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EVALUATION OF NUTRITIONAL STATUS AND HEAVY METAL CONTAMINATION IN SELECTED INDIGENOUS FISH SPECIES FROM KOLLAM HARBOUR, SOUTH WEST COAST OF INDIA

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ABSTRACT

Fishes, an imperative source of easily digestible high-quality proteins, playing a vital role in human health. Marine pollution can increase the concentration of toxic metals in water and may affect fish health.The major objective of the present study was to determine the nutritional quality, condition factor and heavymetal concentration of edible fish species, fin fish *Rastrelliger kanagurta(Cuvier, 1816),* and shell fish *Metapeneusdobsoni(Miers, 1878),* collected from the Arabian Sea coast of Neendakara harbour, during the summer season (February) of 2019. The nutritional quality was determined by the proximate composition analysis of proteins, lipids and carbohydrates. Heavy metal concentration in seawater samples and fish tissues were done by using Atomic Absorption Spectrophotometer. The finfish muscle contains highest protein content, making it a good protein source. This study revealedthat the tissues of both fish species showed lead and cadmium content above the permissible limits for consumption by FAO/WHO, 1989. The seawater analysed showed highest concentration ofcadmium, and this may lead to the increasedcadmium concentration in both fish species. The source of these heavy metals may be from the different anthropogenic activities like fuel from motor boats, sewage discharge, waste disposal. Heavy metals, including iron, zinc are necessary minerals in fish metabolism but are toxic in high concentrations whereas cadmium, chromium, lead, are toxic metals even in trace concentrations.

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INTRODUCTION

Fishes are the foremost source of protein, low saturated fat, and high omega-3 fatty acids contents, which forms part of a healthy human diet.The protein in fish meat is more easily digestible than any other animal protein. This nutritive food source is readily available in the local market and is very cost-effective(Elvevolland James, 2000). The fish can also be a source of contamination as the concentration of heavy elements they hold exceeds, some of which are incredibly toxic (Carvalho *et al*., 2005). Environmental pollution has affected the entire biome by exceeding the critical levels of pollutants. Marine pollution has impacted the aquatic organisms and ultimately the humans consuming it. Continuous mining, agricultural, industrial, fuels from fishing boats, and other rising anthropogenic activities have caused increased metal contamination (Durmuş, 2019; Younis *et al*., 2021). The *Rastrelliger kanagurta (Cuvier, 1816)* (Indian mackerel) is one of India's pelagic marine fishery resources in the context of national food security (Hulkoti *et al*., 2013) and widely distributed in coastal waters. It contains a significant quantity of proteins, carbohydrates, and minerals required for a healthy diet. These species are also noted for their capability to enhance malnutrition and age-related disorder (Sahu and Parida, 2020). Another fish species, the shrimps, is also included in the healthy diet because the edible part of shrimps, the muscle tissue, has all the ideal nutritional ingredients required for humans (Banu *et al*., 2016). Humans consume fish muscle more than any other fish organs. It may act as the reservoir for many contaminants, like heavy metals, reducing the nutritional quality of fish meat (Tashla *et al*., 2018).

MATERIALS AND METHODS

Study area: Neendakara Harbour (8°56'11.49"N 76°32'15.11"E) in Neendakara village of Karunagapally taluk, Kollam district was located 9 km north of Kollam city in Kerala, South India. It is the intermediate fishing port in Kollam district. Fishes are one of the most common sea foods exporting from this Harbour.

Collection of Sea water and Fish samples: Surface water samples were collected in sterile plastic bottles from the sea along with the fish samples with the help of fisherman in the month of February 2019.

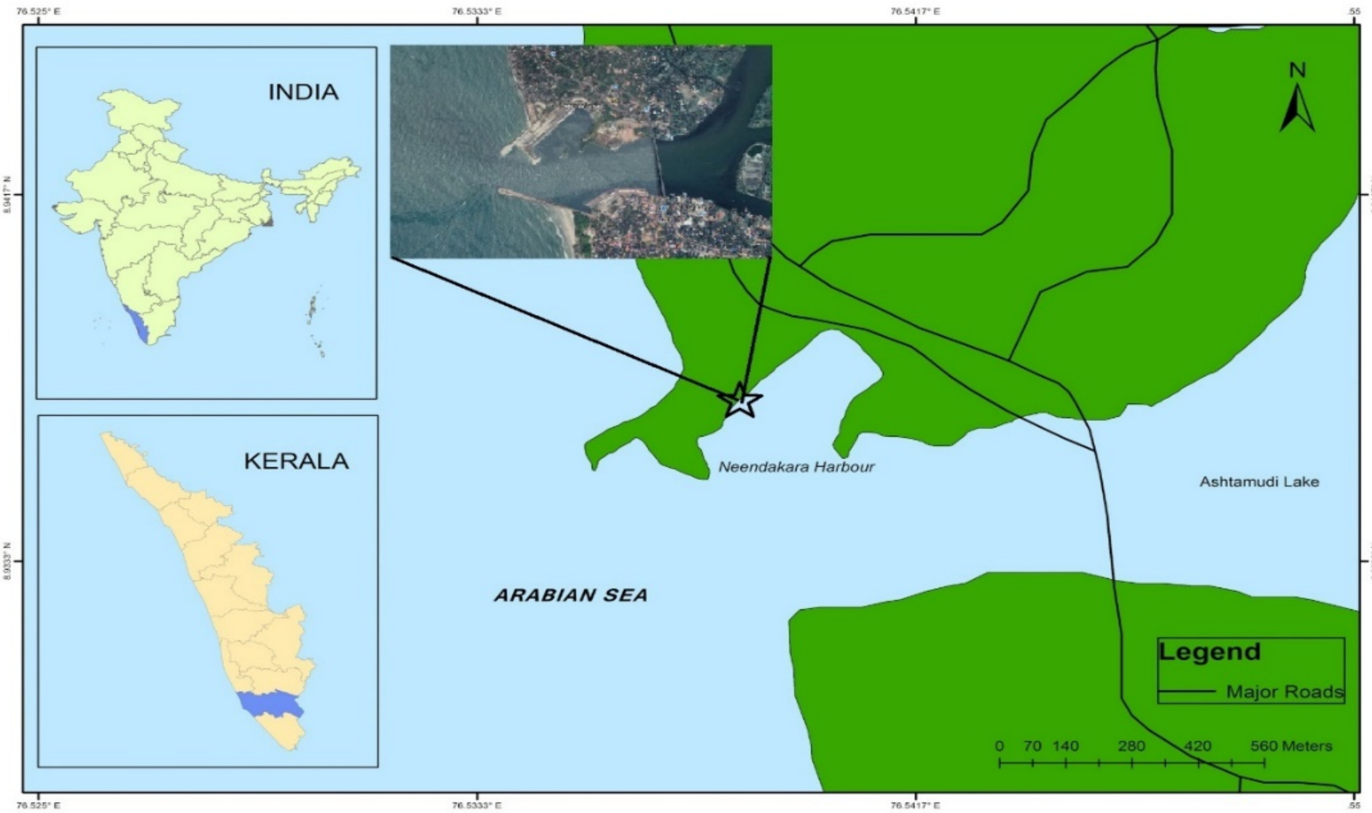


Fig. 1. Location map of Neendakara Harbour, Kollam

Water samples were taken from the site (A1) where the finfishes were collected and also from the site (P1) where the shell fishes were collected. The finfish and shrimp (four replicates) were collected from the Arabian sea in Neendakara harbour area. Indian Mackerel (*Rastrelliger kanagurta* (Cuvier, 1816)) and Kadal shrimp (*Metapenaeusdobsoni* (Miers, 1878)) selected for the study were collected in the early morning. The properly labelled samples were transported to department laboratory in ice boxes and were identified using the keys given by Day (1967). The fishes were sacrificed and the tissues (liver and muscles) were separated and kept in freezer for further analysis.

METHODOLOGY

Seawater Analysis: The physical parameters such as temperature, pH, electrical conductivity, TDS of surface sea water samples were determined using the standard procedures described by Grasshoff *et al*., 2009. And the heavymetal analysis was done by Ammonium PyrollidineDithiocarbamate (APDC) and Methyl Isobutyl Ketone (MIBK) extraction method (Brooks *et al*., 1967), and concentration of heavy metals Zn, Cr, Fe, Pb and Cd were estimated by using Atomic Absorption Spectrophotometer (Perkin Elmer, PinAAcle 500).

Condition Factor

The coefficient of condition 'K' was calculated using equation:

$K= W/L^3 \times 100$

Where, W = weight (g), L = length (cm)
100, a factor to bring the value of 'K' near unity (Fulton, 1904).

Proximate composition analysis: The important biochemical parameters such as total proteins (Lowry *et al*.,1951), total carbohydrates (Roe, 1955) following the standard procedures by Jayaraman (1981) and total lipids(Folch *et al*., 1957) were estimated. The glycogen content in tissues was calculated using the equation:

Glycogencontent = DU/DS ×0.1× [Volume of extract/weight of tissue (gm)] ×100×0.9

DU represents optical density of test sample
D.S. represents optical density of standard.
0.1 represents milligram of glucose in 2ml standard solution.
0.9 represents a factor for converting glucose to glycogen (Carroll*et al*., 1956)

Heavy metal analyses in fish tissues: Heavy metal analyses were done in the extracts of dried powdered fish tissue samples after triacid digestion using an Atomic Absorption Spectrophotometer (Perkin Elmer, PinAAcle 500) following the procedure by Topping (1973).

RESULTS AND DISCUSSION

Analysis of Seawater samples: The survival and growth of fish are positively related to the quality of water it lives (Akongyuure& Alhassan, 2021). Studies by Mohanty *et al*. (2014) reported that the pH of coastal water ranged from 7.9 -8.4 in surface waters and 7.9-8.3 in bottom samples. The analysed samples in this study showed a slightly higher value than the expected pH range of seawater. The range of pH expected for normal seawater is from 8.0 to 8.30, and that for coastal water is from 7.9 to 8.2 (Balachandran, 2001). Temperature is an important environmental factor that plays a significant role in fish growth and metabolism (Islam*et al*., 2019). Both sites in the study area show the same temperature. The surface water temperature influences the growth of aquatic organisms and it is also an important parameter influencing the uptake of metals by the fish. In the present study the temperature noted in the water samples was 28.6°C for both *R. kanagurta* and *M.dobsoni*.

The preferred temperature of *R. kanagurta*is 23.7°C - 28.3°C (mean 27.3 °C) and that for *M. dobsoni* is 25.1°C - 29.2°C (mean 28.5 °C) (Kaschner*et al*., 2016). All the water samples analysed in this study have almost the same electrical conductivity (E.C.) range. The E.C. for sites A1 and P1 were recorded as 74.6 mS/cm and 74.40 mS/cm, respectively. Seawater contains an abundance of highly dissociated salts. These salts give seawater a relatively high electrical conductivity that increases almost linearly with salinity (Wiesenburg and Little, 1988).

Table 1. Physical characteristics of Sea water

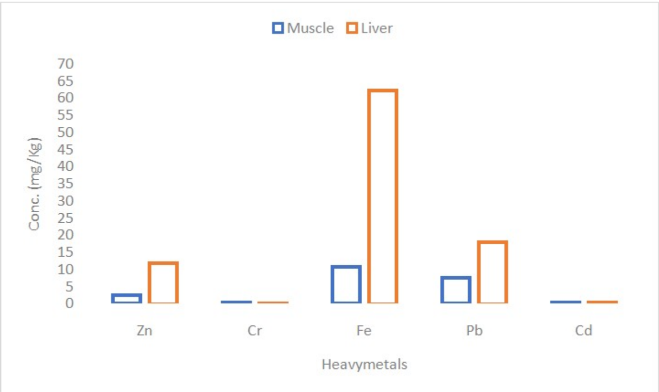
Parameter	Seawater sampling site	
	A1	P1
pH	8.74	8.75
Temperature (°C)	28.6	28.6
Electrical Conductivity (mS/cm)	74.6	74.40
Total Dissolved Solids (ppt)	38.91	38.74

Table 2. Heavy metal content in Seawater collected from the *R. kanagurta* and *M. dobsoni school* area

Heavy metal	Concentration (mg/L)	
	*R.kanagurta*school area	*M. dobsoni*school area
Zn	0.051	0.055
Cr	0.016	0.013
Fe	0.006	0.006
Pb	0.004	0.004
Cd	0.022	0.023

(Values are the average of four replicates)

A high level of conductivity indicates a high concentration of dissolved salts. The values recorded for TDS are 38.91 ppt and 38.74 ppt in the sampling sites A1 and P1, respectively.TDS content is directly related to the amount of pollution in the water. The high content of TDS elevates the density of water, influences the osmoregulation of aquatic organisms and reduces the solubility of gases (Jothivel and Paul, 2014). The average highest concentration was shown by cadmium metal in all the water samples both in the A1 and P1 sites, 0.022 mg/l and 0.023 mg/l, respectively. Followed by cadmium, zinc shows a value of 0.051 mg/l and 0.055 mg/l, respectively, in A1& P1 sites. The concentration of Pb in seawater was above the prescribed limits as Pb concentration should be less than 2.00 mg/l. The Cd concentration was within the limits set as 2 mg/l (Environment (Protection) Rules, 1986).

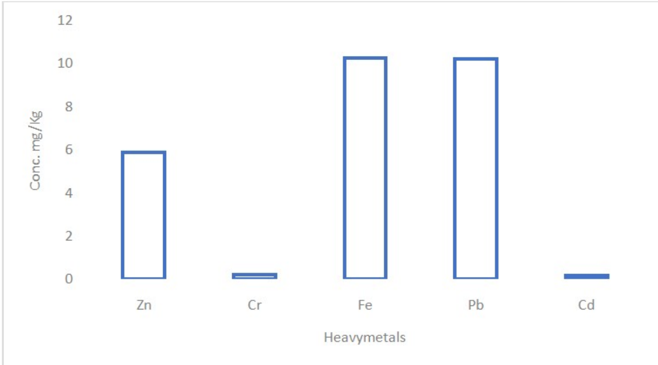


(Values are the average of four replicates)

Fig. 2. Heavy metal content in the tissues of *R. kanagurta*

Analysis of Finfish and Shellfish samples: Finfish and shellfish form important protein sources used for health benefits to consumers (Sujatha *et al*., 2013). The fish species studied in this research work have much importance in the daily diet of humans. Indian Mackeralis one of the essential pelagic, shoaling marine fish and a much-valued table fish. Considering its feeding habit, it mainly feeds on zooplankton, diatoms and phytoplankton (Bhendarkar *et al*., 2014). *M. dobsoni*is another commercially important table fish in India; they are found in benthic brackish with a depth range of 1m-37 m and are voracious feeders (Balasubramanian *et al*., 1979; Holthuis, 1980).

Condition factor analysis of Fishes: Fulton's condition factor (K)is used to know the physical well-being and growth performance of fish studied (Li *et al*., 2016). The physical measurements (length and weight) of both the fish samples were taken, and the condition factor was calculated (Table 3). The total length of *R. kanagurta*samples collectedshow very small variations. The four samples had lengths in the range of 16 cm to 16.5cm. The total body weight varied from 52.21g to 62.71 g. From the four samples collected, all two fishes showed almost equal weight and length (16cm, 57g). The condition factor of *R. kanagurta* samples was above 1, ranging from 1.27 to 1.41. In *M. dobsoni*samples, the total length ranges from 8.8 to 10 cm, and total body weight varies from 5.06g to 5.62g. It had a condition factor below one, with the highest value of 0.79 in the fish with the lowest length (8.8cm). In fish ecology, the condition factor is used to analysis the response of fish to environmental change over time and to assess the overall health, productivity, lipid content and growth rate (Stevenson and Woods, 2006). In shrimp also, the condition factor has been used for assessing the growth (Gopalakrishnan *et al*., 2014). Condition factor value greater than one in the results reveals the well-being of fishes (Datta *et al*., 2013).



(Values are the average of four replicates)

Fig. 3. Heavy metal content in the tissues of *M. dobsoni*

Proximate composition analysis of fishes: It is necessary to know about the nutritional status of fish for it be utilized for nutritional security. In developing countries, it is being used for meeting the micronutrient and undernutrition deficiencies (Mohanty *et al*., 2019). All the essential amino acids needed for humans are found in fish proteins in the essential proportions, and, thereby, it has high nutritive value (Sujatha *et al*., 2013). The total protein content in the muscles of *R. kanagurta* and *M. dobsoni* were 15.745 ± 0.5 mg/kg and 12.6875±0.5 mg/kg, respectively. In *R. kanagurta*the estimated protein was 20.8 %. Therefore, the study revealed that these two species have a good amount of proteins. Lipids have an important role in human health because a deficiency in this can affect the growth of infants and children in the human population. Also, it decreases immunity and poor wound healing. The lipid is a vital factor of the human body that acts as an energy source during the excessive need for energy (Mohanty *et al*., 2019; Sujatha *et al*., 2013). The amount of total lipid content was seen highest in the liver of *R.kanagurta* (14.03 ± 0.3mg/kg). The muscle of *M. dobsoni* had 6.55±0.4mg/kg of total lipids, and lipid content in *R.kanagurta* muscle was 3.05±0.3 mg/kg. Carbohydrate and glycogen content is the main source of energy for animals, and its content in the liver and muscle indicates the health of the fish. In fish, carbohydrates form a small percentage of total composition compared to total proteins, and the amount of carbohydrates in *R. kanagurta*is meagre (Sahu & Parida, 2020). For a healthy human diet, food with fewer carbohydrates is needed; thus, the species studied are excellent nutritious sources. Both species studied show that the carbohydrate and glycogen contents are low.

Heavy metal concentration in R. kanagurta and M. dobsoni: The presence of heavy metals in the fish and the marine environment affects both fish health and the humans consuming it, and it becomes a severe threat to both fish and the human population (Younis *et al*., 2021). Heavy metals get transported through the natural food chain and accumulate in organisms forming dangerous levels of concentration (Yi *et al*., 2011). Vital elements like Zn, Cr, and Fe are among the microelements needed for the wellbeing of fish. These minerals are required in a certain amount. If deficient, it can cause adverse effects on fish health. Its high concentration can negatively affect it, equivalent to or worse than those caused by non-essential metals.

Table 3. Condition Factor of *Rastrelliger kanagurta* and *Metapenaeusdobsoni*

Sample	*Rastrelliger kanagurta*			Sample	*Metapenaeusdobsoni*		
	Length (cm)	Weight (g)	Condition factor(k)		Length (cm)	Weight (g)	Condition factor(k)
F1	16.5	57.17	1.27	S1	10	5.62	0.56
F2	16	52.21	1.27	S2	9	5.42	0.74
F3	16	57.62	1.41	S3	9.8	5.06	0.54
F4	16.3	62.71	1.45	S4	8.8	5.35	0.79

Table 4. Biochemical constituents in the tissues of *R. kanagurta* and *M. dobsoni*

	Total Proteins (mg/kg)	**Total Carbohydrates** (mg/kg)	**Glycogen** (mg/kg)	**Total Lipids**(mg/kg)
Fin Fish Liver	26.388 ± 0.4	0.840 ± 0.3	0.75 ± 0.3	14.03 ± 0.3
Fin Fish Muscle	15.745 ± 0.5	0.351 ± 0.4	0.32 ± 0.4	3.05 ± 0.3
Shell Fish Muscle	12.688 ± 0.5	0.373 ± 0.4	0.34 ± 0.4	6.55 ± 0.4

(Values are the average of four replicates**)**

Metals such as Cd and Pb have no proven role in biological function, and their concentration causes severe toxicity (Tashla *et al*., 2018). The physiological and biochemical mechanisms in fish are disturbed by heavy metals (Ljubojević *et al*., 2014). The average zinc content in the tissues of *R. kanagurta* was 2.530mg/kg in muscle and 12.03mg/ kg in the liver. The study reveals that the concentration of zinc content value is below the permissible limit of 30 mg/kg (FAO/WHO, 1989). Zn forms the constituent of many enzymes responsible for certain critical biological functions. In the species studied, the muscle of *M.dobsoni* (5.865 mg/kg) contains more Zn content than *R. kanagurta* (2.530mg/kg). This difference may be because species found in sandy/muddy bottoms have larger Zn values, and it is also reported that the concentrations of Zn in fish muscle increase with depth (Carvalho *et al*., 2005). Iron is among the essential micro minerals for the human body (Mohanty *et al*., 2019). The permissible limit of iron for daily human intake is 100mg/kg (FAO/WHO, 1989). Both the fish species analysed have a good concentration of iron content which can be utilized for human consumption. Cd and Pb are non-essential metals with no biological function in fish (Int. source: www.epa.gov). The permissible limit of cadmium and lead per day for consumption is 0.05mg/kg and 0.20 mg/kg, respectively. The contamination creates adverse effects on man. The Pb content in the analysed fish samples was very high, and long-term consumption of this fish may create serious health issues. The Cd content was also found to be very high in the fish tissues, which causes the accumulation of this toxic heavy metal in the organs of the consumers and causes disorders in kidneys and osteoporosis.At relatively low levels, lead can participate in synergistic toxicity with other toxic elements like cadmium and mercury.

CONCLUSION

The results obtained from the present study reveal that the examined fish species *R. kanagurta*and *M.dobsoni* are good sources of proteins and lipids and can be included in the diet. But the concentration of toxic metals, Cd and Pb, are above the permissible limits (FAO/WHO,1989) and makes them unfit for long-term consumption. Every pollution created by man ultimately puts them in trouble. Fishes are the best source of nutritional food with fewer carbohydrates; thus, avoiding them in diet will affect health. So, the marine pollution due to solid waste disposal should be reduced to avoid the heavy metal contamination in aquatic organisms, especially in edible fishes.

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