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Nutritional Benefits of Marine Molluscs: A Comprehensive Review

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Abstract: Food of an individual produces a remarkable impact on their health, environment and society. From the time memorial, members of the phylum Mollusca have traditionally been an integral part of human life as a source of colorants, shells, foodstuff and customary medication. Molluscs are rich in vital nutrients, active secondary metabolites, and enhance immune response. Therefore, in many coastal countries, molluscs form the integral part of a daily diet. Consumption of edible gastropods, bivalves and cephalopods has been associated with many health benefits. Marine molluscs are an excellent source of proteins, carbohydrate, lipids, fatty acids, ash, and moisture along with higher amount of essential vitamins and minerals such as niacin, vitamin B6, B12, and E, thiamin, riboflavin, zinc, phosphorous, magnesium, iron, copper, potassium and selenium. This review is a comprehensive account of edible marine molluscs with respect to: classification, ecological roles, nutritional quality, proximate analyses, nutritional and health benefits and marine molluscs cautions related to microbiological hazards.

Keywords: Bivalves, Cephalopods, Gastropods, Macronutrients, Microelements, Molluscs, Nutritional value, Seafood

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Introduction

Oceans constitute 70% of the area on planet Earth, and the biodiversity therein is appraised by many experts to be even greater than that in the tropical rain forests. Marine organisms are a major source of food due to their nutritional value, and potential role in the functional food and health-promoting effects (Khan and Yang, 2019). The marine world is a rich resource of biologically active compounds. Marine organisms live in complex habitats and are exposed to extreme conditions, producing a wide variety of specific and potent active substances that cannot be found anywhere else (Babita *et al.*, 2020; FAO, 2020). Molluscs have been exploited worldwide for food, ornamentation, pearls, lime, and medicine (Ramachandra *et al.*, 2012).

Maintaining good health and a sense of well-being are top priorities for many people today. Both health and well-being are strongly related to diet. The relationship of diet to overall health and the effect of diet on the incidence of certain chronic illnesses, such as heart disease, diabetes and cancer, continue to be active areas of nutrition

research (Dong, 2009). Molluscs (Latin word mollusc, meaning "soft") (Anbalagan and Samuel., 2012) are one of the important groups of invertebrates and include soft bodied macro-benthic heterogeneous group of animals, found attached to the bottom of the intertidal region or free swimming (Das, 2017). Molluscs represent one of the most diverse and species-rich phyla of the animal kingdom and are only second to the arthropods (Pawar and Al-Tawaha, 2017).

Marine molluscs consist of 31,643 species and comprise about 23% of all the named marine invertebrate organisms (Winckworth, 1940). Varied species diversity of marine molluscs and widespread utility as a source of food with high nutritional value has aroused great interest from the scientific community (Khan and Yang, 2019). Periyasamy et al (2014) reported that, marine molluscs have been given more importance, because they have both ecological and economically importance to mankind. Marine molluscs are important for human diet, since it is an important source of nutrients. Consumption of marine molluscs provides an inexpensive source of protein with a high biological value, essential minerals (calcium, potassium, zinc, iron, phosphorus and copper) and vitamins (Vitamin C) (Ajayabhaskar, 2002).

In the tropical marine environment, molluscs occupy every trophic level, from primary producers to top carnivores. Phylum Mollusca includes a variety of familiar animals well-known as decorative shells or as seafood. Taxonomic groups, such as, mussels, oysters, clams, pearl-oysters, window-pane oysters, ark-shells, whelks, chanks, cowries, squids and cuttlefish have been exploited since time immemorial for food, pearls and shells (Mohamed and Venkatesan., 2017). Molluscs have a great potential to be utilized because they have a high nutritional value, with high levels of protein and fatty acids, which are essential for life (Leiwakabessy *et al.*, 2019).

Phylum Mollusca:

Phylum Mollusca is divided into eight classes such as, Bivalvia, Caudofoveata, Cephalopoda, Gastropoda, Monoplacophora, Polyplacophora, Scaphopoda, and Solenogastres (Benkendorff, 2010). Among these, class Bivalvia, Gastropoda, and Cephalopoda account about 98% of the total molluscan species, and were studied in detail for their nutritional value. Representative animals of these classes include:

- Bivalves: Clams, Mussels, Oysters, and Scallops.
- Cephalopods: Octopus, Squid, and Cuttlefish.
- Gastropods: Whelks, Sea-snail, Abalone, and Cockle.

Ecological roles of Molluscs (*Das, 2017*):

Due to their ubiquitous distribution and enormous species number, molluscs play following important ecological roles in aquatic and terrestrial ecosystems of the world.

- Key species for ecosystem functioning, e.g. food for human and other animals (echinoderms, fish, birds and mammals).
- Biomonitoring and bioindication purposes (biological effects of environmental stress and contaminant exposure) (Oehlmann and Schulte-Oehlmann, 2002).
- Filtering phytoplanktons and source of food for fishes.
- Oxygenate the bottom by reworking sediments.
- Breaking down organic materials before bacterial re-mineralization.
- Many of them are commercially important.

Literature Search Strategy:

Articles relevant on nutritional benefits of marine molluscs were searched in EMBASE, Google Scholar, Medline, NCBI, PubMed, Science Direct, Scopus, and Web of Science databases. Data and information was collected from the thorough study of the journal articles, research papers, reports and various literatures. The keywords used for reviewing the literature were the ones

that refer to the issues concerning the 'nutritional benefits' and 'marine molluscs'. For literature search, keyword "marine molluscs" is combined with: classification, ecological roles, biochemical composition, and nutritional benefits.

Nutritional Quality of Marine Molluscs:

According to Nagabhushanam and Mane (1978), the knowledge on biochemical composition of any edible organisms is extremely important since the nutritive value is reflected in its biochemical contents. The biochemical composition is the yardstick to measure and assess the nutritional quality of food sources and biochemical studies are very important from the nutritional point of view. The molluscs are excellent sources of protein, carbohydrate, lipid, etc. which render them highly nutritious for human consumption (Margret *et al.*, 2013).

Zhukova (2019) reported that, clams and snails are traditional seafood items in human diets, and rich in essential polyunsaturated fatty acids (PUFAs). The edible molluscs are commercially harvested and cultured. Marine bivalve molluscs are highly appreciated, partly because of their positive effects on human health arising from their constituents and so their consumption is increasing every year. Panayotova *et al.* (2020) stated that, marine shellfish are characterized as easily digestible food, low in calories, but nutrient-dense. Further, marine bivalves have high nutritional, easily digestible food, low calories but high in proteins.

Molluscs such as squids, mussels, oysters and clams essentially comprise the major part of shell fishery. Despite the abundant data available on the biochemical aspects of fishes, hardly little information is available on mollucs (Suryanarayanan and Alexander, 1972). Hence, the present article reviews the published data on biochemical aspects and nutritive value of marine molluscs. The percentage of edible tissue is comparatively low in bivalves (ranging from 12.06 to 16.50%), intermediate for gastropods (24.7 to 24.7%), and comparatively high in cephalopods (68.5 to 71.38%) (Suryanarayanan and Alexander, 1972; Suryanarayanan *et al.*, 1973).

Molluscs contain relatively low fat and high PUFAs, some of which cannot be synthesised by human and must be obtained from their diet (Smoothey, 2013). Krishnan *et al*. (2019) argued that, nutritional molluscs are considered as nutritious seafood and culinary delicacies. Evaluation of proximate profiles is often essential to guarantee that they meet requirements of commercial specifications and food regulations. Biochemical composition of marine molluscs consists of moisture, carbohydrates, proteins, crude fat, ash and minerals (Das and Joydev, 2017; Oksana *et al.*, 2018; Wright *et al.*, 2022).

Roslizawati *et al.* (2016) documented that, many marine molluscs are harvested around the world for their meat. The nutritional content and fatty acid compositions of molluscs have been intensively investigated in commercially important bivalve species, including oysters. Molluscs are low in fat, with a high concentration of monounsaturated and polyunsaturated fat, and provide high quality protein for the human diet, but their consumption, particularly raw or undercooked, are not risk-free (Francesca *et al.*, 2019). Among the marine molluscs, a total of 180 species have long been a part of the diet of coastal human populations (Serratore, 2018). Seafood is a healthful choice for people of all ages: growing children, pregnant women, active adults, and the elderly (Reames, 2012).

Proximate Analyses of Marine Molluscs:

Table 1 illustrates the nutritional contents (biochemical components) of various molluscs as reported by various investigators.

Nutritional and Health Benefits of Marine Molluscs (*Reames, 2012*):

- An excellent source of lean, high quality, easily digested protein.
- Low in saturated fat and sodium.
- Rich source of many essential vitamins and minerals.

Table 1: Proximate analyses (g 100 g^{-1} wet tissue) of marine molluscs

Mollusc fauna	Area	Biochemical composition	Reference
• *Lamelidens corri'anus* • *Vellorita cochinensis* • *Corbicula striate!la* • *Mytilus edu!is* • *Ostrea cuculatata*	Kerala, India	• Proteins: 68.32 – 88.45% • Carbohydrate: 2.81 – 11.59% • Lipid: 5.43 – 11.04 %. • Ash: 8.12 – 15.32 % • Water: 70.01 – 85.39%	Suryanarayanan and Alexander (1972)
• *Loligo indica* • *Sepiella inermis*	Kerala, India	• Proteins: 81.49 – 83.49% • Carbohydrate: 0.53 – 0.61% • Lipid: 5.40 – 5.56 %. • Ash: 12.5 – 13.42 % • Water: 74.78 – 75.05%	Suryanarayanan *et al.* (1973)
• *Babylonia zeylanica* • *Murex virgineus* • *Babylonia spirata* • *Trochus radiatus*	Kanyakumari Coast, India	• Proteins: 28.55 – 43.2% • Carbohydrate: 6.7 – 19.6% • Lipid: 1.1 – 6.2 %. • Ash: 0.96 – 1.18 % • Water: 66.76 – 82.33%	Margret *et al.* (2013)
• *Donax incarnatus*	Southeast coast of India	• Proteins: 23.51% • Carbohydrate: 10.23% • Lipid: 1.34 %. • Essential amino acids: 58.21 % • Nonessential amino acids: 35.4 % • Vitamins: Vitamin A and C • Macro minerals: 5 • Trace minerals: 2	Periyasamy *et al.* (2014)
Marine Turban Snails • *Turbo militaris,* • *Lunella undulate* • *Lunella torquata*	Northern New South Wales, Australia	• Proteins: 16.0 – 18.50 % • MUFA: 14% of total fatty acids • SFA: 41% of total fatty acids • Ash: 2.0 % • Carbohydrate: 3% • Lipid: 5.0 – 9.0 %. • Water: 68.5 %	Roslizawati *et al.* (2016)
• *Loligo duvauceli* • *Octopus macropus* • *Sepia aculeata* • *Sepiella inermis*	Digha coast, West Bengal, India	• Moisture: 81.19 – 84.44% • Carbohydrate: 1.32 – 2.14% • Proteins: 11.48 – 14.53% • Crude Fat: 0.51 – 0.66 %. • Ash: 0.76 – 1.41 % • Minerals: Na, K, Ca	Das and Joydev (2017)
• *Anadara broughtonii* • *Mactra chinensis*	Sea of Japan coast	• Moisture: 78.55 - 82.32% • Proteins: 12.20 – 16.50 % • Ash: 0.95 – 1.89 % • Fat: 0.43 – 1.37 % • Carbohydrate:11.36 – 20.37 % • Minerals: Na, K, Ca, Mg, Cu, Zn, Fe	Oksana *et al.* (2018)
• *Arca noae* • *Flexopecten glaber* • *Limaria tuberculata* • *Mimachlamys varia* • *Modiolus barbatus* • *Mytilus galloprovincialis* • *Ostrea edulis* • *Solen marginatus*	Southern Coast of Italy, Mediterranean Sea	• Moisture: 79.84 - 84.10 % • Ash: 2.62 – 5.33 % • Proteins: 6.58 – 12.25 % • Lipid: 1.04 – 2.76 %. • Phospholipids: 64.35 – 89.59% • Triacylglycerols: 7.20 – 31.57% • Cholesterol: 3.21 – 10.74% • Minerals: Na, K, Ca, Mg, Cu, Zn, Fe	Francesca *et al.* (2019)

• Indian squid (*Uroteuthis duvaucelii*) • Veined octopus (*Amphioctopus marginatus*) • Spineless cuttlefish (*Sepiella inermis*) • Edible oyster (*Crassostrea bilineata*)	South-west coast of India	• Lipid: 0.92 – 1.58 %. • Proteins: 12.89 – 18.36% • Carbohydrate: 9.86 – 13.39% • Water: 79.11 – 85.21% • Crude Ash: 0.65 – 1.65 % • Cholesterol (mg 100 g-1 wet tissue): 34.74 – 175.61 %	Krishnan *et al*. (2019)
• *Strombus luhuanus* • *Lambis lambis* • *Polymesoda erosa*	Central Maluku, Indonesia	• Saturated fatty acids (SFA) • Monounsaturated fatty acids (MUFA) • Polyunsaturated fatty acids (PUFA) • Omega 6 to omega 3	Leiwakabessy *et al*. (2019)
• Marine Bivalve, *Donax variabilis*	Porayar Coastal area, Nagapattinam District, Tamil Nadu, India	• Carbohydrate: 8 – 12 % • Proteins: 9 – 16 % • Lipid: 7 – 12 %. • Fatty acids: 11 – 18 %	Thilagavathi and Ponni (2019)
• *Mytilus galloprovincialis* • *Chamelea gallina* • *Donax trunculus*	Bulgaria	• Proteins: 8.13 – 17.4% • Carbohydrate: 0.7 – 2.31% • Lipid: 0.69 – 2.2 %	Panayotova *et al* . (2020)
• *Saccostrea cucullata* • *Crassostrea virginica* • *Meretrix meretrix* • *Andara granosa*	Bangladesh	• Crude protein: 59.3 - 75.4% • Carbohydrates: 8.1 - 20.2% • Crude lipid: 2.5 - 11.2% • Ash: 11.4 - 16.8% • Amino acids, and Fatty acids	Mohammad *et al.* (2021)

- Beneficial health effects for the development of nervous system and retina.
- Decrease the risk of heart attack, stroke, obesity and hypertension.
- Low in saturated fat and higher in "heart healthful" polyunsaturated fat, including omega-3 fatty acids.
- Very important during foetal growth and development, early infancy and childhood.
- Source of essential vitamins and minerals: Niacin, vitamin B6, B12 and E, thiamin, riboflavin, Zn, P, Mg, Fe, Cu, K and Se.

Marine Molluscs Cautions: Microbiological Hazards (*Reames, 2012*):

The seafood must be handled safely to prevent foodborne illness. Buying from a retailer who follows proper food handling practices helps ensure that the seafood is safe and of the best quality. Certain groups of people are at a greater risk for foodborne illness and should avoid eating raw or partially cooked fish or shellfish. Those at higher risk are:

- Pregnant women
- Young children
- Older adults
- Persons with decreased stomach
- Persons with HIV/AIDS, liver disease, diabetes, cancer, or gastrointestinal disorders; and people taking steroids, chemotherapy or immune system suppressing drugs.

Conclusion

Results of this study indicate that, molluscs are the "natural functional foods" and are suitable for industrial processing for functional foods, and food supplements. Marine molluscs are an excellent source of proteins, carbohydrate, lipids, fatty acids, ash, and moisture along with higher

amount of essential vitamins and minerals such as niacin, vitamin B6, B12, and E, thiamin, riboflavin, zinc, phosphorous, magnesium, iron, copper, potassium and selenium. They also acts as a rich source of saturated fatty acids (SFA) such as monounsaturated fatty acids (MUFA), polyunsaturated fatty acids (PUFA) and omega 6 to omega 3 fatty acids.

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