Nutrient utilization and growth responses of *Oreochromis niloticus* juveniles fed varying dietary levels of sun-dried watermelon peel waste

ABSTRACT

This study was carried out to evaluate the nutrient utilization and growth response of *O. niloticus* juveniles fed a diet containing watermelon peel (WMP). Four iso-nitrogenous diets containing 0%, 25%, 50% and 75% were formulated. A total of 120 juveniles were fed at 5% body weight per day for 84 days. At the end of the experiment, WMP was most suitable as an energy supplement when it was incorporated at 50% replacement. The carcass analysis of the fish after the experiment revealed that the FCR values ranged between Treatment 1 (5.93 ± 0.73) and Treatment 3 (4.61 ± 0.17). The specific growth rate (SGR) ranged between 0.76 ± 0.04 in Treatment 3 and 0.059 ± 0.06 in Treatment 1. The highest survival value was recorded in Treatment 2 (70 ± 0.00), and the lowest survival value was recorded in Treatment 4 (53.33 ±16.67). The highest value was recorded in Treatment 3 (47.69± 0.97), and the lowest was recorded in Treatment 1 (44.07 ±0.94) for feed intake, while the protein efficiency ratio was the highest in Treatment 1 (0.22 ± 0.03). The highest mean weight gain was recorded in Treatment 3 (10.39 ± 0.54), and the lowest was recorded in Treatment 1 (7.67 ± 0.96).

Keywords: Watermelon, rind waste, growth response, nutrient utilization, *Oreochromis niloticus*

INTRODUCTION

The global population increase necessitates ongoing research to enhance food availability for the human race (Govindan, 2018)The most important feature of this approach is the quality of the protein supply, for which fish protein has been proven to be the safest and least expensive animal protein available (Gasco et al., 2020), considering its low cholesterol content and the availability of essential amino acids and omega-3 fatty acids (Shahzad, 2024). The rapid growth of the Nigerian population has led to an insufficient supply of animal protein sources (Tunde et al., 2015). Consequently, this has also led to tremendous effort, resulting in increased animal production. According to Omojowo, et al. (2012), fish are a major source of animal protein and an essential food item in the diet of many people in Nigeria. Balami, Sharma & Karn (2019) stated that fish are also good sources of thiamine, riboflavin, vitamins A and D, phosphorous, calcium and iron. It is also very high in polyunsaturated fatty-acids, which are important for lowering blood cholesterol levels (Glencross et al., 2024). Therefore, it is suitable for complementing high-carbohydrate diets typical of the low-income group in Nigeria. In addition to being food, fish are also an important source of income for many people in developing countries, including Nigeria (FAO, 2008). The high cost and shortage of commercial feeds for agricultural ventures in Nigeria place great constraints on the successful operation of intensive aquaculture businesses (Ogunji, & Wuertz, 2023). The utilization of compounded commercial feeds is an acceptable practice, but there is a need for feed formulation strategies aimed at using more available feed ingredients. Watermelon peel waste presents a potential solution to the aquaculture feed challenge by serving as an alternative and sustainable feed ingredient. The rising cost and environmental impact of conventional fish feed, particularly those reliant on fishmeal and soybean, have driven the search for cost-effective and eco-friendly alternatives (Sood et al., 2024). According to Vijayan et al., (2024), watermelon peel which is rich in fiber, carbohydrates and essential nutrients; can be processed and incorporated into fish diets to reduce dependency on traditional feed sources. Utilizing agricultural by-products like watermelon rind not only mitigates waste disposal issues but also enhances the circular economy in food production, promoting sustainability in aquaculture, Watermelon in itself serves as a highly concentrated reservoir of the carotenoid lycopene, a fact highlighted by Burton-Freeman et al., (2024). Lycopene, widely recognized for its abundance in tomatoes and enhanced absorption when accompanied by a small amount of fat, as found in olive oil, is also present in substantial quantities in watermelon and mangoes, as noted by Perkins-Veazie (2007). The present study focuses on assessing the nutrient utilization and growth response of *O. niloticus* juveniles when provided with different dietary levels of watermelon (WM) peel waste (rind).

METHODOLOGY

The study was carried out at the Indoor Hatchery of the Department of Aquaculture and Fisheries Management, Federal University of Agriculture, Abeokuta, Ogun State, Nigeria. A total of 120 *O. niloticus* juveniles were selected and acclimated to 10 experimental plastic bowls (44 litres in capacity) at 10 fish per tank for 7 days. The bowls were filled to $^{2}/_{3}$ of their volume with water supplied from a borehole at the experimental site. At the start of the feeding trial, the acclimated fishes were deprived of food for 24 hours which according to Molayemraftar et al., (2019) induces hyperphagia which is as a result of food deprivation and re-feeding in some fish which increases feed efficiency and growth. The fishes were then sorted, and 12 groups were randomly sorted into 12 experimental plastic tanks. Four (4) isonitrogenous diets (35% crude protein) were formulated to contain watermelon peel (WMP) at 0% (WMP_1) as a control and 25% (WMP_2), 50% (WMP_3), and 75% (WMP_4) as replacements for the maize fraction in the diet of the experimental fish.

The watermelon peel was collected from the market, sun-dried for 12 days to remove moisture, increase storage duration, increasing fibre and crude protein weight per kilogram and reduces aerobic deterioration in the feeds (Borreani et al., 2018). It was then ground into fine particles to aid incorporation of the remaining ingredient. The watermelon peel was directly mixed with other finely ground feedstuffs, palletized, sundried and packed into bags and subsequently stored in a cool and dry place. The nutrient utilization and growth response were evaluated using AOAC (1990) methods. All growth data (feed conversion, feed intake, survival) were analysed using the Statistical Package for Social Sciences (SPSS 17 for Windows).

$$\text{FCR} = \frac{\text{Feed consumption (dry matter)}}{\text{Live weight gain}}$$

$$\text{SGR} = \left\{ \frac{(\ln \text{final weight} - \ln \text{initial weight})}{\text{Experimental period (days)}} \right\} \times 100$$

The analysis was performed at a probability level of 5%, and the data were subjected to one-way analysis of variance (ANOVA). When the differences were significant, they were determined by the Duncan multiple range test. The specific growth rate (SGR) was also analysed using the formula described by de *Silva et al.* (1989).

RESULTS AND DISCUSSION

Table 1 shows the percentage composition of the experimental diet. The formulation of the feed was based on the proximate composition of the feed ingredient derived using the Pearson Square Method.

Table 1: Percentage composition of the experimental feed

Ingredient	0%	25%	50%	75%
Fish meal	23.06	22.80	22.54	22.26
Soya bean meal	11.53	11.40	11.27	11.13
Groundnut cake	23.06	22.80	22.54	22.26
Maize	34.10	26.06	17.70	9.02
Water melon	0.00	8.85	17.70	27.07
Vit premix	1.0	1.0	1.0	1.0
Salt	0.25	0.25	0.25	0.25
Vegetable	5.0	5.0	5.0	5.0
Lysinc	0.5	0.5	0.5	0.5
Methionine	0.5	0.5	0.5	0.5
D.C.P	0.5	0.5	0.5	0.5
Total	100	100	100	100

The feed utilization of Tilapia (*O. niloticus*) juveniles fed the experimental diets in terms of weight gain (MWG), feed conversion ratio (FCR) and feed intake (FI) are presented in Table 2. The average final weight ranged between 19.51±1.15 and 22.03 ± 0.37 g, with the highest weight obtained from TD3. The average size of the fish stocked was 12.10 ± 0.017 g. The mean weight gain was significantly greater in the TD_3 treatment (10.39 ± 0.54 g), and the lowest weight gain was recorded in the TD_1 treatment (7.67± 0.96 g). The FCR was greatest in TD3 (4.61±0.17 g).

Table 2: Feed utilization of *O. niloticus* fed the different diets

Parameters	**T1**	**T2**	**T3**	**T4**
Initial weight (g)	11.83±0.20	12.10±0.17	11.63±0.22	11.60±0.25
Final weight (g)	19.51±1.15	20.80±1.31	22.03±0.37	20.54±1.01
MWG (g)	7.67±0.96	8.70±1.26	10.39±0.54	8.94±0.78
SGR (%/day)	0.59±0.06	0.64±0.07	0.76±0.04	0.68±0.03
F I (g/day)	44.07±0.94	45.30±1.38	47.69±0.97	47.22±3.38
FCR	2.93±0.73	2.37±0.57	1.61±0.17	2.30±0.19
PER	0.22±0.03	0.25±0.04	0.30±0.01	0.26±0.02
Survival (%)	60.00±10.00	70.00±0.00	56.67±6.67	53.33±16.67

Means with different superscripts along the row are significantly different (P<0.05).

The gain, specific growth rate (SGR), feed conversion ratio (FCR), and protein efficiency ratio (PER) showed no significant differences ($p > 0.05$) among *O. niloticus* juveniles fed the experimental diets, regardless of their initial weights. The fish had an initial weight of 11.83 ± 0.20 kg/m², and their final weight did not vary significantly ($p > 0.05$) among the different diet groups. The final body weight ranged from 22.03 ± 0.37 kg/m² in TD_3 to 19.51 ± 1.15 kg/m² in TD_1. The FCR exhibited a fluctuating trend, decreasing and increasing with increasing treatment levels, ranging from 2.93±0.73 in TD_1 and from 2.61±0.17 in TD_3.The PER, was not significantly different ($p > 0.05$). The PER ranged between 0.30±0.01 in TD_3 and 0.22±0.03 in TD_1. The SGR ranged between 0.76±0.04 in TD_3 and 0.59±0.06 in TD_1.
FI did not significantly differ ($p > 0.051$) for any of the parameters measured for the growth feed intake of *O. niloticus* juveniles fed watermelon peel at different levels. Research has shown that 50% watermelon peel can be used as an energy source for *O. niloticus*. Analysis of variance ($p > 0.05$) revealed that there was no significant difference in the body weight of *O. niloticus* fed watermelon peel. These findings support the work of Van Doan *et al.* (2021) who opined that watermelon rind WMRP maybe an effective feed additive for Nile tilapia grown in an indoor biofloc system diet.

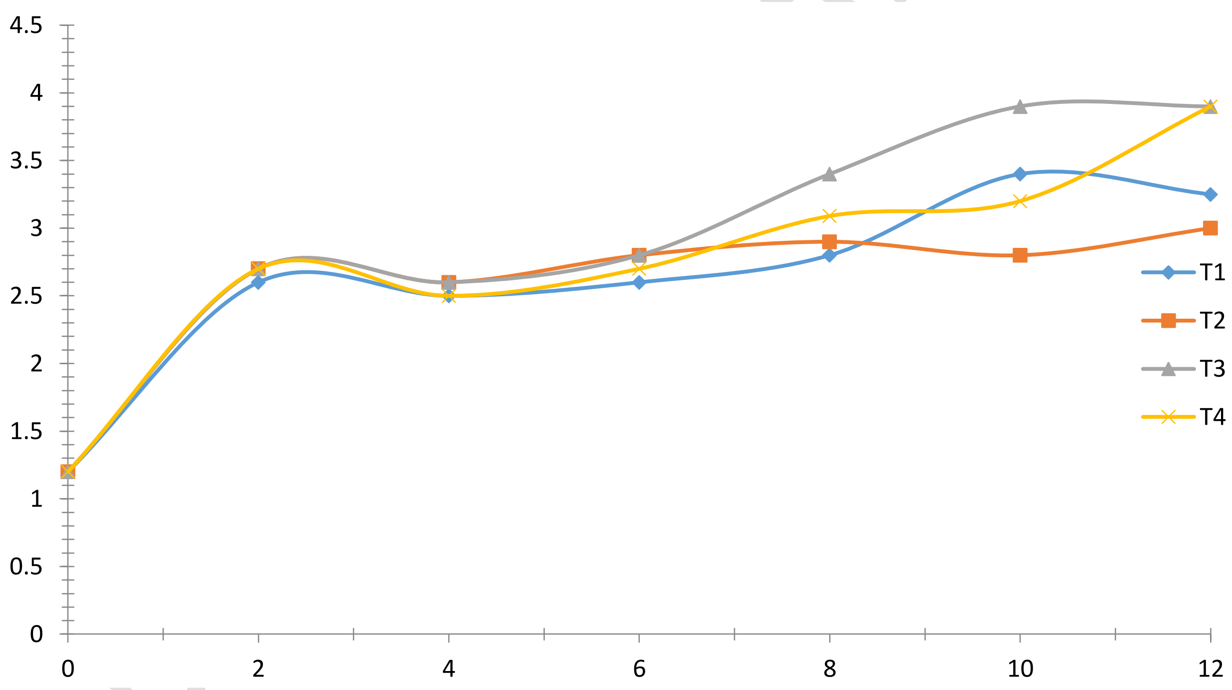

Figure 1: Growth response of *O. niloticus* juveniles fed watermelon peel at different concentrations for 12 weeks.

The initial weight of the fish (11.83 ± 0.20) and the final weight of the fish were not significantly different ($p > 0.05$) between the fish fed the various diets. The final body weight ranged between 22.03 ± 0.37 in TD_3 and 19.51± 1.15 in TD_1. The FCR decreased or increased with different treatment levels. The FCR ranged between 5.93 and 0.73 in TD_1 and 4.61 and 0.17 in TD_3. PER,

but not significantly different ($p > 0.05$). The PER ranged between 0.30 and 0.01 in TD_3 and 0.22 and 0.03 in TD_1. The SGR ranged between 0.76 and 0.04 in TD_3 and 0.59 and 0.06 in TD_1. No significant differences in FI ($p > 0.051$) were detected for any of the parameters measured for growth or feed intake of *O. niloticus* juveniles fed watermelon peels at different levels.
The proximate compositions of the carcasses of the experimental fish before and after the study are presented in Table 3. The final moisture contents were greater for all the fish fed the tested diets than the initial value. The fish had lower fibre contents for all the diets compared to the initial fibre content. The protein concentrations in the final fish samples were greater than the initial values.

Table 3: Proximate Composition of Tilapia Carcass

Parameters	Initial	T1	T2	T3	T4
Moisture	75.83±0.01	77.13±0.16 ^{c}	76.28±0.25 ^{c}	79.04±0.30 ^{b}	82.47±0.32 ^{a}
DM	24.36±0.15	22.87±0.38 ^{a}	23.72±0.31 ^{a}	20.96±0.41 ^{b}	17.53±0.25 ^{c}
Fat	2.87±0.03^{a}	2.47±0.33 ^{b}	3.65±0.27 ^{a}	1.98±0.39 ^{b}	0.86±0.21 ^{c}
Ash	5.21±0.00^{a}	6.55±0.29	6.35±0.29	6.13±0.21	6.69±0.43
Fibre	3.65±0.01^{a}	2.86±0.39 ^{a}	2.51±0.23 ^{ab}	2.22±0.18 ^{ab}	1.77±0.31 ^{b}
Protein	36.74±0.01^{b}	39.79±0.31^{bc}	39.04±0.32 ^{c}	42.51±0.29 ^{a}	40.79±0.38 ^{b}
NFE	1.65±0.01^{a}	1.89±0.39	1.95±0.31	1.72±0.18	1.06±0.10

Means with different superscripts along the row are significantly different ($P<0.05$).

The water quality parameters were tropical and did not negatively affect the growth or well-being of the experimental fish. Table 4 shows the data for the water parameters.

Table 4: Water parameters

Weeks	pH	DO	Temp
0	7.24±0.08	7.20±0.06	29.10±0.58
2	7.20±0.12	7.50±0.29	28.50±0.29
4	7.19±0.12	7.00±0.06	28.91±0.63
6	7.23±0.58	7.40±0.17	29.00±0.58
8	7.18±0.10	7.20±0.46	28.70±0.23
10	7.21±0.13	6.80±0.12	28.30±0.40
12	7.20±0.12	6.70±0.17	28.60±0.23

Conclusion

The results showed that the watermelon peel base diet for *O. niloticus* is a good substitute or replacement for the energy source for maize in compounded feed for tilapia. The results showed no negative effects on the growth or feed utilization of *O. niloticus*; moreover, the feed intake, protein efficiency ratio and survival rate were high. For suitable aquaculture fish production. majorly in developing countries where maize competes is high and quite expensive for livestock feed production, watermelon peel can be used as a substitute for *O. niloticus* feed. Therefore, a 50% inclusion level can be recommended for aquaculture practices.

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REFERENCES

Ait-Yahia, D., Madani, S., Savelli, J. L., Prost, J., Bouchenak, M., & Belleville, J. (2003). Dietary fish protein lowers blood pressure and alters tissue polyunsaturated fatty acid composition in spontaneously hypertensive rats. *Nutrition*, *19*(4), 342-346.

AOAC (1990) Association of Analytical Chemists. W. Hortwitz. Official method of analysis. 15th Edition, Washington, D C

Balami, S., Sharma, A., & Karn, R. (2019). Significance of nutritional value of fish for human health. *Malaysian Journal of Halal Research*, *2*(2), 32-34.

Borreani, G., Tabacco, E., Schmidt, R. J., Holmes, B. J., & Muck, R. A. (2018). Silage review: Factors affecting dry matter and quality losses in silages. *Journal of dairy science*, *101*(5), 3952-3979.

Burton-Freeman, B., Freeman, M., Zhang, X., Sandhu, A., & Edirisinghe, I. (2021). Watermelon and L-citrulline in cardio-metabolic health: Review of the evidence 2000–2020. *Current atherosclerosis reports*, *23*(12), 81.

De Silva, S S., Gunasekera, R M and Atapattu, D (1989) The dietary Protein requirements of young tilapia and an evaluation of the least cost dietary protein levels. *Aquaculture 80: 271-284.*

FAO (2008). Food and Agriculture Organization at the limited Nations the state of World Fisheries and Aquaculture. Rome.

Gasco, L., Acuti, G., Bani, P., Dalle Zotte, A., Danieli, P. P., De Angelis, A., Fortina, R., Marino, R., Parisi, G., Piccolo, G. and Pinotti, L. & Roncarati, A. (2020). Insect and fish by-products as sustainable alternatives to conventional animal proteins in animal nutrition. *Italian Journal of Animal Science*, *19*(1), 360-372.

Glencross, B. D., Bachis, E., Betancor, M. B., Calder, P., Liland, N., Newton, R., & Ruyter, B. (2024). Omega-3 futures in aquaculture: exploring the supply and demands for long-chain Omega-3 essential fatty acids by aquaculture species. *Reviews in Fisheries Science & Aquaculture*, 1-50.

Govindan, K. (2018). Sustainable consumption and production in the food supply chain: A conceptual framework. International *Journal of Production Economics*, *195*, 419-431.

Molayemraftar T., Kochanian, P., Zakeri, M., Yavari, V. & Mousavi, S., M. (2019). Effect of Short Term Food Deprivation and Re-Feeding on Growth, Feeding and Biochemical Body Composition in Sobaity Fish, *Sparidentex hasta. Veterinary Research 12 (2)*: 10-18

Ogunji, J., & Wuertz, S. (2023). Aquaculture Development in Nigeria: The Second Biggest Aquaculture Producer in Africa. *Water*, *15*(24), 4224.

Omojowo, T. M., Omojowo, F. S., & Alatise, P. S. (2012). Growth response and nutritional evaluation of mango peel-based diets on Tilapia (Oreochromis Niloticus) Fingerlings. *Researcher*, *2*(6), 44-49.

Perkins-Veazie, P. (2007). Carotenoids in watermelon and mango. In *International Conference on Quality Management of Fresh Cut Produce 746* (pp. 259-264).

Shahzad, S. M. (2024). Fish as a Healthy Source of Human Nutrition: An Exploratory Study. *Journal of Nautical Eye and Strategic Studies*, *4*(1), 1-14.

Sood, S., Li, K., Sand, C., Pal, L., & Hubbe, M. A. (2024). Fruit wastes: a source of value-added products. In *Adding Value to Fruit Wastes* (pp. 3-48). Academic Press.

Tiamiyu, S. A., Fakoya, E. O., Olaoye, O. J., Ashimolowo, O. R., & Ojebiyi, W. G. (2015). Assessment of the Effect of National Fadama Development Project (Fadama II) on Fish Farming in Lagos State, Nigeria. *Ibadan Journal of Agricultural Research*, *11*(2), 56-65.

Tunde, A. B., Kuton, M. P., Oladipo, A. A., & Olasunkanmi, L. H. (2015). Economic analysis of costs and return of fish farming in Saki-East Local Government Area of Oyo State, Nigeria. *Journal of Aquaculture Research & Development*, *6*(2), 1.

United Nations Department of Economic and Social Affairs, Population Division (2022). World Population Prospects 2022: Summary of Results. UN DESA/POP/2022/TR/NO. 3.

Van Doan, H., Hoseinifar, S. H., Naraballobh, W., Paolucci, M., Wongmaneeprateep, S., Charoenwattanasak, S., ... & Abdel-Tawwab, M. (2021). Dietary inclusion of watermelon rind powder and Lactobacillus plantarum: Effects on Nile tilapia's growth, skin mucus and serum immunities, and disease resistance. *Fish & Shellfish Immunology*, *116*, 107-114.

Vijayan, L., Arumugam, M., Palaniyappan, S., Jayaraman, S., Brown, P. B., Kari, Z. A., ... & Ramasamy, T. (2024). Utilization of sustainable agri-waste watermelon rind for fishmeal in Labeo rohita diets: Effects on nutritional indices, hemato-biochemical properties, histoarchitechtural traits, amino acid and fatty acid profiles. *Aquaculture Reports*, *36*, 102045.