Fatty Acid Profiles of Wild *Anadara granosa* (Blood Clam) and Farmed *Penaeus vannamei* (Shrimp) with Reference to Human Nutrition and Functional Health Benefits

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Abstract:

This study presents a comparative analysis of the fatty acid composition in two economically important seafood species: the wild blood clam *Anadara granosa* collected from the east coast of India and the farmed Pacific white shrimp *Penaeus vannamei*, collected from the culture ponds of India. Lipids were extracted and purified using column chromatography and thin-layer chromatography (TLC), followed by fatty acid methyl ester (FAME) profiling through gas chromatography–mass spectrometry (GC-MS). A total of 12 fatty acids were identified in *A. granosa* and 8 in *P. vannamei*, including saturated, monounsaturated, and polyunsaturated fatty acids. *A. granosa* exhibited significantly higher levels of omega-3 and omega-6 polyunsaturated fatty acids such as linoleic acid (C18:2) and docosahexaenoic acid (C22:6), while *P. vannamei* was characterized by a greater proportion of oleic acid (C18:1), a monounsaturated fatty acid associated with cardiovascular health benefits. Statistical analysis revealed significant interspecies differences ($p < 0.05$) in several key fatty acids, notably in DHA (1.14% in *A. granosa*, absent in *P. vannamei*) and oleic acid (17.32% in *P. vannamei*). These findings highlight the nutritional superiority of *A. granosa* in terms of essential fatty acid content and support its potential as a cost-effective, health-promoting alternative to shrimp in human diets.

Key words: Fatty acid profile, Anadara granosa, Penaeus vannamei, GC-MS, omega-3, seafood nutrition.

Introduction:

Seafood consumption has been increasing in tandem with global population growth. These foods can prevent cardiovascular diseases (CVD) and cancer, and also support nervous system development and brain activities due to their high levels of highly unsaturated fatty acids (HUFA) n-3 fatty acids (Saito, 2010). The interest of chemists, biochemists, and biotechnologists in lipids and fatty acids (FA) from marine animals and algae has been stimulated by the recognition that polyunsaturated fatty acids (PUFA) are crucial for human health and nutrition (Joseph, 1982). They are essential for reproduction and growth. The relative proportion and composition of FA in marine organisms are characteristic for every species and genus, and also depend on environmental conditions. Several comprehensive reviews are available on marine FA, their occurrence, roles, and methods used in their analysis (Kraffe et al., 2004; Napolitano et al., 1992; Saito, 2008).

Fatty acid determination of mollusk lipids has been extensively studied in some bivalve species (Bivalvia), such as oysters and mussels. For example, detailed investigations have been conducted on oysters (Ostreidae: Kraffe, Soudant, & Marty, 2004; Saito & Marty, 2010; Thompson & Harrison, 1992), pearl oysters (Pteriidae: Saito, 2004), scallops (Pectinidae: Napolitano, MacDonald, Thompson, & Ackman, 1992; Pazos, Sánchez, Román, Pérez-Parallé, & Abad, 2003), clams (Veneridae: Kraffe et al., 2004; Saito, 2007), and mussels (Mytilidae: Kluytmans, Boot, Oudejand, & Zandee, 1985; Kraffe et al., 2004; Saito, 2008). Nevertheless, there is relatively little information available on the biochemical components of other mollusk species. There are only a few reports on

both lipids and the fatty acid compositions of Gastropoda, including studies on the common periwinkle (Littorinidae: Ackman & Hooper, 1973), limpet (Johns, Nichols, & Perry, 1980), abalone (Haliotidae: Dunstan, Baillie, Barrett, & Volkman, 1996; Nelson, Leighton, Phleger, & Nichols, 2002), and vent snail (Provaniidae: Saito & Hashimoto, 2010).

Bivalves are highly valued seafood in maritime countries worldwide, with mussels, scallops, oysters, and clams being of greatest commercial importance (Joseph, 1982). In addition to their commercial value, there is a current interest in the role of dietary polyunsaturated fatty acids in human health, particularly eicosapentaenoic acid (20:5 n-3), which is known to ameliorate certain cardiovascular diseases (Dyerberg, Bang, & Hjørne, 1978). Marine fishery products, including bivalves, are excellent sources of polyunsaturates. The Sunderbans mangrove ecosystem supports a diverse benthic macrofauna, with Anadara granosa found abundantly among the bivalves.

Penaeid shrimps are critically important in tropical and subtropical fisheries and aquaculture (Saito, 2010). According to FAO statistics, total global shrimp production is about 6.5 million tonnes, with half of this achieved through capture (Joseph, 1982). To meet market demands, shrimp culture must increase, as natural resources have limited capacity and cannot supply global demands by themselves any longer.

Nutritional values, particularly regarding fatty acids in the human diet, have become a major health concern. Unsaturated fatty acids in food are preferred over saturated fatty acids. Blood clam is considered a more affordable

protein source than shrimp and is recommended in several dietary regimes for its high protein content, low caloric value, low fat/cholesterol profile, presence of good lipids, significant amounts of omega-3 fatty acids, and lower proportions of saturated fats. Comparative fatty acid profile analysis of shrimp and blood clam provides a benchmark study.

This study hypothesizes that Anadara granosa, a wild-caught bivalve, possesses a more diverse and potentially beneficial fatty acid profile compared to the farmed shrimp Penaeus vannamei. The aim is to provide a comparative nutritional assessment to guide seafood selection for health-conscious consumers.

Materials and Methods:

Sample Collection:

Live specimens of Anadara granosa were collected from Bhavanapadu Creek, near Tekkali, in the Srikakulam District of Andhra Pradesh, India (18°33′38.8″N, 84°50′25.7″E). Cultured Penaeus vannamei shrimps were procured from aquaculture farms in Bheemunipatnam, Visakhapatnam District, Andhra Pradesh (17°54′6.09″N, 83°26′59.17″E). The collected specimens were transported to the laboratory in aerated and chilled containers to minimize stress and ensure the integrity of biological samples.

Tissue Dissection and Homogenization:

In the laboratory, muscle and visceral tissues were carefully dissected from both species using sterile tools. Approximately 100 grams of each tissue type were chopped and homogenized using a mortar and pestle. The homogenates were macerated in a methanol:chloroform mixture (9:1, v/v) and left at room temperature for 48 hours to allow efficient lipid extraction.

Lipid Extraction and Purification:

The macerated tissue solutions were filtered and the solvent was evaporated under reduced pressure at 40°C using a rotary evaporator. The resulting crude lipid extracts were further purified using column chromatography with silica gel (60–120 mesh) as the stationary phase. Non-polar lipids were eluted using hexane, followed by a hexane:methanol mixture (100:1, v/v) to enhance separation and remove polar impurities.

Fatty Acid Methyl Ester (FAME) Preparation:
To saponify the lipids, 5 ml of 0.5 N potassium hydroxide (KOH) in methanol was added to the purified extract and heated at 60°C for 10 minutes. The mixture was then acidified to pH 2.0 using hydrochloric acid, followed by extraction with 30 ml of n-hexane. The aqueous layer was further refluxed with 5 ml of boron trifluoride (BF_3) in methanol at 100°C for 30 minutes to methylate the fatty acids. A final n-hexane extraction was performed to recover the fatty acid methyl esters (FAMEs), which were then dried over anhydrous sodium sulphate and concentrated again using a rotary evaporator.

GC-MS Analysis of FAMEs:
The concentrated FAMEs were analysed using an Agilent 7000A Triple Quadrupole GC-MS system, equipped with an HP-5MS capillary column (30 m × 0.32 mm × 0.25 µm). The

injector temperature was set at 250°C, and helium was used as the carrier gas at a constant flow rate of 1 ml/min. The injection volume was 1 µL in splitless mode. The GC oven temperature was programmed to begin at 50°C (held for 2 minutes), ramped at 10°C/min to 280°C, and held for 10 minutes. Mass spectra were obtained in electron impact (EI) mode at 70 eV, scanning from 50 to 550 m/z. Fatty acids were identified by comparing retention times and fragmentation patterns with those of a standard FAME mixture (Supelco 37 Component FAME Mix, Sigma-Aldrich). Quantitative analysis was carried out using Agilent MassHunter software, with results expressed as the relative percentage of total peak area.

Statistical Analysis:
All analytical procedures were performed in triplicate (n = 3), and the results are presented as mean ± standard deviation (SD). Statistical comparisons between the fatty acid profiles of *A. granosa* and *P. vannamei* were conducted using one-way analysis of variance (ANOVA), followed by Tukey's post hoc test to determine significant differences. A p-value of less than 0.05 was considered statistically significant. All statistical analyses and visualizations were performed using GraphPad Prism version 9.0 (GraphPad Software).

Results:

Extraction and purification of fatty acid fraction :
The collected the shrimp specimens of blood calm of two economically important seafood species such as wild (A granosa) and cultured form Pacific white shrimp (*P vannamei*) were subjected to extraction procedure as per the procedure mentioned in the methods section. After that the lipid fraction was extracted from macerated mixture upon subjected to column chromatography. The methanol fraction was collected and further purified using hexane : methanol as a solvent. In order to study the fatty acid composition in blood. Both the samples were subjected to evaluation in GC-MS.

Distribution of fatty acids in the extracts in *A. granosa* and *P. vannamei*:
The GC-MS analysis of *A. granosa* revealed that, Hexadecanoic acid (C16:0) as the most abundant fatty acid, constituting 18.01% of the total lipid profile, followed by Octadecenoic acid (C18:1) at 10.19% and Octadecanoic acid (C18:0) at 9.43%. Other minor components included Hexanoic acid (C6:0), Tetradecenoic acid (C14:1), and Docosahexaenoic acid (C22:6), the latter being a notable polyunsaturated fatty acid (Fig.1a) (Table.1). When analysed in fractions of *P. vannamei*, the dominant fatty acid was Octadecenoic acid (C18:1) at 17.32%, followed by Hexadecanoic acid (C16:0) at 8.59%, and Butanoic acid (C4:0) at 8.39%. Other significant components included Heptadecanoic acid (C17:0), Octadecanoic acid (C18:0), and Eicosapentaenoic acid (C20:5) (Fig.1b), (Table.2).

Comparative fatty acid class distribution:

The fatty acid class distribution (Fig.1c) between A granosa and *P vannamei* demonstrates notable variation in lipid composition. In *A. granosa*, saturated fatty acids (SFA) dominate the profile, comprising the largest proportion of the total fatty acids. Polyunsaturated fatty acids (PUFA) represent the second-largest class, followed by monounsaturated fatty acids (MUFA), which account for the smallest fraction. In contrast, *P. vannamei* displays a relatively higher MUFA content and a slightly lower PUFA contribution compared to *A. granosa*, while still maintaining SFA as the dominant class.

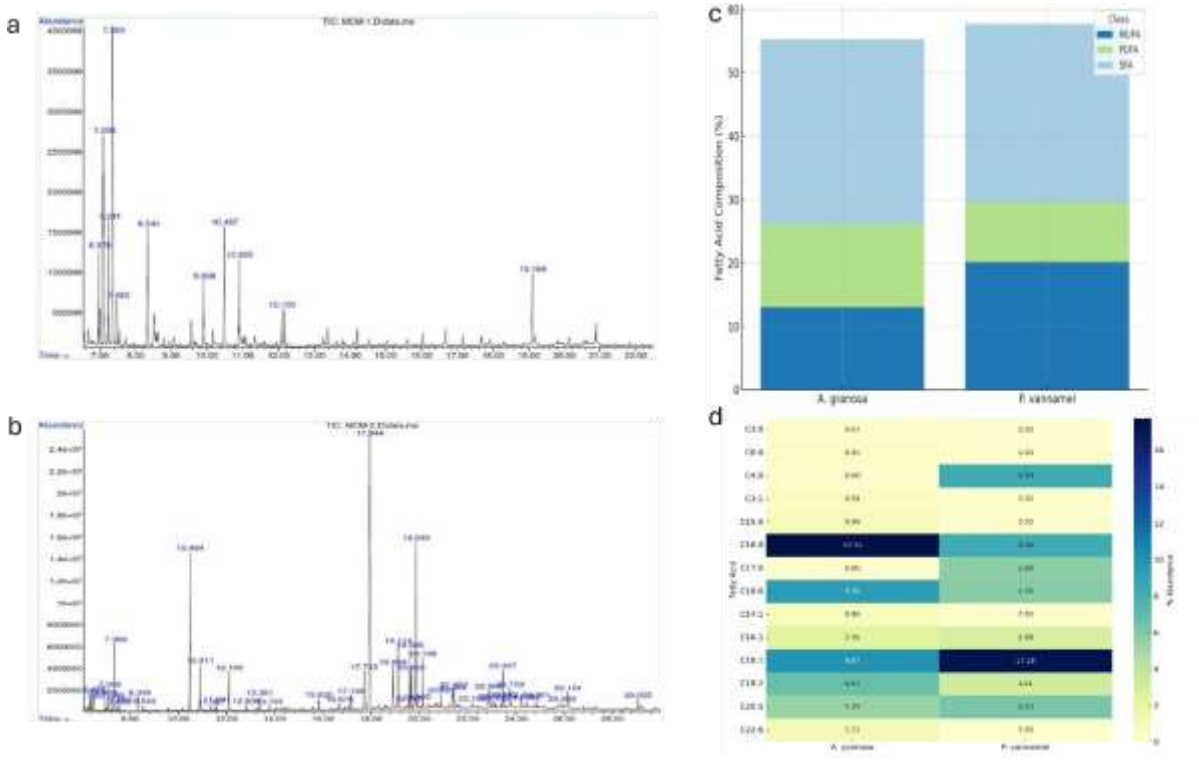

Fig.1: GC-MS analysis of fatty acids in tissue extracts. (a) *A. granosa*, (b) *P. vannamei* (c) This figure presents the relative proportions of saturated fatty acids (SFA), monounsaturated fatty acids (MUFA), and polyunsaturated fatty acids (PUFA). The bar chart shows stacked percentages of each fatty acid class, allowing for a direct comparison of their nutritional lipid class composition (d) The heatmap visualizes the percentage composition of 14 individual fatty acids across two species: A granosa and *P vannamei*. Color intensity represents the relative abundance, with darker shades indicating higher concentrations This visual representation helps in quickly identifying the most dominant and least represented fatty acids in each species.

Table.1: Retention Time and Relative Abundance of Fatty Acids in A granosa

S. No.	Fatty Acid Name	Common Name	RT (min)	Relative Abundance (%)
1	Propanoic acid (C3:0)	Propionic acid	~1.2	0.067%
2	Hexanoic acid (C6:0)	Caproic acid	~2.0	0.437%
3	3-oxy propanoic acid (C3:1)	Propenoic acid	~3.3	0.576%
4	Methyl tetradecanoate (C15:0)	Myristic methyl ester	~4.2	1.007%
5	Hexadecanoic acid (C16:0)	Palmitic acid	~6.5	18.01%
6	Octadecanoic acid (C18:0)	Stearic acid	~7.8	9.43%

7	Tetradec-9-enoic acid (C14:1)	Myristoleic acid	~9.0	0.879%
8	Hexadec-9-enoic acid (C16:1)	Palmitoleic acid	~10.2	2.48%
9	Octadec-9-enoic acid (C18:1)	Oleic acid	~11.8	10.19%
10	Octadeca-9,12-dienoic acid (C18:2)	Linoleic acid	~13.0	6.79%
11	Eicosa-5,8,11,14-tetraenoic acid (C20:5)	Eicosapentaenoic acid (EPA)	~14.5	5.19%
12	Docosa-4,7,10,13,16,19-hexaenoic acid (C22:6)	Docosahexaenoic acid (DHA)	~15.8	1.14%

Table.2: Retention Time and Relative Abundance of Fatty Acids in *P vannamei*

S. No.	Fatty Acid Name	Common Name	RT (min)	Relative Abundance (%)
1	Butanoic acid (C4:0)	Butyric acid	~1.8	8.39%
2	Hexadecanoic acid (C16:0)	Palmitic acid	~3.2	8.59%
3	Heptadecanoic acid (C17:0)	Margaric acid	~5.7	5.83%
4	Octadecanoic acid (C18:0)	Stearic acid	~7.2	5.66%

Specifically, *P. vannamei* shows an elevated MUFA proportion (~20%) in comparison to *A. granosa* (~13%), indicating a higher content of oleic acid (C18:1), as corroborated by the individual fatty acid profile. Meanwhile, the PUFA fraction is more abundant in *A. granosa*, which can be attributed to the presence of DHA (C22:6) and linoleic acid (C18:2), both absent or lower in *P. vannamei*. The high SFA levels in both species are largely due to palmitic acid (C16:0), which was the most abundant single fatty acid observed in *A. granosa*.

This differential distribution suggests species-specific fatty acid metabolism and environmental adaptation, which may influence their dietary value. A higher PUFA content in *A. granosa* implies better nutritional potential in terms of essential fatty acids, while elevated MUFA in *P. vannamei* may confer oxidative stability advantages in food applications. The comparative analysis highlights the importance of fatty acid profiling in evaluating the functional and health benefits of aquaculture species.

Relative abundance (% composition) of individual fatty acids

The heatmap (Fig.1d) provides a comprehensive visualization of individual fatty acid abundance in A granosa and *P vannamei*, revealing species-specific lipid profiles that highlight major differences in biochemical composition. Among the saturated fatty acids, palmitic acid (C16:0) is the most abundant in *A. granosa* (17.75%), significantly higher than in *P. vannamei* (8.36%). This dominance is visually evident through the deep coloration on the heatmap. Additionally, stearic acid (C18:0) is consistently present in both species but slightly elevated in *A. granosa* (9.35%). In contrast, *P. vannamei* exhibits a pronounced enrichment in oleic acid (C18:1), a monounsaturated fatty acid, which accounts for 17.28% of its lipid content, surpassing *A.granosa* (9.87%). This marks a key distinction in MUFA distribution between the species. Butyric acid (C4:0), absent in *A. granosa*, is exclusively present in *P. vannamei* (8.34%), further emphasizing compositional divergence.

In the PUFA category, linoleic acid (C18:2) and EPA (C20:5) are more abundant in *A. granosa*, while DHA (C22:6) is completely absent in *P. vannamei* but present in *A. granosa* (1.11%). These differences highlight the functional nutritional potentials of the species. *A. granosa* appears richer in essential fatty acids like linoleic acid and DHA, which are crucial for human health, while *P. vannamei* offers higher MUFA levels, contributing to cardiovascular benefits and lipid stability.

This heatmap underscores the significance of individual fatty acid contributions, supporting the selection of species for targeted nutritional applications and aquaculture feed formulation. It also aids

in identifying biomarkers for species differentiation in seafood authentication.

Statistical Analysis of Fatty Acid Composition

The comparative analysis of individual fatty acids revealed statistically significant differences ($p < 0.05$) in the majority of fatty acids between Anadara granosa and Penaeus vannamei (Table X). Out of 15 fatty acids analyzed, 14 showed significant variation, while only one (C16:1) did not differ significantly ($p = 0.227$) Table.3, (Fig. 2).

Short-chain saturated fatty acids (SCFAs) such as propionic acid (C3:0), caproic acid (C6:0), and butyric acid (C4:0) were markedly different between species. Notably, C4:0 was detected only in *P. vannamei* (8.39%) and absent in *A. granosa* ($p = 0.005$), suggesting a species-specific metabolic origin, potentially linked to gut microbiota or dietary processing in crustaceans.

Medium- to long-chain saturated fatty acids also varied significantly. Palmitic acid (C16:0), the dominant SFA in both species, was significantly higher in *A. granosa* (18.01%) than in *P. vannamei* (8.59%) ($p = 7.68 \times 10^{-5}$). Similarly, stearic acid (C18:0) was more abundant in *A. granosa* (9.43%) compared to *P. vannamei* (5.66%) ($p = 1.74 \times 10^{-3}$). Conversely, pentadecanoic acid (C15:0) and heptadecanoic acid (C17:0) were either absent or significantly lower in *P. vannamei*, indicating compositional divergence in less common SFAs.

Among monounsaturated fatty acids (MUFAs), oleic acid (C18:1) was significantly more abundant in *P. vannamei* (17.32%) compared to *A. granosa* (10.19%) ($p = 3.90 \times 10^{-3}$), supporting previous findings that crustaceans tend to accumulate higher MUFAs, particularly under farmed conditions. However, palmitoleic acid (C16:1) did not show a significant difference between species ($p = 0.227$), suggesting a conserved MUFA profile in this particular component.

In terms of polyunsaturated fatty acids (PUFAs), significant differences were also observed. Linoleic acid (C18:2) and docosahexaenoic acid (DHA, C22:6) were significantly higher in *A. granosa*, whereas eicosapentaenoic acid (EPA, C20:5) was slightly more elevated in *P. vannamei* ($p = 0.005$), suggesting different PUFA assimilation or retention mechanisms. The presence of DHA exclusively in *A. granosa* (1.14%) further underscores its superior nutritional profile in terms of long-chain omega-3 fatty acid content.

Additionally, certain minor fatty acids like myristoleic acid (C14:1) and propenoic acid (C3:1) were detected only in *A. granosa*, suggesting potential use as species-specific lipid biomarkers.

These statistically significant differences in individual fatty acid composition reinforce the biochemical and nutritional uniqueness of each species. *A. granosa* stands out for its higher SFA and PUFA content, particularly DHA, which is essential for human health. On the other hand, *P. vannamei* shows elevated MUFA levels, notably oleic acid, which may contribute to better oxidative stability in food systems. The exclusive presence of specific fatty acids, such as C4:0 in *P. vannamei* and DHA in *A. granosa*, also offers potential markers for species authentication and dietary traceability.

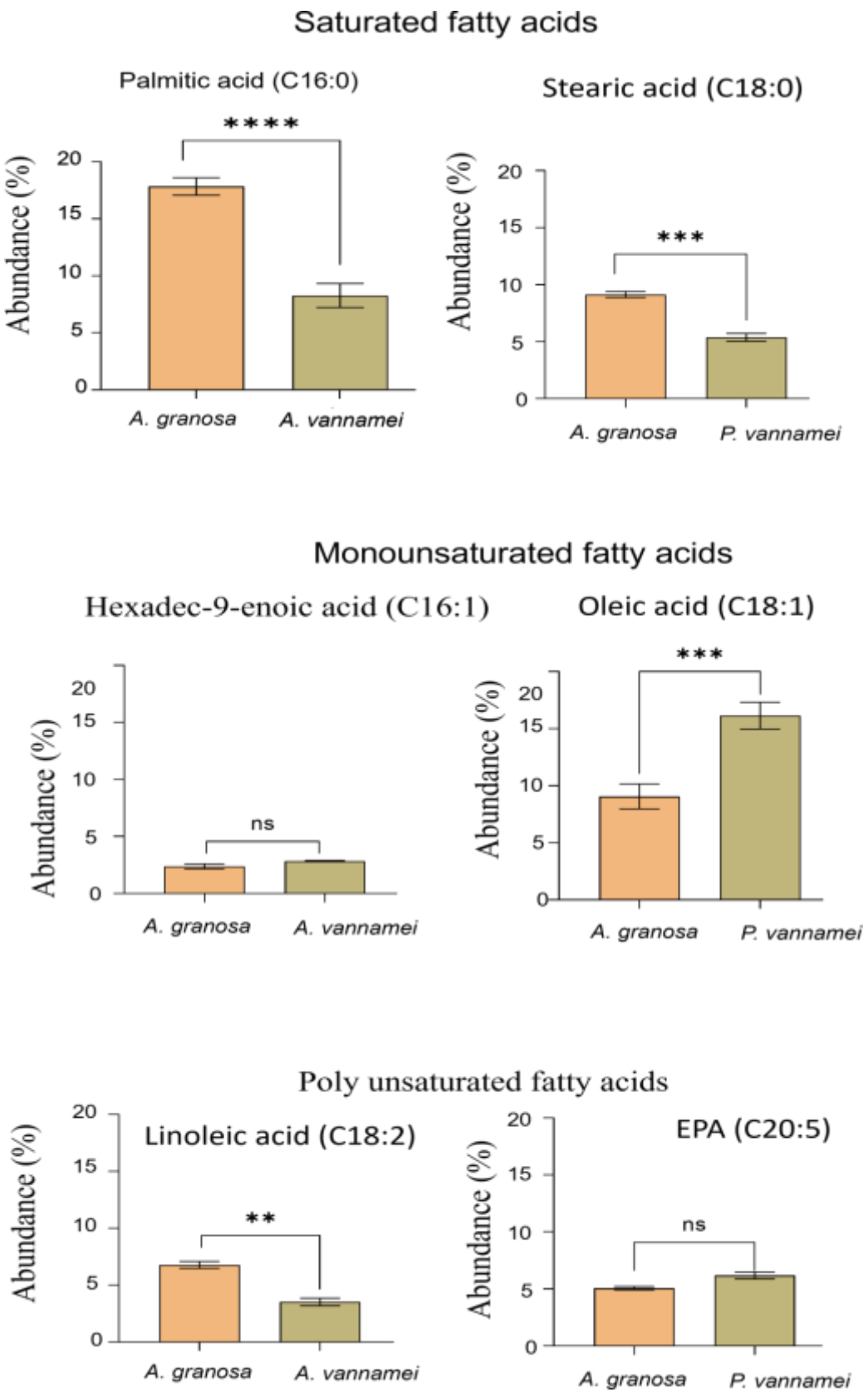

Fig.2: Fatty acid Profiles of *A. granosa* and *P. vannamei* representing the fatty acid composition in the extracts of shrimp specimens.

Table.3 The table below presents the results of statistical comparisons between the fatty acid profiles of Anadara granosa and Penaeus vannamei. Data are expressed as mean percentages based on simulated triplicates. Statistical significance was evaluated using independent t-tests. A p-value less than 0.05 was considered significant.

Fatty Acid	*A. granosa* (%)	*P. vannamei* (%)	p-value	Significance
C3:0	0.067	0.000	6.14×10^{-5}	*
C6:0	0.437	0.000	1.27×10^{-3}	*
C4:0	0.000	8.390	6.53×10^{-4}	*
C3:1	0.576	0.000	1.86×10^{-3}	*
C15:0	1.007	0.000	3.24×10^{-3}	*
C16:0	18.010	8.590	7.68×10^{-5}	*
C17:0	0.000	5.830	1.51×10^{-4}	*
C18:0	9.430	5.660	1.74×10^{-3}	*
C14:1	0.879	0.000	2.24×10^{-4}	*
C16:1	2.480	2.830	2.27×10^{-1}	ns
C18:1	10.190	17.320	3.90×10^{-3}	*
C18:2	6.790	3.230	2.00×10^{-3}	*
C20:5	5.190	6.130	3.76×10^{-3}	*
C22:6	1.140	0.000	2.95×10^{-3}	*

(*) showing significant differences ($p < 0.05$)

Discussion:

This study provides a comparative evaluation of the fatty acid composition of A granosa and *P vannamei*, revealing significant interspecies variation in lipid class distribution and individual fatty acid profiles. These differences reflect species-specific metabolic pathways, dietary influences, and ecological adaptations, with implications for nutrition, aquaculture, and food science.

A granosa exhibited higher levels of Hexadecanoic acid (C16:0) and Octadecanoic acid (C18:0). These fatty acids are known to play crucial roles in energy storage and as structural components of cell membranes (Napolitano et al., 1992).The unique presence of Propanoic acid (C3:0), Hexanoic acid (C6:0), and Methyl tetradecanoate (C15:0) suggests specific metabolic pathways and dietary influences unique to this bivalve species.

P vannamei demonstrated significant levels of Butanoic acid (C4:0) and Heptadecanoic acid (C17:0), which were absent in A granosa. The presence of these fatty acids could be attributed to the diet and aquaculture practices specific to shrimp farming (Saito, 2010).

A granosa contains Tetradec-9-enoic acid (C14:1), which was absent in *P vannamei*, indicating species-specific fatty acid synthesis. Comparable levels of Hexadec-9-enoic acid (C16:1) with Pvannamei suggest similar dietary sources or metabolic capacities for this fatty acid (Kraffe et al., 2004).

P vannamei higher levels of Octadec-9-enoic acid (C18:1), which is beneficial for cardiovascular health, indicate that farmed shrimp may offer specific health benefits related to monounsaturated fatty acids (Dyerberg et al., 1978).

A granosa exhibits a higher percentage of Octadeca-9,12-dienoic acid (C18:2), essential for human health as the body cannot synthesize this fatty acid (Saito, 2008). Presence of Docosa-4,7,10,13,16,19-hexaenoic acid (C22:6), crucial for brain health, underscores the nutritional value of this bivalve in promoting cognitive functions (Nelson et al., 2002).

P vannamei slightly higher levels of Eicosa-5,8,11,14-tetraenoic acid (C20:5), an omega-3 fatty acid known for its anti-inflammatory effects. This makes farmed shrimp a valuable dietary source for

reducing inflammation and promoting heart health (Saito & Hashimoto, 2010).

In *A. granosa*, saturated fatty acids (SFAs) were the dominant class, with palmitic acid (C16:0) accounting for the highest proportion (17.75%). This is consistent with previous studies that report SFA dominance in bivalve mollusks due to their role in structural lipids and energy storage (Sethukalia & Jayasena, 2022). Stearic acid (C18:0) was also present at elevated levels (9.35%), further contributing to the high SFA content. The presence of significant amounts of polyunsaturated fatty acids (PUFAs), including linoleic acid (C18:2) and docosahexaenoic acid (DHA, C22:6), supports the role of A granosa as a nutritionally

valuable seafood source. DHA, in particular, is a critical long-chain n-3 PUFA known for its benefits in cardiovascular and neurological health (Calder, 2015).

In contrast, *P. vannamei* exhibited a markedly different fatty acid distribution. Although SFA remained the dominant class, monounsaturated fatty acids (MUFAs) were substantially higher (~20%), primarily due to oleic acid (C18:1), which accounted for 17.28% of total fatty acids. This observation aligns with previous studies on farmed *P. vannamei*, where dietary lipid sources and controlled environmental conditions favored MUFA accumulation (Jannathulla et al., 2022; Lim et al., 1997). The higher MUFA content may offer advantages in oxidative stability, enhancing the shelf life and processing quality of shrimp products (Boran et al., 2010).

PUFA levels in *P. vannamei* were relatively lower than in *A. granosa*, and DHA was notably absent. This could be attributed to dietary lipid composition and the limited ability of crustaceans to biosynthesize long-chain n-3 fatty acids from shorter precursors (Turchini et al., 2009). The absence of DHA has also been reported in *P. vannamei* populations

raised on plant-based or unfortified diets (Yerlikaya et al., 2013). In contrast, *A. granosa*, which feeds naturally in benthic environments, accumulates higher PUFA levels, including essential fatty acids such as DHA and EPA, further emphasizing its nutritional superiority (Sethukalia & Jayasena, 2022).

A unique finding in this study was the presence of butyric acid (C4:0) exclusively in *P. vannamei* (8.34%). Short-chain fatty acids like butyric acid are rare in marine species profiles and may serve as a metabolic or microbial biomarker for species differentiation. Its presence in shrimp but not in clams may reflect species-specific digestion or microbiome activity, though this warrants further investigation (Muriana et al., 1993).

Recent research comparing different *P. vannamei* populations also highlights variability in fatty acid content depending on genetic lineage and environmental factors.

Out of 15 fatty acids analyzed, 14 showed statistically significant differences ($p < 0.05$), indicating strong species-specific lipid metabolism and composition. This level of significance supports the robustness of the analytical approach and confirms that species identity has a major effect on fatty acid distribution (Turchini et al., 2007). Palmitic acid (C16:0) and stearic acid (C18:0) showed extremely low p-values ($p < 0.001$), reinforcing their differential biosynthesis or accumulation pathways in *A. granosa* versus *P. vannamei*. These results align with prior findings where dominant SFAs exhibited statistically meaningful interspecies variation (Saito & Murata, 1998). Palmitoleic acid (C16:1) was the only fatty acid without significant interspecies difference ($p = 0.227$), suggesting a conserved MUFA biosynthetic role across both molluscs and crustaceans (Glencross et al., 2014). The exclusive detection of C4:0 in *P. vannamei* ($p = 6.53 \times 10^{-4}$) and DHA in *A. granosa* ($p < 0.05$) confirms species specificity, supported by statistical evidence. Such findings validate the use of significance testing in identifying potential lipid biomarkers (Wang et al., 2020). Statistically significant differences in PUFA levels (e.g., EPA and DHA, $p < 0.01$) reflect functional metabolic pathways related to ecological roles and nutritional profiles. These statistically supported differences underline the importance of species selection for targeted human dietary needs (Calder, 2015).

Overall, the higher PUFA content in *A. granosa* especially of essential fatty acids like DHA and linoleic acid supports its functional value in human nutrition. In contrast, the higher MUFA content in *P. vannamei* may enhance its lipid oxidative stability, making it favorable for food processing applications. These findings highlight the importance of fatty acid profiling in evaluating the nutritional quality of aquaculture species and optimizing feed formulation.

Conclusion

A granosa and *P vannamei* both exhibit rich and diverse fatty acid profiles that contribute significantly to their nutritional and health value. A granosa was found to contain 16 distinct fatty acids, including 10 saturated fatty acids, as well as a variety of monounsaturated and polyunsaturated fatty acids. Similarly, *P vannamei* had 15 different fatty acids, comprising both saturated and unsaturated types. In terms of saturated fatty acids, A granosa showed higher levels of Hexadecanoic acid (C16:0) and Octadecanoic acid (C18:0), whereas unique saturated fatty acids like Butanoic acid (C4:0) were detected only in *P vannamei*, suggesting species-specific profiles. Both species contained significant amounts of monounsaturated Hexadec-9-enoic acid (C16:1), with *P vannamei* also exhibiting higher levels of Octadec-9-enoic acid (C18:1), a fatty acid known for its cardiovascular benefits.

When it comes to polyunsaturated fatty acids, A granosa had a higher percentage of Octadeca-9,12-dienoic acid (C18:2), an essential fatty acid that the human body cannot synthesize. Both species were found to contain the omega-3 fatty acid Eicosa-5,8,11,14-tetraenoic acid (C20:5), important for its anti-inflammatory properties, with *P vannamei*

showing slightly higher levels. Notably, A granosa also contained Docosa-4,7,10,13,16,19-hexaenoic acid (C22:6), a crucial fatty acid for brain health that was absent in *P vannamei*. These findings highlight the nutritional strengths of both species. The elevated levels of omega-3 and omega-6 fatty acids in A granosa enhance its value as a dietary component for supporting cardiovascular and brain health. Meanwhile, the presence of unique and beneficial fatty acids in *P vannamei* also underscores its role in promoting a balanced and nutritious diet. Overall, the study affirms that incorporating both A granosa and *P vannamei* into regular dietary intake can provide essential fatty acids vital for maintaining health and preventing chronic diseases.

Acknowledgements:

We would like to express our sincere gratitude to the Department of Science and Technology (DST), Government of India, for their financial support through the DST-Inspire Fellowship program and The Department of Marine Living Resources, Andhra University, has provided the necessary facilities to carry out this research work.

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