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# Evaluation of Fermented Jojoba Meal as a plant Protein Source in Nile tilapia Diets on Growth Performance, Survival rate, Blood Biochemical and Hematological Indices

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## Abstract:

Evaluating the impact of feeding fermented jojoba meal (FJM) as a plant protein source on growth performance, feed consumption, serum biochemicals, and haematological variables was the goal of the study. Five different levels of plant protein sources (jojoba meal) fermented with Saccharomyces cerevisiae yeast (20%, 40%, 60%, and 80%) were fed to Nile tilapia. One of the five diets, T1, was a control diet without FJM, and the other four diets were designed to include FJM as follows: {T2 (20% FJM), T3 (40% FJM), T4 (60% FJM), and T5 (80% FJM)}. According to the results, the FBW, WG%, DWG, FE, and SGR values of the fish fed diets T1 (control), T2, and T3 were considerably ($P<0.05$) higher. However, the T5 had the lowest values compared to other group. The survival rate (SR%) of fish fed diets showed high rates of 97.77% in treatments T1 and T3, but there are no significant differences in this regard. Furthermore, there was no significant difference in tilapia fish FI, FCR, PER, or PPV% between groups. The outcomes demonstrated improvements in hematological and blood biochemical indices during therapy as compared to control. As a result, FJM is advised at a level of T2 (20% FJM) and T2 (20% FJM) diet, with no adverse effects on Nile tilapia fish growth performance, feed utilization, or blood health of Nile tilapia fish.

## Introduction

One significant area of global production is aquaculture **(Qing, 2022)**. Production currently satisfies around half of the world's demand, with that percentage predicted to increase to 70% by 2030 **(Obiero et al., 2019)**. Protein from plant sources, particularly oil seed meals, shows promise. The oil extraction business produces these meals as a byproduct **(Shchekoldina and Aider, 2014; Hassaana et al., 2018)**. Solid state fermentation (SSF), which has been shown to be highly effective with a variety of microbes on a variety of substrate materials, is one of the strategies that have been proposed to reduce anti-nutritional factors (ANFs) and fiber content **(Yuan et al., 2013; Hassaan et al., 2015; Hassaan et al., 2018)**.

Widely accessible and reasonably priced are plant proteins (Amer et al., 2021; Hamid et al., 2022). The worldwide aquaculture industry is becoming more interested in plant components as a cost-effective FM option **(Azarm and Lee, 2014; Mzengereza et al., 2021; Roslan et al., 2024)**. Globally, plant proteins are a practical and affordable substitute for fish production; switching from fish meal to plant proteins provides advantages for the environment, such as lower emissions of phosphorus and nitrogen **(Soltan et al., 2023; Davies et al., 2020; Prachom et al., 2021)**. The most common plant protein sources in aquafeeds, in terms of price, are soybean, linseed, canola, corn gluten, cottonseed meal, and sunflower meal. Scientists, farmers, and business partners are interested in new plant sources like jojoba and jatropha meal since they are less expensive than fishmeal. They have been shown to be suitable as partial replacements for fishmeal **(Hassaan et al., 2018; Awad et al., 2024)**.

Crustacean growth may be hampered if fish meals are substituted with SBM above a certain threshold **(Bulbul et al., 2016)**. Accordingly, plant proteins can be fermented using solid-state fermentation technology, which is becoming increasingly important, to create high-value products from agro-industrial by-products like enzymes **(Buck et al., 2015)**. This technique works well for raising the protein content and eliminating antinutritional elements like phytic acid. Additionally, fish diets should contain less fat, fiber, and ash **(Flores-Miranda et al., 2014; Siddik et al., 2024)**. By dissolving complicated chemicals into simpler forms, fermentation improves fish growth rates and digestibility **(Filipe et al., 2023; Awad et al., 2024)**. Bioprocessing generates bioactive compounds that, when consumed, may have beneficial health effects by aiding in the breakdown of proteins and fibers. **(Mohammady et al., 2023; Sour et al., 2022)**.

**According to Awad et al. (2024),** *Saccharomyces cerevisiae* solid-state fermentation technique (SSF) enhanced the plant-protein blend's nutritional value while lowering its anti-nutritional components. In Nile tilapia diets, fishmeal can be replaced with FCSJM-25% or FCSJM-50% without adversely affecting growth rate, feed efficiency, nutrient digestibility, blood parameters, or immunological response. SSF is a useful technique for increasing the nutritional value of feedstuffs for monogastric fish diets and enhancing the sustainability of aquaculture operations. By converting proteins into tiny peptides and water-soluble molecules, soybean fermentation enhanced the nutritional value and accessibility of amino acids **(Singhania et al., 2009).** Additionally, **Chi and Cho (2016)** demonstrated that fermented soybean meal containing *Lactobacillus species, Bacillus*, and *Saccharomyces cerevisiae* can enhance metal-chelating ability and antioxidant activity, mainly because of increased levels of phenolic compounds and bioactive peptides **(Kim et al., 2010; El-Dakar et al., 2023)**. Furthermore, fermented soybean meal, or FSBM, has expanded in use as a fish feed element. Different microorganism strains are employed in the fermentation process of SBM. Saccharomyces cerevisiae yeast and fungus are used in the meals of Nile tilapia (*O. niloticus*) fish **(Hassaan et al., 2015; Li et al., 2019)**. In order to assess growth performance and survivability, nutrient utilization, body composition, and hematological-biochemical blood indices, the study's objectives were to eliminate anti-nutritional factors, improve the nutritional value of Jojoba meal (JM) by reducing its fiber content, and process non-conventional fermented Jojoba meal in the formulation of diets for Nile tilapia, *O. niloticus*, raised in aquariums.

## Materials and Methods:

This study was carried out at the Central Laboratory for Aquaculture Research, Abbassa, Sharkia, Agriculture Research Center, Ministry of Agriculture, Egypt's Department of Fish Nutrition, Sakha Research Unit. The feeding track lasted for eighty-four days.

**Preparation of fermented Jojoba meal (FJM)**

With a few modifications, JM was produced as previously reported **(Joshi et al., 2011; Ismail et al., 2021**). JM fine particles were autoclaved for 20 minutes at 121 °C. Following autoclaving, 1 kg of JM was soaked in 1.2 L of sterile distilled water with 10% molasses, homogenized for 15 minutes, and inoculated with 3 g of commercial yeast, S. cerevisiae, with a cell density of 5 × 105 cells/g (Levitan, Dox-al Italia S.P.A., Italy). The mixture was then incubated for 5 days at 33 ◦C, which is the ideal growth temperature for S. cerevisiae, with agitation every 12 hours. The fermented JM was spread out on a foil sheet and covered once white dots appeared on the JM surface, indicating mycelial growth and covered with a piece of transparent cloth at 30 ◦C for another 24 h.

**2.1. Experimental fish:**

*Oreochromis niloticus*, the experimental fish, was acquired from a private farm in the Kafr El-Sheikh governorate's EL-Riyadh. June 2022 marked the beginning of the experiment, which ended in August 2022. To help the fish adjust to the experimental circumstances before the experiment began, they were put in a fiberglass tank and dispersed at random throughout the experimental aquaria. For two weeks, fish were fed the basal diet.

**2.2. Experimental conditions:**

The fish were fasted for 24 hours prior to weighing at the beginning of the feeding trial. Juveniles of uniform size and good health (average initial body weight 8.52±0.10 g) were divided among 15 fish per tank in 15 glass aquariums that had been previously set up, each measuring 60 x 30 x 40 cm (72 liters). Three duplicates of each test diet were assigned at random (n = 15). For 84 days, fish in every group were hand-fed pelleted meals (2 mm in diameter) at a daily rate of 3% of their body weight, twice a day, six days a week, at 8.30 am and 2.30 pm. Fish were weighed every two weeks, and the amount of feed was modified based on the weight variations. Fresh, 30% dechlorinated water from a reservoir tank housed in the same lab was used to replace the water every day during the experiment. After the waste was removed, it was changed every day and once a week. The temperature of the water was 28.50± 0.09 °C. Daily measurements of the water's pH (7.63 ± 0.5), dissolved oxygen (> 6.82 mg L), and total ammonia (0.39 ± 0.00 mg L) were made. Using fluorescent light, the photoperiod lasted 14 hours every day. Every day, feed leftovers and fish waste were extracted via siphoning. The water in the aquariums was aerated using nine air stones.

**3-Experimentaldiet preparation**

There are five isonitrogenous diets (32.13% crude protein). To meet the needs of Nile Tilapia (*O. niloticus*), all materials were well combined. The experimental diets' composition and formulation are displayed in Table 1. Commercial components were bought from Feed Control Factory in Damro, Sidi Salem City. All dry ingredients were ground and combined with water and fish oil in a lab mixer. A commercial meat grinder with a 2 mm die plate was then used to create the pellets. After three days of drying at room temperature until the moisture content dropped below 80 g/kg, the prepared meals were broken down. To prevent food spoiling during the trial, the prepared diets were stored at 4.0C in a dry location. To validate the proximate analysis, a sample from each diet was finely powdered. The experimental diets were designed to assess protein content at 0, 20, 40, 60, and 80%.

**Table 1: Composition of the experimental diets.**

| Item Feed Ingredients(%) | T1 Control | T2 20%FJM | T3 40%FJM | T4 60%FJM | T5 80%FJM |
|---|---|---|---|---|---|
| Fish meal | 110 | 125 | 145 | 165 | 175 |
| Soybean meal | 360 | 288 | 216 | 144 | 72 |
| Fermented Jojoba meal (FJM) | 0 | 72 | 144 | 216 | 288 |
| Yellow corn | 165 | 165 | 165 | 165 | 165 |
| Wheat bran | 110 | 110 | 110 | 90 | 80 |
| Rice bran | 52 | 51 | 49 | 67 | 80 |
| Wheat flour | 54 | 54 | 54 | 54 | 54 |
| Corn gluten | 70 | 70 | 70 | 70 | 70 |
| Sun flower oil | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 |
| Di-calcium | 15 | 15 | 15 | 15 | 15 |
| Vit. C | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 |
| premix* | 10 | 10 | 10 | 10 | 10 |
| Choline chloride** | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 |
| Total (g) | 1000 | 1000 | 1000 | 1000 | 1000 |
| Chemical composition (g/kg) | Determined on dry matter basis | | | | |
| Crud protein (CP) | 32.5 | 32.13 | 31.88 | 32.02 | 32.13 |
| Crud lipid (CL) | 7.5 | 7.43 | 7. 5 | 8.4 | 8.7 |
| Ash | 9. 1 | 9.05 | 8.08 | 8.7 | 8.7 |
| Fibers | 4.4 | 4.2 | 4.2 | 4.9 | 5.1 |
| NFE** | 46.5 | 47.19 | 48.34 | 45.98 | 45.37 |
| GE*** | 445.61 | 445.69 | 449.67 | 449.27 | 450.22 |

*Vitamins and minerals premix detailed by Dawood et al (2020).
** NFE (Nitrogen free extract) calculated by differences [NFE = 100 - (CP+ EE+ CF+Ash)]
*** Gross energy was calculated according to NRC (1993) by using factors of 5.65, 9.45 and 4.22 Kcal per gram of protein, EE and NFE, respectively.

**2.5.Proximate analysis of the experimental diets and fish body:**

The Association of Official Analytical Chemists' methods **(AOAC, 2012)** also described the proximate chemical analysis of the diet and fish, as well as the measurement of DM, CP, EE, CF, and ash in the basal diet, experimental diets, and fish bodies at the beginning and end of the experiment for various groups.

Three fish were selected at the end of the trial from each treatment, and the samples were dried for two days at 60°C before being ground in an electrical mill and kept in a deep freezer until analysis.

**2.6.Growth performance and efficiency of feed and protein utilization:**

Every 2 weeks, measurements of each fish's initial live body weight (BW/g) were made in each pond for the duration of the experiment, the growth performance and feed efficiency parameters were calculated according to the following equations:

- Total weight gain (TWG, g) = FW (g) – IW (g).
- Average daily gain (ADG, g) = (TWG (g) / T (days)].
- Survival rate (SR %) = Total number of fish at the end of the experimental × 100 / total number of fish at the start of the experiment.
- Specific growth rate (SGR, %/day) = [(ln FW – ln IW) / T] × 100
- Feed conversion ratio (FCR) = FI (g) / TWG (g).
- Protein efficiency ratio (PER) = TWG (g) / PI (g).

Where:

- FW: final weight; IW: initial weight; T: experimental period by days.

- FI: feed intake, which was calculated by multiplying the daily food quantity by the

number of days of the experiment.

- PI: protein intake, which was calculated as PI = FI × CP diet.

**2.7.Blood sampling and analysis**

According to Cicia et al. (2012), five fish per group were sedated with 100 mg/L tricaine methanesulfonate before a blood sample was drawn from the caudal vein using 3 ml gauge syringes. The blood was divided into two parts, the first of which was kept for hematological testing in tubes that had been heparinized with EDTA. To extract serum for two hours, blood samples were centrifuged for 15 minutes at 4ºC and 3000 rpm. For the purpose of collecting serum, the second section (other tubes) was kept in nonheparinized tubes. The serum was then stored at -20 °C until further immunological and biochemical research could be done.

Erythrocyte and leukocyte counts were measured using the **Stoskopf (1993)** approach, a hemocytometer, and Natt-Herrik solution. However, the cyanmethaemoglobin method, as developed by **Balasubramaniam and Malathi (1992**), was used to measure the hemoglobin level. Additionally, in accordance with the protocol described by **Blaxhall and Daisley (1973)**, blood smear slides were made, allowed to air dry, fixed with methanol for three to five minutes, stained with gimsa stain for eight to ten minutes, rinsed with distilled water, and allowed to dry at room temperature.

According to **Dumas and Biggs (1972)** and **Doumas et al. (1981)**, the following parameters were assessed calorimetrically: albumin (ALB, g/dL) and total protein (TP, g/dL). whereas the amount of globulins was determined mathematically.

**2.8.Digestive enzyme activity**

In order to identify non-hydrolyzed starches, amylase activity was measured using an iodine solution, whereas protease activity was evaluated using the Folin phenol reagent **(Jiang, 1982; Worthington, 1993)**. "Units per mg of protein" was used to express the activity of the protease and amylase.based on the guidelines set forth by **Jin (1995) and Borlongan (1990)**.

**Statistical analysis:**

**2.9.Statistical model and analysis of the data:**

Microsoft Excel (Microsoft Corporation, Redmond, WA, USA) was used to test the data. With SPSS Ver. 15 **(PROC Mixed; SPSS 2006)**, the statistical analyses were carried out. The mean ± standard error is displayed for the data (n = 3). To investigate differences between individual means at a significance level of $P < 0.05$, all variables were calculated using one-way analysis of variance (ANOVA) and Duncan's multiple range tests.

**Result**

***3.1.Water quality parameters:***

Table 2 displays the most crucial tap water parameters employed in this experiment. According to the data, the water quality parameters that were evaluated were appropriate for the growth and raising of Nile tilapia (*O. niloticus*) fish, and there were no significant variations between the test groups.

**Table 2:** Averages of some physic- chemical parameters of water quality.

| ITEMS | WATER PARAMETERS | | | |
|---|---|---|---|---|
| | **Temperature ºC** | **pH value** | **DO mg/l** | **$NH_4$ mg/l** |
| **T1 CONTROL** | **28.53±0.31** | **7.60±0.21** | **6.86±0.14** | **0.40±0.03** |
| **T2 20%FJM** | **28.73±0.24** | **7.52±0.12** | **6.76±0.08** | **0.38±0.01** |
| **T3 40%FJM** | **28.53±0.14** | **7.71±0.11** | **6.90±0.11** | **0.39±0.01** |
| **T4 60%FJM** | **28.23±0.08** | **7.61±0.07** | **6.76±0.21** | **0.42±0.02** |
| **T5 80%FJM** | **28.70±0.20** | **7.70±0.11** | **6.83±0.08** | **0.39±0.02** |

⁎ Values expressed as means ± SE (*n* = 3).

### *3.1. Growth, and Fish survival rate*

According to Table 3's findings, the use of Fermented Jojoba Meal (FJM) in tilapia diets had no discernible effects on the fish's final body weight (FW, g/fish), total weight gain (TWG, g/fish), daily gain (ADG, g/fish/day), or specific growth rate (SGR, %) (P > 0.05). Furthermore, the values for all parameters were noticeably higher in the fish fed diets T1, T2, and T3 (control). In contrast to the other groups, the T5 (80%FJM) obtained the lowest results. The survival rate (SR%) of fish fed diets, however, did not differ significantly between treatments T1 and T3, with high rates of 97.77% in Table 3 (P > 0.05).

**Table 3**. Effect of FJM (%) on the growth performance and survival rate of Nile tilapia.

| ITEM | T1 CONTROL | T2 20%FJM | T3 40%FJM | T4 60%FJM | T5 80%FJM |
|---|---|---|---|---|---|
| **IW** | 8.48±0.08 | 8.57±0.02 | 8.51±0.05 | 8.57±0.05 | 8.44±0.05 |
| **FW** | 27.57±0.86$^{a}$ | 26.63±0.35$^{ab}$ | 25.16±0.22$^{bc}$ | 25.12±0.17b$^{c}$ | 23.67±0.54 c |
| **WG** | 19.08±0.84$^{a}$ | 18.05±0.37$^{ab}$ | 16.65±0.25$^{bc}$ | 16.55±0.22$^{bc}$ | 15.23±0.60 c |
| **WG (%)** | 2.24±10.12$^{a}$ | 2.10±4.91$^{ab}$ | 1.95±3.93$^{bc}$ | 1.93±3.94$^{bc}$ | 1.80±8.38$^{c}$ |
| **DWG** | 0.22±0.01$^{a}$ | 0.21±0.00$^{ab}$ | 0.19±0.00$^{bc}$ | 0.19±0.00b$^{c}$ | 0.18±0.00$^{c}$ |
| **SR** | 97.77±2.22 | 95.55±2.22 | 97.77±2.22 | 95.55±4.44 | 97.77±2.22 |
| **SGR** | 1.40±0.03$^{a}$ | 1.34±0.01$^{ab}$ | 1.29±0.01$^{bc}$ | 1.27±0.01b$^{c}$ | 1.22±0.03$^{c}$ |

⁎ Values expressed as means ± SE (*n* = 3). in the same row with different letters differ significantly ($p < 0.05$). IBW: initial body weight, FBW: final body weight, WG: weight gain, SGR: specific growth rate.

### *3.2. Feed intake and protein utilization.*

Every criterion that was examined and shown in Table 4 indicated that there was no significant difference between groups. In contrast, the control groups T1, T2, and T3 showed improvements (P≤0.05) in tilapia fish FI, FCR, PER, and PPV% when compared to the other group.

**Table 4**. Effect of FJM (%) on Feed intake and conversion rate as well as protein utilization by Nile tilapia fish

| ITEM | T1<br>CONTROL | T2<br>20%FJM | T3<br>40%FJM | T4<br>60%FJM | T5<br>80%FJM |
|---|---|---|---|---|---|
| **FI** | 39.27±1.17$^{a}$ | 39.09±0.62$^{a}$ | 38.12±1.01$^{ab}$ | 36.26±1.14$^{c}$ | 34.13±2.26$^{c}$ |
| **FCR** | 2.06±0.04 | 2.16±0.03 | 2.28±0.02 | 2.19±0.05 | 2.24±0.17 |
| **FE** | 0.48±0.01 | 0.46±0.00 | 0.43±0.00 | 0.45±0.01 | 0.45±0.03 |
| **PER** | 1.51±0.03 | 1.44±0.02 | 1.36±0.00 | 1.42±0.03 | 1.39±0.10 |

⁎ Values expressed as means ± SE (*n* = 3). in the same row with different letters differ significantly (p < 0.05).
FI: feed intake, FCR: feed conversion ratio, FE: Feed efficiency, PER: Protein efficiency ratio.

### *3.3. Haemato-biochemical blood indices.*

Tables 5 and 6 showed the discovered hematological and biochemical blood variables, which showed that the tilapia fed FJM are in a stable state of health (P >.05).

According to the findings of the hematic test, Nile tilapia fish fed diets T1, T2, and T3 had higher Hb and RBC levels than the other groups (p < 0.05). However, feeding FJM at the T4 (60%) and T5 (80%) levels comparatively decreased the value of Hb and RBC (Table 5). Furthermore, WBCs showed little variations between the fish fed varying amounts of FJM and the control group. In contrast, fish fed diets T4 and T5 had significantly lower amounts of total protein (TP) than fish fed the control diet and other treatments (Table 6).

Fish fed diets T4 and T5 had significantly lower levels of plasma albumin (Alb) and globulin (glu) (P > 0.05), whereas fish fed diets T1, T2, and T3 had significantly higher levels of these proteins, respectivel

**Table 5.** Hematological blood analysis of Nile tilapia fed levels of FJM (%).

| ITEM | T1<br>CONTROL | T2<br>20%FJM | T3<br>40%FJM | T4<br>60%FJM | T5<br>80%FJM |
|---|---|---|---|---|---|
| **HB** | **9.00±0.90$^{a}$** | **7.70±0.35$^{ab}$** | **6.93±0.31$^{c}$** | **6.66±0.12$^{c}$** | **6.83±0.14$^{c}$** |
| **RBCS** | **2.25±0.17$^{a}$** | **1.80±0.12$^{b}$** | **1.64±0.12$^{b}$** | **1.59±0.09$^{b}$** | **1.74±0.12$^{b}$** |
| **WBCS** | **88.10±1.94** | **82.16±1.82** | **88.36±1.61** | **91.33±5.84** | **95.16±5.86** |

⁎ Values expressed as means ± SE (*n* = 3). in the same row with different letters differ significantly (p ≤ 0.05). Hb: hemoglobin; RBCs: red blood cells, HCT: hematocrit, WBCs: white blood cells.

**Table 6**. Blood biochemical indices of Nile tilapia fed levels of FJM (%).

| ITEM | T1 CONTROL | T2 20%FJM | T3 40%FJM | T4 60%FJM | T5 80%FJM |
|---|---|---|---|---|---|
| TP (G/DL) | **3.26±0.12$^{a}$** | **2.66±0.08$^{b}$** | **2.80±0.10$^{b}$** | **2.33±0.08$^{c}$** | **2.53±0.23$^{bc}$** |
| ALB (G/DL) | **1.16±0.03$^{a}$** | **1.10±0.05$^{ab}$** | **1.16±0.03$^{a}$** | **0.90±0.00$^{c}$** | **0.96±0.06$^{bc}$** |
| GLU (G/DL) | **2.10±0.10$^{a}$** | **1.56±0.08$^{b}$** | **1.63±0.06$^{b}$** | **1.43±0.08$^{b}$** | **1.56±0.16$^{b}$** |

∗ Values expressed as means ± SE ($n = 3$). in the same row with different letters differ significantly ($p \leq 0.05$).
TP: Total protein, Alb: Albumin, Glu: Globulin.

## Discussion

Given the rising costs of ingredients and raw materials, it's critical to look into unconventional approaches of producing aquafeed **Wang et al. (2020)**. Options that don't affect fish growth and health condition are recommended by **Dawood et al. (2020)**. FJM's high nutritional content, accessibility, and affordability make it a viable protein source for aquafeed development. The results of this study shown that adding FJM did, up to 40%, slightly reduce growth performance (FW, TWG, ADG, g/fish/day) and (SGR, %); however, T5 (80% FJM) caused a fall in growth rate in comparison to the control and other diets. These findings suggested that in order to maintain the Nile tilapia's optimal growth, FJM could be added to the diet at a maximum level of 40%. Furthermore, the values for all parameters were noticeably higher in the fish fed diets T1, T2, and T3 (control). Fish may effectively use the diet combined with FJM, as seen by the data, which also indicated no changes in the survival rate (SR%) of fish fed diets recorded high rates of 97.77% in treatments T1 (Control without FJM) and T3 (60%FJM). However, growth rates may increase or decrease during trials, which can be explained by feed efficiency indices like FI, daily FI, FCR, and PER. The investigation discovered no significant differences between the groups. However, when compared to the other treatment, the control T1, T2, and T3 showed improvements in tilapia fish FI, FCR, PER, and PPV%. However, because of their reduced feed efficiency, higher FCR, and decreased FI, PER, and PPV%, fish fed FJM at received T5 (80% FJM) grew at slower rates. By enhancing digestion, synthesizing nutrients, producing growth-promoting compounds, controlling gut microbiota, and reducing pathogen competition, fermenting plant components with *Lactobacillus spp*. boosts fish development and feed efficiency **(Liu et al., 2023)**. Likewise, supplementing several fish species, such as *Barbonymus gonionotus* **(Das et al., 2018)** and *O. niloticus* **(Yousif et al., 2019; Shimul et al., 2024)**, with fermented plant protein has shown positive outcomes.

According to several studies, fish production and overall health are enhanced when 50% fermented plant components or protein are used **(Kari et al., 2022; Mugwanya et al., 2023; Nandi et al., 2023; Shimul, et al., 2024)**. Additionally, tilapia given all treatments showed substantial decreases in FBW, SGR, FCR, PER, and chemical composition, with the exception of the 30% fermented wheat gluten and yeast derived protein (FWPC) inclusion **(Omar et al., 2022)**. Additionally, **Awad et al. (2024)** demonstrated how the growth performance and anti-nutritional factors content of Nile tilapia (*Oreochromis niloticus*) were affected by diets that contained a blend of plant protein sources (cottonseed meal, sunflower meal, and jojoba meal) fermented with yeast (Saccharomyces cerevisiae) FCSJM at three different levels (25 percent, 50 percent, and 75 percent) in place of fishmeal (FM). FBW, WG, ADG, SGR, FCR, and PER did not differ significantly ($P > 0.05$) among tilapia fed the control diet, FCSJM-25%, and FCSJM-50%; however, tilapia growth rate and feed consumption were negatively impacted by fish fed the FCSJM-75% replacement diet. Generally speaking, tilapia growth performance and feed efficiency are unaffected when 25% to 50% of fish meal is substituted with fermented mixed plant protein (FCSJM). According to **Shimul et al. (2024)**, the fish (Asian catfish fingerlings) fed D0 showed considerably ($p < 0.05$) better growth performance and feed utilization than other treatment groups. In contrast, among the fermented aquatic weed meal (FAWM) dietary groups, the fish supplemented with the D1 diet showed significantly ($p < 0.05$) larger FW (g), SGR (%/day), WG (%), total biomass (g), and ER.

Additionally, the development and feed utilization of Nile tilapia, *O. niloticus*, were shown to be identical when Saccharomyces cerevisiae fermented wheat bran was used **(Mohammady et al., 2023).**

The fish's overall health status was revealed by the blood analyzer detection. According to **Ismail et al. (2021)**, the current investigation showed that tilapia fed FJM had current normal haemato- and biochemical values, which are regarded as being within the usual ranges for healthy fish. When evaluating the health of fish species, hematological values are crucial **(NRC, 2011; Taalab et al., 2022; Awad et al., 2024)**. In the present investigation, The hematic results showed that Nile tilapia fish given diets T1 (20%FJM), T2 (40%FJM), and T3 (60%FJM) had higher Hb and RBC ($p < 0.05$) than the other groups. However, by feeding FJM at the T4 (60%) and T5 (80%) levels, the values of Hb and RBC were comparatively decreased. Similarly, WBC, RBC, and HCT are important markers of fish health and feed antinutritional toxicity, according to **Abdul Kari et al. (2021)**.

When comparing fish given the FSBM diet to those fed the control diet, **Havixbeck et al. (2016)** found negligible variations in the erythrocyte count, Ht, and RBCs values. However, compared to fish fed the FSBM0 diet, fish fed the FSBM150, FSBM225, and FSBM300 had greater WBC counts. Additionally, it produces an antibacterial response against invasive pathogens and is linked to innate immunity **(Phinyo et al., 2024)**. A supplementation concentration of 40 g/kg led to a higher WBC count, according to another study assessing FSBM supplementation in African catfish (*Clarias gariepinus*) **Zakaria et al. (2022)**.

Fish metabolic, physiological, and immunological processes are indicated by serum biochemical metabolites **(Hassaan et al., 2018)**. According to the current study's findings, the blood protein profile (albumin, globulin, and serum total proteins) was assessed **Ismail et al. (2021)**. Similarly, **Lim and Lee (2011)** discovered that the total protein content of Nile tilapia was not significantly impacted by A. oryzae-fermented soybean and cottonseed meals. The obtained results were comparable to those of **Roslan et al. (2024)**, which showed that there were significant differences ($p < 0.05$) across all treatments with varying percentages of fermented wasted coffee grounds (FCG). According to the findings, African catfish, *Clarias gariepinus*, that were fed T2 (10% FCG) produced the best levels of albumin (ALB), globulin (GLOB), and total protein (TP). Additionally, **Ismail et al. (2021)** found that Aspergillus oryzae-fermented olive cake (AFOC) inclusion levels have no effect on blood total protein, including its fractions (albumin and globulin) in Nile tilapia fish (*Oreochromis niloticus*) ($P > 0.05$).

## CONCLUSION

It is highly advised to use FJM as an SBM substitute in order to give Nile tilapia a wholesome diet without lowering their development, feed utilization, or blood indices. Up to 40% of Nile tilapia can successfully accept the addition of FJM. Using FJM lowers the expenses of producing tilapia fish and is a viable technique for farmers.

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## AUTHORS CONTRIBUTION

Ahmed F. Fath El-Bab: General supervision, Conceptualization, Investigation, Methodology, checked and confirmed the final revised manuscript. Ibrahim E. Hegazy: Formal analysis, Investigation, Follow-up, Writing - original draft. Asem A. Amer: Formal analysis, Supervision, Writing, Follow-up, Methodology, original draft. Hamada A. Areda: Formal analysis, Supervision, Writing, Follow-up, Methodology.

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## الملخص العربى

## تقييم كسب الجوجوبا المتخمر كمصدر بروتين نباتي علي أداء النمو، معدل البقاء ،بيوكيمياء الدم ،و مؤشرات الدم لأسماك البلطي

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إن الهدف من الدراسة هو تقييم التأثيرات الغذائية لكسب الجوجوبا المتخمر كأحد مصادر البروتين النباتي على أداء النمو، واستهلاك العلف، وبيو كيمياء الدم ومؤشرات الدم.
تم تغذية أسماك البلطي النيلي على خمس علائق تجريبية تحتوي على مصدر البروتين النباتي من كسب الجوجوبا المتخمر باستخدام الخميرة (سكاروميسس سرفيسيا) عند أربعة مستويات مختلفة (20٪، 40٪، 60٪، 80٪كاستبدال مع كسب فول الصويا).
المعاملة الأولي (الكنترول) لا تحتوي على كسب الجوجوبا المتخمر، وتم إعداد أربعة من المعاملات الأخرى تحتوي على كسب الجوجوبا المتخمر بالنسب التالية: المعاملة الثانية تحتوي (20٪)، المعاملة الثالثة (40٪)، المعاملة الرابعة (60٪)، والمعاملة الخامسة (80٪).
وقد استمرت تغذية الأسماك خلال التجربة لمدة 84 يوم، كان الوزن الابتدائي للأسماك قبل بدء التجربة (8.52 ± 20.0 جرام) وتم تسكين الأسماك بشكل عشوائي في أحواض زجاجية (سعة الحوض الواحد 72 لتر) بواقع 3 مكررات لكل معاملة ومعدل تسكين الأسماك (15 سمكة / الحوض).
ولقد أظهرت النتائج أن الأسماك التي تم تغذيتها على العلائق في المعاملات الأولي (الكنترول)، والثانية والثالثة سجلت بشكل ملحوظ ( P 0.05>) أعلي قيم في الوزن النهائي للجسم (FBW)، والزيادة في الوزن (WG)، والزيادة اليومية في الوزن (DWG)، (FE)، ومعدل النمو النوعي (SGR)، في حين سجلت الأسماك في المعاملة الخامسة أدنى قيم مقارنة بالأسماك في المعاملات الأخرى. في حين أنه لا توجد فروق معنوية بمعدل الإعاشة للأسماك، فقد سجلت الأسماك في كل من المعاملة الأولي والمعاملة الثالثة أعلى معدل اعاشة 97.77٪.
بالإضافة إلى ذلك فإنه لم تظهر اختلافات كبيرة ذات أهمية في معدلات الغذاء المأكول (FI) ، ومعامل التحويل الغذائي (FCR) ، ومعامل كفاءة البروتين (PER) ،و (PPV) بين المعاملات.
في حين أنه قد تحسنت المعاملة الأولي والمعاملة الثانية والمعاملة الثالثة (P≤0.05) بالمقارنة مع المعاملات الأخرى.
وقد أظهرت مؤشرات الدم وعلى وجه التحديد (Hb) و(RBCs) تسجيل أسماك البلطي النيلي في المعاملات الأولي والثانية والثالثة نسبا أعلي بالمقارنة مع باقي المعاملات (P ≤ 0.05)، وبشكل نسبي انخفضت قيم (Hb)،(RBC) عند تغذية الأسماك على مستويات أعلي من كسب الجوجوبا المتخمر في كلا من المعاملة الرابعة والمعاملة الخامسة. وعلاوة على ذلك أظهرت نتائج (WBCs) عن عدم فروق ملحوظه بين الأسماك في المعاملة الأولي (الكنترول) وبين الأسماك التي تم تغذيتها على مستويات مختلفة من كسب الجوجوبا المتخمرفي باقي المعاملات. في حين أن مستويات البروتين الكلي (TP) قد انخفضت بشكل كبير في كل من المعاملة الرابعة والخامسة مقارنة مع المعاملات الأخرى.
وعلاوة على ذلك كانت بلازما الألبومين (Alb)، والجلوبيولين (glu) كانت أقل بشكل ملحوظ (P> 0.05) في الأسماك التي تم تغذيتها على علائق المعاملة الرابعة والمعاملة الخامسة، في حين ازدادت بشكل ملحوظ ايضا في تلك التي تغذت على علائق المعاملة الأولي والثانية والثالثة على التوالي.
وبناءا على ذلك فإنه يوصي باستخدام كسب الجوجوبا المتخمر عند مستوى المعاملة الثانية (20%)، دون تأثير سلبي على أداء النمو، واستهلاك العلف، وصحة الدم في أسماك البلطي النيلي.