THE INFLUENCE OF WOTON (*Sterculia shillinglawii*) LEAVES MEAL SUPPLEMENTATION ON THE GROWTH AND DIGESTIBILITY PERFORMANCES OF TILAPIA (*Oreochromis niloticus*) JUVENILES

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ABSTRACT

This study aimed to evaluate the effect of Woton (*Sterculia shillinglawii*) leaves meal supplementation on the growth performance and digestibility of tilapia (*Oreochromis niloticus*) juveniles. The treatments consisted of Woton leaves meal at inclusion levels of 0% (A), 5% (B), 10% (C), 15% (D), and 20% (E), with each treatment replicated three times. The observed parameters included average daily growth (ADG), average body weight (ABW), growth rate (GR), specific growth rate (SGR), survival rate (SR), feed conversion ratio (FCR), and feed efficiency (FE), as well as protein digestibility and total digestibility. Analysis of variance showed no significant differences in ADG, ABW, GR, and SR among the treatments. However, Treatment B recorded relatively a higher SGR (2.73 ± 0.44 % day^{-1}) compared to the other treatments ($P<0.05$). The analysis of digestibility revealed significant differences. Treatment C (15% inclusion level) resulted in the highest protein digestibility (99.39 ± 0.02%) and total digestibility (99.37 ± 0.01%), while a lower FCR (1.76 ± 0.24) and a higher FE (57.59 ± 7.85%) were found in Treatment B ($P<0.05$). This study highlighted that despite Woton leaves meal improving fish digestibility and feed efficiency, its supplementation in fish feed should be limited to 5-10% due to the adverse effects of its flavonoid compounds.

KEYWORDS: digestibility; growth; tilapia; Woton leaves

***ABSTRAK: Pengaruh Suplementasi Tepung Daun Woton** (Sterculia shillinglawii) **terhadap Kinerja Pertumbuhan dan Kecernaan Juvenil Ikan Nila** (Oreochromis niloticus)*

*Penelitian ini bertujuan untuk mengevaluasi pengaruh suplementasi tepung daun Woton (**Sterculia shillinglawii**) terhadap kinerja pertumbuhan dan kecernaan juvenil ikan nila (**Oreochromis niloticus**). Perlakuan terdiri atas tepung daun Woton pada tingkat inklusi 0% (A), 5% (B), 10% (C), 15% (D), dan 20% (E), dengan setiap perlakuan diulang tiga kali. Parameter yang diamati meliputi rata-rata pertumbuhan harian (RPH), rata-rata bobot tubuh (RBT), laju pertumbuhan (LP), laju pertumbuhan spesifik (LPS), tingkat kelangsungan hidup (TKH),*

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rasio konversi pakan (RKP), dan efisiensi pakan (EP) serta kecernaan protein dan kecernaan total. Analisis varians tidak menunjukkan perbedaan yang signifikan pada RPH, RBT, LP, dan TKH di antara perlakuan. Namun, Perlakuan B menunjukkan LPS yang relatif lebih tinggi (2,73 ± 0,44% hari^{-1}) dibanding dengan perlakuan lainnya (P<0,05). Analisis kecernaan mengungkapkan perbedaan yang signifikan. Perlakuan C (tingkat inklusi 15%) menghasilkan kecernaan protein tertinggi (99,39 ± 0,02%) dan kecernaan total tertinggi (99,37 ± 0,01%), sedangkan RKP yang lebih rendah (1,76 ± 0,24) dan EP yang lebih tinggi (57,59 ± 7,85%) ditemukan pada Perlakuan B (P<0,05). Penelitian ini menunjukkan bahwa meskipun tepung daun Woton meningkatkan kecernaan dan efisiensi pakan ikan, suplementasinya pada pakan ikan sebaiknya dibatasi hingga 5-10% karena dampak negatif senyawa flavonoid yang dikandungnya.

KATA KUNCI: daun Woton; ikan nila; kecernaan; pertumbuhan

INTRODUCTION

Aquaculture activities were widely recognized in the 1980s and are increasing rapidly (Sicuro, 2021). Its central concept is designed to increase the quantity of fish produced beyond its the natural growth rate (Verdegem *et al*., 2023). In Indonesia, the government continues to develop aquaculture with one of the primary objectives being to increase the consumption of affordable, high-quality protein within the community (Kontara *et al*., 2025; Munaeni *et al*., 2020). Considering the low cost of farming and high productivity of Tilapia (*Oreochromis niloticus*), it is considered one of the primary aquaculture fish species to supply the ever-increasing demand for animal protein. Tilapia has a distinct taste, firm meat, is easy to serve, lacks many spines, is readily available, and has a relatively low price (Sicuro, 2021).

Aquaculture needs to consider several factors such as feed quality to improve the fish growth rate. Fish feed plays a crucial role in increasing the aquaculture production. Aquaculture requires high-quality, nutritious, and adequate fish feed. Furthermore, it is necessary to continuously feed fish to maintain the production process and growth rate (Roques *et al.*, 2020; Sarker, 2023). Decreasing or increasing feed protein content will reduce growth (Cho & Jo, 2002). Formulation of fish feed affects feed efficiency and reduces aquaculture waste (Wang *et al.*, 2011). Optimal tilapia growth needs protein levels of 40% or 30% for juveniles (Cho & Jo, 2002). Fish meal is the primary ingredient of fish feed manufacturing. Therefore, there is an increasingly high demand for fish meals. Several efforts are underway to minimize the use of fish meal, including the utilization of waste and endemic materials (El-shafai *et al.*, 2015). Okara meal supplementation was able to replace 75% of the protein in tilapia (El-Saidy, 2011). Aquatic plant supplementation (*Lemna minor*) can significantly increase the protein content of fish and reduce fat and feed conversion ratio (FCR) (El-shafai *et al.*, 2015). In addition, the use of the Woton endemic plant (*Sterculia shillinglawii*) presents a promising opportunity. This research marks the first study of its kind in Indonesia, highlighting the novelty and potential significance of exploring this native species. Its application could open new avenues for sustainable development and the utilization of local biodiversity.

Woton is one of the 26 types of *Sterculia* recorded in Papua. This plant is available in Papua and Maluku. According to proximate analysis, Woton leaves contain 4.8% protein. Phytochemical tests on Woton leaves detected flavonoids, tannins, saponins, and phenols (Sayuti *et al.*, 2017), which are potential ingredients for fish feed. The protein content of Woton may become a source of nutrients for fish. The active compounds of Woton leaves,

like those of other plants, have a potential to be developed as a preventive agent against pathogenic infections. Treatment of 15 g kg^{-1} tamarin peel extract can increase growth and digestibility and increase protection against *Aeromonas hidrophila* (Adeniyi *et al.*, 2022). This study aimed to evaluate the influence of Woton leaves meal addition on the growth and digestibility performance of tilapia juveniles.

MATERIALS AND METHODS

Aquarium Preparation

The study was conducted at the Freshwater Aquaculture Installation of the Marine and Fisheries Polytechnic of Sorong from June to August 2018, over 30 days. The culture unit used a glass aquarium (30x30x25 cm^3) with a water level of 20 cm. The aquarium was rinsed with clean water and dried before being filled with water that had been previously stored in a reservoir and aerated for 24 hours.

Water Quality Management

The rearing medium was managed by siphoning every 3 days and partially replaced once a week (25-30%). Total water replacement were carried out once a month. The measured water quality parameters included temperature, pH, dissolved oxygen (DO), ammonia, nitrate, nitrite, and phosphate. Temperature was measured three times a day (06:00, 14:00, and 18:00). Other parameters were measured once a week.

Test Fish

Tilapia seeds used in the study were 5-7 cm in size. The study used 15 aquariums and stocked each aquarium with 10 fish. The fish were acclimatized to the feed and the rearing medium for 7 days. The fish were fed at a rate of 5% of their biomass three times a day (07:00, 12:00, and 16:00). Fish growth was measured once a week by recording individual weight and standard length. The individual weight was determined using an analytical scale with an accuracy of 0.0001 g. In addition, the standard length of the fish was measured using a ruler.

Test Feed

The commercial feed used to feed the fish contained 26.7% protein, 6.07% fat, 9.86% water, 9.52% ash, and 51.67% carbohydrates mixed with 0.5% chromium dioxide (Cr_2O_3) (re-pelleting) as a digestibility indicator (NRC, 1993). Woton leaves were mixed into the commercial feed at concentrations of 5%, 10%, 15%, and 20%.

Growth Performance

Growth performance is expressed through several key parameters, including average daily growth (ADG), average body weight (ABW), specific growth rate (SGR), growth rate (GR), and survival rate (SR). Average daily growth (ADG) was calculated by the weight and length of the fish using the formula (1):

$$ADG = \frac{(Wt)-(Wo)}{t} \quad \text{.....(1)}$$

Description:
ADG = daily growth average (g day^{-1})
Wt = weight after treatment (g)
Wo = weight before treatment (g)
t = treatment period (day)

Average body weight (ABW) is the average fish weight during treatment (Abdelghany, 1996). The formula (2) was used to calculate ABW.

$$ABW\ (g\ ind^{-1}) = \text{Fish biomass (g)} : \text{total fish(ind)} \quad \text{...(2)}$$

The SGR was calculated using formula (3) (De Silva & Anderson, 1995) as follows:

$$SGR = \frac{\ln Wt - \ln Wo}{t} \times 100\% \quad .....(3)$$

Description:
SGR = specific growth rate (% day^{-1})
Wt = weight after treatment (g)
Wo = weight before treatment (g)
t = treatment period (day)

Growth rate (GR) refers to the increasing fish weight during treatment (Abdelghany, 1996). The GR was determined using the formula (4):

$$GR = Wt - Wo \quad .....(4)$$

Description:
GR = growth rate (g)
Wt = weight after treatment (g)
Wo = weight before treatment (g)

Survival rate (SR) is calculated using the formula (5) (Adeniyi *et al*., 2022):

$$SR = \frac{Nt}{No} \times 100\% \quad .....(5)$$

Description:
SR = survival rate (%)
Nt = total fish after treatment (ind)
No = total fish before treatment (ind)

Digestibility Performance

Digestibility performance (Austreng, 1978; Cho & Slinger, 1979) refers to several parameters:

$$\text{Protein digestibility } (\%) = 100\left(1 - \frac{\%Cr_2O_3 \text{ feed}}{\%Cr_2O_3 \text{ feces}} \times \frac{\%\text{feces protein}}{\%\text{feed protein}}\right) \quad ...(6)$$

$$\text{Total digestibility } (\%) = 100\left(1 - \frac{\%Cr_2O_3 \text{ feed}}{\%Cr_2O_3 \text{ feces}}\right)\% \quad .....(7)$$

Feed conversion ratio (FCR) and feed efficiency (FE) were calculated using the formula (8) and (9):

$$FCR = \frac{F}{Wt + D - Wo} \quad .....(8)$$

$$FE\ (\%) = \frac{1}{FCR} \times 100\ \% \quad .....(9)$$

Description:
FCR = feed conversion ratio
F = total consumed feed during treatment (g)
Wt = biomass final weight (g)
Wo = biomass initial weight (g)
D = dead fish weight (g)
FE = feed efficiency

Statistical Analysis

The data obtained were tested with one-way ANOVA using Minitab 16. Previously, the normality test and homogeneity test were carried out to adequacy the ANOVA test assumptions. If the statistical test showed a significant difference among treatments, we performed the Tukey test at a 95% confidence interval to determine which treatment produced different results.

RESULTS AND DISCUSSION

Growth Performance

Table 1 shows the influence of Woton leaves meal on tilapia growth. Average daily growth (ADG), ABW, and GR showed no difference among treatments. The influence of Woton leaves meal on growth performance of tilapia was expressed by SGR, with the highest value found in treatment B (2.73 ± 0.44 % day^{-1}). Supplementation of Woton leaves meal can occasionally have no noticeable impact on the fish growth. The control treatment resulted in the best growth performance of tilapia, which was not significantly different from treatment B. Therefore, even with negligible results, Woton leaves can help balance commercial feed and reduce the reliance on fish meal, which may lower production costs.

Based on Table 1, ADG values were not significantly different ($P>0.05$) among

Table 1. The influence of woton leaves meal on tilapia growth

Parameter	Woton leaves concentration				
	A(0%)	B (5%)	C(10%)	D (15%)	E(20%)
ADG (g day^{-1})	0.10 ± 0.02^{a}	0.12 ± 0.04^{a}	0.10 ± 0.02^{a}	0.11 ± 0.07^{a}	0.12 ± 0.06^{a}
ABW (g ind^{-1})	5.42 ± 0.84^{a}	6.54 ± 1.20^{a}	5.75 ± 0.34^{a}	6.34 ± 1.51^{a}	7.15 ± 0.96^{a}
GR (g)	3.83 ± 0.64^{a}	4.54 ± 1.21^{a}	3.41 ± 0.51^{a}	3.80 ± 1.23^{a}	3.89 ± 0.69^{a}
SGR (% day^{-1})	2.86 ± 0.07^{a}	2.73 ± 0.44^{a}	2.10 ± 0.36^{ab}	2.10 ± 0.29^{ab}	1.81 ± 0.13^{b}
SR (%)	83.33 ± 20.82^{a}	80 ± 10^{a}	93.33 ± 5.77^{a}	90 ± 0.00^{a}	80 ± 10^{a}

Description: Different letters in the same row indicate differences among treatments ($P<0.05$). The values listed are the average and standard deviation values. ADG: average daily growth, ABW: average body weight, GR: growth rate, SGR: specific growth rate, SR: survival rate.

treatments. This result may be attributed to several factors, such as the relatively short duration of the study and the fact that the level of Woton leaves supplementation did not interfere with the fish's metabolism. According to Safir *et al.* (2017), fish growth is influenced by their ability to utilize feed through the absorption of amino acids in the body. In the case of Woton leaves meal, this effect has not yet been observed, as reported by Palupi *et al.* (2020). Woton leaves may not be effective as growth promoter, but this ingredient may have potentials or functions in aquaculture. Therefore, further studies are needed to investigate other potential effects of Woton, such as on immunity and antioxidant activity.

Specific growth rate (SGR) is the increase fish weight per day during treatment (Rachmawati & Samidjan, 2013). Based on the results, Woton leaves addition influenced SGR, especially in treatment B. A balanced diet may stabilize fish health and growth. Feed supplements may increase fish appetite and growth (Fontaínhas-Fernandes *et al.*, 1999; Gaber, 2005). The difference in SGR values obtained from the treatment is caused by the varying abilities of the fish in utilizing the given feed. This is reinforced by the statement of Abdel-Tawwab *et al.* (2006) that feed composition affects fish growth. Effective feed content increases the growth rate. Fish require a constant supply of amino acids. Woton provides amino acid content and offers similar benefits to commercial feed (Guimarães *et al.*, 2008).

The survival rate is defined as the likelihood of living for a given period (Effendi, 1991). The results in this study showed no difference in SR among treatments. This finding explained that the nutritional content of Woton leaves has the same effect as commercial feed on fish survival. Therefore, Woton leaves may have the potential to be developed as a supplement, and further study is necessary to investigate their long-term influence on culture. Each fish species has a different diet requirement. An appropriate feed diet will stabilize nutrients in the blood (Gomes *et al.*, 1995). The ability of fish to utilize nutrients will have a specific impact on SR (Abadi *et al.*, 2018).

Digestibility and Feed Efficiency

Table 2 presents the effect of Woton meal supplementation on the digestibility of tilapia. The results indicate that all treatments produced relatively similar outcomes in overall digestibility. However, variations were observed in total digestibility across treatments, with Treatment C (10% inclusion level) demonstrating the highest total digestibility. Digestibility refers to the proportion of feed nutrients absorbed and utilized by fish after consumption. Woton leaves supplementation showed a significant difference, which is in line with the statement by Liang *et al.* (2022), that some plant materials can increase the digestibility of fish feed by modulating the production of digestive enzymes. Therefore,

Table 2. The influence of Woton meal on tilapia digestibility

Parameter	Treatment Code				
	A(0%)	B (5%)	C(10%)	D (15%)	E(20%)
Total digestibility (%)	99.32 ± 0.01^{c}	99.34 ± 0.00^{bc}	99.37 ± 0.01^{a}	99.35 ± 0.01^{ab}	99.36 ± 0.00^{a}
Protein digestibility (%)	99.26 ± 0.01^{a}	99.30 ± 0.01^{a}	99.39 ± 0.02^{c}	99.30 ± 0.01^{a}	99.37 ± 0.03^{b}
FCR	1.51 ± 0.18^{c}	1.76 ± 0.2^{4b}c	2.30 ± 0.21^{ab}	2.40 ± 0.39^{ab}	2.57 ± 0.10^{a}
FE (%)	66.79 ± 8.52^{a}	57.59 ± 7.8^{5a}b	43.73 ± 3.97^{b}	42.43 ± 7.40^{b}	38.99 ± 1.55^{c}

Description: Different letters in the same row indicate differences among treatments (P<0.05). The values listed are the average and standard deviation values. FCR: feed conversion ratio, FE: feed efficiency.

higher digestibility in Treatment C suggests that a 10% inclusion level of Woton leaves meal may optimize nutrient availability without negatively affecting the digestive process. In contrast, lower digestibility at other inclusion levels might be related to the presence of anti-nutritional factors, such as fiber or phenolic compounds, which can interfere with the activity of digestive enzymes. (Adeniyi *et al.*, 2022). Feed ingredients and the manufacturing process determine digestibility. Several enzymes directly affect the feed digestibility value (NRC, 1993). The digestibility of a nutrient or energy in a good feed source will increase the concentration of fish energy *(*Allan *et al.*, 2000).

Table 2 confirms the best protein digestibility value found in treatment C (99.39 ± 0.02%), while the lowest value is found in treatment A (99.26 ± 0.01%). The protein digestibility value was relatively high, indicating that the use of test materials was still acceptable in terms of protein digestibility. Protein digestibility is the comparison between the total N filtrate content of the filtrate. The N filtrate shows the total digested protein content and the sample total N content. The sample total N content shows the total initial protein (Ophardt, 2003). Protein derived from feed undergoes various changes when it enters the digestive system. Protein that enters the body are converted into amino acids (Tacon & Shumway, 2024). Supplemented components are easily degraded in the digestive tract of fish. Therefore, the supplement can increase fish digestibility (Maas *et al.*, 2020). The amino acid content in the Woton meal reflects protein digestibility due to different amino acid administration (Milutinović *et al.*, 2021). A feed supplement is required to increase fish farming productivity through increased digestive enzymes production, improved growth, and stimulation of new intestinal microbiota (Maas *et al.*, 2020). Herbal plants like Woton used as fish feed can have negative impacts, such as low digestibility. This is caused by the high levels of flavonoids, terpenoids, and phenolic acids, which disrupt the fish's digestive condition, particularly the gut microbiota. The dose given has a significant effect on the success of a treatment (Abdel-Tawwab *et al.*, 2010). Some of the bioactive effects of this plant have not been widely exposed in the aquaculture sector and still require further research.

Based on Table 2 the highest FCR was found in treatment E, and the lowest was found in treatment A. This showed that the provision of Woton leaves in a high concentration had a negative effect on fish feed conversion. This finding was line with FE. The best value was demonstrated by treatment A, while the lowest was shown by treatment E. This showed that the higher the concentration value of Woton given, the lower the feed efficiency value. This also proved that a high use of Woton in feed tended to reduce the efficiency of feed utilization. The FCR value is negatively correlated with digestibility, meaning that the higher the digestibility, the lower the FCR value. However, this actually has a positive impact considering that the decrease in FCR value indicates that the feed is suitable for the species

cultivated (Milutinović *et al.*, 2021). However, further research on Woton is needed, especially regarding the fish digestion mechanism.

CONCLUSION

Based on the research findings, this study concludes that there are no significant differences among all treatments on tilapia growth performance, except on SGR, with the best value found in the addition of Woton leaves meal at a concentration of 5%. The addition of Woton leaves meal at a level of 5-10% demonstrated better results in the fish digestibility and the feed efficiency. Despite Woton leaves meal improving fish digestibility and feed efficiency, the adverse effects of its flavonoid compounds limit its application in higher concentrations. This study recommends that the best concentration of Woton leaves in fish feed is recommended within the range of 5-10%.

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AUTHOR CONTRIBUTION

IBH: conceptualization, data curation, formal analysis, and writing-original draft; IS: formal analysis, methodology, and resources; MS: formal analysis, methodology, and project administration; IGAB: formal analysis, methodology, and project administration; S: resources and methodology, SA: resources and methodology; VTFP: resources and methodology; ASA: conceptualization, data curation, formal analysis, writing-review, and editing.

CONFLICT OF INTEREST STATEMENT AND USE OF ARTIFICIAL INTELLIGENCE (AI)

The author declares that there is no conflict of interest in this research. We did not use AI in writing this article

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