Evaluation of *Suaeda aegyptiaca* as a Partial Replacement for Wheat Bran in Diets of Nile Tilapia (*Oreochromis niloticus*) Effects on Growth Performance and Feed Conversion under laboratory conditions

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Abstract

The use of alternative feeds is a modern trend in aquaculture aimed at reducing production costs and maintaining productive efficiency. This study aimed to evaluate the growth performance of *Oreochromis niloticus* fish when wheat flour was replaced with *Suaeda aegyptiaca* (salt-producing plant) powder at ratios of 0, 25, 50, and 100%. Ninety-six fish with an average initial weight of 47.28 ± 0.68 g were used. They were randomly distributed into 12 plastic tanks (30 × 30 × 60 cm) at a density of 8 fish per tank. The experiment was designed as a four-treatment system with three replicates per treatment. The fish were fed the experimental diets for 60 days at a daily feeding rate of 3% of their body weight, with adjustments made every 15 days. Statistical analysis revealed significant differences ($P < 0.05$) in Favor of the 25% substitution treatment in final weight, total and daily weight gain, relative and qualitative growth rates, and feed conversion ratio, compared to the other treatments. In contrast, no significant differences ($P > 0.05$) were observed between the 50% and 100% treatments in the studied growth indicators. The 25% treatment achieved the highest weight gain (75.10 g), the best relative (58.94%) and qualitative (1.103%/day) growth rates, and the best feed conversion efficiency (2.16). These results indicate the potential for substituting up to 25% of wheat flour with *S. aegyptiaca* plant powder without negatively impacting growth performance or feed conversion efficiency, thus supporting its use as an alternative feed source in Nile tilapia diets within sustainable aquaculture systems.

Keywords: Tilapia nutrition, halophytic plants, wheat bran replacement, feed conversion ratio, plant protein, aquaculture feed.

Introduction

Aquaculture, especially fish farming, is one of the most important food-producing sectors on a global basis, as the increasing population has led to an increase in the need for it, and thus the intensification of production and aquatic feed (Karlsen & Skov, 2022).

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Fish meat is of high nutritional importance and a good source of proteins, vitamins and essential minerals, as well as a source of long-chain omega-3 unsaturated fatty acids, which have positive health effects on heart and body health, and some minerals, including iodine, iron and zinc (Abolnazr, 2022; Pokorný & Froněk, 2021). The development of fish farming has led to a significant increase in production to meet the increasing demand for fish protein (Wee *et al.*, 2022).

The increasing trend in the cost of fish feed poses a challenge in intensive farming systems (Iqbal *et al.*, 2020a; Bjørndal *et al.*, 2024), with dietary protein identified as the most expensive component in fish production. In general, feed cost accounts for about 56.45–58.49% of the total production expenditure in aquaculture (Hossain *et al.*, 2022). In specific cases, it may escalate to 60–70% (Prodhan and Khan, 2018; Hossain *et al.*, 2020a, b). Rapidly increasing and volatile prices of protein and concentrate feeds are important factors in animal production, with fish feed accounting for more than 50% of the total cost in fish farming. The costs of major feed ingredients such as fishmeal and grains (soybean, rice bran, wheat, maize, etc.) are affected by climate, global economic growth, and fuel costs. As a result, the use of low-cost alternative feeds could be a suitable strategy to increase the sustainability of animal production systems and bridge the gap between feed requirements and availability (Wong *et al.*, 2016; Tiwari & Dhakal, 2021).

Many studies have addressed the possibility of using plants as feed additives or alternatives to traditional feed ingredients in fish feed. They have received a number of studies, including the study by Pu *et al.* (2017) which is related to improving growth performance in fish due to the positive effect of some biologically active substances on metabolism and their ability to enhance protein synthesis and activate digestive enzymes. The study by Mehrim *et al.* (2022) enhanced the growth of gonads in some fish species. The study by Helmiati & Isnansetyo (2021) evaluated the immune response of red tilapia fish fed fermented Moringa oleifera leaves at levels up to 30% of fish meal replacement. Medicinal plants were used as a cheap source of protein to replace protein in fish meal and proved their effectiveness in this regard (Awad & Awaad, 2017).

Other studies have confirmed that the intake of plant extracts improves the digestibility of nutrients, thus leading to increased feed conversion efficiency, as well as protein synthesis (Talpur *et al.*, 2013). The apparent digestibility of protein, energy and individual amino acids is of fundamental importance as a basis for the formulation of feeds for fish. With the information gained from different raw materials, such as plants commonly used in the manufacture of feeds, the use of non-traditional feeds of plant origin has been limited due to the presence of growth inhibitory factors such as alkaloids, glycosides, oxalic acids, phytates, protein inhibitors, hematoglobin, saponins, momosin, cyanoglycosides and linmarin despite their nutritional value and low-cost effects (Sogbesan, 2006).

Apart from being a cost-effective and sustainable alternative to fish meal, plant proteins can support proper fish health and growth performance. The present study aims to evaluate them the *Suaeda aegyptiaca* plants that can be used to improve growth performance, and this plant is considered to be resistant to high temperatures, Salinity and contains high protein. disease resistance and reproduction in these fish species by improving the growth performance and feed conversion of fish.

Materials And Methods

Fish

96 Fish were used in the experiment Juvenile Nile tilapia *O. niloticus* were brought from the aquaculture station of the Marine Science Center, University of Basrah to the laboratory for the purpose of conducting the nutritional experiment. The raw materials used in the composition of the feed (fish meal, soybean meal, yellow corn, wheat flour, barley, vitamins and minerals) were added to it with millet powder in different proportions, according to the methods mentioned in (A.O.A.C., 2005).

Nutritional experience

The experiment included four treatments with three replicates for each treatment as follows:

-First treatment – control.

Plant *Suaeda aegyptiaca* (plat,1). -Second treatment – feed A with 25% Suwwad added.

-Third treatment – feed B with 50% Suwwad added.

-Fourth treatment – feed C with 100% Suwwad added

Fig.1 Nile tilapia *O. niloticus* was used with an initial weight of (0.05±27.85) g and two replicates for each treatment. The fish were distributed into 12 plastic tanks measuring 30 × 30 × 60 cm with a capacity of 45 L with (4) fish per tank and provided with a source of Aeration pumps. Experimental feeds were made from the materials shown in Table (1), where they were ground, sieved, and then heat treated after mixing the formula. After it cooled, a mixture of vitamins and minerals was added to it (Al-Dubakel *et al*., 2014).

The fish were starved for five days before starting the experiment for the purpose of acclimatization and were fed for (60) days at a rate of two meals per day at a feeding rate of 3% of the body weight per day. Weight measurements were taken for the fish every (7) days using a Stanton electric balance to the nearest 0.1 g to monitor the growth of the fish and change the amount of feed provided according to the increase in the weight of the fish, with follow-up of measuring some environmental factors such as dissolved oxygen mg/l, temperature °C, pH, and salinity (g/l). Some growth indicators were studied according to the following equations (Jobling, 1993).

weight gain rate (g)= Final wt – Initial wt

Growth rate (g)= Final wt – Initial wt/ Time

Relative growth rate (%)= [(final weight - initial weight) / Initial weight] × 100

Specific growth rate (% /day)= [ln (final weight)–ln (initial weight)] / Period (days) × 100

Feed conversion ratio = dry food consumption (g) / Weight gain(g).

Growth rate = Final wt – Initial wt/ Time.

Statistical analysis

The ready-made statistical program (SPSS, 2000) was used to compare the results of growth rates and feed conversion across for the different treatments, and the results they were compared at a significance level of (0.05), The Minitab program version 16.1 software was used to perform analysis of variance (One-Way ANOVA) to determine whether there were significant differences or not.

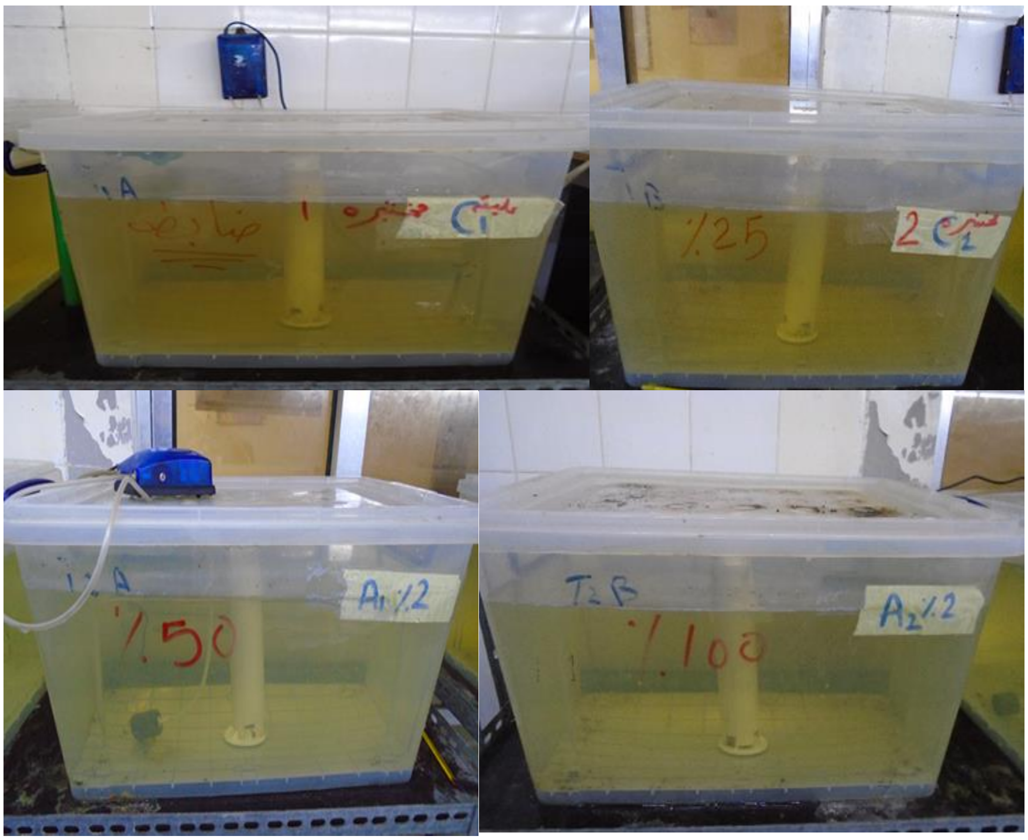
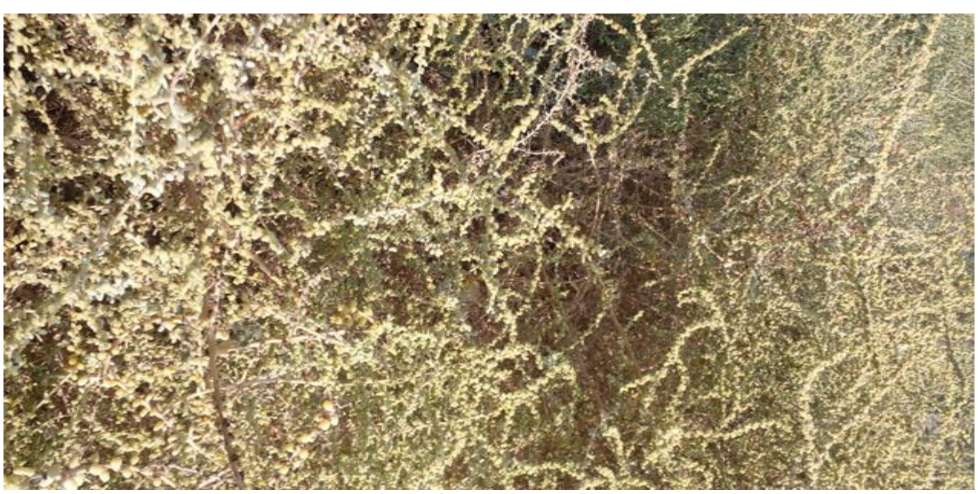


Figure (1) The Tanks used in the experiment.



Plat (1) *Suaeda aegyptiaca* plant.

Table (1): Proportions and components of raw materials for the feeds used during the trial period.

The components	%			
	Diet 1	Diet 2	Diet 3	Diet 4
fish meal	30	30	30	30
Soybean meal	25	25	25	25
yellow corn powder	15	15	15	15
Wheat	20	14	8	0
Barley	8	8	8	8
Vitamins and minerals	2	2	2	2
Schanginia aegyptiaca powder	0	6	12	20

Results

This study was conducted over 60 days to evaluate the replacement of wheat bran with tahini plants by assessing growth performance and determining initial and final weight rates, weight gain, specific and daily growth rates, and feed conversion ratio of tilapia fish. Environmental factors of the rearing water were evaluated within the appropriate limits for rearing, with temperature between 0.90-30.17°C, oxygen concentration rates ranging between 0.07-6.25 and 0.27-7.05 mg/l, salinity between 0.09-5.03 g/l and 1.15-10.43 g/l, and pH between 0.29-7.76 and 0.35 - 7.83.

Table (2) shows significant differences ($P<0.05$) in tilapia fish between initial and final weight rates, daily and qualitative growth rates, and feed conversion ratio across control ponds and ponds A, B, and C. Statistical analysis of the differences between rates also revealed significant differences ($p<0.05$) between all growth indicators for tilapia fish.

Table (2): Growth indicators during the experimental period (mean ± standard deviation).

Growth indicators	Treatments			
	Control	A	B	C
Initial weight (g)	1.05±47.27a	0.58±47.25a	0.76±47.00a	0.56±47.60a
Final weight (g)	0.55±70.77b	0.60±75.10a	0.66±59.13c	0.85±59.40c
Weight gain rate (g)	0.53±23.50b	0.06±27.85a	0.25±12.13c	0.72±11.80c
Growth rate (g/day)	0.013±0.560b	0.001±0.663a	0.006±0.289c	0.016±0.281c
Relative growth rate (%)	2.20±49.71b	0.69±58.94a	0.83±25.81c	1.66±24.79c
Specific growth rate (%/day)	0.036±0.961b	0.01±1.103a	0.015±0.547c	0.03±0.527c
Feed conversion ratio	0.09±2.47b	0.02±2.16a	0.11±4.34c	0.32±4.53c

*Different letters indicate significant differences at the 0.05 level

Table (3) shows the chemical composition of the feeds used in the experiment for *Suaeda aegyptiaca*. It is noted that the protein content is high in feeds from Control to C, which leads to high energy production.and Energy was calculated based on Changsu *et al*. (2021) using the following formula:

Energy (Kcal / 100g) = (%protein × 5.56) + (%Carbohydrate × 4.45) +(%Fat × 9.2)

Table (3): The actual chemical composition of the feeds used in the experiment.

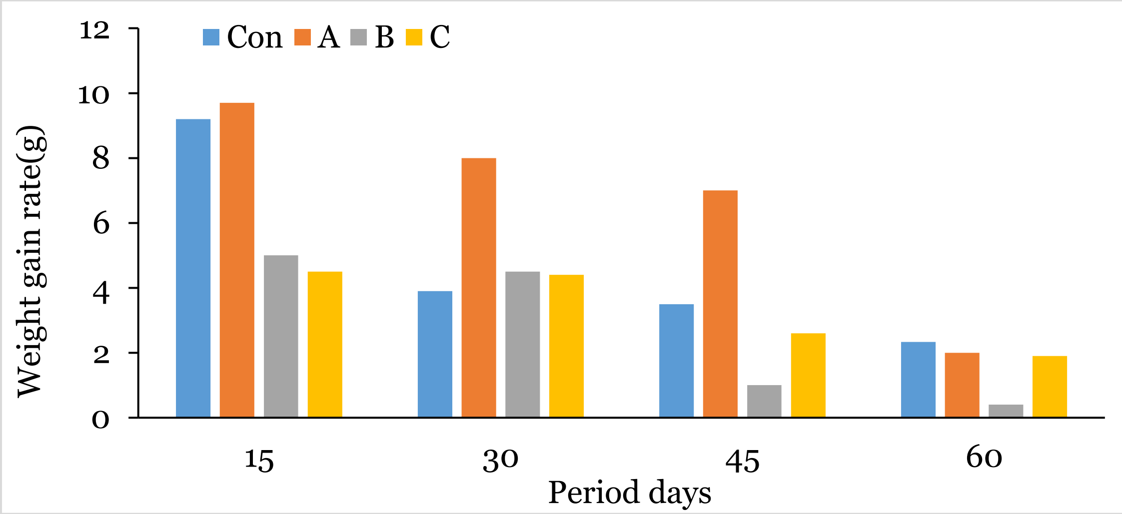
The components	**%**			
	Control	**A**	**B**	**C**
moisture	11.6	9.39	10.38	9.52
Protein	32.75	32.65	32.55	32.43
Fat	7.34	7.43	7.53	7.66
Ash	7.30	8.42	9.56	11.09
carbohydrate	38.08	39.00	36.68	35.75
Energy (kcal/100g)	419.06	423.43	413.46	409.86

When measuring certain elements through plant extract *Suaeda aegyptiaca* there is an increase in some extracted elements. (Table,4).

Table (4) shows the measurement of mineral elements for the plant in the laboratory of the substituted *Suaeda aegyptiaca* plant.

Mineral Elements	**Concentrations**
P µg/g	0.0525
Zn µg/g	887.162
K µg/g	90664.48
Na µg/g	133146.9
Cu µg/g	535.705
Mn µg/g	1611.289
Fe µg/g	45.6
Mg µg/g	33.701
Pb µg/g	39.36
Cd µg/g	8.145
N µg/g	433.289
Mo µg/g	27.339

Figure (2) shows the high rate of weight gain in A, reaching 9.7 g during 15 days, and while the lowest Weight gain rate during 60 days was recorded in B, reaching 0.4 g



Figure(2) Weight gain rate (g) for tilapia fish fed on different feeding ratios.

Figure (3) shows the final weights of the tilapia fish, with the highest average weight in A reaching 61.75g during 30 day, while the lowest average weight in diet control reached 52.35g, during 45 day, and shows that the rate of specific growth (%/day) during the experimental period recorded the highest specific growth in diet A, reaching 1.1g during 30 days, while the lowest specific growth was recorded in diet B, reaching 0.44g during 60 days (Figure, 4). Figure (5) shows the daily growth rate (g/day) during the experimental period. The highest growth was recorded in A group, reaching 8.8 g/day over 45 days, while the lowest growth was recorded over 15 and 30 days, reaching 0.04 g/day in groups B and C.

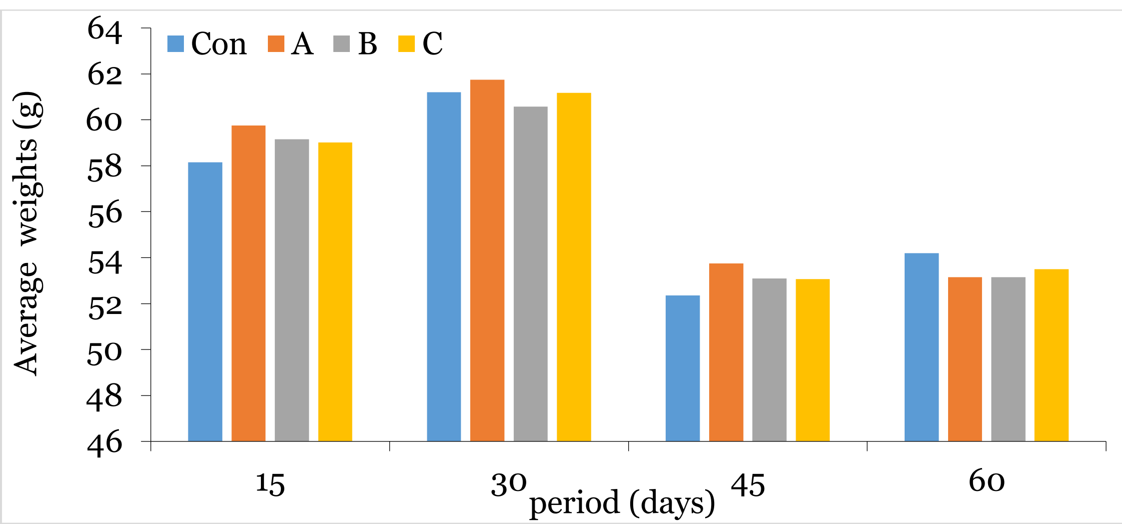


Figure (3) shows the average final weights (g) of tilapia fish fed on different feeding ratios.

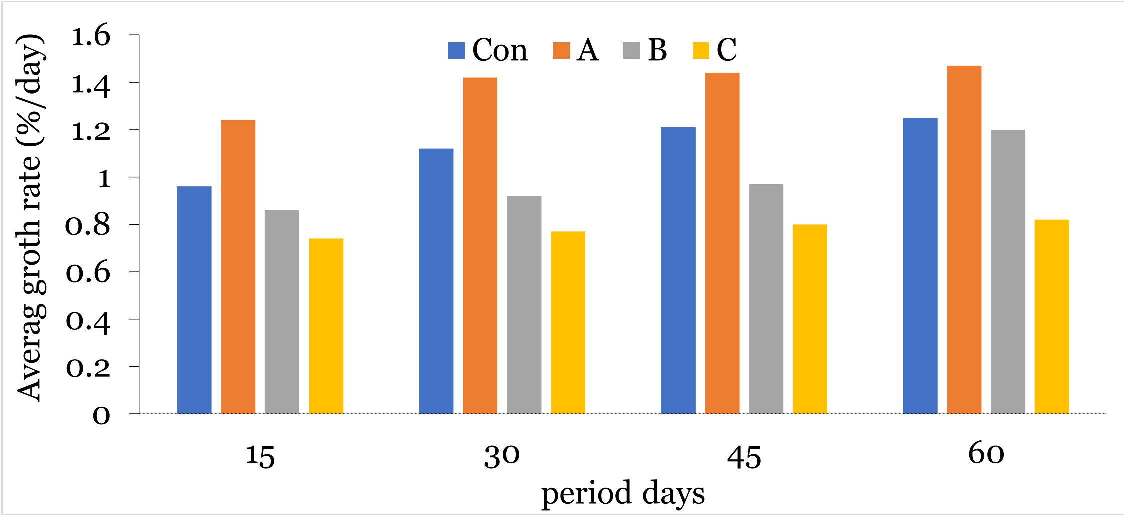


Figure (4). shows the average growth rate (%/day) of tilapia fish during different day.

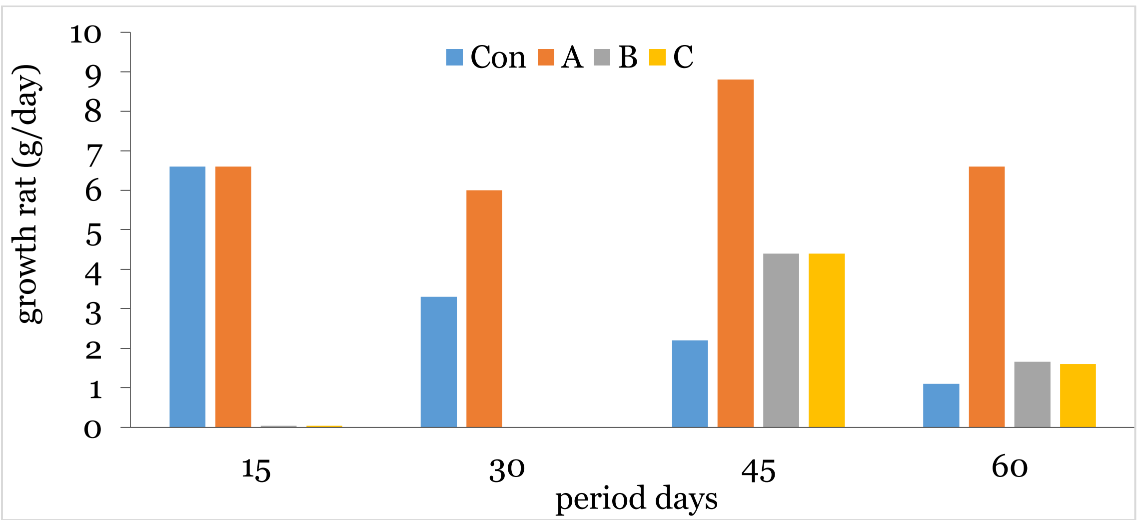


Figure (5). shows the average growth rate (g/day) of tilapia fish during different day.

Discussion

One of the most significant problems in fish farming and production is the actual amount of feed the fish need. If they are fed in insufficient quantities, most of the feed is used for survival and maintenance, resulting in poor growth and wasting time for the fish to reach marketable size at the end of the season. Conversely, if they are fed in excess of their needs, some of the feed may go uneaten, leading to a high feed conversion ratio and economic losses. Therefore, it is essential to accurately calculate the amount of feed required, especially for fish raised at high densities, where the fish rely solely on manufactured feed. Excess feed, if not consumed by the fish, will be swept away by the current, causing economic losses for the farmer (Taher *et al*., 2014). The statistical analysis in the current study revealed significant differences in final weights, weight gain, and daily and qualitative growth rates based on feeding variations.

The amount of feed provided was sufficient for the Nile tilapia, in addition to the natural food available to the fish as a result of supplying the ponds with water from the source (Russell *et al.,* 1996). When wheat bran is replaced with spelt plant to *Suaeda aegyptiaca* powder It was found that there was an increase in weight and growth indicators for the fish *O. niloticus*, and it is noted that the superiority of treatment a may be due to the high protein content in the sedge plant, and that the 15-day fish stage made the food more palatable, thus promoting faster growth. The lower fiber content in the plant is also a contributing factor. This result is consistent with what Gallagher (1994) found during his study on fish growth *Takifugu obscurus* When replacing soybean meal with small fish, and Agani *et al.* (2016) conducted an experiment in which fishmeal was replaced with four different types of soybean meal: partially soybean meal, no soybean meal, soybean meal only, and soybean meal with methionine. The results showed an average weight gain of 22.77g and an increase in length of 16.90 g.

Table (3) shows no significant differences in moisture, fat, carbohydrates, and ash, while protein levels are high for plants that receive adequate nutrition during the experiment Treatment A (32.65) showed high protein content and also high carbohydrate content., and When measuring the mineral content of the plant, it was observed that all measured elements were found in high proportions, indicating that this plant *Suaeda aegyptiaca* demonstrates nutritional efficiency under standard conditions, as shown in (Table 4), It was also noted that the weight gain and average weight in the control sample and diet A showed a greater response during the 30-60 days of the plant, reaching 27.8 g within 60 days in diet A. This result was found to be consistent with Shabbir *et al.* (2024) During his study of fish *Acanthopagrus arabicus* for cultivation experiments and biochemical analysis to evaluate feed effectiveness, as he pointed out Alanara (1996) Increasing feeding rates beyond the ideal feeding rate, or providing a quantity of food exceeding the satiation level, will prevent the fish from benefiting from the excess food.

The present study showed that increasing the feeding ratio led to higher feed conversion rates for tilapia and higher growth rates for feed rations. The current study showed higher growth rates in ration A, where the substitution ratio was 25%, as the fish accepted the ration more than the other ratios and sometimes even surpassed the control ration. This led to the fish accepting the ration as being of higher quality than the other ratios. As noted by Chowdhury (2011), increasing the feeding rate as a percentage of body weight in cultured *O. niloticus* fish in ponds did not significantly affect weight gain or final weight, but it did significantly affect feed conversion ratios and growth. It is also noted that the growth rate during the present study was evident in diet A over 60 days, with the best growth observed in diet A, followed by diets B and C respectively. Furthermore, the qualitative growth rate obtained in the current study is better than the growth rates obtained by previous researchers, including those. Appelbaum and Arockiaraj (2009) the fish were cultured and average growth rate ranged between 0.49 and 0.61 g When farming fish *sparus auratus* gilthead sea bream, and they recorded Salama and Harbi (2007) Specific growth rates of fish fingerlings Lates calcarifer, the cultured were fed levels of 1%, 2% and 4% and reached 0.04, 0.086 and 0.133 respectively. Meanwhile Bulut.*et al* (2014) achieved a qualitative growth rate when raising Two banded seabream Diplodus vulgaris fish in glass tanks using a recycling system, Shabbir *et al.* (2024) also obtained little qualitative growth when they cultured tank fish in 162L glass tanks in India, Feed conversion rates were significantly correlated with increasing feeding rates, indicating that feed conversion rates increased with higher feeding rates. This finding aligns with the 2014 study by Yusr *et al.* (2014). On the impact of feeding levels on fish *A. arabicus* the cultivated shank in concrete tanks. This does not agree with (Muhammed, 2024) during his testing of four fish feed rations grass carp *Ctenophryngodon idella* in glass tanks, the feed conversion ratio of three tested diets did not increase.

Conclusions

We conclude from the current study that Nile tilapia *O. niloticus* grows significantly and gain weight at the experimental feeding levels, Sample A showed the best growth in the study over 15 days. indicated by replacing wheat bran with plant *Suaeda aegyptiaca* during the experimental period.

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تقييم نبات السويدا المصرية كبديل جزئي لنخالة القمح في علائق سمك البلطي النيلي وتأثيراته على أداء النمو وكفاءة تحويل العلف في ظروف مختبرية

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المستخلص

يُعدُّ استخدام الأعلاف البديلة أحد الاتجاهات الحديثة في الاستزراع المائي، بهدف خفض تكاليف الإنتاج والحفاظ على كفاءة الأداء الإنتاجي. هدفت هذه الدراسة إلى تقييم أداء النمو لأسماك *Oreochromis niloticus* عند إحلال مسحوق النبات الملحي *Suaeda aegyptiaca* محل دقيق الحنطة بنسب 0، 25، 50، و100%. استُخدمت 96 سمكة بمتوسط وزن ابتدائي بلغ (47.28 ± 0.68 غم). وُزعت عشوائياً على 12 حوضاً بلاستيكياً (30 × 30 × 60 سم) بكثافة 8 أسماك/حوض. صُممت التجربة وفق نظام المعاملات الأربع مع ثلاث مكررات لكل معاملة. غذّيت الأسماك على العلائق التجريبية لمدة 60 يوماً بمعدل تغذية يومي قدره 3% من وزن الجسم، مع تعديل الكميات كل 15 يوماً. أظهرت نتائج التحليل الإحصائي وجود فروق معنوية ($P < 0.05$) لصالح معاملة الإحلال بنسبة 25% في الوزن النهائي، الزيادة الوزنية الكلية واليومية، ومعدلات النمو النسبي والنوعي، فضلاً عن معدل التحويل الغذائي، مقارنةً ببقية المعاملات. في المقابل، لم تُسجّل فروق معنوية ($P > 0.05$) بين معاملتي 50% و100% في مؤشرات النمو المدروسة. وقد حققت معاملة 25% أعلى زيادة وزنية (75.10 غم)، وأفضل معدل نمو نسبي (58.94%) ونوعي (1.103%/يوم)، إضافة إلى أفضل كفاءة تحويل غذائي (2.16). تشير هذه النتائج إلى إمكانية إحلال مسحوق نبات *S. aegyptiaca* محل دقيق الحنطة بنسبة تصل إلى 25% دون التأثير سلباً في أداء النمو وكفاءة التحويل الغذائي، مما يدعم استخدامه كمصدر علفي بديل في علائق أسماك البلطي النيلي ضمن أنظمة الاستزراع المائي المستدامة.

الكلمات المفتاحية: تغذية سمك البلطي، النباتات الملحية، استبدال نخالة القمح، نسبة تحويل العلف، البروتين النباتي، علف الاستزراع المائي.