Pertanika Proceedings 1 (7): 183 - 187 (2025)

PERTANIKA JOURNALS

PERTANIKA PROCEEDINGS

Journal homepage: http://www.pertanika.upm.edu.my/

Palm Kernel Meal as Sustainable Ingredient for Tilapia (*Oreochromis* sp.) Feed: Effects on Growth Performance, Body Colour, and Carcass Composition

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ABSTRACT

The inconsistent availability of imported feed ingredients like fishmeal and soybean meal has driven the aquaculture industry to explore sustainable protein alternatives. This study assessed the effects of varying inclusion levels of palm kernel meal (PKM) and its premium variant, PURAFEX on the growth performance, body colour, and carcass composition of tilapia fish. Six isonitrogenic and isocaloric diets were tested: T1 (control, without PKM or PURAFEX), T2 (10% PKM), T3 (20% PKM), T4 (10% PURAFEX), T5 (20% PURAFEX), and T6 (30% PURAFEX). After a 16-week feeding trial, fish fed T3 had the highest ($P<0.05$) body weight, feed intake and the best feed conversion ratio among treatments. The body colour analysis showed no significant differences ($P>0.05$) in lightness (L*), but the values for redness (a*) and yellowness (b*) varied significantly ($P<0.05$) with increasing inclusion levels of PKM and PURAFEX. Carcass analysis revealed similar moisture levels across groups, but diets with PKM or PURAFEX had lower ash content (13%) compared to the control (15.93%). Crude protein (CP) was highest in T3 but decreased with higher PURAFEX levels, while gross energy increased with PKM or PURAFEX inclusion levels (4.4–5.2 kcal/g). The results showed that incorporating PKM and PURAFEX into tilapia diets enhanced growth performance, improved colour intensity, and boosted the fish's appearance and nutritional compositions. The findings suggest that PKM and PURAFEX can serve as nutritionally valuable alternatives to conventional imported feed ingredients for tilapia feed.

Keywords: Carcass composition, colour analysis, growth performance, palm kernel meal, tilapia

ARTICLE INFO

Article history:
Received: 27 October 2025
Published: 10 December 2025

DOI: https://doi.org/10.47836/pp.1.7.033

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e-ISSN: 3083-9475

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INTRODUCTION

The rapid growth of aquaculture has increased the demand for high-quality protein sources such as fishmeal and soybean meal. However, reliance on these imported ingredients raises concerns regarding cost, sustainability, and environmental impact. Overfishing has reduced fish stocks, driving up prices (Ritchie & Roser, 2025), while the production of soybean meal competes with food production and contributes to deforestation soybean meal competes with food production and causes deforestation (Caro et al., 2018).

Palm Kernel Meal (PKM) and its premium variant, PURAFEX, are by-products of palm oil production that offer a sustainable alternative for fish feed. Studies show that PKM can replace fishmeal without affecting fish growth (Ng et al., 2020), while also supporting a circular economy by reducing waste. Since feed accounts for 70% of aquaculture costs (Zhao et al., 2020), identifying cost-effective alternative ingredients is crucial. Therefore, this study examines the effects of PKM and PURAFEX in tilapia diets, focussing on growth performance, body colour, and carcass composition, to assess their potential as sustainable feed options.

Problem Statement

Although palm-kernel hold potential as cost-effective, sustainable feed ingredients, their role as partial replacements in tilapia feed and the consequent effects on growth performance, body colour and carcass composition of tilapia, remain under-investigated. Thus, further research is required to evaluate and optimise the inclusion levels of PKM and PURAFEX in tilapia diets to enhance feed sustainability while maintaining or improving production outcomes.

Research Questions

How do PKM and PURAFEX affect tilapia growth and carcass composition?

MATERIALS AND METHOD

Six experimental diets were formulated to be isonitrogenous and isocaloric, with different inclusion levels of PKM or PURAFEX as partial replacements of conventional feed ingredients. The diets included: T1 (control, without PKM or PURAFEX); T2 (10% PKM); T3 (20% PKM); T4 (10% PURAFEX); T5 (20% PURAFEX); and T6 (30% PURAFEX). In this study, the percentages refer to % w/w of the total feed (i.e., 10 % or 20 % of the complete diet by weight was comprised of PKM or PURAFEX).

A total of 900 juvenile Nile tilapia was evenly distributed across eighteen pond partitions (50 fish per partition; three replicates per treatment), each equipped with continuous aeration and a water-recycling system. After a two-week acclimatisation period,

the fish were fed their respective diets five times daily (Fava et al., 2022) for 16 weeks. Body weight was measured every two weeks, and at the end of the trial, growth performance parameters were calculated. Body colour was assessed using a chromameter and carcass composition was determined in accordance with the procedures of the Association of Official Analytical Chemists (AOAC 2005). Data were statistically analysed using one-way analysis of variance (ANOVA) and Duncan's multiple-range test ($P<0.05$) to identify significant differences among treatments.

RESULTS AND DISCUSSION

Growth Performance

The results in Table 1 show that the inclusion of PKM and PURAFEX significantly influenced ($P<0.05$) the growth performance parameters of tilapia, except for the survival rate. Fish in the T3 group exhibited the highest ($P<0.05$) final body weight. Additionally, fish in this group had the highest feed intake (160.51 g) and the most efficient FCR (1.53) compared to other treatment groups.

Table 1
Growth performance of tilapia fed PKM and PURAFEX at different inclusion levels

Growth performance	Experimental diet						SEM	P-value
	T1	T2	T3	T4	T5	T6		
Final weight (g)	85.36^{ab}	80.28^{b}	121.63^{a}	64.74^{c}	98.29^{ab}	75.25^{b}	2.09	<0.05
SGR (% per day)	0.93^{ab}	0.83^{ab}	1.15^{a}	0.61^{b}	1.01^{a}	0.78^{b}	0.28	<0.05
Survival rate (%)	96.67^{a}	94.67^{a}	98.67^{a}	100.00^{a}	94.00^{a}	93.33^{a}	1.25	0.18
Feed intake (g)	125.57^{b}	105.93^{c}	160.51^{a}	101.65^{c}	126.34^{b}	118.99^{b}	2.58	<0.05
FCR	1.81^{ab}	1.67^{b}	1.53^{b}	2.16^{a}	1.54^{b}	2.03^{a}	0.34	<0.05

Note. T1 – Control (0% PKM); T2 – 10% PKM; T3 – 20% PKM; T4 – 10% PURAFEX; T5 - 20% PURAFEX; T6 – 30% PURAFEX; ADG – average daily gain; SGR – specific growth rate; FCR – feed conversion ratio

Body Colour and Carcass Composition

Table 2 presents the body colour and carcass composition of tilapia fed diets with varying levels of PKM or PURAFEX. The analysis of body colour showed that a* and b* values were significantly influenced ($P<0.05$) by the inclusion levels of PKM and PURAFEX. The increased levels of PKM and PURAFEX appeared to enhance the a* and b* values, which potentially improved the market appeal of farmed tilapia. The impact of dietary ingredients on fish pigmentation has been well-documented, with studies indicating that carotenoid-rich feeds can intensify skin colouration, thus influencing consumer preference (Micah et al., 2022).

Carcass analysis data on the tilapia whole-body revealed that total moisture levels were consistent across all groups. However, diets containing PKM or PURAFEX resulted in a significantly lower ($P<0.05$) total ash content (13.33 – 13.77%) compared to the control (15.93%). Crude protein content was highest in T3 but exhibited a decreasing trend as PURAFEX inclusion levels increased. Gross energy levels increased with the inclusion of PKM and PURAFEX (4.4–5.2 kcal/g), indicating enhanced energy availability in these diets. Similar findings have been reported in studies on alternative feed ingredients, where carcass composition was positively influenced by PKM inclusion (Sangavia et al., 2020).

Table 2
Body colour analysis and carcass composition of tilapia fed PKM or PURAFEX at different inclusion levels

Parameter	Experimental diet						SEM	P-value
	T1	T2	T3	T4	T5	T6		
Colour analysis								
Lightness (L*)	59.68^{a}	56.92^{a}	55.41^{a}	57.54^{a}	55.73^{a}	55.01^{a}	1.98	0.24
Redness (a*)	3.95^{ab}	4.98^{a}	5.46^{a}	2.99^{b}	4.34^{ab}	5.29^{a}	0.85	<0.05
Yellowness (b*)	5.03^{b}	7.24^{ab}	9.43^{a}	7.05^{b}	7.96^{ab}	9.14^{a}	0.29	<0.05
Carcass composition								
Total Moisture (%)	9.80^{a}	9.50^{a}	9.21^{a}	10.08^{a}	10.09^{a}	9.99^{a}	0.21	0.57
Total Ash (%)	15.93^{a}	13.33^{b}	13.77^{b}	13.59^{b}	13.47^{b}	13.31^{b}	0.24	<0.05
Crude fat (%)	16.77^{b}	25.07^{a}	23.55^{a}	13.43^{c}	17.35^{b}	24.65^{a}	0.52	<0.05
Crude protein (%)	12.27^{a}	12.03^{a}	12.90^{a}	12.51^{a}	11.18^{ab}	10.69^{b}	0.38	<0.05
Crude fibre (%)	2.18^{a}	2.08^{a}	2.09^{a}	2.12^{a}	2.07^{a}	2.25^{a}	0.14	0.16
Gross energy (kcal/g)	4.45^{b}	5.24^{a}	5.10^{a}	4.73^{b}	4.69^{b}	5.09^{a}	0.04	<0.05

Note. T1 – Control; T2 – 20% PKM; T3 – 30% PKM; T4 – 10% PURAFEX; T5 - 20% PURAFEX; T6 – 30% PURAFE

CONCLUSION

The findings of this study highlight the potential of PKM and PURAFEX as sustainable feed ingredients for tilapia. The inclusion of 20 % PKM (T3) yielded the highest growth performance, optimal carcass composition and improved colour intensity. While both ingredients show promise, the PKM treatments out-performed the PURAFEX treatments under the conditions tested, suggesting that PKM may be the more effective alternative to conventional imported feed ingredients. These results support the use of PKM as a viable alternative ingredient, promoting sustainability in aquaculture feed production.

ACKNOWLEDGEMENT

The authors would like to thank the Malaysian Palm Oil Board (MPOB) for funding this research (Project No.: VA3-3(c)/2021), as well as the MPOB Feed Research Group staff for their valuable assistance.

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