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Effects of Fish Discards as a Substitute for Fish Meal on the Growth Rates and Health Status of *Oreochromis niloticus*

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ABSTRACT

Discards decrease natural resources and harm the viability of fisheries. The current experiment was conducted to determine the suitability of fish discards for cultivating the Nile tilapia (*Oreochromis niloticus*) and their effect on growth rates and the health condition of the fish. 300 healthy live Nile tilapia specimens were obtained and divided into five equal groups, coded as 0, 25, 50, 75, and 100% DF diets. The experiment lasted for 60 days. All growth performance parameters revealed no discernible difference between fish fed 0 (control group) and 100% DF diets. Fish fed 75% DF diet recorded the best significant feed conversion rate of 1.1± 0.4. Fish fed 50 and 75% DF diets recorded the highest significant weight gain (25.4± 3.02, 25.3± 2.7g, respectively). The glucose value showed a significant decrease in the 25% DF treatment and an increase in 100% DF treatment, while it showed a non-significant decrease in 50 and 75% DF treatments. This study determined that the haematological values remained acceptable for tilapia production. The present work concluded that fish discards are suitable as dietary protein sources for the Nile tilapia; it contributed significantly to fisheries' sustainability and the Nile tilapia feeding cost reduction.

INTRODUCTION

One of the most wasteful human activities in the ocean is discarding marine fisheries, which can have significant socioeconomic and ecological effects, particularly in trawl fisheries, and this has a substantial impact on ecosystem dynamics, as well as on the food web structure **(Gilman *et al.*, 2020; Blanco *et al.*, 2023)**. The amount of fish sorted as discards are offloaded back to the water, either live or dead, for many reasons, such as business, personal, or legal concerns **(Blanco *et al.*, 2023)**. They cause changes in trophic interactions, affecting ecosystem structure and function **(Kopp *et al.*, 2016)**, and they cannot be destined for use as a food source; consequently, they have to be managed according to an alternative commercialization and management strategy. Fish discards peaked at 27 million tons annually in the late 1980s **(Damiano & Lercari, 2022)**. Monitoring fish discarding is highly challenging, particularly in areas where it is prohibited **(Sturludottir, 2018)**. Fishing discards are often viewed as immoral due to the many tons of protein wasted and discarded in the ocean **(Hall & Mainprize, 2005; Damiano & Lercari, 2022)**. International guidelines have urged reducing discards to help achieve the 14th Sustainable Development Goal of the

United Nations to protect and use marine resources from the oceans, seas and lakes for sustainable development **(Gilman *et al*., 2020)**.

The efficiency of aquatic farming feed, which depends on protein given to it, is dependent on the high amounts of protein (fish meal) and (fish oil) lipids derived from wild fish in recent years **(Hua *et al*., 2019)**. Fish meal is an essential amino acid source, making it the most extensively utilized protein component in aquafeeds **(Hardy & Barrows, 2003)**. Therefore, fishery by-products that are affordable and free of disease transmission waste may make up to 30– 80 percent of an unprocessed fish's body weight, which could be promising **(Dave *et al*., 2015)**. Commercial fish meals made from small pelagic fish stocks may be replaced with acceptable alternatives if fisheries discard and processing waste are combined **(Barlow, 2000)**. The discarded components encompass various parts such as the bones, guts, shell, fin, skin, head, and all the other body parts. These components may potentially contain essential nutrients such as long-chain omega-3 polyunsaturated fatty acids (PUFAs), peptides, carotenoids, and essential amino acids, as well as vitamins B3, A, B12, B6, and D. Additionally, they may also contain a diverse array of minerals including pigments, iodine, potassium, selenium, copper, calcium, sodium, zinc, and selenium in addition to other unidentified substances **(Cretton *et al*., 2021)**.

Aquaculture has established itself as a significant source of excellent proteins and healthful fats to satisfy the rising human demand for fish as a dietary source **(Mohan Dey *et al*., 2005)**, especially in Egypt, where aquaculture has grown with significance in providing a quick source of animal protein for the expanding population of the nation. Animal protein sources have a generally higher quality of protein than plant sources although animal protein is preferred but it is more expensive than plant protein. The aquaculture industry's challenge is to lessen the proportion of fishmeal used in aquafeeds, particularly for cultivated carnivorous fish and sea prawns. Identifying economically viable and ecologically friendly sustainable fishmeal substitutes is imperative since it is a significant component in many existing aquafeeds **(Gatlin *et al*., 2007)**.

Several sources have been evaluated as a tilapia diet protein, such as blood, shrimp, bone meals, flesh, and poultry by-product meals, which could reduce environmental problems **(Heu *et al*., 2003)**. Fishery discards have attracted some interest as a tilapia feed component **(Goddard *et al*., 2003; Goddard & Perret, 2005)**. Given that tilapia diets contain less protein than carnivorous species, diets produced from fish meals from by-catch will have less ash **(Goddard *et al*., 2008)**. Additionally, the phosphorus content may improve primary production and pond fertilization **(Goddard *et al*., 2003)**. **Rathbone *et al*. (2001)**, **Hardy *et al*. (2005)** and **Whiteman and Gatlin (2005)** studied its viability as a complete or partial substitute for commercial fish meal in the diets of species, such as red drum, rainbow trout, and coho salmon. The known fish in Lake Nasser consists of 15 families and 52 species; however, only four species comprise the bulk of the catch, accounting for 80% of the total catch, and the remaining species are considered discards **(Halls *et al*., 2015)**. As a result, fishery discards could be employed as an alternative protein source in fish diet formulation, giving more sustainable remedy for the challenge of environmental pollution and changes in ecosystem dynamics and food web structure caused by returning it to the water, thus adding value to fishery discards.

Therefore, the present study aimed to evaluate the potential of using Lake Nasser fishery discards as an alternative protein source by total or partial replacement of commercial fish meal in *Oreochromis niloticus* diet, as well as assessing the effect of this on its growth rate and health status.

MATERIALS AND METHODS

Fresh finfish discards of several species were collected from the commercial landing site of Lake Nasser. The study procured various feed materials, including a commercial fish meal, soya bean, wheat flour, wheat bran, yellow corn, fish oil, gelatin, ascorbic acid, and a vitamin and mineral mix from a reputable fish feed ingredient manufacturer located in Cario, Egypt. The 300 live, healthy Nile tilapia (*Oreochromis niloticus*) specimens were obtained from the Sahari hatchery in Aswan, Egypt. The average fish specimen's body weight was 7.1g; fish specimens were placed in a recirculation condition to maintain optimal water quality. They were then acclimatized for two weeks to adjust to the laboratory circumstances.

The study was carried out using a total of fifteen cylindrical tanks, each having a capacity of 300 liters. These tanks were filled with 250 liters of water previously treated to remove chlorine. Before experimenting, the fish population was partitioned into five homogeneous groups, one of which was the control group. Each group consisted of three replicates, with each duplicate containing 20 fish. Discard fish (DF) was created by cooking freshwater fish, pressing them to remove water and body oil, and ultimately drying them at temperatures ranging from 70 to 100ºC.

Five diets were prepared, differing only in the percentage of the main protein source. This involved partial or total replacement of commercially used fish meal with discard fish as follows. The first diet consisted of commercial fish meal only (0% DF). In the second diet, 25% of the commercial fish meal was replaced with DF. For the third diet, 50% of the commercial fish meal was substituted for DF. In the fourth diet, 75% of the commercial fish meal was replaced with DF. While, for the fifth diet, the commercial fish meal was completely replaced with DF. For each of the five alternative main protein sources, commercial fish meal and discard fish (17.5% by weight), other ingredients were added to each diet. They were mechanically mixed with commercial fish meal and/ or discard fish, and water was added until the desired texture was achieved, then pellets were formed using a pelleting machine and air dried to minimize moisture. The five tested diets (the first- the fifth) were coded as 0, 25, 50, 75, and 100% DF diets, respectively. The formulation of the present research diets is presented in Table (1), including the commercial fish meal weight, discard fish and other common ingredients.

The fish were given two daily feedings at nine a.m. and five p.m., with a rate corresponding to 5% of their body weight. They were kept alive for 60 days from October the 1st to November the 30th 2022.

Table 1. Formulation of experimental diets

Ingredient (g)	0% DF	25% DF	50% DF	75% DF	100% DF
Commercial fish meal	175	131.3	87.5	43.75	0
Discard fish	0	43.75	87.5	131.25	175
Soya bean meal	175	175	175	175	175
Wheat flour	248	248	248	248	248
Wheat bran	150	150	150	150	150
Yellow corn	150	150	150	150	150
Fish oil	60	60	60	60	60
Gelatin	30	30	30	30	30
Vitamin & mineral mix	8	8	8	8	8
Ascorbic acid	4	4	4	4	4
Total (g)	**1000**	**1000**	**1000**	**1000**	**1000**

All growth parameters were estimated every 30 days. The following equations were used to determine every growth parameter such as specific growth rate (SGR), weight gain (WG), feed survival rate (SR), conversion rate (FCR) and condition factor (K):

- Weight gain (WG, g) = FW – IW.
- Specific growth rate (SGR %) = log FW – log IW/ t * 100.
- Feed conversation ratio (FCR) = FI / WG (g).
- Condition factor (K) = W (g) * 100 / L^3 (cm).
- Survival rate (SR) = Number of live fishes / Total fish initial number * 100.

Where, IW is the initial fish weight (g); FW is the final fish weight (g); WG is the fish weight gain (g); FI is feed intake (g); t is the total days' number of experiments; W is the fish weight (g), and L is the fish length (cm).

Using a spectrophotometer (Jasco-V530), the chosen biochemical parameters were determined colorimetrically. By the parameter assessed, the sample's absorbance was evaluated at a suitable wavelength between 340 and 546nm. Glucose (mg/ dl) assays were performed using commercial diagnostic kits from biomatrix chemicals described by **Trinder (1969)**. Total protein content, creatinine, albumin (g/ dl), urea, and uric acid (mg/ dl) were assessed following the method of **Henry (1964)**, triglycerides (mg/ dl) according to **Friedewald *et al.* (1972)**, and cholesterol (mg/ dl) according to **Thomas (1992)**. Moreover, alanine aminotransferase (ALT, U/I), and aspartate aminotransferase (AST, U/I) were assesed following the method of **Reitman and Frankel (1957)**.

Haemoglobin level, red blood cell value, hematocrit, and white blood cell value were all estimated using whole-blood samples utilizing an automated technical method (Celtic MEK-6400J/K, TOKYO, JAPAN) analyzer. The mean corpuscular haemoglobin (MCH), mean corpuscular volume (MCV) and mean corpuscular haemoglobin concentration (MCHC) were determined in line with **Dacie and Lewis (2002)** description as follows:

- MCH (pg) = Hb / RBC * 10
- MCV (fl) = Hct / RBC * 10
- MCHC (g/dl) = Hb / Hct * 100

The statistical package computer program **(SPSS, 2013)** was used. One-way (ANOVA) analysis of variance was used to analyze experimental data. $P< 0.05$ was used to detect if there were significant differences or not. Duncan's multiple-range tests were used to determine if there were discernible differences between experimental groups **(Duncan, 1955)**.

RESULTS

Table (2) displays the growth performance characteristics of *O. niloticus* fed tested feeds. Compared to initial weight in all treatments, there was a considerable rise in final weight in the treatments of 50 and 75% DF (25.4± 3.02 and 25.3± 2.7g, respectively). In addition, there is no negative impact on feed or growth efficiency when replacing 25 or 100% compared with 0%. The highest specific growth rate (SGR) value was found in fish that were fed on discards, with values of 50 and 75% DF, followed by 25% DF, while 0 and 100% DF had the lowest. Fish fed 75% DF recorded the best significant feed conversion ratio (FCR) value and the highest condition factor. Fish fed 50% diet showed the highest significant

survival rate of the Nile tilapia, followed by 0% DF, and the 25, 75, and 100% DF recorded no significant difference between each other.

Table 2. Growth performance parameters of fish of *O. niloticus* as affected by different levels of discard fish at the end of the experiment

Parameter	0% DF	25% DF	50% DF	75% DF	100% DF
Initial fish weight(g)	6.7±1.4	7.1±1.1	7.2±1.8	7.2±1.2	6.9±0.9
Final fish weight (g)	24.2±1.8^{a}	24.1±1.1^{a}	25.4±3.02^{b}	25.3±2.7^{b}	24.6±2.4^{a}
Weight gain (g)	17.5±0.8^{a}	17.0±0.9^{a}	18.2±1.9^{b}	18.1±1.9^{b}	17.7±1.8^{a}
Specific growth rate	١.٧±0.1	1.8±0.2	١.٩±0.2	١.٩±0.2	١.٧±0.2
Feed conversion ratio	1.7±0.5^{c}	1.5±0.5^{ab}	1.3±0.6^{b}	1.1±0.4^{a}	1.6±0.3^{c}
Condition factor	1.2±0.5	1.1±0.5	1.3±0.3	1.4±0.4	1.2±0.4
Survival rate (%)	95.4±1.0^{b}	93.1±1.0^{a}	96.8.4±1.0^{c}	95.1.4±1.0^{ab}	93.8±1.0^{a}

Means within the same row, not sharing a superscript letter, differ significantly ($P< 0.05$).

Table (3) lists the average values for the blood serum components: glucose, albumin, total protein, uric acid, urea, creatinine, cholesterol, triglycerides, AST, and ALT in the blood serum of *O. niloticus*. The average levels of all identified biochemical items were significantly ($P< 0.05$) different in fish given the various discard fish diets and those fed the commercial fish meal (0% DF) after 60 days of trial (except uric acid and triglyceride, which showed insignificant differences between each treatment (Table 3).

Table 3. Effects of discards for 60 days on biochemical parameters in *O. niloticus*

Parameter	0% DF	25% DF	50% DF	75% DF	100% DF
Glucose (mg/dl)	68.1±2.0^{b}	59.6±3.1^{c}	63.5±5.3^{ab}	74.4±6.5^{b}	91.4±3.6^{a}
Total protein (mg/dl)	6.8±0.2^{b}	5.6±0.5^{c}	6.6±0.4^{ab}	7.1±0.8^{b}	9.3±0.6^{a}
Albumin (mg/dl)	8.2±1.2^{a}	7.3±1.1^{b}	6.5±0.^{ab}	9.4±0.9^{a}	9.9±0.9^{a}
Creatinine (mg/dl)	0.8±0.3^{b}	0.6±0.2^{b}	0.9±0.1^{a}	0.9±0.04^{a}	0.9±0.1^{a}
Urea (mg/dl)	30.1±2.1^{ab}	33.6±3.6^{b}	45±8.9^{a}	45.6±5.3^{a}	46.3±3.2^{a}
Uric Acid (mg/dl)	43.5±14.4^{a}	43.3±7.6^{a}	42.7±4.1^{a}	41.7±4.7^{a}	41±9.5^{a}
Cholesterol (mg/dl)	101.7±14.6^{a}	105±12.6^{a}	68.5±4.5^{ab}	88.3±9.3^{b}	98.3±11.6^{a}
Triglyceride (mg/dl)	124±11.5^{a}	121.7±20.2^{a}	122.7±11.2^{a}	122.3±13.7^{a}	123.7±21.4^{a}
ALT(U/L)	22.1±1.5^{a}	17.3±1^{a}	16.3±1.5^{b}	13.3±0.6^{b}	13.1±1.5^{b}
AST(U/L)	23.1±2.6^{a}	19.5±2.5^{a}	19.1±3.2^{a}	16.5±2.2^{b}	14.5±1.8^{b}

Means within the same row, not sharing a superscript letter, differ significantly ($P< 0.05$).

The average concentration for WBCs (eosinophils, monocytes, neutrophils and lymphocytes), Hb, RBCs, Hct, MCHC, MCV, MCH and platelets of *O. niloticus* fed food at various amounts of discards are represented in Table (4). The Hb levels, RBCs, and MCHC showed significant increases with an increase in discard diet concentration, and the highest values were 10.8± 0.8, 2.9± 0.06, and 43.5± 4.1 recorded in the highest discard values at 50, 100, and 25%, respectively. Significant variations ($P< 0.05$) were noticed in Hct, MCV, MCH, and WBCs concentration between all groups compared to 0%. The lymphocyte concentration fluctuated with change in discard concentration, and the highest values were 89.3± 1.0, 84.6± 3.6, and 79.6± 2.2, recorded in the highest discard values at 100, 75, and 25%, respectively. The blood of fish fed 100 and 75% DF showed a decrease in the concentration of monocytes and neutrophils. In contrast, all the groups fed with leftovers except for 25% DF which had a significantly ($P< 0.05$) rise in eosinophil level. In contrast, platelet levels were elevated in all groups compared to 0% DF.

Table 4. Effects of discards for 60 days on select haematological variables in *O. niloticus*

Parameter	0% DF	25% DF	50% DF	75% DF	100% DF
Hb (g/dl)	9.3±0.6^{a}	10.6±0.7^{b}	10.8±0.8^{ab}	10.6±0.7^{b}	10.2±0.6^{a}
RBCs (×10^{6} µl)	1.7±0.08^{b}	2.5±0.08^{a}	2.5±0.08^{a}	2.8±0.07^{a}	2.9±0.06^{a}
Hct (%)	30.9±0.4^{a}	24.5±0.9^{b}	31.5±0.9^{a}	29.5±0.5^{a}	23.5±0.9^{b}
MCV (fl)	182.0±7.4^{a}	97.9±0.4^{ab}	126.5±8.2^{b}	105.6±2.8^{ab}	81.2±0.7^{c}
MCH (pg)	55.2±5.4^{a}	42.6±3.9^{a}	43.3±3.7^{a}	38.0±3.3^{b}	35.1±1.8^{b}
MCHC (g/dL)	30.3±2.5^{b}	43.5±4.1^{a}	34.3±3.1^{b}	35.9±2.2^{a}	43.2±2.3^{a}
WBCs (×10^{3} µl)	30.4±0.9^{a}	30.4±1.7^{a}	28.8±1.2^{b}	28.9±10.8^{b}	29.8±2.9^{b}
Lymphocytes (%)	81±2.3^{a}	79.6±2.2^{a}	77±1.7^{b}	84.6±3.6^{ab}	89.3±1.0^{c}
Monocytes (%)	3.3±0.5^{b}	3.4±0.4^{b}	6.6±1.5^{a}	1.3±0.5^{c}	1.3±0.5^{c}
Neutrophils (%)	14.3±6.8^{a}	16±0.8^{a}	10.6±0.5^{b}	12.3±1.3^{b}	7.3±1.3^{c}
Eosinophils (%)	1.4±0.2^{b}	1.0±0.0^{ab}	5.8±0.1^{a}	1.8±0.2^{b}	2.1±0.5^{b}
Platelets (×103 µl)	178.3±1.3^{c}	189.3±9.8^{ab}	215±4.4^{b}	262±9.4^{a}	211.6±9.8^{b}

Means within the same row, not sharing a superscript letter, differ significantly ($P< 0.05$).

DISCUSSION

Large-scale research has produced conflicting findings about the significance of discards, indicating that they are either influential **(Catchpole *et al.*, 2006)** or have limited effects **(Lejeune *et al.*, 2022)**. Previous studies recorded discard consumption by *Buccinum undatum* **(Evans *et al.*, 1996)**, crabs, and spider crabs **(Bozzano & Sardà, 2002)** and sea urchins **(González-Irusta *et al.*, 2014)**. In the present study, dietary protein sources substantially affected growth performance. Replacement of commercial fish meal with 50, 75, and 100% of the protein diet (discards) increased the final growth in this study. The findings of this research support other research conclusions that fish fed by-catch meals gained more weight than fish fed commercial fish meal diet **(Hardy *et al.*, 2005)**. On the other hand, diets containing fish muscle protein, such as by-catch meal, were preferred for their high digestibility and indispensable amino acid composition provided by skeletal muscle, as opposed to processing wastes, which primarily consisted of frames or viscera **(Moon & Gatlin, 1994)**. In contrast, **Babbitt (1990)** hypothesized that some processing by-products, such as Alaskan cod fillet waste, include large quantities of connective tissue, which can lower their usefulness as a possible protein source due to decreased digestibility and a weaker amino acid profile. The FCR measures how effectively an animal converts feed material into body mass.

The fish fed on 75% DF had the best significant FCR and the greatest significant K value, possibly since tilapia fish do not require a diet high in protein, and the fish fed on discard fish diet received a high content of phosphorus, calcium and other nutrients than in the commercial fish meal **(Nag *et al.*, 2022)**. A higher amount of indigestible substances like ash and chitin in those diets may be why Atlantic salmon report worse feed conversion rates with increased quantities of krill in the feed **(Olsen *et al.*, 2006)**. The same findings were recorded for Atlantic salmon when fish meal was substituted with Antarctic krill in diets at all concentrations: 20, 40, 60, 80, and 100 **(Olsen *et al.*, 2006)**. The K factor increases by raising the concentration of fish discards in the diet. According to survival rates in all groups, tilapia may eat fish leftovers without harm. Red drum fish are fed by-catch meals of various concentrations and controls, as rainbow trout **(Hardy *et al.*, 2005)**, which is close to the current study.

According to **Teixeira *et al.* (1984)**, hematologic and biochemical tests of a particular population or animal species may reveal physiological heterogeneity since they are impacted

by the environment, gender, age, origin, breeding method, diet, and lineage. The studies related to discards application in fish on growth and health status are scant.

Following various feeding trials, fish health status can be assessed using blood biochemical indices **(Badrey *et al.*, 2019)**. In the present study, validation of the experiment's successful growth performance was achieved since blood glucose levels have been utilized as markers of environmental stress **(Badrey *et al.*, 2019)**. Discards did not elevate glucose levels, therefore they did not stress the fish, which indicated that discards were suitable for tilapia feeding. **Adam and Agab (2008)** recorded that blood glucose varied by different growth performances and negatively correlated with total weight and length. Blood glucose is close to **Tavares-Dias *et al.* (1999)** for *Piaractus mesopotamicus* and **Bittencourt *et al.* (2003)** for the Nile tilapia. The total protein values are higher than those reported for the Nile tilapia by **Bittencourt *et al.* (2003)**. The immune system, liver function, hydration, and osmoregulation can all be assessed using total protein, albumin, and globulin. Blood chemicals can also reflect changes in organ function. Additionally, glucose and electrolytes can reveal information regarding stress levels. Similar blood values were found for the majority of analysis in some studies **(Terao & Ogawa, 1984; McDonald & Milligan, 1992)** for *Tilapia nilotica* and other finfish species. Tilapia fish were in a good nutritional condition, and there were no discernible differences between the treatments according to triglycerides, cholesterol, uric acid, urea, and albumin measurements. The same findings were recorded by **Olsen *et al.* (2006)** when they replaced fish meal in the meals of Atlantic salmon with Antarctic krill. All blood parameters assessed were within the normal ranges. It showed that fish from discards suitable for tilapia feed have normal growth and health status.

Believes that discards are significant resource waste and negatively affect fisheries' financial sustainability, as well as the exploitation of marine biological resources and ecosystems **(Madsen *et al.*, 2022)**. Little information about how it affects the Nile tilapia's blood traits and immunity is available. Given that farming practices impact the fundamental physiological processes of farmed fish, blood monitoring is crucial in aquaculture **(Tavares-Dias & Moraes, 2007)**. In the current experiment, the RBCs showed an insignificant increase with an increase in discard concentration, which was within the range described for *Prochilodus lineatus* **(Ranzani-Paiva *et al.*, 2000)** and for *Schizodon borellii*. However, it is considered less than those mentioned by **Tavares-Dias *et al.* (2000a)** for Florida red tilapia and *Piaractus mesopotamicus* **(Tavares-Dias *et al.*, 1999)**. Haemoglobin concentration is similar to those determined for *S. borellii* **(Tavares-Dias *et al.*, 1999)**, *P. lineatus* **(Ranzani-Paiva *et al.*, 2000)**, and hybrid tambacu **(Tavares-Dias *et al.*, 2000b)**. However, it was higher than those for Florida red tilapia **(Tavares-Dias *et al.*, 2000)** and for *S. borellii* **(Ranzani-Paiva *et al.* 2000)**. The present study negligible alterations in RBCs and Hb imply that the discard diet may not have impacted *O. niloticus's* health.

The hematocrit levels are comparable to those reported for *Leporinus macrocephalus* **(Tavares-Dias *et al.*, 1999)**, *S. borellii* **(Ranzani-Paiva *et al.*, 2000)**, and Florida red tilapia **(Tavares-Dias *et al.*, 2000a)**. Still, levels were lower than those reported for *P. lineatus* **(Ranzani-Paiva *et al.*, 2000)** and hybrid tambacu **(Tavares-Dias *et al.*, 2000b)**. MCV values are close to those recorded in the study of **Bittencourt *et al.* (2003)** for the Nile tilapia. while, values determined are higher than those referred to for *L. macrocephalus* **(Tavares-Dias *et al.*, 1999)**. WBCs and their types observed in the present experiment are within the same line as those recorded for *O. mossambicus* **(Doggett *et al.*, 1987)** and *Oreochromis hybrid* **(Hrubec *et al.*, 1997)**. The hematologic levels recorded in this experiment are comparable to those published for *Tilapia nilotica* **(Terao & Ogawa, 1984)**, *O. mossambicus* **(Haniffa & Vijayarani, 1989)** and *Oreochromis hybrid* **(Hrubec *et al.*, 1997)**. All blood parameters denoted no adverse health effects, even at high discard levels.

CONCLUSION

Based on the current results, fish discards are suitable as dietary protein sources for tilapia, and the substitution recommended is 75%, which gives the best growth performance. All blood parameters measured indicated no effect on tilapia health when fed discards. From a haematology and biochemical viewpoint, tilapia fish fed discards grow normally and are healthy.

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