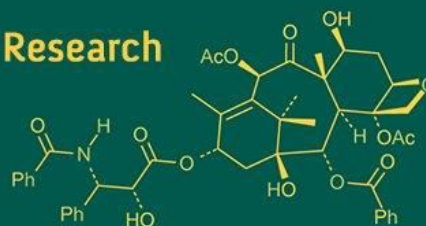


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Supplementation of fish meal with *moringa oleifera* seed meal (MOSM) and its effect on growth performance and survival in ROHU, *Labeo rohita* (Hamilton, 1822) fry

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Abstract

The present experiment was conducted for 60 days to examine the effects of supplementation of fish meal with *Moringa oleifera* seed meal (MOSM) on the growth performance and survival in rohu, *Labeo rohita* (Hamilton, 1822) fry. The fish were divided into five groups with different inclusion levels of Moringa seed meal (MSM) in their diets: T₀ (without MSM), T₁ (5%), T₂ (10%), T₃ (15%), and T₄ (20%). *L. rohita* fry (1.264±0.02 g) were stocked at a density of 20 nos. per tank in a total of 15 tanks. The results of the experiment showed that the group fed with a 5% inclusion level of MSM (T₁) exhibited the highest mean weight gain, percent weight gain, specific growth rate, and protein efficiency ratio. Regarding feed utilization, T₁ group demonstrated the best feed conversion ratio (FCR). On the other hand, T₄ group had the highest FCR. The analysis of fish body (carcass) composition revealed that the T₁ group had the highest protein content, control group (T₀) had the highest moisture content, T₁ group had the highest fat content, and T₃ group had the highest ash content. In conclusion, the research findings suggest that costly fishmeal can be supplemented with cost-effective plant products like *Moringa oleifera* seed meal (MOSM) at 10% can promote good growth, body composition, and feed utilization without any adverse effects.

Keywords: *Moringa oleifera* seed meal (MOSM), *Labeo rohita*, fishmeal replacement, supplementation, carcass composition

Introduction

Global fisheries and aquaculture are progressive sectors whose production plays a crucial role in providing food and nutrition to the growing population in the present as well as in the future (FAO, 2022) ^[9, 10]. Besides food production, this sector contributes to economic growth, employment opportunities, and livelihood generation among the local to literate populates (Ngasotter *et al*, 2020) ^[18]. Commercially important wild stock is declining day by day due to numerous reasons. One of the main reasons remains unsustainable fishing practices, which affected approximately 35.4% of the global marine fisheries stocks in 2019 (FAO, 2022) ^[9, 10]. Therefore, from the past few years, the supply of seafood has remained constant and limited, to rectify these problems aquaculture is the foremost solution to increase production and to meet the growing world's demand for seafood (Das *et al*, 2022) ^[7].

Indian major carp are widely cultured farm fishes due to their fast growth, taste and consumer demand, thus forming the backbone of freshwater aquaculture in India (Bais, 2018). *Labeo rohita* is the principal species among the other two IMCs, the reason behind its popularity is its delicious taste and public preference. The Rohu is a species which is high in nutrients, including omega-3 fatty acids, vitamins A, B, and D. (Kitchen, 2022) ^[15].

For successful culture operations, it is important to provide a well-balanced diet and proper feeding as the cost of feed in an intensive culture system is about 40-60% (Bamidele *et al*, 1995) ^[6]. Fish meal is commonly employed in the formulation of aquaculture diets because it is a major source of protein and lipids (Miles and Chapman, 2006) ^[16]. The expensive rate of fish meal and the continuous reduction in the availability of dietary fish meal over the last decade, it is required to find alternative protein sources for aquafeed (Abdel-Latif *et al*, 2022)

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[1]. Nowadays, Plant-based protein sources are being utilized to replace or supplement proteins in fish diets because they are constantly available, relatively cheap, eco-friendly, environmentally safe, and sustainable (Gatlin *et al*, 2007) [11]. *Moringa oleifera* (also known as a tree of life, drumstick tree, or miracle tree) is a widely distributed plant in the Moringaceae family (Falowo *et al*, 2018) [18]. The moringa plant has various components, including roots, leaves, flowers, fruits, and seeds. These parts are rich in phytochemicals, especially tannins, anthraquinones, carotenoids, flavonoids, and proanthocyanidins. (Abdel-Latif *et al*, 2022) [1]. *Moringa oleifera* seeds are spherical or triangular in shape when completely grown and the kernel is covered by a thin woody shell with three paper wings (Bamidele *et al*, 1995) [6]. The seeds are high in protein, vitamins, and minerals, as well as high in essential amino acids (EAA), such as cysteine, methionine, and tryptophan (Yuangsoi *et al*, 2014) [22]. The major macromolecule in moringa seeds is protein and it contains more protein than leaves i.e., 33.53 % in seeds and 18.63 % in leaves (Mune *et al*, 2016) [17]. Therefore, *M. oleifera* seeds powder is suitable to use in aquaculture diets to improve the growth, survival, and immunity of culture organisms. Due to its coagulation capabilities, *M. oleifera* seed powder is utilized successfully in many nations for water purification in aquaculture farms (Kavitha *et al*, 2012) [14].

Materials and Methods

Experimental laboratory

The research titled "supplementation of fish meal with *Moringa oleifera* seed meal (MOSM) and its effect on growth performance and survival in rohu, *Labeo rohita* (Hamilton, 1822) fry" took place at the College of Fisheries Science, KU, Veraval. The experiment lasted for 60 days, commencing on October 20, 2022, and concluding on December 20, 2022.

Experimental animal

For the experiment, fry of *L. rohita* (1.264±0.02 g) were

procured from a commercial fish hatchery located in Gujarat. Fry were carefully packed in oxygen-filled polythene bags and brought to the College of Fisheries Science, KU, Veraval. The fry was acclimatized in the cleaned and disinfected FRP tanks (500 L) with continuous aeration and fed three times a day. The fish were provided with a basal diet containing 30% crude protein during this period.

Experimental diet preparation

"Sterile-A" grade fish meal was obtained from a local fish meal plant located in Veraval. Other feed ingredients such as wheat flour, tapioca flour, ground nut oil cake, plant oil and vitamin minerals premix were obtained from the local market of Veraval. Fish oil was obtained from the nearby fish processing plant at Veraval. The moringa seeds were collected from the dry drumsticks of the moringa tree which is locally available. They were sun-dried for 6-7 days, ground into a powder using an electronic mixer grinder, and then sieved to remove any impurities. After processing, the obtained moringa seed powder was stored in a sealed plastic container at room temperature until further use. The proximate composition of ingredients was analysed by using the standard methods (AOAC, 2000) [13].

The Pearson square method was used to produce the experimental feeds. Based on the treatment details, five experimental diets were formulated and labeled as T₀, T₁, T₂, T₃, and T₄. According to the feed formula, the required quantities of the ingredients were collected and then carefully weighed. The ingredients were combined in a plastic tray along with the necessary amount of water, and mixed thoroughly to create a dough. The prepared dough was placed in the autoclave at 121 °C and 15 lbs. pressure for 15-20 minutes. After the steaming process, vitamins and minerals premix was incorporated into the feed mixture. Feed pellets were prepared using a mechanical pelletizer. The prepared feed pellets were spread out on steel trays and dried under the direct sunlight. Then, the pelleted feed was stored in clearly labeled air-tight plastic bottles.

Table 1: Feed formulation and proximate composition of feed ingredients (% dry matter).

Ingredients (%)	Diet T ₀ (Control)	Diet T (5%)	Diet T (10%)	Diet T (15%)	Diet T (20%)
Moringa oleifera seed meal (MOSM)	0	5	10	15	20
Fishmeal	26	24	22	20	19
Ground nut oil cake	50	48	46	45	41
Wheat flour	10	10	9	7	7
Tapioca powder	8	7	7	7	7
Plant oil	2	2	2	2	2
Fish oil	2	2	2	2	2
Vitamin & mineral premix	2	2	2	2	2
Total	100	100	100	100	100
Proximate composition (%)	Fishmeal	MOSM	GNOC	Wheat flour	Tapioca
Crude protein	59.01	36.6	36.6	16.92	4.24
Crude fat	4.50	41.72	4.80	1.40	0.64
Crude ash	13.89	11.03	7.96	4.98	0.16
Moisture	7.69	7.18	7.43	7.7	10.57

Experimental arrangement

The experiment was carried out in 15 plastic tanks. Prior to use, thorough washing and disinfection of all plastic tanks were performed using chlorinated water, followed by flushing and drying, to ensure cleanliness and sterility. The tanks were then arranged on stands within the Department of Aquaculture and filled with freshwater. The experiment encompassed five treatments and three replications, and it

was executed utilizing a completely randomized design (CRD).

Experimental tank management

L. rohita fry was stocked at the density of 20 nos. per tank in all 15 experimental tanks. During the experimental period, *L. rohita* fry were fed twice daily at 5% of their body weight, with morning and evening feeding sessions. The

required amount of feed was weighed before feeding it to *L. rohita* fry. The diet contained 30% protein, and feed amounts were adjusted based on fortnightly sampling of the fish weight.

Freshwater that had been filtered and disinfected was used to partially replace the water in the experimental units every other day. To ensure appropriate amounts of dissolved oxygen in each tank, continuous aeration was supplied throughout the entire study period. Additionally, to prevent the accumulation of extra feed pellets and any residual feces, the experimental tanks were diligently cleaned and siphoned each day prior to both the morning and evening feedings. These cleaning measures helped maintain optimal water quality and hygiene within the tanks.

Growth, survival and feed utilization analysis

At the 15-days interval, all the fish in each treatment were counted with their body weight for analysis of the growth performance, feed utilization and survival. Before taking the weight, fish were starved overnight. To calculate the growth parameters and feed utilization in the experiment, the following formulas were used:

Mean weight gain = Final average body weight – Initial average body weight

Weight gain (%) = (Final weight – Initial weight) / Initial weight × 100

Specific Growth Rate (SGR) (%/day) = $\ln(\text{Final weight}) - \ln(\text{Initial weight}) / \text{Experiment duration} \times 100$

Feed Conversion Ratio (FCR) = Feed intake (g) / Weight gain (g)

Protein Efficiency Ratio (PER) = Weight gain (g) / Protein intake (g)

Survival (%) = Total no. of live fish / Total no. of fish stocked × 100

Body composition analysis

After the completion of the experiment, the proximate

compositions of *L. rohita* were determined. For the proximate analysis, fish were taken from each experimental treatment and ice-killed. The experimental fish were subjected to determine the crude protein, moisture, crude fat, and ash contents using standard analytical methods (AOAC, 2000) [13]. Moisture was determined by taking a known weight of samples in a clean dried petri dish and drying them in a hot air oven at $100 \pm 1^\circ\text{C}$ overnight until a constant weight was attained. The crude protein of the samples was determined as total nitrogen by the micro Kjeldahl method after acid digestion. The Soxhlet extraction method was used to determine the crude fat content of the sample. The ash content was calculated by placing a known weight of the sample in a silica crucible, heating it in a muffle furnace at 600°C for 6-8 hours.

Analysis of water quality parameters

Throughout the experimental period, water quality parameters including temperature, pH, dissolved oxygen (DO), total alkalinity, ammonia, and total hardness were examined weekly using the standard methods of APHA (2017) [3].

Statistical analysis

Statistical analysis was performed by using standard statistical methods (Snedecor and Cochran, 2014) [19].

Results

Growth performance and survival rate of *L. rohita*

The experimental results for the 60-day study on the supplementation of fishmeal with *Moringa oleifera* seed meal (MOSM) are provided in the Table 2. The outcomes include mean weight gain (MWG), percentage weight gain (PWG), specific growth rate (SGR), and survival rate (SR) for all five treatment groups were calculated.

The higher growth performance was reported in T₁ (5% MOSM) treatment at the end of the experiment, followed by in T₂, T₀, T₃ and lowest in T₄. Based on the statistical analysis, there were significant difference ($p < 0.05$) observed in MWG, PWG and SGR among the treatment groups. There was no significant difference ($p > 0.05$) in the survival rate of *L. rohita* when given different amounts of moringa seed meal.

Table 2: Growth performance of *L. rohita*, fed diet with 0% (Control), 5, 10, 15, and 20% supplementation of *M. oleifera* seed meal

Parameters	Control	Treatments			
	T ₀	T ₁ (MOSM 5%)	T ₂ (MOSM 10%)	T ₃ (MOSM 15%)	T ₄ (MOSM 20%)
IW (g)	1.262±0.02	1.196±0.01	1.243±0.01	1.304±0.01	1.317±0.01
FW (g)	3.634±0.00	4.386±0.01	4.229±0.02	3.625±0.03	3.633±0.05
MWG (g)	2.371±0.01 ^a	3.190±0.00 ^c	2.985±0.01 ^b	2.321±0.02 ^a	2.316±0.03 ^a
PWG (g)	187.9±3.36 ^b	266.7±2.12 ^d	240.1±1.38 ^c	177.9±0.99 ^a	175.8±0.83 ^a
SGR (%)	1.76±0.02 ^b	2.17±0.01 ^d	2.04±0.01 ^c	1.70±0.01 ^a	1.69±0.00 ^a
SR (%)	96.67±3.33 ^a	96.67±3.33 ^a	93.33±3.33 ^a	95.00±2.89 ^a	93.33±3.33 ^a

* Mean of triplicate measurements ± standard deviation (SD). Different lowercase letters on the values within the same sample indicate significant differences ($p < 0.05$).

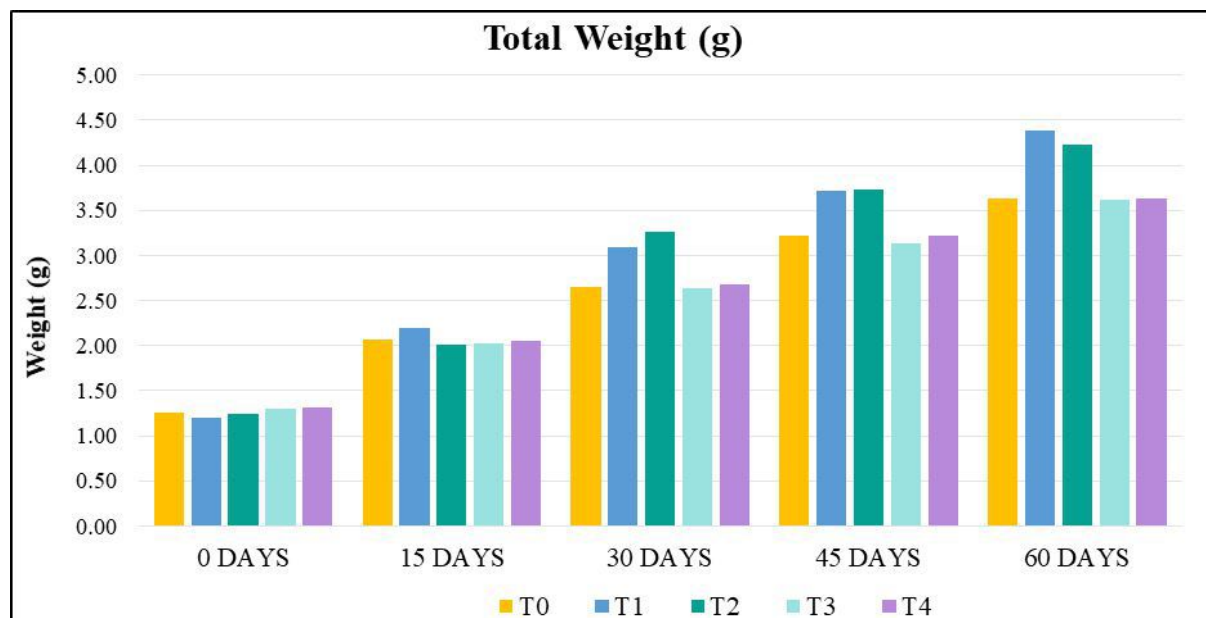


Fig 1: Effect of *M. oleifera* seed meal supplemented diets on mean weight of *L. rohita* fry

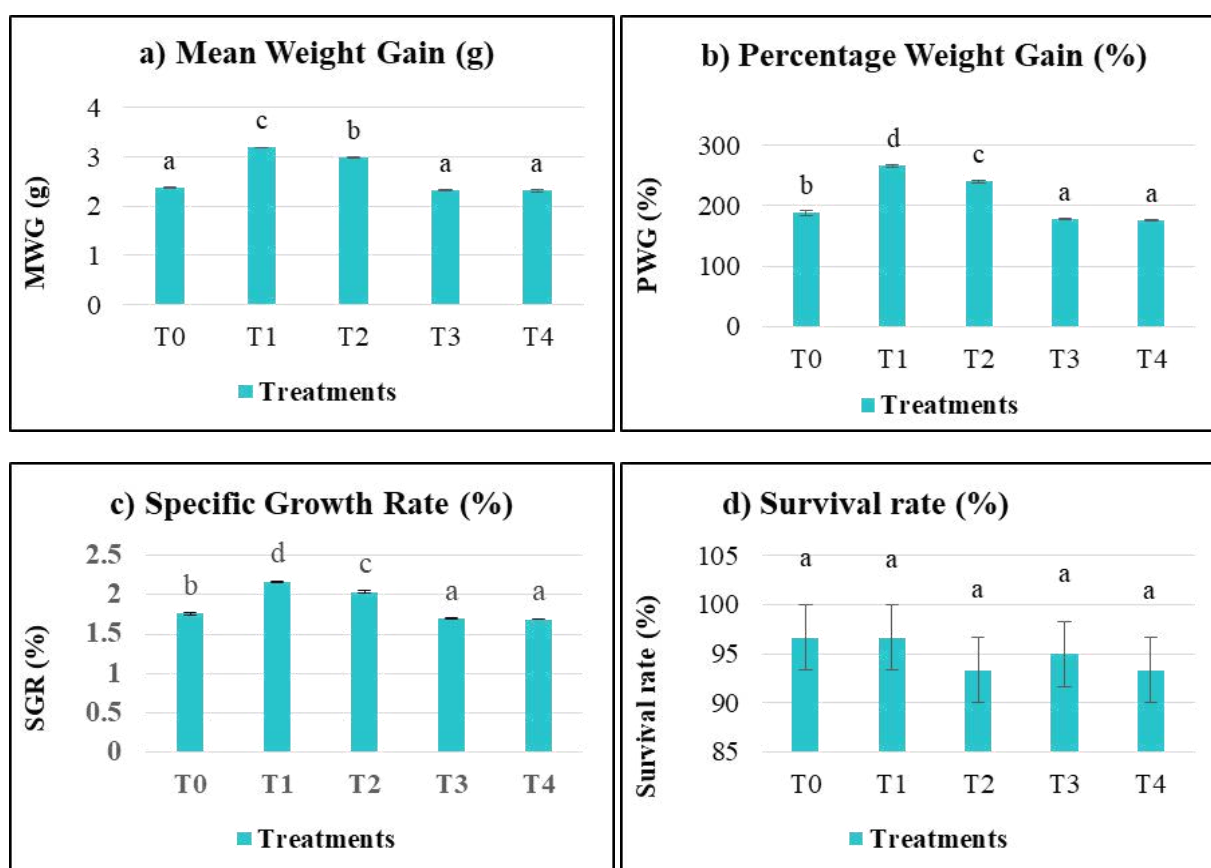


Fig 2a-d: Mean weight gain (a), Percentage weight gain (b), Specific growth rate (%) (c) and Survival rate (%) (d) of *L. rohita* fry fed with different dietary groups after 60 days. Lines represent the mean of triplicate measurements $\pm$ standard deviation (SD); Different lowercase letters on the lines within the same sample indicate significant differences ($p < 0.05$).

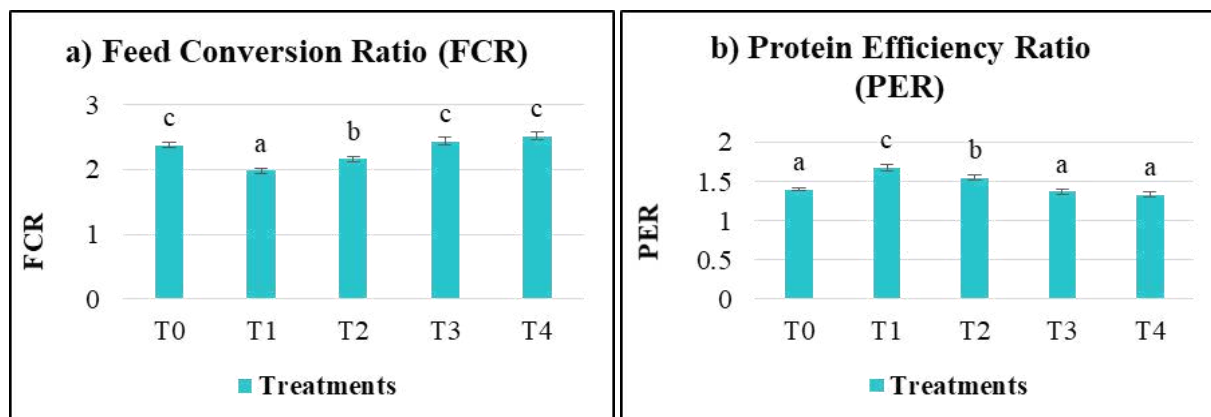
Feed utilization by *L. rohita*

In the present research feed utilization of *L. rohita* fry in the various treatments was analyzed through parameters such as feed conversion ratio (FCR) and protein efficiency ratio (PER), which are displayed in Table 3. Lowest (best) FCR was observed in T₁ treatment group followed by in T₂. The

highest PER was observed in T₁ treatment group followed by in T₂. The statistical analysis of the FCR and PER revealed significant differences ($p < 0.05$) between the T₁ and T₂ treatment groups compared to the others. However, no significant differences ($p > 0.05$) were observed among the T₀, T₃, and T₄ treatment groups.

Table 3: Feed utilization of *L. rohita*, fed diet with 0% (Control), 5, 10, 15, and 20% supplementation of *M. oleifera* seed meal

Parameters	Control	Treatments			
	T ₀	T ₁ (MSM 5%)	T ₂ (MSM 10%)	T ₃ (MSM 15%)	T ₄ (MSM 20%)
FCR	2.38±0.04 ^c	1.98±0.04 ^a	2.16±0.05 ^b	2.44±0.06 ^c	2.52±0.06 ^c
PER	1.40±0.02 ^a	1.68±0.04 ^c	1.55±0.03 ^b	1.37±0.03 ^a	1.33±0.03 ^a

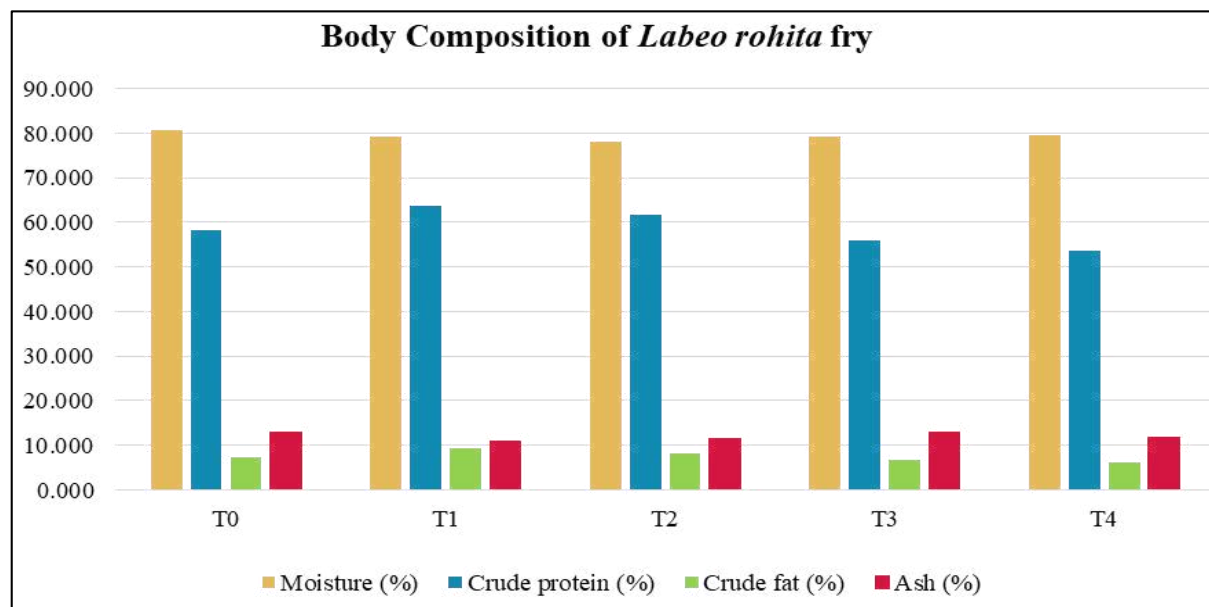
**Fig 3a-b:** Feed conversion ratio (a) and protein efficiency ratio (b), of *L. rohita* fry fed with different dietary groups after 60 days. Lines represent the mean of triplicate measurements ± standard deviation (SD); Different lowercase letters on the lines within the same sample indicate significant differences ($p < 0.05$).**Body proximate composition analysis of *L. rohita***

The proximate composition of *L. rohita* fry was estimated shortly after the experiment was completed and the results obtained from the study were presented in Table 4. The

proximate composition of the experimental fish *L. rohita* fry indicated that the protein and fat content was higher in the treated groups.

Table 4: Carcass composition of *L. rohita*, fed diet with 0% (Control), 5, 10, 15, and 20% supplementation of *M. oleifera* seed meal

Parameters	Control	Treatments			
	T ₀	T ₁ (MSM 5%)	T ₂ (MSM 10%)	T ₃ (MSM 15%)	T ₄ (MSM 20%)
Moisture (%)	80.85	79.14	78.02	79.31	79.53
Protein (%)	58.36	63.76	61.58	56.02	53.69
Lipid (%)	7.23	9.46	8.17	6.83	6.06
Ash (%)	12.86	10.86	11.55	12.91	11.81

**Fig 4:** Moisture (%), Crude protein (%), Crude fat (%) and Crude ash (%) of whole-body composition of *L. rohita* fry fed with different dietary groups after 60 days.**Discussion**

The availability of low-cost protein sources for the formulation of aquafeed lowers the production cost in aquaculture systems (FAO, 2020) [9, 10]. Among the various

feed ingredients available, fish meal is commonly employed in the formulation of aquaculture diets because it is a major source of protein and lipids (Miles and Chapman, 2006) [16]. As a result, due to the expensive rate of fish meal and the

continuous reduction in the availability of dietary fish meal over the last decade, it is required to find alternative protein sources for aquafeed (Abdel-Latif *et al.*, 2022) ^[1]. *Moringa oleifera* seeds (MOS) are high in protein, vitamins, and minerals, as well as high in essential amino acids (EAA), such as cysteine, methionine, and tryptophan (Yuangsoi *et al.*, 2014) ^[22]. However, there is less information available on the use of moringa seed powder in the diet of rohu. The findings obtained demonstrate that, the application of 5% MOSM supplementation yielded significantly superior outcomes in terms of mean weight gain (MWG), percent weight gain (PWG), specific growth rate (SGR), feed conversion ratio (FCR), and protein efficiency ratio (PER) when compared to the other treatments. Possibly, this could be due to the high crude protein content and sufficient levels of essential amino acids in MOSM, meeting the specific requirements of *L. rohita*.

The present study revealed that increasing the level of MOSM more than 10% led to a decline in the growth performance and feed utilization of *L. rohita*. A similar result was observed in a study by Tabassum *et al.* (2021) ^[20] on *Cirrhinus mrigala* fingerlings, replacing fish meal with *M. oleifera* leaf meal (MOLM) in their diets showed positive effects on growth parameters. The researchers came to the conclusion that adding MOLM at a level of 10% enhanced growth performance without having a negative effect on fish health. However, it was noted that higher levels of replacement had negative effects on the observed parameters. Likewise, Al-Dubakel and Taher (2020) ^[2] conducted a study where they supplemented *M. oleifera* leaf meal (MOLM) into the diet of common carp at various levels (0%, 5%, 10%, and 15%). In comparison to other supplementation doses, their research showed that feeding animals 5% MOLM increased growth performance and feed utilization. Feeding *L. rohita* with varying levels of MSM in the present study did not significantly influence the survival rate.

The proximate analysis of the fish samples revealed variations in their composition across different treatment groups. The highest moisture content was observed in T₀, T₁ exhibited the highest protein content, T₂ had the highest fat content and Ash content was highest in T₃ treatment group. The similar result was obtained by the Arsalan *et al.* (2016) ^[4], who investigated the effect of *Moringa oleifera* leaf meal (MOLM) diets on the carcass composition of *L. rohita* fingerlings. Their investigation led them to the conclusion that MOLM can substitute for fish meal in diets up to 10%, enhancing the nutritional value of *L. rohita* fingerlings.

To conclude, the research findings provide evidence that expensive fishmeal can be effectively supplemented with affordable plant products, such as *Moringa oleifera* seed meal (MOSM) at a rate of 10%. This supplementation has demonstrated positive outcomes in terms of growth, body composition, and feed utilization, all without any adverse effects.

Conclusion

The present study demonstrates that *Moringa oleifera* seed meal (MOSM) can effectively replace fishmeal in the diet of *Labeo rohita* fry, improving growth performance, feed utilization, and body composition. The optimal supplementation level was found to be 5% MOSM, which yielded the best results for mean weight gain, specific growth rate, feed conversion ratio, and protein efficiency

ratio. Higher supplementation levels led to diminished growth, while no significant differences were observed in survival rates across treatments. Overall, MOSM proves to be a cost-effective and sustainable alternative protein source for aquaculture feed, reducing reliance on fishmeal without compromising fish health or performance.

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References

1. Abdel-Latif HM, Abdel-Daim MM, Shukry M, Nowosad J, Kucharczyk D. Benefits and applications of *Moringa oleifera* as a plant protein source in Aquafeed: A review. *Aquaculture*. 2022;547: 737369. <https://doi.org/10.1016/j.aquaculture.2021.737369>
2. Al-Dubakel AY, Taher MM. Use of moringa (*Moringa oleifera*) leaf meal as partial replacement of soybean meal in common carp feed. *Iraqi Journal of Aquaculture*. 2020;17(2):103-115.
3. APHA. Standard methods for the examination of water and wastewater. 23rd ed. New York: American Public Health Association; c2017. p. 1546.
4. Arsalan MZH, Hussain SM, Asrar M, Anwar H, Rehan MMH, Shahzad MM, Wahab N. Effects of *Moringa oleifera* leaf meal (MOLM)-based diets on carcass composition and hematology of *Labeo rohita* fingerlings. *Journal of Biodiversity and Environmental Sciences*. 2016;9(1):214-223.
5. Bais B. Fish scenario in India with emphasis on Indian major carps. *International Journal of Avian & Wildlife Biology*. 2018;3(6):409-411.
6. Bamidele NA, Obasa SO, Ikeiwenwe NB, Abdulraheem I, Adeoye AA, Odebiyi OC. Effect of dried moringa (*Moringa oleifera*) seed meal-based diets on the growth, hematological, biochemical parameters and histopathology of the African catfish (*Clarias gariepinus*) fingerlings. *International Journal of Fisheries and Aquatic Studies*. 1995;2(4S):27-34.
7. Das BK, Behera BK, Sajina AM, Mishal P, Swain HS, Meena DK, *et al.*, editors. *Souvenir of 1st Indian Fisheries Outlook 2022*. Director, ICAR-CIFRI; Convener, 1st Indian Fisheries Outlook; President, PFGF; c2022. p. 84-99.
8. Falowo AB, Mukumbo FE, Idamokoro EM, Lorenzo JM, Afolayan AJ, Muchenje V. Multi-functional application of *Moringa oleifera* Lam. in nutrition and animal food products: A review. *Food Research International*. 2018;106:317-334. <https://doi.org/10.1016/j.foodres.2017.12.079>
9. FAO. The State of World Fisheries and Aquaculture 2020: Sustainability in action. Rome: FAO; c2020. <https://doi.org/10.4060/cc0461en>
10. FAO. The State of World Fisheries and Aquaculture 2022: Towards Blue Transformation. Rome: FAO; c2022. <https://doi.org/10.4060/ca9229en>
11. Gatlin DM, Barrows FT, Brown P, Dabrowski K, Gaylord TG, Hardy RW, *et al.* Expanding the

- utilization of sustainable plant products in aquafeeds: A review. *Aquaculture Research*. 2007;38(6):551-579.
<https://doi.org/10.1111/j.1365-2109.2007.01704.x>
12. Hamilton B. An account of the fishes found in the river Ganga and its branches. Edinburgh: Edinburgh Press; c1822. p. 1-405.
 13. Horwitz W, George WL. Official methods of AOAC international. Gaithersburg: Association of Official Analytical Chemists International; c2000.
 14. Kavitha C, Ramesh M, Kumaran SS, Lakshmi SA. Toxicity of *Moringa oleifera* seed extract on some hematological and biochemical profiles in a freshwater fish, *Cyprinus carpio*. *Experimental and Toxicologic Pathology*. 2012;64(7-8):681-687.
<https://doi.org/10.1016/j.etp.2011.01.001>
 15. Kitchen C. Labeo rohita nutrition facts - Cully's Kitchen. Cully's Kitchen. 2022 Jan 8. Available from: <https://cullyskitchen.com/labeo-rohita-nutrition-facts/>
 16. Miles RD, Chapman FA. Benefits of fish meal in aquaculture diets. *EDIS*. 2006;2006(12).
<https://doi.org/10.32473/edis-fa122-2006>
 17. Mune MAM, Nyobe EN, Bassogog CBB, Minka SR. A comparison on the nutritional quality of proteins from *Moringa oleifera* leaves and seeds. *Cogent Food & Agriculture*. 2016;2(1):1213618.
<https://doi.org/10.1080/23311932.2016.1213618>
 18. Ngasotter S, Panda SP, Mohanty U, Akter S, Mukherjee S, Waikhom D, *et al*. Current scenario of fisheries and aquaculture in India with special reference to Odisha: A review on its status, issues and prospects for sustainable development. *International Journal of Bio-resource and Stress Management*. 2020;11(1):370-380.
<https://doi.org/10.23910/1.2020.2126a>
 19. Snedecor GW, Cochran WG. Statistical methods. 8th ed. New York: Wiley Blackwell; c2014.
 20. Tabassum S, Hussain SM, Ali S, Arsalan M, Ahmad B, Asrar M, *et al*. Partial replacement of fish meal with *Moringa oleifera* leaf meal in practical diets of *Cirrhinus mrigala* fingerlings. *Brazilian Journal of Biology*. 2021;83:246333.
<https://doi.org/10.1590/1519-6984.246333>
 21. Yuangsoi B, Masumoto T. Replacing moringa leaf (*Moringa oleifera*) partially by protein replacement in soybean meal of fancy carp (*Cyprinus carpio*). *Songklanakarin Journal of Science & Technology*. 2012;34(5):479-485.
 22. Yuangsoi B, Klahan R, Charoenwattanasak S. Partial replacement of protein in soybean meal by moringa seed cake (*Moringa oleifera*) in bocourti's catfish (*Pangasius bocourti*). *Songklanakarin Journal of Science & Technology*. 2014;36(2):125-135.