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GROWTH PERFORMANCE AND COLOUR OF RED TILAPIA (*Oreochromis niloticus*) USING FE'I BANANA PEEL FEED

Performa Pertumbuhan dan Warna Ikan Nila Merah (*Oreochromis niloticus*) Menggunakan Pakan Berbahan Kulit Pisang Tongkat Langit

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ABSTRACT

Red tilapia is a fishery commodity with high demand and relatively rapid growth. To meet this demand, productivity must be increased by focusing on growth performance and colour. The use of feed made from local resources is thought to improve these aspects. Fe'i banana is a local resource of the Maluku region, characterised by its upright bunch, reddish-orange peel when ripe, and high carotenoid content. To date, fe'i banana peel has never been utilised as a feed ingredient in sustainable aquaculture efforts. The objective of this study was to analyse the growth performance and colour of red tilapia using feed on fe'i banana peel flour. The study employed a completely randomised design with treatments involving different concentrations of fe'i banana peel flour in the feed, comprising 0%, 10%, 20% and 30%. The stages of this study included feed preparation, analysis of the feed's proximate and antioxidant content, fish collection and rearing, growth measurement, and analysis of the test fish's colour. The data obtained were analysed using ANOVA in SPSS 22.0. The results showed that the highest protein, fat and carbohydrate content were found in the 10% treatment, whilst the highest fibre content was found in the 30% treatment. The highest body size and weight resulting from feed administration were found in the 10% treatment, with average total length, standard length, body width and body weight of 9.269±0.14 cm; 7.280±0.15 cm; 2.761±0.09 cm; 10.93±0.06 g. Fish in this treatment also exhibited a predominantly red colour. It is hoped that this study will contribute in the development of local materials as feed to help accelerate growth mechanisms and colour quality in red tilapia.

Keywords: Fe'i Banana, Growth Performance, Oreochromis niloticus

ABSTRAK

Ikan nila merah termasuk komoditas perikanan dengan permintaan yang tinggi dan pertumbuhan relatif cepat. Untuk memenuhi permintaannya, diperlukan peningkatan produktivitas dengan memperhatikan performa pertumbuhan dan warna. Penerapan pakan berbahan potensi lokal diduga dapat meningkatkan hal ini. Pisang tongkat langit adalah potensi lokal daerah Maluku dengan ciri khas arah tandan tegak ke atas dan warna kulit buah masak

oranye kemerahan, serta kandungan karoten yang tinggi. Sejauh ini, kulit pisang tongkat langit belum pernah dimanfaatkan sebagai bahan pakan dalam upaya budidaya secara berkelanjutan. Tujuan penelitian ini adalah menganalisis performa pertumbuhan dan warna ikan nila merah menggunakan pakan berbahan tambahan kulit pisang tongkat langit. Penelitian menggunakan rancangan acak lengkap dengan perlakuan konsentrasi kulit tepung pisang tongkat langit yang terdiri dari 0%, 10%, 20% dan 30%. Tahapan dalam penelitian ini meliputi pembuatan pakan, analisis kadar proksimat dan fitokimia pakan, koleksi dan pemeliharaan, pengukuran pertumbuhan dan analisis warna ikan uji. Data yang diperoleh dianalisis dengan ANOVA pada SPSS 22,0. Hasil penelitian menunjukkan bahwa kadar protein, lemak dan karbohidrat tertinggi ditemukan pada perlakuan konsentrasi pakan 10% sedangkan kadar serat tertinggi pada konsentrasi 30%. Ukuran dan bobot tubuh tertinggi akibat pemberian pakan ditemukan pada perlakuan 10% dengan rerata panjang total, panjang standar, lebar tubuh dan bobot tubuh adalah 9,269±0,14 cm; 7,280±0,15 cm; 2,761±0,09 cm; 10,93±0,06 g. Ikan pada perlakuan ini juga memiliki warna yang dominan merah. Diharapkan penelitian ini memberikan kontribusi dalam pengembangan bahan lokal sebagai pakan untuk membantu mempercepat mekanisme pertumbuhan dan kualitas warna pada ikan nila merah.

Kata Kunci: Pisang Tongkat Langit, Performa Pertumbuhan, *Oreochromis niloticus*

INTRODUCTION

The red tilapia (Oreochromis niloticus) is a freshwater fish species of high economic value, making it a key commodity (Akbar, 2022). This fish has a distinctive flavour, pure white flesh without bones, and a relatively high nutritional content (Aliyas & Ya'la, 2016). Furthermore, (Robisalmi, et al., 2017) note that Nile tilapia have a high reproductive rate. Within 2–3 months, the fry reach maturity and can reproduce once a month. This is significantly influenced by the uniformity of the fry produced. On the other hand, tilapia have several advantages, including relatively rapid growth, ease of rearing, and high tolerance to environmental conditions (Abdel-Tawwab et al., 2017).

Consumption of tilapia has seen a significant increase year on year. To meet this rising demand, optimal aquaculture practices are required to achieve maximum production. Tilapia production data shows an increase at both national and global levels (KPP, 2020) In 2021, tilapia production reached 1.49 million tonnes (DJPB, 2020). The growing public interest in red tilapia requires farmers to produce fish in larger quantities.

A key challenge in red tilapia farming is the difficulty in obtaining fry of a quality that meets market criteria, namely rapid growth and an attractive red colour. Based on observations, red tilapia tend to have a rather pale red colour. Reduced growth and colour quality may be caused by environmental stress, lack of sunlight, disease, the use of a single feed, and, in particular, a lack of colour-enhancing components in the feed (Pratiwi et al., 2022). Furthermore, reliance on imported feed raw materials is disadvantageous for farmers, given that feed costs account for 60–70% of the operational expenses of the farming business. Another issue faced is the outbreak of disease caused by imbalances and interactions between fish, an environment unfavourable to fish, and the proliferation of disease-causing pathogens. To prevent disease outbreaks, functional feed fortified with prebiotics can be administered (Hartika et al., 2014) Prebiotics are non-viable food components that confer health benefits on the host through the modulation of the microbiota (FAO, 2007). Therefore, there is a need to develop affordable, high-quality feed made from local raw materials that also possesses functional properties. One approach involves the addition of plant-based additives (Fatima et al., 2025).

Indonesia's wealth of local plant species, particularly in Maluku, offers potential for the provision of feed raw materials, especially from agricultural and agro-processing waste. The

use of waste is driven by its easily degradable nature; one such example is peel waste. Several studies on the use of waste as feed ingredients have been conducted. (Nanariain et al., 2017) noted that the inclusion of 20% plantain peel flour in feed formulations can result in a relative growth rate of 88.9% in tilapia. (Jeharu et al., 2015) found that banana peel flour formulated into feed can enhance the relative growth of tilapia. In addition to using waste, the feed was also enriched with 1% synthetic probiotics, resulting in the highest tilapia survival rate of 93.33 ± 5.77% and a high blood cell count (Hartika et al., 2014).

In addition to growth, several studies have been conducted on the use of agricultural waste as a source of colour pigments, including the use of kepok banana peel flour (Faturrahman et al., 2020) dragon fruit peel flour and mangosteen peel extract (Luciana, 2023) have been shown to improve colour quality in the ornamental fish *Amphiprion percula* and A. ocellaris. To date, the use of feed made from waste materials has not been employed to improve colour quality in red tilapia.

Based on the results of observations, a local resource in Maluku that can be used as a source of functional feed from waste is the peel of the fe'i banana (Musa troglodytarum L.). This banana variety is classified as a plant endemic to the Maluku region; its fruit clusters grow upright, distinguishing it from other bananas, and the flesh of the ripe fruit is yellow to orange in colour. Furthermore, the colours of the ripe fruit peel vary, including brownish-red, reddish-orange, brownish-orange, yellowish-orange, and yellow (Hiariej & Karuwal, 2015). There are two varieties of this banana based on fruit size: the long-fruit variety and the short-fruit variety. Letelay et al., (2020) demonstrated that the carotenoid content of the skin of the long-fruit variety, at 60.02 mg/100 g, is higher than that of the short-fruit variety, at 37.12 mg/100 g. Consequently, the peel of the fe'i banana could potentially be utilised as an innovative local functional feed to enhance the growth and colour quality of red tilapia.

METHODS

Research Location and Time

This study was conducted from October to December 2024 at the Taar Village Mini Aquaculture Laboratory in Tual City for preparation, maintenance and observation. Proximate and phytochemical analyses of the feed were carried out at the Basic Chemistry Laboratory, Faculty of Science and Technology, Pattimura University.

Research Design

The design of this study was a completely randomised design (CRD) with treatments consisting of fe'i banana peel at concentrations of 0%, 10%, 20% and 30%, each repeated three times, resulting in 12 experimental units. The composition of the materials in each treatment consisted of:

0%: MS Preo 320 commercial feed
10%: Fe'I banana peel flour 10 g + honey 10 mL + commercial feed 80 g
20%: Fe'I banana peel flour 20 g + honey 10 mL + commercial feed 70 g
30%: Fe'I banana peel flour 30 g + honey 10 mL + commercial feed 60 g

Research Procedure

The fe'i bananas used were physiologically ripe and sourced from the Langgur Traditional Market in Southeast Maluku Regency. The bananas were removed from the bunch, then cleaned and peeled. The peel from each fruit was weighed, then cut into small pieces and dried in an oven at 50 °C to facilitate the flour-making process. The dried banana peel waste was ground in a blender and then sieved to produce flour.

The feed was prepared according to Faturrahman et al., (2020), with modifications. Commercial feed was ground using a mill. The weight of the flour and feed was measured according to the treatment, and the feed was then mixed with fe'i banana peel flour. Honey was added to the feed mixture little by little until the dough became pliable, and it was moulded

using a grinding machine. The moulded pieces were dried in an electric oven at 50 °C for one hour until the feed was completely dry. The prepared feed for each treatment underwent proximate analysis before being fed to the test fish.

The proximate analysis was carried out in accordance with the AOAC method (2012) and comprised moisture content, ash content, protein content, lipid content, fibre content and carbohydrate content. The phytochemical content of the feed was analysed by spectrophotometry.

For the maintenance and observation phase, the fish used were farmed fish at the fry stage. Ten fry were placed in each 40×40×30 cm aquarium containing 50 litres of water. An acclimatisation process was carried out first. Water changes were carried out daily and water quality was monitored periodically. Natural feed was provided ad libitum at 08:00, 12:00 and 16:00 according to body weight. The total feed provided was 3% of the fish biomass weight to calculate the feed intake rate.

Growth observations were conducted by measuring total length and body weight at the start and end of the rearing period. Fish length was measured using a caliper (accuracy 0.01 cm). Body weight was measured using digital scales with an accuracy of 0.01 g. Growth rates were calculated based on the length and body weight data. Observations of colour characteristics included digital colour profiling (Kusumah et al. 2016). The colour profile of the skin and fins was measured as a percentage of red using the RGB Measure tool in ImageJ software version 1.48f. At the end of the study, the survival rate of red tilapia was observed following feeding with a diet made from sky-stick banana peel.

Data Analysis

The data in this study, in the form of level of feed consumption, were obtained using the formula below (Aisyah et al., 2021):

$$FC = F1 - F2$$

Where FC is level of feed consumption (g), F1 is total weight of initial feed (g), and F2 is weight of leftover feed (g).

Specific weight growth rate using formula below (Effendie, 1997):

$$SWGR = \frac{\ln Wt - \ln W0}{t} \text{ x } 100\ \%$$

Where SGR is specific weight growth rate (%), Wt average weight of fish at the end of the experiment (g), W0 is average fish weight at the beginning of the experiment (g), t is Time during the experiment (days).

Specific length growth rate using formula below (Effendie, 1997):

$$SLGR = \frac{\ln Lt - \ln L0}{t} \text{ x } 100\ \%$$

Where SLGR is specific length growth rate (%), Lt average length of fish at the end of the experiment (cm), L0 is average fish length at the beginning of the experiment (cm), t is Time during the experiment (days).

Fish survival is measured using formula below (Hopkins, 1992):

$$SR = \frac{\text{Nt}}{N0} \text{ x } 100\ \%$$

Where SRis survival rate (%), Nt is number of individu at the end of the experiment (ind), N0 is number of individu at the beginning of the experiment (ind).

Overall, the data obtained were analysed using analysis of variance at a 95% significance level. To examine differences between treatments, a post-hoc test was conducted using Duncan's Multiple Range Test with SPSS version 20.

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Proximate Content of Feed Fe'i Banana Peels

The proximate content of the feed fe'i banana peels analysed includes moisture content, ash content, protein content, fat content, carbohydrate content and fibre content. The results of the proximate analysis are shown in Table 1.

Table 1. Proximate content of feed fe'i banana peels

Treatment	MC (%)	AC (%)	PC (%)	LC (%)	CC (%)	FC (%)
10%	19,1109^{b}	12,6164^{a}	32,3561^{c}	10,2942^{b}	25,3902^{c}	18,0377^{a}
20%	18,4623^{a}	16,1664^{b}	31,4895^{b}	10,0852^{ab}	23,6339^{b}	23,1146^{b}
30%	19,854^{ab}	18,6186^{c}	29,1172^{a}	9,7298^{a}	22,6586^{a}	26,6169^{c}

Note: MC: moisture content, AC: ash content, PC: protein content, LC: lipid content, CC: carbohydrate content, FC: fibre content. Different notation indicates differences between treatments

Table 1 shows that the concentration of the treatment substance affects the proximate content of the feed. There were significant differences between the treatments. The highest proximate component was protein content, found in the 10% treatment at 32.3561%, followed by carbohydrate content, moisture content, and fat content at 25.3902%, 19.1109%, and 10.2942% respectively. Conversely, the highest ash and fibre contents were found in the 30% treatment at 18.6186% and 26.6169% respectively.

Phytochemical Content of Feed Fe'i Banana Peels

The phytochemical content of the feed fe'i banana peels analysed includes flavonoid total, anthocyanin, carotenoid total, tannin, and phenol total. The results of the phytochemical analysis are shown in Table 2.

Table 2. Phytochemical content of feed fe'i banana peels

Treatment	Flavonoid Total (mg/100 g)	Anthocyanin (mg/100 g)	Carotenoid Total (ppm)	Tannin (mg/100 g)	Phenol Total (mg GAE/100 g)
10%	132,73^{a}	6,98^{a}	19,41^{a}	535,02^{a}	68,60^{a}
20%	178,08^{c}	7,87^{b}	24,93^{b}	546,12^{a}	88,29^{c}
30%	166,59^{b}	8,58^{c}	31,73^{c}	722,20^{b}	71,98^{b}

Note: Different notation indicates differences between treatments

The results of the analysis in Table 2 show that the treatment of the material affects the phytochemical content of the feed. There were significant differences between the treatments. The highest phytochemical components found were tannins, carotenoids and anthocyanins in the 30% treatment, at 722.20 mg/100 g, 31.73 ppm and 8.58 mg/100 g respectively. High levels of flavonoids and phenols were found in the 20% treatment, at 178.08 mg/100 g and 88.29 mg GAE/100 g, respectively.

Feed Consumption of Feed Fe'i Banana Peels

The results of the analysis of feed consumption for each treatment group are shown in Figure 1. The calculations indicate that as the feed concentration in the treatment groups increased, feed consumption decreased. Compared with the control group, the highest feed consumption was observed in the 10% treatment group.

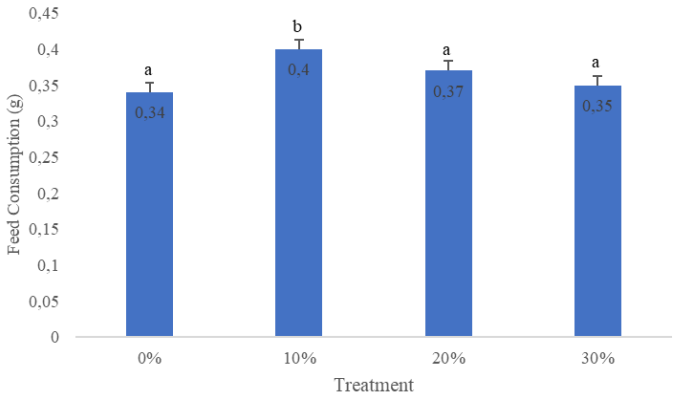


Figure 1. Feed consumption of feed fe'i banana peels. Different notation indicates differences between treatments

Growth Performance of Red Tilapia

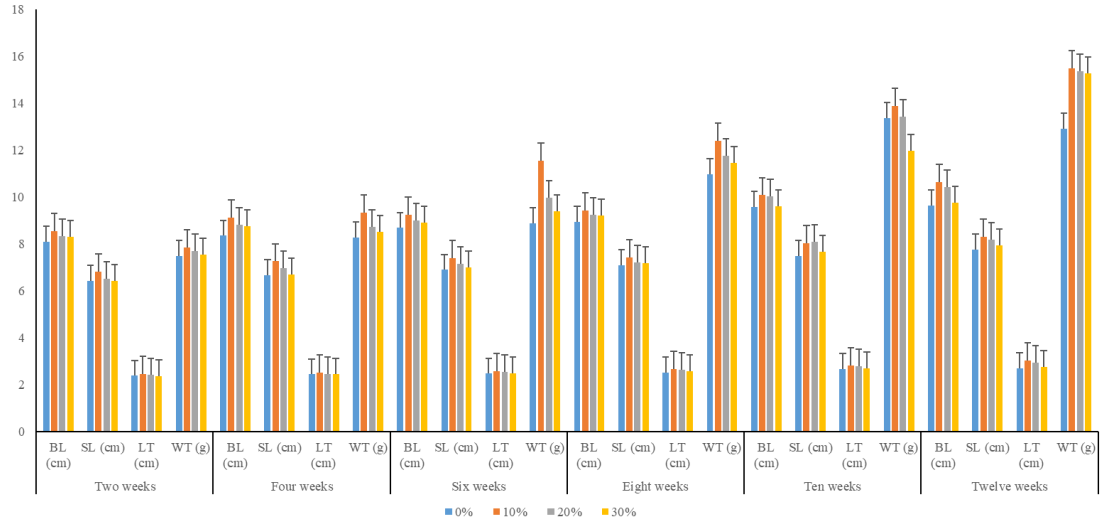


Figure 2. Size and weight of red tilapia. BL: total length, SL: standart length, LT: body width, WT: body weight

Figure 2 also shows significant differences in body size and weight across the feed concentration treatments. It is shown that the highest average body size and weight were found in the 10% treatment and the lowest in the 30% treatment. In turn, the average total length, standard length, body width and body weight for treatment 10% in the second week of measurement were 8.55±0.16 cm; 6.83±0.09 cm; 2.46±0.14 cm; 7.85±0.165 g. Furthermore, the average total length, standard length, body width and body weight in the 12th week were 10.64±0.346 cm; 8.3±0.25 cm; 3.02±0.2 cm; 15.48±1.047 g. The relative growth rates of red tilapia following the administration of feed based on banana stems are shown in Table 3 below. The highest growth rates for body length and weight were observed in the 10% treatment.

Table 3. Specific growth rate of red tilapia

Treatment	Specific weight growth rate (%/day)	Specific length growth rate (%/day)
0%	0.61±0,135	0.19±0,040
10%	0.78±0,02	0.25±0,017
20%	0.77±0,091	0.24±0,032
30%	0.75±0.064	0.18±0,036

Note: Different notation indicates differences between treatments

Survival Rate of Red Tilapia

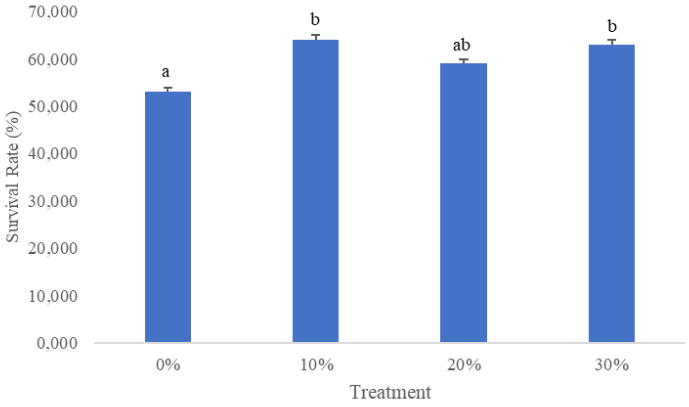
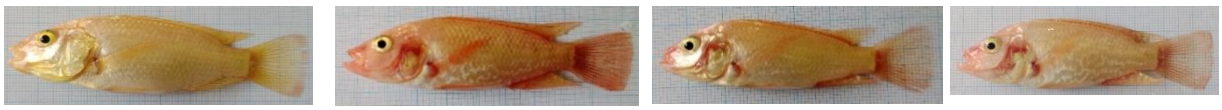


Figure 3. Survival rate of red tilapia. Different notation indicates differences between treatments

Figure 3 shows a significant difference in fish survival rates between treatment groups. Over the 90-day observation period, the survival rate of red tilapia ranged from 53% to 64%.

Colour Profile of Red Tilapia

The colour characteristics of the red tilapia in the feeding treatments are shown in Table 4. Visually, the colour of each fish can be seen in Figure 4. Figure 4 shows significant differences in fish colour between the treatments and the control. Striking differences are clearly visible across the entire body of the fish, including the skin, head and fins. Fish in the 10% treatment group have a predominantly red colour. Fish in the control group have a clear colour with a yellow tinge accumulated in certain areas.



0% 10% 20% 30%

Figure 4. Colour visual of red tilapia

Table 4. Percentage *red* value of red tilapia

Treatment	Skin (%)	Head (%)	Anal fin (%)	Caudal fin (%)	Dorsal fin (%)	Ventral fin (%)	Pectoral fin (%)
0%	159,033^{a}	190,129^{a}	137,595^{a}	149,482^{a}	167,899^{a}	155,679^{a}	172,575^{a}
10%	176,462^{c}	203,971^{c}	167,424^{c}	172,381^{c}	176,916^{c}	174,856^{c}	186,808^{b}
20%	172,001^{c}	195,768^{b}	156,478^{b}	171,777^{c}	176,40^{c}	167,209^{b}	185,579^{b}

30%	169,351[b]	195,378[b]	155,532[b]	162,452[b]	173,526[b]	163,688[b]	182,412[b]

Note: Different notation indicates differences between treatments

Table 4 shows the colour profile of tilapia following feeding. The colour profile was measured based on the percentage of the 'Red' value in the ImageJ software. The percentage of 'Red' was measured on the skin, head, and fins—including the anal, caudal, dorsal, ventral and pectoral fins. Based on Table 4, the highest average red percentage was found in the 10% treatment on the skin, head, anal fin, tail fin, dorsal fin, ventral fin, and pectoral fin. Thus, the 10% treatment can enhance the colour profile of red tilapia.

DISCUSSION

The results of the proximate analysis in this study are largely consistent with those of Oluwatosin & Solomon (2017), who determined the proximate composition of feed made from soaked plantain flour. The protein content varied between 34.67–35.68%, fibre 3.69–3.87%, moisture ranged from 9.74–9.98%, lipids ranged from 3.11–3.78%, and ash ranged from 11.26–12.41%. Other research findings indicate that the proximate composition of molasses-fermented banana peel feed shows higher levels compared to non-fermented peel. The protein content is 32.1%, lipids (6.03%), fibre (6.13%), ash (12.85%), and carbohydrates (42.89%). The increase in protein content is attributed to the degradation of polysaccharides in the banana peel following fermentation (Olorunnisola et al., 2018; Oguntoyinbo et al., 2020; Ozabor et al.,2020). Differences in proximate composition may be due to variations in geographical conditions, plant species, environmental conditions, and sample processing methods. According to Abou-Arab & Abu-Salem, (2018) banana peel is generally rich in fibre, with a content of around 50% on a dry matter basis. The high fibre content in banana peel influences the fibre content found in the derived products produced. Furthermore, the ash content in banana peel is influenced by the soil used (Ansari et al., 2023).

Ansari et al., (2023) also note that banana peel is rich in nutrients and bioactive compounds. However, the content of these nutrients and bioactive compounds varies depending on the banana variety and environmental conditions. According to Fatemeh et al., (2012) banana peel contains more phenolic compounds than the fruit flesh. This is supported by Shinichi et al., (2002) who found that the total phenolic compounds in banana peel range from 0.90–3.0 g/100 g dry weight. This study demonstrates that each treatment has a high content because it is made from the peel. Furthermore, Letelay et al., (2020) indicated that the carotenoid content in fe'i banana peel was 60.02 mg/100 g. Mathew & Negi, (2017) noted that banana peel is a rich source of bioactive compounds, particularly antioxidants such as flavonoids, vitamin C, and tannins. This is also evident in this study, where tannins and flavonoids were found to have the highest levels compared to other compounds. The presence of tannins is indicated by an astringent taste. Fe'i banana peel has a slightly astringent taste even when ripe. The high levels of phytochemicals in banana peel lead to an increase in these levels in derivative products such as enriched feed. However, this can also result in a decrease due to the production method and the nature of these compounds. In this study, fe'i banana peel additive was incorporated into the feed after drying.

This study is largely consistent with Aisyah et al., (2021) who found that the dosage of fermented banana peel flour in the feed had a significant effect on the average feed consumption of Siamese catfish. However, this study revealed significant differences compared to the study by Aisyah et al., (2021). This is due to differences in the nutritional composition of each treatment. One such difference is the high fibre content in the 30% treatment. According to Indriyanti, (2011), the higher the crude fibre content in the feed, the greater the feeling of satiety, as the complex carbohydrate composition suppresses appetite.

This results in reduced feed consumption. According to Razak et al., (2016), a balanced ratio of protein and energy in the feed leads to similar feed consumption. In this study, the protein content was higher than the carbohydrate content in the 10% treatment. This led to a higher difference in feed consumption in the 10% treatment as well. On the other hand, commercial feed additives using fe'i banana peel flour were well accepted by red tilapia.

In this study, the highest growth performance was observed in the 10% treatment. This was due to the nutritional composition of the feed. Growth is influenced by dietary nutrients, namely protein (Daudpota et al., 2016). According to Guo et al., (2012), the presence of protein and energy in the feed is crucial for fish growth. Furthermore, banana peel extract enhances growth by improving nutrient assimilation and digestion due to its high mineral and fibre content (Rawat et al., 2024). Tannins and flavonoids stimulate enzymatic activity in the gut, enabling better breakdown of carbohydrates and proteins (Barrett et al., 2018). Research indicates that diets supplemented with banana peel extract or powder can reduce FCR and significantly increase body weight (Arathi, 2021). A similar finding was reported in the study by Giri et al., (2016), which showed that supplementing feed with 5% banana peel flour could enhance growth over 60 days in L. rohita. This is because the carbohydrates and lipids in the feed have the ability to conserve feed protein by reducing protein catabolism for energy, which can improve retention and ultimately growth in the animals (Esteban, 2012). This is further supported by (Al Hafedh, 2001), who noted that tilapia of different sizes require varying amounts of protein for their growth. Young tilapia weighing 0.02 to 10 g require 35–40% protein in their feed. Conversely, Intharathat et al., (2024) demonstrated that the high-dose administration of fermented banana peel meal resulted in a decline in growth performance and feed efficiency in red tilapia.

This is similar to the findings of Melanie et al., (2024), which showed that the survival rate of carp after being fed banana peel flour ranged from 56.67% to 76.66%. According to Putranti et al., (2015), feed with different protein content but the same protein energy value affects growth but does not affect survival rates. In addition to feed, survival is also supported by water quality, which is one of the biotic and abiotic factors influencing survival.

Generally, the colour of a fish's skin is influenced by chromatophores containing colour pigments, one of which is carotenoids. Fish in the 10% feed treatment group had more attractive colouration due to the contribution of carotenoids in that feed.

CONCLUSION

This study shows that the use of feed made from fe'i banana peel has a significant effect on the proximate composition, phytochemical content, feed consumption, growth performances and colour characteristics of red tilapia. The treatment with a 10% concentration resulted in high proximate composition and feed consumption, enhancing growth and colour characteristics in red tilapia. Consequently, fe'i banana peel flour can be used as an additive in fish feed production.

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REFERENCES

Abdel-Tawwab, M., El-Sayed, G. O., & Shandy, S. H. (2017). Effect of Dietary Active Charcoal Supplementation on Growth Performance, Biochemical and Antioxidant Responses, and Resistance of Nile Tilapia, *Oreochromis niloticus* (L.) to Environmental Heavy Metals Exposure. *Aquaculture*, *479*, 17–24.

https://doi.org/10.1016/j.aquaculture.2017.05.016

Abou-Arab, A. A., & Abu-Salem, F. M. (2018). Nutritional and Anti-Nutritional Composition of Banana Peels As Influenced by Microwave Drying Methods. *International Journal of Nutrition and Food Engineering*, *11*(12), 845–852.

Aisyah, A., Gustiningrum, A. S., Agustono, & Al-Arif, M. A. (2021). Substitution of commercial Feed with Fermented Banana Peel Flour (*Musaceaea* sp.) and Fish Meal to Feed Consumption Level, Specific Growth Rate, Feed Efficiency, Fat Retention, and Energy Retention in Siam Catfish (*Pangasius hypophthalmus*). *IOP Conference Series: Earth and Environmental Science*, *679*(012056), 1–11. https://doi.org/10.1088/1755-1315/679/1/012056

Akbar, S. (2022). *Meramu Pakan Ikan Kerapu*. Penebar Swadaya.

Al Hafedh, Y. S. (2001). Effects of Dietary Protein on Growth And Body Composition of Nile Tilapia, *Oreochromis niloticus* L. *Aquaculture Research*, *30*, 385–393. https://doi.org/10.1046/j.1365-2109.1999.00343

Aliyas, S., & Ya'la, Z. R. (2016). Pertumbuhan dan Kelangsungan Hidup Ikan Nila (*Oreochromis* sp.) yang Dipelihara pada Media Bersalinitas. *Jurnal Sains dan Teknologi Tadulako*, *5*(1), 19–27.

Ansari, N. A. I. M., Ramly, N. Z., Huda-Faujan, N., & Arifin, N. (2023). Nutritional Content and Bioactive Compounds of Banana Peel and its Potential Utilization: A Review. *MJoSHT*, *9*(1), 74–85.

AOAC. (2012). *Analysis Official Analysis Chemistry*.

Arathi, S. (2021). Dietary Incorporation of Raw Banana Peel Silage on Growth and Nutrient Utilisation in Weaned Malabari Kids. *Kerala Veterinary and Animal Sciences University*, Wayanad.

Barrett, A. H., Farhadi, N. F., & Smith, T. J. (2018). Slowing Starch Digestion and Inhibiting Digestive Enzyme Activity Using Plant Flavanols/Tannins— A Review of Efficacy and Mechanisms. *LWT*, *87*, 394–399. https://doi.org/10.1016/j.lwt.2017.09.002

Daudpota, A. M., Abbas, G., Kalhoro, H., Shah, A. A., Ferrando, S., Gallus, L., … Hafeez-ur-Rehman, M. (2016). Comparison of Growth, Feed Conversion and Body Composition of Juvenile Hybrid Red Tilapia (*Oreochromis niloticus* × *O. mossambicus*) and Nile Tilapia (*O. niloticus*) Reared in Concrete Tanks. *Zoological Society of Pakistan*, *48*(3), 809–816.

Direktorat Jenderal Perikanan Budidaya. (2020). *Laporan Kinerja (LKj) Perikanan Budidaya Tahun 2020*.

Effendie, M. I. (1997). *Biologi Perikanan*. Yayasan Pustaka Nusatama.

Esteban, M. A. (2012). An Overview of The Immunological Defenses in Fish Skin. *ISRN Immunology*, *853470*, 1–29. https://doi.org/10.5402/2012/853470

Fatemeh, S. R., Saifullah, R., Abbas, F. M. A., & Azhar, M. E. (2012). Total Phenolics, Flavonoids and Antioxidant Activity of Banana Pulp and Peel Flours: Influence of Variety and Stage of Ripeness. *International Food Research Journal*, *19*(3), 1041.

Fatima, G., Shumail, M. U., Naseer, T., Akram, H. I., Khan, R. W., Muntaha, S. T., … Shakeel, R. (2025). Exploring The Effect of Banana and Pomegranate Peel Extract on The Growth Performance, Antioxidant Status and Immunological Profile of Raho Fish (*Labeo rohita*). *IJBR*, *3*(10), 121–125. https://doi.org/10.70749/ijbr.v3i10.2437

Faturrahman, Junaidi, M., & Setyono, B. D. H. (2020). Efektivitas Penambahan Bubuk Kulit Pisang pada Pakan Buatan Terhadap Kecerahan Warna pada Ikan Nemo (*Amphiprion ocellaris*). *Jurnal Perikanan*, *10*(2), 112–122. https://doi.org/10.29303/jp.v10i2.166

Food and Agriculture Organization. (2007). *FAO Technical Meeting on Prebiotics*.

Giri, S. S., Jun, J. W., Sukumaran, V., & Park, S. C. (2016). Dietary Administration of Banana (*Musa acuminata*) Peel Flour Affects The Growth, Antioxidant Status, Cytokine Responses, and Disease Susceptibility of Rohu, *Labeo rohita*. *Journal of Immunology*

Research, 1–11. https://doi.org/10.1155/2016/4086591

Guo, Z. Q., Zhu, X. M., Liu, J. S., Han, D., Yang, Y. X., Lan, Z. Q., & Xie, S. Q. (2012). Effects of Dietary Protein Level on Growth Performance, Nitrogen and Energy Budget of Juvenile Hybrid Sturgeon, *Acipenser baerii* ♀ × *A. gueldenstaedtii*. *Aquaculture*, *338--341*, 89–95. https://doi.org/10.1016/j.aquaculture.2012.01.008

Hartika, R., Mustaha, & Putra, A. N. (2014). Gambaran Darah Ikan Nila (*Oreochromis niloticus*) dengan Penambahan Dosis Prebiotik yang Berbeda dalam Pakan. *Jurnal Perikanan Dan Kelautan*, *4*(4), 259–267. https://doi.org/10.33512/jpk.v4i4.174

Hiariej, A., & Karuwal, R. L. (2015). Profil Lingkungan Tumbuh Pisang Tongkat Langit (*Musa troglodytarum* L.) di Kabupaten Maluku Tengah. *BioWallacea Jurnal Ilmiah Ilmu Biologi*, *3*(1), 1–12.

Hopkins, K. D. (1992). Reporting Fish Growth: A Review of The Basics. *Journal of The World Aquaculture Society*, *23*(3), 173–179. R

Indriyanti, N. (2011). Evaluasi Kecernaan Campuran Bungkil Inti Sawit dan Onggok yang difermentasi oleh *Trichoderma harzianum* rifai untuk Pakan Ikan Nila *Oreochromis* sp. *Institut Pertanian Bogor*, Bogor.

Intharathat, B., Ponza, P., & Karaket, T. (2024). Feasibility of Molasses-Fermented Banana Peel As A Protein Source in Practical Diet for Hybrid Tilapia (*Oreochromis* spp.): Effect on Growth and Feed Efficiency. *Acta Scientiarum. Animal Sciences*, *46*(e68154), 2–7. https://doi.org/10.4025/actascianimsci.v46i1.68154

Jeharu, A. A. Y., Lumenta, C., & Sampekalo, J. (2015). Pemanfaatan Tepung Kulit Pisang Kepok (*Musa balbisiana* Colla) dalam Formulasi Pakan Ikan Nila (*Oreochromis niloticus*). *Budidaya Perairan*, *3*(3), 1–11.

Kementerian Kelautan dan Perikanan. (2020). *Statistik Ekspor Hasil Perikanan Tahun 2015-2019*.

Letelay, O. P., Hiariej, A., & Pesik, A. (2020). Analisis Beta Karoten dan Vitamin pada Kulit dan Daging Buah Pisang Tongka Langit (*Musa troglodytarum* L.) di Kota Ambon. *Jurnal Agritechno*, *13*(1), 24–33. https://doi.org/10.70124/at.v13i1.243

Luciana, G. E. (2023). Efektivitas Penambahan Sumber B-Karoten Ekstrak Kulit Buah Naga Merah, Kulit Mangga, Kunyit dan Kulit Manggis pada Pakan Buatan terhadap Peningkatan Kecerahan Warna Ikan Badut *(Amphiprion percula)*. *Universitas Sriwijaya*, Riau.

Mathew, N. S., & Negi, P. S. (2017). Traditional Uses, Phytochemistry and Pharmacology of Wild Banana (*Musa acuminata* Colla): A Review. *Journal of Ethnopharmacology*, *196*, 124–140. Https://doi.org/10.1016/j.jep.2016.12.009

Melanie, K., Nazlia, S., Saputra, J., Febri, S. P., & Aprita, I. R. (2024). The Effect of Banana Peel Flour (*Musa paradisiaca*) As Additional Feed Raw Materials for Common Carp (*Cyprinus carpio*). *BIO Web of Conferences*, *87*, 3024. https://doi.org/10.1051/bioconf/20248703024

Nanariain, R. M., Lumenta, C., & Pangkey, H. (2017). Pemanfaatan Tepung Kulit Pisang Raja (*Musa paradisiaca*) dalam Formulasi Pakan Ikan Nila (*Oreochromis niloticus*). *Budidaya Perairan*, *5*(1), 21–31.

Oguntoyinbo, O. O., Olumurewa, J. A. V, & Omoba, O. S. (2020). Chemical Composition, Dietary Fiber and Antioxidant Activity Of Fermented Ripe Banana Peel Flour. *Journal of Food Stability*, *3*(2), 27–42. https://doi.org/10.36400/J.Food.Stab.3.2.2020-0034

Olorunnisola, K. S., Jamal, P., & Alam, M. Z. (2018). Protein Improvement of Banana Peel Through Sequential Solid State Fermentation Using Mixed-Culture of *Phanerochaete chrysosporium* and *Candida utilis*. *Biotech*, *8*(10), 416. https://doi.org/10.1007/s13205-018-1435-4

Oluwatosin, O. O., & Solomon, R. J. (2017). Growth Performance of The African Catfish

(*Clarias gariepinus*) Fed Soaked Ripe Plantain Peel Meal (*Musa paradisiaca*). *Direct Research Journal of Veterinary Medicine and Animal Science*, *2*(2), 51–65.

Ozabor, P. T., Ojokoh, A. O., Wahab, A. A., & Aramide, O. O. (2020). Effect of Fermentation on The Proximate and Antinutrient Composition of Banana Peels. *The International Journal of Biotechnology*, *9*(2), 105–117. https://doi.org/10.18488/journal.57.2020.92.105.117

Pratiwi, R., Mulyono, M., Saputra, S., Farkan, M., Samsuharapan, S. B., & Panjaitan, A. S. (2022). Enhancement of Color Brightness on Clown Fish (*Amphiprion percula*) with Addition of Tomato Powder Extract. *Asian Journal of Fisheries and Aquatic Research*, *20*(16), 117–124. https://doi.org/10.9734/ajfar/2022/v20i6523

Putri, W., Mukhlis, A., & Lestari, DP (2024). Peningkatan Kualitas Pakan dengan Penambahan Maggot Tepung (*Hermetia illucens*) Terhadap Pertumbuhan dan Sintasan Ikan Karper (*Cyprinus carpio*). *Media Akuatika: Jurnal Ilmiah Jurusan Budidaya Perairan*, *9*(3), 1-12.

Rawat, N., Das, S., Wani, A. W., Javeed, K., & Qureshi, S. (2024). Antioxidant Potential and Bioactive Compounds in Banana Peel: A Review. *International Journal of Research in Agronomy*, *7*(7), 7–16. https://doi.org/10.33545/2618060x.2024.v7.i7sa.968

Razak, A. D., Kiramang, K., & Hidayat, M. N. (2016). Pertambahan Bobot Badan, Konsumsi Ransum dan Konversi Ransum Ayam Ras Pedaging yang Diberikan Tepung Daun Sirih (*Piper betle* Linn) Sebagai Imbuhan Pakan. *Jurnal Ilmu dan Industri Peternakan*, *3*(1), 135–147. https://doi.org/10.24252/jiip.v3i1.3924

Robisalmi, A., Setyawan, P., & Gunadi, B. (2017). Efek Nisbah Kelamin Jantan dan Betina yang Berbeda Terhadap Kinerja Pertumbuhan Yuwana Ikan Nila Biru, *Oreochromis aureus* (Steindachner1864). *Jurnal Iktiologi Indonesia*, *17*(1), 55–65.

Shinichi, S., Yumiko, Y., & Kazuyoshi, O. (2002). Antioxidant Compounds from Bananas (*Musa cavendish*). *Food Chemistry*, *79*(3), 351–354. https://doi.org/10.1016/S0308-8146(02)00186-3