiority of the floating feeds can be explained by its high protein content and low protein loss during feeding, which positively reflects on growth performance and improved feed conversion efficiency of Nile tilapia juveniles. There were no significant differences observed in the survival rate of Nile tilapia, which ranged from 98.3% to 98.1%.

Keywords: floating feeds, sinking feeds, Nile tilapia, growth performance, survival rate.

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Introduction:

The aquaculture sector is experiencing rapid growth worldwide, making it one of the most advanced food production activities in recent decades. This expansion is attributed to its ability to effectively contribute to meeting the growing demand for animal protein, in addition to its role in improving livelihoods by increasing income and creating job opportunities in coastal and rural communities (Endalew *et al*., 2020; Graham *et al.,* 2023). Among the vital elements that directly impact production efficiency in aquaculture projects, fish nutrition stands out as a crucial factor. The feeding systems used influence growth rates, improve feed conversion, and reduce feed waste, improving production quality and operational costs (Azzaydi *et al*., 2000; Mounes *et al.*, 2024).

Producing high-quality, marketable fish at a low cost is a primary goal in aquaculture activities. Therefore, nutrition is one of the most prominent daily management practices. Inappropriate feeds or ineffective feeding strategies can negatively impact overall farm performance. Hence, it is essential to select the appropriate feed quality and implement effective feeding systems as pivotal operational factors contributing to technical and economic success, primarily since feeding costs represent a significant proportion of the total operating budget (Fernandes *et al.*, 2024).

Feed is an essential component of intensive fish farming systems due to its direct impact on growth rates, body composition, and health status of farmed fish and its decisive role in determining the economic viability of fish farms (Fernández Sánchez *et al*., 2023; Rodríguez-Hernández, *et al*. 2025). Feed is also one of the most prominent components of operational costs, which may hinder the expansion of fish production when they are high (Sorensen, 2012).

Commercial fish feeds are widely available and are classified based on their physical properties, particularly buoyancy, into two main types: floating and sinking. Sinking feeds are often manufactured locally using raw materials available in the local markets, while floating feeds require more complex manufacturing processes such as extrusion, which increases their cost (Kannadhason *et al.,* 2009; Adewumi and Olaleye, 2011). Good feeds must contain all essential nutrients, including proteins, fats, minerals, and vitamins, in carefully considered proportions and a balanced composition that meets the nutritional requirements of farmed fish species (Mustapha *et al.,* 2014). These feeds should also be highly palatable, attractive to fish, and affordable for fish farmers, ensuring good economic returns (Diyaolu, 2012). Despite the low cost of sinking feeds, most do not meet ideal quality and nutritional balance standards, leading many farmers to prefer floating feeds. The advantage of floating feeds is that they are easy to monitor fish consumption, in addition to reducing the energy expended by fish to obtain food, given that they remain on the water surface, which is positively reflected in the efficiency of food conversion and growth performance (Saleh and El-Far, 2023) (Morgina *et al.,* 2025). A study by Nwokocha and Nwokocha (2013) showed that fish farmers prefer floating feeds in pond culture systems, allowing for easy monitoring of feeding rates and satiation levels. However, some fish species, especially demersal species, prefer sinking feeds, which poses a challenge in mud ponds due to increased water turbidity, which hinders fish visibility and affects the assessment of actual feeding (Kadye and Booth, 2012).

Whether floating or sinking, the choice of diet type is a significant factor influencing growth performance, survival rates, and the overall success of aquaculture projects (Hossain et al., 2018). Despite this importance, many studies on fish nutrition do not adequately address the physical properties of feed, such as buoyancy or sinking ability, hardness, and hydrostatic stability. These properties may influence fish's feeding behavior and biological responses. Ignoring these variables may lead to experimental biases that affect the accuracy of scientific interpretation of results.

This study aims to evaluate and compare the effects of using two different feed types-sinking and floating feeds-on the productive performance of juvenile Nile tilapia (*O. niloticus*). This comparison includes an analysis of differences in growth rates, feed utilization efficiency, and feed conversion ratios to identify the optimal diet type that achieves the highest production and economic efficiency in intensive aquaculture systems.

Materials and Methods

Experimental Design

Juvenile Nile tilapia (*O. niloticus*) were obtained from the fish farm of the Marine Science Center at the University of Basrah and transported to the laboratory for experimentation. The average initial weight of the fish was 13.53 ± 1.16 grams. The fish were distributed in 45-liter plastic tanks equipped with a continuous aeration system. These tanks were sterilized with a 200 ppm sodium hypochlorite solution for one hour. The fish underwent a three-day acclimatization phase before the experiment began under the same laboratory conditions. Two types of commercial diets available in local markets in Basrah Governorate were used: the sinking feeds (A) and the floating feeds (B).

The basic chemical components (moisture, crude protein, crude fat, ash, and crude fiber) were determined according to the standard methods set forth by the American Society of Agricultural Chemistry (A.O.A.C., 1990), while the carbohydrate content was calculated mathematically according to Al-Aswad (2000). Dietary energy (kcal/100g) was calculated based on (Changsu e*t al.,* 2021), using the following formula:

Energy (kcal/100g) = (protein %× 5.56) + (carbohydrate %× 4.45) + (fat %× 9.2)

Nutritional Experiment

The study included two feeding experiments using two treatments, each with three replicates. Nile tilapia juveniles were randomly distributed at the beginning of the experiment into six plastic tanks, with 10 fish per tank. The experimental feed was provided at a rate of 3% of the total fish weight daily, once at 9:00 a.m., and the experiment lasted for 60 days. Fish weights were recorded every 15 days to adjust the feed intake according to weight change. 30% of the tank water was replaced daily to maintain water quality, and unconsumed feed residues were removed using a siphon method. Environmental parameters of the tank water were monitored throughout the experiment, including temperature (C°), dissolved oxygen concentration (mg/L), and pH, using a multi-meter (YSI MPS 556 USA).

Some biological parameters were studied, according to Jobling (1993):

Weight gain (g) = final weight (g) - initial weight (g)

Relative growth rate (%) = [weight gain (g) / initial weight (g)] x 100

Specific growth rate (g%/day) = {In of final weight (g) – In of initial weight (g)} / Duration in days x 100

Fed conversion ratio = Weight of feed consumed (g) / Weight gain of fish (g)

The survival rate (%) was calculated according to the equation mentioned in Carlos (1988):

Survival rate (%) = [Number of fish at the beginning of the experiment / Number of fish at the end] x 100.

Statistical Analysis

A completely randomized design (CRD) was used to distribute the coefficients, and the resulting data were analyzed using SPSS (2000) statistical software. A comparison of significant differences between coefficients was performed at a probability level of 0.05, according to the method described by Al-Rawi and Khalafallah (2000).

Results and Discussion

The nutritional requirements of any farmed fish depend on several factors, including fish species and size, as well as other environmental parameters such as water temperature, physiological condition, and stress (Piska and Naik, 2013). Some ecological factors were monitored during the different periods of the experiment. Water temperature ranged between

24.6°C and 26.2°C, dissolved oxygen concentration ranged from 6.5 to 6.8 mg/L, and pH ranged from 6.7 to 6.8. The measurement results indicated that all of these environmental parameters fall within the optimal limits for raising Nile tilapia juveniles, as confirmed by Abdel-Hakim *et al.* (2002) and Abdelhamid *et al.* (2002), who considered these values suitable for the growth of this species. Nile tilapia juveniles responded well to the commercial feeds used in the experiment after a short acclimatization period.

Figures 1 and 2 illustrate the chemical composition of the sinking and floating feeds, with 25.1% and 31.58% crude protein contents, respectively. These levels are consistent with recent recommendations for protein requirements in Nile tilapia diets during the grow-out phase. Novodworski *et al.* (2024) indicated that the optimum crude protein level is approximately 29.8% when using fishmeal-free diets. Meurer *et al.* (2025) demonstrated that reducing protein levels to approximately 25–30%, while enriching the diet with essential amino acids, contributes to good growth performance and improved protein utilization efficiency, which enhances environmental sustainability in intensive aquaculture systems. In this regard, Santiago and Lovell (1988) recommended an optimum protein requirement for Nile tilapia growth of 25–35%, and the dietary protein content in the current study is consistent with their recommendations.

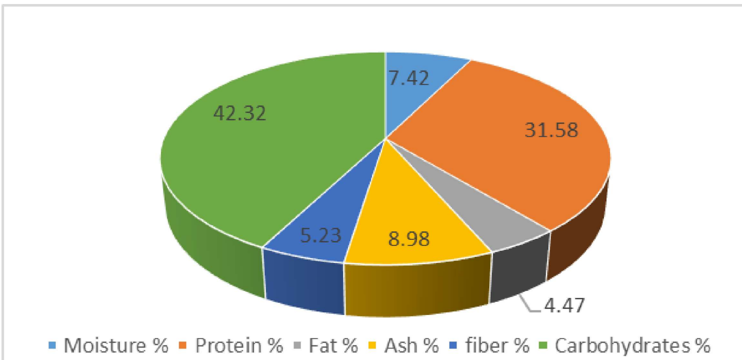

Figure (1): The chemical composition of the floating feeds used in the feeding experiment.

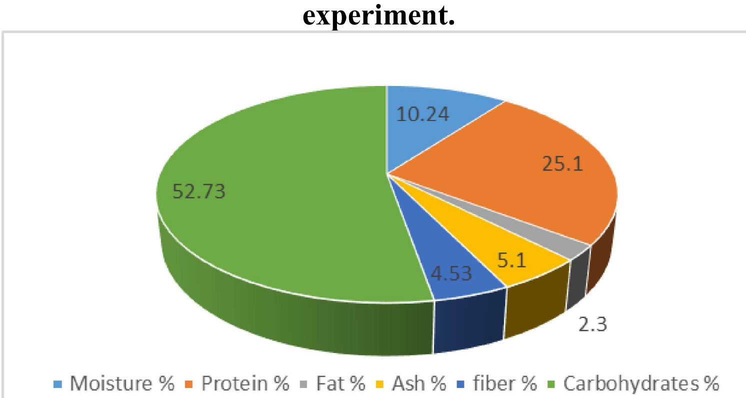

Figure (2): The chemical composition of the sinking feeds used in the feeding experiment.

The analysis results showed that the floating feeds contained higher percentages of crude fat and energy values compared to the sinking feed, recording 4.47% crude fat and 405.02 kcal/100 g of feed, compared to 2.30% fat and 395.35 kcal/100 g in the sinking feed. Figure (3) shows the energy values of the two feeds. It was also found that the ash percentage was higher in the floating feed (8.98%) compared to 5.10% in the sinking feed, reflecting a significant difference in the nutritional composition between the two types (El Sayed, 2019).

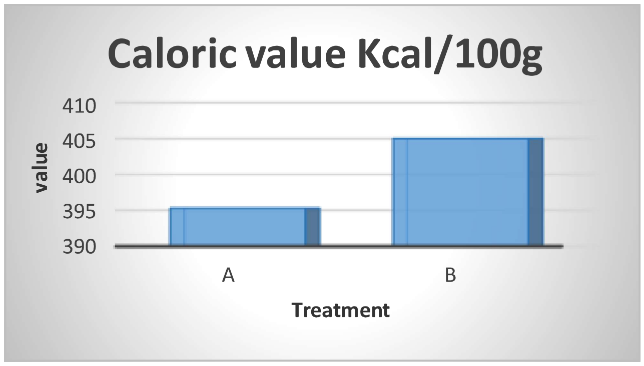

Figure (3): Energy values in the diets used during the experiment

Data from Table 1 on growth parameters during the feeding trial period showed no significant differences (P>0.05) between treatments A and B concerning the initial weight averages, which reached 13.52 g and 13.54 g, respectively, indicating the homogeneity of the fish at the start of the trial. However, statistical analysis revealed significant differences (P<0.05) in the final weight averages, relative growth rate, specific growth rate, and feed conversion efficiency between the two groups. Treatment B, which used a diet containing 31.58% protein, outperformed treatment A in production performance, recording a total weight gain of 5.36 g compared to 3.28 g in treatment A. This indicates that Nile tilapia juveniles could utilize higher protein more efficiently under the current study conditions, making this protein level suitable for improving growth. These results are consistent with the findings of El-Sayed (2019), which indicated that Nile tilapia exhibits the best growth rates when diets containing 30–32% protein, especially in the early stages of growth. The results of the current study support the findings of Amany *et al.* (2019), who found that increasing the protein level in the feed is associated with increased growth rates and feed conversion efficiency in tilapia, provided that the feed components are balanced. This superiority is partly attributed to the type of diets used (floating or sinking), as the kind of diet plays a vital role in feeding efficiency. Recent studies have shown that floating feeds contribute to improving growth performance due to their ease of consumption by fish and reducing waste, compared to sinking feeds, which may lose part of their nutritional value at the bottom of the pond. This makes choosing the diet a key factor in improving feeding efficiency and growth (Paulpandi *et al.,* 2024).

Table 1: Growth parameters during the experimental period (average ± standard deviation)

Growth parameters	Feeds A	Feeds B
Initial weight (g)	^{a}0.13 ±13.52	^{a}13.54±0.21
Final weight (g)	0.39 ^{a}± 16.80	^{b}0.54 18.90 ±
Total weight gain rate (g)	^{a}3.28 ± 0.12	^{b}5.36 ± 0.28
Relative growth rate (%)	^{a}0.68±24.26	^{b}1.32± 39.58
Specific growth rate (% g/day)	^{a}0.362 ±0.01	^{b}0.02 0.556 ±
Food conversion rate	^{a}0.11 5.12±	^{b}0.10 2.65 ±
Survival rate (%)	%98.3	%98.1

Abou-Zied (2015) and Abdelhamid *et al.* (2019) indicated that Nile tilapia-fed floating feeds showed higher final weight and weight gain rates than those fed sinking feed. Statistical analysis of the data presented in Table 1 showed significant differences ($P<0.05$) between the studied vital indicators. This is attributed to the effect of the feeds type (floating or sinking) and the resulting interaction on growth performance, as the floating feeds remains on the surface, encouraging fish movement and adequate feeding, thus enhancing final weight gain. Regarding the relative and specific growth rates, treatment A recorded values of 24.26% and 0.362 (g/day%), respectively, while these values increased in treatment B to 39.58% and 0.556 (g/day%), respectively. These results indicate that fish fed on the floating feeds showed faster growth rates than those fed the sinking feeds. These results are consistent with those of Yaqoob *et al.* (2010). Researchers have observed higher growth rates in fish species when using floating feeds. A recent study (Zaabwe *et al*., 2024) supported these findings, finding that feeding *Coptodon rendalli* fish with floating feeds resulted in higher growth rates, improved feed conversion efficiency, and protein digestibility compared to sinking feeds. Treatment A showed an apparent decline in feed conversion efficiency, with a Feed Conversion Ratio (FCR) of 5.12 compared to treatment B, which recorded a better FCR of 2.65. This difference can be explained by the fact that the type of feed and water quality contributed to the improved FCE. El-Sayed (2019) indicated that the type and method of feed provision, in addition to environmental factors such as water temperature and oxygen concentration, play a pivotal role in determining FCE in farmed fish. Survival rates were similar in both treatments, possibly due to technical reasons related to the fish farming system. No significant differences were observed in the survival rate of Nile tilapia, which ranged from 98.3% to 98.1%. In a previous study, the survival rate of tilapia in floating cages ranged from 95.76% to 97.54% (Ahmed *et al*., 2014) and 95.39% to 95.87% (Kunda *et al.*, 2015).

The improved growth of fish fed on floating granular feed above the water surface may be due to the increased fish movement and increased fish activity resulting from fish ascent to the water surface to feed, which improves digestion and feed absorption. However, sinking feed will lose some nutrients due to fish movement, and some will sink to the bottom and mix with the mud. Consequently, the fish will not benefit from it. Instead, water properties will change due to the accumulation of dissolved feed residues in the water, causing an increase in the total ammonia concentration in the pond. Floating feed performed better than sinking feed with the same composition due to more nutrients leaching from the sinking feed than the floating feed (Yaqoob *et al.,* 2010). Therefore, pelleted feed floating above the water surface may be responsible for the improved growth parameters of the floating feeds fed to fish. Hence, the low water stability of sinking feeds leads to excessive leaching of nutrients in the feed before the fish consume it. This reduces feed conversion, impairs water quality, increases production costs, and thus reduces economic efficiency (Abdelhamid *et al.,* 2019).

Conclusions:

1. The data showed that environmental parameters (temperature, dissolved oxygen, and pH) were within the optimal range for raising Nile tilapia juveniles, providing a suitable environment for their natural and efficient growth.

2. Nile tilapia juveniles responded well to the two commercial feeds used (floating and sinking), but their performance was better when using the floating feed with the higher protein content.

3. The floating feed, which contained 31.58% crude protein, significantly improved production performance compared to the sinking feeds, which contained 25.1%, in terms of growth rates, feed conversion efficiency, and weight gain.

4. The results showed that the type of (floating or sinking) significantly affected feed consumption and growth rates. The floating feeds performed better due to its ability to remain on the water surface, ease of consumption, and reduced food loss.

5. The floating feeds had a superior feed conversion ratio (2.65) compared to the sinking diet (5.12), indicating greater utilization efficiency and better economic growth.

6. Survival rates were high in both treatments (98.1–98.3%), indicating that the diet type did not significantly affect survival rates.

Recommendations:

1. During the grow-out stages, it is recommended that Nile tilapia juveniles be fed high-protein floating diets (30–32%) to achieve the highest growth rates and feed conversion efficiency.
2. If using a sinking diet, it is recommended that manufacturing techniques and nutrient content efficiency be improved to improve stability in the water and reduce feed loss.
3. Continuous monitoring and stabilization of environmental factors, such as temperature, pH, and oxygen levels, is necessary to ensure a suitable environment for growth and avoid stress.
4. Sinking diets should be avoided in systems that do not allow for easy cleaning or waste removal to reduce organic matter accumulation and improve water quality.
5. Adopting a feeding system based on floating diets reduces feed costs by reducing waste and enhances environmental sustainability by reducing pollutants from feed residues.
6. Additional studies are recommended to compare different types of artificial diets (floating, semi-floating, and sinking) with various protein levels to determine the optimal formulation in terms of economic and environmental efficiency.

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