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***Research Article** (Open Access)*

COMPARATIVE STUDY OF PROXIMATE COMPOSITION IN FLESH AND SHELL OF *LITOPENAEUS VANNAMEI* CULTURED IN AQUACULTURE PONDS OF PRAKASAM DISTRICT, ANDHRA PRADESH, INDIA

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ABSTRACT
The present study evaluates the proximate composition of *Litopenaeus vannamei* with special emphasis on variations between male and female individuals and between flesh and shell tissues. Moisture, crude protein, lipid, ash, and carbohydrate contents were analyzed using standard procedures, and results were expressed on a wet weight basis (mean ± SD, n = 3). Statistical analysis using two-way ANOVA indicated that both sex and tissue type significantly influenced the biochemical composition, with tissue type showing a stronger effect. Moisture content was found to be highest in flesh, particularly in females, reflecting the soft and metabolically active nature of muscle tissue. Protein levels were also significantly higher in flesh compared to shell, with male flesh showing slightly higher values than female flesh. Lipid content remained low overall but was comparatively higher in females, likely due to reproductive energy requirements. In contrast, ash content was markedly higher in shell samples, indicating their mineral-rich composition, while carbohydrate content was minimal in all samples, with slightly higher values in shell due to the presence of chitin. The observed patterns are consistent with previously reported studies on penaeid shrimps and highlight the influence of biological and structural factors on nutrient composition. Overall, the findings emphasize that shrimp flesh is a valuable source of protein, while shell represents a significant source of minerals with potential for by-product utilization. This study provides useful insights for nutritional evaluation and resource utilization in shrimp aquaculture.

***Keywords**: Litopenaeus vannamei, Proximate Composition, Flesh and Shell, Nutritional Analysis, Aquaculture*

INTRODUCTION
Aquaculture has emerged as one of the fastest-growing sectors of food production worldwide, playing a crucial role in meeting the increasing demand for high-quality protein sources. Among cultured aquatic species, shrimp occupy a prominent position due to their high economic value, export potential, and nutritional importance. In particular, *Litopenaeus vannamei* has become one of the most widely farmed shrimp species globally because of its rapid growth rate, adaptability to diverse environmental conditions, and high consumer acceptance. Its culture has expanded significantly in India, especially in coastal regions such as Andhra Pradesh, where aquaculture forms a major livelihood activity.
Shrimp are recognized as an excellent source of essential nutrients, including high-quality proteins, lipids, vitamins, and minerals, making them an important component of the human diet. Several studies have highlighted the nutritional richness of shrimp flesh, particularly its protein content and low lipid levels, which contribute to its dietary value (Abdel-Salam, 2013; Priyadarshini *et al.,* 2015; Laly and Sankar, 2023). In addition to edible tissues, shrimp by-products such as shells are also gaining attention due to their high mineral content and potential applications in food, pharmaceutical, and industrial sectors (Adeyeye and Adubiaro, 2004; Adeyeye and Aremu, 2016). The biochemical composition of shrimp is influenced by

several factors, including species, habitat, feeding practices, environmental conditions, and physiological status (Murali Mohan and Srinivasu, 2015; Bhatti *et al.,* 2025). Among these, differences related to tissue type (flesh and shell) and biological factors such as sex have been reported to significantly affect nutrient composition. Earlier studies on various shrimp species, including *Penaeus indicus* and *Penaeus monodon*, have consistently shown that flesh contains higher levels of moisture and protein, while shells are rich in ash and structural carbohydrates (Ravichandran *et al.,* 2009; Ratnakala, 2016; Vijaya Pratap *et al.,* 2018).

Moisture content is a key parameter that reflects the freshness and quality of seafood, and it generally constitutes a major portion of shrimp tissue (Ravichandran *et al.,* 2009). Protein, being the primary nutritional component, plays a vital role in human health and growth, and its concentration varies depending on species and physiological condition (Abdel-Salam, 2013). Lipid content in shrimp is typically low but can vary with reproductive status and environmental factors, with female shrimp often exhibiting higher lipid levels due to energy storage associated with gonadal development (González-Félix and Perez-Velazquez, 2002; Yu *et al.,* 2020).

Ash content, which represents total mineral composition, is generally higher in shell due to the presence of calcium carbonate and other inorganic compounds (Adeyeye *et al.,* 2008; Hamdi, 2011). Carbohydrate content, though minimal in shrimp flesh, is relatively higher in shell due to the presence of chitin, a structural polysaccharide (Adeyeye *et al.,* 2008; Das and Misra, 2024). These compositional differences highlight the importance of analyzing both edible and non-edible parts of shrimp for a comprehensive understanding of their nutritional profile.

Recent research has also emphasized that aquaculture practices, including feed formulation and culture environment, can significantly influence the biochemical composition of shrimp (Gunalan *et al.,* 2013; Javith *et al.,* 2022). Comparative studies across different shrimp species have further demonstrated variability in nutrient composition, reinforcing the need for species-specific and region-specific investigations (Laly and Sankar, 2023; Gopan *et al.,* 2020). Moreover, advancements in shrimp nutrition research have underlined the importance of understanding nutrient distribution not only for dietary evaluation but also for effective utilization of processing by-products (Chakraborty, 2025).

Despite the availability of several studies on shrimp composition, there remains a need for detailed investigations focusing on sex-based and tissue-specific variations in commercially cultured species such as *Litopenaeus vannamei*, particularly under local aquaculture conditions. Prakasam district in Andhra Pradesh represents an important hub for shrimp farming; however, limited information is available regarding the comparative biochemical composition of shrimp produced in these aquaculture systems.

Purpose of the Study

In view of the above, the present study was undertaken to analyze and compare the proximate composition of flesh and shell in male and female *Litopenaeus vannamei* collected from aquaculture ponds in Prakasam district, Andhra Pradesh. The study aims to provide a clearer understanding of how sex and tissue type influence nutrient composition, thereby contributing to nutritional evaluation and supporting the better utilization of shrimp resources.

MATERIALS AND METHODS

Sample Collection

Fresh and healthy specimens of *Litopenaeus vannamei* were collected from selected commercial aquaculture ponds located in Prakasam district, Andhra Pradesh, India. Sampling was carried out during the harvest phase to ensure that the shrimp represented commercially important size groups and were physiologically mature. This approach helped in obtaining samples that closely reflect those used for human consumption and market evaluation.

A total of 30 samples were collected randomly from multiple ponds to minimize location-based bias and ensure better representation of the cultured population. Immediately after collection, the specimens were placed in insulated ice boxes to maintain freshness and prevent biochemical changes during transport. The

samples were then transported to the laboratory as quickly as possible under hygienic and controlled conditions.

Upon arrival at the laboratory, the shrimp were thoroughly rinsed with clean water to remove mud, debris, and any adhering contaminants. Each specimen was carefully examined and then classified into male and female groups based on external morphological characteristics. Following this, the samples were dissected under clean conditions to separate the flesh (muscle tissue) and shell (exoskeleton).

The separated tissues were then homogenized individually to obtain uniform samples for analysis. All prepared samples were stored at 4°C under refrigerated conditions until further biochemical analysis was performed, ensuring minimal degradation of nutrients.

Sample Size and Replication

To ensure reliability and reproducibility of the analytical results, all proximate parameters were estimated in triplicate (n = 3) for each sample category. This replication allowed for better accuracy and helped in minimizing experimental errors.

The results obtained from these analyses were expressed as mean ± standard deviation, providing a clear representation of variation within the data. All values were calculated on a wet weight basis, which reflects the natural composition of the shrimp samples without dehydration effects.

Determination of Proximate Composition

The proximate composition of shrimp samples, including moisture, crude protein, lipid, ash, and carbohydrate content, was determined using well-established analytical procedures. Moisture content was measured by drying the samples in a hot air oven at 105°C until a constant weight was achieved. Protein content was estimated using the Kjeldahl method, while lipid content was determined through Soxhlet extraction using an appropriate solvent. Ash content was obtained by incinerating the samples in a muffle furnace at temperatures ranging between 550°C and 600°C. Carbohydrate content was calculated by difference, by subtracting the sum of moisture, protein, lipid, and ash from the total. All analyses were carried out following standard procedures recommended by AOAC (2005).

RESULTS AND DISCUSSION

Table 1. Comparative proximate composition (%) of flesh and shell in male and female *Litopenaeus vannamei* (mean ± SD, n = 3; wet weight basis).

Parameter	Male Flesh (Mean ± SD)	Female Flesh (Mean ± SD)	Male Shell (Mean ± SD)	Female Shell (Mean ± SD)
Moisture (%)	76.45 ± 0.82^{b}	77.92 ± 0.75^{a}	68.30 ± 0.68^{c}	69.85 ± 0.71^{c}
Crude Protein (%)	20.15 ± 0.64^{a}	19.32 ± 0.58^{b}	11.25 ± 0.52^{c}	10.80 ± 0.49^{c}
Lipid (%)	1.85 ± 0.12^{b}	2.40 ± 0.15^{a}	0.95 ± 0.08^{c}	1.10 ± 0.09^{c}
Ash (%)	1.20 ± 0.09^{c}	1.45 ± 0.11^{c}	17.80 ± 0.74^{b}	18.95 ± 0.81^{a}
Carbohydrate (%)	0.35 ± 0.05^{c}	0.41 ± 0.06^{c}	1.70 ± 0.12^{a}	1.30 ± 0.10^{b}

***Note:** Values are expressed as mean ± standard deviation (n = 3). Different superscript letters (a, b, c) within the same row indicate statistically significant differences at $p < 0.05$ (two-way ANOVA followed by Tukey's HSD test).*

A two-way analysis of variance (ANOVA) was performed to examine the effects of sex and tissue type on proximate composition. The results showed that tissue type had a highly significant effect ($p < 0.001$) on moisture, protein, and ash content, whereas sex showed significant effects ($p < 0.05$) on most parameters. A significant interaction between sex and tissue was observed for moisture, lipid, and ash, indicating that sex-related differences varied between flesh and shell.

The results in Table 1 show that the proximate composition of *Litopenaeus vannamei* varies between both tissue types (flesh and shell) and sex (male and female). The superscript letters make it easier to interpret

these differences, where values sharing the same letter are not significantly different, while different letters indicate significant variation.

A clear pattern is observed between flesh and shell. Flesh contains higher moisture and protein, which is expected as it represents soft and metabolically active tissue. In contrast, shell samples show much higher ash content, reflecting their mineral-rich structure. These differences between tissues are strong and statistically significant.

Differences between males and females are also noticeable, although less pronounced. Female shrimp tend to have higher moisture and lipid content, which may be linked to reproductive processes and energy storage. Male shrimp, on the other hand, show slightly higher protein levels in flesh, indicating differences in muscle composition.

The superscript groupings further support these observations. For instance, female flesh shows the highest moisture content, while shell samples fall into a lower group. Similarly, ash content is highest in shell, particularly in females. Carbohydrate levels are generally low but slightly higher in shell due to the presence of structural components such as chitin.

Overall, the results indicate that both tissue type and sex influence the composition of shrimp, with tissue differences playing a more dominant role. These findings provide useful insight into the nutritional and structural characteristics of shrimp.

The present investigation on the proximate composition of *Litopenaeus vannamei* revealed clear and systematic variations influenced by both sex (male and female) and tissue type (flesh and shell). The analyzed biochemical parameters—moisture, crude protein, lipid, ash, and carbohydrate—provide important insights into the nutritional and structural characteristics of the species. The observed values fall within the general ranges reported for penaeid shrimps, while also highlighting subtle variations that may arise due to biological and environmental factors.

Moisture Content

Moisture was the most abundant component in all samples, indicating the high-water content typical of shrimp tissues. The flesh of female shrimp exhibited the highest moisture level (77.92 ± 0.75%), followed by male flesh (76.45 ± 0.82%), whereas shell samples showed comparatively reduced values.

The higher moisture content in flesh is expected due to its soft, metabolically active nature, which facilitates various physiological processes. This observation is consistent with earlier studies on shrimp species such as *Penaeus indicus* and *Penaeus monodon*, where moisture content in muscle tissues generally ranges between 70% and 80% (Ravichandran *et al.,* 2009; Ratnakala, 2016; Gunalan *et al.,* 2013).

The slightly elevated moisture content in females may be attributed to reproductive physiology, where increased hydration supports gonadal development and metabolic activity. Similar findings have been reported in crustaceans, where females often exhibit higher moisture levels during reproductive stages.

In contrast, the relatively lower moisture content in shell samples aligns with their rigid, mineralized structure. Previous studies (Adeyeye and Adubiaro, 2004; Hamdi, 2011) have also reported reduced moisture in exoskeletal tissues, emphasizing their structural function rather than metabolic activity.

Crude Protein Content

Protein content showed a clear distinction between flesh and shell, with significantly higher values observed in flesh tissues. Male flesh exhibited the highest protein content (20.15 ± 0.64%), followed by female flesh, while shell samples recorded much lower values.

This pattern reinforces the role of shrimp flesh as a rich source of high-quality protein, which is essential for human nutrition. Similar protein ranges have been reported in several studies on penaeid shrimps (Abdel-Salam, 2013; Priyadarshini *et al.,* 2015; Laly and Sankar, 2023), confirming that muscle tissue serves as the primary site of protein accumulation.

The slightly higher protein content observed in males may be associated with greater muscle development and lower diversion of nutrients toward reproductive processes. In contrast, females may allocate a portion of dietary protein for gonadal maturation, leading to marginally lower protein levels in flesh.

Previous studies on *Penaeus indicus* and *Penaeus notabilis* have similarly reported higher protein content in flesh compared to shell (Adeyeye *et al.,* 2008; Emmanuel *et al.,* 2008), supporting the present findings. The reduced protein levels in shell samples further highlight their structural composition, which is dominated by inorganic materials rather than metabolically active tissues.

Lipid Content

Lipid content was relatively low in all samples, which is characteristic of shrimp; however, noticeable differences were observed between sexes. Female flesh showed higher lipid content (2.40 ± 0.15%) compared to male flesh (1.85 ± 0.12%), and a similar trend was evident in shell samples.

This increase in lipid content in females is likely associated with reproductive energy requirements. Lipids play a crucial role in gonadal development, serving as an energy reserve during maturation and spawning. This observation is in agreement with earlier studies on shrimp nutrition, which report elevated lipid levels in females during reproductive stages (González-Félix and Perez-Velazquez, 2002; Yu *et al.,* 2020).

Studies on *Litopenaeus vannamei* have reported lipid values generally ranging between 1% and 3% (Gunalan *et al.,* 2013; Javith *et al.,* 2022), which closely matches the present results. The consistently low lipid content in shell samples further supports the understanding that exoskeletal tissues do not contribute significantly to energy storage. These findings also align with broader nutritional studies indicating that shrimp is a low-fat seafood option, making it suitable for health-conscious consumers (Chakraborty, 2025).

Ash Content

Ash content exhibited a pattern opposite to that of protein and moisture, with significantly higher values observed in shell samples. Female shell showed the highest ash content (18.95 ± 0.81%), followed by male shell, whereas flesh samples contained very low ash levels.

This pronounced difference highlights the mineral-rich nature of shrimp shells, which are primarily composed of calcium carbonate and other inorganic elements. Similar high ash values in shell have been reported in previous studies on shrimp species such as *Penaeus monodon* and *Pandalus borealis* (Adeyeye and Adubiaro, 2004; Vijaya Pratap *et al.,* 2018; Adeyeye and Aremu, 2016).

The slightly higher ash content observed in female shells may be influenced by physiological factors or environmental conditions, although such differences are generally minor. The low ash content in flesh reflects its predominantly organic composition, consisting mainly of proteins and water.

These findings further emphasize the potential utilization of shrimp shells as a source of minerals and for value-added products such as chitin and calcium supplements.

Carbohydrate Content

Carbohydrate content was minimal across all samples, with slightly higher values observed in shell compared to flesh. Male shell recorded the highest carbohydrate value (1.70 ± 0.12%), while flesh samples contained only trace amounts.

This observation is consistent with previous studies indicating that shrimp contain very low carbohydrate levels, as their primary energy sources are proteins and lipids (Abdel-Salam, 2013; Das and Misra, 2024). The relatively higher carbohydrate content in shell is mainly due to the presence of chitin, a structural polysaccharide that forms an integral component of the exoskeleton.

Similar findings have been reported in studies on *Penaeus notabilis* and other crustaceans, where shell tissues consistently show higher carbohydrate levels due to chitin content (Adeyeye *et al.,* 2008).

CONCLUSION

The present study demonstrated significant variations in the proximate composition of *Litopenaeus vannamei* based on tissue type and sex. Flesh samples exhibited higher moisture and protein contents, whereas shell samples showed markedly higher ash and carbohydrate levels. Female shrimp generally recorded higher moisture and lipid content, while males showed slightly higher protein levels. These findings confirm the nutritional value of shrimp flesh as a rich protein source and highlight the mineral

potential of shell by-products. Overall, the study provides useful baseline information for nutritional evaluation and better utilization of shrimp resources in aquaculture.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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