

MANGROVE APPLE (*SONNERATIA CASEOLARIS*): A PROMISING FRUIT IN PATUAKHALI COAST OF BANGLADESH

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Abstract

Mangrove apple (*Sonneratia caseolaris*) is a widespread underutilized fruit species of coastal region of Bangladesh. The present study was undertaken to find out the flowering, fruiting, nutritional quality and extent of variability among different mangrove apple germplasm. Twelve germplasm were selected from three locations - six (SC 02, SC 03, SC 04, SC 05, SC 06 and SC 07) from Dumki sadar, two (SC 01 and SC 08) from PSTU germplasm centre and four (SC 09, SC 10, SC 11 and SC 12) from Patabuniya, Dumki, Patuakhali. Flowering season started from May and continued up to November. Percentage of fruit setting ranged from 96.03 to 89.96% in SC 01 and SC 12, respectively. Required time for fruit maturation ranged from 106 days (SC 06) to 55 days (SC 05). Single fruit weight varied from 122.3 g (SC 01) to 54.33 g (SC 04). The length and diameter of fruit ranged from 2.9 cm (SC 05) to 2.20 cm (SC 07) and 5.20 cm (SC 05) to 3.60 cm (SC 04), respectively. The maximum edible portion (66.15%) was recorded in SC 01, and it was the lowest (51.45%) in SC 07. Chemical analysis was done with the pulp of selected germplasm where the germplasm SC 01 exhibited the best performance in all parameters of chemical analysis. This analysis was performed at four different ripening stages. The highest TSS (8.72%) was recorded in stage I. The highest pH level (3.51) was observed in stage III and the lowest pH level (2.83) was found in stage I. The highest ascorbic acid content (37.50 mg/100g) was noted in stage IV. Flower of mangrove apple produces a kind of honey. Fresh fruits and seeds have high nutritional and medicinal value. Wood of this plants provides great livelihood support to the local residents for fetching good price in the markets. Proper utilization of *S. caseolaris* may contributes-the nutritional security of the women and children of this area by fulfilling the demand for micronutrients, especially vitamin C.

Keywords: Coastal region, Diversity, Germplasm, Mangrove apple, Underutilized fruit

Introduction

In Bangladesh over 10 million people live in coastal areas. Roughly 55% of the coastal population lives within 100 km of the 710 km long coastal belt of Bangladesh. The majority of those living in this area are highly vulnerable to cyclones and storm surges. Most of them are low-income agricultural workers; 70% of whom are landless and relatively asset poor. These people are directly or indirectly live under the mangrove natural protection. Among the mangrove plant, mangrove apple (*Sonneratia caseolaris*)

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under the family Lythraceae is the salt tolerant plants of tropical and subtropical intertidal regions of the world. It can be found widely in Malaysia, Indonesia, Philippines, Singapore, Sri Lanka, Vietnam and Thailand (Whitmore, 2002). In Bangladesh, this fruit is grown well in coastal districts such as Barisal, Patuakhali, Pirozpur, Khulna, Chittagong coastal area and many other coastal regions. This plant is more familiar to the coastal people of Bangladesh as “*Soila*”.

Mangrove apple plant growing up to 15m tall, they have cream, grey to brown bark with slight vertical fissures, with no buttresses or prop roots. Their pneumatophores are cone-shaped (unlike the pencil-like ones of *Avicennia*). Leaves are rounded, leathery, opposite, with similar upper and undersides of the leaf. Flowers are white and pom-pom-like and open only for one night. Their fruits are large (4cm) green, leathery berries with a star-shaped base containing 100-150 tiny seeds that are white, flattened and buoyant (Peter and Sivasothi, 1999). They are able to survive inundation by salt water twice a day, and in "soil" which is unstable and poor in oxygen (anaerobic). They also have to deal with swollen rivers carrying silt during the wet season, as well as violent storms that hit the coasts. They provide a variety of important ecosystem roles: a refuge and food for a variety of flora and fauna, a natural water filter, and an important stabilizer of coastal and river banks. This plant is highly used in dam, dyke and embankment preparation to protect the coast from water wave, flood, stream, flow-tide and swelling of water. The heavy timber is resistant to shipworm and pests and is used for building boats, piling and posts for bridges and houses.

This valuable mangrove plant is not only helpful for the protection of coastal area but also provides a lot of nutrition. Almost all the people including children like it very much in coastal region due to its test. The ripe fruit contain high amount of vitamin c (30g/100g) (Ray *et. al.*, 2015). Mangrove apple fruits are consistent with the optimal value of carbohydrate, protein and vitamin-c mainly regarding culinary property and nutritional perspectives. Electrospray Ionization Mass Spectrometry (ESI-MS) study proves the presence of phenolic compounds responsible antioxidant nature. As far as our knowledge goes, there was little work done in Bangladesh to characterize this plant. Hence, the study was undertaken to observe flowering characters and behaviors, fruit parameters and the nutritional quality of mangrove apple at different maturity stages.

Materials and Methods

The field experiment was conducted in different locations of Dumki upazilla at Patuakhali district following Randomized Complete Block Design (RCBD) with four replications and lab experiment in the Department of Horticulture, Patuakhali Science and Technology University following Completely Randomized Design (CRD) with three replications. After primary observation of 12 germplasm (single plant) were selected having better performance and diversity which were SC01, SC02, SC03, SC04, SC05, SC06, SC07, SC08, SC09, SC10, SC11 and SC12 to characterizes morpho-chemically. Randomly one branch was selected in each direction (North, South, East and West) to collect field data from each plant. Data on (48 flower buds where 1 bud × 4 branches × 12 plants) plant characteristics viz. tree age, branching pattern and leaf area measurement: morphological parameters like days required for flower bud development, duration of flowering season, length of flower bud, length of petal, width of petal, number of stigma, percent fruit setting, percent fruit drop, time required for fruit

maturation (days), fruit shape, weight of fruit, length of fruit, diameter of fruit, number of seeds per fruit, rind weight, seed weight, weight of non-edible portion (rind + seed), percentage of edible and non-edible portions; chemical characteristics like titratable acidity (TA), total soluble solids (TSS), pH and ascorbic acid content were recorded at the time of flowering, fruiting and after harvest.

Ascorbic acid (Vitamin C)

Ascorbic acid was determined according to the dye method by Ranganna (1977). Ten gram of pulp tissue was homogenized with 40 mL of 3% cold metaphosphoric acid (HPO₃) using a blender for two minutes. Five milliliters of aliquot was titrated with 2, 6-dichlorophenol-indophenol dye until the filtrate changed to pink color that persisted for at least 15 seconds. The titre volume of dye solution used was recorded and ascorbic acid content was calculated using the following formula:

$$\text{Ascorbic acid (mg /100 g)} = \frac{\text{Titre (mL)} \times \text{dye factor} \times \text{vol. made up} \times 100}{\text{Aliquot used for estimation (5mL)} \times \text{sample weight (10 g)}}$$

To standardize the dye, 5 mL of standard ascorbic acid solution was added to 5 mL of 3% cold HPO₃. The mixture was titrated with the dye solution to a pink colour, which persisted for 15 seconds. The dye factor was calculated as follows:

$$\text{Dye factor} = \text{Titre (mL)} \times \text{dye factor} \times \text{vol. made up} \times 100$$

Titratable acidity (% citric acid)

Titratable acidity (TA) was determined according to the method by Ranganna (1977). Ten gram of pulp tissues was homogenized with 40 ml of sterilized water using a kitchen blender (MX-798S, National, Malaysia) for two minutes. Five milliliters of the filtrate was transferred into a 100 ml conical flask and two drops of 1% phenolphthalein solution as an indicator was added. The sample was titrated with 0.1 M sodium hydroxide (NaOH) solution until the colour changed to pink and persistent at least 15 seconds. The titre volume was recorded and the result was expressed as percentage citric acid using the following formula:

$$\text{Citric acid (\%)} = \frac{\text{Titre (0.5 mL)} \times \text{NaOH normality} \times \text{vol. made up} \times \text{citric acid eq. weight} \times 100}{\text{Volume of sample for titrate} \times \text{weight of sample taken} \times 1000}$$

Determination of pH

The pH of fruit juice was recorded by using an electric pH meter. The pH meter was standardized with the help of a buffer solution as described by Ranganna (1997).

Total soluble solids (TSS)

The TSS of guava pulp was determined by using a digital refractometer (Model N-1 α , Atago, Japan). The remaining of the filtrated juice from TA determination was

used to measure the TSS of the fruit pulp. Before measurement, the refractometer was calibrated with sterilized water to give a 0% reading. About 1-2 drops of the filtrate was placed on the prism glass of the refractometer to obtain the % TSS reading. The readings were multiplied by dilution factor to obtain an original % TSS of the pulp tissues. Since differences in sample temperature could affect the measurement of TSS (Boourne, 1982), each of the reading was standardized to a temperature of 20 °C by adding 0.28% to obtain % TSS at 26 ± 1 °C.

The collected data on various parameters were statistically analyzed using MSTATc statistical package. The means for all the treatments were calculated and analyses of variances (ANOVA) for all the parameters were performed by F-test. The significance of difference between the pairs of means was compared by Duncan Multiple Range Test (DMRT) at 5% levels of probability (Gomez and Gomez, 1984).

Results and Discussion

Plant characteristics

The age of twelve germplasm under study was in the range of 9 to 25 years. The trees had optimum growth and good canopy area. Although no recorded data were found but counted as possible as correctly. The branching patterns of the germplasm were found to be different (Table 1). Opposite pattern was found in germplasm (SC 01, SC 02, SC 03, SC 04, SC 06, SC 07, SC 11 and SC 12), verticillate (SC 09) and irregular (SC 05, SC08 and SC10). Peter KLNg *et. al.*, 1999 have been reported that the plant is small to medium- sized evergreen tree 8 to 10 m tall with open spreading crown, horizontal branches and slender twigs. Significant variation was observed among the studied germplasm in respect of area of leaves. The largest size of leaf area was found in germplasm SC 10 (48.21 cm²) and the smallest size was exhibited in germplasm SC 02 (37.17cm²). Colin Field, 1995 have been reported that leaves simple, opposite-decussate, estipulate; petiole 5-10 mm long, stout, red, glabrous; lamina 4-11 x 3.5-6.5 cm.

Flowering and fruiting behavior

The required days for flower bud development of twelve germplasm varied considerably ranging from 28 to 39 days (Table 2). The longest duration (39 days) required to develop flower bud was recorded in the germplasm SC 10, while SC 05 was found to require shortest duration (28 days). The maximum duration of flowering season (days) was found in germplasm SC 08 (104.3 days) followed by SC 10 (101.3 days) and the minimum duration of flowering season (days) was found in germplasm SC 02 (78 days). (Tan *et al.*, 2001) who reported that flowering season includes from May to August. From close observation it was found that the maximum flower buds setting position was on the tip of the branch and were green in color. The Length of flower buds ranged from 4.70 cm (SC 06) to 1.40 cm (SC 04). The length of petal of flowers also differed considerably. The highest length was exhibited in SC 10 (2.89 cm) which was followed by that of SC 11 (2.84) while the lowest length was found in SC 05 (2.46 cm). The highest width was found in SC 07 and SC 11 (1.59) but it was statistically identical with all germplasm except SC 02 (0.47 cm), SC 07 (0.45 cm) and SC 08 (0.50 cm). The lowest width was exhibited in SC04 (1.21cm). The highest number of stigma (280) was

found in SC 04 and SC 07 followed by SC 12 (277) and the lowest (210) in SC 09. The percentage of fruit setting under natural pollination showed a wide range of significant variation. The highest percentage of fruit setting was found in germplasm SC 01 (96.03 %) which was statistically similar to SC 07 (95.07%) while the lowest percentage of fruit setting was found in SC 07 (89.96%). It was found that; fruit drop percentages were low in south branches. The highest fruit drop percentage was exhibited in germplasm SC12 (30.34%) followed by SC 08 (24.30%) and the lowest percentage of fruit drop was found in SC01 (16.20%) which was statistically similar with SC 10 (17.85).

Table 1. Branching pattern and leaf area of 12 mangrove apple germplasm

Acc. No.	Branching pattern	Leaf Area (cm ²)
SC01	Opposite	44.27d
SC02	Opposite	37.17j
SC03	Opposite	42.90f
SC04	Opposite	39.17i
SC05	Irregular	39.37h
SC06	Opposite	42.47g
SC07	Opposite	43.14e
SC08	Irregular	44.21d
SC09	Verticillate	47.34b
SC10	Irregular	48.21a
SC11	Opposite	45.01c
SC12	Opposite	44.24d
CV (%)		0.26

Means in a column followed by the same letter(s) do not differ significantly at the 5% level of probability by DMRT

It is the most important character for a fruit crop. A wide range of significant variation was observed among the selected germplasm in respect of time required for fruit maturation (Table 3). Time required for fruit maturation may be depending on the genetic characteristics of plant or availability of water and essential nutrients. The highest time required for fruit maturation was recorded in the germplasm SC 06 (106 days) while the lowest time was recorded in the germplasm SC 07 (50 days). Fruit shapes of different germplasm were classified into different categories such as spheroid, flatted–globes and ellipsoid. Most of the fruits (SC 02, SC 03, SC 04, SC 06, SC 07, SC 09 and SC 12) were globular in shape, globosely, slightly flattened in SC 01, SC05 and SC 11 (Table 3). (Tan *et. al.*, 2001) who reported that fruit is a drupe, globosely, slightly flattened, calyx lobes horizontal, pericarp smooth. The highest fruit weight was recorded in SC 01 (122.3g) followed by SC 10 (112.3 g) while the lowest fruit weight was recorded in SC 07 (52.33 g). A wide range of significant variation was observed among the selected germplasm in respect of fruit length. The highest fruit length was obtained from germplasm SC 05 (2.90 cm) followed by SC 07 (2.20 cm) and the lowest fruit length was found in SC 04 (2.35

cm) followed by SC 07 (2.20 cm). The highest fruit diameter was found in SC 05 (5.20cm) and the lowest fruit diameter was in SC 07 (3.28 cm). The highest rind weight was exhibited in SC10 (2.82 g) which was statistically identical to SC 06 (2.76 g) and the lowest rind weight was recorded in germplasm SC08 (1.79 g). The highest seeds weight was recorded in germplasm SC 11 (8.34 g) which was statistically identical with SC 10 (8.24 g), SC 06 (8.20 g), SC 05 (8.12 g) and SC 02 (8.12 g) while the lowest seeds weight was recorded in SC 08 (7.42 g). The maximum weight of non-edible portion was found in germplasm SC 06 (46.37 g) followed by SC 10 (44.0 g) while the minimum weight was noted in SC 03 (29.20 g). The highest percentage of non- edible portion was found in the germplasm SC 07 (48.54%) followed by SC 04 (45.66%). The lowest percentage was found in SC 10 (12.67%) which was statistically similar to SC 02 (36.19%). The highest percentage of edible portion was found in the germplasm SC 01 (66.15%) followed by SC 10 (64.37%) while the lowest percentage was observed in germplasm SC 07 (51.45%).

Table 2. Flowering and fruiting behavior of 12 Mangrove apple germplasm

Acc. No.	Days required for floral bud development	Duration of flowering (Days)	Length of flower bud (cm)	Length of petal (cm)	Width of petal (cm)	Number of stigma/ fruit	% fruit setting	% fruit drop
SC01	37.00b	83.67f	4.48b-e	2.51gh	1.40d	230g	96.03a	16.20e
SC02	30.00h	78.67g	4.48c-f	2.83b	1.32e	255f	92.07d	20.01d
SC03	32.00f	82.00f	4.63a-c	2.61f	1.46bc	260d	92.01d	20.66d
SC04	34.64d	82.33f	4.27f	2.54g	1.21f	280a	90.00e	22.30c
SC05	28.00j	94.33d	4.39d-f	2.46h	1.3d	220h	92.83cd	20.80d
SC06	29.00i	94.33d	4.70ab	2.55g	1.50b	188j	93.75bc	22.30c
SC07	31.00g	99.00c	4.69a-c	2.72cd	1.59a	280a	95.07ab	18.34d
SC08	32.00f	104.3a	4.69a-c	2.73c	1.48bc	270c	91.64d	24.03b
SC09	36.00c	95.33d	4.60a-d	2.62ef	1.43cd	210i	93.77bc	22.13c
SC10	39.00a	101.3b	4.50b-e	2.89a	1.48bc	255e	94.39b	17.85e
SC11	30.00h	90.67e	4.32ef	2.84b	1.59a	260d	92.87cd	20.55d
SC12	33.00e	88.33e	4.60a-d	2.67de	1.46b	277b	89.96e	30.34a
CV (%)	0.51	1.47	2.48	1.12	1.73	1.48	0.84	5.31

Means in a column followed by the same letter(s) do not differ significantly at the 5% level of probability by DMRT

Chemical analysis

Ascorbic acid (Vitamin C)

Significant variation was observed among different stages in respect of ascorbic acid content (Fig. 1A). The trend of development of ascorbic acid in mangrove apple fruit in this study increased during ripening. The highest amount of ascorbic acid was obtained in stage IV (31.36 mg/100g) and the lowest amount in the stage I (16.37 mg/100g). This gradual increasing of ascorbic acid content in different stage might be due to increased

internal oxygen that resulted in accelerating the oxidation of ascorbic acid. A similar trend in increased ascorbic acid content has been reported on coated apples, pear and apricot during storage (Sumnu and Bayindrili, 1995).

Titrateable acidity (% citric acid)

A significant variation was observed among different stages in respect of titrateable acidity (Fig. 1B). In this study, the increase in titrateable acidity of mangrove apple fruits followed a linear trend with increased the maturation days and time of senescence. The highest percentage of titrateable acidity was obtained from stage IV (13.23%) while the lowest percentage was recorded in stage I (3.33%). This result is consistent with Garcia *et al.*, (1998) on strawberry that the decreased in acidity during ripening demonstrated fruit senescence.

Table 3. Fruit characteristics of 12 mangrove apple germplasm

Acc. No.	Days required for fruit maturation	Weight of fruit (g)	Length of fruit (cm)	Diameter of fruit (cm)	Rind weight (g)	Seed weight (g)	Weight of non-edible portion (g)	Non-edible portion (%)	Edible portion (%)
SC01	80d	122.3a	2.60e	4.48d	2.19b	8.06bc	33.43d	37.43d	66.15a
SC02	90c	92.33d	2.70d	4.58c	2.24b	8.12a-c	30.83e	36.19e	63.80bc
SC03	75e	77.33g	2.60e	3.87f	2.12b	7.97c	29.20g	37.74d	62.25d
SC04	80d	54.33j	2.35h	3.60g	1.97c	7.69d	24.77j	45.56b	54.43f
SC05	52g	107.3c	2.90a	5.20a	2.69a	8.12a-c	36.34c	44.10b	62.56cd
SC06	106a	57.33i	2.75c	4.60c	2.76a	8.20a-c	46.37a	37.89d	62.14d
SC07	50h	52.33k	2.20i	3.28h	1.85cd	7.49de	25.4i	48.54a	51.45g
SC08	59f	61.33h	2.50f	4.45d	1.79d	7.42e	26.53h	43.24c	56.75e
SC09	75e	77.67f	2.50f	4.48d	2.11b	7.98c	29.83f	37.96d	62.03d
SC10	100b	112.3b	2.80b	4.90b	2.82a	8.24ab	40.37b	35.62e	64.37b
SC11	105a	82.33e	2.60e	3.90f	1.89cd	8.34a	36.34c	43.71c	56.28e
SC12	55g	82.34e	2.42g	4.00e	1.90cd	7.62de	25.63i	33.84f	55.89e
CV (%)	1.48	0.20	1.68	1.60	3.66	1.63	1.20	1.87	1.07

Means in a column followed by the same letter (s) do not differ significantly at 5% level of probability by DMRT

pH

The pH of fruit decreased gradually as different stages progressed with yielding significant differences (Fig. 1C). In this study, the decrease in pH of mangrove apple fruits followed a linear trend with increased the maturation process and time of

senescence. The highest pH content was recorded in stage I (3.82) while the lowest pH content (2.68) was recorded in stage IV.

Total Soluble Solids (TSS)

Changes in the TSS of mangrove apple fruits with different stage of maturity are presented in Fig.1D. The percentage of total soluble solids (TSS) showed significant variation among different stages. The TSS of SC01 germplasm fruits were highest initially and decreased gradually with advance in ripening which indicates the increases of ascorbic acids. The highest percentage of TSS was found in stage I (8.72 %) while the lowest percentage was recorded in stage IV (1.76 %). Similar observation has also been reported on *S. alba* (Lee, 1996).

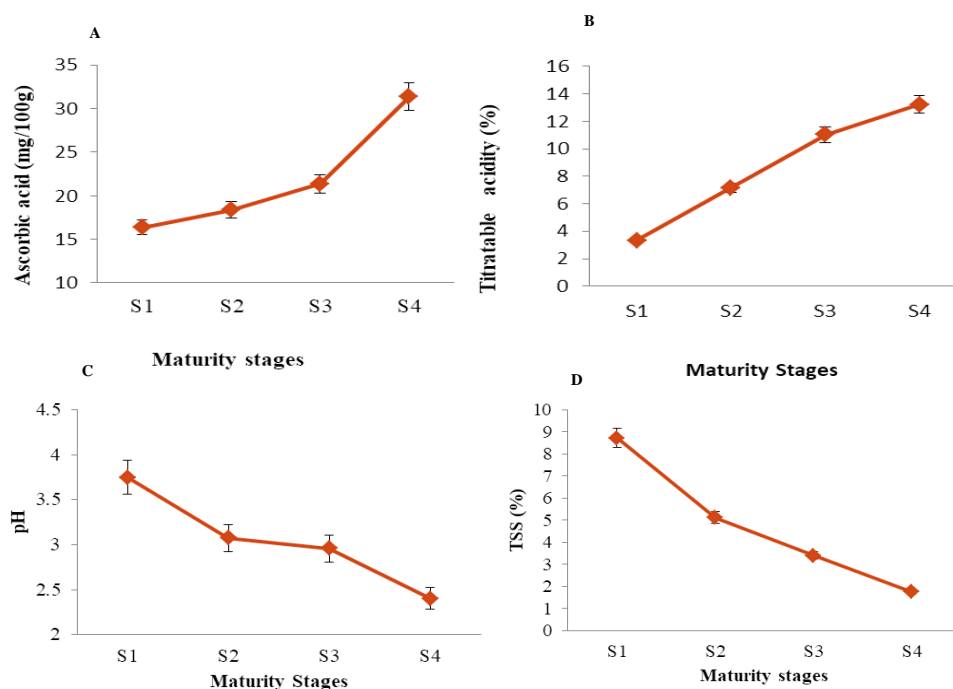


Fig. 1. Chemical analysis of germplasm SC 01 at different maturity stages. A. Ascorbic acid (mg/100g) content, B. % Titratable acidity (TA), C. pH and D. Total soluble solids (TSS) content. Error bar means?

Conclusion

From the above discussion, it may be said that mangrove apple has the potentiality for growing in the coastal region of Bangladesh. So, research and development activities should be initiated on mangrove apple for its improvement and popularization.

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