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RESEARCH ARTICLE

Mangrove Fruit Products: A Search for Alternative Livelihood for Island Dwellers of Lower Gangetic Delta

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ABSTRACT

Sonneratia apetala is a common mangrove tree in the Indian Sundarbans located at the apex of Bay of Bengal in the lower Gangetic delta region. The fruit of this species appears during the monsoon season and is extensively consumed by the island dwellers of Sundarbans. Pulp and jelly prepared from the fruit pulp extract were analyzed for vitamin C, Mg, Na, K, Ca, Cu, Co, Mo and Zn with the objective to generate alternative livelihood for Sundarban people who are the worst sufferers of climate change related impacts in the Indian sub-continent. The results of the fruit products were compared with the jelly prepared from other edible fruits to evaluate the nutritional status of the present product. Vitamin C of the fruit pulp and jelly were significantly higher than other citrus fruits. The major and trace elements of the jelly were well within the range of accepted level for human consumption. A master plan for creating back up nurseries of *S. apetala* in lower Gangetic delta complex can open up and sustain a mangrove based alternative livelihood for Sundarban people.

KEYWORDS

Sonneratia Apetala, Vitamin C, Major Elements, Trace Elements

INTRODUCTION

Estimation of vitamin C, major elements and essential trace elements of fruit and fruit products is a growing trend in nutritional studies throughout the world. Vitamin C is an antioxidant and has great role to prevent cough and cold. Major elements have significant role in human metabolism and control the normal functioning of body. Trace elements don't provide any calories, but play an important role in the metabolic regulation in human body by maintaining the body pH, osmotic regularity and used as coenzyme which regularize the metabolic action.[1] Elemental composition of fruits and vegetables depend on different factors e.g. genetic, weather, soil and the harvesting stage of maturity. Trace elements are the natural constituents of soil and due to variation of environmental condition their uptake varies through root to the shoot.[2] In Indian Sundarbans significant variation of carbon content in mangrove trees due to variations of salinity and other edaphic factors has been reported by several researchers.[3-6]

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S. apetala is a common mangrove tree abundantly found in the western sector of Indian Sundarbans, where salinity is relatively low (average water salinity is ~12 psu) compared to the central sector (average value is ~18 psu).[3,6-9] The fruit of this species is sour in taste with greenish-yellow pulp (Figure 1) and appear in plenty during the months of August and September, the period characterized by heavy rainfall, low salinity and relatively low pH of the aquatic phase. The fruits are mainly preferred by deer population of Sundarbans, but a large fraction of island dwellers consume the fruit after processing and cooking. No report on the nutritional status of the fruit is yet available from this part of sub-continent. The present observation is therefore a baseline study of the same and has the potential of opening an alternative livelihood for the people of the deltaic region, if proper backup nursery of the species can be created in the islands involving the local people.

Figure 1: *Sonneratia apetala* fruit

MATERIALS AND METHODS

Study Site

The Indian Sundarbans (21˚13′N to 22˚40′N and 88˚03′E to 89˚07′E) at the apex of Bay of Bengal is a mangrove dominated delta in the lower Gangetic region. This mangrove forest has been declared as the World Heritage Site by IUCN in 1987, Biosphere Reserve under Man and Biosphere programme by UNESCO 1989 and is a proposed RAMSAR site.[10]

The region is extremely vulnerable to climate change related impacts and the sea level rise is 3.14 mm/yr, which is higher than the mean global sea level rise.[11] The frequent intrusion of saline water into the agricultural lands, fisheries etc. pose acute adverse impact on the livelihood sectors of the local pollution. Hence search for alternative livelihood has become imperative as a part of adaptation to climate change scenario. The adaptation would be sustainable if the livelihood can be linked with the endemic mangrove vegetation of the deltaic complex. On this background the present programme was initiated by the Techno India University, Kolkata researchers to rationally utilize the mangrove products for the benefit of the local people.

The western sector of the Indian Sundarbans, adjacent to Hooghly estuary sustains a large population of *S. apetala*, from where the ripe fruits were collected during August, 2013.

Analysis of Biochemical Composition

The seed and pulp of *S. apetala* fruits were segregated for biochemical analyses. Jelly was prepared as per the standard method[12] from the pulp of the fruit.

The pulp and jelly samples were oven dried at 45˚C to constant weight for analysis of major and trace elements.

Inductively Coupled Plasma – Mass Spectrometry (ICP-MS) is now - a - day accepted as a fast, reliable means of multi-elemental analysis for a wide variety of sample types.[13] A Perkin-Elmer Sciex ELAN 5000 ICP mass spectrometer was used for the elemental analysis. A standard torch for this instrument was used with an outer argon gas flow rate of 15 L/min and an intermediate gas flow of 0.9 L/min. The applied power was 1.0 kW. The ion settings were standard settings recommended, when a conventional nebulizer/spray is used with a liquid sample uptake rate of 1.0 mL/min. A Moulinex Super Crousty microwave oven of 2450 MHz frequency magnetron and 1100 W maximum power Polytetrafluoroethylene (PTFE) reactor of 115 ml volume, 1 cm wall thickness with hermetic screw caps, were used for the digestion of the fruit pulp and jelly samples. 20 mg composite samples of dried fruit pulp and dried jelly were weighed separately

and successively treated with 4 ml aqua regia, 1.5 mL HF and 3 ml H_2O_2 in a hermetically sealed PIFE reactor, inside a microwave oven, at power levels between 330-550 W, for 12 min to obtain a clear solution. The use of microwave-assisted digestion appears to be very relevant for sample dissolution, especially because it is very fast.[14] After digestion, 4 ml H_2BO_3 was added and kept in a hot water bath for 10 min, diluted with distilled water to make up the volume to 50 ml. Taking distilled water in place of fruit pulp and jelly samples and following all the treatment steps described above the blank was prepared. The final volume was made up to 50 ml. Finally, the samples and process blank solutions were analyzed by ICP-MS. All analyses were done in triplicate and the results were expressed with standard deviation.

The accuracy and precision of our results were checked by analyzing standard reference material (SRM, Dorm-2). The results indicated good agreement between the certified and the analytical values (Table 1).

The Ascorbic acid (vitamin C) of the fresh fruit was determined by Indophenol method as per the procedure as outlined by Food Analysis Laboratory Manual.[15]

Table 1: Concentrations of metals found in Standard Reference Material DORM-2 (dogfish muscle) from the National Research Council, Canada (all data as means ± standard errors, in ppm dry wt)

Value	Zn	Cu	Pb	Cd
Certified	26.8	2.34	0.065	0.043
SE	2.41	0.18	0.009	0.005
Observed*	23.9	2.29	0.060	0.040
SE	1.99	0.17	0.006	0.006
Recovery (%)	89.2	97.8	92.3	93.0

*Each value is the average of 5 determinations

Table 2: Comparison of the major and trace elements and vitamin C

Fruits	Vitamin C (mg/100 gm)	Major elements (ppm)				Trace elements (ppm)			
		Na	K	Mg	Ca	Zn	Cu	Co	Mo
Lemon	44.5	20	1160	70	220	0.5	0.31	-	-
Lime	19.5	10	680	40	220	0.7	0.44	-	-
Orange	69.7	-	2370	130	520	0.9	0.59	-	-
Grape fruit	79.1	-	3200	180	280	1.6	1.08	-	-
S. apetala fruit pulp (our study)	423.71	9274.19	17425.53	1440	2714.29	20.80	11.11	0.25	0.01
S. apetala jelly (our study)	42.71	2984.05	3003.80	1160	71.43	13.54	9.54	BDL	BDL

RESULTS

Table 2 lists the results of the vitamin C in the pulp and jelly prepared from the fruit pulp extract. The order is pulp > jelly. The major element of the pulp and jelly followed the order K > Na > Ca > Mg.

Trace elements like Zn, Cu, Co and Mo have also been documented in the pulp and jelly prepared from the fruit pulp. In the pulp the order is Zn > Cu > Co > Mo. The jelly prepared from the fruit pulp showed complete absence of Co and Mo, but exhibited the presence of other two trace elements in the order Zn > Cu.

We are compared our data with the standard fruits (Table 2) to evaluate the nutritional status of the mangrove fruit and its product.

DISCUSSION

People of the present century are extremely health conscious. They are better informed about diet and health and desire more foods, which offer in addition to convenience, high quality, safety, optimum nutrient balance, less fat and sugar and fewer calories.[16] At the same time, consumers also have demand for tasty food at an economical price.[17] Jelly prepared from *S. apetala* fruit can meet these criteria and hence we initiated the study not only from the nutritional point of view of the fruit products, but also to provide an alternative livelihood to island dwellers of Indian Sundarbans. The species *S. apetala* are abundant in the study area, but the fruits appear only during the monsoon season. The fresh fruits have high content of vitamin C compared to other citrus fruits (Table 2). Vitamin C is one of the important antioxidants and help to fight cough and cold. The vitamin C level was 423.71 mg/100 gm in the pulp, but it reduced to 42.71 mg/100 gm in jelly (89.91% reduction). This may be attributed to the boiling of the pulp extract during jelly preparation as loss of ascorbic acid occurs with the increase in temperature.[18]

We also studied the levels of major and trace elements in the fresh fruit pulp and jelly prepared from the pulp extract of *S. apetala*. The importances of these elements are listed in Table 3.

Na occurs naturally in many foods and also added in the form of salt or other sodium containing substances during fruit product preparation The jelly prepared from *S. apetala* pulp extract contains 2984.05 ppm Na, which is within the standard range of 200 ppm (found in Apricot) to 4800 ppm (found in olive pickles).[19] The level of K in the jelly is 3003.80 ppm which is more than the level found in fruit juice of sour orange (570 ppm)[20] and strawberry jam where the concentration ranges between 1407.20 ppm and 1988.60 ppm.[16] The high value of K is due to addition of Potassium meta bisulfite ($K_2S_2O_5$) as preservative. The preservative is mixed because the jelly is acidic and hence susceptible to microbial growth. The Mg concentration in the jelly is 1160 ppm, which is higher than the strawberry jam (164.60 ppm – 184.80 ppm) as reported by.[16] The value of Ca is 71.43 ppm almost similar to the level found in pineapple juice (60 ppm).[21]

Trace elements like Zn, Cu, Co and Mo are reported to act as coenzymes, but their concentrations above the permissible level in food items may pose an adverse impact on human health.[1,3,22] In the present study, the jelly prepared from *S. apetala* pulp extract contains 13.54 ppm Zn, 9.54 ppm Cu and no trace of Co and Mo confirming the fruit to be free of toxic heavy metals.

Table 3: Importance of vitamin C and major and trace elements

Ingredients	Functions	Reference
Vitamin C	Vitamin C is a water soluble antioxidant and has a great role to prevent cough and cold. Deficiency of vitamin C can lead to anemia, scurvy, infections, bleeding gums, muscle degeneration, delayed wound healing and	23

		neurotic disturbances	
Major elements	Na	Na is one of the essential elements required in an appropriate amount in daily diet to regulate the blood pressure and nerve processes for transmitting impulses through the body as well as stabilize the water in human body cells.	1
	K	K is one of the essential elements of human diet, and plays important role in vital cellular mechanism. It acts as a cofactor to catalyze the conversion of the ADP to ATP and also plays a role in excitability of the nerve.	1
	Mg	Mg plays an important role in nervous system stability, muscle contraction as activator of alkaline phosphatase.	24,25
	Ca	Ca helps in the development and growth of skeletal system e.g. bones and also teeth. It acts as coenzyme in metabolic regulations of biomolecules.	1

Trace elements	Zn	Zn mainly acts as a coenzyme of about 200 enzymes involved in immunity, new cells growth, acid base regulation etc. Lack of sufficient amount of Zn results in reduced activity of related enzymes e.g. carbonic anhydrase.	26,27
	Cu	Cu is an essential trace element and is required as cofactor in different oxidative and reductive enzymes.	1
	Co	Co is an indispensible element and contributes to vitamin B_{12}.	1
	Mo	Epidemiologic findings have implicated molybdenum deficiency in the incidence of esophageal cancer in Africa, China and Russia. Cancer is often caused by xenobiotic compounds. The molybdoenzymes xanthine oxidase, aldehyde oxidase and sulfite oxidase may be involved in the detoxification of xenobiotic compounds.	28,29

CONCLUSION

The present study generates few core findings as highlighted here.

1. *S. apetala* has considerable high concentration of vitamin C compared to other citrus fruits, and it is also reflected in the jelly prepared from the fruit pulp extract.
2. The fruit as well as the jelly are rich sources of major and trace elements.
3. The low concentrations of Cu and complete absence of Co and Mo in the jelly minimizes the chance of toxic effects of these elements on human beings.
4. *S. apetala* is available only during the monsoon season; hence there may be a shortage of raw material if the jelly preparation from pulp is considered from the industrial point of view. However, this small-scale cottage industry can be translated into reality if several backup nurseries of *S. apetala* can be created through peoples' participation. During nursery raising of *S. apetala*, care should be taken to create a congenial habitat. As the species thrive luxuriantly with *Avicennia* spp., therefore it is recommended that the nursery should be created considering the optimum biotic and abiotic parameters required for the growth of both the species.

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