Heliyon 8 (2022) e09696

Contents lists available at ScienceDirect

Heliyon

journal homepage: www.cell.com/heliyon

Research article

Nutritional properties of wild and fattening mud crab (*Scylla serrata*) in the south-eastern district of Bangladesh

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ARTICLE INFO

Keywords:
Scylla serrata
Proximate composition
Minerals
Recommended nutrient intake (RNI)

ABSTRACT

Mud crab (*Scylla serrata*) is one of the most important crustacean species in Bangladesh due to its high economic value. Crab fattening is widely practiced in the country to meet export demand while the supply for domestic consumption is mainly dependent on wild sources. This work reported for the first time a comparative evaluation of the nutritional properties of wild and fattening mud crabs. For this purpose, the proximate compositions were determined in terms of total contents of protein, moisture, ash, lipid, and minerals. Female fattening mud crabs had the highest levels of protein (17.07 ± 1.52%) and moisture (76.95 ± 1.39%) content, while the highest percentages of ash (4.9 ± 1.03%) were detected in male fattening mud crabs. Male fattening mud crabs also contained high amounts of minerals, especially calcium (1199.71 ± 343.43 mg/100g) and iron (14.21 ± 1.28 mg/100g). Male and female wild crabs showed the highest levels of magnesium and phosphorus, respectively. Additionally, the calculated percentage of recommended nutrient intake (RNI) value revealed that mud crab contributes 4.4–59.99%, 6.6–53.98%, and 7.33–54.53% for infants, adults, pregnant and lactating women, respectively. The present study indicates that mud crab had a balanced nutritional composition that would be nutrient-rich excellent diet for consumers.

1. Introduction

Mud crab (*Scylla serrata*) is considered the major, fastest growing, and most anticipated aquaculture species (Rodriguez et al., 2007; Ye et al., 2011; Meng et al., 2017; Yusof et al., 2019). Mud crab, which belongs to the family Portunidae and class Crustacea of the phylum Arthropoda, is a significant fishery commodity in Bangladesh's coastal region (Sarower et al., 2013; Paul et al., 2015; Kar et al., 2017). Its geographical position and climatic conditions have made the coastal area of Bangladesh one of the most productive regions in the world for producing mud crabs. Mud crab contributes significantly to the fishery industry of the coastal regions of Bangladesh and hence significantly influences the livelihoods of local fishers (Kar et al., 2017). Among the 16 species recognized, it is known that only the mud crab (*Scylla serrata*) and the swimming crab (*Neptunus pelagicus*) are consumed in Bangladesh (Paul et al., 2015; Kar et al., 2017). Three species of the genus Scylla, namely *S. transquebarica* (Fabricius), *S. serrata* (Forskal), and *S. oceunica* (Dana), and one additional variety, *S. serrata* var. *Paramamosain* are edible (Estampador, 1949). The genus *Scylla* is represented by four species in Vietnam and Malaysia (Ong, 1966). *S. serrata* of the genus *Scylla* is only known in Bangladesh (Paul et al., 2015). The demand for seafood, including live crab, lobster, and shrimp, for export has increased significantly (Romano and Zeng 2008). Crabmeat is a widespread delicacy sold at high market prices (Wu et al., 2010; Noorbaiduri et al., 2014; Azra and Ikhwanuddin, 2016). In Bangladesh, the mud crab, especially *S. serrata* is found and harvested throughout the coastal districts of the country, including Cox's Bazaar, Chittagong, Satkhira, Bhola, Noakhali, Patuakhali, Khulna, and Bagerhat. The density of the mud crab populations in the intertidal areas of estuaries and coastal backwater swamps of Cox's Bazaar, Chittagong, Bagerhat, Satkhira, and Khulna appears to be relatively higher than in

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https://doi.org/10.1016/j.heliyon.2022.e09696
Received 28 August 2021; Received in revised form 10 January 2022; Accepted 4 June 2022
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other regions such as Noakhali, Bhola, Patuakhali, and Barisal due to the deltaic muddy shores with new vegetation of these latter four districts, while the first five coastal areas have mangrove vegetation (Ahmed, 1992; Sarower et al., 2013).

Mud crab fattening plays an important role in the livelihoods of the coastal communities in Bangladesh. The term "fattening" is used when underweight soft-shelled crabs are stocked and raised for a few weeks until their gonad develops (Rahman et al., 2020; Sujan et al., 2021). Mud crab fishing supports the livelihoods of more than 50,000 fishers, traders, brokers, transporters, and exporters in Bangladesh, belonging to 300,000 households (Molla et al., 2009). Mud crabs have become the second most exported crustacean product from Bangladesh. The total earnings from mud crab exports in 2008 were US $7,068,000 (Zannatul et al., 2010). Compared with other aquacultural activities, crab fattening requires less space and time, with higher profitability playing an important role in generating income for Bangladesh's economy (Zannatul et al., 2010; Sarower et al., 2013). The inhabitants of the coastal region follow the traditional fattening process for crab cultivation. Small single ponds are used in the coastal areas for crab fattening in Bangladesh (Chandra, 2012). Crustaceans are of commercial and nutritional importance to humans. Shellfish differ widely in their nutrient content, as indicated by the differences in the contents of moisture, fat, ash, and protein. Amongst the edible marine crustaceans, crabs rank third after shrimp and lobsters in their significance as a favored delicacy and the value of the fishery they sustain (Sarower

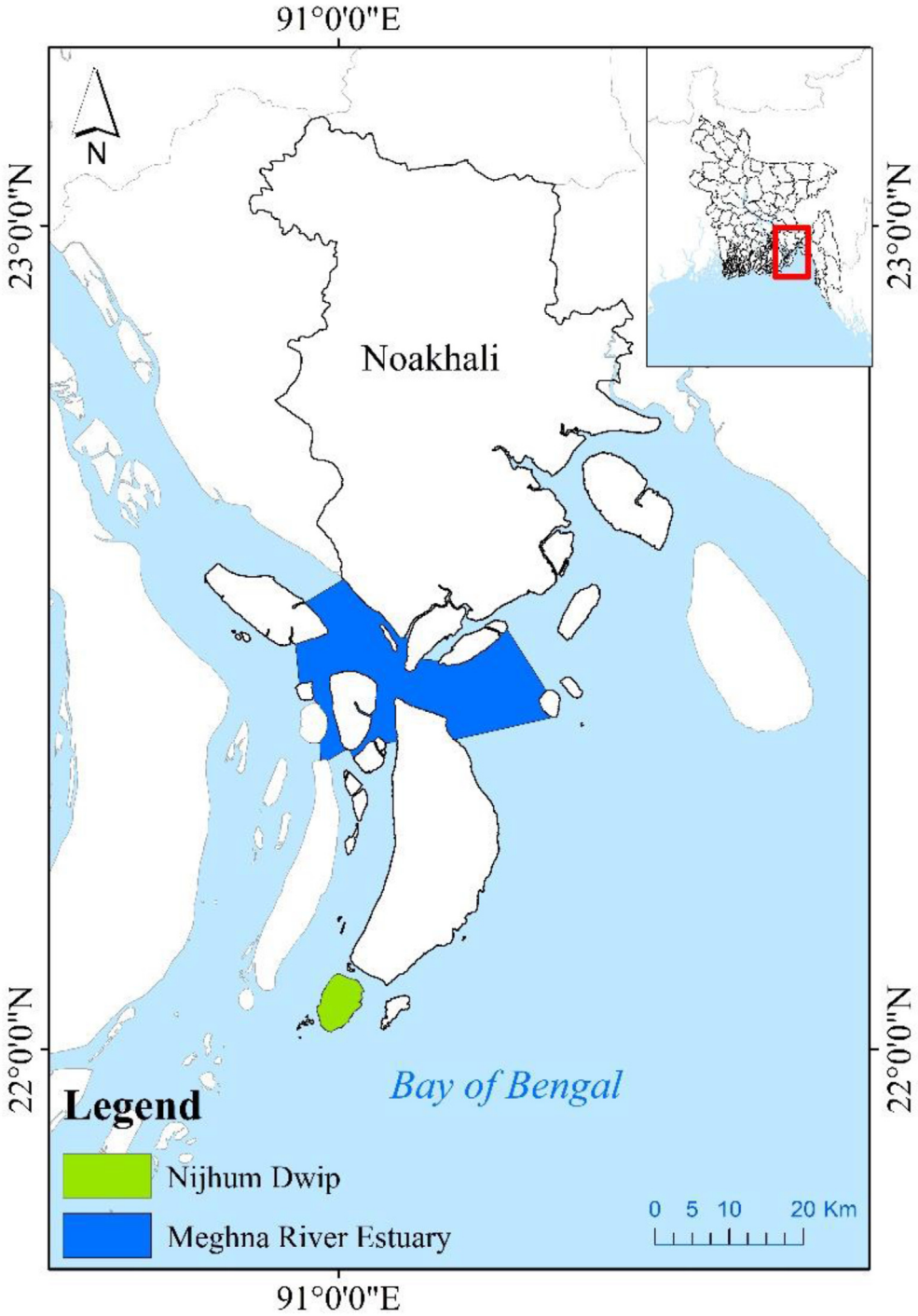

Figure 1. Sampling locations of mud crabs (Meghna River Estuary and Nijhum Dwip).

et al., 2013). The crab is one of the most abundant marine animals. Crabs are much in demand as a delicacy and quality food due to their meat content, size, and unique flavor and hence fetch high prices in the domestic and international markets. Crabs are not only rich in nutrients but also have commercial value (Baklouti et al., 2013). Lipids are nutritionally significant in crustaceans (Sreelakshmi et al., 2016). From the nutritional point of view, studies on the biochemical compositions of aquatic edible organisms are very important. However, very limited studies have been conducted so far on the nutritional composition of the mud crab. Crab is a nutritionally important species that many Bangladeshis consume as traditional food (Gokoolu and Yerlikaya, 2003). Hence, acceleration of the production of this species can meet a large portion of the nutritional needs of the people of Bangladesh. Thus, the primary objectives of the study were to quantify the nutritional profiles and percentage of recommended nutrient intake (RNI) of wild and fattening mud crabs that would be base line data for consumers, the food industry, and policy makers.

2. Materials and methods

2.1. Sampling sites

The fattening mud crabs (n = 24, 13 males and 11 females) were collected from a crab fattening farm owned by a local farmer near Nijhum Dwip, Noakhali, and wild mud crabs (n = 16, 7 males and 9 females) were caught from the Meghna estuary by the local crab collectors (Figure 1). The habitat, feeding, water salinity, weight, length, and gender types are presented in Table 1. The mud crabs were kept in an icebox (HDPE ice box, Aristo, India) and transported to the laboratory instantly. The samples were packed in a sterile polythene bag with ice to avoid cross contamination and transported to the Institute of Food Science and Technology (IFST) of the Bangladesh Council of Science and Industrial Research (BCSIR), Dhanmondi, Dhaka. It took approximately 6 h for the transportation from Noakhali to Dhaka.

2.2. Sample preparation

The collected mud crab samples were pooled and labelled based on sex (male and female) and two available sources (fattening farm and wild) and kept in a freezer (SJC-328-GY, Sharp, Japan) at -20 °C until analyzed. A cleaned stainless-steel knife was used to dissect and separate muscle from the body and claw portions of mud crab samples. After that, the muscle of mud crabs was thoroughly blended by using an electric blender (Preethi Steel Max MF-212, Preethi Kitchen Appliances Pvt. Ltd. India) to make a homogenous pulp for analysis. Then the samples were packed into polythene bags with labels and stored at -20 °C for further analysis.

2.3. Determination of proximate composition

The proximate composition of the mud crab samples was analyzed following the standard AOAC (2000) procedures: moisture content (1 g homogenized sample (HS)) by drying in an oven at 105 °C for 24 h; crude protein content (0.5 g HS) by the Kjeldahl method using an Auto Kjeldahl system (KjeltecTM 2300 Foss Tecator AB, Hoganas, Sweden) and then the nitrogen content was multiplied by 6.25; lipid (1 g HS) by the ether extraction method (Soxtec System HT6, Tecator AB, Hoganas, Sweden) and ash (2 g HS) by incineration of the sample in a muffle furnace at 600 °C for 6 h.

2.4. Determination of minerals

The mineral contents (calcium (Ca), iron (Fe), phosphorus (P), and magnesium (Mg)) of the sample were determined following the standard methods described by AOAC (2010). To begin, five grams of sample were placed in an acid-washed crucible and oven-dried for 24 h at 105 °C. Then the dried samples were digested in an oven at a temperature of 550 °C overnight. After that, 5 ml of 65% nitric acid (HNO_3) was added and the mixture was boiled for 2 min, followed by cooling the sample to room temperature. Whatman filter paper (No. 41) was used to filter the cooled solution, and a 65% nitric acid solution was added to make the total volume 25 ml. Finally, minerals were analysed by using an atomic absorption spectrophotometer (AA-7000, Shimadzu, Kyoto, Japan) (Gokoglu et al., 2004).

2.5. Calculation of potential contribution to RNI

The potential contribution of mud crab to RNI was calculated by using the reference value for each nutrient (protein, fat, Ca, and Fe) for infants (I), adults (A), and pregnant and lactating women (PLW). The standard portions (25 g/day for infants, 45 g/day for adults, and 50 g/day for PLW) of mud crab were considered based on Bogard et al. (2015).

2.6. Ethical considerations

All procedures performed in this study were approved by the post-graduate research ethics committee of the Department of Fisheries and Marine Science at Noakhali Science and Technology University.

2.7. Statistical analysis

The data was presented as mean ± SD and subjected to a two-way ANOVA. The statistical analyses were conducted using the XL-stat version 16 and means were compared at a 5% level of significance ($p < 0.05$). ArcGIS (version 10.3) was used for mapping the sampling locations.

3. Results and discussion

3.1. Proximate composition of mud crab

3.1.1. Protein

The protein contents of the fattening male and female crabs were 13.65% and 17.07%, respectively (Figure 2). In the wild male and female

Table 1. List of fattening and wild mud crab samples.

Mud crab types	Habitat	Feeding type	Feed type	Water salinity ppt (min-max)	Sampled number	Weight (g) (min-max)	Length (cm) (min-max)	Gender type
Fattening male	Neritic	Omnivores	Trash fishes	7–12	13	102–145	16–18	 Male crab
Wild male	Neritic	Omnivores	Natural	15–21	7	55–79	10–13	
Wild female	Neritic	Omnivores	Natural	15–21	9	65–85	11–14	 Female crab
Fattening female	Neritic	Omnivores	Trash fishes	7–12	11	95–138	14–17	

ppt = parts per thousand.

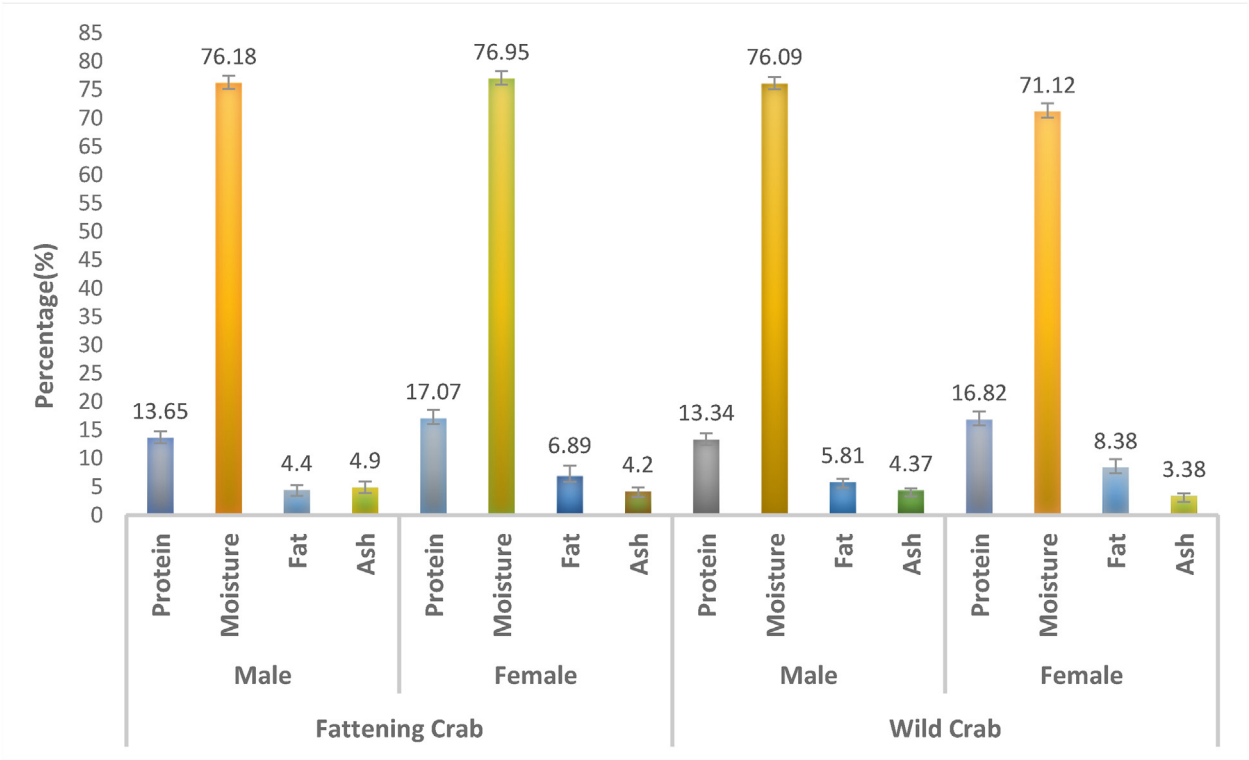

Figure 2. Proximate composition (%) of mud crabs.

crabs, the protein contents were 13.34% and 16.82%, respectively. In this study, the protein content was found to be higher in the female body. This was similar to the results reported by Sreelakshmi et al. (2016) which showed that the protein levels in male and female mud crabs were 12.22% and 16.42%, respectively. Our study also showed fattening mud crabs contained higher amounts of protein than wild-sourced crabs. This was supported by Sarower et al. (2013) who found the protein contents in wild and fattening mud crabs to be 22.77% and 27.43%, respectively. In addition, Zafar et al. (2004) found a high protein content in female *S. serrata.* These differences in protein content between male, female, fattening, and wild mud crabs could be attributed to environmental factors such as water salinity and temperature, as well as age, sex, season, place of collection, stage of maturity, and availability of food (Oliveira et al., 2008; Kala and Chandran 2014). The high level of protein content in mud crab found in this study indicated that it could be used as a daily food item. As a result, crab proteins may play an important role in the development of various organ components, transportation of gases, and metabolism in the human body (Omotayo et al., 2013).

3.1.2. Moisture

Moisture is depicted to be the major component in Figure 2. The moisture contents of fattening male and female crabs were 76.18% and 76.95%, respectively and in wild male and female crabs they were 76.09% and 71.12%, respectively. It showed that the moisture content in the female mud crab was lower than in the male, as was also reported by Sreelakshmi et al. (2016) who found in the moisture contents of wild male and female mud crabs to be 81.67% and 78.51%, respectively. Zafar et al. (2004) reported the moisture content of *S. serrata* as being 83.5–76.5% in males and 79.5–74.98% in females. The moisture content of 78.8% was observed by Wu et al. (2010). However, the moisture content of mud crabs could vary due to their special involvement in maintaining ionic balance in the body during movements in different ecosystems (Eddy and Bath, 1979).

3.1.3. Ash

From Figure 2, the ash contents of fattening male and female crabs were 4.9% and 4.2%, respectively. In wild male and female crab, ash was 4.37% and 3.38%, respectively. This study showed significant differences ($p < 0.05$) in ash content between sexes and sources. The fattening mud crab male body showed a higher amount of ash than the wild-sourced male. This finding was supported by Sarower et al. (2013) who showed the ash content in fattening and wild mud crab bodies was 3.54% and 2.09%, respectively. Zafar et al. (2004) found an ash content of 1.2%–2.22% in males and 1.62%–2.34% in females of *S. serrata.* This variation might be linked to mud crab sizes and seasonal conditions at the time of the study (Oliveira et al., 2008).

3.1.4. Fat

Figure 2 shows the fat content of fattening male and female crabs to be 4.40% and 6.89%, respectively. In wild male and female crabs, the fat

Table 2. Mineral concentrations (mg/100g) of mud crabs.

Minerals	Fattening crab		Wild crab	
	Male n = 13	Female n = 11	Male n = 7	Female n = 9
Calcium (Ca)	1199.71 ± 343.43^{a}	903.22 ± 155.66^{b}	760.75 ± 66.26^{c}	702.09 ± 68.25^{d}
Magnesium (Mg)	22.65 ± 1.30^{d}	29.56 ± 7.07^{b}	39.95 ± 9.78^{a}	25.82 ± 6.33^{c}
Iron (Fe)	14.21 ± 1.28^{a}	12.68 ± 0.39^{b}	13.77 ± 2.88^{a}	12.18 ± 1.12^{b}
Phosphorus (P)	46.53 ± 23.54^{c}	56.93 ± 17.42^{b}	46.02 ± 15.02^{c}	65.54 ± 21.94^{a}

Values are presented as mean ± SD; values of the same row that do not share the same superscript are significantly different ($p < 0.05$).

Table 3. Potential contribution of mud crabs in a standard portion*, RNI% for different level of consumers.

Parameters	Protein (g/day)			Fat (g/day)			Ca (mg/day)			Fe (mg/day)		
	I	A	PLW	I	A	PLW	I	A	PLW	I	A	PLW
Reference value**	20	60	74	25	30	30	500	1000	1100	7	17	15
Male fattening crab	17.06	10.23	9.22	4.4	6.6	7.33	59.99	53.98	54.53	50.75	37.61	47.36
Female fattening crab	21.33	12.81	11.53	6.89	10.33	11.48	45.16	40.64	41.05	45.28	33.56	42.26
Male wild crab	16.68	10.01	9.01	5.81	8.75	9.68	38.03	34.23	34.57	49.18	36.45	45.9
Female wild crab	21.03	12.62	11.36	8.38	12.57	13.96	35.11	31.59	31.91	43.5	32.24	40.6

I = Infants (7–25 months), A = Adults (18–60 + years), PLW = Pregnant and lactation women (Throughout the three trimesters of pregnancy and first 12 months of lactation), * Standard portion 25 g/day, 45 g/day and 50 g/day for infant, adults and PLW respectively, ** Lupton et al., (2002); Bogard et al., (2015)..

content was 5.81% and 8.38%, respectively. This showed that the content of fat in the female mud crab was higher than in the male, which agreed with the results of Sreelakshmi et al. (2016) who reported the fat contents in male and female crabs to be 0.53% and 1.26%, respectively. According to Zafar et al. (2004), the fat content of *S. serrata* was 0.51 ± 0.12% in males and 0.62 ± 0.13% in females. Variations in fat content in mud crabs might be due to maturity, sampling season, and location (Sarower et al., 2013). Additionally, the size (55–145 g) and type of feed (natural or trash fishes) are responsible for the variation of fat content in the mud crabs of the present study. Furthermore, the highest percentage of fat was detected in female crabs compared to males, and the deviation in fat content can occur due to a difference in gonad maturation stages among the collected mud crab samples. However, our study revealed that mud crabs were rich in protein and poor in fat, and these findings were consistent with those of other studies (Bhavan et al., 2010; Baklouti et al., 2013; Soundarapandian 2013). In fact, due to its high protein and very low-fat content, the mud crab could be a healthy food choice for humans.

3.2. Minerals in mud crab

Crustaceans are good sources of different minerals and proteins, and mud crabs are common. Crabmeat is an excellent source of essential minerals, particularly potassium, calcium, phosphorus, iron, and zinc (Naczk et al., 2004; Kumari et al., 2015). Marine foods are rich in minerals such as iodine, sodium, magnesium, potassium, calcium, phosphorus, and iron, which are essential for human sustenance (Sikorski et al., 2020). Table 2 shows that the mineral compositions of mud crabs varied significantly ($p < 0.05$) between sexes and sources.

3.2.1. Calcium

Calcium is very essential for the human body. It gives rigidity to the skeleton and plays an essential role in many metabolic processes. It is necessary for the structure of hard tissues, blood coagulation, muscle contraction, nerve transmission, and osmoregulation, as well as being an enzyme cofactor. The calcium contents in fattening male and female mud crabs were 1199.71 mg/100g and 903.2 mg/100g, respectively, while in wild male and female mud crabs they were 760.75 mg/100g and 702.09 mg/100g, respectively. These findings indicated that calcium contents in fattening crabs were higher than in wild crabs, which was consistent with the findings of Dayal et al. (2019), who reported the highest amount of Ca (4817 mg/100g) detected in fattening crabs. The greater Ca content in male crabs is probably because this species has sexual dimorphism, in which males have larger claws and stiffer exoskeletons that are composed of calcium phosphate (Soundarapandian et al., 2013).

3.2.2. Magnesium

Magnesium is essential for human nutrition as it is needed for the body's enzymatic system. In addition to maintaining healthy bones, magnesium acts in all soft tissue cells where it is part of the protein-making mechanism, and it is also needed for energy metabolism. Mg is a cofactor for many enzyme systems (Soundarapandian et al., 2013). Magnesium levels in fattening male and female mud crabs were 22.65 mg/100g and 29.56 mg/100g, respectively. In wild male and female mud crabs, their contents were 39.95 mg/100g and 25.82 mg/100g, respectively. This showed that magnesium in wild mud crab was higher than in cultured crab. The variation of Mg levels might have occurred due to sampling size, different ecosystems, and seasonal conditions at the time of the study (Yanar et al., 2011).

3.2.3. Iron

Iron is one of the important trace elements which play vital roles in the human body system, especially as a carrier of oxygen to tissues from the lungs and for the avoidance of major health problems (Camara et al., 2007; Thanonkaew et al., 2006). In the present study, the iron content was found to be higher in the fattening and wild male crabs (14.21 mg/100g and 13.77 mg/100g) than in the fattening and wild female crabs (12.68 mg/100g and 12.18 mg/100g, respectively). The findings of this study were not consistent with those of Mohapatra et al. (2009) on *S. serrata*, which showed lower Fe content of 0.15–0.16 mg/100g in males and 0.17–0.18 mg/100g in females muscle tissues. This variation might be due to different ecosystem and seasonal conditions at the time of the study (Mohapatra et al., 2009).

3.2.4. Phosphorus

Phosphorous (adenosine polyphosphate) acts as a significant substance for energy discharge and is present in phospholipids (Decker and Tuczek, 2000). Phosphorus levels in fattening male and female mud crabs were 46.53 mg/100g and 56.93 mg/100g, respectively. In wild male and female mud crabs, the phosphorus levels were 46.02 mg/100g and 65.54 mg/100g, respectively. This finding of a higher amount of phosphorus in female mud crabs was similar to that of Abdel-Salam (2013).

3.3. Potential contribution to RNI by mud crab

The potential contribution to RNI by mud crab meat for infants, adults, and PLW is given in Table 3. The results showed mud crab contributed 4.4–59.99%, 6.6–53.98%, and 7.33–54.53% of RNI in infants, adults, and PLW respectively, whereas protein contributed 16.68–21.33%, 10.01–12.81%, and 9.01–11.53% in infants, adults, and PLW, accordingly. In addition, the contribution rate of fat was 4.4–8.38%, 6.6–12.57%, and 7.33–13.96% in infants, adults, and PLW, while Ca contributed 35.11–59.99%, 31.59–53.98%, and 31.91–54.53% for infants, adults, and PLW, correspondingly. Finally, Fe contributes 43.5–50.75%, 32.24–37.61%, and 40.6–47.36% for infants, adults, and PLW, respectively. Our findings coincided with Bogard et al. (2015) who stated the Ca level of shellfish contributes 29–64% and 26–58% for infant and PLW, respectively, while Fe contributes 9–45% and 9–42% for infant and PLW, accordingly.

4. Conclusion

The nutritional properties of both wild and fattening male and female mud crabs were found to be different. These differences might be due to the influences of various factors such as sex, living conditions, and

nutrition of the animals, which play vital roles as they could influence the body's biochemical pathways. Our results showed that the fattening mud crabs were more nutritious than the wild ones from the viewpoint of protein and calcium contents and that female mud crabs were fattier relative to the males. We found that both wild and fattening mud crabs are good sources of protein, energy, and essential minerals for humans, and that the shells of mud crabs can serve as an alternative protein source for animal feed. Additionally, mud crab contributes a great percentage of RNI value for infants, adults, and PLW. Hence, the study suggests that female fattening, and wild mud crabs would be suitable nutrient-rich foods for consumers.

Declarations

Author contribution statement

Tajimul Islam: Performed the experiments; Analyzed and interpreted the data; Wrote the paper.

Debasish Saha: Analyzed and interpreted the data; Wrote the paper.

Shuva Bhowmik: Conceived and designed the experiments; Analyzed and interpreted the data; Wrote the paper.

Noordiana Nordin: Conceived and designed the experiments; Wrote the paper.

Shabiha Islam; As-Ad Ujjaman Nur: Performed the experiments; Wrote the paper.

Mohajira Begum: Contributed reagents, materials, analysis tools or data; Wrote the paper.

Funding statement

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Data availability statement

Data included in article/supp. material/referenced in article.

Declaration of interests statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

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