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## Study on fatty acids composition of *Pinna nobilis* species collected in the coastal areas of Phan Rang Bay and South Binh Thuan, Vietnam

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### ABSTRACT

The fatty acid composition of *Pinna nobilis* samples collected from Phan Rang Bay and South Binh Thuan, Vietnam, was investigated. A total of 40 fatty acids, with chain lengths ranging from C14 to C24, were identified across the samples. The fatty acid profiles exhibited notable diversity, comprising saturated fatty acids (SFAs), branched-chain saturated fatty acids, monounsaturated fatty acids (MUFAs), and polyunsaturated fatty acids (PUFAs). SFAs accounted for 39.09% of the total fatty acids in the *P. nobilis* sample from Phan Rang Bay, compared to only 7.50% in the South Binh Thuan sample. The MUFA contents were 7.95% and 13.58%, respectively. Notably, the PUFA content was markedly higher in the South Binh Thuan sample (77.48%) than in the Phan Rang Bay sample (43.73%). The predominant fatty acids included 16:0, 18:1n-7, 18:1n-9, 16:1n-9, eicosapentaenoic acid (EPA, 20:5n-3), docosahexaenoic acid (DHA, 22:6n-3), and arachidonic acid (AA, 20:4n-6). Among these, DHA was the most abundant fatty acid in both samples, representing 16.39% and 29.30%, respectively. The total omega-3 (n-3) fatty acid content ranged from 22.89% to 51.07%, while the omega-6 (n-6) fatty acid content ranged from 20.84% to 26.41%, yielding favorable n-3/n-6 ratios of 1.10 and 1.93. These findings indicate that *P. nobilis* from these regions is a highly nutritious marine resource rich in essential fatty acids with an optimal n-3/n-6 ratio. Consequently, it holds significant economic value and high potential for future commercial exploitation and functional food development.

**Keywords:** *Pinna nobilis*, fatty acids, Phan Rang Bay, South Binh Thuan.

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## Introduction

Lipids play a fundamental role in bivalve physiology, functioning as energy reserves, structural components of cellular membranes, and precursors of bioactive signaling molecules, thereby contributing to growth, reproduction, and adaptation to environmental variability [1, 2]. The fatty acid composition of lipids is a key biochemical characteristic of bivalves and has been widely applied as a trophic and ecological indicator.

Bivalves are particularly rich in long-chain polyunsaturated fatty acids (PUFAs), especially omega-3 fatty acids such as eicosapentaenoic acid (EPA, 20:5n-3) and docosahexaenoic acid (DHA, 22:6n-3), which are primarily derived from microalgae and transferred through the food web [3, 4]. For instance, in *Beguinia semiorbiculata* collected from Nam Du and Phu Quoc Islands (Kien Giang Province, Vietnam), the dominant PUFAs were C20 and C22 fatty acids, mainly belonging to the n-3 and n-6 series. The n-3/n-6 ratios ranged from 1.08 to 1.26, values considered optimal for the prevention of chronic diseases [5, 6]. Fatty acid profiles in bivalves are strongly influenced by diet, species, habitat, and seasonal variability, reflecting changes in phytoplankton communities and environmental conditions [7].

*Pinna nobilis* is a marine bivalve mollusk (Bivalvia: Pinnidae) capable of reaching up to 120 cm in length, making it one of the largest bivalves globally. A comprehensive review of the biology and conservation status of *P. nobilis* was previously provided by Basso et al. [8]. In various regions, *P. nobilis* is highly regarded as a culinary delicacy and is frequently incorporated into premium gastronomy. Beyond its culinary value, *P. nobilis* exhibits significant potential in pharmaceutical and cosmeceutical applications, including functional foods, antibacterial agents, and skincare formulations. The antioxidant properties of *P. nobilis* extracts can protect cells from oxidative stress induced by free radicals, thereby reducing the risk of chronic conditions such as cardiovascular diseases, cancer, and skin aging.

Nutritionally, *P. nobilis* is a dense resource characterized by high protein content, high-

quality lipids, and essential vitamins and minerals. A previous study by Trinh et al. reported that the total lipid content of this species was approximately 1.82%, with polar lipids and monoalkyldiacylglycerols as the major components [9]. Although the overall lipid yield is relatively low, the nutritional quality of these lipids is exceptional, primarily due to an abundance of omega-3 fatty acids and B vitamins [10]. Research has demonstrated that the omega-3 fatty acids present in *P. nobilis* possess notable anti-inflammatory properties, which may aid in the management of chronic inflammatory conditions such as arthritis and enteritis. Furthermore, *P. nobilis* contains natural antimicrobial peptides capable of inhibiting or eradicating pathogenic bacteria. This highlights its potential for the development of novel antibacterial therapeutics, a critical need amidst the current antimicrobial resistance crisis [11]. Moreover, several studies examining stress responses in *P. nobilis* have utilized lipid peroxidation as a key biochemical marker, underscoring the importance of lipid-based biomarkers in assessing environmental and physiological stressors [12].

Similar to many other marine organisms, the lipid and fatty acid profiles are critical biochemical indices for *P. nobilis*. In the present study, we investigated the composition and content of fatty acids in two *P. nobilis* populations collected from the coastal areas of Phan Rang Bay and South Binh Thuan. This research aims to provide a fundamental biochemical baseline for future investigations into the biological activities of this species, thereby supporting its potential application in health-oriented and commercial products.

## Materials and methods

### Materials

Two samples of *P. nobilis* were collected in Phan Rang Bay in May 2023 and in South Binh Thuan in June 2023 (Fig. 1). Hua Thai Tuyen identified the specimen's names at the Nha Trang Institute of Oceanography. The specimens are kept at the Nha Trang Institute of Oceanography.

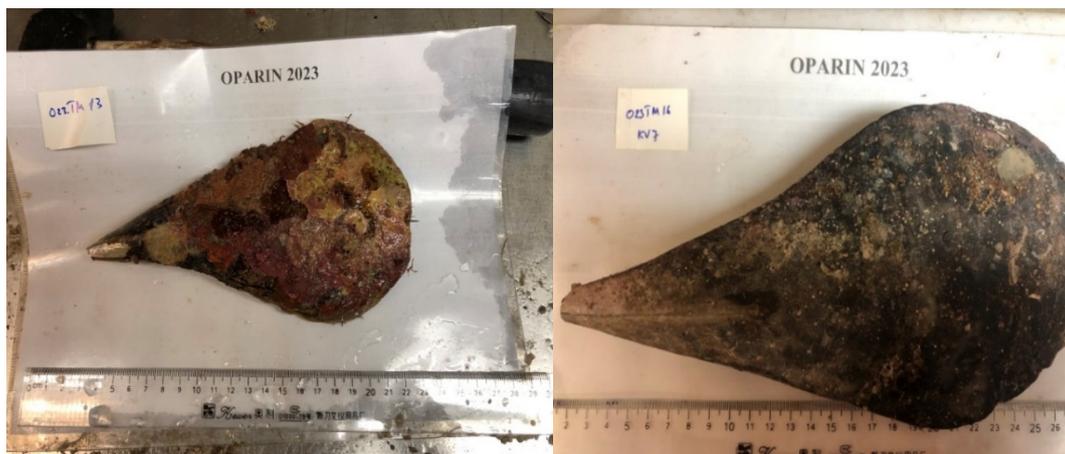


Figure 1. *Pinna nobilis* samples collected in Phan Rang Bay (left) in 2023 and in South Binh Thuan (right)

## Methods

The total lipids of the samples were extracted according to the Folch J. F method, using a solvent system of  $\text{CHCl}_3$ :MeOH in a ratio of 2:1 by volume [13]. The total lipid extract was methylated to its methyl ester form using 2%  $\text{H}_2\text{SO}_4$ /MeOH 2% at 80°C for 2 h. The resulting mixture was dissolved in n-hexane, and the fatty acid methyl ester mixture was purified on a thin-layer plate using the solvent system n-hexane:Et<sub>2</sub>O (85:15, by volume) [14]. The fatty acid methyl ester mixture was dissolved in n-hexane and analyzed on a gas chromatograph (GC) and a gas chromatograph-mass spectrometer (GC-MS) (Shimadzu, Kyoto, Japan) using the NIST standard spectrum library for comparison.

## Results

### Composition and content of fatty acids in total lipid

The results obtained on the composition and content of fatty acids in two *P. nobilis* samples were diverse (Table 1).

Fatty acids are essential because they affect the taste, preservation, and nutritional value of *P. nobilis*, as well as its potential uses. In both samples, 40 fatty acids were identified, ranging from C14 to C24. The fatty acid composition was diverse, including saturated fatty acids, branched-

chain saturated fatty acids, monounsaturated fatty acids, and polyunsaturated fatty acids. The chromatograms of the fatty acid composition analyzed by GC-MS are shown in Figures 2 and 3.

The two samples studied have similar fatty acid compositions; however, the fatty acid content in each sample differs significantly. Figure 4 shows the distribution ratio of fatty acid groups between the two *P. nobilis* samples collected at the two locations.

### Saturated fatty acids (SFAs)

According to the analysis results, the content of saturated fatty acids (SFAs) in the *P. nobilis* sample collected in Phan Rang Bay accounted for 39.09% of total fatty acids, while this value in the sample from South Binh Thuan was 7.5%. The SFAs content in the two previously studied *P. nobilis* samples collected in Mat Cat - Hon Me and Vinh Kim - Ran Da was 69.68 and 13.94%, respectively [15].

In the *P. nobilis* sample collected from Phan Rang Bay, hexadecanoic acid (16:0) was the saturated fatty acid with the highest proportion compared to other saturated fatty acids, with a content of 19.83% of total fatty acids, followed by stearic acid (18:0) with a content of 11.2%. Tetradecanoic acid (14:0) and heptadecanoic acid (17:0) accounted for a small proportion, 2.06%, and 3.41%, respectively. In addition, branched-chain saturated fatty acids in the form of iso and anteiso were also present, with a total content of about 1.5%. These fatty acids were not present in the sample collected from South Binh Thuan. The amount of saturated

fatty acids in the sample from South Binh Thuan was more diverse than that of the sample from Phan Rang Bay. The saturated fatty acids composition was relatively low in the sample from South Binh Thuan; the fatty acid content of

hexadecanoic acid (16:0) and stearic acid (18:0) only accounted for 4.62% and 0.6% of total fatty acids. Other saturated fatty acids in the sample accounted for tiny amounts, less than 2% of total fatty acids (Fig. 5).

Table 1. Composition and content of fatty acids in total lipid of *P. nobilis* samples

No.	Fatty acids	Total lipid (%)		No.	Fatty acids	Total lipid (%)	
		Phan Rang Bay	South Binh Thuan			Phan Rang Bay	South Binh Thuan
1	14:0	2.06	1.84	22	20:0	0.15	-
2	15:0	0.55	0.18	23	20:1n-7	0.52	0.2
3	15:0 eiso	0.97	-	24	20:1n-9	1.49	0.94
4	15:0 antieiso	0.06	-	25	20:2n-6	0.78	0.75
5	16:0	19.83	4.62	26	20:3n-6	0.1	0.29
6	16:1n-7	0.14	0.7	27	20:4n-3	0.27	1.08
7	16:1n-9	1.64	5.07	28	20:4n-6 (AA)	7.1	12.07
8	16:2n-6	0.31	0.71	29	20:5n-3 (EPA)	3.6	13.93
9	16:3n-3	0.1	0.3	30	21:0	0.05	-
10	16:4n-3	0	0.43	31	22:0	0.1	-
11	17:0	3.41	0.26	32	22:2n-6	4.44	1.67
12	17:0 eiso	0.2	-	33	22:3n-6	1.92	1.06
13	18:0	11.2	0.6	34	22:4n-6	2.53	2.04
14	18:1n	0.07	0.19	35	22:5n-3	1.29	1.83
15	18:1n-7	0.96	1.24	36	22:5n-6	2.01	2.65
16	18:1n-9	3.13	4.81	37	22:6n-3 (DHA)	16.39	29.3
17	18:2n-6	1.29	4.09	38	24:0	0.05	-
18	18:3n-6	0.12	0.53	39	24:4n-6	0.24	0.55
19	18:4n-3	1.08	3.76	40	24:5n-3	0.16	0.44
20	18:0 eiso	0.27	-	41	Others	9.23	1.87
21	19:0	0.19	-				

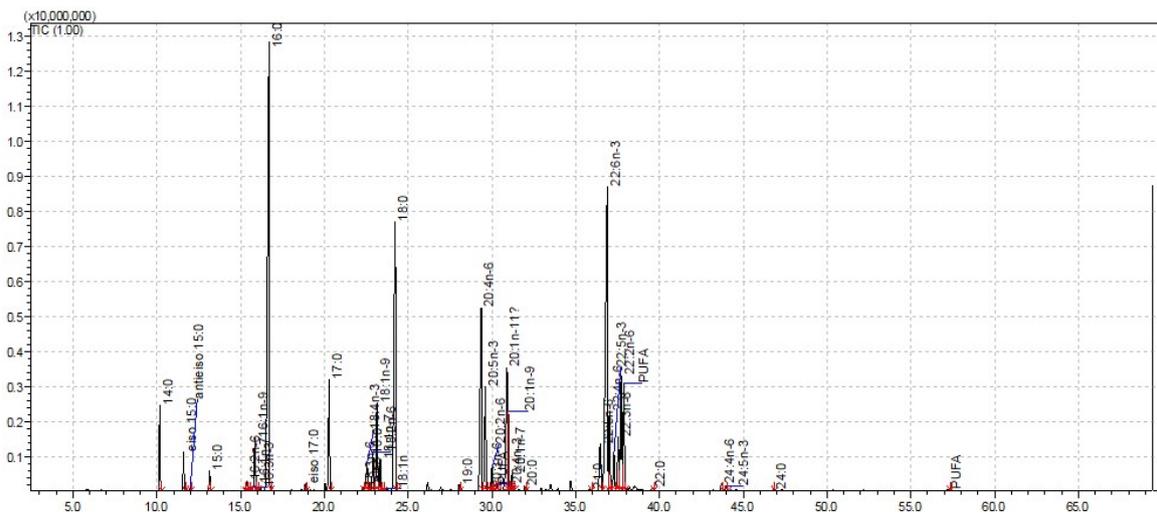


Figure 2. Chromatogram of fatty acids in *P. nobilis* collected in Phan Rang Bay

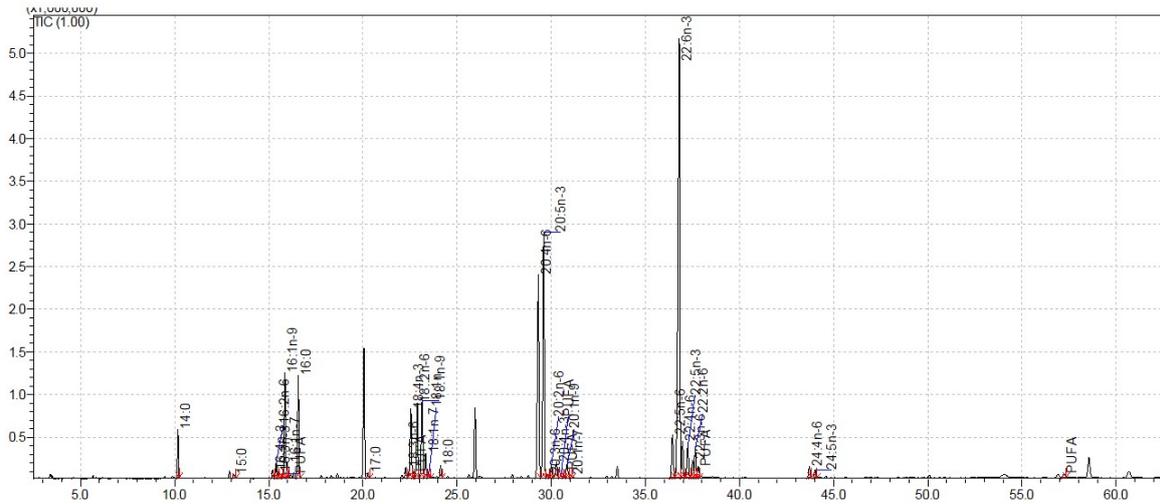


Figure 3. Chromatogram of fatty acids in *P. nobilis* collected in South Binh Thuan

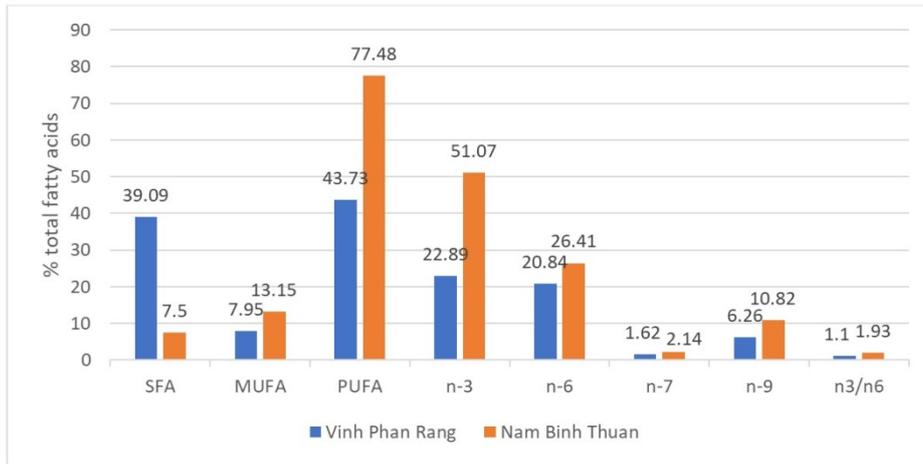


Figure 4. Contents of fatty acids SFAs, MUFAs, PUFAs, n-3, n-6, n-7, n-9 and n-3/n-6 ratio of two *Pinna nobilis* samples

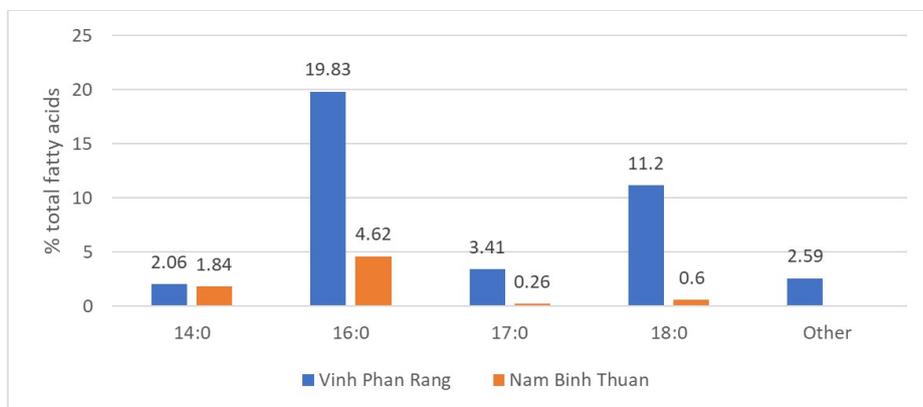


Figure 5. The SFAs content in two *P. nobilis* samples

Monounsaturated fatty acids (MUFAs)

Monounsaturated fatty acids are present in the n-7 and n-9 types. The MUFA content in the total lipids of the two *P. nobilis* samples from Phan Rang Bay and South Binh Thuan was 7.95% and 13.58%, respectively. In the Phan Rang Bay sample, the fatty acid 18:1n-9 has the highest content (3.13% of total fatty acids); other fatty acids are present in minor content,

less than 2% of total fatty acids. In the South Binh Thuan sample, 16:1n-9 is the fatty acid with the highest content (5.07% of total fatty acids), and the ratio of 18:1n-9 fatty acid is 4.81% of total fatty acids. The monounsaturated fatty acids with the highest content in samples collected from Mat Cat - Hon Me and Vinh Kim - Ran Da were also 16:1n-9 and 18:1n-9, respectively (Fig. 6) [15].

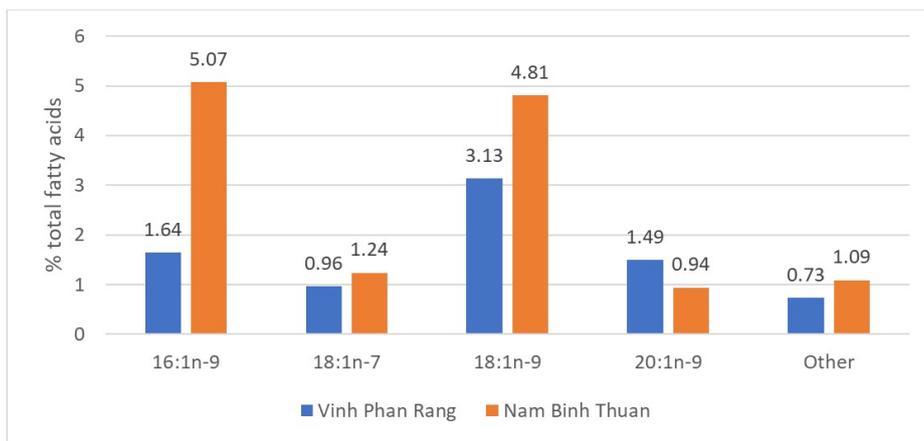


Figure 6. MUFAs content in two *P. nobilis* samples

- Omega-7 (n-7) fatty acids

In the *P. nobilis* sample collected from Phan Rang Bay, the total omega-7 fatty acid content was 1.62%, with 18:1n-7 as the highest component, accounting for 0.96% of total fatty acids. In the sample collected from South Binh Thuan, the total omega-7 fatty acid content was 2.14%; the highest component was 18:1n-7, accounting for 1.24% of total fatty acids.

- Omega-9 (n-9) fatty acids

Both *P. nobilis* samples collected in Phan Rang Bay and South Binh Thuan have total omega-9 fatty acid contents of 6.26% and 10.82%, respectively. The specific omega-9 fatty acid that had the highest content in the sample collected from Phan Rang Bay, 18:1n-9, accounted for 3.13%. Meanwhile, in the sample collected from South Binh Thuan, 16:1n-9 accounted for 5.07%.

Polyunsaturated fatty acids (PUFAs)

PUFAs represented the largest fraction of total fatty acids in both samples, particularly in the South Binh Thuan sample. The total PUFA content reached 77.48% in the South Binh

Thuan sample, compared with 43.73% in the Phan Rang Bay sample (Fig. 4).

- Omega-3 (n-3) fatty acids

The total content of omega-3 fatty acids in the *P. nobilis* sample from Phan Rang Bay was 22.89% of total fatty acids. Of which, docosahexaenoic fatty acid (DHA 22:6n-3) accounted for 16.39%, followed by eicosapentaenoic fatty acid (EPA 20:5n-3) with 3.6% of total fatty acids. In the sample collected from South Binh Thuan, the total content of omega-3 fatty acids was 51.07%, with the highest fatty acid being DHA (22:6n-3) at 29.3%, followed by 20:5n-3 at 13.93%. DHA 22:6n-3 was also the fatty acid with the highest content among the PUFAs of the two studied samples (Fig. 7). The presence of n-3 fatty acids in both samples was significant as the two important omega-3 fatty acids for the human body, EPA and DHA, both accounted for an impressive proportion in both *P. nobilis* samples. Other omega fatty acids present in the two samples were 16:3n-3, 16:4n-3, 18:4n-3, 20:4n-3, 22:5n-3, and 24:5n-3, of which 16:4n-3 was only found

in the sample from South Binh Thuan (0.43% of total fatty acids) and was not present in the sample collected in Phan Rang Bay.

- Omega-6 (n-6) fatty acids

In the sample collected from Phan Rang Bay, the total content of omega-6 fatty acids was 20.84%, the highest being arachidonic acid (AA 20:4n-6) with a content of 7.1% of total

fatty acids (Fig. 7). In the sample collected from South Binh Thuan, the total content of omega-6 fatty acids was 26.41%, and the content of arachidonic fatty acid was 12.07% of total fatty acids. Other omega-6 fatty acids were 16:2n-6, 18:2n-6, 18:3n-6, 20:2n-6, 20:3n-6, 22:2n-6; 22:3n-6, 22:4n-6, 22:5n-6 and 24:4n-6, present in both samples.

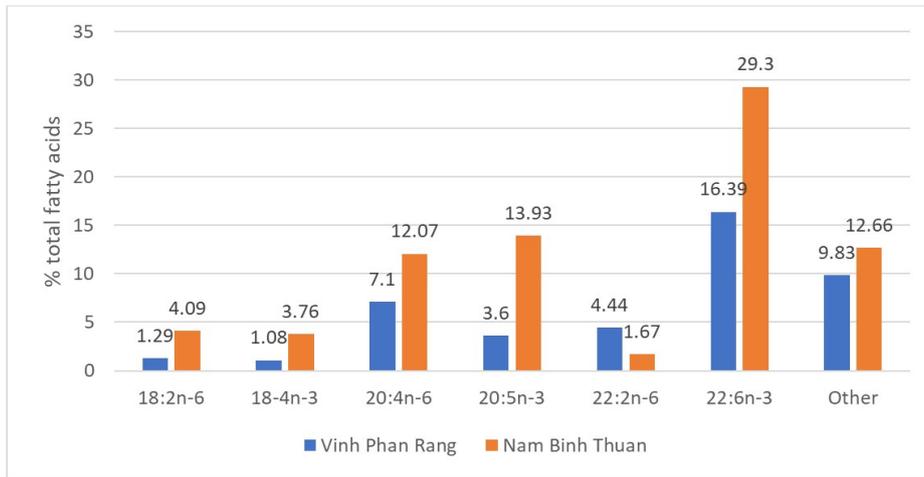


Figure 7. Some polyunsaturated fatty acids omega-3 and omega-6 of two *P. nobilis* samples

The ratio of n-3/n-6

In this study, the n-3/n-6 ratio in total lipids of *P. nobilis* samples collected in Phan Rang Bay was 1.1; the ratio of the sample collected from South Binh Thuan was 1.93. These values are at a good index level, with a diverse and rich composition of omega-3, omega-6 fatty acids as well as other fatty acids. Thus, *P. nobilis* species collected in this area could be a very nutritious health food.

Discussion

This study shows that *Pinna nobilis* samples collected from coastal areas of South-Central Vietnam contain a diverse range of fatty acids, including saturated, monounsaturated, and polyunsaturated fatty acids. Although the overall fatty acid profiles of the two samples were qualitatively similar, clear quantitative differences were observed, particularly in the proportions of SFAs and PUFAs. Such spatial variation in fatty

acid composition has frequently been reported in marine bivalves and is associated with differences in environmental conditions, food sources, and biological factors such as body size and reproductive status [10].

Saturated fatty acids represent an essential component of lipid metabolism. In animal tissues, lipids are primarily stored as triglycerides and serve as an important energy reserve during periods of limited food availability. In addition, SFAs contribute to the structural stability of cellular membranes. Nevertheless, excessive dietary intake of saturated fatty acids has been associated with elevated cholesterol levels and an increased risk of cardiovascular diseases, therefore, their consumption is generally recommended to be moderated [16]. In the present study, the higher SFA content recorded in the Phan Rang Bay sample may reflect habitat-specific conditions, including sediment characteristics, hydrodynamic regimes, and local trophic structure. The occurrence of branched-chain SFAs only in this sample could also indicate

differences in microbial contributions to the diet, since such fatty acids are commonly associated with bacterial lipids.

Monounsaturated fatty acids were also detected in considerable amounts in both samples. Among them, omega-9 fatty acids such as oleic acid (18:1n-9) and omega-7 fatty acids such as palmitoleic acid (16:1n-7) are known to play beneficial physiological roles. Oleic acid, in particular, has been widely recognized for its potential cardioprotective effects. Palmitoleic acid has also attracted attention due to its possible involvement in glucose–lipid metabolism and mucosal health [17, 18]. Some studies further suggest that omega-7 fatty acids may contribute to improved insulin sensitivity and favorable lipid profiles, including reduced triglycerides and LDL cholesterol and increased HDL cholesterol [19, 20]. Unlike omega-3 and omega-6 fatty acids, omega-7 and omega-9 fatty acids can be synthesized in the human body; however, they still play an important role in maintaining lipid balance and metabolic regulation [21].

A contrasting pattern was observed for polyunsaturated fatty acids. The South Binh Thuan sample exhibited a notably higher PUFA content, especially long-chain n-3 PUFAs. This variation may reflect differences in local food availability, particularly the contribution of planktonic organisms that are naturally rich in PUFAs. Polyunsaturated fatty acids are widely recognized for their nutritional and biomedical significance, as they have been associated with anti-inflammatory, anticancer, anti-obesity, and cardioprotective effects [22].

Among the detected PUFAs, docosahexaenoic acid (DHA, 22:6n-3) and eicosapentaenoic acid (EPA, 20:5n-3) were the most abundant components in both samples, with DHA representing the predominant fatty acid. Omega-3 fatty acids are essential nutrients because humans possess a limited capacity for their de novo synthesis and therefore depend largely on dietary sources. The principal omega-3 fatty acids in marine ecosystems include  $\alpha$ -linolenic acid (ALA), EPA, and DHA. EPA has been linked to cardiovascular protection through the regulation of eicosanoid production, which can reduce platelet aggregation and lower the risk of

thrombosis and atherosclerosis. Furthermore, DHA is a major structural component of neuronal membranes and plays a crucial role in brain and visual development. It constitutes a significant proportion of the lipids in both the brain gray matter and the retina [23, 24].

The relatively high content of arachidonic acid (AA, 20:4n-6) observed in both samples is also noteworthy. AA serves as a key precursor for eicosanoids involved in immune regulation and inflammatory responses, and its presence alongside high levels of n-3 PUFAs suggests a balanced and physiologically relevant fatty acid profile. Similar coexistence of high AA and n-3 PUFA contents has been documented in other marine bivalves from Vietnamese waters, indicating that these species may provide a broad spectrum of essential fatty acids.

The n-3/n-6 ratios obtained in this study were 1.10 and 1.93. Previous studies have demonstrated that maintaining a balanced n-6/n-3 PUFA ratio is associated with improved glucose tolerance, reduced obesity, decreased inflammation, and a lower risk of metabolic disorders [25]. According to the World Health Organization (WHO), an n-3/n-6 ratio of  $\geq 0.1$  is considered beneficial for human health. Excessive intake of omega-6 polyunsaturated fatty acids has been linked to an increased risk of cardiovascular diseases, cancer, and inflammatory and autoimmune disorders, whereas omega-3 fatty acids exert protective effects against these conditions [26]. Furthermore, European nutrition guidelines recommend that this ratio should not exceed 5 to reduce the risk of inflammatory, cardiovascular, and neurological disorders [27].

The variations in fatty acid composition observed between the two sampling sites may be attributed to differences in habitat conditions, environmental characteristics, and individual biological traits. Because the samples were collected in different summer months (May and June), seasonal fluctuations likely influenced the fatty acid profiles. Such variations have been widely reported in bivalves, particularly during periods of gametogenesis when lipids are mobilized to support reproductive development. Additionally, according to Mirjana Najdek et al. (2012), the contents of saturated and monounsaturated

fatty acids decrease with increasing individual size, whereas the PUFA content tends to increase [28]. This relationship between size, maturity, and PUFA accumulation—especially n-3 PUFAs—in marine invertebrates may partly explain the elevated PUFA levels observed in the South Binh Thuan sample.

Overall, the present results indicate that *P. nobilis* from both Phan Rang Bay and South Binh Thuan is a rich source of biologically and nutritionally important fatty acids. The observed variability in fatty acid composition highlights the importance of considering environmental conditions, trophic factors, and biological characteristics when evaluating the lipid profiles of marine organisms. These findings provide a valuable scientific baseline for future studies on seasonal dynamics, ecological adaptation, and the sustainable exploitation of *P. nobilis* as a functional food and a potential source of bioactive lipids.

## Conclusion

In conclusion, while the *P. nobilis* samples collected from the coastal areas of Phan Rang Bay and South Binh Thuan exhibited qualitative similarities in their overall fatty acid profiles, significant quantitative differences were observed between the two locations. Both populations demonstrated a diverse fatty acid composition characterized by substantial amounts of omega-3 and omega-6 polyunsaturated fatty acids, particularly the essential fatty acids DHA, EPA, and AA. Coupled with an optimal n-3/n-6 ratio, these findings indicate that *P. nobilis* from these regions possesses excellent nutritional quality and health-promoting benefits. Consequently, it represents a marine resource of high economic value that warrants sustainable exploitation and further research for functional food and nutraceutical development.

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