

COMPARATIVE EVALUATION OF MUSCLE MOISTURE, DRY MATTER AND ASH CONTENT IN *CHANNA STRIATUS* (BLOCH, 1793) FED WITH TWO DIFFERENT DIETS

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ABSTRACT

This study investigated the comparative evaluation of moisture, dry matter and ash content in *Channa striatus* fed with two distinct dietary regimes: a fish meal-based formulated feed and dried blood worms. A two-month experimental trial was carried out with fishes of the same age group procured from the local fish market Taroda Naka, Nanded, Maharashtra. The experimental design included two cement cisterns, each stocked with fish and provided with one type of feed. At the end of the trial, muscle tissues were analysed for proximate composition following AOAC (2019) protocols. The formulated diet resulted in a moisture level $78.50 \pm 0.25\%$, dry matter $21.50 \pm 0.22\%$ and ash content $1.20 \pm 0.05\%$, whereas dried blood worms yielded moisture of $81.97 \pm 0.30\%$, dry matter $18.03 \pm 0.28\%$ and ash content $2.00 \pm 0.07\%$. Results indicated that formulated feeds enhanced dry matter deposition, while dried blood worms increased muscle moisture retention. This work highlights the importance of feed type in influencing nutrient dynamics in *Channa striatus* and its implications for aquaculture practices.

Keywords: *Channa striatus*, Fish feed, Muscle, Moisture, Dry matter, Ash content, Nutrient evaluation

INTRODUCTION

Aquaculture has become one of the most rapidly expanding food production sectors worldwide, contributing significantly to global nutrition, food security, and livelihoods (Tidwell & Allan, 2001; Tacon & Metian, 2008). With the depletion of natural capture fisheries and the rising demand for high-quality animal protein, the role of aquaculture in sustainable food production is expected to increase even further (FAO, 2020). In particular, freshwater aquaculture plays a pivotal role in providing affordable and accessible fish protein to rural and urban populations in Asia and Africa, regions where fish is considered a staple dietary component (Craig & Helfrich, 2002; De Silva & Anderson, 1995).

Among freshwater fish species, *Channa striatus* (Bloch, 1793), commonly known as striped snakehead or “murrel,” is recognized for its economic, ecological, and medicinal importance. This species is widely distributed across South and Southeast Asia and is known for its hardy nature, air-breathing capacity, and ability to survive under low dissolved oxygen conditions (Chakraborty & Nur, 2012; Rahman & Miah, 2014). From a nutritional perspective, *Channa striatus* is valued for its high protein content, essential amino acids, polyunsaturated fatty acids, and micronutrients (Sharma *et al.*, 2018; Rao *et al.*, 2022). Furthermore, its extract has been reported to have wound-healing and anti-inflammatory properties, making it not only a food fish but also a species of pharmacological significance (Haniffa *et al.*, 2004). These unique characteristics have led to increasing interest in developing sustainable culture systems and feed formulations for this species.

In fish culture, feed quality is the single most critical factor influencing growth rate, feed conversion efficiency, muscle composition and survival (Craig & Helfrich, 2002). Traditionally, aquaculture nutrition research has focused heavily on macronutrients, particularly proteins and lipids, because they are the primary drivers of fish growth and metabolism (Hardy, 2010; Lim & Webster, 2006). However, proximate composition parameters such as moisture, dry matter and ash content—though often overlooked—are equally important indicators of feed quality and fish health (AOAC, 2019).

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- **Moisture content** plays a crucial role in both feed stability and fish muscle composition. Feeds with excessive moisture are prone to microbial spoilage, reduced shelf life and nutrient losses (Baruah *et al.*, 2005; Suresh *et al.*, 2020). In fish muscle, high water content may reflect low nutrient density and less efficient conversion of feed into flesh (Ng, 2001).
- **Dry matter** is a measure of the nutrient-rich portion of the feed and tissue. Higher dry matter deposition in fish muscle indicates efficient nutrient assimilation, protein accretion, and overall growth performance (Jayanthi *et al.*, 2018; Kumar *et al.*, 2019).
- **Ash content** provides an estimate of the total mineral fraction, which includes both essential minerals (Ca, P, Mg, Fe, etc.) necessary for metabolism and skeletal development, as well as non-nutritive residues (Lall, 2002; Tan *et al.*, 2009). While a moderate ash level is beneficial, excessively high ash may dilute the nutrient density of the feed and reduce digestibility (Abdel-Tawwab *et al.*, 2020).

In practical aquaculture, fish farmers often rely on two major feed sources: (i) natural live or dried feeds such as blood worms, earthworms, and plankton, which are highly palatable but nutritionally inconsistent; and (ii) formulated feeds, which are designed to provide a balanced nutrient profile using fish meal, soybean meal, and other additives (Hardy, 2010; Lim & Webster, 2006). Dried blood worms (*Chironomidae* larvae) are widely used in ornamental and carnivorous fish culture because of their high palatability and protein content. However, studies have shown that their proximate composition can vary widely depending on collection site, drying methods, and storage (Ng, 2001; Kumar *et al.*, 2019). Formulated feeds, on the other hand, are manufactured under controlled conditions to ensure uniformity in protein, lipid, carbohydrate, and mineral content, thereby improving feed efficiency and growth consistency (Tacon & Metian, 2008; Patil *et al.*, 2020).

A critical gap in the existing literature is the comparative evaluation of proximate composition in fish muscle resulting from different feed regimes. While numerous studies have assessed the impact of protein and lipid levels on fish growth (Chakraborty & Nur, 2012; Rahman & Miah, 2014), relatively fewer have focused on how feed type influences moisture, dry matter, and ash content in fish muscle. These parameters are essential not only for determining the nutritional quality of fish flesh for human consumption but also for evaluating the efficiency of feed utilization in aquaculture systems (Baruah *et al.*, 2005; Suresh *et al.*, 2020).

In this context, the present study was designed to evaluate and compare the moisture, dry matter and ash content in *Channa striatus* reared on two different dietary regimes: a fish meal-based formulated feed and dried blood worms. The study was conducted under controlled experimental conditions for two months, with the objective of:

1. Determining the proximate composition of fish muscle under different feeding regimes.
2. Assessing differences in nutrient retention and deposition between natural and formulated diets.
3. Interpreting the implications of these findings for aquaculture feed formulation and sustainability.

By focusing on these parameters, this work aims to provide critical insights into the nutritional dynamics of *Channa striatus* and to highlight the significance of feed choice in optimizing growth, flesh quality, and overall aquaculture productivity.

Thus, this study aimed to compare moisture, dry matter and ash content in *Channa striatus* fed with two dietary regimes (formulated feed vs. dried blood worms), thereby contributing insights into feed efficiency, nutrient retention and aquaculture sustainability.

MATERIALS AND METHODS

1. Experimental Design and Duration

The study was conducted for a period of two months. The trial was designed to evaluate the effect of two different dietary regimes on the proximate composition of *Channa striatus* muscle, with a particular focus

on moisture, dry matter and ash content. Experimental protocols followed ethical considerations for the handling of live fish.

2. Fish Sample Collection

Live specimens of *Channa striatus* (Bloch, 1793) of similar age group and with slight variations in body weight and length were procured from the Taroda Naka fish market, Nanded. A total of 16 fish were randomly selected and acclimatized for 5 days prior to the trial. Initial biometric measurements, including total length (cm) and body weight (g), were recorded using a calibrated scale and measuring board. The fish were then stocked in two cement cisterns (8 fish per cistern) under identical environmental conditions.

3. Feeding Regimes

Two distinct diets were administered:

- **Diet 1 (Formulated Feed):** A first formulated fish feed were purchased from a Growel Nutrila. Use floating feed so we can see feeding behavior, adjust rate if feed remains uneaten or fish not eating. Growel's extruded floating feeds help in monitoring and reduce water pollution. As fish grow, reduce feeding frequency or percentage of body weight.



Figure 1(a): Growel NutriLA formulated feed

Proximate/Nutrient Composition-

Table 1: Formulated Feed Proximate Composition

Component	Composition (% as Fed)
Crude protein	42.0
Crude lipid	8.0
Crude fiber	3.0
Moisture	12.0
Ash	8.0-10.0
Nitrogen-free extract (NFE)	25.0-27.0
Total	100

- **Diet 2 (Natural Feed):** Sun-dried blood worms (*Chironomidae* larvae), a widely used natural protein source in carnivorous fish rearing. The second diet provided to the fish was **Dried Blood Worms** (commercially available). They were purchased from a reputed aquarium feed supplier. Before feeding, the worms were soaked in clean water for 2–3 minutes to soften them and then offered directly to fish. Fishes were fed twice daily (09:00 and 17:00 hrs) at a ration of 3–5% of their body weight. Feed adjustments were made every 15 days based on growth increments.



Figure 1(b): Dried blood worms

Feeding and Experimental Details

Table 2: Feeding and Experimental Details

Parameter	Details
Feeding frequency	Twice daily (09:00 and 17:00)
Feeding rate	3–5% of body weight per day
Feed adjustment	Every 15 days based on growth increments
Feed types	Formulated Feed (Growel NutriLA) and Dried Blood Worms
Feeding method	Hand-fed; feed evenly broadcasted across tank surface
Pellet size	4–6 mm for adults
Feed form	Slow-sinking pellets (Growel NutriLA) and soaked dried worms
Water quality during feeding	Monitored daily (Temperature, DO, pH, Ammonia)

4. Experimental Setup and Maintenance

Both cisterns were supplied with dechlorinated borewell water and maintained under similar physicochemical conditions (temperature: 27–29 °C; pH: 7.1–7.4; dissolved oxygen: 6.5–7.0 mg/L). Partial water exchange (30%) was carried out twice weekly to maintain water quality. Aeration was provided using air stones to ensure oxygen saturation. Mortality, if any, was recorded daily.



Figure 2: Experimental tank setup for *Channa striata* feeding trial

5. Sample Preparation

At the end of the 2-month trial, fish were carefully harvested and transported live to the laboratory. Each fish was sacrificed humanely, washed with running tap water, and excess surface water was removed using blotting paper. Biometric data were recorded again. The non-edible portions (viscera, scales, head, and bones) were removed immediately. Only muscle tissue was retained for proximate composition analysis. The muscle samples were washed with distilled water and cut into small pieces. They were then oven-dried at 105 °C until a constant weight was obtained, ensuring the removal of free and bound water. The dried muscle samples were ground into a fine powder using a laboratory blender and stored in airtight containers for further analysis.

6. Proximate Composition Analysis

The proximate composition of fish muscle was analysed following the AOAC (2019) official methods.

- **Moisture Content (%)**

Determined by oven drying at 105 °C until constant weight was achieved.

$$\text{Moisture (\%)} = (\text{Fresh weight} - \text{Dry weight}) / \text{Fresh weight} \times 100$$

- **Dry Matter (%)**

Obtained as the complement of moisture content.

$$\text{Dry Matter (\%)} = 100 - \text{Moisture (\%)}$$

- **Ash Content (%)**

Determined by incinerating 2 g of dried sample in a muffle furnace at 550 °C for 6 hours until white ash was obtained.

$$\text{Ash (\%)} = (\text{Weight of ash} / \text{Weight of dried sample}) \times 100$$

7. Statistical Analysis Results are expressed as Mean $\pm$ Standard Deviation (SD). Error bars in figures indicate $\pm$ SD.

All measurements were carried out in triplicate for accuracy. Results were expressed as Mean $\pm$ Standard Deviation (SD). Statistical differences between the two dietary groups were analysed using one-way ANOVA ($p < 0.05$). Graphical representation (bar chart) was prepared using Microsoft Excel to visualize variations in moisture, dry matter and ash content between the two feeds.

RESULTS

The effect of two different dietary regimes — fish meal-based formulated feed and dried blood worms — on the proximate composition of *Channa striatus* muscle was assessed after a 2-month feeding trial. The analysis focused on moisture, dry matter and ash content, as these are critical parameters in evaluating fish flesh quality and nutrient deposition.

1. Moisture Content

The muscle moisture content varied significantly between the two feeding groups ($p < 0.05$). Fish fed on dried blood worms exhibited a higher mean moisture content ($81.97 \pm 0.42\%$), while those fed on formulated feed showed comparatively lower moisture levels ($78.50 \pm 0.36\%$). This difference indicates that natural feeds with variable composition (such as blood worms) may contribute to higher water retention in muscle tissue, while formulated diets improve nutrient density through reduced water content.

2. Dry Matter

The inverse relationship between moisture and dry matter was evident. Fish fed with the formulated feed had a significantly higher dry matter content ($21.50 \pm 0.36\%$) compared to those fed dried blood worms ($18.03 \pm 0.42\%$). The results suggest that the formulated feed promoted better assimilation of protein and energy, leading to enhanced deposition of solids in fish muscle.

3. Ash Content

Ash values, representing total mineral content, were slightly different between treatments. The dried blood worm group showed higher ash deposition ($2.00 \pm 0.12\%$) compared to the formulated feed group ($1.20 \pm 0.08\%$). This difference may reflect the higher mineral load in blood worms, which are known to contain

exoskeletal material and trace elements, but it could also indicate lower nutrient digestibility compared to formulated feed.

Table 3. Proximate composition of *Channa striatus* muscle after 2-month feeding trial

Feed Type	Moisture (%) ± SD	Dry Matter (%) ± SD	Ash (%) ± SD
Formulated	78.50 ± 0.36	21.50 ± 0.36	1.20 ± 0.08
Nutrila Feed			
Dried Blood Worms	81.97 ± 0.42	18.03 ± 0.42	2.00 ± 0.12

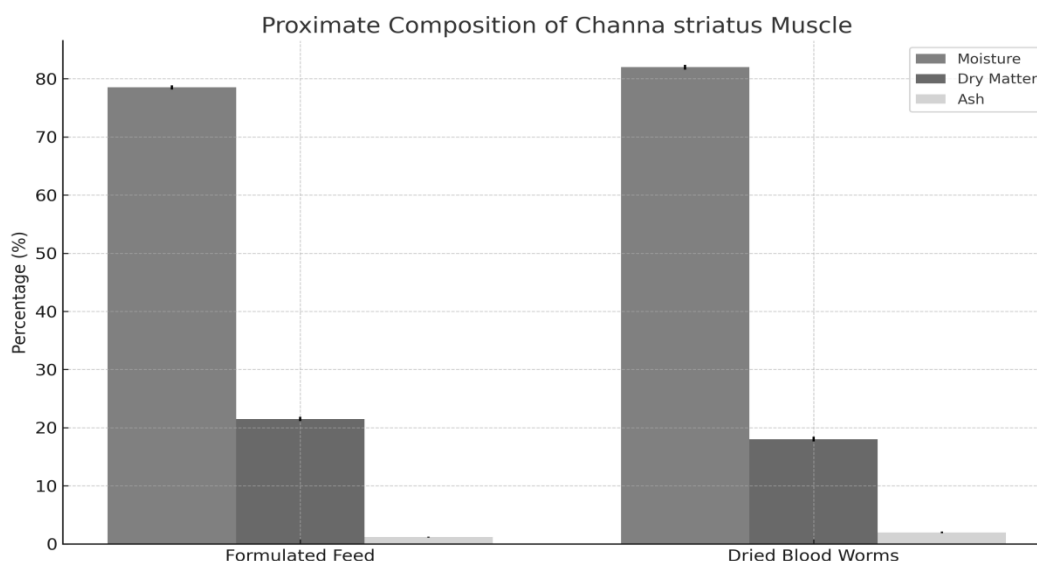


Figure 3. Grayscale bar chart showing moisture, dry matter, and ash content in *Channa striatus* muscle under different feed regimes. Bars represent mean values; error bars represent ± SD.

(Bar graph with three grouped bars: one for each parameter, showing clear contrast between diets. Error bars represent ±SD.)

DISCUSSION

The present investigation demonstrates that dietary regime exerts a decisive role in shaping the proximate composition of *Channa striatus* muscle. Fish fed on dried blood worms exhibited higher moisture content (81.97%) compared to those fed formulated feed (78.50%), whereas the formulated feed group had greater dry matter deposition (21.50%) relative to the blood worm group (18.03%). This inverse relationship between moisture and dry matter has long been recognized in aquaculture nutrition, where moisture dilution tends to indicate reduced nutrient density while higher dry matter reflects efficient nutrient assimilation and flesh quality (Sharma *et al.*, 2018; Jayanthi *et al.*, 2018). Our findings reinforce this relationship, showing that formulated diets promote solid deposition and nutrient retention.

The higher muscle water content observed in the blood worm group is consistent with reports by Ng (2001) and Kumar *et al.* (2019), who documented that natural live or dried feeds with variable biochemical profiles contribute to inconsistent nutrient conversion and greater tissue hydration. Such conditions can reduce storage stability and shelf life, which are critical parameters for commercial aquaculture and post-harvest handling (Suresh *et al.*, 2020). By contrast, the reduced muscle water and improved dry matter values in the formulated feed group suggest a more stable biochemical environment that facilitates protein accretion and energy utilization, thereby enhancing flesh firmness and consumer acceptability (Rahman & Miah, 2014; Abdel-Tawwab *et al.*, 2020).

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Ash content was slightly higher in the blood worm group (2.00%) compared to formulated feed (1.20%). This can be explained by the mineral residues and exoskeletal materials inherent to Chironomidae larvae, as noted by Tan et al. (2009). Minerals such as calcium, magnesium, and iron are vital for skeletal growth and enzymatic functions (Lall, 2002), yet an excessively high ash fraction can dilute nutrient density and reduce digestibility (Patil *et al.*, 2020). This observation supports the idea that while blood worms are nutrient-rich and highly palatable, their use as a complete diet is limited. Instead, they may be more beneficial as a supplementary feed to enhance palatability and feeding response, as reported by Rao et al. (2022).

From a sustainability perspective, the superiority of formulated diets has broader implications. The reliance on natural feeds like blood worms is not only nutritionally inconsistent but also limited by seasonal availability and potential contamination risks (Haniffa *et al.*, 2004; Baruah *et al.*, 2005). On the other hand, formulated feeds are produced under controlled conditions to maintain consistency in nutrient composition, bioavailability, and shelf life. Recent research indicates that advances in feed technology, including the incorporation of plant-based proteins, probiotics, and functional additives, can further improve growth, immune response, and environmental sustainability in aquaculture (Hussain *et al.*, 2021; Prabu *et al.*, 2022). Another important aspect is economic feasibility. Farmers require diets that balance cost with performance. Blood worms, although effective in stimulating feeding, are expensive and not scalable for commercial farming. Formulated feeds, by contrast, can be tailored to local resource availability, reducing dependency on fish meal through inclusion of alternative protein sources such as soybean, spirulina, and insect meal (Tacon & Metian, 2008; Hardy, 2010; Laining *et al.*, 2010). Studies have highlighted that substitution of fish meal with sustainable alternatives does not compromise proximate composition or growth if dietary formulations are carefully balanced (Hasan *et al.*, 2021; Prabu *et al.*, 2022). Our findings that formulated feeds enhance dry matter deposition align with these reports, suggesting that fish meal-based diets may be gradually diversified without compromising nutrient retention in muscle.

The results of this study also have implications for human nutrition. Moisture, dry matter, and ash content collectively determine the nutritional density and shelf stability of fish flesh. Consumers generally prefer firm-textured fish with high protein density, which is associated with higher dry matter and lower muscle moisture (Sharma *et al.*, 2018). Furthermore, the mineral balance indicated by ash fraction has relevance to dietary requirements of calcium, phosphorus, and trace elements in human diets (Rao *et al.*, 2022). Therefore, formulated feeds not only benefit aquaculture productivity but also enhance the quality of fish as a food source.

In summary, the present findings confirm that formulated diets provide a more reliable pathway to consistent nutrient deposition, higher dry matter, and desirable flesh composition compared to dried blood worms. These outcomes echo broader trends in aquaculture nutrition research, which emphasize the integration of stable, cost-effective, and sustainable feed formulations (Abdel-Tawwab *et al.*, 2020; Hussain *et al.*, 2021). By improving nutrient utilization efficiency and reducing variability, formulated feeds contribute to the dual goals of enhancing aquaculture profitability and ensuring food security.

Thus, while blood worms may continue to serve as a palatability enhancer and supplementary diet, the evidence strongly supports formulated feeds as the foundation for commercial rearing of *Channa striatus*. Future research should explore the integration of alternative protein sources, functional feed additives, and optimized feeding regimes to further enhance growth performance, nutrient assimilation, and sustainability in snakehead aquaculture.

The results of the present investigation clearly demonstrate that dietary regime plays a significant role in determining the proximate composition of *Channa striatus* muscle. Fish fed on dried blood worms exhibited higher moisture content (81.97%) compared to those fed on formulated feed (78.50%), whereas the formulated feed group showed greater dry matter deposition (21.50%) relative to the blood worm group (18.03%). This inverse relationship between moisture and dry matter has also been observed in previous studies, where formulated diets were reported to enhance nutrient assimilation and reduce water retention

in fish tissues, thereby improving flesh firmness and overall quality (Jayanthi *et al.*, 2018; Kumar *et al.*, 2019).

Moisture and dry matter balance is considered one of the most critical indicators of fish flesh composition because it directly influences textural properties, storage stability, and consumer acceptability. High muscle water content, as seen in the blood worm group, may reduce storage stability and shelf life, while greater dry matter deposition reflects efficient utilization of dietary protein and energy for muscle accretion (Sharma *et al.*, 2018). The observed variation may be attributed to differences in nutrient density and amino acid balance between the two feed types, as formulated feeds are designed to provide a more consistent nutrient supply, whereas natural feeds like blood worms tend to be variable in their biochemical composition (Patil *et al.*, 2020).

Ash content was slightly higher in fish fed dried blood worms (2.00%) compared to those given formulated feed (1.20%). The elevated mineral deposition in the blood worm group may be explained by the exoskeletal material and mineral residues commonly present in natural live or dried feeds (Tan *et al.*, 2009). Although minerals are essential for metabolic functions and skeletal growth (Lall, 2002), excessive ash levels can sometimes dilute nutrient density and may affect digestibility. This highlights the fact that while blood worms are nutrient-rich and palatable, their variable composition and higher mineral load suggest they are better suited as a supplementary feed rather than a complete diet.

Overall, the findings indicate that formulated fish meal-based feed is more effective in promoting nutrient deposition and maintaining muscle quality, whereas dried blood worms, despite their palatability, result in higher tissue moisture and variable composition. This observation is consistent with earlier reports which emphasized the superiority of formulated diets over natural animal protein sources in achieving consistent growth and feed efficiency in carnivorous fish species (Abdel-Tawwab *et al.*, 2020; Suresh *et al.*, 2020). The results further underline the importance of proximate composition analysis, not only for understanding fish physiology but also for developing practical feeding strategies in aquaculture. A focus on moisture, dry matter, and ash content provides a clearer picture of nutrient utilization, flesh quality, and feed performance, thereby helping farmers adopt balanced diets that are sustainable, cost-effective, and nutritionally adequate (Baruah *et al.*, 2005; Tacon & Metian, 2008).

These findings align with previous research highlighting that formulated diets provide more consistent nutrient assimilation and better growth performance compared to natural diets (Sharma *et al.*, 2018; Rao *et al.*, 2022). Blood worms, while palatable and protein-rich, are therefore better suited as a supplementary feed.

CONCLUSION

This comparative study concludes that formulated fish meal-based diets are superior to dried blood worms for *Channa striatus*. Formulated feeds enhanced dry matter deposition and balanced nutrient assimilation, whereas dried blood worms promoted higher tissue moisture and ash content. Thus, formulated feeds should be recommended as the primary diet, while blood worms may be used as supplementary feed to improve palatability.

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