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Proximate composition, fatty acid profile, vitamin and mineral composition of marine neogastropod *Melo melo* (Lightfoot, 1786)

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Abstract
Proximate composition, fatty acid profile, vitamins and mineral composition of edible tissue and hepatopancreas of *Melo melo* of Puducherry coastal waters of India was evaluated. The average protein content of edible tissue of *Melo melo* was found to be high (23.62± 0.03%) than the hepatopancreas (16.37± 0.02%). The study revealed the presence of 24 fatty acids where the saturated fatty acids of edible tissue constitute 51.38% and hepatopancreas remain 72.31%. Among the 15 SFA, the palmitic acid, stearic acid and arachidic acid were found to be predominant. The gamma-linolenic acid and EPA were found to be high in PUFA. Presence of vitamin C, vitamin B3 and vitamin B12 in high concentration in both edible tissue and hepatopancreas demonstrate the antioxidant and erythropoietic properties. Macro and microminerals found to be in appreciable quantities in both edible tissue and hepatopancreas. The Na/K ratio remains less than 1.5. Therefore, the present study provides valuable information about *Melo melo* as a potential health food, highlighting its importance and advocating for its inclusion in regular human diets.

Keywords: *Melo melo*, neogastropod, beggar's bowl, proximate composition, fatty acid profile

Introduction

As the human population grows, there is an increasing demand for food resources that are not only high in protein but also with medicinal value. This demand has spurred the exploration of underutilised or unconventional resources of marine organisms. Marine organisms, due to their diversity and abundance, form a vital source of food with high nutritional value, health benefits and therapeutic pluralities, gaining impulse as an attractive field of research. The nutritional quality of finfish and shell fish (crustaceans and molluscs) is similar and provides a righteous combination of amino acids, fatty acids, vitamins and minerals than that in meat and dairy products. Shell fish especially molluscs are an important animal groups which interacted intimately both culturally and commercially with indigenous people of coastal nations. Mollusca is the second largest animal phylum, with more than 52000 fully characterised species, constituting about 7% of all marine organisms which indicates the broad spectrum of diversity (Khan and Liu, 2019; Boulajfene, 2022) [17, 6]. The phylum Mollusca is classified into Monoplacophora, Aplacophora, Polyplacophora, Bivalvia, Scaphopoda, Gastropoda, and Cephalopoda based upon their phylogenetic analysis (Haszprunar & Wanninger, 2012; Pechenik, 2014) [12, 23]. Among the seven classes of these soft-bodied invertebrates, bivalves (oysters, scallops, mussels, and clams), cephalopods (octopus, squid, and cuttlefish), and gastropods (whelks, sea-snail, abalone, and cockle) represent the economically significant molluscs (Venugopal and Gopakumar, 2017) [32]. Molluscs provide an inexpensive source for animal protein, fatty acids, vitamin B complex and minerals. Minerals are crucial for human nutrition as they are vital components of bones and soft tissues, and also serve as co-factors and co-activators in various enzymatic reactions (Thivakaran, 1998) [31].

Marine molluscs are playing a crucial role in traditional medicine in China, India and Middle East to treat various human ailments. The crude or semi-purified extracts of marine molluscs are used as nutraceuticals (Chin *et al*., 2006) [9]. The secondary metabolites described from the various molluscan species exhibiting anticancer, antioxidant, antibacterial and antiviral activities. The limited consumption of molluscs, especially gastropods, is mostly attributed to individuals' conservative eating habits and a lack of awareness regarding the nutritional content of these organisms. Understanding the nutritional profile of every species is crucial for human consumption (Palpandi *et al.*, 2010) [7]. Therefore, the present study was carried out to investigate the proximate composition, fatty acid profile, vitamin and minerals of *Melo melo* to ascertain its importance and inclusion in human diets.

Materials and Methods

Sample Collection

The fresh samples of *Melo melo* were collected from Thengaithittu fish landing centre, Puducherry (Latitude 11°54'42.08"N and longitude 79°49'3.57"E) during June and October 2022.

Sample preparation

Immediately after collection, the specimens were brought to the laboratory and washed with running water. The shells were cracked using hammer and the soft tissues such as mantle, visceral mass, foot (edible tissue), and hepatopancreas were excised and kept in the hot air oven at 55 °C (Constant temperature) for one hour. The dried edible tissue (sample 1) and hepatopancreas (sample 2) were powdered separately using a mortar and pestle and stored at 0 °C for further analysis.

Proximate composition

The total protein (Kjeldahl, 1883) [18], lipid (Folch *et al.*,1957) [11], carbohydrate (Hedge *et al.*, 1962) [13], moisture, ash and fatty acids (AOAC, 2015) [4] of *Melo melo were* analysed.

Vitamin analysis

The water-soluble vitamins (B1, B2, B6, B12, and C) and fat-soluble vitamins (A, D, E, and K), were analysed using the method reported by Sadasivam and Manickam (Sadasivam *et al*., 1996) [27]. Folic acid was quantified using Sethi's calorimetric method (Sethi, 1997) [29].

Mineral analysis

The mineral composition of *Melo melo were* analysed after microwave-assisted acid digestion by Inductively Coupled Plasma Mass Spectrometry and expressed in mg/kg (AOAC.2015) [4].

Results and Discussion

The proximate composition *viz.* moisture, protein, lipid, carbohydrate and ash of the edible tissue and hepatopancreas of *Melo melo* were presented in Table 1. In the present study, the moisture content in the hepatopancreas and edible tissue was 76.03± 0.04 and 72.58± 0.05% respectively. The values of the present study were very well compared to the moisture content ranged from 76.55 ± 2.26 to 83.48 ± 1.84% reported in the body tissues of *Cymbium melo* (Palpandi et.al. 2010) [7]. In general, aquatic organisms have a high-water content to maintain osmotic pressure ensuring cellular stability and metabolic functions. The average protein content of edible tissue of *Melo melo* was found to be 23.62± 0.03% and 16.37± 0.02% in the hepatopancreas. The present investigation was in good agreement with the protein content of 23.6% in the mantle of *Rapana rapiformis,* reported by Rajkumar, (1995), and the observation made by Babu *et al*. (2010) [5], who reported 22.1% in the foot, 19.25% in the mantle, 27.95% in the gonad, and 24.18% in other body tissues of *Babylonia spinosa.*

Table 1: Proximate composition of *Melo melo*

Parameter	Content in % Mean ± SD	
	Edible tissue	Hepatopancreas
Moisture	72.58± 0.05	76.03± 0.04
Protein	23.62± 0.03	16.37± 0.02
Lipid	1.13± 0.01	2.44 ± 0.05
Carbohydrates	0.44± 0.02	0.98± 0.01
Ash	2.23± 0.04	4.18 ± 0.03

The present study revealed that the lipid constituted a minor fraction when compared to the moisture and protein. The hepatopancreas of *Melo melo* exhibited 2.44 ± 0.05% and the edible tissue recorded 1.13± 0.01%. Saravanakumar (1998) [28] reported that the mantle of *M. meretrix* possesses the highest lipid content of 4.38% and Soma Saha (2004) [30] reported that the visceral mass of *K. opima* exhibited the lipid content at 3.94%. In contrast, *Donax cuneatus* gastrointestinal diverticula showed the highest lipid content at 8.3% (Rajan, 1987) [25]. Lipids exhibit a remarkable efficiency in energy provision, containing over twice the energy content found in carbohydrates and proteins. Lipids are a vital source of essential fatty acids, crucial for healthy growth (Ponnusami, 1997) [24]. The value of the lipid content shows considerable variation across various species and organs due to various factors like habitat alterations and other influences (Kunusaki, 2000) [19].

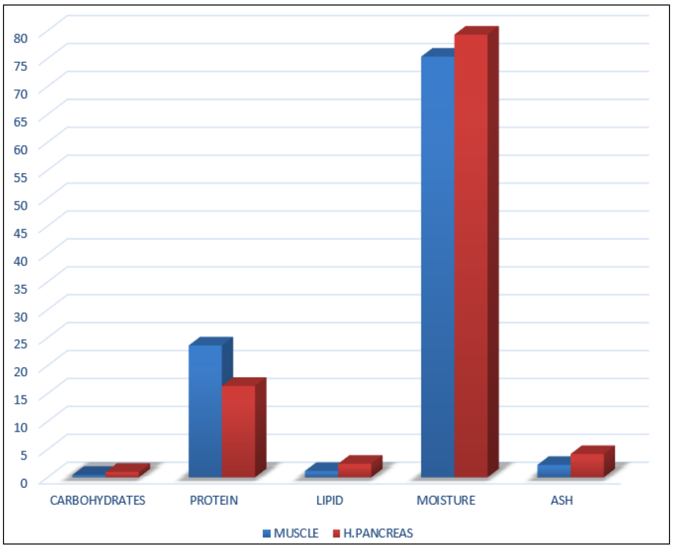

Fig 1: Proximate composition of various body parts of M. melo

The carbohydrate content in hepatopancreas was 0.98± 0.01% when compared to edible tissue (0.44± 0.02%). The differences in carbohydrate content could be linked to the storage and further use of glycogen at various stages of life. Generally, the carbohydrate is stored as glycogen in hepatopancreas as reserves and may be utilized under unfavourable conditions (Ansari *et al*., 1981) [3]. The regulation of proximate composition including protein, carbohydrate and fat is primarily governed by the type of food and feeding behaviour, reproductive cycles and ageing processes of organisms. The ash content in the edible tissue and hepatopancreas of *Melo melo* were 2.23± 0.04 and 4.18 ± 0.03% respectively. Swapnaja have reported the ash content of *M. meretrix* varied from 6.77% to 22.25% at Ratnagiri coast and a similar range of value was observed in *Gafrarium divaricatum* at Mumbai coast by Eswar.

The fatty acid profile of the edible tissue and hepatopancreas of *Melo melo* (Table 2) revealed the presence of 24 fatty acids belonging to saturated fatty acids (SFA), monounsaturated fatty acids (MUFA), polyunsaturated fatty acids (PUFA), and trans fatty acid (TFA). The saturated fatty acids of edible tissue and hepatopancreas constitute 51.38% and 72.31% respectively. Among the 15 saturated fatty acids of edible tissue and hepatopancreas of *Melo melo*, the palmitic acid was found to be 16.29% and 18.73% respectively. Palmitic acid played an important role in the regulation of physical properties of cell membrane, biosynthesis of palmitoylethanolamide and surface-active agent "surfactant" synthesis in the alveoli of the lungs. But the role of palmitic acid has been focused negatively for a long period as an agent detrimental to health, shadowing its remarkable physiological functions (Kavipriya and Ravitchandirane, 2021) [15]. The arachidic acid (17.37%) and stearic acid (14.25%) were also found significantly in hepatopancreas and served as a source of stored energy in the form of triglycerides and responsible for increasing the low-density lipoprotein.

Table 2: Percentage composition of fatty acids of *M.melo*

Sl. No.	Fatty acids	Edible tissue	Hepatopancreas
Saturated Fatty acids (SFA)			
1.	C4:0 (Butyic acid)	1.53	-
2.	C8:0 (Caprylic acid)	-	0.94
3.	C10:0 (Capric acid)	-	0.68
4.	C11:0 (Undeccanoic acid)	1.80	-
5.	C12:0 (Lauric acid)	-	0.90
6.	C13:0 (Tridecanoic acid)	-	1.65
7.	C14:0 (Myristic acid)	3.47	-
8.	C15:0 (pentadecanoic acid)	2.02	-
9.	C15:1(Cis-10-pentadecanoic acid)	4.90	-
10.	C16:0 (Palmitic acid)	16.29	18.73
11.	C17:0 (Heptadecanoic acid)	5.44	2.75
12.	C18:0 (Stearic acid)	6.99	14.25
13.	C20:0 (Arachidic acid)	8.94	17.37
14.	C22:0 (Behenic acid)	-	10.0
15.	C24:0 (Lignoceric acid)	-	-
Total		51.38	72.31
Mono-unsaturated fatty acids (MUFA)			
16.	C16:1 (Palmitoleic acid)	5.10	-
17.	C18:1 (Oleic acid)	7.12	2.16
18.	C22:1 (Erucic acid)	10.01	1.68
19.	C24:1 (Nervoric acid)	-	4.59
Total		22.23	8.43
Poly-unsaturated fatty acids (PUFA)			
20.	C18:3 (Alpha-linolenic acid)	7.57	2.82
21.	C18:3(Gamma-linolenic acid)	16.31	0.50
22.	C20:5 (EPA acid)	-	10.85
23.	C22:6 (DHA acid)	-	3.35
Total		23.88	17.52
Trans fatty acids (TFA)			
24.	C18:2 (Linoelaidic acid)	2.51	1.73
Total		2.51	1.73

The percentage availability of monounsaturated fatty acids (MUFA) was 22.23% in edible tissue but in hepatopancreas it was recorded 8.43%. The polyunsaturated fatty acids (PUFA) of edible tissue and hepatopancreas of *Melo melo* accounted for about 23.88% and 17.52% respectively, considered being significant in the present investigation. The gamma-linolenic acid (16.31%), eicosapentaenoic acid (10.85%), alpha-linolenic acid (7.57%) and docosahexaenoic acid (3.35%) were the predominant polyunsaturated fatty acids in the edible tissue and hepatopancreas. The above findings were consistent with the findings of fatty acids in *Octopus vulgaris* reported by Culkin and Morris, (1970) [10]; Nash *et al*., (1978) [21]. The TFA content was found to be 2.51% in the edible tissue and 1.73% in the hepatopancreas. The polyunsaturated fatty acids play an important role in the prevention and management of cardiovascular diseases, hypertension, inflammation, diabetes. The PUFA is found high in marine organisms, Nair and Mathew (2000) [20] reported that 15.25% of PUFA was found in *Perna canaliculus,* out of 30 fatty acids, the PUFA were dominant in both frozen and freeze-dried samples of *Perna canaliculus.* Therefore, the edible tissue of *Melo melo* can be considered as a significant natural source for n-3 PUFAs and the best alternative to the fin fishes. The SFAs are the fundamental building blocks of almost all lipids. Essential fatty acids (EFA) are necessary parts of structural lipids and play a role in membrane characteristics such as fluidity, permeability and regulation of membrane-bound protein.

In the present investigation, 5 vitamins *viz.* vitamin C, vitamin B3, vitamin B6, vitamin B9 and vitamin B12 were detected from the edible tissue and hepatopancreas of *Melo melo* (Table 3). Among the five vitamins, vitamin C was found to be highly significant in both edible tissue (2.263 ± 0.01mg/g) and hepatopancreas (2.093 ± 0.10mg/g). Vitamin B3 and B12 were remain high in both edible tissue and hepatopancreas, whereas the vitamins B6 and B9 were found in below detectable limit. Chakraborty *et al*. (2016) [15] reported that vitamin C content was found to be significantly high in *Uroteuthis. duvauceli* and *Sepia inermis* (2.8-2.9 µg/100g) than othercephalopods.

Table 3: Vitamin composition of *M.melo* (mg/g of the sample)

Sl. No	Vitamins	Edible tissue	Hepatopancreas
1	Vitamin C	2.263 ± 0.01	2.093 ± 0.10
2	Vitamin B3	0.305 ± 0.02	0.444 ± 0.04
3	Vitamin B12	0.74 ± 0.10	0.45 ± 0.03
4	Vitamin B6	Below detectable limit	
5	Vitamin B9		

Ajaya Bhaskar (2002) [2] evaluated the vitamin levels of three bivalve species, *P. viridis, C. madrasensis,* and *M. casta*, and determined that the levels of vitamin B1, B2, and B6 were 0.11mg/g, 0.31 mg/g, and 0.31 mg/g, respectively. Vitamin C or ascorbic acid, the potent free radical scavenger, is a fundamental nutritional supplement for humans and helps the body to absorb iron and calcium, and assists in wound healing but should be taken through external dietary source because it is not synthesized by human metabolism (Iqbal et.al., 2004) [16]. Vitamin B12 or cyanocobalamin is playing a crucial role in erythropoiesis and DNA synthesis. Vitamin B3 or Niacin is essential for energy metabolism (Chakraborty and Joseph, 2015) [14]. Therefore, in agreement with previous study, the *Melo melo* is considered as a rich source of vitamins, which must be consumed on a regular basis to supplement the human requirements.

The mineral composition of edible tissue and hepatopancreas of *Melo melo* were shown in Table 4. The macrominerals Na, K and Mg of edible tissue (Na. 5965.40 µg/g; K. 4672.57 µg/g; Mg. 176.21 µg/g) and hepatopancreas (Na. 5549.50 µg/g; K. 4632.29 µg/g; Mg. 176.95 µg/g) were found to be similar and remain in appreciable quantities. The microminerals such as Cu (266.97µg/g), Mn (15.79 µg/g), Fe (48.41 µg/g) and Zn (132.91 µg/g) were found exceptionally high in hepatopancreas than in edible tissue. The Na/K ratio in edible tissue (1.27) and hepatopancreas (1.19) remains less than 1.5. Even though minerals do not have any calorific value, they are an essential part of diet and playing a vital role in the regulation of metabolic functions. Na being an extracellular and K being intracellular ions are playing key roles in maintaining the physiological balance of the body. Less than 1.5 Na/K ratio of the present study indicates that the *Melo melo* is a potential source of food for human consumption and able to protect from strokes, kidney stones and reduce blood pressure (Kavipriya and Ravitchandirane, 2021) [15].

Table 4: Mineral composition of *M.melo* (µg/g)

Sl. No	Minerals	Edible tissue	Hepatopancreas
1	Na	5965.40	5549.50
2	K	4672.57	4632.29
3	Cu	16.81	266.97
4	Mn	1.13	15.79
5	Mg	176.21	176.95
6	Fe	11.24	48.41
7	Zn	33.20	132.91

In the present study the microminerals *viz.* Cu (266.97µg/g), Mn (15.79 µg/g), Fe (48.41 µg/g) and Zn (132.91 µg/g) were found exceptionally high in hepatopancreas of *Melo melo* may be valued as a potential natural source for human consumption. Zn and Mn act as a cofactor for more than 200 enzymes which are involved in various functions like immunity, new cell growth, acid-base regulation, etc. Zn is directly involved in the carbonic anhydrase synthesis. Deficiency of Zn in the diet may be more dangerous to living organisms including humans than its high concentration in the diet (Ogunlesi *et al*., 2010) [22].

Conclusion
The present study demonstrated that the edible tissue and hepatopancreas of *Melo melo*, commonly called beggar's bowl is a valuable gastropod with rich source of protein, fatty acids, vitamins and minerals. The palmitic acid, stearic acid, arachidic acid along with erucic acid, gamma-linolenic acid and eicosapentaenoic acids relative percentage composition in the edible tissue and hepatopancreas made this gastropod mollusc as a good source of well-balanced diets. Presence of vitamin C, vitamin B3, vitamin B12 and essential minerals found in appreciable quantities have proved that this organism would be a right choice for the regulation of various metabolic functions of the body. In general, the nutritional composition and benefits of gastropods remain unexplored due to limited scientific awareness and research. Therefore, the results obtained from this study revealed valuable information about *Melo melo* as a potential health food, highlighting its importance and advocating for its inclusion in regular human diets.

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