

# Comparative Study on the Effects of Extruded and Non-Extruded Local Feeds versus Commercial Feed on the Zootechnical Performance of *Oreochromis niloticus* (Linnaeus, 1758)

*by* Jana Publication & Research

---

**Submission date:** 04-Jun-2025 01:35PM (UTC+0700)

**Submission ID:** 2690345585

**File name:** IJAR-52070.docx (59.75K)

**Word count:** 5740

**Character count:** 31730

# <sup>1</sup>Comparative Study on the Effects of Extruded and Non-Extruded Local Feeds versus Commercial Feed on the Zootechnical Performance of *Oreochromis niloticus* (Linnaeus, 1758)<sup>52</sup>

## ABSTRACT

<sup>20</sup>Aquaculture plays a crucial role in bridging the gap left by declining wild fisheries. However, <sup>46</sup>the reliance on fish meal and fish oil for feeding farmed fish, along with the importation of industrial feed in developing countries like Senegal, limits the sector's growth. Thus, finding alternative solutions to these challenges is essential. <sup>13</sup>The objective of this study was to compare the effectiveness of imported industrial feed with extruded and non-extruded local feeds, while also evaluating the effects of replacing fish meal entirely with poultry by-product meal on the zootechnical performance and economic profitability of *Oreochromis niloticus*. A total of 180 *O. niloticus* fry were used, divided into three feeding diets (in triplicate), and monitored over a 60-day period. pH and temperature were recorded twice daily before siphoning, tank refilling, and feeding. <sup>35</sup>Fish were weighed biweekly to assess biomass and adjust feed rations. Prior to the study, the non-extruded local feed (R2) was formulated and produced. The results showed that the best weight gains (GPMa and GPMr, TCS), TCA and TS were observed <sup>1</sup>in fish fed with industrial feed (R0) compared to those fed with non-extruded local feed (R2), which primarily contained poultry by-product meal. However, given the statistical results showing no significant differences between diet R0 and the economic profitability of diet R1, extruded local feed (R1) appears to be the optimal choice among the three.

**Keywords:** *Oreochromis niloticus*, fishmeal, poultry by-product meal, industrial feed, extruded local feed, non-extruded local feed

## INTRODUCTION

Aquatic food products are a vital component of healthy, balanced diets worldwide (FAO, 2022). Fish, in particular, serves as a critical source of energy, protein, and various easily digestible nutrients with high biological value (Peng et al., 2014). In recent decades, global consumption of aquatic food products has significantly increased, and this trend is expected to

continue. Global fish consumption per capita has risen from an average of 9.9 kg in the 1960s to an estimated 20.7 kg in 2022 (FAO, 2024).

However, fishery resources continue to decline due to overfishing, pollution, climate change, and inadequate management. As a result, aquaculture has become essential for increasing the production of aquatic animal protein to meet growing global demand. One of the primary challenges in aquaculture is feeding. While fish meal and fish oil are crucial ingredients in fish feed, their high cost contributes to rising feed prices (Olaniyi and Salau, 2013), and their continued use could lead to the depletion of certain fish species. Moreover, in developing countries like Senegal, there is a lack of efficient and affordable feed, leading to the importation of costly feed, which further increases production expenses.

Therefore, replacing fish meal with more affordable alternative protein sources and developing extruded local feeds are critical strategies to reduce production costs in aquaculture. Poultry by-product meal, with its high protein content and favorable essential amino acid profile (Tacon, 1993; Gaylord and Rawles, 2005) is a suitable and viable protein source for fish. Its wide availability and lower cost make it an ideal candidate for replacing fish meal in aquaculture feeds. Additionally, the production of extruded local feed offers a promising alternative to imported industrial feeds, potentially leading to significant reductions in production costs.

The integration of poultry by-products could reduce dependence on fish meal, while the extrusion of local feeds would contribute to the development of efficient, cost-effective feeds for farmed fish such as Nile tilapia (*Oreochromis niloticus*). Nile tilapia is one of the most widely farmed species globally due to its rapid growth and adaptability to various aquatic environments, and it serves as a crucial protein source for millions of people worldwide.

The primary objective of this study is to compare the effectiveness of imported industrial feed with local extruded and non-extruded feeds on the zootechnical parameters and biochemical composition of Nile tilapia (*Oreochromis niloticus*). This research aims to assess the viability of more sustainable and economical feeding solutions. The specific objectives are as follows:

- Evaluate the impact of different feeding regimes on growth, feed efficiency, survival, and biochemical composition of Nile tilapia fry.

- Analyze the production costs associated with each feeding regime to identify the most economical solution for tilapia farming.

## MATERIAL AND METHODS

### Methods

#### Raw Materials

##### Sourcing of Raw Materials

The ingredients for the non-extruded local feed were selected based on standard criteria for feed ingredient selection, including availability, accessibility, cost, and protein content. Some ingredients were sourced from the station, while others were purchased from the Tilène market in Dakar

##### Processing Chicken By-Products into Meal

A specific processing method was used to convert chicken by-products into poultry meal. After purchasing the by-products, they were thoroughly cleaned and cooked for at least one hour to extract the oil. Following this, the by-products were sun-dried and then ground into a fine powder.

##### Biochemical Analysis of Raw Materials

To formulate a <sup>50</sup> balanced diet that meets the nutritional requirements of *Oreochromis niloticus* fry, the ingredients used were analyzed for their protein and fat content. In this study, only the poultry by-product meal was analyzed (Table 1) at the biochemistry laboratory of the ESP (École Supérieure Polytechnique), while the nutritional profiles of other ingredients (such as fish meal, wheat bran, peanut cake, soybean cake, etc.) were sourced from the station's existing database.

**Table 1: proximate composition of Chicken Viscera Meal**

Chicken Viscera Meal	Results (%)
Protein Content	61.25
Fat Content	19.33

## Formulation Method for Non-Extruded Local Feed

### Feed Formulation

Feed formulation is the process of calculating the proportions of each ingredient (agricultural by-products, agro-industrial products, and animal products) required to create a balanced feed. The goal is to combine ingredients with varying nutritional qualities to produce a feed that meets the specific nutritional needs of the species. In this study, the formulation was done using the Pearson's Square method, resulting in a feed composition of 31% protein and 12% lipids derived from the selected ingredients (Table 2).

**Table 2: Nutritional Composition of Different Diets**

Non-Extruded Local Feed		Extruded Local Feed	Commercial Feed (naturAlleva caliber 3mm)
Ingredients	IR (%)	Ingredients	Ingredients
Wheat bran	14	Fish meal Sorghum flour Corn flour Wheat flour Peanut cake Baobab leaf powder (lalo) Fish oil Vitamins Minerals Yeast	Fish meal Soybean meal Sunflower cake Rapeseed cake Poultry meal Blood meal Peas dehulled Guar germ cake Whey protein Monoammonium phosphate Hydrolyzed animal proteins Soy oil Additives (vitamins, iron, iodine, etc.)
Soybean cake meal	16		
Peanut cake meal	14		
Corn flour	10		
Cassava flour	6		
Neocarya pulp	8		
Chicken viscera meal	18		
Yeast	5		
Vitamins <sup>a</sup>	2		
Minerals <sup>b</sup>	2		
Chicken viscera oil	5		

<b>Total</b>	<b>100</b>	<b>100</b>	<b>100</b>
<b>Protein Contribution</b>	<b>31%</b>	<b>37%</b>	<b>30%</b>
<b>Lipid Contribution</b>	<b>12%</b>	<b>7,39%</b>	<b>6%</b>

#### IR = Incorporation Rate

2 a= vit A 250000 UI; vit D3 250000 UI; vit E 5000mg; vit B1 100mg; vit B2 400mg; vit B3(pp) 1000mg; vit B5 pantode Ca2000mg; vit B6 300mg; vit K3 1000g; vit C 5000mg; H biotin 15mg; choline 100g; anti-oxylant (BHT), crushed and calcined attapulgitte qs 1000mg;  
10 bephosphorus 7%; calcium 17%; sodium 1,5%; potassium 4,6%; magnesium 7,5%; manganese 738mg; zinc 3000mg; iron 4000mg; copper 750mg; iodine 5mg; cobalt 208mg; calcined and ground attapulgitte qs 1000g; fluorine 1,5% (approximately).

Note: For R0 (industrial or commercial feed) and R1 (extruded local feed), incorporation rates are not provided.

### II.3.3 Feed Manufacturing Process

After formulating the non-extruded local feed, the manufacturing process (with a total production of 1 kg for this regime) involves several steps. Ingredients are sourced from the Tilène market. Before weighing the required quantities, the flours are sifted through a fine sieve to remove large particles and any undesirable materials. After weighing, the ingredients are manually mixed to ensure a homogeneous blend. Oil is added last, followed by the incorporation of 30% water to compact the mixture. A manual grinder (Moulinex) is used to convert the dough into long strands resembling spaghetti. The mixture is fed into the grinder, and the strands are collected in a container. The processed product, still moist from the machine, is left to dry for two to three days. This step ensures better preservation by preventing mold growth and making the feed easier to handle. In the final phase, the dried feed is ground into powder for appropriate feeding of the fry.

### II.3.4 Rearing Conditions

This study begins with the collection of *Oreochromis niloticus* fry from the IUPA aquaculture station. After a 15-day acclimatization period, the fry were weighed and assigned to three

feeding diets in triplicate, with a density of 20 individuals per tank for a duration of 60 days. Throughout this period, physicochemical parameters, including pH and temperature, are measured twice daily (morning and evening) before siphoning, refilling the basins, and feeding the fry. The fry were weighed biweekly to assess biomass and adjust the feed ration accordingly.

### II.3.5 Growth, Survival, and Feed Efficiency Parameters

To estimate the growth and survival of the fish during the experiment and to assess the efficiency of the tested feeds, different parameters were calculated:

**Specific Growth Rate (SGR, %/d) = ((ln IW - ln FW) / rearing time) x 100**

**Absolute Mean Weight Gain (AMWG, g) = FW - IW**, With IW = initial weight and FW = final weight of the fish

**Relative Mean Weight Gain (RMWG, %) = (FW - IW) \* 100 / IW**. With IW = initial weight and FW = final weight of the fish

**Survival rate (SR, %) = (FN / IN) \* 100**, With FN: Final numbers; IN: initial Numbers

**Feed Conversion rate (FCR) = Quantity of feed distributed / absolute weight gain**

### Economic Analyses

Calculations were made for each of the three diets to evaluate the cost per kilogram of feed. The total feed cost was determined by summing the prices of all ingredients used, along with additional expenses such as transportation and labor ect. The production cost of one kilogram of fish was determined by multiplying the production cost of one kg of feed and the FCR.

### Statistical Analysis

The collected data were entered and processed using Microsoft Excel. Data analysis was performed using the Statistical Analysis System (SAS-PC) software, with the results subjected to an analysis of variance (ANOVA). The Tukey test was applied to identify significant differences between treatments.

## RESULTS AND DISCUSSION

### RESULTS

#### Water quality parameters

The physico-chemical parameters, specifically temperature and pH, are summarized in Table 3. The average daily temperatures measured during the experiment ranged from 25.90°C to 26.03°C. The average temperature for diet R2 (25.94±0.026°C) was slightly higher than those for diets R0 and R1, which were 25.91±0.017°C and 25.94±0.026°C, respectively. However, no significant differences were observed among these three diets.

The pH values ranged from 7.26 to 7.38. The average pH values for all three diets were similar, with diet R0 showing a value of 7.26±0, and diets R1 and R2 having values of 7.30±0.069. No statistically significant differences were found among these regimes.

**Table 3: Water quality parameters**

Diets	R0	R1	R2
Water parameters			
Average Temperature (°C)	25,91±0,017 <sup>a</sup>	25,94±0,026 <sup>a</sup>	25,98±0,055 <sup>a</sup>
Average pH	7,26±00 <sup>a</sup>	7,30±0,069 <sup>a</sup>	7,30±0,069 <sup>a</sup>

Note: a indicate no significant differences (P >0.05) between dietary treatments

#### Growth, Feed Efficiency, and Survival Parameters



During the experiment, various parameters were determined to evaluate the growth and survival of fish in each regime, as well as the efficiency of the feeds used. The results obtained are presented in Table 4.

**Table 4: Zootechnical Parameters**

Diets Parameters	R0	R1	R2
IMW (g)	0,11 <sup>a</sup>	0,11 <sup>a</sup>	0,11 <sup>a</sup>
FMW(g)	2,63±0,74 <sup>a</sup>	1,69±0,11 <sup>ab</sup>	0,81± 0,21 <sup>b</sup>
AMWG (g)	2,52±0,74 <sup>a</sup>	1,58±0,12 <sup>ab</sup>	0,70±0,21 <sup>b</sup>
RMWG (%)	2282,86±665,36 <sup>a</sup>	1447,87±104,90 <sup>ab</sup>	639,25 ± 189,42 <sup>b</sup>
SGR (%/d)	5,61±0,49 <sup>a</sup>	4,89±0,12 <sup>ab</sup>	3,53± 0,48 <sup>b</sup>
FCR	1,43±0,21 <sup>a</sup>	1,68±0,04 <sup>ab</sup>	2,08± 0,18 <sup>b</sup>
SR (%)	96,67±5,77 <sup>a</sup>	85±0 <sup>ab</sup>	71,67±7,64 <sup>b</sup>

Note: a,b indicate significant differences ( $P < 0.05$ ) between dietary treatments.

IMW: initial mean weight, FMW: final mean weight, AMWG, absolute mean weight gain, RMWG, relative mean weight gain, SGR: specific growth rate, FCR: feed conversion ratio, SR: survival rate.

The growth parameters (FMW, AMWG, RMWG, and SGR) obtained in this study reveal a significant difference between diets R0 and R2. Diet R0 achieved the best results, with a FMW of 2.63±0.74g, a AMWG of 2.52±0.74g, RMWG, of 2282.86±665.36%, and a SGR of 5.61 ±0.49%/day. However, no significant differences were observed between R0 and R1, nor between R1 and R2.

Regarding the feed conversion ratio (FCR), the most efficient diet is the one with the lowest value. The results show that R0 (1.43±0.21) is significantly different from R2, which has a FCR of 2.08±0.18. R1, with a FCR of 1.68±0.04, shows no significant difference compared to either R0 or R2.

The survival rates (SR) observed during the experiment ranged from 71.67±7.64% for R2 to 96.67±5.77% for R0. A significant difference was found between R0 and R1. However, R1,

with a survival rate of 85±0%, showed no significant difference when compared to R0 and R2.

### Flesh Analysis

The biochemical composition of initial fry of *O. niloticus* and those obtained at the end of the experiment is presented in Table 6.

**Table 5: Composition of Fry Flesh**

Samples	Crude Protein (%)	Crude Fat (%)	Crude Ash (%)
Initial fish	15,61±0,01 <sup>a</sup>	8,16±0,02 <sup>a</sup>	4,44±1,74 <sup>a</sup>
R0	14,55 ±0,80 <sup>a</sup>	8,21 ±0,20 <sup>a</sup>	3,19 ±0,23 <sup>a</sup>
R1	15,70 ±0,40 <sup>a</sup>	6,09 ±0,61 <sup>b</sup>	3,73 ±0,23 <sup>a</sup>
R2	15,2 ±2,32 <sup>a</sup>	9,18 ±0,88 <sup>a</sup>	3,78 ±1,33 <sup>a</sup>

Note: a,b indicate significant differences ( $P < 0.05$ ) between dietary treatments.

Statistical analysis indicates no significant difference in crude protein and ash content among the fry fed different experimental regimes. The crude protein content of Nile tilapia fry ranged from 14.55±0.80% to 15.70±0.40%, while the ash content varied from 3.19±0.23% to 3.78±1.33%. No statistical differences were observed between the initial fish and those from the different regimes (R0, R1, and R2).

Regarding fat content, fish fed R0 and R2 exhibited the highest levels, with values of 8.21%±0.20 and 9.18%±0.88, respectively. In contrast, the fat content of fry fed R1 (6.09%±0.61) showed a significant difference compared to fish fed diets R0 and R2, as well as the initial fish

### Economic Estimation of Feeds

The estimated costs of the experimental feeds are presented in Table 6.

**Tableau 6: Estimated Costs of Experimental Feeds and fish**

Non-Extruded Local Feed			Extruded Local Feed		Commercial Feed NaturAlleva (3mm)	
Ingredients	Price/kg	Price/% TI	Ingredients	Price/kg	Ingredients	Price/kg
Wheat bran	125	17,5	Fish meal Sorghum flour Corn flour Wheat flour Peanut cake Baobab leaves (lalo) Fish oil Vitamins Minerals Others		Fish meal Wheat flour Canola cake Sunflower cake Poultry meal Blood meal Defatted peas Guar germ meal Monoammonium phosphate Whey protein Soybean oil Additives (vitamins, iron, iodine...)	
Soybean cake	400	64				
Peanut cake	200	28				
Corn flour	200	20				
Cassava flour	150	9				
Neocarya pulp	150	12				
Chicken viscera meal	250	45				
Yeast	3000	150				
Vitamins	2380	47,6				
Minerals	760	15,2				
Viscera oil	250	12,5				
Others		82				
<b>TOTAL</b>		<b>420,8Fcfa</b>		<b>661,4Fcfa</b>		<b>1050Fcfa</b>
<b>TCA</b>	<b>2,08</b>			<b>1,68</b>		<b>1,43</b>
<b>Production</b>						
<b>Cost of fish</b>	<b>875 Fcfa</b>			<b>1110Fcfa</b>		<b>1500Fcfa</b>

The table 6 shows that the prices per kilogram of the three feeds range from 420,8 FCFA (local non-extruded feed) to 1050 FCFA (industrial feed). The price of the extruded local feed is estimated at 661.4 FCFA per kilogram. Thus, the local non-extruded feed is the cheapest, followed by the extruded local feed. However, based on the FCR results from this study, the non-extruded local feed presents the best fish production cost at 875FCFA /kg, compared to the extruded local feed and commercial diet, which cost 1110 and 1500 FCFA/kg, respectively.

## DISCUSSION

### Physicochemical Parameters

<sup>2</sup> The recorded temperature values <sup>23</sup> during this study ranged from 25.90°C to 26.03°C. These values align with the findings of Balarin and Hatton (1979), who reported that the thermal tolerance range for *Oreochromis niloticus* in laboratory conditions is between 8°C and 40°C, with optimal growth occurring between 24°C and 28°C. Our results are also consistent with those of Diago (2019), who recorded temperatures ranging from 25°C to 29.4°C. These findings suggest that temperature <sup>45</sup> did not limit the growth of *O. niloticus* fry during the study.

Regarding pH, the values ranged from 7.26 to 7.38, falling <sup>4</sup> within the optimal range identified by Malcolm et al. (2000), which is between 6.5 and 8.5 for optimal biological and physiological performance in *O. niloticus*. Our results also support the findings of Bahnasawy et al. (2009), who found that *O. niloticus* fry grow best at a pH between 7 and 9. Therefore, <sup>60</sup> we can conclude that the pH conditions during our study were suitable and did not hinder the growth of Nile tilapia fry.

### <sup>1</sup> Growth, Feed Efficiency, and Survival Parameters

#### Growth Parameters

The results of the experiment show that fry fed the R0 diet (commercial feed) had the highest average daily weight gain (ADWG) of 2.52±0.74 g, followed by those fed the R1 diet (extruded local feed), which had an ADWG of 1.58±0.12 g. <sup>11</sup> However, no significant difference was observed between these two diets. These results indicate that the extrusion of the feed made from local ingredients positively impacted <sup>1</sup> the growth of Nile tilapia fry.

In contrast, fry fed the non-extruded local feed (R2) showed the lowest performance, with an ADWG of 0.70±0.21 g. These findings are consistent with those of Fall (2023) and Hong et al. (2019), who reported better growth performances in control diets containing only fish meal, with weight gains of 3.34 g and 15.83 g, respectively, compared to diets containing poultry by-products. This could be explained by the lower levels of methionine and lysine in poultry by-product meal and the high inclusion rate of poultry meal in the non-extruded local feed. Koch et al. (2016) suggested that the use of poultry meal supplemented with lysine, methionine, and taurine leads to the best growth outcomes in juvenile Nile tilapia.

Tacon et al. (2009) recommended poultry by-product meal inclusion levels of 5% to 25% in fish feed, and Turker et al. (2005) found no significant reduction in growth performance when turbot was fed diets containing 25% poultry by-product meal compared to fish meal-based control diets. These findings underscore the importance of optimizing feed formulations to maximize the growth of aquaculture fry.

### Feed Efficiency Parameters

Feed efficiency results indicated that diets R0 and R1 achieved the best feed conversion ratios (FCR), with values of  $1.43 \pm 0.21$  and  $1.68 \pm 0.04$ , respectively. However, the R2 diet showed a significantly higher FCR of  $2.08 \pm 0.18$  compared to the control diet. These results suggest that incorporating poultry meal into the diet was not effective for *O. niloticus* fry. Similar findings were reported by Hong et al. (2019) and Fall (2023), who observed the best FCRs (1.75 and 1.69) in control diets containing only fish meal and noted significant differences between the control and poultry by-product meal diets.

Incorporating poultry meal into fish diets can reduce feed efficiency (Hatlen et al., 2015). Davis et al. (1991) noted that some poultry by-products are deficient in essential amino acids such as lysine and methionine (Yang et al., 2004), which can affect feed quality unless supplemented. However, Dawood et al. (2020) found the best FCR (1.22) in fish fed a diet containing 20% fermented poultry by-product meal, suggesting that fermentation may improve the nutritional quality of poultry by-products and increase feed efficiency.

### Survival Parameters

The highest survival rate was observed in fish fed the R0 diet ( $96.67\% \pm 5.77\%$ ), followed by those fed the R1 diet ( $85\% \pm 0\%$ ). The R2 diet showed the lowest survival rate ( $71.67\% \pm 7.64\%$ ), which was significantly different from the R0 diet. The low mortality rate observed in the R0 and R1 diets seems to be unrelated to feeding, as most mortalities occurred one to two days after fish handling or tank cleaning, likely due to stress or handling accidents.

For the R2 diet, mortalities appeared to be linked to the feed quality. Fish on this diet appeared thin, weak, and showed very slow growth. This could be attributed to the high poultry meal content, which led to poor feed quality and slow adaptation to the diet. These

results contrast with those of Palupi et al. (2020), who reported 100% survival in tilapia fed diets containing varying levels of poultry by-product meal replacing fish meal.

### Flesh Analysis

Bromatological analysis of the fish flesh revealed that fish from the R1 and R2 diets had the highest protein contents, at 15.70% and 15.2%, respectively, which were slightly higher than the initial fish (15.61%). In contrast, the R0 diet had a slightly lower protein content. This can be explained by the differences in protein content among the three tested feeds, which were 30% for R0, 37% for R1, and 31% for R2. Ahmad et al. (2012), Tidwell et al. (2005), and Pedro et al. (2001) report that flesh protein content increases with higher dietary protein levels.

The lipid content of fish from the R1 diet (with the highest protein intake of 37%) significantly decreased to  $6.09\% \pm 0.61$  ( $P < 0.05$ ). In contrast, the fat content in fish from the R0 and R2 diets ( $8.21\% \pm 0.20$  and  $9.18\% \pm 0.88$ , respectively) was slightly higher than in the initial fish ( $8.16\% \pm 0.02$ ), but no significant difference was observed. These results are consistent with Bahnasawy (2009), who noted that fat content decreases as dietary protein increases.

Conversely, these findings do not align with Loum (2013), who recorded the highest crude fat content (9.4%) in fish fed a diet with the highest protein intake of 45.50%. Regarding ash content, no significant differences were found among the three diets, although the values were slightly lower than those of the initial fish.

### Economic Estimation of Feeds

Economic analysis revealed that the R2 diet (420,8 FCFA/kg) was the cheapest, followed by the R1 diet (661.4 FCFA/kg), while the R0 diet had the highest cost (1050 FCFA/kg). However, considering feed efficiency (FCR), and feed production costs, the extruded local feed (R1) proved to be the most economically viable option. The results from this diet showed satisfactory performance compared to the R2 diet (non-extruded feed) and were statistically similar to those from the R0 diet (commercial feed).

### Conclusion

Reducing the reliance on fishery products such as fish meal and fish oil in aquaculture feeds through partial or total substitutions is a major challenge for the future of global aquaculture. Similarly, the high dependence on imported, expensive feeds threaten the economic viability of local producers in developing countries.

The primary objective of this study was to compare industrial feed with local feeds (extruded and non-extruded) to identify which one promoted better growth and survival of Nile tilapia fry while being economically feasible. This approach aims to tackle issues related to the use of wild fish stocks and the lack of efficient and affordable feeds for fish farmers, contributing to the growth of aquaculture in Senegal and other developing countries.

The study found that the R0 diet (non-extruded local feed) offered the best cost-to-benefit ratio. Future research could further explore the effects of incorporating poultry by-products in extruded local feeds for other aquaculture species, as well as the potential economic and environmental benefits of replacing fish meal with locally sourced alternatives.

## REFERENCES

Ahmad, M., Qureshi, T.A., Singh, A.B., Susan, M., Kamlesh, B., Salman, R.C., (2012). Effect of dietary protein, lipid and carbohydrate contents on the growth, feed efficiency and carcass composition of *Cyprinus carpio communis* fingerlings. *International Journal of Fisheries and Aquaculture*, 4, 30-40.

Al dilaimi A., 2009. Détermination de la ration lipidique alimentaire optimale chez les alevins du tilapia du Nil 3 (*Oreochromis niloticus*). Mémoire de Magister. Université d'Oran. 52p.

Aquaculture Nutrition 17: e389–e395.

Badillo, D. ; Pares-Sierra, G. ; Durazo, E. ; Ponce, M. A. ; Correa-Reyes, G. ; and Viana, M.T. (2014). Partial to total replacement of fishmeal by poultry by-product meal in diets for juvenile rainbow trout (*Oncorhynchus mykiss*) and their effect on fatty acids from muscle tissue and the time required to retrieve the effect. *Aquaculture Research* 45(9) : 1459-1469.

Bahnasawy M. H., (2009). Effect of Dietary Protein Levels on Growth Performance and

Bailly, N. (2009). *Oreochromis niloticus* (Linnaeus, 1758). In: Froese, R. and D. Pauly.

**Benzidane D., 2012.** Effet d'une supplémentation de l'aliment avec de l'antioxydant

Body Composition of Monosex Nile Tilapia, *Oreochromis niloticus* L. Reared in Fertilized Tanks. *Pakistan Journal of Nutrition*, 8, 674-678

**Burel Christine, 2017.** Bases de la nutrition et formulation en aquaculture. Durabilité des aliments pour le poisson en aquaculture: réflexions et recommandations sur les aspects technologiques, économiques, sociaux et environnementaux, UICN - Union Internationale pour la Conservation de la Nature; Comité Français de l'UICN, 296 p., 2017, 9782831718316. hal-01607152. Cahiers Agricultures, 18(2-3): 393-401.

**CAHU, C. 2004.** « Domestication et fonction nutrition chez les poissons ». *INRAE Productions Animales* 17 (3): 205-10. <https://doi.org/10.20870/productions-animales.2004.17.3.3593>.

**Cruz-Suarez, L. E.; Nieto-Lopez, M.; Guajardo-Barbosa, C.; Tapia-Salazar, M.; Scholz, U.; Ricque-Marie, D.(2007).** Replacement of fish meal with poultry by-product meal in practical diets for *Litopenaeus vannamei*, and digestibility of the tested ingredients and diets. *Aquaculture*, 272: 466-476.

d'Ivoire. Environmental Biology of

**Davies SJ, Nengas I, Alexis M (1991).** Partial substitution of fish meal with different meat meals products in diets for sea bream (*Sparus aurata*). In: Kaushik, S.J., Luquet (Eds.), Fish Nutrition in Practice. Coll. Les Colloques, vol. 61. INRA, Paris, pp. 907-911.

**Dawood, M. A., Shukry M., Zayed M. M., Omar A. A., Zaineldin A. I., El Basuini M. F. (2020).** Digestive enzymes, immunity and oxidative status of Nile Tilapia (*Oreochromis niloticus*) reared in intensive conditions. *Sloven Vet Res.* 56:99-108.

**Diago (2019).** Effet de l'incorporation de différentes formes de farines de feuilles de *Boscia senegalensis* sur les performances de croissance et de survie des alevins de *O. niloticus*. Mémoire de Master. IUPA/UCAD

**Duponchelle F, Panfili J. 1998.** Variations in age and size at maturity of female Nile Tilapia, *Oreochromis niloticus*, populations from man-made lakes of Côte d'Ivoire. *Environmental Biology of Fishes*, 52: 453-465. DOI: 10.1023/A:1007453731509



**Fall S. K LO (2023).** Substitution partielle de la farine de poissons par d'autres farines d'origine animale dans l'alimentation du Tilapia du Nil : effets sur les paramètres zootechniques et la rentabilité économique. THÈSE ED-SEV/UCAD.

**FAO, 2022.** Situation mondiale des pêches et de l'aquaculture

**FAO, 2024.** Rapport de Rabobank, septembre 2024.

**Francis, George, Harinder P.S Makkar, et Klaus Becker. 2001.** « Antinutritional Factors Present in Plant-Derived Alternate Fish Feed Ingredients and Their Effects in Fish ». *Aquaculture* 199 (3,4): 197-227. [https://doi.org/10.1016/S0044-8486\(01\)00526-9](https://doi.org/10.1016/S0044-8486(01)00526-9).

**Froese, R. et Pauly, D. (2017).** *Oreochromis niloticus* summary page. Fish Base. World Wide Web electronic publication. [www.fishbase.org](http://www.fishbase.org).

**Gaylord TG, Rawles SD (2005).** The modification of poultry by-product meal for use in hybrid striped bass *Morone chrysops* 3 *M. saxatilis* diets. *Journal of the World Aquaculture Society* 36:365–376.

**Gomes, Emídio F., Paulo Rema, et Sadasivam J. Kaushik. 1995.** « Replacement of Fish Meal by Plant Proteins in the Diet of Rainbow Trout (*Oncorhynchus Mykiss*): Digestibility and Growth Hamburg. *Aquaculture*; 130:177-186.

**Hatlen, B. ; Jakobsen, J. V. ; Crampton, V. ; Alm, M. ; Langmyhr, E. ; Espe, M. ; Hevroy, E. M. ; Torstensen, B. E. ; Liland, N. and Waagbo R. (2015).** Growth, feed utilization and endocrine responses in Atlantic Salmon (*Salmo salar*) fed diets added poultry by-product meal and blood meal in combination with poultry oil. *Aquaculture Nutrition* 21:714–725.

**Hernandez, C.; Olvera-Novoa, M.; Hardy, R., Hermosillo, A.; Reyes, C.; Gonzalez, B. (2010).** Complete replacement of fish meal by porcine and poultry by-product meals in practical diets for fingerling Nile tilapia *Oreochromis niloticus*: digestibility and growth performance. *Aquaculture Nutrition* 16: 44–53.

**Hong, Y. C.; Chien, A. and Sheen Shyn-S. (2019).** The effects of replacement of fish meal protein with a mixture of poultry by-product meal, fish silage and fish protein hydrolysate on the growth performances of asian sea bass (*Lates calcarifer*). *Journal of marine science and technology*: 27(6): 10p.

**Huchette, S. M. H, et M. C. M Beveridge. 2003.** « Technical and Economical Evaluation of PeriphytonBased Cage Culture of Tilapia (*Oreochromis Niloticus*) in Tropical Freshwater Cages ». *Aquaculture* 218 (1): 219-34

**Kestemont, P., Micha, J. C., Falter, U. (1989).** Les méthodes de production d'alevins de Tilapia nilotica. FAO/tDCPIREP/89i46: 132 pp.

**Koch, J. F. ; Rawles, S. D. ; Webster, C. D. ; Cummins, V. ; Kobayashi, Y. ; Thompson , K. R. ; Gannam, A. L. ; Twibell, R. G. ; and Hyde, N. M. (2016).** Optimizing fish meal-free commercial diets for Nile Tilapia, *Oreochromis niloticus*. *Aquaculture* 452: 357–66.

**Koch, J. F. ; Rawles, S. D. ; Webster, C. D. ; Cummins, V. ; Kobayashi, Y. ; Thompson , K. R. ; Gannam, A. L. ; Twibell, R. G. ; and Hyde, N. M. (2016).** Optimizing fish meal-free commercial diets for Nile Tilapia, *Oreochromis niloticus*. *Aquaculture* 452: 357–66.

**Kureshy, N.; Davis, D. A. ; Arnold, C. (2000).** Partial replacement of fish meal with meat-andbone meal, flash-dried poultry by-product meal, and enzyme-digested poultry by-product meal in practical diets for juvenile red drum. *N Am J Aquac.* 62: 266–272.

**Lacroix E. 2004.** Pisciculture en Zone Tropicale. GTZ & GFA Terra Systems: Hamburg.

**Lazard J. 2009.** La pisciculture des tilapias. *Cahiers Agricultures*, 18(2-3): 393–401.  
<http://cat.inist.fr/?aModele=afficheN&cpsidt=21713651>

**Lévêque C, Paugy D. 2006.** Les Poissons des Eaux Continentales Africaines: Diversité, Ecologie, Utilisation par l'Homme. IRD: Paris.

**Loum Abdoulaye, (2013).** Effets de différents régimes protéiques sur la croissance, la survie et la composition biochimique de la chair du tilapia *Oreochromis niloticus* Linnaeus (1758). MEMOIRE DE MASTER. IUPA/UCAD.

**Luquet, Pierre, et Yann Moreau. 1989.** « Energy: protein management by some warmwater finfishes » 9 (janvier). *ADVANCES IN TROPICAL AQUACULTURE* Tahiti Feb 20 - March 4 . 1989AQUA COP IFREMER Acres de Colloque 9 pp. 751-755

**Malcom C.; Beveridge H.; Mc Andrew B.J.; (2000).** Tilapias : biologie and exploitation. Institut of aquaculture. University of Stirling, Scotland. Kluwer Academic Publishers : 185 p.

**Mashai N, Rajabipour F, Mohammadi M, Sarsangi H, Bitaraf A, Hossein-Zadeh H, Sharif-Rohani M. 2016.** Reproduction of Nile Tilapia, *Oreochromis niloticus* in Brackish Water. Journal of Applied Aquaculture, 28(1): 1–8. DOI:10.1080/10454438.2015.1104943

**MBONDO BIYONG Serge René, 2021.** Effet du remplacement de la farine de poisson par la farine de mouche soldat noire (MSN) enrichie en acides gras essentiels et en chitinase, sur la croissance, le système digestif et la capacité de défense immunitaire du tilapia du Nil *Oreochromis niloticus* (Linnaeus, 1758).

**Mélard, Ch., (1986).** Les bases biologiques de l'élevage intensif du tilapia du Nil. Cahiers d'Ethologie appliqué, 6, 224p. Mémoire de MAGISTER. Université d'Oran. 71p

**MERAH Abderezak, 2023.** Essai d'incorporation de quelques ingrédients localement disponibles dans l'alimentation chez le Tilapia du Nil. Thèse Université Kasdi Merbah Ouargla. 149 p.

National Research Council. 2011. *Nutrient Requirements of Fish and Shrimp*. Washington, DC: The National Academies Press. <https://doi.org/10.17226/13039>.

**Olaniyi CO, Salau BR (2013)** Utilization of maggot meal in the nutrition of African cat fish. Afr J Agric Res 8(37):4604–4607

**Palupi, E.T.; Setiawati, M. ; Lumlertdacha, S. ; Suprayudi, M.A. (2020).** Growth performance, digestibility, and blood biochemical parameters of Nile Tilapia (*Oreochromis niloticus*) reared in floating cages and fed poultry by-product meal, Journal of Applied Aquaculture, 32: 16-33.

**Pedro, N.D., Guijarro, A.I., Delgado, M.J., Patina, L.P., Pinillos, M.L., Bedate, M.A.**

**Peng M., Xu W., Mai K., Zhou H., Zhang Y., Liufu Z., Zhang K. et Ai Q., 2014.** Growth performance, lipid deposition and hepatic lipid metabolism related gene expression in juvenile turbot (*Scophthalmus maximus* L.) fed diets with various fish oil substitution levels by soybean oil. Aquaculture 433, 442–449.

**Rossi, W. J. and Davis, D. (2012).** Replacement of fishmeal with poultry by-product meal in the diet of Florida Pompano *Trachinotus carolinus* L. *Aquaculture*, 338–341:160–166.

**salah, Azaza, Mensi Fethi, Ibrahim Toko, Mohamed Dhraief, A Abdelmouleh, B Brini, et M.M. Kraïem. 2006.** « Effets del incorporation de la farine de tomate dans l'alimentation du tilapia du Nil (*Oreochromis niloticus*, L., 1758) en élevage dans les eaux géothermales du sud tunisien ». *Bull Inst Nat Sci Tech Mer* 33 (Janvier).

**Shapawi, R.; Ng, W. K. and Mustafa, S. (2007).** Replacement of fish meal with poultry byproduct meal in diets formulated for the Humpback Grouper, *Cromileptes altivelis*. *Aquaculture* 273: 118–126.

**Tacon AGJ (1993).** Feed ingredients for warm water fish. Fish meal and other processed feed stuffs. FAO Fish. Circ., vol. 856. FAO, Rome, Italy. 64 pp.

**Tacon, A. G. J.; Hasan, M. R. and Subasinghe, R. P. (2006).** Use of fishery resources as feed inputs to aquaculture development: trends and policy implications. FAO Fisheries Circular 1018.

**Takakuwa, F.; Fukada, H.; Hosokawa, H. and Masumoto, T. (2006).** Availability of poultry byproduct meal as an alternative protein source for fish meal in diet for Greater Amberjack (*Seriola dumerili*). *Aquaculture Science* 54: 473–480.

**Tidwell, J.H., Coyle, S.D., Bright, L.A., Yasharian, D., (2005).** Evaluation of plant and animal source proteins for replacement of fish meal in practical diets for the largemouth bass, *Micropterus salmoides*. *Journal World Aquaculture Society*, 36, 454-463

**Trewavas, E. (1983).** Tilapine Fishes of the Genera *Sarotherodon*, *Oreochromis* and *Danakilia*. London British Museum (Natural History), 583 p.

**Turker A, Murat Y, Sebahattin E, Burcu K, Erteken A (2005).** Potential of Poultry By-Product Meal as a substitute for fish meal in diets for Balck Seabass Turbot *Scophthalmus maeoticus*: Growth and Nutrient Utilization in Winter. *The Israeli Journal of Aquaculture – Bamidgeh* 57(1), 2005, 49-61.

**Welcomme, R.L. (1988).** International introduction of inland aquatic species. F.A.O. Fish techn. 318 pp

**Yang, Y. ; Xie, S. ; Cui, Y. ; Lei, W. ; Zhu, X. ; Yang, Y. ; Yu, Y. (2004).** Effect of replacement of dietary fish meal by meat and bone meal and poultry byproduct meal on growth and feed utilization of gibel carp, *Carassius auratus gibelio*. Aquacult Nutr 10: 289-294.

**Yang, Y. ; Xie, S. ; Cui, Y. ; Lei, W. ; Zhu, X. ; Yang, Y. ; Yu, Y. (2004)** Effect of replacement of dietary fish meal by meat and bone meal and poultry byproduct meal on growth and feed utilization of gibel carp, *Carassius auratus gibelio*. Aquacult Nutr 10: 289-294.

**Yang, Y.; Xie, S. ; Cui, Y. ; Zhu, X. ; Lei, W. ; Yang, Y. (2006).** Partial and total replacement of fishmeal with poultry by-product meal in diets for gibel carp, *Carassius auratus gibelio* Bloch. Aquacult Res 37: 40-48.

**Yones, A. M. M. and Metwalli, A. A. (2015).** Effect of fishmeal substitution with poultry byproduct meal on growth performance, nutrient utilization and blood content of juvenile Nile tilapia (*Oreochromis niloticus*). Journal of Aquaculture Research and Development, 6: 389.

**Yu, Y. (2004).** Replacement of fishmeal with poultry byproduct meal and meat bone meal in shrimp, tilapia, and trout diets. In Essentials of rendering: All about the animal by-product industry, Arlington, VA: National Renderers Association ed. D. L. Meeker, 182–201.

**Zhu, H.; Gong, G.; Wang, J.; Wu, X.; Xue, M.; Niu, C.; Guo, L. and Yu, Y. (2011).** Replacement of fishmeal with blend of rendered animal protein in diets for Siberian sturgeon (*Acipenser baerii* Brandt), result in performance equal to fish meal fed fish. Aquaculture Nutrition. <https://doi.org/10.1111/j.1365-2095.2010.00773.x>

# Comparative Study on the Effects of Extruded and Non-Extruded Local Feeds versus Commercial Feed on the Zootechnical Performance of Oreochromis niloticus (Linnaeus, 1758)

## ORIGINALITY REPORT

25%

SIMILARITY INDEX

19%

INTERNET SOURCES

21%

PUBLICATIONS

3%

STUDENT PAPERS

## PRIMARY SOURCES

- 1

Jean Fall, Yoba Oumou Balde, Paul Mamadou Ndour, Ndeye Codou Mbaye, Alla Ndione, Aliou Ndao. "Comparative Study of the Effects of Imported Industrial Feed and Local Feed on the Growth of Nile Tilapia (Oreochromis niloticus) Fry", Journal of Agricultural Studies, 2025  
Publication

4%
- 2

Alla Ndione, Jean Fall, Ndeye Codou Mbaye. "Effects of Replacement of Fish Oil with Black Soldier Fly (Hermitia illucens) Oil on the Growth Performance and Biochemical Composition of the Flesh of Nile Tilapia (Oreochromis niloticus) Fry", Journal of Applied Biotechnology, 2025  
Publication

3%
- 3

[www.macrothink.org](http://www.macrothink.org)  
Internet Source

2%
- 4

Alla Ndione, Jean Fall, Daouda Mbow, Ndeye Codou Mbaye. "Effects of the Substitution of Fish Meal by a Combination of Black Soldier fly meal (Hermitia illucens) and Shea Butter Meal (Cirina butyrospermi) on the Growth Performance and Biochemical Composition of the Flesh of Nile tilapia Oreochromis niloticus Fry", Journal of Biology and Life Science, 2025

1%

5	<a href="http://www.garj.org">www.garj.org</a> Internet Source	1 %
6	Esti Tuhu Palupi, Mia Setiawati, Sonkphan Lumlertdacha, Muhammad Agus Suprayudi. " Growth performance, digestibility, and blood biochemical parameters of Nile tilapia ( ) reared in floating cages and fed poultry by-product meal ", Journal of Applied Aquaculture, 2019 Publication	1 %
7	<a href="http://res.mdpi.com">res.mdpi.com</a> Internet Source	1 %
8	<a href="http://www.m.elewa.org">www.m.elewa.org</a> Internet Source	<1 %
9	<a href="http://ijcmas.com">ijcmas.com</a> Internet Source	<1 %
10	<a href="http://journalissues.org">journalissues.org</a> Internet Source	<1 %
11	<a href="http://ojs.uok.edu.in">ojs.uok.edu.in</a> Internet Source	<1 %
12	<a href="http://tamucc-ir.tdl.org">tamucc-ir.tdl.org</a> Internet Source	<1 %
13	<a href="http://www.aquahana.com">www.aquahana.com</a> Internet Source	<1 %
14	<a href="http://ijnss.org">ijnss.org</a> Internet Source	<1 %
15	<a href="http://www.icssca.org">www.icssca.org</a> Internet Source	<1 %
16	<a href="http://www.researchgate.net">www.researchgate.net</a> Internet Source	<1 %

17	Submitted to Federal University of Technology Student Paper	<1 %
18	sciencescholar.us Internet Source	<1 %
19	M. S. Azaza, A. Assad, W. Maghrbi, M. El-Cafsi. " The effects of rearing density on growth, size heterogeneity and inter-individual variation of feed intake in monosex male Nile tilapia L. ", animal, 2013 Publication	<1 %
20	"Sustainable Feed Ingredients and Additives for Aquaculture Farming", Springer Science and Business Media LLC, 2024 Publication	<1 %
21	Kalaivanan Rajalakshmi, Nathan Felix, Amit Ranjan, Uma Arumugam, Govindharaj Sathishkumar. " Physiological, immunological and nutritional assessment of fed with different combinations of novel feed ingredients ", Annals of Animal Science, 2025 Publication	<1 %
22	macrothink.org Internet Source	<1 %
23	www.fisheriesjournal.com Internet Source	<1 %
24	epubs.icar.org.in Internet Source	<1 %
25	Ameneh Khoshvaghti, Raha Rahbari. "The effect of ellagic acid on sex hormones and miRNA-21 expression in rats with polycystic ovary syndrome", Research Square Platform LLC, 2023 Publication	<1 %



26	horizon.documentation.ird.fr Internet Source	<1 %
27	journalijar.com Internet Source	<1 %
28	Ikram Ennayer et al.. "The effect of the substitution of fishmeal with mealworm ( <i>Tenebrio molitor</i> ) on the survival, growth and quality of the European seabass ( <i>Dicentrarchus labrax</i> ) reared in Morocco", <i>Egyptian Journal of Aquatic Biology and Fisheries</i> , 2022 Publication	<1 %
29	M.A Hossain, U Focken, Klaus Becker. "Evaluation of an unconventional legume seed, <i>Sesbania aculeata</i> , as a dietary protein source for common carp, <i>Cyprinus carpio</i> L.", <i>Aquaculture</i> , 2001 Publication	<1 %
30	Md.Shahidul Islam. "Evaluation of supplementary feeds for semi-intensive pond culture of mahseer, <i>Tor putitora</i> (Hamilton)", <i>Aquaculture</i> , 2002 Publication	<1 %
31	science.buu.ac.th Internet Source	<1 %
32	"Byproducts from Agriculture and Fisheries", Wiley, 2019 Publication	<1 %
33	A.J. Vizcaíno, G. López, M.I. Sáez, J.A. Jiménez et al. "Effects of the microalga <i>Scenedesmus almeriensis</i> as fishmeal alternative in diets for gilthead sea bream, <i>Sparus aurata</i> , juveniles", <i>Aquaculture</i> , 2014 Publication	<1 %

34 P. Psoufakis, I.T. Karapanagiotidis, E.E. Malandrakis, E. Golomazou, A. Exadactylos, E. Mente. "Effect of fishmeal replacement by hydrolyzed feather meal on growth performance, proximate composition, digestive enzyme activity, haematological parameters and growth-related gene expression of gilthead seabream (*Sparus aurata*)", *Aquaculture*, 2020

Publication

<1 %

35 Riche, Marty. "Nitrogen utilization from diets with refined and blended poultry by-products as partial fish meal replacements in diets for low-salinity cultured Florida pompano, *Trachinotus carolinus*", *Aquaculture*, 2015.

Publication

<1 %

36 Thanakorn Srisuwan, Pramote Puengjinda, Napat Kaewtrakulchai, Sirayu Chanpee et al. "NiO-YSZ anode composite material derived from mechano-chemical for solid oxide fuel cells application", *Case Studies in Chemical and Environmental Engineering*, 2025

Publication

<1 %

37 [flore.unifi.it](http://flore.unifi.it)

Internet Source

<1 %

38 [sherekashmir.informaticspublishing.com](http://sherekashmir.informaticspublishing.com)

Internet Source

<1 %

39 [www.tandfonline.com](http://www.tandfonline.com)

Internet Source

<1 %

40 I. Saadiah, A. M. Abol-Munafi, C. M. Che Utama. "Replacement of fishmeal in cobia (*Rachycentron canadum*) diets using poultry by-product meal", *Aquaculture International*, 2010

<1 %

- 41 Karga, J., and S.C. Mandal. "Effect of different feeds on the growth, survival and reproductive performance of zebrafish, *Danio rerio* (Hamilton, 1822)", *Aquaculture Nutrition*, 2016. <1 %

Publication

- 42 Maila V. Pan, Rex Ferdinand M. Traifalgar, Victor Marco Emmanuel N. Ferriols, Liberato V. Laureta, Jose P. Peralta. " Efficacy of squid by-product hydrolysate supplementation on the growth performance, digestive enzyme activities and muscle growth-related genes expression of fed on plant protein-based diet ", *Cogent Food & Agriculture*, 2022 <1 %

Publication

- 43 Shuqing He, Mingyan Ding, Gyan Watson Ray, Qihui Yang, Beiping Tan, Xiaohui Dong, Shuyan Chi, Hongyu Liu, Shuang Zhang. " Effect of dietary vitamin D levels on growth, serum biochemical parameters, lipid metabolism enzyme activities, fatty acid synthase and hepatic lipase mRNA expression for orange-spotted grouper ( ) in growth mid-stage ", *Aquaculture Nutrition*, 2021 <1 %

Publication

- 44 Yubo Wu, Hengjia Ma, Xiujuan Wang, Xing Ren. " Taurine supplementation increases the potential of fishmeal replacement by soybean meal in diets for largemouth bass ", *Aquaculture Nutrition*, 2021 <1 %

Publication

- 45 [article.sciencepublishinggroup.com](https://www.sciencepublishinggroup.com) <1 %

Internet Source

46	Internet Source	<1 %
47	eprints.utar.edu.my Internet Source	<1 %
48	mdpi-res.com Internet Source	<1 %
49	oaktrust.library.tamu.edu Internet Source	<1 %
50	pearl.plymouth.ac.uk Internet Source	<1 %
51	prp.hec.gov.pk Internet Source	<1 %
52	scholars.ntou.edu.tw Internet Source	<1 %
53	www.biorxiv.org Internet Source	<1 %
54	www.fao.org Internet Source	<1 %
55	www.fisheries.go.th Internet Source	<1 %
56	www.frontiersin.org Internet Source	<1 %
57	www.science.gov Internet Source	<1 %
58	Joachim W. Hertrampf, Felicitas Piedad-Pascual. "Handbook on Ingredients for Aquaculture Feeds", Springer Nature, 2000 Publication	<1 %
59	Kalaivanan Rajalakshmi, Nathan Felix, Amit Ranjan, Uma Arumugam, Mir Ishfaq Nazir, Govindharaj Sathishkumar. "Effects of diets	<1 %

formulated with different combinations of novel feed ingredients on growth performance, apparent digestibility, digestive enzymes and gene expression activities of Pacific white shrimp, *Penaeus vannamei*", Aquaculture International, 2025

Publication

60

El-Sayed, A.F.M.. "Effects of photoperiod on the performance of farmed Nile tilapia *Oreochromis niloticus*: I. Growth, feed utilization efficiency and survival of fry and fingerlings", Aquaculture, 20040305

<1 %

Publication

Exclude quotes On

Exclude matches Off

Exclude bibliography On