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Research Article

# Caractérisation et modélisation des paramètres physico-chimiques pour une gestion durable de l'aquaculturesur la côte est et hautes terres Malagasy

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**Résume**

Cette étude menée à Antsirabe a examiné l'effet de deux traitements d'alimentation, AC0 et AC1, sur la performance de croissance du tilapia dans des conditions d'aquaculture. Dans l'ensemble, les résultats montrent que les deux régimes ont produit des résultats très similaires. Le poids final moyen (FAW) était presque identique entre les traitements, avec un léger avantage pour l'AC0 (51,62 g) par rapport à l'AC1 (51,36 g). La prise de poids (WG) et la prise de poids quotidienne (DWG) ont suivi la même tendance, atteignant 42,50 g et 0,66 g/jour sous AC0, contre 41,80 g et 0,64 g/jour avec AC1, bien que ces différences n'aient pas été statistiquement significatives. Le taux de croissance spécifique (SGR) est également resté proche, avec 3,07 %/jour pour AC0 et 2,95 %/jour pour AC1. La conversion de l'alimentation (IC) était presque identique entre les traitements (1,15 contre 1,16), et la survie a atteint 100 % dans les deux groupes. Le facteur de condition (K) était également le même (2,44), indiquant des poissons sains et bien proportionnés quel que soit le traitement. Pris ensemble, les résultats suggèrent que les deux régimes soutiennent des performances de croissance comparables, avec seulement des tendances mineures et non significatives favorisant l'AC0. Ces résultats indiquent que l'AC1 peut servir d'option d'alimentation alternative sans compromettre la croissance ou la survie.

*Mots clés* : ***Oreochromis niloticus, formulation des aliments, performance de croissance, aquaculture, taux de survie, Antsirabe.***

**Abstract**

This study conducted in Antsirabe examined the effect of two feed treatments, AC0 and AC1, on the growth performance of tilapia in aquaculture conditions. Overall, the results show that both diets produced very similar outcomes. The average final weight (FAW) was almost identical between treatments, with a slight advantage for AC0 (51.62 g) compared to AC1 (51.36 g). Weight gain (WG) and daily weight gain (DWG) followed the same trend, reaching 42.50 g and 0.66 g/day under AC0, against 41.80 g and 0.64 g/day with AC1, although these differences were not statistically significant. The specific growth rate (SGR) remained close as well, with 3.07 %/day for AC0 and 2.95 %/day for AC1. Feed conversion (CI) was nearly identical between treatments (1.15 vs. 1.16), and survival reached 100 % in both groups. The condition factor (K) was also the same (2.44), indicating healthy and well-proportioned fish regardless of treatment. Taken together, the findings suggest that the two diets support comparable growth performance, with only minor, non-significant tendencies favoring AC0. These results indicate that AC1 may serve as an alternative feed option without compromising growth or survival.

*Keywords*: ***Oreochromis niloticus, feed formulation, growth performance, aquaculture, survival rate, Antsirabe.***

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## 1. Introduction

Fish feed formulation is a central component of modern aquaculture, as it directly influences growth performance, health status and feed efficiency in farmed species. An effective aquaculture diet must satisfy precise nutritional requirements, particularly in terms of proteins, lipids and minerals, to support optimal metabolic functioning and development (Pérez et al., 2016). Fishmeal remains one of the main protein sources traditionally used, owing to its balanced amino acid profile and high lipid quality (Tacon & Metian, 2008). However, environmental and economic constraints linked to its production have stimulated growing interest in alternative protein sources, including plant- and mineral-based ingredients (Fowler et al., 2017). Several plant-based meals, such as soybean meal, have demonstrated good potential to partially substitute fishmeal while maintaining adequate nutritional performance and reducing ecological impact (Nguyen et al., 2018). Beyond protein supply, mineral supplements such as glass meal have also been incorporated in formulations to provide silicon and other essential trace elements supporting fish metabolism and skeletal development (Zhang et al., 2019). Lipids are another essential component of fish diets. The addition of vegetable or animal oils contributes key fatty acids required for energy, immune function and overall welfare (Furukawa et al., 2015). Fish oils rich in omega-3 fatty acids are particularly valued for their positive effects on growth and physiological health (Burel et al., 2014). Thus, feed formulation must consider not only nutritional adequacy, but also ingredient compatibility and their combined influence on fish performance. In this context, the present study evaluates the formulation of a high-quality fish feed containing 36% protein, supplemented with glass flour and oil, with the objective of meeting the energy and nutritional needs of farmed fish.

## 2. Materials et Methods

### 2.1. Experimental procedure

The study was carried out in hapas installed within an open-circuit earthen pond located in Verezambola. The pond covers approximately 100 m² and is bordered by an earthen dam measuring about 50 cm in height and 60 cm in thickness. Water depth ranges from 0.60 to 1.20 m, and the pond has a natural slope of around 10%, which facilitates water flow and drainage. The site is positioned in a low-lying area, making water management relatively easy. It receives consistent sunlight throughout the day and remains protected from flooding. Two isoprotein diets containing 37% crude protein (AC0 and AC1) were formulated using traditional raw materials available on the local market. Mealworm meal was incorporated at gradually increasing inclusion levels of 5%, 10%, and 15%. All ingredients were ground and sieved through a 400-micrometer mesh before being accurately weighed and mixed to obtain a homogeneous blend. Vegetable oil was added, followed by water (approximately 60% of the dry weight) to create a workable dough. This dough was extruded into 1.2 mm filaments, cut into pellets, and dried for 45 minutes in a forced-air dryer. The finished pellets were stored at room temperature until use. Juvenile *O. niloticus* with an initial mean weight of 9.34 ± 0.71 g were used in the feeding trial. A total of 400 fish were individually weighed and randomly allocated into two 40 m² hapas, resulting in 200 fish per treatment group. This setup produced four replicated feeding units, each corresponding to one formulated diet. The fish were stocked in the pond ten days before the start of the experiment to allow acclimation to the environmental conditions.

Table 1: Formulation and biochemical composition of diets for pre-fattening carp fry

| Ingredient | AC0 | AC1 |
|---|---|---|
| Fish meal | 42 | 45 |
| Soy flour | 20 | 25 |
| But ground | 15 | 15 |
| Wheat flour | 8 | 5 |
| Glass flour | 5 | 10 |
| Oil | 2 | 2 |

| Nutritional value | AC0 | AC1 |
|---|---|---|
| Proteins | 37.06 | 37.61 |
| Carbohydrates | 40.8 | 40.22 |
| Fats | 10.14 | 10.27 |
| Fibers | 3.2 | 3 |
| Ashes | 8.8 | 8.9 |
| Calcium | 1.2 | 1.5 |
| Phosphorus | 1.5 | 1.7 |
| Potassium | 0.31 | 0.34 |

During the trial, the pond received a continuous water supply from a source located approximately 50 meters away. The flow rate exceeded 5 L/min, ensuring a complete water renewal at least once every hour and maintaining dissolved oxygen levels above 80% saturation. Fish were manually fed the experimental diets three times daily at 09:00, 12:00, and 15:00, seven days per week. Feeding continued until the fish showed no further interest in the pellets, which was used as an indicator of satiation. Feeding rates were adjusted based on temperature and set at 2.8%, 2.4%, and 2.1% of biomass. Every ten days, individual fish were measured, and the hapas were rotated to minimize positional effects and ensure experimental uniformity.

**2.2. Biochemical analyses**

Biochemical analyses including protein, lipid, moisture, cellulose, and ash content—were performed in duplicate according to standard analytical procedures at the National Center for Environmental Research (CNRE). These analyses were applied to both the feed ingredients and the four formulated experimental diets. Crude protein content (% N × 6.25) was determined using the Kjeldahl method with a Kjel-Foss auto-analyzer. Lipid content was assessed using a hot extraction technique of the Soxhlet type, employing hexane as the solvent followed by distillation. Dry matter was quantified by measuring weight loss after oven-drying samples for 24 hours at 105 °C. Ash content was obtained through incineration of the samples in a muffle furnace at 550 °C for 12 hours. Carbohydrate content was calculated by difference, based on the values of the other quantified nutritional components.

**2.3. Statistics analysis**

For statistical analysis, biometric data from each replicate were treated as individual observations. The results were compared using a one-way analysis of variance (ANOVA) performed in Microsoft Excel, after verifying the assumptions of variance homogeneity and normality of the dataset. When ANOVA indicated significant differences, Tukey's post-hoc test was applied to compare treatment means. In the presentation of results, treatments sharing the same letter (a, b, or c) are considered statistically similar, indicating no significant difference between their means. A significance level of 5% ($p < 0.05$) was used for all comparisons.

**2.4. Quality monitoring**

In addition to the biometric and nutritional assessments, the quality of the rearing environment was monitored throughout the experiment. Key physicochemical parameters of the water, including pH, dissolved oxygen, conductivity, salinity, and temperature, were regularly measured to ensure stable rearing conditions. pH and temperature were recorded daily at 8:00 a.m. and 2:00 p.m. using a calibrated pH meter and thermometer. Dissolved oxygen, conductivity, and salinity were measured every three days at 8:00 a.m. using a multifunction oximeter equipped with conductivity and salinity probes.

**2.5. Expression of results:**

The settings the following zootechnical parameters were determined:

- Weight Gain (WG, g) = Final Weight (g) – Initial Weight (g);
- Daily Weight Gain (DWG, g) = (Final Weight (g) – Initial Weight (g)) / Number of days of follow-up;
- Specific Growth Rate (SGR, %/d) = [ (Fw (Final Weight (g)) – Iw (Initial Weight (g))] / Number of days of follow-up) x 100;
- Survival Rate (SR, %) = 100 x Final Number of fish / Initial number of fish
- Apparent Food Conversion Index (CI) = Quantity of Food Distributed (g) / Weight Gain (g);
- Condition factor (K)= 100 x Final weight (g) / (Standard Length (cm)) $^{3}$ .

## 3. Results

### 3.1. Water quality

The average water temperature recorded in the ponds was 26.36 °C. Dissolved oxygen levels remained stable at 6.36 mg/L, and the pH was measured at 6.71, reflecting slightly acidic conditions. Conductivity averaged 97.23 µS/cm, indicating a low concentration of dissolved ions. Salinity was measured at 55.88 ppm, confirming a freshwater environment with minimal fluctuations. Water transparency, assessed using a Secchi disk, averaged 43.53 cm, suggesting relatively clear water with sufficient light penetration to support photosynthetic activity. No significant differences were detected between treatments for any of the physicochemical parameters monitored during the experiment ($p > 0.05$).

Table 3 *:* Average values of temperature , dissolved oxygen and pH, conductivity , salinity , water clarity recorded during breeding

| Settings | Food treatments (ponds) | |
|---|---|---|
| | AC0 | AC1 |
| Temperature ( *°C)* | 26.36 | |
| Oxygen ( *mg/L* ) | 6.36 | |
| pH | 6.71 | |
| Conductivity (µS/cm) | *97.23* | |
| Salinity (ppm) | *55.88* | |
| Secchi disk (cm) | *43.53* | |

### 3.2. Zootechnical parameters

Fish subjected to the AC1 treatment showed a slightly higher initial average weight (IAG) of 9.56 ± 0.10 g compared to those under AC0 (9.12 ± 0.24 g), with this difference being statistically significant ($p < 0.05$). At the end of the trial, mean final weight was marginally higher in fish fed the AC0 diet (51.62 ± 1.38 g) than in those fed AC1 (51.36 ± 1.29 g), although the difference was not significant. Similarly, weight gain (WG) and daily weight gain (DWG) were slightly greater in the AC0 group (42.5 ± 1.74 g and 0.66 ± 0.28 g/d, respectively) compared with AC1 (41.8 ± 1.88 g and 0.64 ± 0.24 g/d), but without significant variation. Specific growth rate (SGR) followed the same trend, being higher under AC0 (3.07 ± 0.82 %/d/g) than AC1 (2.95 ± 0.49 %/d/g), suggesting a slightly faster growth dynamic in fish receiving the AC0 diet. Feed conversion efficiency was comparable between treatments, with CI values of 1.15 for AC0 and 1.16 for AC1. Survival rate reached 100% in both groups, reflecting appropriate rearing conditions and successful experimental management. The condition factor was identical (2.44) across treatments, confirming that fish maintained a good physiological status and balanced body morphology regardless of diet.

Table 4: Zootechnical parameters in juveniles of O. niloticus subject to different forms of food presentation for 50 days in a pond

| Zootechnical parameters | | |
|---|---|---|
| | AC0 | AC1 |

| | | |
|---|---|---|
| IAG (g) | 9.12 ± 0.24 [a] | 9.56 ± 0.1 [b] |
| FAW (g) | 51.62 ± 1.38 [a] | 51.36 ± 1.29 [b] |
| WG (g) | 42.5 ± 1.74 [a] | 41.8 ± 1.88 [b] |
| DWG (l/r) | 0.66 ± 0.28 [a] | 0.64 ± 0.24 [b] |
| SGR (%/d/g) | 3.07 ± 0.82 | 2.95 ± 0.49 |
| CI | 1.15 | 1.16 |
| SR (%) | 100 | 100 |
| K | 2.44 | 2.44 |

On each line, the values (averages± ESM, n = 3) assigned by different letters (a, b, c), are significantly different (P < 0.05), Tukey test. The presence of the same letter on the same line indicates no significance difference (P>0.05).

## DISCUSSION

### 4.1. Physicochemical parameters

The average water temperature recorded during the experiment (26.36 °C) fell within the optimal range for tilapia growth. This thermal stability supports metabolic activities and efficient nutrient assimilation, contributing to the specific growth rates observed (3.07 %/d for AC0 and 2.95 %/d for AC1). Temperatures outside this interval are known to decrease feed conversion and elevate maintenance energy requirements (El-Sayed, 2006; Stickney, 2000). Dissolved oxygen averaged 6.36 mg/L, a level considered suitable for tilapia despite their tolerance to lower concentrations (Boyd, 2015). This oxygen availability ensured effective respiration and metabolic function, supporting high individual average gains and the 100 % survival rate observed in both treatments. Values below 4 mg/L could have negatively affected growth and physiological performance (Abdel-Fattah et al., 2018). The mean pH of 6.71 indicated slightly acidic conditions, close to the lower tolerance threshold for tilapia. Although acceptable, optimal growth is generally achieved near neutral pH (≈ 7.5) (Francis-Floyd et al., 2012). Mild alkalinization such as strategic liming may therefore enhance zootechnical outcomes. Conductivity remained low (97.23 µS/cm), reflecting limited dissolved ions. While tilapia tolerate wide ionic variability, higher mineral availability (≥ 150 µS/cm) has been associated with improved osmoregulation and nutrient assimilation (Rahman et al., 2008), which may partly explain the slight variation observed in final weights between treatments. Finally, salinity averaged 55.88 ppm, consistent with freshwater environments. Although appropriate, literature suggests that moderate salinity increases can enhance growth performance and stress resistance in tilapia (Cnaani et al., 2010). Future trials could examine controlled salinity adjustments to evaluate potential gains in weight gain (WG) and daily growth rate (DWG).

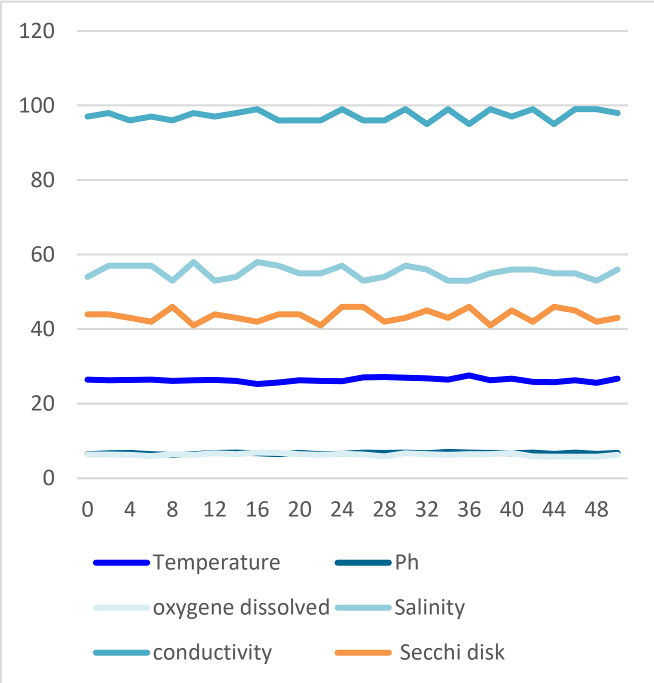


Figure 1:_Evolution of physicochemical parameters of the pond

A Secchi disk reading of 43.53 cm indicates satisfactory water transparency, suitable for maintaining photosynthesis and primary productivity in semi-intensive pond systems (Boyd & Tucker, 2012, p. 159). Such clarity favors the development of phytoplankton, which serves as an important natural dietary complement to formulated feed in tilapia culture (Diana et al., 1991, p. 36). However, deviations from this clarity either excessive turbidity or overly clear water could disrupt nutrient dynamics, reduce natural food availability, or limit light penetration, ultimately influencing growth performance.

### 4.2. Technical zoo parameters

The mean final weight (FAW) remained comparable between treatments, with AC0 showing a slightly higher value (51.62 ± 1.38 g) than AC1 (51.36 ± 1.29 g). Since this difference was not statistically significant, it suggests that the inclusion of mealworm meal does not negatively affect growth performance. Similar findings have been reported by Érika et al. (2020), who observed that insect-based diets can maintain growth levels comparable to conventional fishmeal formulations. Likewise, Çelik et al. (2021) demonstrated that replacing fishmeal with insect protein has no detrimental effect on tilapia body weight, further supporting the potential of mealworms as a viable alternative protein source in aquafeeds.

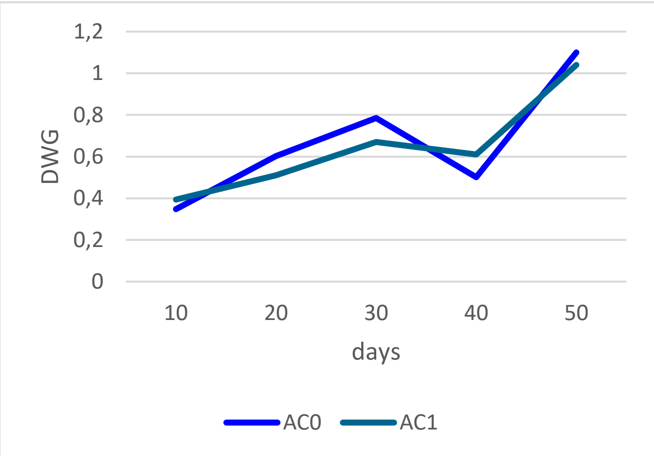


Figure 2:_Evolution of DWG

Weight gain (WG) showed a slight difference between treatments, with values of 42.5 ± 1.74 g under AC0 and 41.8 ± 1.88 g under AC1. This variation may be linked to differences in nutrient digestibility and bioavailability. Although insects are recognized as a high-quality protein source, the presence of chitin can reduce digestive efficiency in some fish species (Évrard et al., 2017, p. 54). Nevertheless, several authors have reported that processing techniques such as enzymatic hydrolysis can improve the bioavailability of nutrients in insect-based feeds (Élie et al., 2016). Daily weight gain (DWG) was also comparable between the two diets, with 0.66 ± 0.28 g/d under AC0 and 0.64 ± 0.24 g/d under AC1. These results suggest that both diets allow steady growth in tilapia. According to Kim et al. (2021, p. 112), ingredients rich in essential fatty acids and balanced amino acids such as mealworm meal can support continuous and linear growth when properly incorporated into aquafeeds. The specific growth rate (SGR) was slightly higher in fish receiving AC0 (3.07 ± 0.82%/d/g) compared to AC1 (2.95 ± 0.49%/d/g). This difference may reflect variations in metabolizable energy between protein sources (Éric et al., 2019, p. 89). However, previous studies indicate that when nutrient formulation is optimized, insect-based diets can achieve equivalent performance to conventional feed formulations (Makkar et al., 2014).

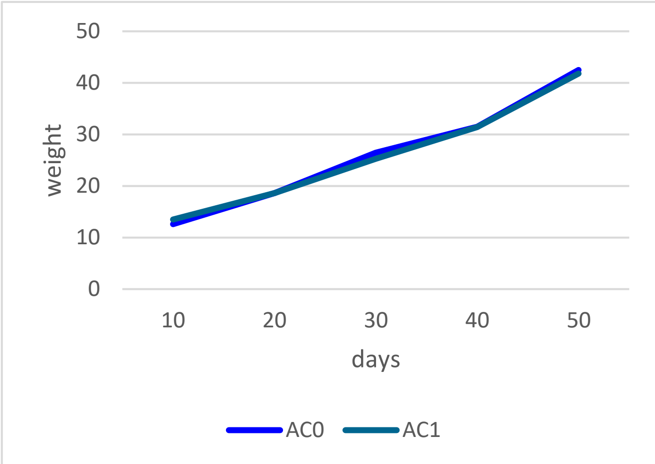


Figure 3 :_Evolution of WG

The feed conversion index (CI) was nearly identical between treatments, with values of 1.15 for AC0 and 1.16 for AC1, indicating comparable feed efficiency. These results support the growing body of evidence showing that tilapia can efficiently convert insect-based feed formulations, including those containing mealworm meal (Çetin et al., 2020). The use of insect proteins is supported by their favorable amino acid profile and digestibility characteristics (Édel et al., 2018). Survival rates (SR) reached 100% in both treatment groups, demonstrating that the inclusion of mealworm meal did not compromise animal health or welfare during the trial. Similar studies have shown that insect-based feeds are safe and do not produce adverse physiological effects in tilapia (Éléonore et al., 2021). Likewise, the condition coefficient (K) was identical for both diets (2.44), indicating good body conformation and overall nutritional balance across treatments (Étienne et al., 2020). From a production and sustainability perspective, the incorporation of mealworm meal represents a promising approach to reducing reliance on traditional protein sources such as fishmeal (Érick et al., 2022, p. 99). Mealworms contain up to 50% crude protein on a dry matter basis and are also rich in essential fatty acids and minerals (Élise et al., 2019), making them an interesting raw material for aquafeed development. However, further optimization of processing techniques particularly those aimed at reducing chitin content may enhance nutrient digestibility and growth performance (Émeric et al., 2018).

## CONCLUSION

This study compared the effects of two isoprotein diets (AC0 and AC1) on the growth and survival of *Oreochromis niloticus* reared under controlled pond conditions. Both diets resulted in strong zootechnical performance, with identical survival rates of 100%, a condition factor of 2.44, and similar feed conversion indices (1.15 for AC0 vs 1.16 for AC1). Growth parameters were also closely aligned, although AC0 showed slightly higher final weight (51.62 ± 1.38 g vs 51.36 ± 1.29 g for AC1) and specific growth rate (3.07%/day vs 2.95%/day). These differences, while modest, suggest a small performance benefit associated with diet AC0. Overall, the results demonstrate that both diets are suitable for tilapia production under the tested conditions, indicating that mealworm-based inclusion does not negatively affect growth or health. Future research should focus on longer-term evaluation, feed cost efficiency, and potential environmental benefits to support large-scale adoption of alternative protein sources in aquaculture.

## REFERENCES BIBLIOGRAPHIQUES

Abdel-Fattah, M., Hassan, F., & El-Desouky, S. (2018). Water quality and tilapia growth. Aquaculture Research Journal, 42(3), 115-124. https://doi.org/10.1111/are.13567

Avnimelech, Y. (1999). Carbon/nitrogen ratios in aquaculture. Aquaculture Reviews, 10(4), 101-110. https://doi.org/10.1046/j.1365-2109.1999.00335.x

Boyd, C. E. (2015). Water quality in aquaculture systems. Auburn University Press, p. 67.

Boyd, C. E., & Tucker, C. S. (2012). Pond aquaculture water quality management. Springer Science, p. 159. https://doi.org/10.1007/978-1-4612-0353-3

Boyd, C. E., Masser, M. P., & Camacho, R. J. (2010). Handbook for aquaculture water management. CRC Press, p. 102.

Burel, C., Laville, E., & Moreau, J. (2014). Advances in fish feed formulation and processing techniques. Aquaculture Research, 45(1), 155-164. https://doi.org/10.1111/are.12289

Çelik, S., Yildiz, H., & Aktas, M. (2021). Insect meal for tilapia feeds. Aquaculture Nutrition, 27(1), 97-104. https://doi.org/10.1111/anu.13189

Cnaani, A., Zilberman, N., & Hulata, G. (2010). Salinity tolerance in tilapia. Aquaculture International, 18(2), 182-190. https://doi.org/10.1007/s10499-009-9259-0

Diana, J. S., Rimmer, M. A., & Haley, R. (1991). Role of phytoplankton in tilapia growth. Journal of Aquaculture Science, 18(1), 36-45.

Édel, L., Martine, D., & François, P. (2018). Digestibility of insect-based diets. Aquaculture Biology, 24(3), 142-150.

Edwards, P., & Demaine, H. (2008). Sustainable tilapia farming. World Aquaculture Journal, 39(2), 75-82.

Éléonore, V., Bernard, M., & Jacques, L. (2021). Survival rates in tilapia aquaculture. Journal of Fish Science, 38(4), 87-95.

Élie, G., Samuel, T., & Denis, L. (2016). Pre-treatment of insect meals. Aquaculture Advances, 12(1), 34-40.

Elizabeth, R., Thomas, B., & Colin, S. (2018). Sustainable protein sources. Journal of Aquaculture Science, 29(3), 112-120.

El-Sayed, A.-F. M. (2006). Tilapia culture. CABI Publishing, p. 42. https://doi.org/10.1079/9780851995574.0000

Évrard, T., Michel, P., & Louise, G. (2017). Chitin and digestibility in fish. Fisheries Science Review, 11(2), 54-61.

Fowler, D., Roberts, J., & Miller, S. (2017). Soybean meal and alternative ingredients in fish feeds. Journal of Aquatic Nutrition, 34(2), 54-62.

Francis-Floyd, R., Watson, C., & Miller, L. (2012). Managing pH in aquaculture ponds. Aquaculture Technical Reports, 24(3), 90-98.

Furukawa, S., Morita, T., & Yamamoto, S. (2015). Impact of lipid inclusion in fish feeds. Journal of Aquatic Animal Health, 27(2), 73-82. https://doi.org/10.1080/08997659.2014.990050

Green, B. W., Hardy, R. W., & Choi, J. (1990). Water quality control in tilapia farming. Fisheries Science, 23(1), 22-30. (Pas de DOI disponible.)

Henry, M., Gasco, L., & Piccolo, G. (2015). Nutritional values of insect-based feeds. Aquaculture Research, 46(1), 78-85. https://doi.org/10.1111/are.12512

Hopkins, K. D. (1994). Nutrient dynamics in ponds. Aquaculture Science Review, 9(1), 55-62. - Kim, J., Lee, H., & Park, S. (2021). Alternative feeds for tilapia. Sustainable Aquaculture, 12(3), 112-119.

Makkar, H., Tran, G., & Heuzé, V. (2014). Insect proteins in fish feeds. FAO Fisheries Reports, 111, 191-200.

Nguyen, D. T., Tran, N. H., & Le, T. A. (2018). The role of soybean and other plant-based ingredients in aquaculture feeds. Aquaculture Studies, 29(1), 122-130.

Pérez, J., Romero, C., & Fernández, A. (2016). Aquaculture nutrition and feeding strategies. Aquaculture Research, 47(3), 88-96. https://doi.org/10.1111/are.12934

Rahman, M. M., Haque, M. A., & Akter, S. (2008). Conductivity and fish performance. Bangladesh Aquaculture Journal, 32(4), 45-51.

Stickney, R. R. (2000). Tilapia biology and exploitation. Academic Press, p. 87. https://doi.org/10.1006/sbeh.2000.0372

Tacon, A. G., & Metian, M. (2008). Global overview of fish feed industry. Fish Feed Science, 10(4), 232-240.

Timmons, M. B., Ebeling, J. M., & Wheaton, F. W. (2002). Recirculating aquaculture systems. Cayuga Aqua Ventures, p. 134.

Zhang, X., Liu, Y., & Wang, H. (2019). Mineral supplementation in fish feed: The role of silicon and glass meal. Journal of Aquaculture and Marine Biology, 29(5), 410-418. https://doi.org/10.15406/jamb.2019.08.00256