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NUTRITIONAL EVALUATION OF ASIATIC MANGROVE *RHIZOPHORA MUCRONATA* – ITS PROXIMATE COMPOSITION, AMINO ACID PROFILES AND PHYSICO-CHEMICAL PROPERTIES

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Key words:

Rhizophora mucronata, Amino acid, fatty acid, Macronutrient, micronutrient, physicochemical properties

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ABSTRACT: The present study explores the nutritional properties of *R. mucronata* leaves, an edible red mangrove which has been proven as an antidiabetic and as an alternative source of tea leaves and animal feed. Proximate composition, amino acid profiles and physico-chemical properties were analyzed to evaluate the nutritional property. Nutritional evaluation of *R.mucronata* illustrates it as a rich source of essential aminoacids and unsaturated fatty acid (alpha linoleic and linoleic acid). Total dietary fiber content, protein, ash, carbohydrate and lipid content was found to be 11.9 ± 0.2, 2.445 ± 0.179, 13.5 ± 0.0021, 79.277± 0.079 and 0.749 ± 0.049 % DW respectively. Mineral and vitamin analysis per 100 g (DW) showed the presence of sodium (80.804 ± 4.0 g), calcium (22.32± 1.1g), potassium (7.96 ± 3.9 g), iron (53.6 ± 0.5mg), magnesium (38.15 ± 0.38 mg) and Vitamin A (2.2 ± 0.02 mg), Vitamin C (3.23 ± 2.3g), Vitamin E (1.180± 1.8 g), vitamin B1 and B2 (18.04 ±0.1 and 0.89 ± 0.08 mg). Swelling, water-holding and oil-holding capacity showed strong positive correlation with their total fiber and protein content. Hence, the leaves of *R. mucronata* could be used as a supplement for complementing nutritional deficits prevailing in developing countries

INTRODUCTION: Plants and their products serve directly or indirectly as source of food, medicinal product and energy to man and his livestock. Increase in population and fast depletion of natural resources, necessitates domestication of many wild plants in order to meet various human needs [1]. Hence nowadays research on nutritional analysis of vast wild under-utilized and under-exploited plants were carried out, so that these plants can act as a source of food to the nutritionally marginal populations particularly to the inhabitants of the developing world where food shortages and famine is most experienced [2].

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Mangrove forest is a vegetation community formed by a variety of salt tolerant species growing in the inter-tidal areas and estuary mouth between land and sea. Earlier in 13th century, mangroves were established sources of food, fuel, medicine, and tanning leather in Middle East countries [3]. Presently, mangrove leaves are being used as a feed ingredient for dairy cows, sheep, and poultry with some advantages over their common commercial feeds [4]. *Rhizophora mucronata* a red mangrove belonging to the family *Rhizophoraceae* is the predominant species in mangrove ecosystem and it is the preferred species for mangrove restoration. For long years leaves of *R. mucronata* have been used as alternative source of tea leaves, anti diabetic agent and as animal feed [5, 6].

Recent studies showed that the methanolic leaf extract of *R. mucronata* exhibited excellent antioxidant activity, cholinesterase inhibitory activity [7]. In spite of the popular use of *R.*

mucronata in traditional medicine, its nutritional properties have not been completely exploited when compared to terrestrial plants. Hence the present study focuses on evaluation of nutritional properties of leaves of *R. mucronata* with a hope that it would be incorporated into the food basket of the country. In this work, we considered nutritional values of leaves of *R. mucronata* as important food plant with food analytical methods.

MATERIALS AND METHODS:

Plant material:

The fresh leaves of *Rhizophora mucronata* were collected from Parangipettai, Vellar estuary, Tamilnadu, India during October 2009. The collected plant material was placed in a polyethylene bag to prevent loss of moisture during transportation to the laboratory. Taxonomic identification of the plant was carried out by Professor K. Kathiresan, CAS in Marine Biology, Annamalai University, Tamilnadu (Voucher No: AU1723). Fresh leaves were air dried, powdered and stored at -20˚C prior to further nutrient composition analysis. The sample analysis were carried out in Department of Biotechnology Alagappa University, A to Z laboratories, Sankara Nethralaya medical research foundation, IIT Chennai.

Instruments:

Soxhlet apparatus (JEIOTECH / VELP SER 143/6; 2010), Dessicator, Lyophiliser (Martin Christ, Germany), Atomic absorption spectrophotometer (Varian model spectra 220, Agilent Technologies, USA), UV-visible spectrophotometer (UV 2450, Shimadzu, Japan), Oven, Reverse phase HPLC (HPLC, HP-1101 Agilent Technologies), GC-MS (6890N system for GC, Agilent Technologies fitted with HP-5 capillary column), Fluorescence spectrometer (Perkin Elmer Model 512, USA)

Nutritional property evaluation:

Physicochemical properties such as swelling capacity (SWC), water retention capacity (WHC) and oil holding capacity (OHC) of *R. mucronata* leaf samples were assessed by following the experimental protocol used in a European collaborative study [8, 9].

Proximate composition analysis:

The recommended methods of the Association of Official Analytical chemists [10] were used for the determination of moisture, ash, crude lipid, crude fibre and crude protein content.

Protein content:

Approximately 1gm of the sample was extracted with diethyl ether and water (1:4) for 3 h in shaker. The supernatant was discarded and 1 N NaOH was added to the pellet and kept in shaker for 3 h. The mixture was centrifuged at 7000 rpm for 10 min. The supernatant collected was precipitated with 10% solution of TCA at pH 4.0. The samples were kept in ice for 30 min until visible precipitate appears. The samples were then centrifuged at 7000 rpm for 20 min. The precipitated protein was washed and dried. The pellet was dissolved in 0.1 N NaOH and the protein concentration was determined according to Lowry et al., method[11] using bovine serum albumin as the standard.

Extraction of crude lipids:

The total lipid content was determined in duplicate by a modified version of AACC Method 30-25[12]. About 3 gm of powdered leaf sample was defatted with petroleum ether and extracted with chloroform: methanol (2:1 v/v) in a Soxhlet extractor for 6 h. The extract was evaporated in oven at 80°C overnight and the content of crude lipid was determined gravimetrically.

Determination of proline content: [13]

About 500 mg of the plant material was homogenized in 2 ml of aqueous sulfosalicylic acid (1%) and then filtered through Whatman # 2 filter paper. About 2 ml of the filtrate was treated with 2 ml of acid ninhydrin (1.25 gm/30 ml glacial acetic acid) for 1 h at 100˚C and then the reaction was terminated in ice bath. The reaction mixture was extracted with 4 ml toluene, mixed vigorously with a test tube stirrer for 15-20 s. The chromophore containing toluene was aspirated from the aqueous phase, warmed to room temperature and the absorbance was read at 520 nm using toluene as blank. The proline concentration was determined from a standard curve using proline as a standard. The concentration of proline is calculated as below

[(µg proline / ml × Vol. of toluene) / 115.5 µg/µM] / [(g sample)/5] = µM proline/g of fresh weight material.

Estimation of total chlorophyll content:
Approximately 1gm of the sample was homogenized with 96% methanol (50 ml) in B-Brawn type homogenizer at 1000 rpm for 1 min. The homogenate were then centrifuged at 2500 rpm for 10 min. The supernatant was separated and the absorbance was read at 400 -700 nm under UV-spectrophotometer (UV 2450, Shimadzu). It was recorded that Chlorophyll a showed the maximum absorbance at 662 nm, chlorophyll b at 646 nm and total carotene at 470 nm and the amount of these pigments were calculated according to the formulas of Lichtentaler and Wellburn[14].

Total carbohydrate estimation by phenol sulphuric acid method:
Approximately 500 mg of sample were weighed and subjected to hydrolysis with 5 ml of 2.5 N HCl by keeping the tubes in a boiling water bath for 3 h. Tubes were cooled to RT and then neutralized with solid sodium carbonate until the effervescence ceases. The volume of the sample was made up to 100 ml and centrifuged. The supernatant was collected for carbohydrate estimation by phenol sulfuric acid method [15].

Mineral Analysis:
Mineral content of *R. mucronata* leaves were estimated according to method of Santoso et al.[16]. Approximately 2 gm of powdered leaf sample were dissolved in 10 ml of perchloric acid and incubated at 100°C for 5 min. Processed samples were then treated with 10 ml of conc. HNO_3 followed by 10 ml of conc. H_2SO_4. Acid treatments were carried out at 100°C for 5 min each in hot plate. Finally the sample was evaporated to dryness and diluted with 10% HCl. Diluted samples were then filtered through an ash-free, acid washed filter paper. Major mineral elements (Na, K, Ca, Mg) and trace elements (Fe, Zn and Pb) were determined in Atomic Absorption Spectrophotometer (Varian model spectra 220, Agilent Technologies) equipped with single hollow cathode lamps for each element and an air-acetylene burner.

Analysis of fatty acid composition:
Preparation of fatty acid methyl ester (FAMES):
The fatty acid composition was analyzed by GC-MS chromatography after derivatization of fatty acid to methyl esters (FAMEs) according to the method of Yayli et al.[17]. The crude lipid samples (75 mg) were dissolved in toluene (1 ml) in a test tube fitted with a condenser, and to this H_2SO_4 in methanol (2 ml, 1%) was added. The mixtures were left overnight in a stoppered tube at 50°C followed by the addition of sodium chloride solution (5 ml, 5%). The required esters were extracted with hexane (2x, 5 ml), and the organic layer was separated using Pasteur pipettes for both samples. The hexane layers were washed with potassium bicarbonate solution (4 ml, 2%) and dried over anhydrous Sodium thiosulfate (Na_2SO_4) and filtered. The organic solvent was removed under reduced pressure on a rotary evaporator to give fatty acid methyl esters. The FAMEs were separated and identified in GC analysis using 6890N system for GC (Agilent Technologies) fitted with HP-5 capillary column.

The inlet oven temperature was kept at 70°C initially. Injection temperature was kept at 220°C and detector temperature was maintained at 280°C. 1 µl of the sample was injected into GC for analysis. Helium was used as carrier gas at the flow rate of 1 ml/min. Individual fatty acid methyl esters were identified by comparison with standard FAMEs obtained from Sigma Chemical Company, U.S.A. The results were expressed as a percentage of individual fatty acids in the lipid fraction.

Total amino acid analysis
Approximately 1 g of *R. mucronata* leaf was extracted with 10 ml of phosphate buffer pH 7.0. Total amino acid contents were determined after hydrolysis of pellet with 6 N HCl at 100°C in vacuum hydrolysis tubes, for 24 hrs. After hydrolysis the tubes were centrifuged at 3500 rpm for 15 min and the supernatant was filtered. The filtrate was neutralized with 1N NaOH and diluted to 1:100 of the volume with milliQ-water. The analysis was performed by reverse phase HPLC, HP-1101 Agilent Technologies with UV and Fluorescent detector [18].

Vitamin analysis
Analysis of Vitamin A, E and C
Vitamins A, E and C were extracted from the leaf sample according to the method of Singh and Bradbury [19], Murcia et al. [20] and Abdulnabi et al. [21]. The extracted leaf samples were used for HPLC

analysis. Mobile phase used for the analysis of Vitamin A and E was n-hexane and orthophosphoric acid: methanol in the ratio 95:5. In the case of vitamin C, 0.1M potassium acetate pH 4.9 and acetonitrile-water (50:50) was used as mobile phase. The liquid chromatography was equipped with 325-nm detector and 4.6-mm × 15-cm column that contains 3-µm packing L8. The flow rate was about 1 ml per minute. Retinyl acetate and retinyl palmitate (7.5µg/ml), α-tocopherol (2 mg/ml) and ascorbic acid (1 mg/ml) were used as standards for Vitamin A, E and C respectively.

Equal volumes (about 40 µL) of the standard preparation and the sample preparation were separately injected into the chromatograph. The chromatograms were recorded as peak area of retinyl acetate or retinyl palmitate in the chromatogram of the sample preparation. Similarly results for vitamin E and C were recorded as mg of V equivalent or ascorbic acid equivalent.

Spectrophotometric analysis of Vitamin B1 (Thaimine HCl) and Vitamin B2 (Riboflavin):

Thiamine and Riboflavin content in the leaf sample was determined according to the method of Bradbury and Singh [22]. 1 g of powdered leaf sample was homogenized in 0.1M HCl and was incubated at 100˚C for 1 h. The supernatant was treated with lead acetate, dilute sulfuric acid and centrifuged. To the supernatant alkaline solution of potassium ferricyanide was added which converted thiamin to fluorescent thiochrome which was finally extracted with isobutanol. The fluorescence was measured in fluorescence spectrometer with excitation and emission wavelength of 370 nm and 445 nm (Perkin Elmer Model 512). For estimation of riboflavin, 1 g of powdered leaves was extracted was homogenized with acetate buffer of pH 4.3 and heated at 100°C for 1 h. The supernatant was then oxidized with potassium permanganate and excess of potassium permanganate was removed by the addition of hydrogen peroxide. The fluorescence of riboflavin was measured in a fluorescence spectrometer (Ex 440 nm and Em 530 nm). The fluorescence of the sample was compared with standard thiamine hydrochloride (10µg/ml) for vitamin B1and riboflavin (12µg/ml) for vitamin B2.

Statistical analysis:

All results are presented as mean ± S.D. Data were analyzed using one-way analysis of variance (ANOVA) and, when appropriate, by a Student–t - test. Results were considered significant at $p < 0.05$.

RESULT AND DISCUSSION:

Proximate composition analysis:

Macronutrient composition of *R. mucronata* leaves were tabulated in **Table 1**. The crude protein content of the leaf sample of *R. mucronata* was found to be 2.445 ± 0.179 % DW which is higher than the level reported in other mangrove leaves such as *Suaeda maritime*, *Lumnitizera racemosa*, *Avicennia marina*, *Bruguiera gymnorrhiza*, *Sonneratia apetala* and *Derris trifoliata* respectively [23, 24]. Similar values have been reported in the edible leaves of traditional Indian medicinal plants (~ 2–3% DW) and conventional green leafy vegetables of India [25, 26].

The crude lipid of the leaf sample was found to be 0.749 ± 0.049 % DW which is higher than the reported values of mangrove leaves [25] and edible green leafy vegetables (0.33-1%) [27]. Although the moisture content in *R. mucronata* (18.2 ± 0.18% per g of DW), is lesser than leafy vegetables, fruits of Indian origin [27, 28], and higher when compared to cereals and pulses of south India [29]. TDF in the form of soluble and insoluble fractions in food plays a significant role in human nutrition. Soluble dietary fiber reduces blood sugar and cholesterol level, while insoluble fiber increases fecal bulk and decreases intestinal transit time. Intake of DF reduces the risk of coronary heart disease, hypertension, constipation, diabetes, colon and breast cancer [30].

TDF content of *R. mucronata* leaves was found to be 11.9 ± 0.2 % DW which is higher than the level of edible mangrove leaves (1.2-2% DW), Indian fruits (1-10%) and tropical Indian vegetables [23, 28 & 31]. The high crude fiber content of *R. mucronata* provides a good indication of nutritive value of it as feeding materials. Total ash content of *R. mucronata* leaves was found to be 13.5 ± 0.0021% DW which is higher than the reported value of edible mangrove leaves (2.76-5.25% DW), green leafy vegetables ranging from 1-3% [23, 27]. The high

ash content that was observed in the leaves of the R. *mucronata* is an indication that the plant is a good source of minerals. Total carbohydrate level of leaf sample was found to be 79.277± 0.079 % DW which is observed to be considerably higher when compared to the leaves, fruits and twigs (4-22%) of various mangrove plants [23], green leafy vegetables particularly amarnathus species (9-21%) from various parts of India [32]. According to Food and Nutrition Board [33], USA, carbohydrate rich vegetables with high dietary fiber content reduces plasma cholesterol levels. Hence *R. mucronata*, the analyzed leaf sample rich in carbohydrate and fiber content can act as beneficial diet for diabetes and cardiovascular diseases.

Leaves of *R. mucronata* exhibited high carotenoid level of 48.433 ±0.6327 mg/100g of DW when compared to the leafy vegetables (10-33.21mg/100g of DW) [34]. Chlorophyll a and b level of leaf sample was found to be 0.6754±0.007; 0.540±0.0034 mg/g respectively, which is higher when compared to the chlorophyll level of other mangroves leaves ranging from 0.05-0.36 mg/g [35].

TABLE 1 PROXIMATE COMPOSITION ANALYSIS OF LEAVES OF *RHIZOPHORA MUCRONATA*

S. No:	Analysis	Concentration
1	Dietary fiber content (g/100g of DW)	11.9 ± 0.2
2	Crude protein (g/100g of DW)	2.445 ± 0.179
3	Ash content (g/100g of DW)	13.5 ± 0.0021
4	Crude lipid (g/100g)	0.749 ± 0.049
5	Proline content (μM/g)	26.25±2.701
6	Chlorophyll a (μg/g)	7.1629±0.727
7	Chlorophyll b (μg /g)	5.646±0.341
8	Moisture content (%/ g)	18.2±0.18
9	Total carotene (mg/100g)	53.123±66.327
10	Total CHO (mg/g of DW)	79.277± 0.079

Mineral content of *R. mucronata* leaves:

R. mucronata leaf sample has significant amount of essential elements, as shown in **Table 2**. Calcium (223.23 ± 0.001 g/100 g dry weight) was the most abundant element followed by sodium level (80.804 ± 0.004 g/100 g DW). The other elements found were potassium (7.916 ± 0.003 g/100 g DW) and magnesium (0.038 ± 0.00038 g/100g). The level of major elements of *R. mucronata* leaf sample was observed to be higher than the level reported in green leafy vegetables, cereals, pulses, and amaranthus species commonly consumed in south India [31, 32] .

TABLE 2: MAJOR MINERAL AND MINOR ELEMENTS PRESENT IN LEAVES OF RED MANGROVE *R. MUCRONATA*

S. No	Name of the elements	Concentration (mg/100g DW)
1	Sodium	80804.2 ± 4.0
2	Potassium	7916.2± 3.9
3	Calcium	22323.8 ± 1.1
4	Magnesium	38.15 ± 0.38
5	Iron	53.6 ± 0.5
6	Lead	0.2± 0.01
7	Zinc	6.5 ± 0.065

Trace element Zn in the leaves of *R. mucronata* was found to be 6.5 ± 0.06 mg/100 g DW which is higher than the level observed in vegetables (25-50.2 mg/Kg) such as potato, rice, tomato, peas, onion [36] and similar to leafy vegetables (2.4-6 mg/100gm DW) [27]. High concentration of zinc in leaves of *R. mucronata* suggests its use in treatment of bleeding, wounds and insect bites. The concentration of Fe in the leaves of *R. mucronata* was found to be 53.6 ± 0.5 mg/100 g DW which is greater than the Fe content in green leafy vegetables (5-15 mg/100g DW), cereals, pulses and vegetables commonly used in South India (2.7-50 mg/100 g DW) [27, 29]. This indicates that the leaves

of *R. mucronata* with a good source of dietary Fe could provide energy and help in enhancement of hemoglobin counts.

Fatty acid Profile:

Results of fatty acid analysis along with retention time are shown in **Table 3**. Analysis of the fatty acid revealed the presence of both saturated (SFA) and poly unsaturated fatty acids (MUFA and PUFA). The UFA oleic acid (22.47%) and the essential fatty acids α Linolenic acid (ALA-60.68%), and Linolenic acid (LA - 8.28%) were present in higher concentration when compared to SFA levels. The observed value of ω6 (LA) and ω3 (ALA) fatty acid of *R. mucronata* was found to be higher than the green leafy vegetables, spices, other vegetables of Indian diet which ranges from 0.009-3.44 (LA) and 0.48-1.87 (ALA) g/100 g respectively [37].

TABLE 3: FATTY ACID PROFILE OF LEAVES OF *RHIZOPHORA MUCRONATA*

Peak	Fatty acid	Retention time	% of fatty acid
	Saturated fatty acid (SFA)		
1	C14:e (Myristic acid)	26.3	1.41
2	C16:0 (Palmitic acid)	30.5	0.55
3	C18:0 (Stearic acid)	33.5	5.67
	Monousaturated fatty acid (MUFA)		
4	C18:1 (Elaidic acid)	30.3	0.61
5	C18:1 (Oleic acid)	35.4	22.47
	Polyunsaturated fatty acid (PUFA)		
6	C18:2 (Linoleic acid, n-6)	37.5	8.28
7	C18:3 (alpha linolenic acid, n-3)	39.5	60.68
8	C22:02 (Arachidonic acid)	46.1	0.33
	Ratio ω6/ω3	0.136	

Intake of foods rich in ω6 and ω3 FA's reduces the risk of coronary heart disease, insulin resistance type 2 diabetes and age related neurodegenerative disorders. In a nutritionally balanced diet, the LA/ALNA ratio should be less than 10. The ratio of LA/ALA in the leaves of *R. mucronata* was found to be 0.136 and the level of SFA is very less, which further substantiates the use of mangroves in traditional medicine.

Aminoacid content:

Amino acid content of leaves of *R. mucronata* are illustrated in **Fig. 1**. The total amino acid content in the leaves of *R. mucronata* were found to be 116.352 mg/g of protein, of which, 78.623 mg/ g are essential amino acids. Ratio of essential to non-essential amino acids was observed to be 2.083 and the ratio of essential to total amino acid is 0.67, which shows that almost 3/4th of the amino acid in leaves of *R. mucronata* are essential amino acids. The food protein quality is valued based on the ten essential amino acids which imply that this leaves have a high biological protein value. In addition the leaves also contains all the essential amino acid composition according to the FAO requirement pattern of children and adults [38] which implies that leaves of *R. mucronata* could act as complementary source of food proteins for human and animal nutrition.

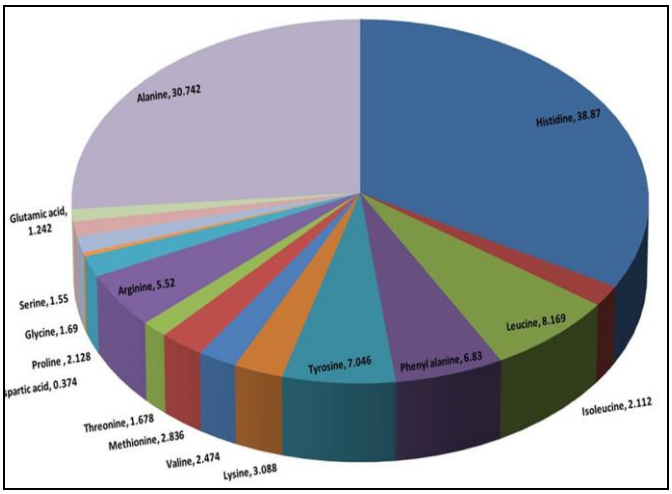

FIG. 1: TOTAL AMINOACID COMPOSITION OF LEAVES OF *RHIZOPHORA MUCRONATA*

Vitamin level in leaves of *R. Mucronata:*

Results of Vitamin content (**Table 2**) were observed to be higher than RDA for Indian adults (ICMR, 2010). Vitamin A content of leaf sample was observed to be 2.2 ± 0.02 mg RE/100g of leaves, which is lesser when compared to the level

of seed and husk of *nypa fruticans* (8±0.21; 30.50±0.64 mg/100g DW), edible green leaves, common leafy vegetables and non conventional leaves in India [23, 39]. Ascorbic acid content of *R. mucronata* leaves was found to be 3.23 ± 0.23g/100g sample which is higher than the reported level in Indian edible green leaves and leafy vegetables such as carrot, cauliflower, amaranth, spinach (23-110 m g/100g) [26, 27]. Thiamine and riboflavin content of the leaf sample was found to be 18.04 ±0.1 and 0.89 ± 0.08 mg/100g which was found to be higher than the level of cereals, pulses grown in developing countries and Indian green leafy vegetables [34]. Observed values of water soluble Vitamin C, B1 and B2 were found to be higher when compared to level of green leaves, vegetables and fruits [40]. Vitamin E content of leaves of *R. mucronata* was found to be 1.180± 1.8 mg/100g DW. Rich source of the Vitamins A, C and E in leaves of *R. mucronata* makes this plant an additional dietary means for prevention of oxidative stress disorders as these plant derived sterols has potent antioxidant effect.

TABLE 4: VITAMIN COMPOSITION OF LEAVES OF *RHIZOPHORA MUCRONATA*

S.No:	Vitamin	Concentration (mg/100gm sample)
1	Vitamin A (mg of retinol equivalent)	2.2 ± 0.02(0.715)
2	Vitamin E (mg of tocopherol equivalent)	1180± 1.8(7.5-10)
3	Vitamin C (mg of ascorbic acid equivalent)	3230± 23.2(74.8)
4	Vitamin B_1 (mg of thiamine equivalent)	18.04 ±0.1(1.15)
5	Vitamin B_2(mg of riboflavin equivalent)	0.89 ± 0.08(2.45)

Values in (parentheses) represent RDA in mg (RDA 2010):

Physicochemical properties:

The physiological effect of dietary fiber content is correlated with its physicochemical properties like SWC, WHC and water retention capacities. Hydration properties of dietary fibers determine their optimal usage levels in food because a desirable texture must be retained [41]. SWC, WHC and OHC of leaves of *R. mucronata* are shown in Table 4. SWC was found to be 3±1.414 and 4.5± 0.707 ml/g DW at 25 and 37˚C respectively. WHC of *R. mucronata* was found to be 4.69 ±0.127 and 5.33±0.438 g/g of DW at 25 and 37˚C. WHC of observed leaf sample was found to be higher when compared to the level of oat bran, wheat bran and fruits fiber [42]. Study on effect of temperature on SWC and WHC showed that both SWC and WHC increased significantly with temperature (**Table 6**). Such increase was probably related to the increase in the solubility of fibers and proteins [42]. The two hydration properties, SWC and WHC determined by dietary fiber content, confer the ability of the fiber to absorb and hold water.

Hence these polysaccharides are considered beneficial to gut health, contributing to water binding, faecal bulking and decreasing transit time, which is a positive factor in preventing colon cancer [42]. OHC an important property of food ingredients used in formulated food. OHC of *R. mucronata* leaf was found to be 1.51±0.014 g/g DW which is similar to the OHC of Orange (0.86±1.28 g/g DW) and Peach (1.02±1.11 g/g DW). Enhanced OHC of the leaf sample might be due to the hydrophobic nature of protein present. Increase OHC property suggests that the red mangrove leaf would be able to stabilize food emulsions with high fat content.

TABLE 5: PHYSICO-CHEMICAL PROPERTIES OF *RHIZOPHORA MUCRONATA*

S.no:	SWC (ml/g) DW		WHC (g/g) DW		OHC (g/g) DW
1	25˚C	37˚C	25˚C	37˚C	1.51±0.014
	3±1.414	4.5 ±0.707	4.69 ± 0.127	5.33 ± 0.438	

CONCLUSION: Results of nutritional analysis in comparison with green leafy vegetables consumed in India revealed to be good source of dietary fiber, lipid and protein content. Leaves were found to be rich in PUFA with relatively high level of ALA (ω3) which is regarded beneficial to health. Amino acid composition of leaf sample was found to be within the reference of FAO/WHO requirement.

Micronutrient analysis showed rich source of ascorbic acid, thiamine, riboflavin, tocopherol, sodium, iron and calcium which could help in overcoming micronutrient malnutrition at a negligible cost. Physicochemical properties together with their chemical composition reveal their suitability to be a good source of food fiber for human consumption. Thus results of the present study conclude that leaves of *R. mucronata* is a potential health food in human diets and may be of use to the food industry as a source of ingredients with high nutritional value.

CONFLICT OF INTEREST: The manuscript is an original article which has not been submitted for publication elsewhere. The author Dr. K. Pandima Devi reports that she has no conflict of interest. Author Mrs. N. Suganthy declares that she has no conflict of interest. This article does not contain any studies with human or animal subjects.

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