Project ID 384

Competitive Research Grant

Sub-Project Completion Report

on

Characterization and Documentation of Minor Fruits in Bangladesh with Special Emphasis on Coastal and Hilly Areas Fruits

Project Duration

May 2016 to September 2018

Department of Horticulture
Bangladesh Agricultural University
Mymensingh

Submitted to
Project Implementation Unit-BARC, NATP 2
Bangladesh Agricultural Research Council
Farmgate, Dhaka-1215

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Acronyms

ACS	: Accession
BAU	: Bangladesh Agricultural University
BAU-GPC	: Bangladesh Agricultural University Germplasm Center
CRG	: Competitive Research Grant
LoA	: Letter of Agreement
PCR	: Project Completion Report
TSS	: Total Soluble Solids

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Executive Summery

Minor fruits are valuable source of vitamins and minerals of human diet. Bangladesh is the hub of genetic diversity of different kinds of fruits including major and minor fruits. About seventy native fruits are grown in Bangladesh. As fruit is the key source of vitamins and minerals, therefore, it is necessarily important to incorporate more fruit species in the cultivation list and daily uses. Minor fruits are available in August to October which is the lean period of fruit supply. A number of indigenous minor fruits namely monkey jack (*Artocarpuslakoocha*Roxb.*)*, velvet apple (*Diospyros discolor* Willd.), river ebony (*Diospyrosperegrina*), cowa (*Garciniacowa*Roxb.), governor's plum (*Flacourtiaindica*) etc. are found in the coastal areas of Bangladesh while the hilly areas are full of various indigenous minor fruits such as lukluki(*Flacourtiajangomas*), gutgutia (*Protiumserratum*) etc. But detailed studies on these fruits are not available in Bangladesh. Therefore, this project has been undertaken to collect, conserve and evaluate them morphologically, biochemically and nutritionally and record the data for further improvement. To do so five minor fruits like monkey jack, velvet apple, river ebony, cowa and governor's plum from the coastal areas (Barishal and Patuakhali districts) and two minor fruits such as lukluki and gutgutia were selected from the hilly area (Bandarban district) of Bangladesh. *In situ* data on Morphological characters of selected minor fruits were recorded following other crop descriptors. Saplings of those fruits were collected and conserved at Bangladesh Agricultural University Germplasm Center (BAU-GPC). Fruit samples were collected and biochemical and nutritional analysis of selected minor fruits were assessed in the laboratory following standard methods. Results on morphological traits, biochemical and nutritional value have been presented in plates, tables and figures. From the results we found five germplasm of monkey jack, eight germplasm of velvet apple, three germplasm of river ebony, five germplasm of cowa and the rest three minor fruits have a single germplasm. It was observed that each germplasm of each fruit species bears significantly different morphological features and nutritional quality. In case of vitamin C content, it was evident that maximum vitamin C (21.74 mg/100g) contained in gutgutia followed by monkey jack (20.86 mg/100g) and the minimum (5.73 mg/10g) found in velvet apple. It was also observed that river ebony contained highest amount of potassium (258.68 mg/100 g) and phosphorus (293.47 mg/100g), while gutgutia contained maximum amount of calcium (112.59 mg/100g), magnesium (98.88 mg/100g), zinc (2.08 mg/100g), and cowa contained highest amount iron (4.56 mg/100g) as compared to other test fruits. It can be concluded that the selected minor fruits have tremendous potentiality in human nutrition and soci-economic development of Bangladesh. The information could be useful for further improvement of minor fruits in the country. Some valuable minor fruits in the coastal and hilly areas of Bangladesh are about to extinct. It is urgently necessary to conserve and multiply them for increase fruit production in the country. So, future work could be on conservation of extinct plant genetic resources especially minor fruits of Bangladesh.

CRG Sub-Project Completion Report (PCR)

A. Sub-project Description

1. **Title of the CRG sub-project**: Characterization and Documentation of Minor Fruits in Bangladesh with Special Emphasis on Coastal and Hilly Areas Fruits
2. **Implementing organization:**
   Department of Horticulture
   Bangladesh Agricultural University, Mymensingh
3. Name and full address with phone, cell and E-mail of PI/Co-PI (s):
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   Sub-project budget (Tk):
   3.1 Total:**1500,000.00** (Fifteen Lac Taka)
   3.2 Revised (if any): _____
4. **Duration of the sub-project:**
   4.1 Start date (based on LoA signed): **May 2017**
   4.2 End date: **30 September 2018**
5. **Justification of undertaking the sub-project:**
   This project was undertaken to characterize and document some selected minor fruits and evaluate their biochemical and nutritional value.
6. **Sub-project goal:** The project has been designed for characterization and documentation of minor fruits in Bangladesh with special emphasis on coastal and hilly areas fruits for varietal development and protect from piracy.
7. **Sub-project objective (s):**
   The proposed research project is designed to achieve the following objectives:
   - collect and conserve important minor fruits from coastal and hilly areas of Bangladesh;
   - characterize the morphological features, biochemical and nutritional value of collected minor fruits from coastal and hilly areas of Bangladesh; and
   - document the information for future use for varietal improvement and protect these local landraces from piracy.
8. **Implementing location (s):** Bangladesh Agricultural University Germplasm Center (BAU-GPC), Coastal (Barishal, Patuakhali) and Hilly (Bandarban) Areas

9. Methodology in brief:

This project work was executed in studying the morphological characters, biochemical and nutritional status of selected minor fruits from coastal area (Monkey jack, Velvet apple, River ebony, Cowa and Governor's plum) and hilly areas (Lukluki (Flacourtia) and Gutgutia (Indian red pear)) of Bangladesh.

Morphological characterization of minor fruits:

Although there is no recommended descriptor for morphological characterization of the test minor fruits, therefore, data were recorded following other crop descriptors. *In situ* data on morphological characters of selected minor fruits were collected from the Coastal areas (Barishal and Patuakhali districts) and the Hilly area (Bandarban district). Saplings of selected minor fruits were collected from the Coastal and Hilly areas and conserved them at BAU-GPC for future study. Length and diameter of leaves, petiole of leaves and fruits were measured using digital slid calipers and a measuring scale. Color of leaves was recorded using color chart. Leaf area (LA) was measured by CI-202 Laser Leaf Area Meter.

Biochemical analysis of Minor Fruits:

Biochemical compounds of selected minor fruits were determined from Department of Biochemistry and Molecular Biology, BAU, Mymensingh. The following biochemical compounds were determined from minor fruits such as –

i) Total soluble solids (TSS % Brix): TSS of fruits was measured using hand held refractometer in the Postgraduate Laboratory of the Department of Horticulture, Bangladesh Agricultural University, Mymensingh. In brief, a drop of fruit juice squeezed from the pulp and placed on the prism of the Refractometer thereafter, the percentage of TSS was recorded from the direct reading of the instrument. Temperature corrections were made as described by Ranganna (1979), using the temperature correction chart.

ii) Moisture content (%): Ten grams of fruit flesh were weighed in a petridish from each treatment out of each replication. The petridish was placed in an electric oven at 80°C for 72 hours until the weight became constant. It was then cooled and weighed again. Finally, the percent moisture content of fruit pulp was calculated using the following formula:

$$\% \text{ moisture content} = \frac{\text{Initial weight of flesh (g)} - \text{Final weight of flesh (g)}}{\text{Initial weight of flesh (g)}} \times 100$$

iii) Dry matter content (%): Dry matter content is generally calculated by weight obtained after drying the velvet apple pulp in oven and then subtracting it from initial weight. Here, percent dry matter content of the flesh was calculated from the data obtained during moisture content estimation using the following formula:

$$\% \text{ dry matter} = 100 - \% \text{ moisture content}$$

iv) Fruit pH: Fruit pH was determined by using a glass electrode pH meter (SensoDirect pH 110, UK) as described by Jackson (1973). Five grams of fruit flesh from each sample was taken in a 50 ml beaker separately and 25 ml of distilled water was added to each beaker. The suspension was stirred well for 1 hour and allowed to stand for about 10 minutes.

v) Ascorbic acid (Vitamin C) content: Ascorbic acid content was determined according to Plummer (1971). The following reagents were used for the estimation of ascorbic acid content:

(a) **6% Metaphosphoric acid (HPO_3):** It was prepared by dissolving the sticks of HPO_3 and 80 cc glacial acetic acid in distilled water and volume up to 1 liter,

(b) **Standard ascorbic acid solution:** 10% of L-ascorbic acid solution was prepared by dissolving ascorbic acid in 6% metaphosphoric acid solution,

(c) **Dye solution:** It was prepared by dissolving 260 mg of the sodium salt of 2, 6 dichlorophenol indophenols in one litre of distilled water that contained 210 mg of sodium bicarbonate.

The following steps were followed for the estimation of ascorbic acid

Standardization of dye solution: Five (5) ml of standard ascorbic acid solution was taken in a conical flask and 5 ml of metaphosphoric acid (HPO_3) was added to it. A micro burette was filled with the dye solution. The content of the conical flask was titrated with dye till the pink-colored end point appeared. The milliliters of dye solution required to complete the titration was recorded. Dye factor was calculated using the following formula:

$$\text{Dye factor} = \frac{0.5}{\text{Titre}}$$

Preparation of sample: About ten (10) grams of fresh fruits and 70 ml 6% metaphosphoric acid solution was taken in a blender and homogenized for 2 minutes. After blending, it was filtered and centrifuged at about 2000 ppm for 5 minutes. The supernatant homogenized liquid was transferred to a 100 ml volumetric flask and made up to the volume with 6% metaphosphoric acid.

Titration: Five (5) ml of the aliquot was taken in a conical flask and titrated with dye solution. The ascorbic acid content of the samples was calculated by using the following formula.

$$\text{Ascorbic acid content (mg/100g)} = \frac{T \times D \times V1}{V2 \times W} \times 100$$

Where, T = Titre, D = Dye factor, V_1 = Volume made up (ml), V_2 = Volume of extract used for estimation (ml), W = Weight of sample (gm)

v) **Titratable acidity (%):** Titratable acid content of fruit flesh was determined by Ranganna (1979).

vi) **Total sugar content of fruit flesh:** Total sugar content of fruit flesh was determined calorimetrically by the Anthrone method (Jayaraman, 1981).

vii) **Reducing sugar content of fruit flesh:** Reducing sugar content of fruit flesh was determined by dinitrosalicylic acid method (Miller, 1972).

viii) **Non-reducing sugar content of fruit flesh:** Non-reducing sugar content of velvet apple flesh was calculated by using the following formula:

Percent non-reducing sugar = % Total sugar - % Reducing sugar

Nutritional Analysis of Minor Fruits:

Different mineral nutrient contents of selected minor fruits were assessed using laboratory facilities of Department of Agricultural Chemistry, BAU, Mymensingh. The following mineral nutrients were determined:

i) Determination of sodium: The content of sodium was determined with the help of a flame emission spectrophotometer (Model- Jenway PFT 7, UK) using appropriate filters. Exactly, 10 ml aliquot was taken in a test tube and then the sample was aspirated in a gas flame set at 12-PSI air pressure. The intensity of light emitted by sodium at 590 nm was directly proportional to the concentration of sodium present in the sample (Ghosh *et al*., 1983).

ii) Determination of potassium: The content of potassium was determined with the help of a flame emission spectrophotometer (Model- Jenway PFT 7, UK) using appropriate filters. Exactly, 1 ml aliquot was taken in a test tube and 9 ml distilled water was added with it. Then the sample was aspirated in a

gas flame set at 12-PSI air pressure. The intensity of light emitted by potassium at 768 nm was directly proportional to the concentration of potassium present in the sample (Ghosh *et al*., 1983).

iii) Determination of calcium: Calcium Content in fruit samples was determined by complexometric method of titration using Na_2EDTA as a complexing agent at pH 12 where calcon was used as indicator (Page *et al*., 1982). Exactly 5 ml of sample was taken into a 250 ml conical flask followed by the addition of 30 ml water, 3-4 ml 0f 10% NaOH solution, 10 drops each of the hydroxylamine hydrochloride ($NH_2OH.HCL$), potassium ferrocyanide [$K_4Fe(CN)_6.3H_2O$] and TEA (triethanol amine; $C_6H_{35}NO_3$) as a masking agent. After the addition of calcon indicator solution, the test sample was titrated against standard Na_2EDTA (0.01M) solution from a burette until the pink color of the solution turned into pure blue color.

iv) Determination of magnesium: First of all calcium and magnesium content in fruit extract was determined combinedly by complexometric method of titration using Na_2EDTA as a complesing agent at pH 10 where EBT (Eriochrome Black T) was used as ion selective indicator (Page *et al*., 1982). Exact 5 ml of aliquot was taken into a 250 ml conical flask followed by the addition of 30 ml water, 5 ml of NH_3-NH_4 buffer solution, 10 drops each of the hydroxylamine hydrochloride ($NH_2OH.HCL$), potassium ferrocyanide [$K_4Fe(CN)_6.3H_2O$] and TEA (Tri-ethanol amine; $C_6H_{35}NO_3$) as a masking agent. After the addition of EBT indicator solution, the aliquot was titrated against standard Na_2EDTA (0.01M) solution from a burette until the pink color of the solution turned into pure blue color. Then the concentration of magnesium in the extract was calculated by subtracting the amount of calcium from the total content of calcium plus magnesium.

v) Determination of phosphorus: The phosphorus content was determined by developing phosphomolybdate blue complex with stannous chloride ($SnCl_2.2H_2O$) and measuring the absorbance of color with the help of a spectrometer (Model- T60, PG Instruments, UK) at 660 nm wavelengths (Page *et al*., 1982). Stannous chloride ($SnCl_2.2H_2O$) was used as a reducing agent to form molybdophosphoric blue complex with sulphomolybdate. Exactly, 1 ml aliquot was taken in a 100 ml volumetric flask followed by the addition of 4 ml of sulphomolybdate acid and 6 drops of stannous chloride solution. The volume was made up to the mark with distilled water and was shaken thoroughly. Finally, the intensity of blue color (absorbance) was measured with the help of a spectrometer.

vi) Determination of iron and zinc

The determination of micro elements (Fe and Zn) was done by an Atomic Absorption Spectroscopy (AAS) (Model- AA 7000, Shimadzo, Japan). Mono element hollow cathode lamp was employed for the determination of each micro element. At first the AAS was calibrated followed by the manufacturer's recommendation. Then, the extract was run directly in AAS for the determination of micro elements in the sample. A standard curve was prepared by plotting the absorbance reading on Y-axis versus the concentration of each standard solution of micro elements on X-axis. Then, the concentration of specific element was calculated in sample of interest by plotting the AAS reading on the standard curve.

Statistical analysis

The collected data on various parameters were statistically analyzed using MSTAT-C statistical package program to find out the variation resulting from experimental treatments following F variance test. The significance of difference between the pair of means was compared by Least Significant Difference (LSD) test at 1% and 5% level of probability (Gomez and Gomez, 1984).

10.Results and Discussion

This project work was conducted in order to characterize the morphological features, biochemical and nutritional value of selected minor fruits from coastal and hilly areas of Bangladesh. This study was done during the period from May 2017 to September 2018. Data on morphological traits were recorded following other crop descriptors. Biochemical and nutritional evaluation of selected minor fruits were done at the laboratory. Collected data were statistically analysis and present in this section in different tables, figures and plates. Results and discussion on morphological characterization, biochemical analysis and nutritional status of five minor fruits from Coastal areas (Monkey jack, Velvet apple, River ebony, Cowa and Governor's plum) and two minor fruits from Hilly areas (Lukluki and Gutgutia) are given below-

a) Monkey jack (*Artocarpus lakoocha* Roxb.)

Monkey jack (*Artocarpus lakoocha*) belongs to the family Moraceae is a valuable tree species native to Bangladesh. The fruits are generally eaten after ripe. It is locally known as Dewa. Now it is found in different countries of East Asia such as Bangladesh, India, Sri Lanka and Malaysia. It is widely found in Barishal, Patuakhali, Khulna, Mymensingh, Gazipur, Tangail, and hilly areas Khagrachori, Rangamati and Bandarban districts. As far as we have found five (5) accessions of monkey jack germplasms from various locations of Barishal and Patuakhali. The accessions are -i) ACS AL1, ii) ACS AL2, iii) ACS AL3, iv) ACS AL4, v) ACS AL5

Results on morphological characters of monkey jack:

Leaf Characteristics: Laves are large, elliptic to ovate-elliptic, obovate, covered with yellow bristles, leaf margin entire or wavy, tip blunt (Table 1).

Leaf Shape: Leaves are categorized into ovate, obovate, ovate-elliptic (Plate 1, Table 1).

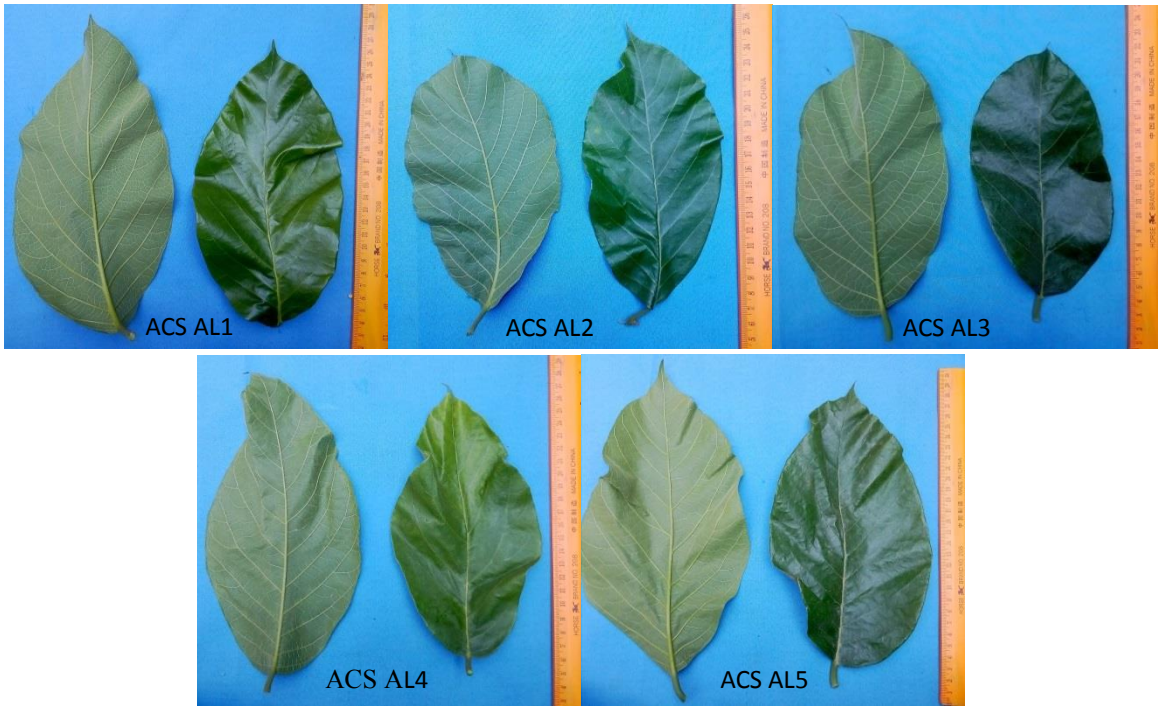


Plate 1. Leaf shape of monkey jack germplasm

Young leaf colour: Young leaves are mainly light green.

Mature leaf colour: Mature leaves are mainly dark green.

Leaf margin: Leaves margin are mainly catagorized asentire and wavy.

Leaf apex: Leaves apex are categorized into acuminate, acute, apiculate (Plate 2, Table 1).

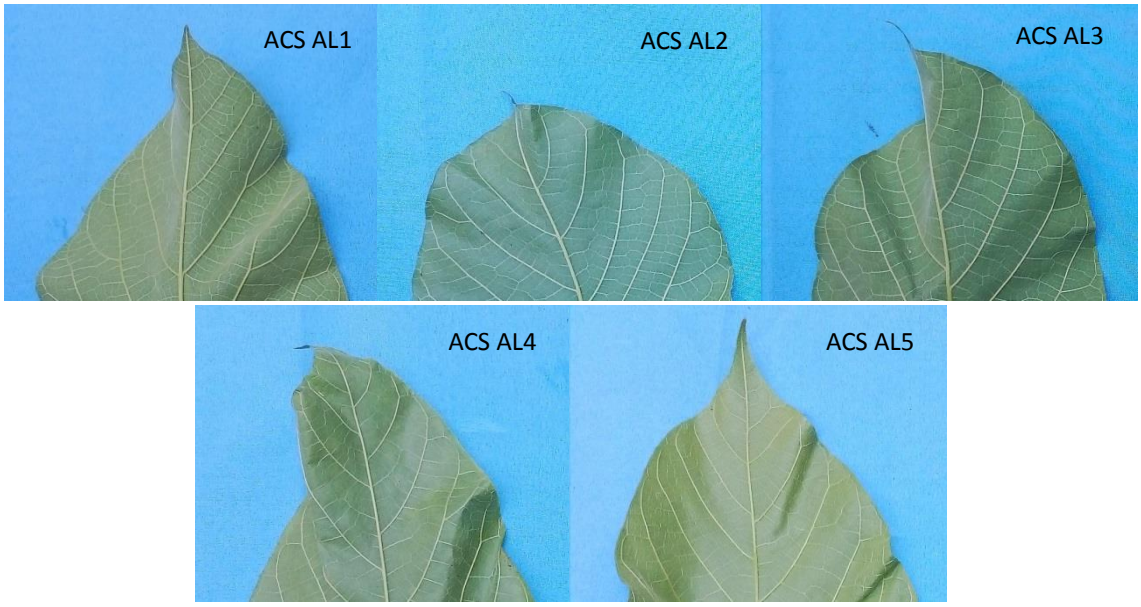


Plate 2. Leaf apex of monkey jack germplasm

Leaf base: Leaf base are categorized into cuneate, rounded, oblique (Plate 3, Table 1).

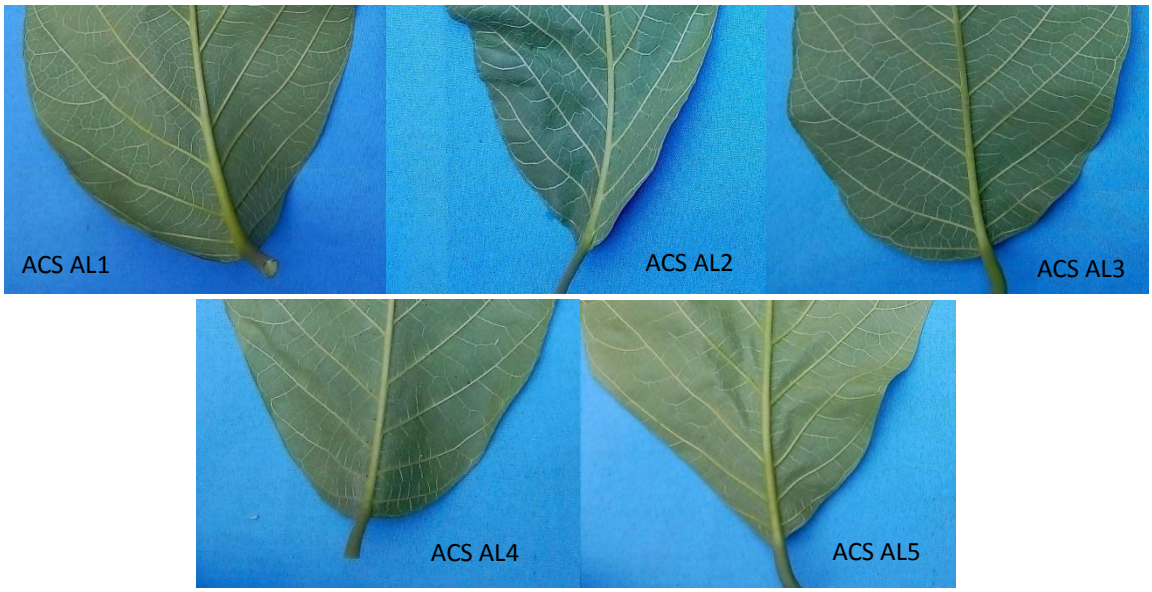


Plate 3. Leaf base of monkey jack germplasm

Table 1. Leaf shape, apex and base of five monkey jack germplasm

Germplasm	Leaf shape	Leaf apex	Leaf base
ACS AL1	Ovate-elliptic	Acute	Cuneate
ACS AL2	Obovate	Apiculate	Cuneate
ACS AL3	Ovate-elliptic	Apiculate	Almost rounded
ACS AL4	Ovate-elliptic	Acuminate	Almost rounded

ACS AL5	Ovate-elliptic	Acuminate	Cuneate

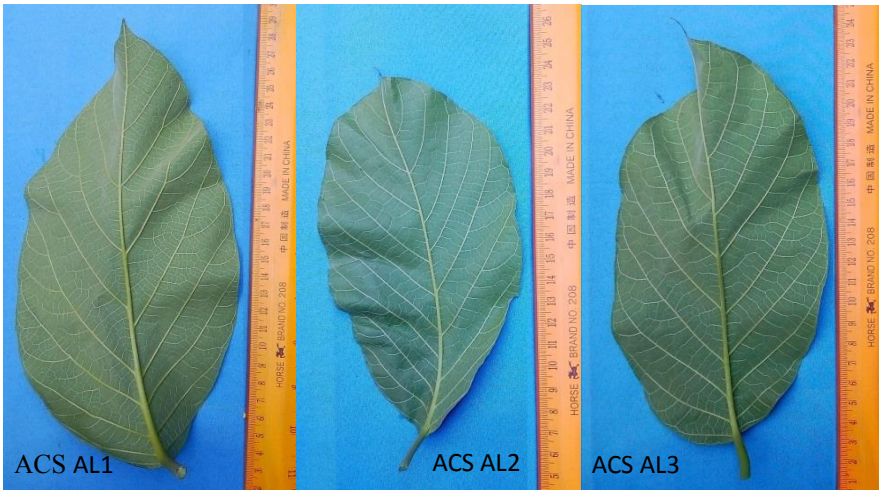
Leaf length: The highest leaf length was found in ACS AL5 (31.20 cm) followed by ACS AL1 (27.20 cm), ACS AL4 (25.60 cm) and ACS AL3 (23.80 cm) and the lowest length was found in ACS AL2 (19.20 cm) (Plate 4, Table 2).

Leaf width: The maximum leaf width was found in ACS AL1, ACS AL5 (12.3 cm) followed by ACS AL4 (12.1 cm), ACS AL3 (11.9) and the minimum width was found in ACS AL2 (10.1 cm) (Table 2).

Petiole length: The highest petiole length was found in ACS AL5 (2.7 cm) followed by ACS AL1 (1.9 cm), ACS AL3, ACS AL4 (1.80 cm) and the lowest was found in ACS AL2 (1.7 cm) (Table 2).

Petiole width: The highest petiole width was found in ACS AL4, ACS AL5 (0.41 cm) followed by ACS AL3 (0.39 cm), ACS AL1 (0.38 cm) and the lowest width was found in ACS AL2 (0.37 cm) (Table 2).

Leaf area: The maximum leaf area was recorded in ACS AL5 (230.06 cm^2) followed by ACS AL1 (208.70 cm^2), ACS AL4 (188.31cm^2), ACS AL3 (176.34 cm^2) and the minimum leaf area was found in ACS AL2 (138.43 cm^2) (Table 2).



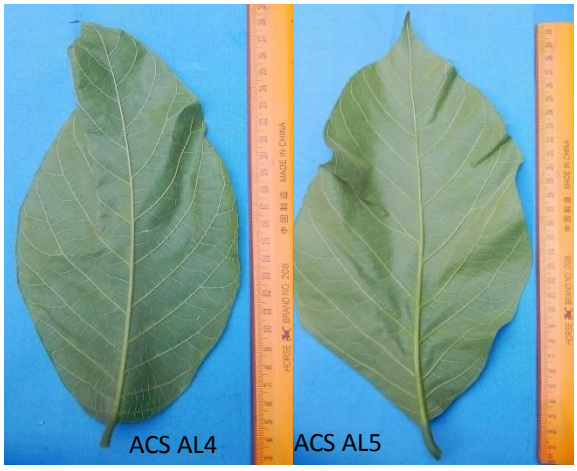


Plate 4. Leaf length of monkey jack germplasm

Table 2. Leaf length, width, petiole length, width and area of monkey jack germplasm

Germplasm	Leaf length (cm)	Leaf width (cm)	Petiole length (cm)	Petiole width (cm)	Leaf area (cm^2)
ACS AL1	27.2	12.3	1.9	0.38	208.70
ACS AL2	19.2	10.1	1.7	0.37	138.43
ACS AL3	23.8	11.9	1.8	0.39	176.34
ACS AL4	25.6	12.1	1.8	0.41	188.31
ACS AL5	31.2	12.3	2.7	0.41	230.06
Mean±SD	**25.40±4.41**	**11.74±0.93**	**1.98±0.41**	**0.39±0.02**	**188.37±34.61**

Flower characteristics: Both male and female flowers of monkey jack are borne separately on the same tree. It is a monoecious type fruit plant. Flowers are tiny, fused in a round inflorescence. Male flowers are orange-yellow in color and females are greenish in color. Both sepals and petals are absent in flower body.

Regularity of flowering: They are cauterized into regular bearing.

Inflorescence position: Both male and female flowers body arise from the leaf axils. Therefore, the position of flower body is axillary (Plate 5).

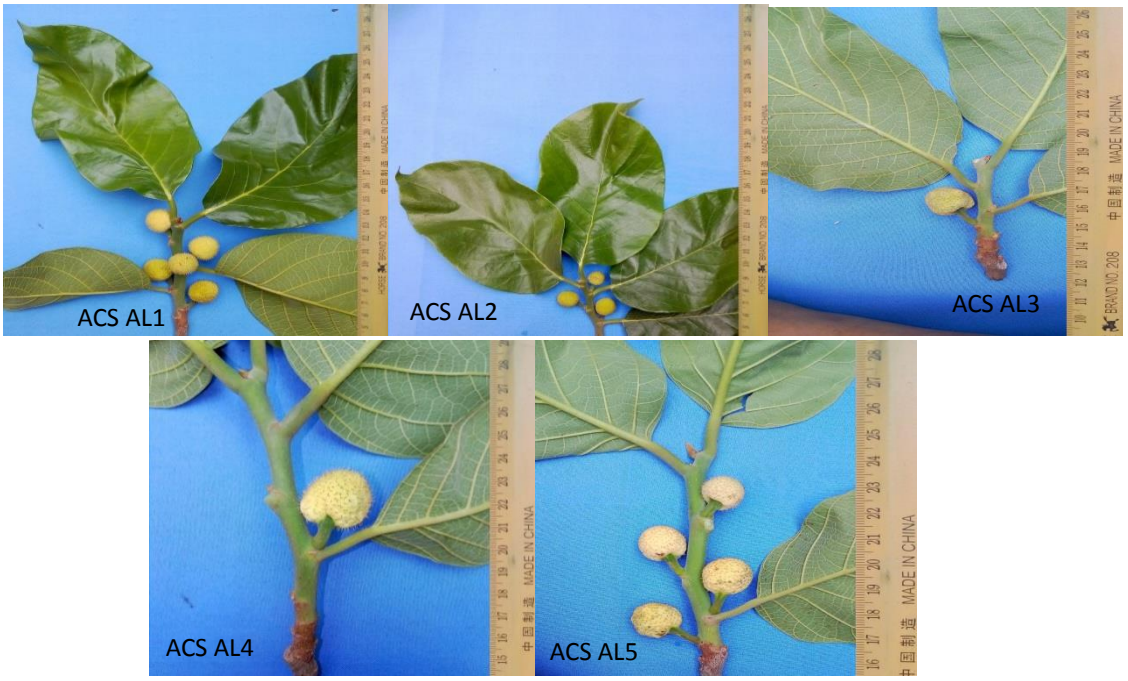


Plate 5. Inflorescence position of monkey jack germplasm

Inflorescence shape: Both male and female flowers body are categorized into round, elongate, irregular shape (Plate 6, Table 3).

Table 3. Shape of male and female inflorescence of five monkey jack germplasm

Monkey jack Germplasm	Shape of male inflorescence	Shape of female inflorescence
ACS AL1	Elongate	Almost round
ACS AL2	Elongate	Almost round
ACS AL3	Almost round	Almost round

ACS AL4	Elongate	Almost round
ACS AL5	Elongate	Almost round

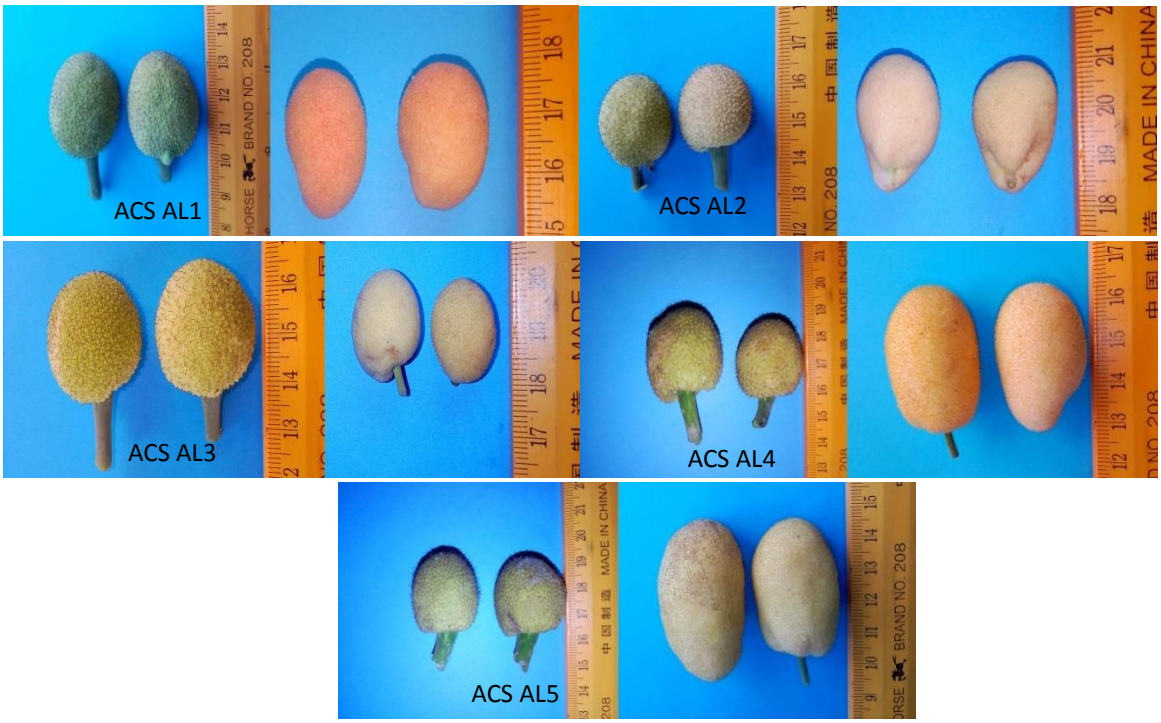


Plate 6. Inflorescence shape of monkey jack germplasm

Inflorescence length: The highest length of male inflorescence was found in ACS AL5 (4.9 cm) followed by ACS AL4 (3.4 cm), ACS AL2 (2.7 cm), ACS AL1 (2.4 cm) and the lowest length was found in ACS AL3 (2.2 cm) (Plate 6 & Table 5). On the other hand, the highest length of female inflorescence was found in ACS AL5 (3.5 cm) followed by ACS AL4 (3.4 cm), ACS AL1 (3.3 cm), ACS AL3 (2.9 cm) and the lowest was found in ACS AL2 (2.2 cm) (Plate 6, Table 4).

Table 4. **Length of male and female inflorescences of monkey jack germplasm**

Germplasm	Length of male inflorescence (cm)	Length of female inflorescence (cm)
ACS AL1	2.4	3.3
ACS AL2	2.7	2.2
ACS AL3	2.2	2.9
ACS AL4	3.4	3.4
ACS AL5	4.9	3.5
Mean±SD	**3.12±1.09**	**3.06±0.53**

Inflorescence width: The highest width of male inflorescence was found in ACS AL5 (2.9 cm) followed by ACS AL4 (2.8 cm), ACS AL2 (2.3 cm), ACS AL1 (2.1 cm) and the lowest was found in ACS AL3 (2.0 cm). Similarly, the highest width of female inflorescence was found in ACS AL4 and ACS AL5 (3.3cm) followed by ACS AL1 (3.0 cm), ACS AL3 (2.70 cm) and the lowest width was found in ACS AL2 (2.1 cm) (Plate 6, Table 5).

Table 5.Width of male and female inflorescences of monkey jack germplasm

Monkey jack Germplasm	Width of male inflorescence (cm)	Width of female inflorescence (cm)
ACS AL1	2.1	3.0
ACS AL2	2.3	2.1
ACS AL3	2.0	2.7
ACS AL4	2.8	3.3
ACS AL5	2.9	3.3
Mean ± SD	**2.42±0.41**	**2.88±0.50**

Inflorescence colour: Male inflorescences are yellowish and females are greenish.
Inflorescence size: The size of male and female flower body are categorized into small, medium and large (Table 6).

Table 6. Size of male and female flowers of monkey jack germplasm

Monkey jack Germplasm	Size of male inflorescence	Size of female inflorescence
ACS AL1	Medium	Large
ACS AL2	Medium	Medium
ACS AL3	Medium	Medium
ACS AL4	Medium	Medium
ACS AL5	Medium	Medium

Colour of Inner Surface of Inflorescence: The color of inner surface of both male and female flowers body are categorized into whitish and pinkish (Plate 7, Table 7).

Table 7. Color of male and female inflorescences of monkey jack germplasm

Monkey jack Germplasm	Color of male inflorescence	Color of female inflorescence
ACS AL1	Whitish	Whitish
ACS AL2	Whitish	Whitish
ACS AL3	Whitish	Whitish
ACS AL4	Pinkish	Whitish
ACS AL5	Pinkish	Whitish

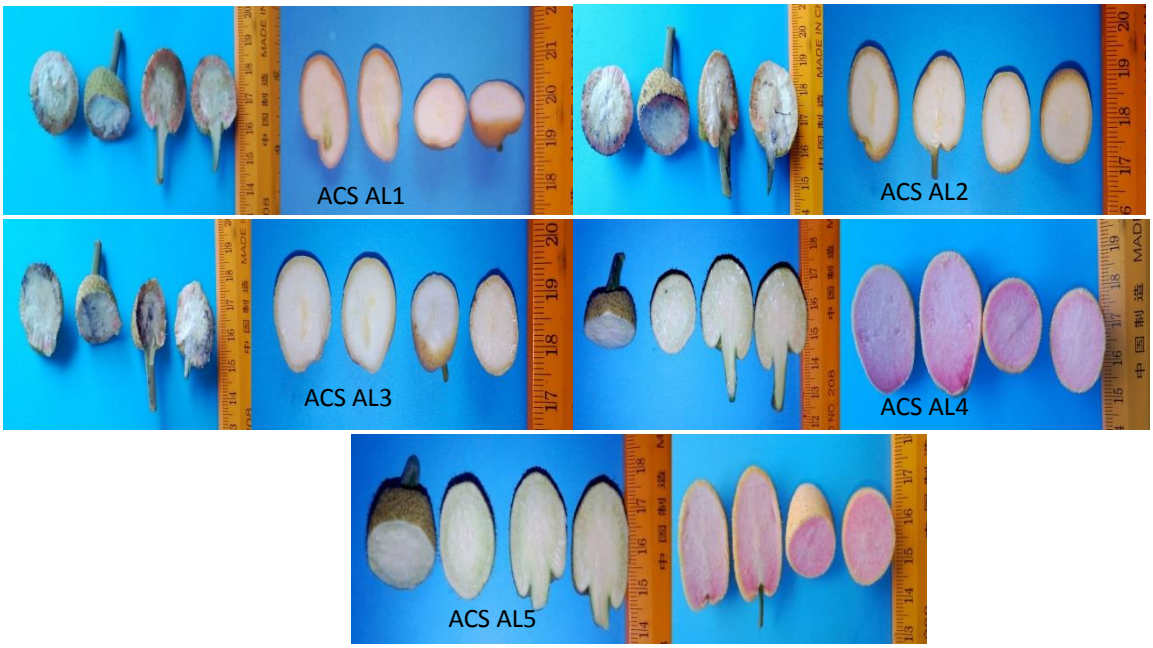


Plate 7. Color of inner surface of inflorescence of monkey jack germplasm

Peduncle length: The highest peduncle length of male inflorescence was found in ACS AL5 (1.15 cm) followed by ACS AL4 (0.94 cm), ACS AL1 (0.41 cm) and the lowest length was found in ACS AL2 and ACS AL3 (0.26 cm). On the other hand, the highest peduncle length of female inflorescence was observed in ACS AL4 (1.67 cm) followed by ACS AL1 (1.53 cm), ACS AL3 (1.46 cm) and the lowest length was found in ACS AL2 and ACS AL5 (1.38 cm) (Table 8).

Peduncle width: The highest peduncle width of male inflorescence was recorded in ACS AL3 (0.19 cm) followed ACS AL2 and ACS AL5 (0.18 cm), ACS AL4 (0.17 cm) and the lowest length was found in ACS AL1 (0.16 cm). On the other hand, the maximum peduncle width of female inflorescence was found in ACS AL5 (0.39 cm) followed by ACS AL2 (0.38 cm), ACS AL3 and ACS AL4 (0.36 cm) and the minimum length was found in ACS AL1 (0.35 cm) (Table 8).

Table 8. Peduncle length and peduncle width of male and female inflorescence of monkey jack germplasm

Germplasm	Peduncle length of male inflo.(cm)	Peduncle length of female inflo.(cm)	Peduncle width of male inflo.(cm)	Peduncle width of female inflo.(cm)
ACS AL1	0.41	1.53	0.16	0.35
ACS AL2	0.26	1.38	0.18	0.38
ACS AL3	0.26	1.46	0.19	0.36
ACS AL4	0.94	1.67	0.17	0.36
ACS AL5	1.15	1.38	0.18	0.39
Mean±SD	**0.60±0.41**	**1.48±0.12**	**0.18±0.01**	**0.37±0.02**

Fruit Characteristics:

Fruit shape: Fruits are rounded or irregular in shape, yellowish in colour (Plate 8, Table 9).

Table 9. Fruit shape and colour of monkey jack germplasm

Monkey jack Germplasm	Fruit shape	Fruit colour
ACS AL1	Rounded	Yellowish
ACS AL2	Globose	Yellowish
ACS AL3	Irregular	Yellowish
ACS AL4	Irregular	Yellowish
ACS AL5	Irregular	Yellowish

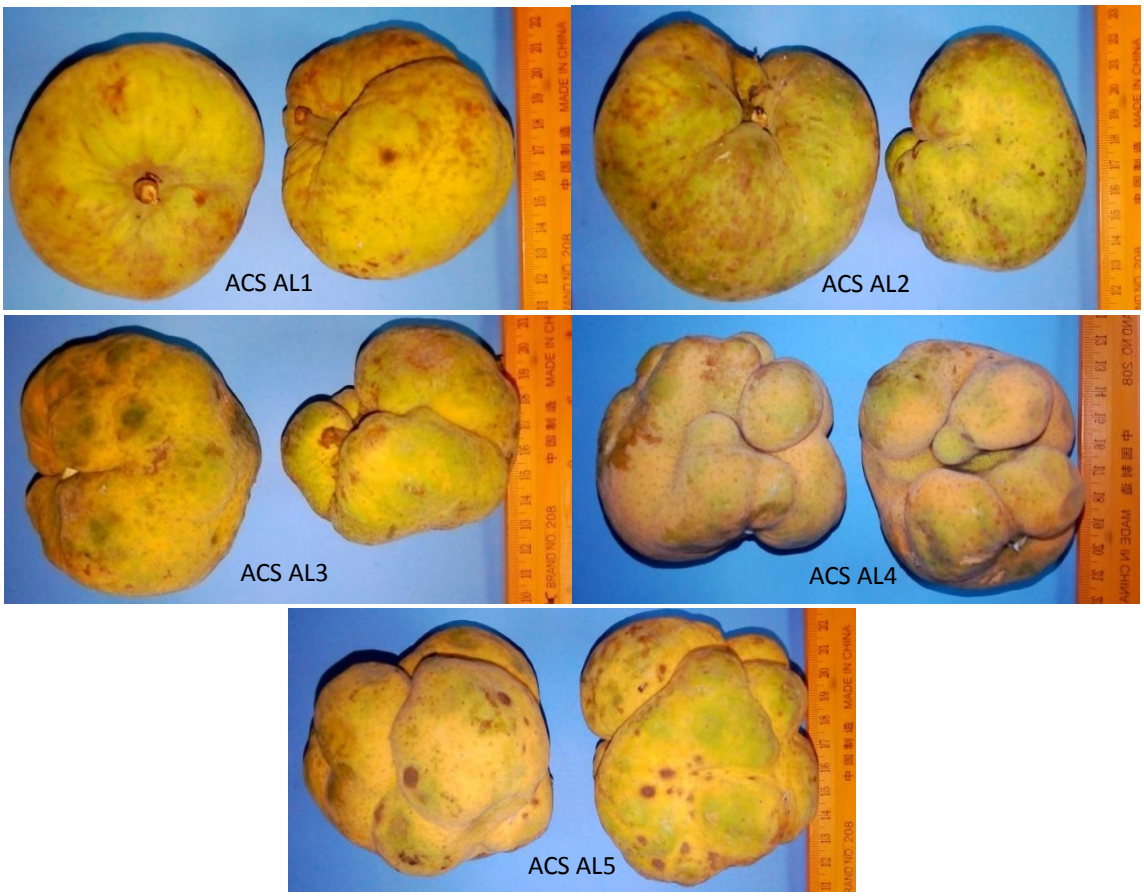


Plate 8. Fruit shapes of monkey jack germplasm

Fruit color: Fruits are yellowish in color (Table 9).

Fruit weight: The highest fruit weight was found in ACS AL5 (226.72 gm) followed by ACS AL1 (205.83 gm), ACS AL4 (184.28 gm), ACS Al3 (177.40 gm) and lowest was found in ACS AL2 (130.20 gm) (Table 10).

Fruit length: The highest fruit length was found in ACS AL5 (8.15 cm) followed by ACS AL1 (7.95 cm), ACS Al4 (6.41 cm), ACS AL3 (6.37 cm) and the lowest was found in ACS AL2 (5.58 cm) (Plate 9, Table 10).

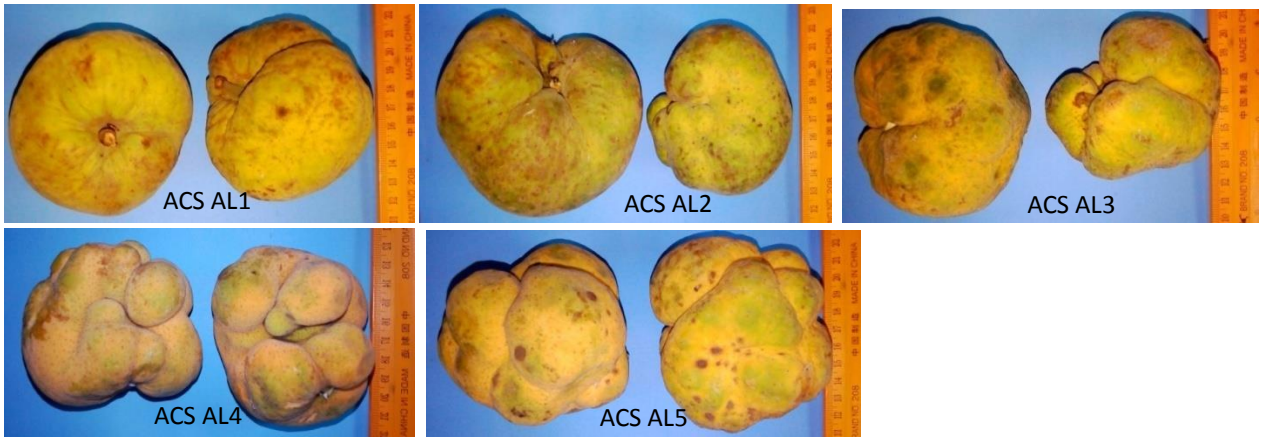


Plate 9. Fruit length of different monkey jack germplasm

Fruit width: The highest fruit width was found in ACS AL5 (7.38 cm) followed by ACS AL4 (7.33 cm), ACS AL3 (7.21 cm), ACS AL1 (6.82 cm) and the lowest was found in ACS AL2 (6.69 cm) (Table 10).
Flesh colour: The flesh of the fruits are yellowish (Plate 10).

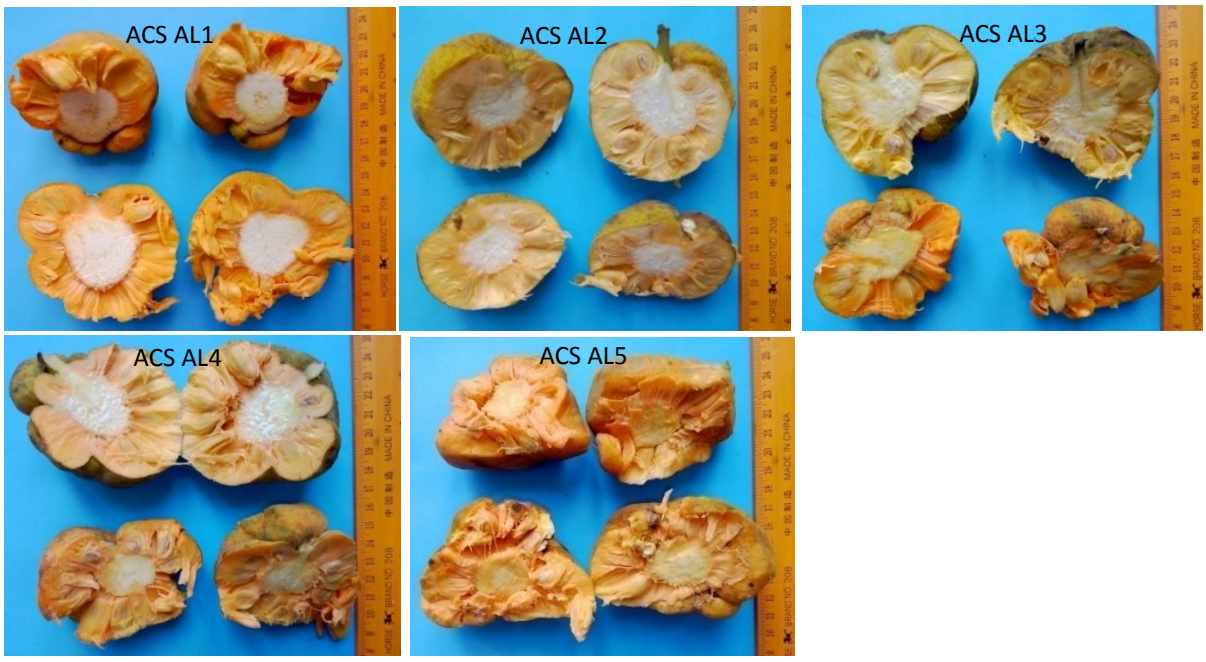


Plate 10. Flesh color of different monkey jack germplasm

Table 10.Fruit weight, length, width, TSS, % moisture and % dry matter of monkey jack germplasm

Germplasm	Fruit weight (gm)	Fruit length (cm)	Fruit width (cm)	TSS (%)	Moisture %	Dry matter %
ACS AL1	205.83	7.95	6.82	17	74.03	25.97
ACS AL2	130.20	5.58	6.69	13	78.37	21.63
ACS AL3	177.40	6.37	7.21	19	76.99	23.01
ACS AL4	184.28	6.41	7.33	20	73.98	26.02
ACS AL5	226.72	8.15	7.38	20	78.95	21.05
Mean±SD	**184.89±36.18**	**6.89±1.11**	**7.09±0.31**	**17.8±2.95**	**76.46±2.36**	**23.54±2.36**

Seed Characteristics:

Seed colour: Seeds are mainly whitish.

Seed number: The maximum number of seeds were found in ACS AL3 (74) followed by ACS AL2 (71), ACS AL1 (59), ACS AL5 (55) and minimum number of seeds were found in ACS AL4 (50) (Table 11).

Seed weight: The highest seed weight was found in ACS AL5 (29.56 gm) followed by ACS AL3 (26.17 gm), ACS AL1 (22.31 gm), ACS AL4 (20.77 gm) and the lowest seed weight was found in ACS AL2 (20.57 gm) (Table 11).

Seed length: The highest seed length was recorded in ACS AL5 (1.27 cm) followed by ACS AL4 (1.25 cm), ACS AL3 (1.21 cm), ACS AL1 (1.19 cm) and the lowest length was found in ACS AL2 (1.14 cm) (Plate 11, Table 11).

Plate 11. Seed length of monkey jack germplasm

Seed width: The highest seed width was found in ACS AL5 (0.93 cm) followed by ACS AL4 (0.89 cm), ACS AL3 (0.81 cm), ACS AL2 (0.79 cm) and the lowest was found in ACS AL1 (0.76 cm) (Table 11).

Table 11. Number of seeds, seed weight, seed length and seed width of monkey jack germplasm

Germplasm	No. of seed	Seed weight (gm)	Seed length (cm)	Seed width (cm)
ACS AL1	59	22.31	1.19	0.76
ACS AL2	71	20.57	1.14	0.79
ACS AL3	74	26.17	1.21	0.81
ACS AL4	50	20.77	1.25	0.89
ACS AL5	55	29.56	1.27	0.93
Mean±SD	**61.80±10.33**	**23.88±3.89**	**1.21±0.05**	**0.84±0.07**

Biochemical Compounds of Monkey jack

The following biochemical compounds were determined from three accessions of river ebony fruit:

Total Soluble Solids (TSS): The highest TSS (20%) was found in ACS AL4 and ACS AL5 followed by ACS AL3 (19), ACS AL1 (17) and the lowest TSS (13%) was found in ACS AL2 (Table 10).

Moisture content (%): The highest moisture content was recorded in ACS AL5 (78.95 %) followed by ACS AL2 (78.37%), ACS AL3 (76.995), ACS AL1 (74.03%) and the lowest was in ACS AL4 (73.98 %) (Table 10).

Dry matter (%): The highest dry matter content was found in ACS AL4 (26.02 %) followed by ACS AL1 (25.97%), ACS AL3 (23.01%), ACS AL2 (21.63%) and the lowest was in ACS AL5 (21.05 %) (Table 10).

pH content: It was found that fruits of accession ACS AL1 contained the highest pH value (3.53) followed by the accession ACS AL3 (3.38), while it was the lowest (3.24) in the accession ACS AL5 (Table 12).

Ascorbic acid (Vitamin C) content: It was found that fruits of accession ACS AL5 contained the highest amount of vitamin C (21.74mg/100g) followed by the accession ACS AL1 (21.73mg/100g), while it was the lowest (19.55mg/100g)) in the accession ACS AL2 (Table 12).

Titratable acidity (%): The highest percentage (5.11%) of titratable acidity was found in accession ACS AL2 followed by accession ACS AL5 (4.76%), while it was the lowest (3.72%) in accession ACS AL1 (Table 12).

Total sugar content: It was found that fruits of accession ACS AL5 contained the highest amount of total sugar content (4.11%) followed by accession ACS AL1 (3.45%), while it was the lowest (1.77%) in accession ACS AL3 (Table 12).

Reducing sugar content: It was observed that fruits of accession ACS AL5 contained the highest amount of reducing sugar (2.24%) followed by accession ACS AL1 (1.96%), while it was the lowest (0.98%) in accession ACS AL3 (Table 12).

Non-reducing sugar content: It was observed that fruits of accession ACS AL5 contained the highest amount of non- reducing sugar content (1.86%) followed by accession ACS AL1 (1.49%), while it was lowest (0.79%) in accession ACS AL3 (Table 12).

Table 12.Fruit pH, vitamin C, titratable acidity, total sugar, reducing sugar and non-reducing sugar contents of monkey jack germplasm

Germplasm	pH	Vitamin C (mg/100g)	Titratable acidity (%)	Total sugar (%)	Reducing sugar (%)	Non-reducing sugar (%)
ACS AL1	3.53	21.73	3.72	3.45	1.96	1.49
ACS AL2	3.29	19.55	5.11	2.32	1.42	0.89
ACS AL3	3.38	19.57	4.53	1.77	0.98	0.79
ACS AL4	3.26	21.72	4.64	2.88	1.56	1.31
ACS AL5	3.24	21.74	4.76	4.11	2.24	1.86
Mean±SD	**3.34±0.12**	**20.86±1.19**	**4.55±0.51**	**2.91±0.92**	**1.63±0.49**	**1.27±0.44**

Nutritional status of Monkey jack germplasm:

Amount of Sodium: It was found that fruits of accession ACS AL5 contained the highest amount of Na (22.90mg/100g) followed by accession ACS AL2 (22.60mg/100g), while it was the lowest (21.22mg/100g) in accession ACS AL4 (Table 13).

Amount of Potassium: It was observed that fruits of the accession ACS AL3 contained the highest amount of K (205.80mg/100g) followed by accession ACS AL5 (186.46mg/100g), while it was the lowest (131.41mg/100g) in accession ACS AL1 (Table 13).

Amount of Calcium: It was observed that accession ACS AL1 gave maximum amount of Ca (56.11mg/100g) followed by ACS AL3 (52.19mg/100g), whereas the minimum (39.46mg/100g) was observed in ACS AL4 (Table 13).

Amount of Magnesium: It was observed that the accession ACS AL1 gave maximum amount of Mg (48.62mg/100g) followed by ACS AL2 (48.34mg/100g), whereas minimum (46.56mg/100g) was observed in ACS AL5 (Table 13).

Amount of Phosphorus: Fruits of the accession ACS AL5 contained the highest amount of P (215.46mg/100g) followed by the accession ACS AL1 (212.68mg/100g), while it was lowest (163.38mg/100g) in accession ACS AL2 (Table 13).

Amount of Iron: It was observed that fruits of the accession ACS AL5 contained the highest amount of Fe (3.11mg/100g) followed by ACS AL1 (2.29mg/100g), while it was the lowest (1.36mg/100g) in accession ACS AL2 (Table 13).

Amount of Zinc: It was found that fruits of the accession ACS AL1 contained the highest amount of Zn (0.18mg/100g) followed by accession ACS AL5 (0.15mg/100g), while it was lowest (0.02mg/100g) in accession ACS AL3 (Table 13).

Table 13.Sodium, potassium, calcium, magnesium, phosphorus, iron and zinc content of monkey jack germplasm

Germplasm	Na (mg/ 100g)	K (mg/ 100g)	Ca (mg/ 100g)	Mg (mg/ 100g)	P (mg/ 100g)	Fe (mg/ 100g)	Zn (mg/ 100g)
ACS AL1	21.43	131.41	56.11	48.62	212.68	2.29	0.18
ACS AL2	22.60	148.31	40.08	48.34	163.38	1.36	0.03
ACS AL3	21.93	205.80	52.19	46.86	189.32	2.27	0.02
ACS AL4	21.22	153.73	39.46	48.15	201.19	2.25	0.05
ACS AL5	22.90	186.46	48.09	46.56	215.46	3.11	0.15
Mean±SD	**22.02±0.73**	**165.14±30.24**	**47.19±7.34**	**47.71±0.93**	**196.41±21.16**	**2.26±0.62**	**0.09±0.07**

b) Velvet Apple (*Diospyros discolor* Willd.)

Velvet apple (*Diospyros discolor* Willd.) is a medium to large size evergreen tree belongs to the family Ebenaceae found in the saline belt in Bangladesh. In Bangladesh it is commonly known as Bilati Gab. The fruits are velvety reddish orange in color as the shape and size of an apple fruit and covered with velvet or resddish-like skin. It is a native of Malaysia and Phillipines but now widely cultivated in many countries like India and Bangladesh. In Bangladesh it is mainly found in Khulna, Barisal, Sathkhira, Chuadanga, Borguna, Mymensingh, Potuakhali, Tangail and Gazipur.

Eight accessions of velvet apple germplasm were collected from various locations of Barishal and Patuakhali districts. The following accessions were identified:

i)ACS DD1, ii) ACS DD2, iii) ACS DD3, iv) ACS DD4, v) ACS DD5, vi) ACS DD6, vii) ACS DD7, viii)ACS DD8

Leaf Characteristics: Leaves are oblong, acute, almost rounded at base, light green to dark green in colour (Plate 12).

Leaf shape: Leaves are categorized as oblong and elliptic oblong (Plate 12, Table 14).

Plate 12. Leaf shape of different velvet apple germplasm

Young leaf colour: Young leaves are mainly light green.

Mature leaf colour: Mature leaves are mainly dark green.

Leaf margin: Leaf margin is mainly catagorized as entire and wavy.

Leaf apex: Leaf apex is categorized into acute and acuminate (Plate 13, Table 14).

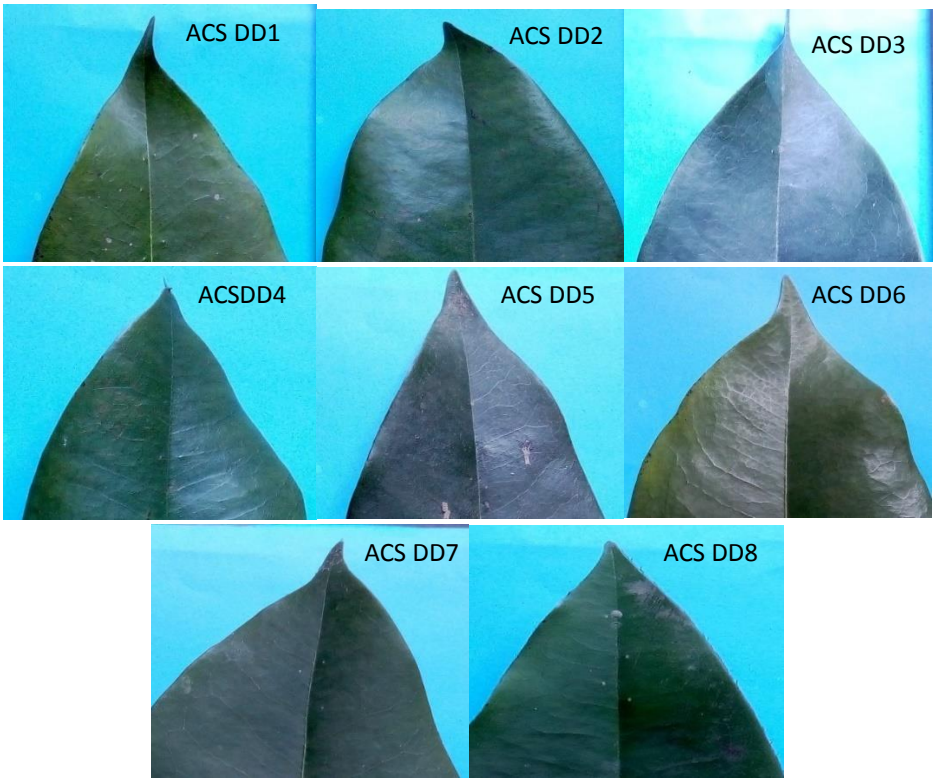


Plate 13. Leaf apex of velvet apple germplasm

Leaf base: Leaf base is categorized as obtuse and almost rounded (Plate 14, Table 14).

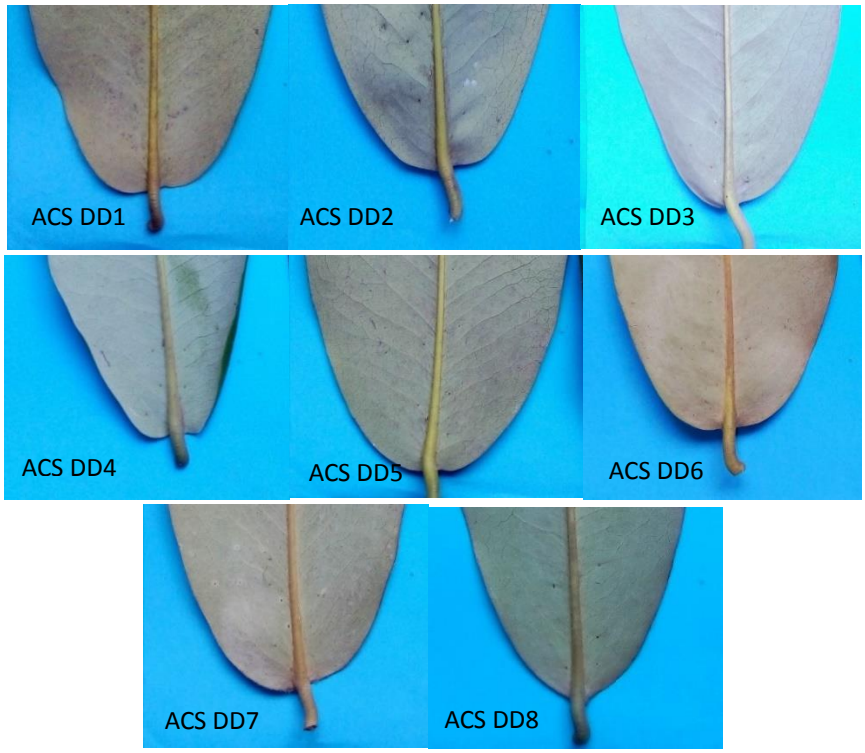


Plate 14. Leaf base of velvet apple germplasm

Table 14. Leaf shape, apex and base of velvet apple germplasm

Germplasm	Leaf shape	Leaf apex	Leaf base
ACS DD1	Elliptic oblong	Acuminate	Almost rounded
ACS DD2	Elliptic oblong	Acute	Almost rounded
ACS DD3	Elliptic oblong	Acuminate	Almost rounded
ACS DD4	Oblong	Acute	Almost rounded
ACS DD5	Oblong	Acute	Almost rounded
ACS DD6	Oblong	Acuminate	Almost rounded
ACS DD7	Oblong	Acuminate	Almost rounded
ACS DD8	Elliptic oblong	Acute	Obtuse

Leaf length: The highest leaf length was found in ACS DD5 (28.27 cm) followed by ACS DD3 (28.10 cm), ACS DD1 (27.73 cm), ACS DD8 (26.83 cm) and the lowest was found in ACS DD2 (20.57 cm) (Plate 15, Table 15).

Leaf width: The maximum leaf width was found in ACS DD5 (10.2 cm) followed by ACS DD1 (9.83 cm), ACS DD7 (9.3 cm), ACS DD6 (9.2 cm) and the minimum width was found in ACS DD8 (6.53 cm) (Table 15).

Petiole length: The highest petiole length was observed in ACS DD1 and ACS DD5 (1.5 cm) followed by ACS DD6 (1.47 cm), ACS DD4 (1.43 cm), ACS DD7 (1.40 cm), ACS DD3 (1.33 cm) and the lowest length was found in ACS DD2 and ACS DD8 (1.13 cm) (Table 15).

Petiole width: The highest petiole width was recorded in ACS DD5 (0.41 cm) followed by ACS DD8 (0.40 cm), ACS DD1 (0.39 cm), ACS DD6 (0.38 cm) and the lowest was found in ACS DD2 (0.31 cm) (Table 15).

Leaf area: The highest leaf area was found in ACS DD5 (174.70 cm^2) followed by ACS DD1 (166.25 cm^2), ACS DD3 (163.11 cm^2), ACS DD7 (159.63 cm^2) and the lowest leaf area was found in ACS DD2 (115.30 cm^2) (Table 15).

Table 15. Leaf length, width, petiole length, width and leaf area of velvet apple germplasm

Germplasm	Leaf length (cm)	Leaf width (cm)	Petiole length (cm)	Petiole width (cm)	Leaf area (cm^2)
ACS DD1	27.73	9.83	1.50	0.39	166.25
ACS DD2	20.57	7.87	1.13	0.31	115.30
ACS DD3	28.1	8.63	1.33	0.36	163.11
ACS DD4	23.27	8.07	1.43	0.34	130.72
ACS DD5	28.27	10.2	1.50	0.41	174.70
ACS DD6	25.1	9.2	1.47	0.38	141.15
ACS DD7	26.3	9.3	1.40	0.33	159.63
ACS DD8	26.83	6.53	1.13	0.40	138.96
Mean±SD	**25.77±2.69**	**8.70±1.19**	**1.36±0.15**	**0.37±0.04**	**148.73±20.36**

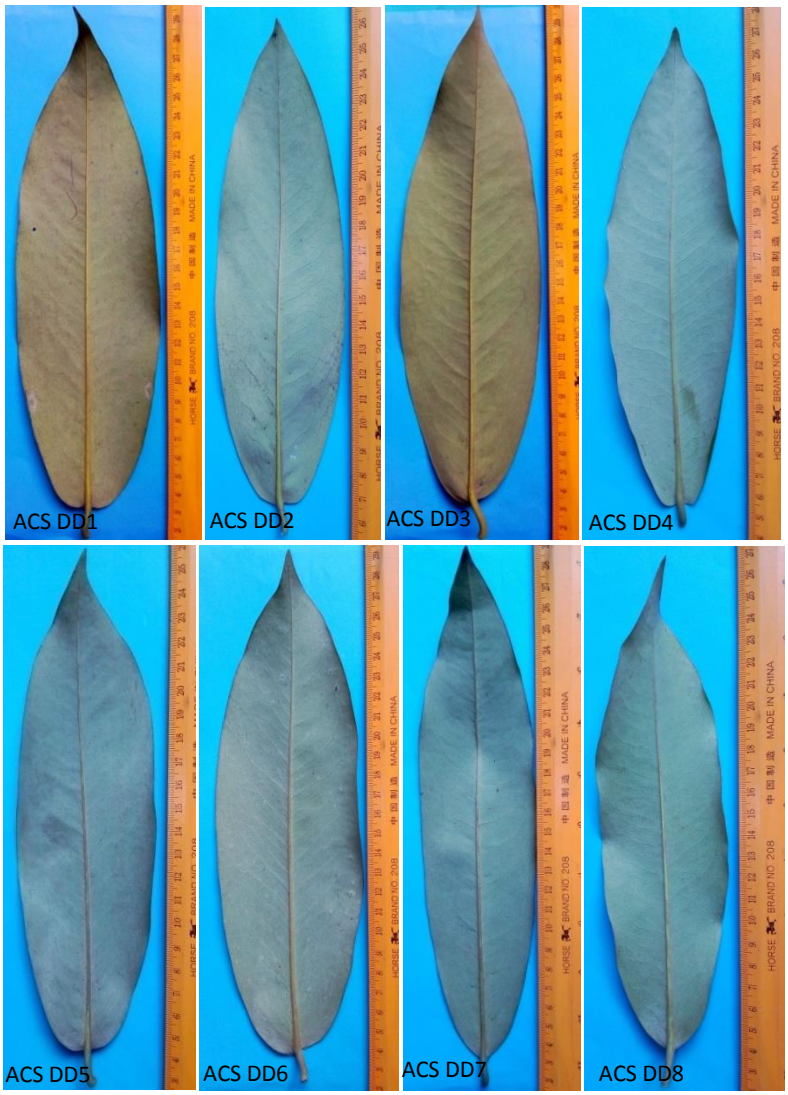


Plate 15. Leaf length of different velvet apple germplasm

Flower Characteristics: Flowers of velvet apple are dioecious, calyx 4-lobed, corolla tubular, white in color, flower bud green in color. The arrangement of calyx and corolla are known as aestivation. The arrangement was determined according to botanical description of flower and was expressed as twisted and velvet respectively (Dutta, 1975).

Male flower: Male flower arise as a cymes near the ends of the branches, stamens 25-30. White male flowers have 4 petals and form tube at the base (Plate 16).

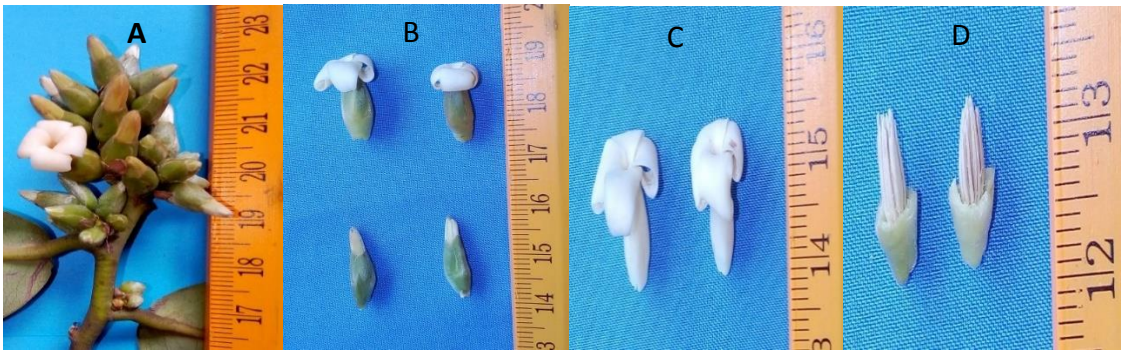


Plate 16. Male flower of velvet apple germplasm : (A) Flower position, (B) Flower bud with opened flower, (C) Petals, (D) Anther filaments.

Female flower: The white waxy female flower have 4 petals, flower buds are ovoid in shape.

Bearing habit: They are categorized as a regular bearing.

Bud length: The highest bud length was found in ACS DD5 (1.72 cm) followed by ACS DD6 (1.7 cm), ACS DD2 (1.67 cm), ACS DD7 (1.52 cm) and the lowest bud length was found in ACS DD1 (1.22 cm) (Plate 17, Table 16).

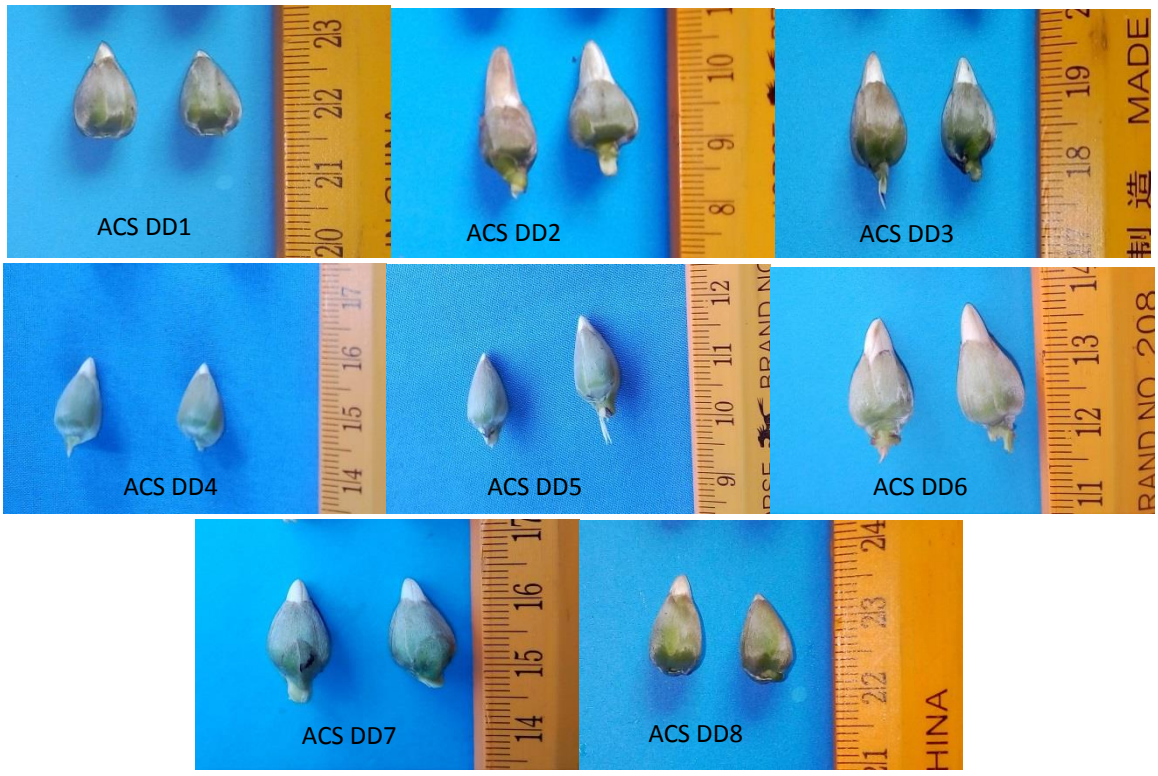


Plate 17. Bud length of different velvet apple germplasm

Number of sepals: The female flowers have 4 sepals.
Sepal color: The color of sepals ranges from light green to dark green.
Length of sepals: The highest sepal length was found in ACS DD6 (0.87 cm) followed by ACS DD5 (0.83 cm), ACS DD1, ACS DD7 and ACS DD8 (0.77 cm) and the lowest sepal length was found in ACS DD2 and ACS DD3 (0.63 cm) (Plate 18, Table 16).

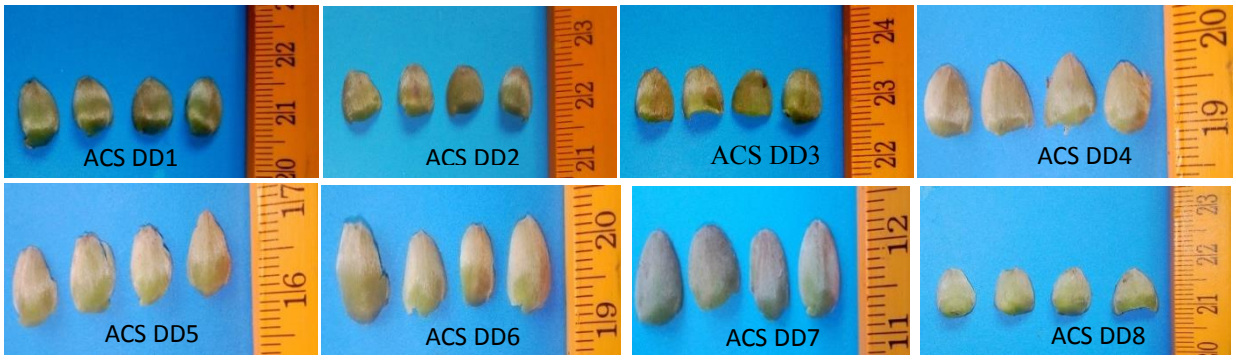


Plate 18. Sepal length of different velvet apple germplasm

Width of sepals: The maximum sepal width was recorded in ACS DD1 (0.70 cm) followed by DD3, DD4 and DD8 (0.67 cm) and the lowest width was found in ACS DD6 (0.53 cm) (Plate 18, Table 16).
Number of petals: The female flowers have 4 petals.
Petal colour: They are categorized as milky white to white (Plate 19).
Length of petals: The highest petal length was found in ACS DD5 (2.03 cm) followed by ACS DD7 (1.57 cm), ACS DD1 (1.47 cm) and the lowest length was found in ACS DD3 (1.23 cm) (Plate 19, Table 16).

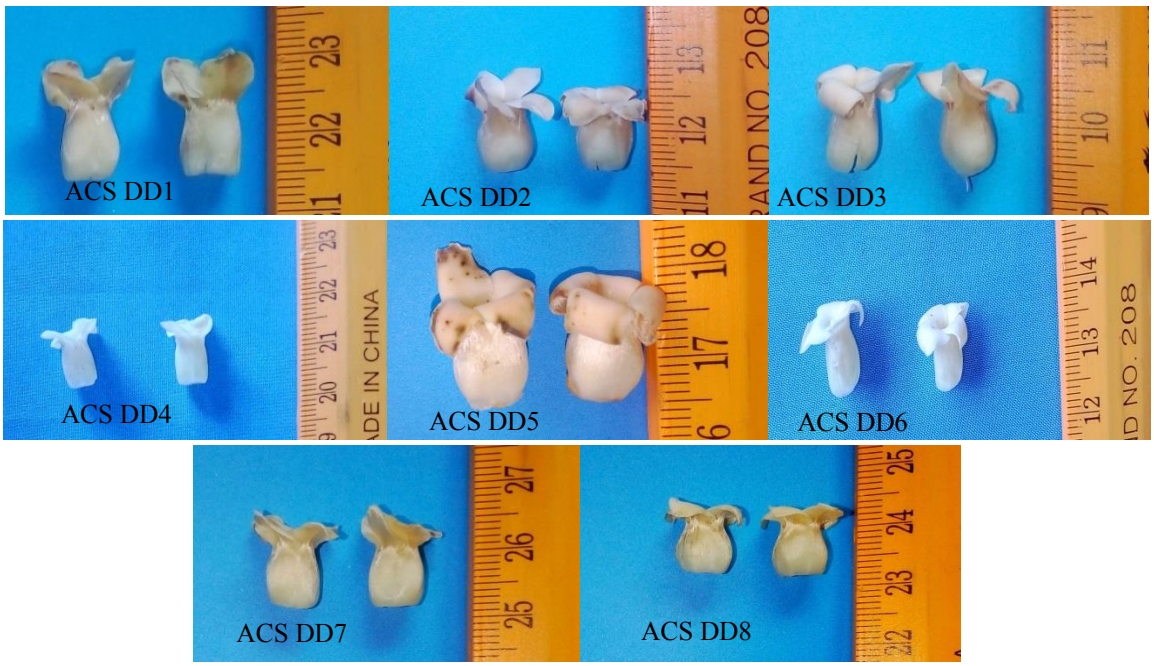


Plate 19. Petal length and width of different velvet apple germplasm

Width of petals: The maximum petal width was found in ACS DD5 (0.56 cm) followed by ACS DD4 and ACS DD8 (0.54 cm) and the minimum width was found in ACS DD6 (0.49 cm) (Plate 19, Table 16).
Pedicle length: The highest pedicel length was found in DD2, DD4, DD5 (0.17 cm) and the lowest length was found in DD6 (0.1 cm) (Table 16).

Table 16. Bud length, length and width of Sepals, length and width of petals, pedicel length of velvet apple germplasm

Germplasm	Bud length (cm)	Length of sepals (cm)	Width of sepals (cm)	Length of petals (cm)	Width of petals (cm)	Pedicel length (cm)
ACS DD1	1.22	0.77	0.7	1.47	0.53	0.13
ACS DD2	1.67	0.63	0.57	1.27	0.52	0.17
ACS DD3	1.33	0.63	0.67	1.23	0.52	0.13
ACS DD4	1.48	0.8	0.67	1.37	0.54	0.17
ACS DD5	1.72	0.83	0.6	2.03	0.56	0.17
ACS DD6	1.70	0.87	0.53	1.37	0.49	0.1
ACS DD7	1.52	0.77	0.63	1.57	0.51	0.13
ACS DD8	1.25	0.77	0.67	1.37	0.54	0.13
Mean±SD	**1.49±0.20**	**0.76±0.09**	**0.63±0.06**	**1.46±0.25**	**0.53±0.02**	**0.14±0.03**

Flower position: They are categorized as terminal and axillary (Plate 20, Table 17).

Table 17. Flower position of velvet apple germplasm

Germplasm	Flower position
ACS DD1	Terminal
ACS DD2	Terminal
ACS DD3	Axillary
ACS DD4	Terminal
ACS DD5	Axillary
ACS DD6	Axillary
ACS DD7	Terminal
ACS DD8	Axillary

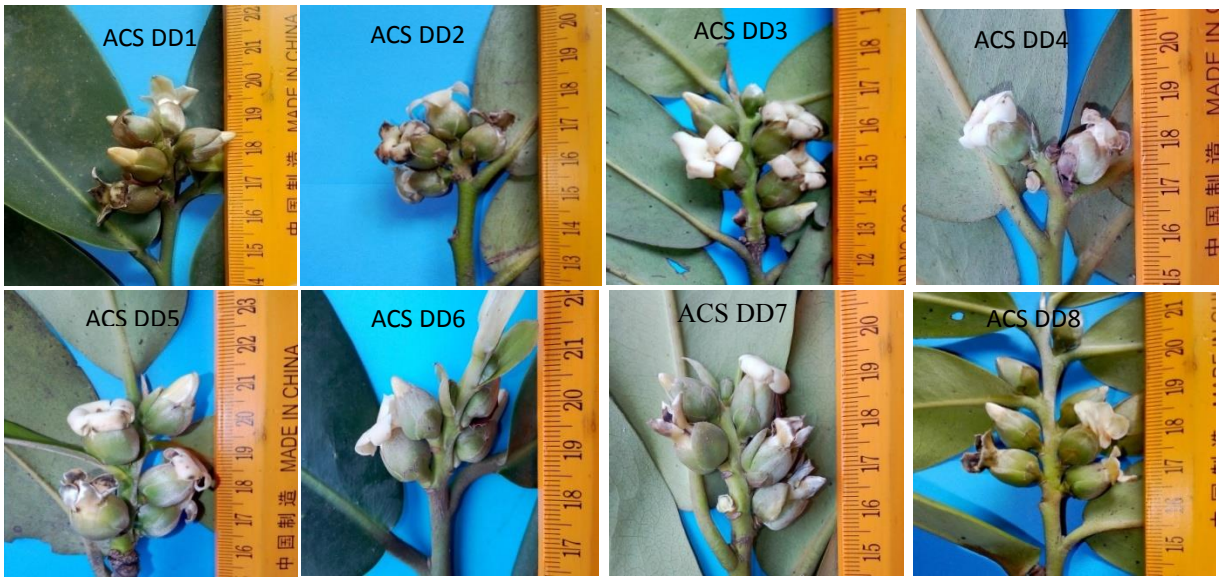


Plate 20. Flower position of different velvet apple germplasm

Fruit Characteristics:

Fruits are elongate, round, flattened globose in shape, ellipsoid, reddish brown to orange in colour.

Fruit shape: Fruits are categorised as elongate, round, flattened globose in shape (Plate 21, Table 18).

Table 18. Fruit shape and fruit colour of velvet apple germplasm

Germplasm	Types	Fruit colour
ACS DD1	Elongate	Reddish brown
ACS DD2	Elongate	Reddish brown
ACS DD3	Almost round	Light brown
ACS DD4	Elongate	Reddish brown
ACS DD5	Almost round	Reddish brown
ACS DD6	Globose	Reddish brown
ACS DD7	Almost round	Reddish brown
ACS DD8	Almost round	Reddish brown

Plate 21. Fruit shape of different velvet apple germplasm

Fruit color: Fruits are reddish brown (Plate 21, Table 18).

Fruit weight: The highest fruit weight was found in ACS DD5 (288.67gm) followed by ACS DD6 (150.46 gm), ACS DD3 (143.07 gm), ACS DD1 (141.60 gm) and the lowest was found in ACS DD2 (94.30gm) (Table 19).

Fruit length: The highest fruit length was found in ACS DD1 (8.69 cm) followed by ACS DD5 (8.01 cm), ACS DD6 (7.73 cm), ACS DD7 (7.46 cm), ACS DD3 (7.42 cm) and the lowest was found in ACS DD2 (5.74 cm) (Plate 22, Table 19).

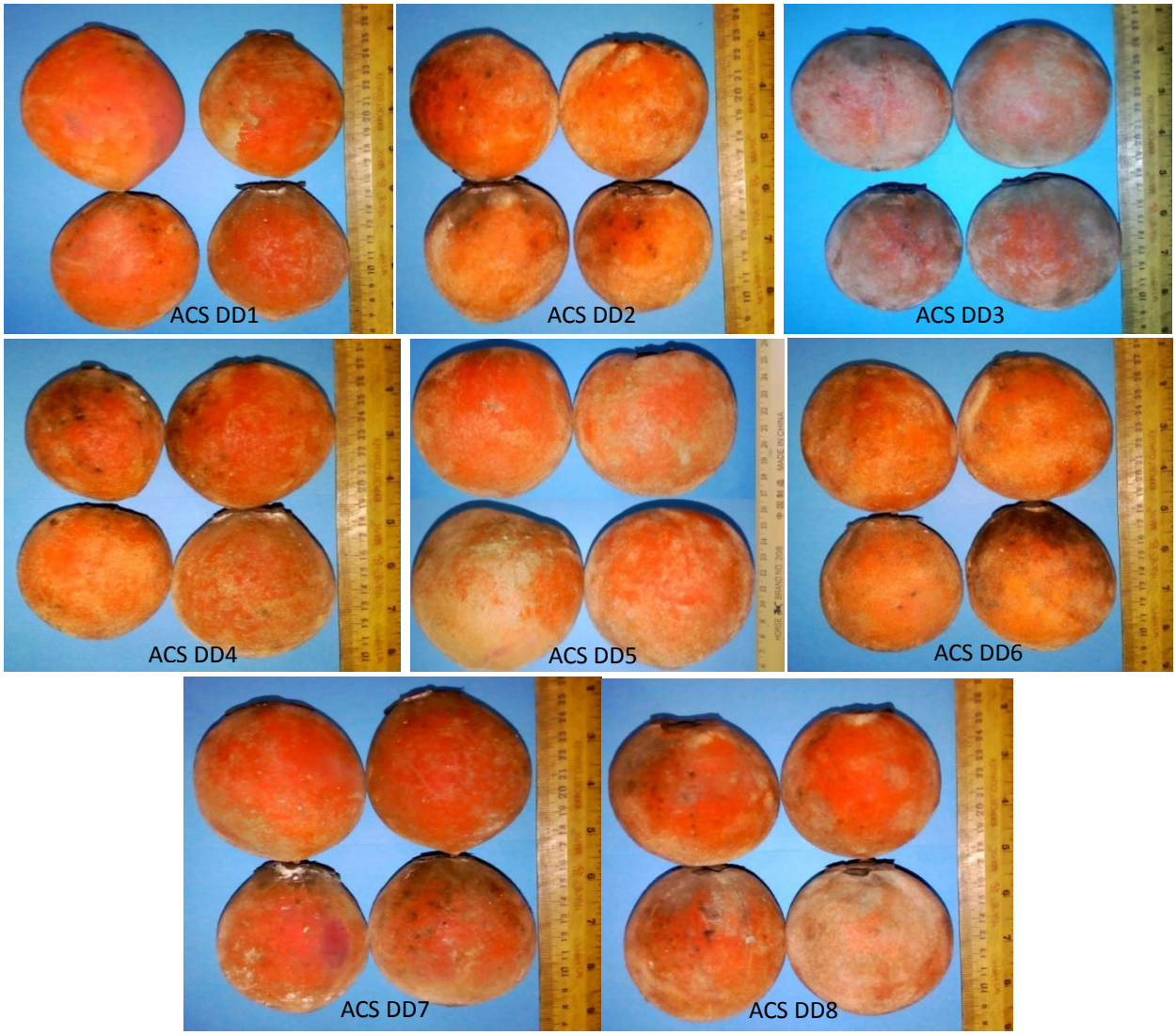


Plate 22. Fruit length of different velvet apple germplasm

Fruit width: The highest fruit width was found in ACS DD5 (8.24 cm) followed by ACS DD1 (6.75 cm), ACS DD4 (6.68 cm), ACS DD6 (6.63 cm), ACS DD7 (6.53 cm) and the lowest was found in ACS DD2 (5.92 cm) (Table 19).

Flesh colour: The flesh of the fruits are whitish (Plate 23).

Plate 23. Fruit flesh color of different velvet apple germplasm

Table 19. Fruit weight, length, width, TSS, % moisture and % dry matter of velvet apple germplasm

Germplasm	Fruit weight (gm)	Fruit length (cm)	Fruit width (cm)	TSS (%)	Moisture (%)	Dry matter (%)
ACS DD1	141.60	8.69	6.75	10.83	77.71	22.29
ACS DD2	94.30	5.74	5.92	10.00	81.75	18.25
ACS DD3	143.07	7.42	6.52	11.00	80.83	19.17
ACS DD4	135.31	6.71	6.68	10.50	82.28	17.72
ACS DD5	288.67	8.01	8.24	12.17	82.2	17.8
ACS DD6	150.46	7.73	6.63	11.00	78.37	21.63
ACS DD7	135.84	7.46	6.53	11.83	79.07	20.93
ACS DD8	131.40	6.98	6.11	11.67	80.76	19.24
Mean±SD	**152.58±57.52**	**7.34±0.89**	**6.67±0.70**	**11.13±0.72**	**80.37±1.77**	**19.63±1.77**

Seed Characteristics:

Seed colour: Seeds are mainly greyish to deep greyish (Plate 24).

Seed number: The maximum number of seeds were recorded in ACS DD1, ACS DD5 and ACS DD8 (7.67) followed by ACS DD2 and ACS DD6 (7.33) and the lowest number of seeds were found in ACS DD4 (6.33) (Table 20)

Seed weight: The highest seed weight was found in ACS DD3 (42.26 gm) followed by ACS DD6 (40.94 gm), ACS DD8 (37.39 gm), ACS DD7 (36.73 gm) and the lowest seed weight was found in ACS DD2 (20.95 gm) (Table 20).

Seed length: The highest seed length was found in ACS DD1 (3.9 cm) followed by ACS DD3 (3.82 cm), ACS DD5 (3.8 cm), ACS DD7 (3.75 cm) and the lowest was found in ACS DD2 (3.23 cm) (Plate 24, Table 20).

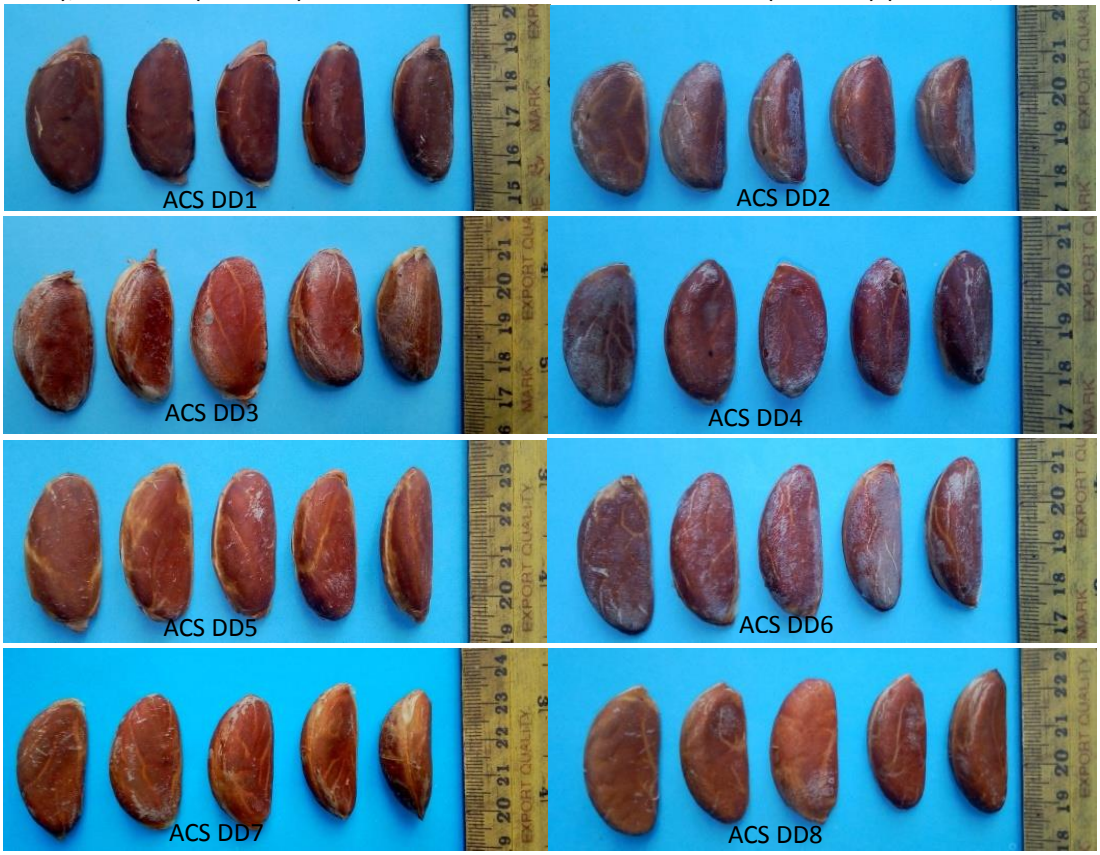


Plate 24. Seed length of velvet apple germplasm

Seed width: The highest seed width was noticed in ACS DD5 (1.94 cm) followed by ACS DD7 (1.87 cm), ACS DD3 (1.78 cm), ACS DD6 (1.77 cm) and the lowest was found in ACS DD2 (1.6 cm) (Table 20).

Table 20. Number of seeds, seed weight, length and width of velvet apple germplasm

Germplasm	No. of seed	Seed weight (gm)	Seed length (cm)	Seed width (cm)
ACS DD1	7.67	33.47	3.9	1.73
ACS DD2	7.33	20.95	3.23	1.6
ACS DD3	7.0	42.26	3.82	1.78
ACS DD4	6.33	27.87	3.65	1.74
ACS DD5	7.67	35.85	3.8	1.94
ACS DD6	7.33	40.94	3.71	1.77
ACS DD7	7.0	36.73	3.75	1.87
ACS DD8	7.67	37.39	3.26	1.64
Mean±SD	**7.25±0.46**	**34.43±7.02**	**3.64±0.26**	**1.76±0.11**

Biochemical Compounds of Velvet apple

The following biochemical compounds were determined from three accessions of river ebony fruit:

Total Soluble Solids (TSS): The total soluble contents of velvet apple fruits was significantly different among the accessions. However, the highest TSS (12.17%) was obtained in ACS DD5 followed by ACS DD7 (11.83%), ACS DD8 (11.67%) and the lowest TSS (10%) was recorded in accession ACS DD2 (Table 19).

Moisture content (%): Moisture contents of fruits was also significantly varied among the assessions. The highest moisture content was found in ACS DD4 (82.28%) followed by ACS DD5 (82.2%), ACS DD2 (81.75%), ACS DD3 (80.83%) and the lowest moisture content was found in ACS DD1 (77.71%) (Table 19).

Dry Matter (%): Dry matter contents of diferent velvet apple accessions were found significantly different. The highest dry matter content was found in ACS DD1 (22.29%) followed by ACS DD6 (21.63%), ACS DD7 (20.93%), ACS DD8 (19.24%) and the lowest dry matter content was obtained in accession ACS DD4 (17.72%) (Table 19).

pH content: It was found that fruits of the accession ACS DD1 contained the highest pH value (5.40) followed by the accession ACS DD7 (5.31), while it was the lowest (4.02) in accession ACS DD2 (Table 21).

Ascorbic acid (Vitamin C) content: It was found that fruits of the accession ACS DD5 contained the highest amount of vitamin-C (6.69mg/100g) followed by the accession ACS DD8 (6.68mg/100g), while it was lowest (4.33mg/100g)) in the accession no. ACS DD2 (Table 21).

Titratable acidity (TA) content (%): Results shows that TA contents of different velvet apple accessions were significantly varied among them. The highest percentage of TA (0.81%) was noticed in accession ACS DD7 followed by accession ACS DD1 and ACS DD4 (0.58%), while it was the lowest (0.23%) in accession ACS DD5 and ACS DD8 (Table 21).

Total sugar content: It was found that fruits of accessions ACS DD5 and ACS DD7 contained the highest amount of total sugar content (4.08%) followed by accession ACS DD8 (4.0%), while it was the lowest (3.38%) in accession ACS DD2 (Table 21).

Reducing sugar content: It was observed that fruits of the accession ACS DD8 contained the highest amount of reducing sugar (2.32%) followed by accession ACS DD2 (2.20%), while it was the lowest (2.0%) in accession ACS DD4 (Table 21).

Non-reducing sugar content: It was noticed that non-reducing sugar content of different velvet apple accessions was significantly different among the accessions. Fruits of accession ACS DD5 contained the highest amount of non-reducing sugar content (2.01%) followed by accession ACS DD7 (1.89%), while it was the lowest (1.18%) in accession ACS DD2 (Table 21).

Considering the biochemical compounds of eight velvet apple accessions it can be summarized that accession ACS DD5 showed superior performances in ascorbic acid and total sugar contents.

Table 21. Fruit pH, vitamin C, titratable acidity, total sugar, reducing sugar and non-reducing sugar contents of velvet apple germplasm

Germplasm	pH	Vitamin C (mg/100g)	Titratable acidity (%)	Total sugar (%)	Reducing sugar (%)	Non-reducing sugar (%)
ACS DD1	5.40	4.34	0.580	3.78	2.06	1.72
ACS DD2	4.02	4.33	0.460	3.38	2.20	1.18
ACS DD3	5.00	6.53	0.460	3.89	2.07	1.82
ACS DD4	5.16	6.53	0.580	3.48	2.00	1.47
ACS DD5	5.26	8.69	0.230	4.08	2.07	2.01
ACS DD6	4.74	4.35	0.350	3.80	2.05	1.74
ACS DD7	5.31	4.35	0.810	4.08	2.19	1.89
ACS DD8	5.24	8.68	0.230	4.00	2.32	1.69
Mean±SD	**5.02±0.45**	**5.73±1.63**	**0.46±0.20**	**3.81±0.26**	**2.12±0.11**	**1.69±0.26**

Nutritional Status of Velvet apple:

Amount of Sodium (Na): In terms of sodium content in fruits there was a significant different among the velvet apple accessions. It was found that fruits of the accession ACS DD5 contained the highest amount of Na (25.63mg/100g) followed by accession ACS DD8 (25.23mg/100g), while it was the lowest (19.58mg/100g) in accession ACS DD2 (Table 22).

Amount of Potassium (K): Results shows that there was a significant variation among the velvet apple accessions. It was observed that fruits of accession ACS DD4 contained the highest amount of K (280.42mg/100g) followed by accession ACS DD3 (269.48mg/100g), while it was the lowest (205.67mg/100g) in accession ACS DD1 (Table 22).

Amount of Calcium (Ca): It was observed that different velvet apple accessions performed differently in terms of Ca content. From the results it was noted that accession ACS DD1 and ACS DD3 gave the maximum amount of Ca (48.07mg/100g) followed by ACS DD5 (40.03mg/100g), whereas the minimum Ca (32.02mg/100g) was observed in ACS DD2 (Table 22).

Amount of Magnesium (Mg): Magnesium contents in fruits of different velvet apple accessions showed significantly different. It was observed that accession ACS DD5 gave maximum amount of Mg (38.88mg/100g) followed by ACS DD4 (34.03mg/100g), whereas the minimum Mg (29.18mg/100g) was observed in ACS DD2 (Table 22).

Amount of Phosphorus (P): Fruits of different velvet apple accessions exhibited differently in terms of phosphorus content. However, it was noticed that accession ACS DD8 contained the highest amount of P (145.74mg/100g) followed by accession ACS DD3 (138.20mg/100g), while it was the lowest (49.55mg/100g) in accession ACS DD5 (Table 22).

Amount of Iron (Fe): There was a significant variation in terms of iron contents of different velvet apple accessions. It was observed that fruits of accession ACS DD5 contained the highest amount of Fe (2.49mg/100g) followed by ACS DD4 (2.45mg/100g), while Fe content was the lowest (0.93mg/100g) in accession ACS DD1 (Table 22).

Amount of Zinc (Zn): Zinc content in fruits of different velvet apple accessions varied significantly. It was found that fruits of accession ACS DD2 contained the highest amount of Zn (0.877mg/100g) followed by accession ACS DD6 (0.707mg/100g), while Zn content was the lowest (0.147mg/100g) in accession ACS DD1 (Table 22).

From the findings on nutritional status in fruits of different velvet apple accessions it can be stated that accession ACS DD5 was the superior accession because it contains higher Na, Mg and Fe as compared to other accessions.

Table 22. Sodium, potassium, calcium, magnesium, phosphorus, iron and zinc contents of different velvet apple germplasm

Germplasm	Na (mg/100g)	K (mg/100g)	Ca (mg/100g)	Mg (mg/100g)	P (mg/100g)	Fe (mg/100g)	Zn (mg/100g)
ACS DD1	20.66	205.67	48.07	29.97	118.09	0.93	0.147
ACS DD2	19.58	220.71	32.02	29.18	64.58	2.11	0.877
ACS DD3	22.53	269.48	48.07	34.01	138.20	0.97	0.423
ACS DD4	21.23	280.42	36.77	34.03	79.58	2.45	0.587
ACS DD5	25.63	239.39	40.03	38.88	49.55	3.49	0.693
ACS DD6	24.26	235.58	32.06	30.33	105.26	1.77	0.707
ACS DD7	20.85	232.22	35.27	32.08	100.16	3.23	0.500
ACS DD8	25.23	224.59	38.46	31.11	145.74	1.53	0.353
Mean±SD	**22.50±2.29**	**238.51±24.94**	**38.84±6.34**	**32.45±3.15**	**100.15±34.06**	**1.81±0.62**	**0.54±0.23**

c) River ebony (*Diospyros peregrina)*

River ebony (*Diospyros peregrina*) is a medium to large size evergreen tree belongs to the family Ebenaceae grown as homestead plants in the coastal area. In Bangladesh, it is commonly known as Deshi Gab. It is an underutilized fruit used by the coastal people. The fruits are reddish velvety in color, berry, turn into yellow when ripened. It is originated from India but now widely cultivated in many countries like Bangladesh and Myanmar. In Bangladesh, it is mainly found in Khulna, Barisal, Sathkhira, Chuadanga, Borguna, Mymensingh and Patuakhali. Three accessions of river ebony were identified and collected from various locations of Barishal and Patuakhali districts these are stated as-i) ACS DP1, ii) ACS DP2, iii) ACS DP3

Morphological characters of river ebony:

Leaf Characteristics: Leaves of river ebony are oblong-lanceolate, apex acute to obtuse, base acute to attenuate, young leaves are reddish in colour, matured are green in colour.
Leaf shape: Leaves are categorized as oblong, ovate and obovate (Plate 25, Table 23).

Table 23. Leaf shape, leaf apex and leaf base of river ebony germplasm

River ebony germplasm	Leaf shape	Leaf apex	Leaf base
ACS DP1	Oblong	Acute	Rounded
ACS DP2	Oblong	Obtuse	Rounded

ACS DP3	Oblong	Acute	Rounded

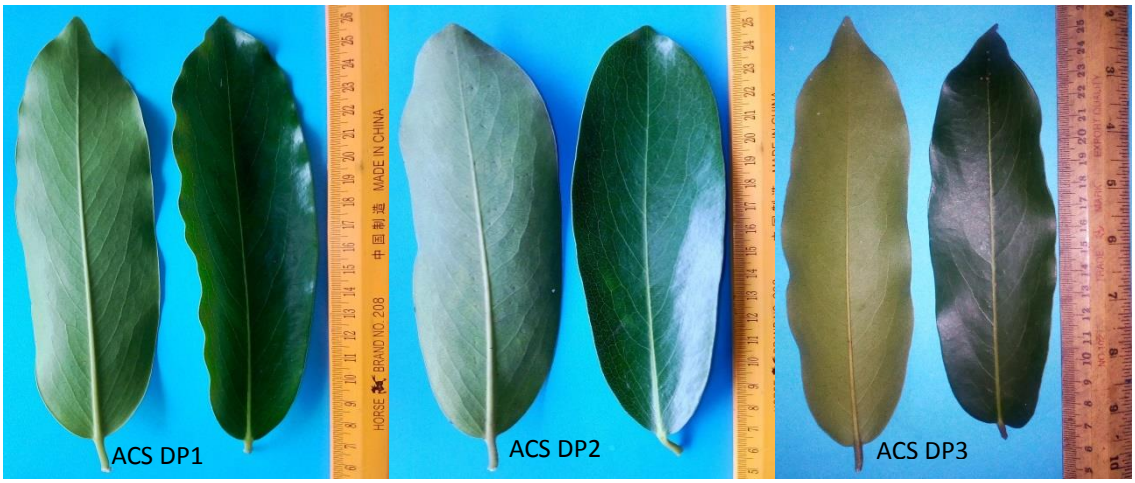


Plate 25. Leaf shape of different river ebony germplasm

Young leaf colour: Young leaves are mainly reddish.
Mature leaf colour: Mature leaves are mainly dark green.
Leaf margin: Leaf margins are mainly catagorized as entire and wavy
Leaf apex: Leaf apex is categorized as acute and obtuse (Plate 26, Table 23).

Plate 26. Leaf apex of river ebony germplasm

Leaf base: Leaf base is categorized as rounded or acute (Plate 27, Table 23).

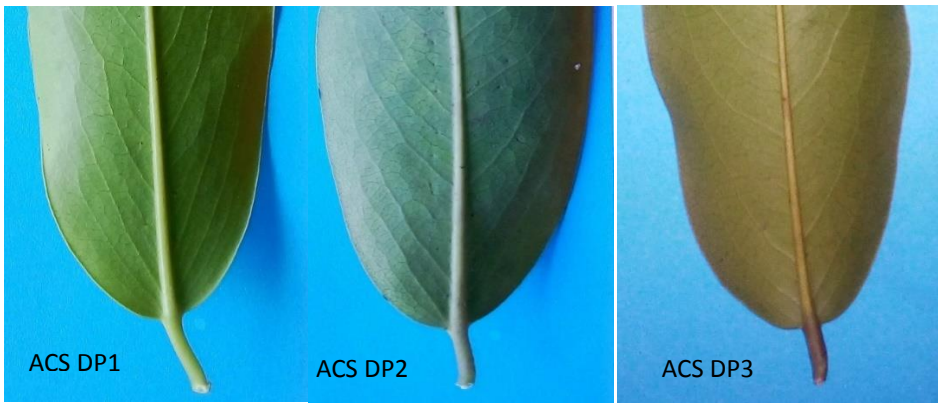


Plate 27. Leaf base of river ebony germplasm

Leaf length: Results showes that the highest leaf length was found in ACS DP1 (20.8 cm) followed by ACS DP3 (20.5 cm) and the lowest length was obtained in ACS DP2 (20.2 cm) (Plate 28, Table 24).

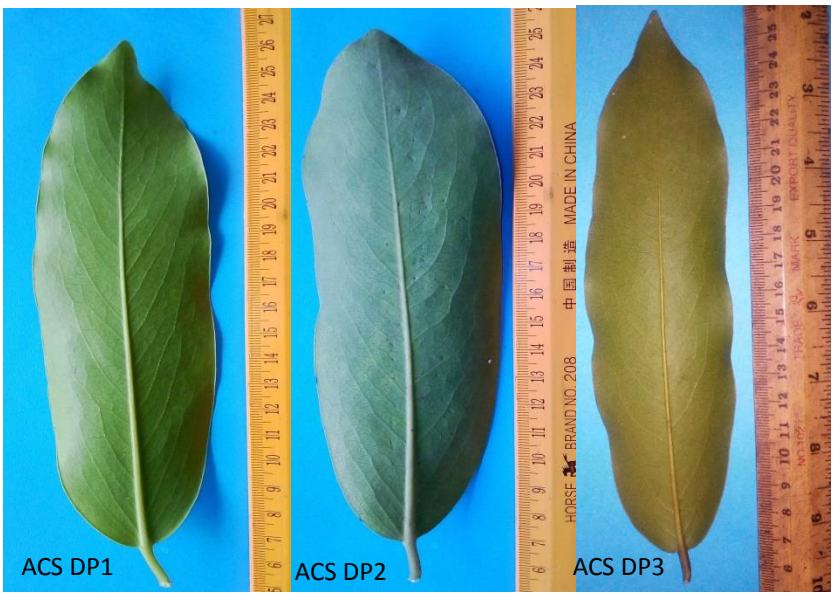


Plate 28. Leaf length of river ebony germplasm

Leaf width: It was observed that the highest leaf width was noticed in ACS DP1 and ACS DP3 (5.6 cm) and the lowest lenth was found in ACS DP2 (5.4 cm) (Table 24).

Petiole length: The highest petiole length was found in ACS DP1(1.6 cm) and the lowest was found in ACS DP2 and ACS DP3 (1.5 cm) (Table 24).

Petiole width: Petiole width of river ebony was varied among the accessions. The highest petiole width was reported in ACS DP1 (0.31cm) followed by ACS DP2 (0.29 cm) and the lowest was found in ACS DP3 (0.28 cm) (Table 24).

Leaf area: In case of leaf area, it was observed that a wide variation existed among the accwssions of river ebony. The highest leaf area was found in ACS DP1 (91.67 cm^2) followed by ACS DP3 (90.03 cm^2) and the lowest was found in ACS DP2 (87.38 cm^2) (Table 24).

Table 24. Leaf length, width, petiole length, width and leaf area of river ebony germplasm

Germplasm	Leaf length (cm)	Leaf width (cm)	Petiole length (cm)	Petiole width (cm)	Leaf area (cm^2)
ACS DP1	20.8	5.6	1.6	0.31	91.67
ACS DP2	20.2	5.4	1.5	0.29	87.38
ACS DP3	20.5	5.6	1.5	0.28	90.03
Mean±SD	**20.5±0.3**	**5.53±0.12**	**1.53±0.06**	**0.29±0.02**	**89.69±2.16**

Flower Characteristics: Flowers are unisexual, dioecious.
Male flower: Male inflorescence is 3-7 flowered axillary cymes. Stamens are 70-100, flower buds are yellow in color, yellow male flowers have 4 petals and form tube at the base (Plate 29).

Plate 29. Male flower of river ebony germplasm : (A) Flower branch, (B) Flower position, (C) Male flowers, (D) Petals, (E) Anther filaments

Female flower: The white colored female flowers have 4 petals joined at the base, 4 sepals, flower buds are ovate in shape, ovary ovate in shape.
Bearing habit: They are categorized as regular bearing.

Bud length: The length of flower bud exhibited a wide variation among the river ebony accessions. However, the highest bud length was found in ACS DD2 (1.67 cm) followed by ACS DD3 (1.34 cm) and the lowest bud length was recorded in ACS DD1 (1.23 cm) (Table 25).
Number of sepal: The female flowers have 4 sepals.
Sepal colour: The color of sepals ranges from light green to dark green.
Length of sepal: Sepal length was also varied significantly. The highest sepal length was noticed in ACS DD1 (0.8 cm) and the lowest length was recorded in ACS DD2 and ACS DD3 (0.7 cm) (Table 25).
Width of sepal: Sepal width was varied among the accessions. The maximum sepal width was found in ACS DD1 and ACS DD3 (0.7 cm) and the minimum width was found in ACS DD2 (0.6 cm) (Table 25).
Number of petal: From our observation we observed that the female flowers have 4 petals.
Petal colour: Based on the petal color they are categorized as milky white to white.

Length of petal: In case of petal length significant variation was noticed among the accessions. However, the highest petal length was found in ACS DD1 (1.5 cm) and lowest was found in ACS DD2 and ACS DD3 (1.3 cm) (Table 25).

Width of petal: Similarly, petal width was also found to be varied among the accessions. The highest petal width was found in ACS DD1 (0.54 cm) and the lowest was found in ACS DD2 and ACS DD3 (0.53 cm) (Table 25).

Pedicel length: Pedicel length of river ebony found to be varied significantly. The highest pedicel length was found in ACS DD1 and ACS DD2 (0.2 cm) and the lowest was found in ACS DD3 (0.1 cm) (Table 25).

Plate 30. Flower bud of river ebony germplasm, **Plate 31.** Sepal length of river ebony germplasm

Plate 32. Petal length of different river ebony germplasm

Flower Position: They are categorized as axillary.

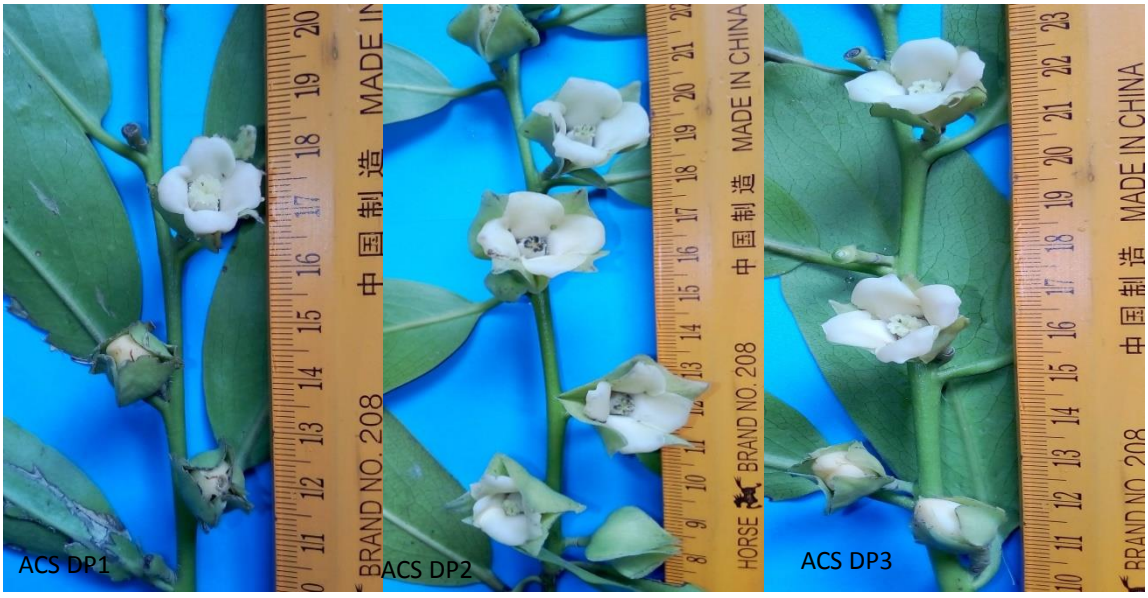


Plate 33. Flower position of different river ebony germplasm

Table 25. Bud length, length and width of Sepals, length and width of petals, pedicel length of river ebony germplasm

Germplasm	Bud length (cm)	Length of sepal (cm)	Width of sepal (cm)	Length of petal (cm)	Width of petal (cm)	Pedicel length(cm)
ACS DP1	1.23	0.8	0.7	1.5	0.54	0.2
ACS DP2	1.67	0.7	0.6	1.3	0.53	0.2
ACS DP3	1.34	0.7	0.7	1.3	0.53	0.1
Mean±SD	**1.41±0.23**	**0.73±0.06**	**0.67±0.06**	**1.37±0.12**	**0.53±0.01**	**0.17±0.06**

Fruit Characteristics: Fruits are flattened globose or rounded in shape, yellowish in colour.

Fruit shape: Fruits are categorized as flattened globose or rounded in shape (Plate 34, Table 26).
Fruit colour: Fruits are yellowish or brown (Plate 34, Table 26).

Plate 34. Fruit shapes of river ebony germplasm

Table 26. Fruit shape and fruit skin colour of river ebony germplasm

Germplasm	Fruit shape	Fruit colour
ACS DP1	Rounded	Yellowish
ACS DP2	Globose	Yellowish
ACS DP3	Rounded	Light Yellow

Fruit weight: Fruit weight was measured after harvesting from plants. Results showed that fruit weight varies among the accessions of river ebony. The maximum fruit weight was obtained from ACS DP1 (79.24 gm) followed by ACS DP3 (78.01 gm) and the minimum fruit weight was found in ACS DP2 (71.73 gm) (Table 27).

Fruit length: Fruit length was measured using measuring tape and observed that it was varied among the accessions. However, the longest fruit length was found in ACS DP3 (5.63 cm) followed by ACS DP1 (5.60 cm) and shortest fruit length was found in ACS DP2(4.82 cm) (Plate 35, Table 27).

Plate 35. Fruit length of different river ebony germplasm

Fruit width: It was observed that fruit width varies among the accessions of river ebony. The highest fruit width was found in ACS DP1 (5.55 cm) followed by ACS DP3 (5.52 cm) and the lowest fruit width was found in ACS DP2 (4.49 cm) (Table 27).

Flesh colour: The flesh of the fruits are light brown or yellowish (Plate 36).

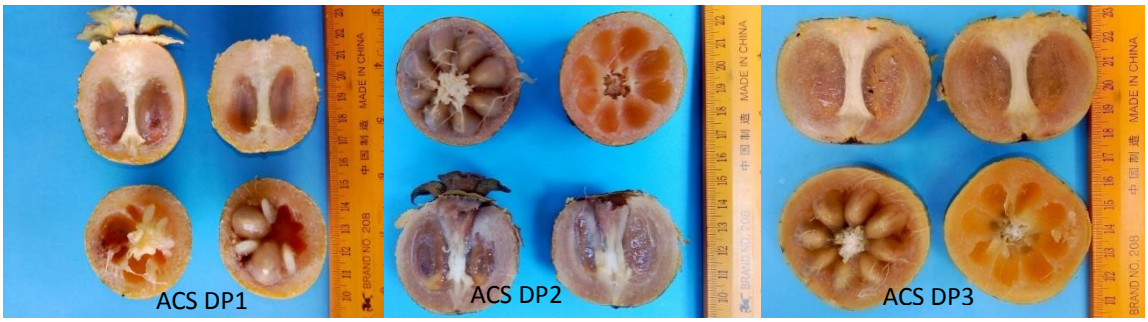


Plate 36. Flesh color of different river ebony germplasm

Table 27. Fruit weight, fruit length, fruit width, TSS, moisture and dry matter content of river ebony germplasm

Germplasm	Fruit weight (gm)	Fruit length (cm)	Fruit width (cm)	TSS (%)	Moisture (%)	Dry matter (%)
ACS DP1	79.24	5.60	5.55	28	71.37	28.63
ACS DP2	71.73	4.82	4.49	26	78.4	21.60
ACS DP3	78.01	5.63	5.52	24	75.28	24.72
Mean±SD	**76.33±4.03**	**5.35±0.46**	**5.19±0.6**	**26±2**	**75.02±3.52**	**24.98±3.52**

Seed Characteristics:

Seed colour: Seeds are mainly brownish or yellow (Plate 37).

Seed number: The maximum number of seeds were found in ACS DP3 (8) followed by ACS DP2 (7) and the minimum number of seeds were counted in ACS DP1 (6) (Table 28).

Seed weight: Seed weigth of different accessions of river ebony varies significantly. The highest seed weight was found in ACS DP3 (19.18 gm) followed by ACS DP2 (15.53 gm) and the lowest seed weight was found in ACS DP1 (12.85 gm) (Table 28).

Seed length: Lenght of seeds was measured using slide calipers and it was observed that seed length was varied among different accessions. The longest seed length was found in ACS DP2 (2.89 cm) followed by ACS DP1 (2.84 cm) and the shortest lenth was recorted in ACS DP3 (2.59 cm) (Plate 37, Table 28).

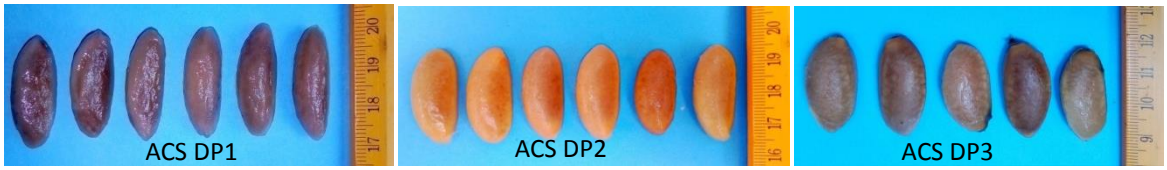


Plate 37. Seed length of river ebony germplasm

Seed width: Highest seed width was found in ACS DP2 and ACS DP3 (1.34 cm) and lowest was found in ACS DP1 (1.14 cm) (Table 28)

Table 28. Number of seed, seed weight, seed length and seed width of three river ebony germplasm

Germplasm	No. of seed	Seed weight (gm)	Seed length (cm)	Seed width (cm)
ACS DP1	6	12.85	2.84	1.14
ACS DP2	7	15.53	2.89	1.34
ACS DP3	8	19.18	2.59	1.34
Mean±SD	**7±1**	**15.85±3.18**	**2.77±0.16**	**1.27±0.12**

Biochemical Compounds of River ebony

The following biochemical compounds were determined from three accessions of river ebony fruit:

Total Soluble Solids (TSS): Percent TSS was determined using hand held refractometer. It was observed that % TSS was varied among the three accessions of river ebony. The highest TSS (28%) was found in ACS DP1 followed by ACS DP2 (26%) and the lowest TSS (24%) was found in ACS DP3 (Table 27).

Moisture content (%): Moisture content among the three river ebony accessions were varied significantly. However, the highest moisture content was found in ACS DP2 (78.4 %) followed by ACS DP3 (75.28%) and the lowest moisture content was found in ACS DP1 (71.37 %) (Table 27).

Dry matter (%): Percent dry matter content was varied among the accessions of river ebony. Result showed that the highest dry matter content was found in ACS DP1 (28.63 %) followed by ACS DP3 (24.72%) and the lowest dry matter was noticed in ACS DP2 (21.6 %) (Table 27).

pH content: It was noticed that pH content of different river ebony accessions varied differently. It was also found that fruits of accession ACS DP1 contained the highest pH value (4.98) followed by accession ACS DP2 (4.83), while it was the lowest (4.50) in accession ACS DP3 (Table 29).

Ascorbic acid (Vitamin C): Vitamin C content was varied among the three accessions of river ebony. Results showed that fruits of accession ACS DP3 contained the highest amount of vitamin-C (10.86mg/100g) followed by accession ACS DP1 (8.70mg/100g), while it was the lowest (8.69mg/100g)) in accession ACS DP2 (Table 29).

Titratable acidity (%): Like ascorbic acid, titratable acidity was also varied among the accessions of river ebony. The highest percentage (1.28%) of titratable acidity was found in accession ACS DP1 followed by accession ACS DP2 (1.16%), while it was the lowest (1.11%) in accession ACS DP3 (Table 29).

Total sugar (%): Total sugar content of three river ebony accessions was varied significantly. It was observed that fruits of the accession no. ACS DP2 had the highest amount of total sugar content (3.76%) followed by the accession ACS DP3 (3.41%), while it was the lowest (3.03%) in accession ACS DP1 (Table 29).

Reducing sugar (%): In case of reducing content, it was noticed that river ebony accessions have differ among them. It was observed that fruits of accession ACS DP2 contained the highest amount of reducing sugar (2.07%) followed by accession ACS DP3 (1.82%), while it was the lowest (1.71%) in accession ACS DP1 (Table 29).

Non-reducing sugar (%): Non-reducing sugar content of river ebony accessions was significantly different. It was observed that fruits of accession ACS DP2 contained the highest amount of non- reducing sugar content (1.69%) followed by accession ACS DP3 (1.58%), while it was the lowest (1.32%) in accession ACS DP1 (Table 29).

Table 29. Fruit pH, vitamin C, titratable acidity, total sugar, reducing sugar and non-reducing sugar of river ebony germplasm

Germplasm	pH	Vitamin C (mg/100g)	Titratable acidity (%)	Total sugar (%)	Reducing sugar (%)	Non-reducing sugar (%)
ACS DP1	4.98	8.70	1.28	3.03	1.71	1.32
ACS DP2	4.83	8.69	1.16	3.76	2.07	1.69
ACS DP3	4.50	10.86	1.11	3.41	1.82	1.58
Mean±SD	**4.77±0.25**	**9.42±1.25**	**1.18±0.09**	**3.40±0.37**	**1.87±0.18**	**1.53±0.19**

Nutritional Status of River ebony

The following nutritional elements were determined from three accessions of river ebony fruit:

Amount of Sodium (Na): Sodium content of three river ebony accessions varied differently. It was found that fruits of accession ACS DP1 contained the highest amount of Na (24.34mg/100g) followed by accession ACS DP2 (24.06mg/100g), while it was the lowest (21.55mg/100g) in accession ACS DP3 (Table 30).

Amount of Potassium (K): Different accessions of river ebony exhibited differently on contents of potassium. It was observed that fruits of accession ACS DP2 contained the highest amount of K (324.83mg/100g) followed by accession ACS DP1 (229.61mg/100g), while accession ACS DP3 contained the lowest amount of K (220.61mg/100g) (Table 30).

Amount of Calcium (Ca): In case of calcium contents in fruits, significant variation was noticed among the accessions of river ebony. It was observed that accession ACS DP1 gave maximum amount of Ca (56.11mg/100g) followed by ACS DP3 (53.22mg/100g), whereas the minimum (48.09mg/100g) was observed in ACS DP2 (Table 30).

Amount of Magnesium (Mg): There was a wide variation observed among the accessions of river ebony. It was noticed that accession ACS DP3 contained the maximum amount of Mg (39.02mg/100g) followed by ACS DP1 (38.62mg/100g), whereas the minimum Mg (31.18mg/100g) was observed in ACS DP2 (Table 30).

Amount of Phosphorus (P): In case of phosphorous contents in fruits significant variation was observed among the accessions of river ebony. Fruits of accession ACS DP1 contained the highest amount of P (313.62mg/100g) followed by accession ACS DP2 (286.17mg/100g), while it was the lowest (280.66mg/100g) in accession ACS DP3 (Table 31).

Amount of Iron (Fe): Iron content was also varied among the accessions of river ebony. It was observed that fruits of accession ACS DP1 contained the highest amount of Fe (3.42mg/100g) followed by ACS DP3 (1.92mg/100g), while it was the lowest (1.34mg/100g) in accession ACS DP2 (Table 31).

Amount of Manganese (Mn): In terms of manganese content in fruits there was a wide variation among the accessions of river ebony. It was noticed that fruits of accession ACS DP1 contained the highest amount of Mn (2.79mg/100g) followed by ACS DP3 (1.78mg/100g), while it was the lowest (1.61mg/100g) in accession ACS DP2 (Table 31).

Amount of Zinc (Zn): Zinc content was also varied among the accessions of river ebony. It was found that fruits of accession ACS DP3 contained the highest amount of Zn (0.79mg/100g) followed by accession ACS DP2 (0.73mg/100g), while accession ACS DP1 contained the lowest amount of Zn (0.44mg/100g) (Table 31).

Table 30. Sodium, potassium, calcium and magnesium content of river ebony germplasm

Germplasm	Na (mg/100g)	K (mg/100g)	Ca (mg/100g)	Mg (mg/100g)
ACS DP1	24.34	229.61	56.11	38.62
ACS DP2	24.06	324.83	48.09	31.18
ACS DP3	21.55	220.61	53.22	39.02
Mean±SD	**23.32±1.54**	**258.35±24.94**	**52.47±4.06**	**36.27±4.42**

Table 31. Phosphorus, iron, manganese and zinc content of river ebony germplasm

Germplasm	P (mg/100g)	Fe (mg/100g)	Mn (mg/ 100g)	Zn (mg/100g)
ACS DP1	313.62	3.42	2.79	0.44
ACS DP2	286.17	1.34	1.61	0.73
ACS DP3	280.66	1.92	1.78	0.79
Mean±SD	**293.48±17.66**	**2.23±1.07**	**2.06±0.64**	**0.65±0.19**

d) Cowa (*Garcinia cowa* Roxb.)

Cowa (*Garcinia cowa* Roxb.) is a round shaped wild attractive fruit of the tropical belongs to the family Clusiaceae. It occurs wild frequently in evergreen and semi evergreen forests or along streams in deep valleys. In Bangladesh, it is commonly known as Kawphal, in Chittagong it is known as Kao-gola. It is possibly originated in the forests of Bangladesh, India and Myanmar. In Bangladesh, it is found in the forests of Chittagong Hill Tracts, Cox's Bazar, Sylhet, Moulavibazar, Barisal, Patuakhali and Bagerhat districts. Five accessions of cowa germplasm were collected from Barishal and Patuakhali districts and these are named as-i) ACS GC1, ii) ACS GC2, iii) ACS GC3, iv) ACS GC4, v) ACS GC5

Morphological characters of Cowa

Leaf characteristics: Leaves are broadly to elliptically lanceolate, acuminate, oblong-lanceolate, apex acuminate or long acuminate, rarely obtuse, light green to dark green in colour.

Leaf shape: Leaves are categorized as elliptically lanceolate, lanceolate and acuminate (Plate 38, Table 32).

Table 32. Leaf shape, apex and base of cowa germplasm

Germplasm	Leaf shape	Leaf Apex	Leaf Base
ACS GC1	Elliptically lanceolate	Obtuse	Cuneate
ACS GC2	Elliptically lanceolate	Acuminate	Rounded
ACS GC3	Lanceolate	Acuminate	Cuneate
ACS GC4	Lanceolate	Acuminate	Cuneate
ACS GC5	Acuminate	Acuminate	Acute

Young leaf colour: Young leaves are mainly light green.

Mature leaf colour: Mature leaves are mainly dark green.

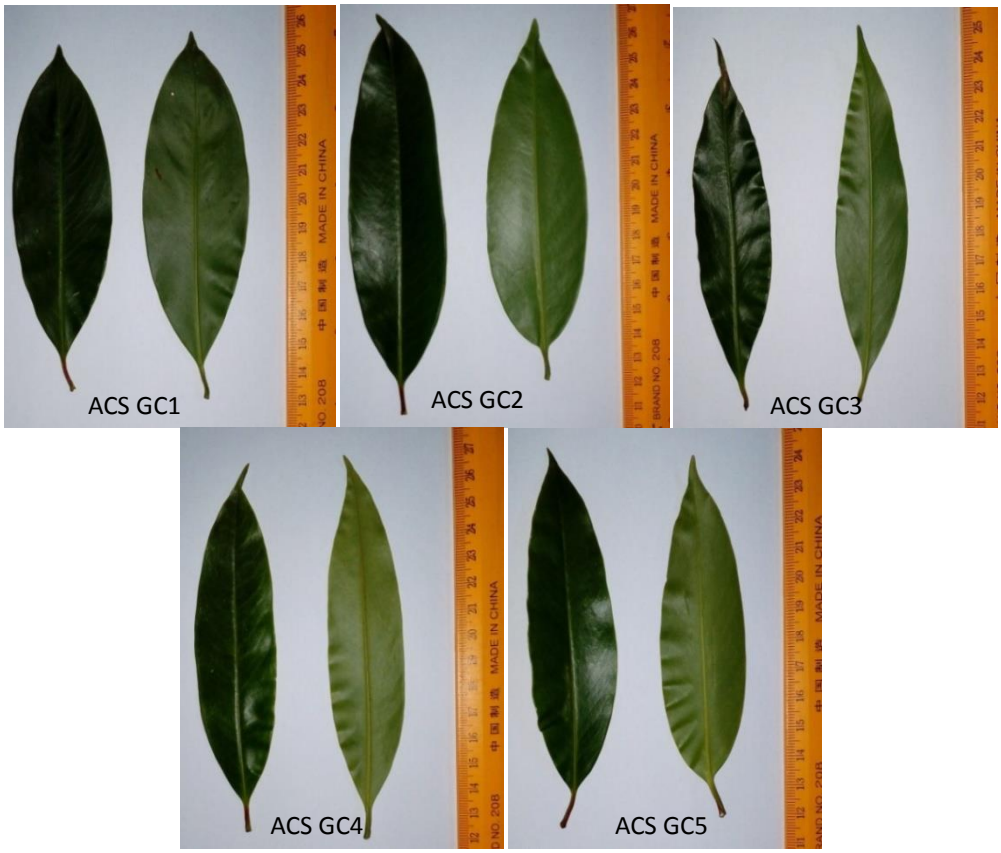


Plate 38. Leaf shape of cowa germplasm

Leaf margin: Leaves margin are mainly categorized as entire and wavy.

Leaf apex: Leaves apex are categorized as acuminate and obtuse (Plate 39, Table 32).

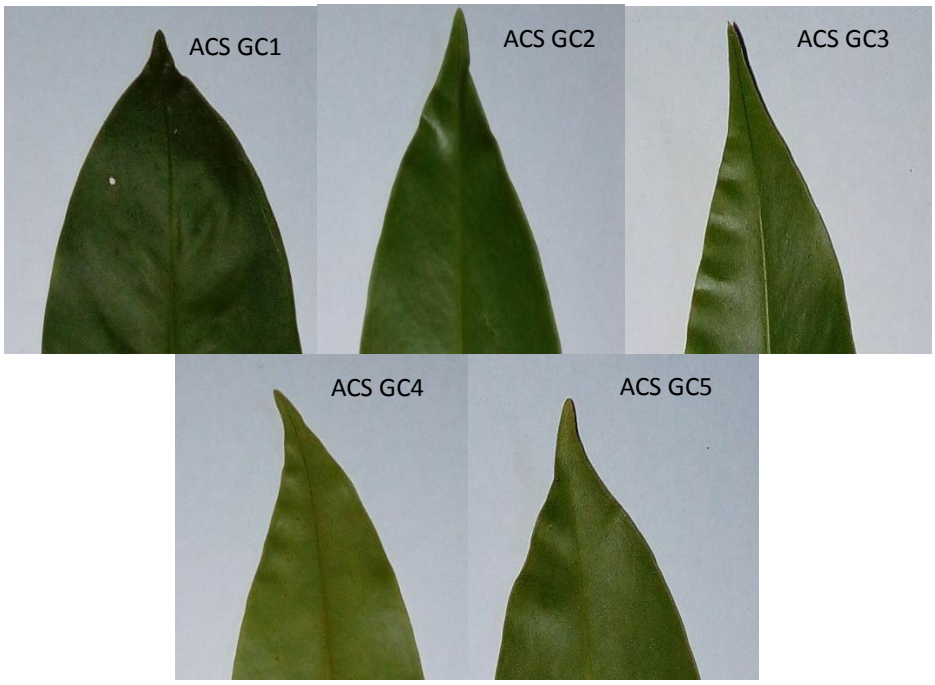


Plate 39. Leaf apex of cowa germplasm

Leaf base: Leaf base are categorized into cuneate, rounded and acute (Plate 40, Table 32).

Plate 40. Leaf base of cowa germplasm

Leaf length: A wide variation was noticed in case of different accessions of cowa. The highest leaf length was found in ACS GC4 (15.2 cm) followed by ACS GC2 (14.9 cm), ACS GC3 (14.5 cm) and the lowest length was found in ACS GC5 (12.6 cm) (Plate 41, Table 33).

Leaf width: Leaf width was also varied among the accessions of cowa. However, the highest leaf width was found in ACS GC1 (4.9 cm) followed ACS GC2 (4.8 cm), ACS GC4 (4.5 cm) and the lowest width was found in ACS GC3 (4.0 cm) (Table 33).

Petiole length: The length of petiole was varied among the accessions. The maximum petiole length was found in ACS GC4 (1.1 cm), followed ACS GC2 and ACS GC5 (1.0 cm) and the minimum length was found in both ACS GC1 and ACS GC3 (0.9 cm) (Table 33).

Petiole width: Petiole width of different accessions of cowa was also varied significantly. The highest petiole width was found in ACS GC4 (0.20 cm) followed by ACS GC1 and ACS GC2 (0.19 cm) and the lowest width was found in ACS GC3 and ACS GC5 (0.18 cm) (Table 33).

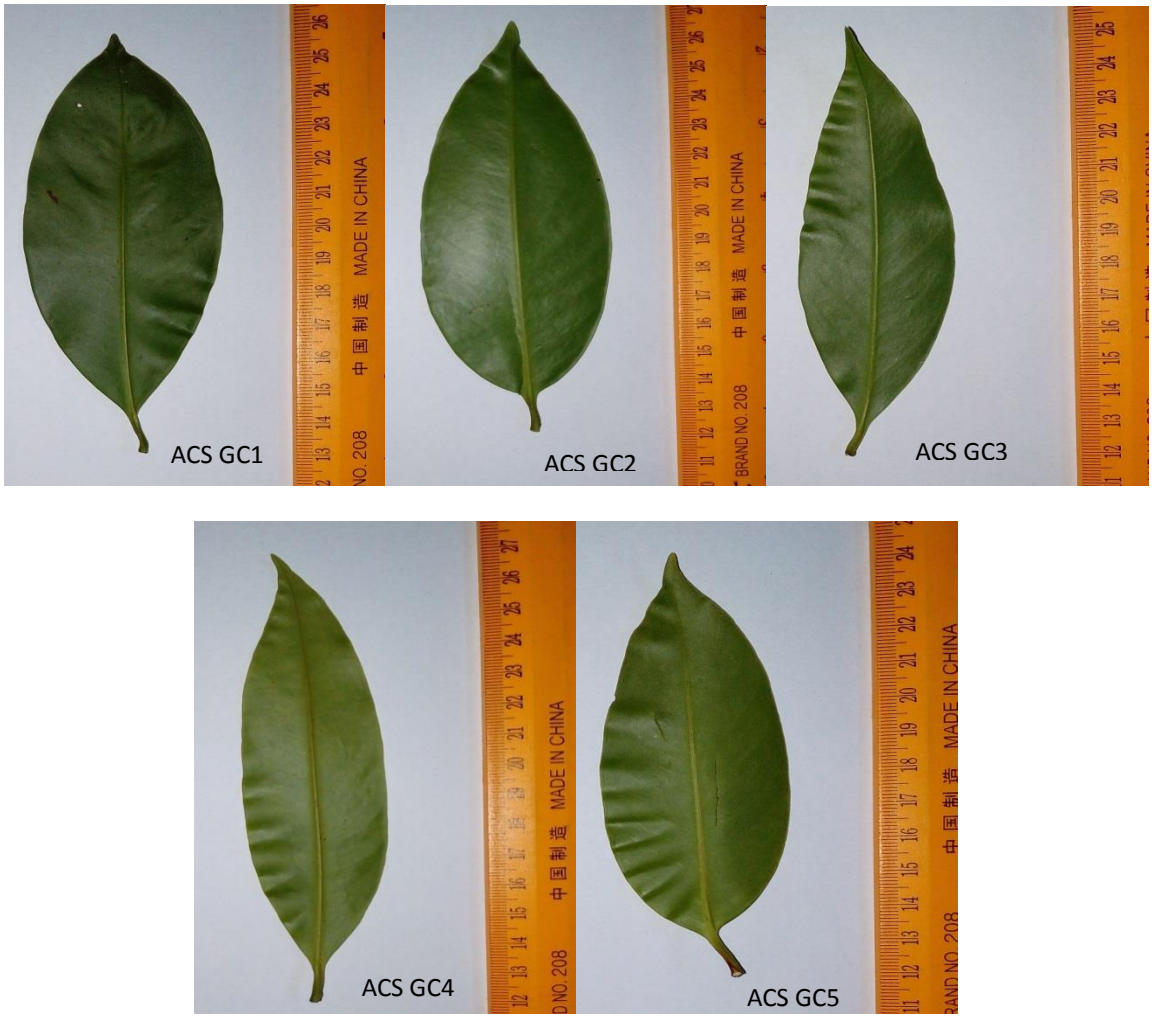


Plate 41. Leaf length and width of cowa germplasm

Leaf area: In comparison to leaf area different accessions of cowa germplasm showed a wide variation. Results showed that the highest leaf area was found in ACS GC4 (56.09 cm^2) followed by ACS GC2 (52.12

cm^2), ACS GC1 (49.51 cm^2), ACS GC3 (47. 39 cm^2) and the lowest leaf area was found in ACS GC5 (36.09 cm^2) (Table 33).

Table 33. Leaf length, width, petiole length, width and leaf area of cowa germplasm

Germplasm	Leaf length (cm)	Leaf width (cm)	Petiole length (cm)	Petiole width (cm)	Leaf area (cm^2)
ACS GC1	13.9	4.9	0.9	0.19	49.51
ACS GC2	14.9	4.8	1.0	0.19	52.12
ACS GC3	14.5	4.0	0.9	0.18	47.39
ACS GC4	15.2	4.5	1.1	0.20	56.09
ACS GC5	12.6	4.3	1.0	0.18	36.09
Mean±SD	**14.22±1.03**	**4.5±0.37**	**0.98±0.08**	**0.19±0.01**	**48.24±7.53**

Flower Characteristics: Flowers are dioecious, small and yellow in color, the males are smaller than the females, flowers are axillary or terminal.

Male flower: Male flowers are terminal or axillary, petals yellow, 4-bracteate at base, 40-50 anther filaments forming a mass (Plate 42).

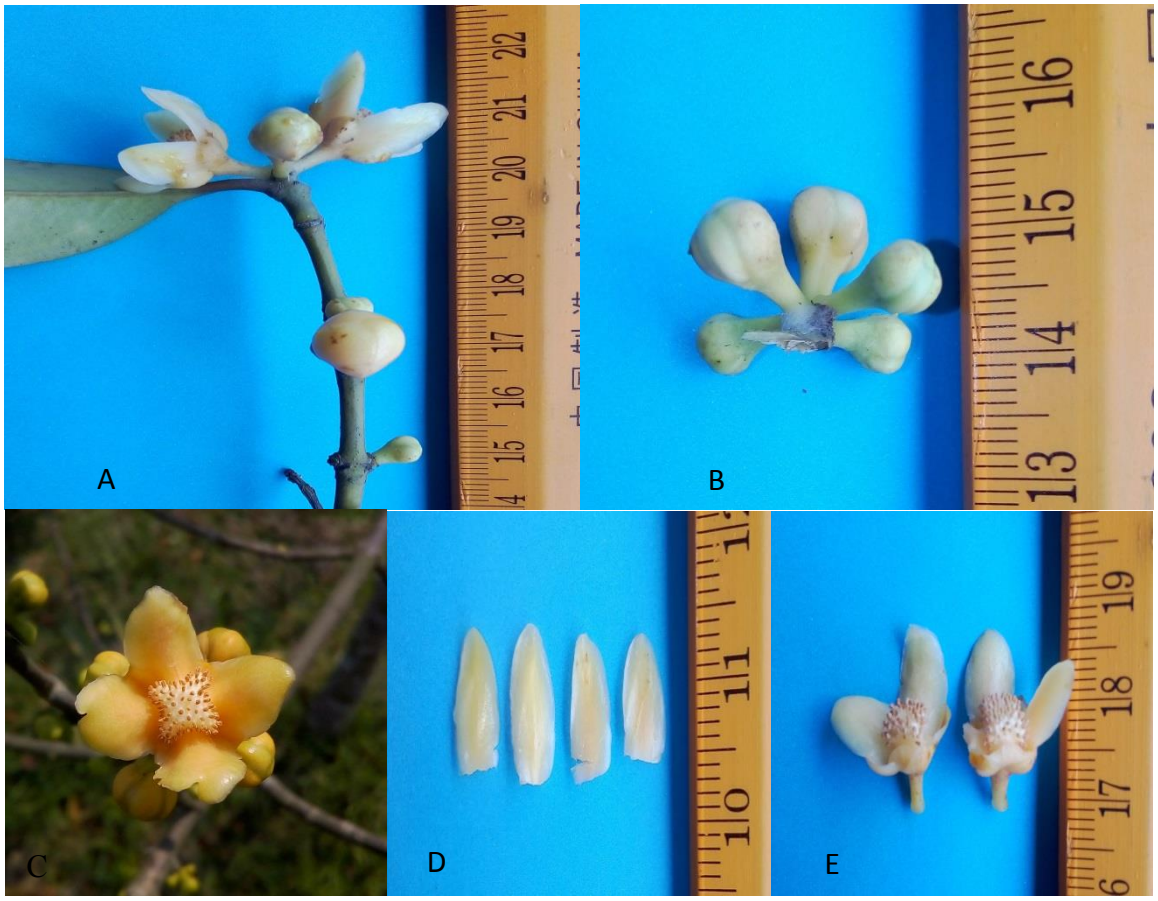


Plate 42. Male flower of cowa germplasm: (A) Flower position, (B) Flower bud, (C) Open flower, (C) Petals, (D) Anther filaments of Cowa

Female flower: The light yellow female flowers are usually solitary, axillary, larger than male, pedicel robust, have 4 petals, ovary ovoid, 4-8 loculed, flower buds are round in shape.

Bearing habit: They are categorized as regular bearing.

Bud length: B**ud** length was varied among the accessions of cowa. The highest bud length was found in ACS GC1 and ACS GC4 (1.2 cm) followed by ACS GC2 (1.1 cm) and the lowest length was found in ACS GC3 and ACS GC5 (1.0 cm) (Plate 43, Table 34).

Number of sepals: The female flowers have 4 sepals.

Sepal Color: Color of sepals ranges from light green to dark green.

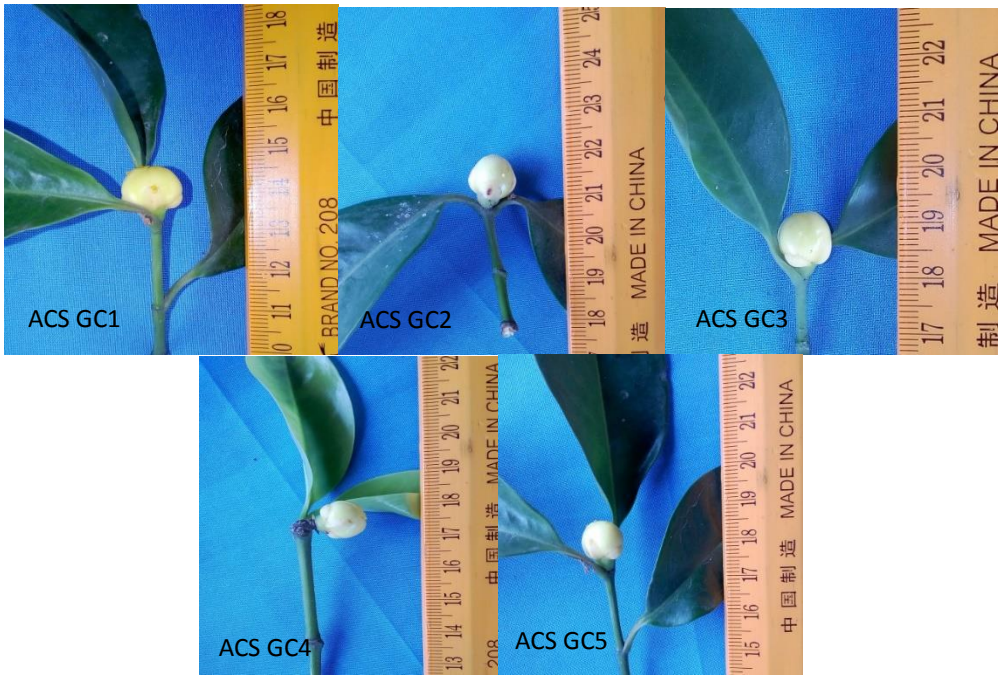


Plate 43. Bud length of cowa germplasm

Length of sepal: Sepal length was measured using measuring tape and found that it was varied among the accessions. The maximum sepal length was found in ACS GC2 and ACS GC4 (0.60 cm) followed by ACS GC1 (0.55 cm) and minimum was found in ACS GC5 (0.40 cm) (Table 34).

Width of sepal: Sepal width was also varied among the cow accessions. It was noticed that the maximum sepal width was found in ACS GC3 and ACS GC4 (0.30 cm) and the minimum was found in ACS GC1, ACS GC2 and ACS GC5 (0.25 cm) (Table 34).

Number of petal: The female flowers have 4 petals.

Petal color: They are categorized as light yellow (Plate 44).

Length of petal: Petal length of Cowa accessions found to be varied among the accessions. The results showed that the highest petal length was found in ACS GC1, ACS GC3 and ACS GC4 (1.2 cm) followed by ACS GC2 (1.0 cm) and the lowest length was found in ACS GC5 (0.9 cm) (Plate 44, Table 34).

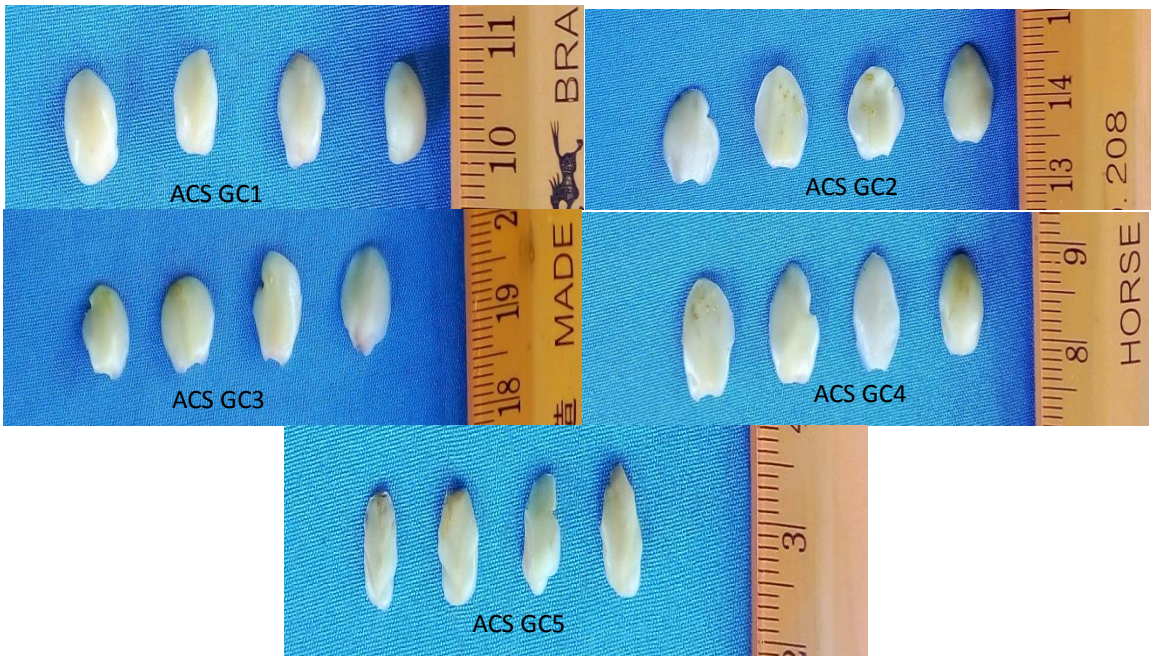


Plate 44. Petal length of cowa germplasm

Width of petal: Petal width was also found to be varied among the accessions. It was noticed that the highest petal width was found in ACS GC2 and ACS GC4 (0.70 cm) followed by ACS GC3 (0.65 cm), ACS GC1 (0.60 cm) and the lowest petal width was found in ACS GC5 (0.50 cm) (Table 34).

Flower position: They are categorized as terminal (Plate 45).

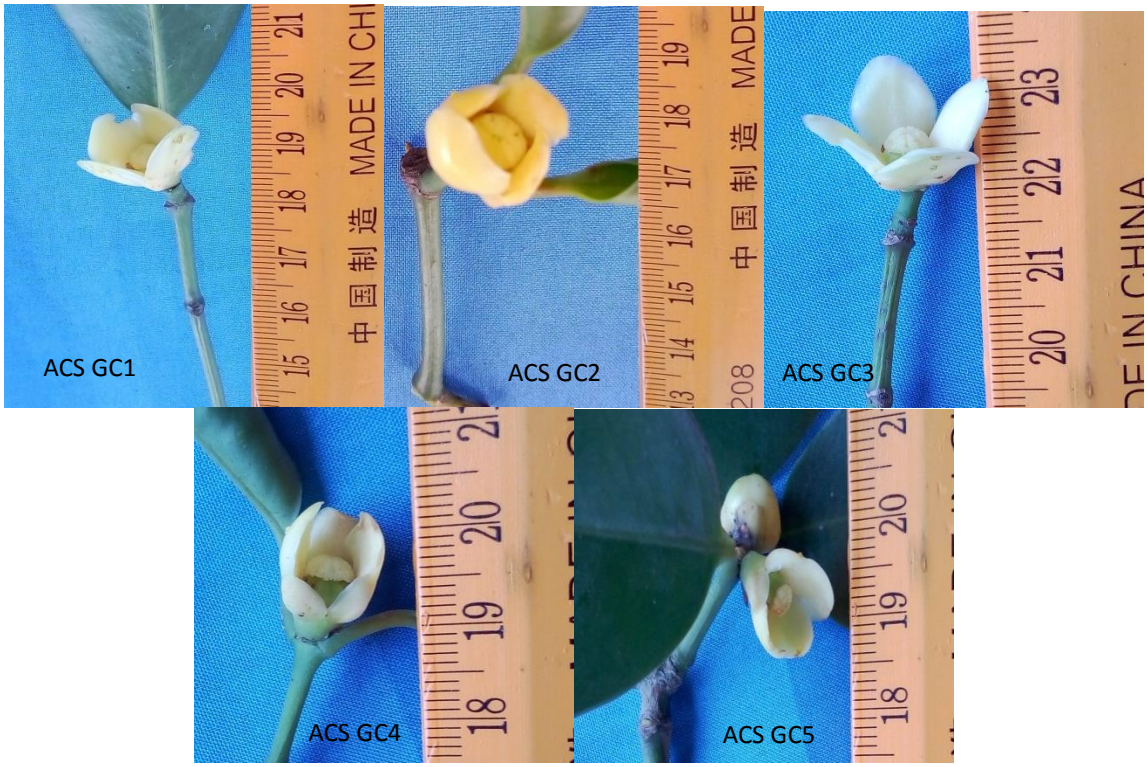


Plate 45. Flower position of cowa germplasm

Table 34. Bud length, length and width of sepals, length and width of petals, pedicel length of cowa germplasm

Germplasm	Bud length (cm)	Length of sepals(cm)	Width of sepals(cm)	Length of petals(cm)	Width of petals(cm)
ACS GC1	1.2	0.55	0.25	1.2	0.60
ACS GC2	1.1	0.60	0.25	1.0	0.70
ACS GC3	1.0	0.45	0.30	1.2	0.65
ACS GC4	1.2	0.60	0.30	1.2	0.70
ACS GC5	1.0	0.40	0.25	0.9	0.50
Mean±SD	**1.1±0.1**	**0.52±0.09**	**0.27±0.03**	**1.1±0.14**	**0.63±0.08**

Fruit Characteristics: Fruits are globose, rounded in shape, yellow to orange in colour.

Fruit Shape: They are categorized as globose, rounded in shape (Plate 46, Table 35).

Table 35. Fruit shape and colour of cowa germplasm

Germplasm	Fruit Shape	**Fruit Colour**
ACS GC1	Rounded	Brownish
ACS GC2	Rounded	Brownish
ACS GC3	Globose	Brownish
ACS GC4	Globose	Yellow
ACS GC5	Rounded	Brownish

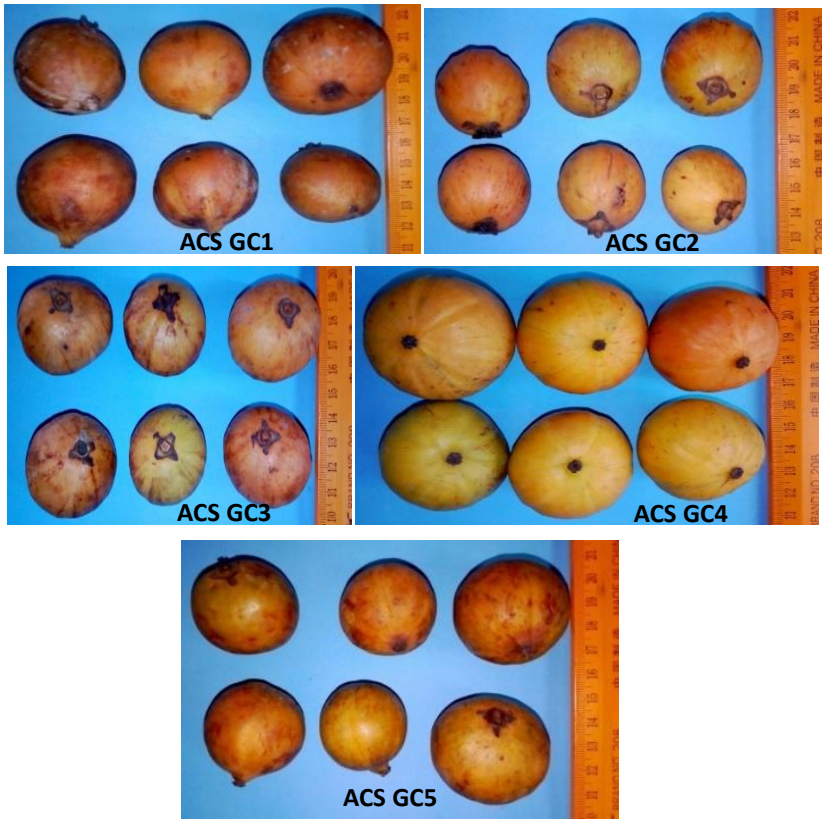


Plate 46. Fruit shapes of cowa germplasm

Fruit color: Fruits are yellowish or brownish (Plate 46, Table 35).

Fruit weight: Fruit weight was measured after harvesting and it was noticed that fruit weight was differ among the accessions. Results showes that the highest fruit weight was found in ACS GC4 (30.56 gm) followed by ACS GC3 (28.67 gm), ACS GC2 (24.76 gm) and the lowest fruit weight was found in ACS GC5 (18,78 gm) (Table 36).

Fruit length: Fruit length was also varied among the accessions. Results showes that the highest fruit length was found in ACS GC4 (4.38 cm) followed by ACS GC3 (4.23 cm), ACS GC2 (3.67 cm) and lowest was found in ACS GC5 (3.04 cm) (Plate 47, Table 36).

Plate 47. Fruit length of different cowa germplasm

Fruit width: HFruit width of different cowa accessions was found varied among each other. It was noticed that the highest fruit width was recorded in ACS GC4 (3.89 cm) followed by ACS GC3 (3.83 cm), ACS GC1 (3.74 cm) and the lowest fruit width was found in ACS GC5 (3.40 cm) (Table 36).
Flesh color: The flesh of the fruits are orange (Plate 48).

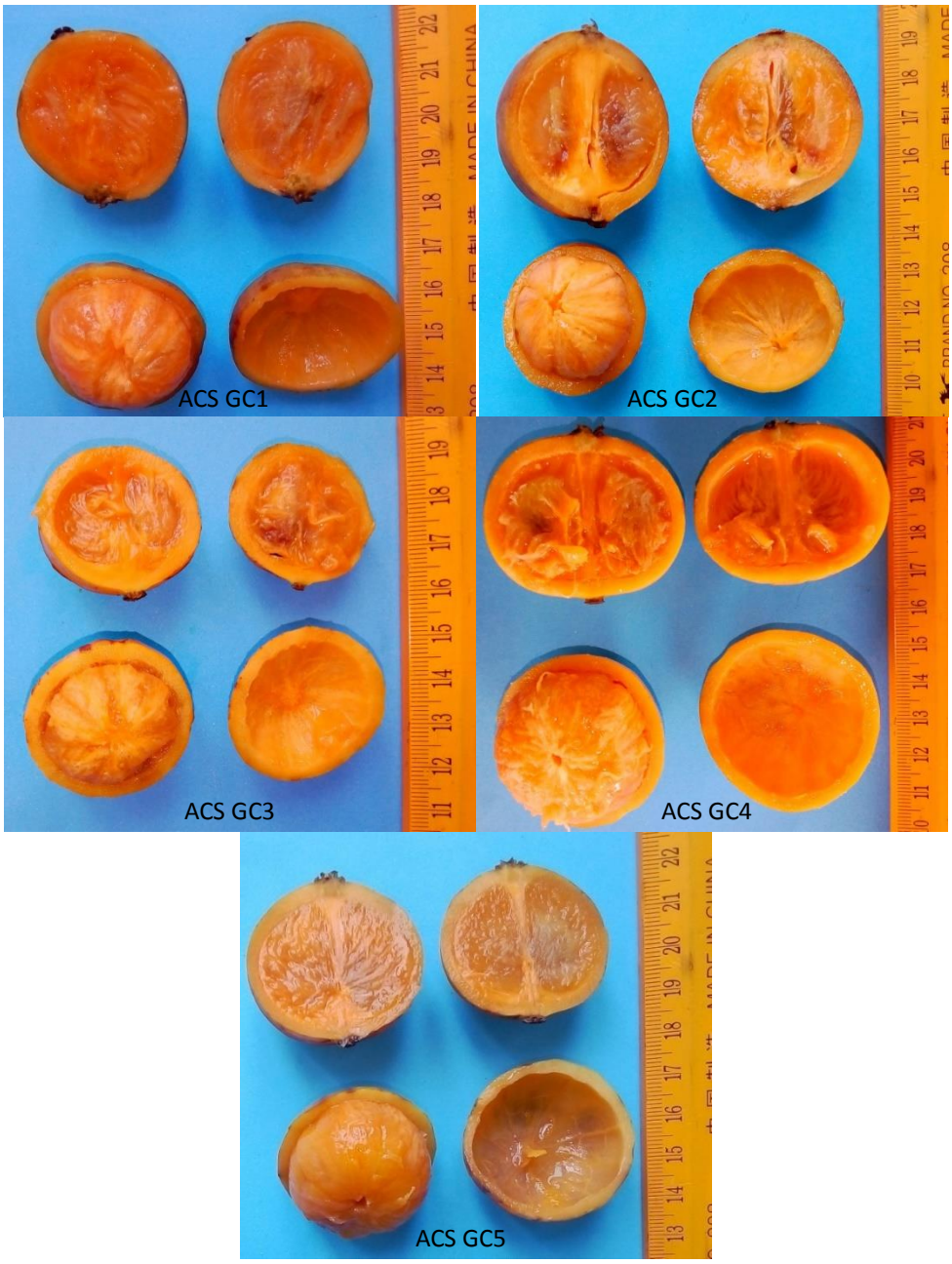


Plate 48. Flesh color of different cowa germplasm

Table 36. Fruit weight, length, width, TSS, moisture% and dry matter% of cowa germplasm

Germplasm	Fruit weight (gm)	Fruit length (cm)	Fruit width (cm)	TSS (%)	Moisture %	Dry matter %
ACS GC1	24.08	3.52	3.74	12	85.11	14.89
ACS GC2	24.76	3.67	3.73	10	86.51	13.49
ACS GC3	28.67	4.23	3.83	11	87.95	12.05
ACS GC4	30.56	4.38	3.89	12	86.62	13.38
ACS GC5	18.78	3.04	3.40	10	86.57	13.43
Mean±SD	**25.37±4.56**	**3.77±0.55**	**3.72±0.19**	**11±1**	**86.55±1.01**	**13.45±1.01**

Seed Characteristics:

Seed colour: Seeds are mainly yellowish (Plate 49).

Seed number: The highest number of seeds were found in ACS GC2 and ACS GC4 (7) followed by ACS GC1 (6), ACS GC5 (5) and the lowest number of seeds were found in ACS GC3 (4) (Table 37).

Seed weight: Results on seed weight showed there was a wide variation on seed weight of cowa accessions. It was found that the highest seed weight achieved from ACS GC4 (7.15 gm) followed by ACS GC2 (7.04 gm), ACS GC3 (6.99 gm) and the lowest seed weight was recorded in ACS GC5 (5.32gm) (Table 37).

Seed length: The length of seeds were measured using measuring tape and found that it was varied among the acessions. However, the highest seed length was found in ACS GC3 (2.54 cm) followed by ACS GC4 (2.44 cm), ACS GC1 (2.17 cm) and lowest was found in ACS GC5(1.89 cm) (Plate 49, Table 37).

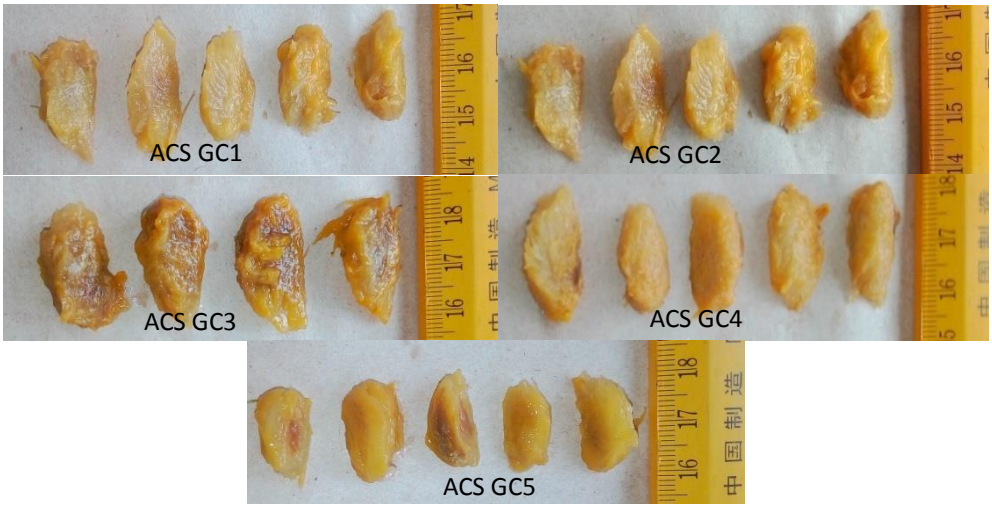


Plate 49. Seed length of cowa germplasm

Seed width: The width of seed was found to be varied among the accessions. The highest seed width was found in ACS GC3 (1.31 cm) followed by ACS GC4 (1.21 cm), ACS GC1 (1.12 cm) and the lowest seed width was found in ACS GC5 (0.78 cm) (Table 37).

Table 37. Number of Seeds, seed weight, seed length and seed width of cowa germplasm

Germplasm	No. of seeds	Seed weight (gm)	Seed length (cm)	Seed width(cm)
ACS GC1	6	6.05	2.17	1.12
ACS GC2	7	7.04	2.08	1.09
ACS GC3	4	6.99	2.54	1.31
ACS GC4	7	7.15	2.44	1.21
ACS GC5	5	5.32	1.89	0.78
Mean±SD	**5.80±1.3**	**6.51±0.8**	**2.22±0.27**	**1.1±0.2**

Biochemical Compounds of Cowa

The following biochemical compounds were determined from the fruits of different cowa accessions:

Total Soluble Solids (TSS): TSS was determined from the fruit juice using the hand held refractometer. It was varied among the accessions. The highest TSS (12%) was found in ACS GC1 and ACS GC4 followed by ACS GC3 (11%) and the lowest TSS (10%) was found in ACS GC2 and ACS GC5 (Table 36).

Moisture content (%): In case of moisture content, it was noticed that It was determined from the fruits of all accessions of cowa and found that they have differe on moisture content. However, it was found that the maximum moisture content was found in ACS GC3 (87.95 %) followed by ACS GC4 (86.62%), ACS GC5 (86.57%) and the lowest was in ACS GC1 (85.11 %) (Table 36).

Dry matter (%): The dry matter content of fruits varied among the accessions. It was observed that the highest dry matter content was found in ACS GC1 (14.89 %) followed by ACS GC2 (13.49%), ACS GC5 (13.43%) and the lowest was in ACS GC3 (12.05 %) (Table 36).

pH content: Fruit pH was varied among the Cowa accessions. It was found that fruits of accession ACS GC4 contained the highest pH value (2.72) followed by accession ACS GC1 (2.71), while it was the lowest (2.63) in accession ACS GC3 (Table 38).

Ascorbic acid (Vitamin C) content: Results showed that ascorbic acid content of different cowa accessions varied differently. It was found that fruits of accession ACS GC4 contained the highest amount of vitamin C (10.87mg/100g) followed by accession ACS GC3 (10.80mg/100g), while it was the lowest (8.66mg/100g) in accession ACS GC5 (Table 38).

Titratable acidity (TA) content (%): Titratable acidity content was varied among the accessions. The highest percentage of TA (4.76%) was found in accession ACS GC5 followed by accession ACS GC1 (3.25%), while it was the lowest (2.91%) in accession ACS GC3 (Table 38).

Total sugar content: In case of total sugar content, different cowa accessions varied significantly. It was observed that fruits of accession ACS GC4 contained the highest amount of total sugar content (4.01%) followed by accession ACS GC3 (3.42%), while it was the lowest (1.75%) in accession ACS GC2 (Table 38).

Reducing sugar content: It was observed that the reducing sugar content of Cowa varied significantly different among the accessions. It was noticed that accession ACS GC4 contained the highest amount of reducing sugar (2.28%) followed by accession ACS GC3 (1.93%), while accession no. ACS GC2 contained the lowest amount of reducing sugar (1.03%) (Table 38).

Non-reducing sugar content: Results of this study showed that non-reducing content of cowa varied among the accessions. It was observed that fruits of accession ACS GC4 contained the highest amount of non- reducing sugar (1.72%) followed by accession ACS GC3 (1.49%), while it was the lowest (0.65%) in accession ACS GC1 (Table 38).

Table 38. Fruit pH, vitamin C, titratable acidity, total sugar, reducing sugar and non-reducing sugar content of cowa germplasm

Germplasm	pH	Vitamin C (mg/100g)	Titratable acidity (%)	Total sugar (%)	Reducing sugar (%)	Non-reducing sugar (%)
ACS GC1	2.71	8.71	3.25	1.82	1.16	0.65
ACS GC2	2.65	8.69	3.20	1.75	1.03	0.73
ACS GC3	2.63	10.80	2.91	3.42	1.93	1.49
ACS GC4	2.72	10.87	3.13	4.01	2.28	1.73
ACS GC5	2.65	8.66	4.76	2.21	1.40	0.81
Mean±SD	**2.67±0.04**	**9.55±1.18**	**3.45±0.74**	**2.64±1.02**	**1.56±0.53**	**1.08±0.49**

From the biochemical composition point of view it was observed that ACS GC4 was superior as it contained highest amount of vitamin C, total sugar, reducing and non-reducing sugar.

Nutritional Status of Cowa

The following nutritional constituents of fruits were determined:

Amount of Sodium (Na): Sodium content of fruit varied among the accessions of Cowa. It was observed that fruits of the accession ACS GC5 contained the highest amount of Na (32.79mg/100g) followed by the accession ACS GC4 (30.28mg/100g) and the lowest Na (25.31mg/100g) was found in the accession ACS GC1 (Table 39).

Amount of Potassium (K): Potassium content of fruits was also varied among the accessions. It was observed that fruits of the accession ACS GC4 contained the maximum amount of K (183.48mg/100g) followed by the accession ACS GC5 (176.05mg/100g), while it was the lowest (123.90mg/100g) in the accession ACS GC1 (Table 39).

Amount of Calcium (Ca): In case calcium content of fruit, results showed that different accessions contained different amount of Ca. However, **i**t was noticed that, the accession ACS GC3 gave the maximum amount of Ca (72.12mg/100g) followed by ACS GC1 (67.32mg/100g), whereas the minimum Ca (54.33mg/100g) was observed in ACS GC4 (Table 39).

Amount of Magnesium (Mg): Different accessions performed differently in terms of magnesium content. It was observed that, the accession ACS GC2 gave the maximum amount of Mg (43.75mg/100g) followed by ACS GC3 (42.36mg/100g), whereas the minimum amount of Mg (37.48mg/100g) was obtained from ACS GC5 (Table 39).

Amount of Phosphorus (P): In case of phosphorus content, it was noticed that there was a wide variation among the accessions. Fruits of the accession ACS GC1 contained the highest amount of P (286.14mg/100g) followed by the accession ACS GC4 (278.61mg/100g), while it was the lowest (211.48mg/100g) in the accession ACS GC2 (Table 40).

Amount of Iron: Iron is the important constituents for human. We observed that the amount of iron varied significantly among the accessions. It was observed that fruits of the accession ACS GC4 gave the highest amount of Fe (5.71mg/100g) followed by ACS GC3 (5.56mg/100g), while it was the lowest (2.95mg/100g) in the accession ACS GC5 (Table 40).

Amount of copper (Cu): Copper content in fruits was also varied among the accessions. It was observed that fruits of the accession ACS GC2 contained the highest amount of Fe (0.25mg/100g) followed by ACS GC3 (0.21mg/100g), while it was the lowest (0.17mg/100g) in the accession ACS GC1 (Table 40).

Amount of Zinc (Zn): Results showed that zinc content in fruits shows wide variation among the accessions. It was found that fruits of the accession ACS GC4 gave the highest amount of Zn (2.18mg/100g) followed by the accession ACS GC5 (2.01mg/100g) and the lowest amount Zn (1.62mg/100g) recorded in the accession ACS GC2 (Table 40).

Table 39. Sodium, potassium, calcium, magnesium content of cowa germplasm

Germplasm	Na (mg/100g)	K (mg/100g)	Ca (mg/100g)	Mg (mg/100g)
ACS GC1	25.31	123.90	67.32	38.89
ACS GC2	29.81	158.19	64.12	43.75
ACS GC3	28.88	160.14	72.12	42.36
ACS GC4	30.28	183.48	54.33	40.78
ACS GC5	32.79	176.05	56.44	37.48
Mean±SD	**29.41±2.71**	**160.35±22.99**	**62.87±7.44**	**40.65±2.53**

Table 40. Phosphorus, iron, cu and Zinc contents of cowa germplasm

Germplasm	P (mg/100g)	Fe (mg/100g)	Cu (mg/100g)	Zn (mg/100g)
ACS GC1	286.14	3.32	0.17	1.74
ACS GC2	211.48	5.27	0.25	1.62
ACS GC3	224.08	5.56	0.21	1.88
ACS GC4	278.61	5.71	0.18	2.18
ACS GC5	267.42	2.95	0.20	2.01
Mean±SD	**253.55 ± 33.62**	**4.56 ±1.32**	**0.20 ±0.03**	**1.89 ±0.22**

From the above results it was observed that ACS GC5 performed superior from nutritional point of view as this accession contained highest amount potassium (K), iron (Fe) and zinc (Zn).

e) Governor's plum (*Flacourtia indica*)

Governor's plum (*Flacourtia indica*) is a plant species belongs to family Flacourtiaceae and is native to Africa and tropical and temperate parts of Asia. In Bangladesh, it is comonly known as Boichi which is a large shrub or small tree. It has been spreaded to Northeast and East tropical Africa and also in Southern Africa. It has also been spreaded to temperate parts of China, tropical parts of Asia and Malaysia. In Bangladesh, it is widely grown in Noakhali, Barisal, Cox's Bazar, Chattagram, Rangamati and Bandarban districts. Plants are usually 5 to 10 m tall. Bark is usually pale, grey, may become brown to dark grey. A single germplasm of governor's plum was collected from various locations of Barishal and Patuakhali districts and the gerplasm is shown as- ACS FI1

Morphological Characters of Governor's plum

Leaf Characteristics: Leaves are red to pink when young, oval to round in shape, edge toothed, sevaral pairs of veins clear on both surfaces.

Leaf shape: Leaves are categorized into oblong, ovate and obovate (Plate 50).

Plate 50. Leaf shape of governor's plum, **Plate 51.** Leaf margin of governor's plum

Young leaf colour: Young leaves are mainly red or pink.

Mature leaf colour: Mature leaves are mainly dark green (Plate 50).

Leaf margin: Leaf margin is mainly catagorized as asserrate (Plate 51).

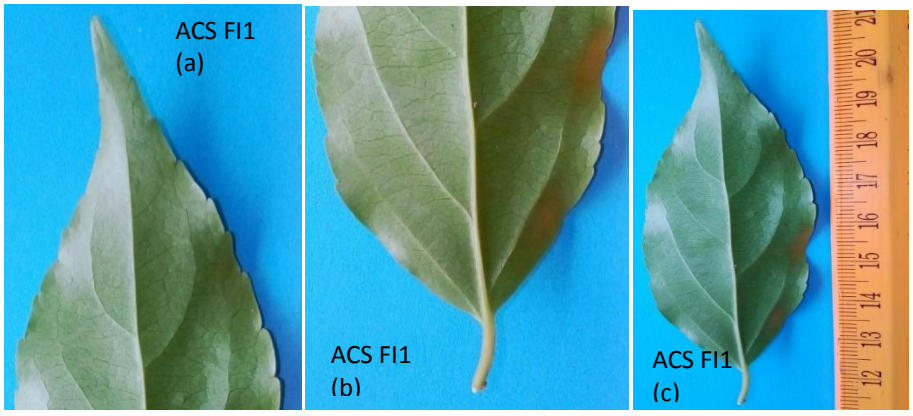


Plate 52. Leaf apex (a), base (b) and length (c) of governor's plum

Leaf apex: Leaf apex is categorized as acuminate (Plate 52a).
Leaf base: Leaf base is categorized as obtuse (Plate 52b).
Leaf length: Leaf length was measured using measureing tape. Result show that the leaf length was found in ACS FI1 (9.10 cm) (Plate 52c, Table 41).
Leaf width: Leaf width was measured using measuring tape and found that leaf width in ACS FI1 (3.5 cm) (Table 41).
Petiole length: The petiole length of leaf was found 0.9 cm in ACS FI1 (Table 41).
Petiole width: The petiole width of leaf was found (0.12 cm) in ACS FI1 (Table 41).
Leaf area: Leaf area was measured using leaf area meter and found (19.85 cm^2) in ACS FI1 (Table 41).

Table 41. Leaf length, width, petiole length, width and leaf area of governor's plum germplasm

Germplasm	Leaf length(cm)	Leaf width(cm)	Petiole length(cm)	Petiole width(cm)	Leaf area(cm^2)
ACS FI1	9.1	3.5	0.9	0.12	19.85

Flower Characteristics: Flowers are unisexual, occasionally bisexual.
Male flower: Male flowers are axillary racemes, 0.4-0.5 cm long, 4-5 sepals, stamens 25-30 (Plate 53a).

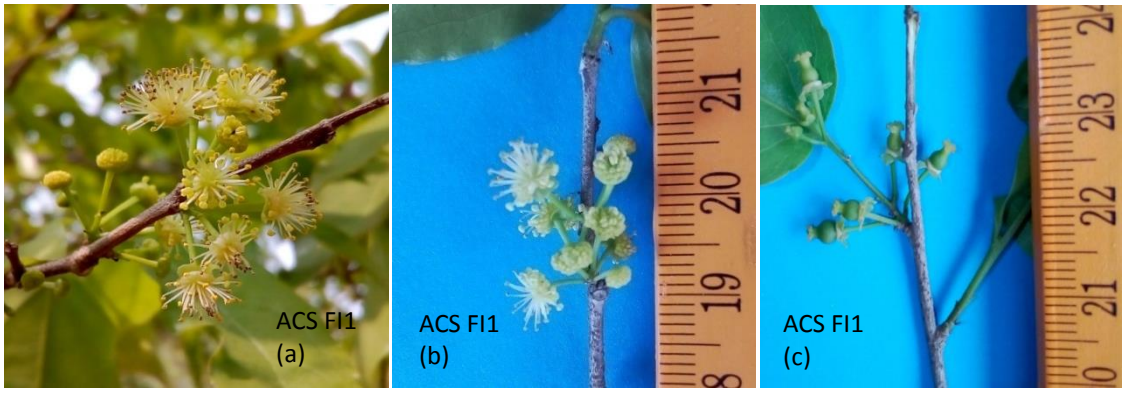


Plate 53. Male flowers (a) with flower position (b) and female flower with position (c) of governor's plum germplasm

Female flower: Female flowers are green to light yellow color, female flowers have 4-5 sepals, ovate in shape, petals fused at the base, and ovary is broadly ovoid in shape (Plate 53c).
Bearing habit: Governor's plum is categorized as regular bearing.
Number of sepal: The female flowers have 4-5 sepals.
Sepal color: Color of sepals ranges from light green to dark green.
Length of sepal: Sepals are 0.2 to 0.25 cm long.
Width of sepal: The width of sepals ranges from 0.15-0.2 cm.
Pedicel length: The pedicel length was found 0.8 cm in ACS FI1.
Flower position: Flowers are categorized as axillary (Plate 53).
Fruit Characteristics: Fruits are globose or round in shape, immatures are green in color and matures are light red in colour.

Fruit shape: Fruits are round or globose (Plate 54a).

Plate 54. Mature fruits (a), fruit length (b) and seeds (c) of governor's plum germplasm

Fruit color: Fruits are light red (Plate 54a).
Flesh colour: The flesh of the fruits are light red.
Fruit weight: Fruit weight was found 7.31 gm in ACS FI1 (Table 42).
Fruit length: Fruit length was found 1.54 cm in ACS FI1 (Plate 54b, Table 42).
Fruit width: Fruit width was found 2.17cm in ACS FI1 (Table 42).
Table 42. Fruit weight, length, width, TSS, moisture % and dry matter % of governor's plum germplasm

Germplasm	Fruit weight (gm)	Fruit length (cm)	Fruit width (cm)	TSS (%)	Moisture (%)	Dry matter (%)
ACS FI1	7.31	1.54	2.17	24	75.14	24.86

Seed Characteristics:
Seed color: Seeds are mainly in reddish (Plate 54c).
Seed number: The average number of seeds were found 14 in ACS FI 1 (Table 43).
Seed weight: Seed weight was measured using digital balance and the average weight of seeds was found 2.07 gm in ACS FI1 (Table 43).
Seed length: Seed length was measured using meauring scale and it was found 0.54 cm in ACS FI1 (Table 43).
Seed width: Seed width was measured by using measuring scale and the average width was found 0.53 cm in ACS FI1 (Table 43).
Table 43. Seed number, weight, length and width of governor's plum germplasm

Germplasm	No. of seed	Seed weight (gm)	Seed length (cm)	Seed width (cm)
ACS FI1	14	2.07	0.54	0.53

Biochemical Compounds of Governor's plum

The biochemical compounds of governor's plum were determined at the laboratory and results shows that fruit of ACS FI1 contained 24% total soluble solids, 75.14% moisture, 24.86% dry matter, pH 3.49, ascorbic acid (Vitamin C) 13.04 mg/100g, titratable acidity 3.56%, total sugar 2.53%, reducing sugar 1.41%, and non-reducing sugar 1.12% (Table 44).
Table 44. Biochemical compounds of governor's plum germplasm

Germplasm	pH	Vitamin C (mg/100g)	Titratable acidity (%)	Total sugar (%)	Reducing sugar (%)	Non-reducing sugar (%)
ACS FI1	3.49	13.04	3.56	2.53	1.41	1.13

Nutritional Status of Governor's plum

Nutritional constituents of governor's plum were determined at different laboratories. Results shows that fruits of ACS FI1 contained sodium 27.56mg/100g, potassium 146.29 mg/100g, calcium 80.16 mg/100g, magnesium 48.62 mg/100g, phosphorus 36.76 mg/100g, iron 1.02 mg/100g, copper 0.31mg/100g, manganese 14.20 mg/100g and zinc 1.92mg/100g of fruit (Table 45).

Table 45. Nutritional status of governor's plum germplasm

Germplasm	Na (mg/ 100g)	K (mg/ 100g)	Ca (mg/ 100g)	Mg(mg/ 100g)	P(mg/ 100g)	Fe(mg/ 100g)	Cu(mg/ 100g)	Mn(mg/ 100g)	Zn(mg/ 100g)
ACS FI1	27.56	146.29	80.16	48.62	36.76	1.02	0.31	14.20	1.92

f) Lukluki (*Flacourtia jangomas*)

Lukluki (*Flacourtia jangomas*) is a lowland and mountain forest tree belongs to the family Salicaceae. It is widely cultivated in southeast and east asia. It is a small deciduous tree, compound thorns on the main trunk and branches are full of small spine. In Bangladesh, it is found in the forests of Chittagong Hill Tracts, and Sylhet districts and commonly known as Tipa fol. Tribal peoples are like it very much. One accession of Lukluki was collected from Bandarban. This fruit will be matured in the month of July-August. One accession of lukluki germplasm was collected and stated as-ACS FJ1

Morphological characters of Lukluki

Leaf Characteristics: Leaves are elliptic, ovate elliptic, young leaves are light green, serrated, glabrous, matures are dark green in colour.

Leaf shape: Leaf is categorized as elliptic (Plate 55).

Plate 55. Leaf shape of lukluki germplasm, **Plate 56.** Leaf margin of flacourtia germplasm

Young leaf color: Young leaves are mainly light green.

Mature leaf color: Mature leaves are mainly dark green.

Leaf margin: Leaf margin is mainly categorized as serrate (Plate 56).

Leaf apex: Leaf apex is categorized as acute (Plate 57a).
Leaf base: Leaf base is categorized as acute (Plate 57b).

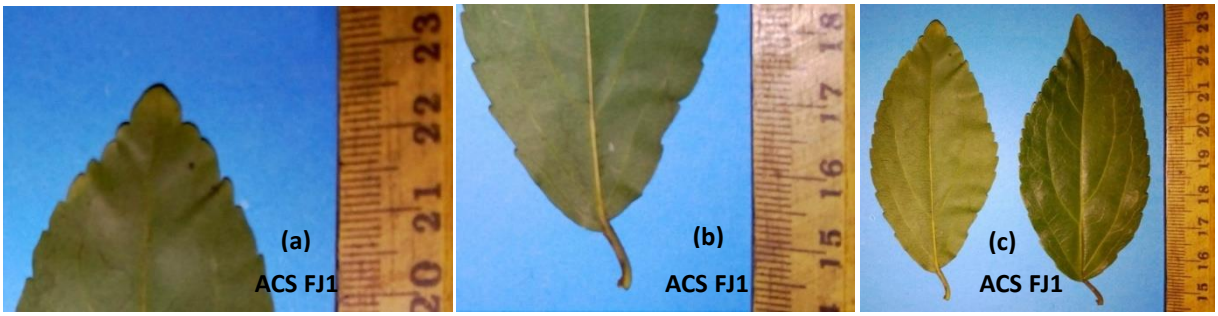


Plate 57. Leaf apex (a) leaf base (b) and leaf length (c) of lukluki germplasm

Leaf length: Leaf length was found 8.76 cm (Plate 57c, Table 46).
Leaf width: Leaf width was found 3.89 cm (Table 46).
Petiole length: Petiole length was found 1.17 cm (Table 46).
Petiole width: Petiole width was found 0.15 cm (Table 46).
Leaf area: Leaf area was found 16.22 cm^2 (Table 46).

Table 46. Leaf length, width, petiole length, width and leaf area of lukluki germplasm

Germplasm	Leaf length (cm)	Leaf width (cm)	Petiole length (cm)	Petiole width (cm)	Leaf area (cm^2)
ACS FJ1	8.76	3.89	1.17	0.15	16.22

Flower Characteristics: Lukluki is a dioecious plant bearing male and female flowers in different plants. Flowering time is February to March.
Male flower: Male flowers are in axillary racemes, 0.5-1.5 cm long, 4-5 sepals, stamens 25-30 (Plate 58a).
Female flower: The green to light green female flowers have 4-5 sepals, ovate in shape, petals fused at the base, ovary are broadly ovoid in shape (Plate 58b).

Plate 58. Male flowers (a) and Female flowers (b) of lukluki germplasm

Bearing habit: They are categorized as regular bearing.
Number of sepals: The female flowers have 4-5 sepals.
Sepal color: Color of sepals ranges from light green to dark green.
Length of sepal: Sepals are 0.2 to 0.25 cm long.
Width of sepal: The width of sepals ranges from 0.15-0.2 cm.
Pedicel length: Pedicel length was found 0.5 to 0.7 cm.
Flower position: They are categorized as axillary.

Fruit Characteristics: Fruits are green in color at young stage, round shape, petiolate (Plate 59).

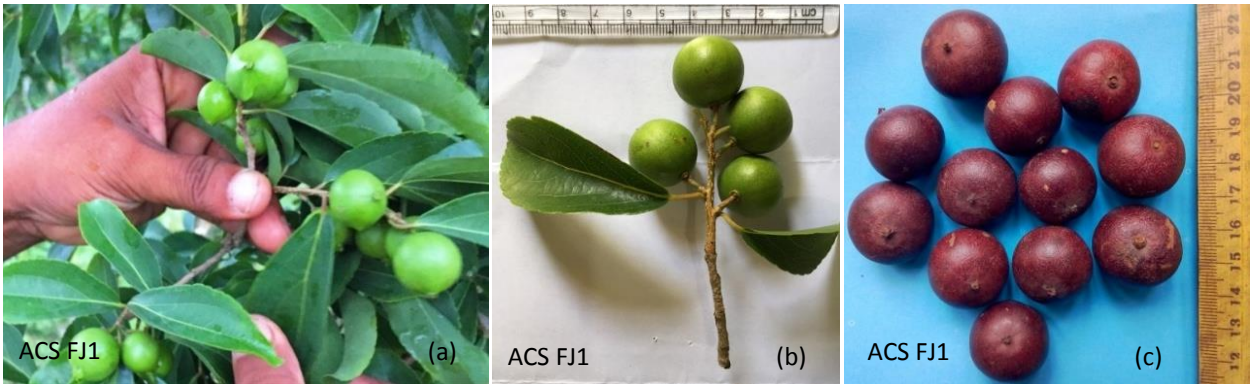


Plate 59. Young (a) mature (b) and ripe (c) fruits of Lukluki germplsm

Fruit shape: Fruits are usually globose in shape (Plate 59).
Fruit color: Immature fruits are green and mature fruits are reddish brown (Plate 59)
Fruit weight: Average fruit weight was found 7.94 gm (Table 47).
Fruit length: Average fruit length was found 1.52 cm (Plate 60, Table 47).

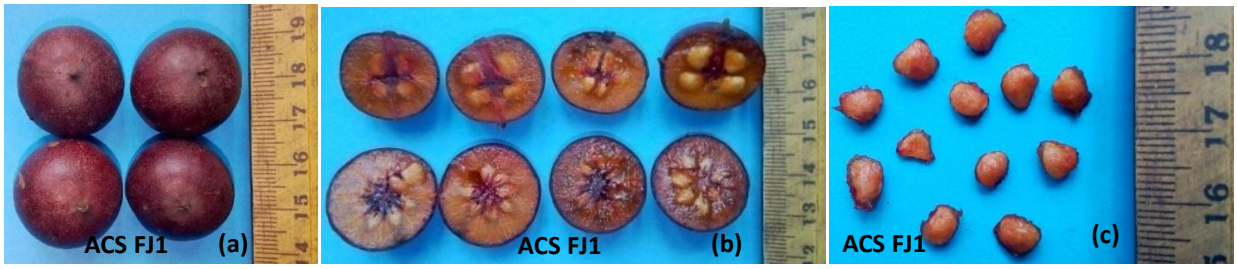


Plate 60. Fruit length (a), flesh color (b) and seeds (c) of lukluki germplasm

Fruit width: Fruit width was found 2.27 cm (Table 47).
Flesh colour: Flesh of the ripe fruits are reddish (Plate 61a).

Table 47. Fruit weight, length, width, TSS, moisture and dry matter content of lukluki germplasm

Germplasm	Fruit weight (gm)	Fruit length (cm)	Fruit width (cm)	TSS (%)	Moisture (%)	Dry matter (%)
ACS FJ1	7.94	1.52	2.27	23.5	76.26	23.74

Seed Characteristics:
Seed color: Seeds are mainly whitish (Plate 60c).
Seed number: Number of seeds were found 14 per fruit (Table 48).
Seed weight: The average seed weight was found 2.12 gm/fruit (Table 48).
Seed length: The average length of seed was found 0.49 cm (Plate 60c, Table 48).
Seed width: The average seed width was found 0.46 cm (Table 48).
Table 48. Seed number, weight, length and width of lukluki germplasm

Germplasm	No. of seed	Seed weight (gm)	Seed length (cm)	Seed width (cm)
ACS FJ1	14	2.12	0.49	0.46

Biochemical Compounds of Lukluki

The following biochemical compounds of lukluki were determined at the laboratory and the results are given below:
Total Soluble Solids (TSS): The average TSS of lukluki was found 23.5 (Table 47).
Moisture content (%): The average moisture content of fruits of accession ACS FJ1 was found 76.26 % (Table 47).
Dry matter (%): The average dry matter content of lukluki accession ACS FJ1 was found 23.74 % (Table 47).
pH content: It was found that fruits of accession ACS FJ1 contained pH value 3.55 (Table 49).

Ascorbic acid (Vitamin C) content: It was found that fruits of accession ACS FJ1 contained 15.21mg/100g of vitamin C (Table 49).

Titratable acidity content (%): It was found that fruits of accession ACS FJ1 contained 2.32% titratable acidity (Table 49).

Total sugar content: It was found that fruits of accession ACS FJ1 contained 3.83% total sugar (Table 49).

Reducing sugar content: It was found that fruits of accession ACS FJ1 had 2.15% reducing sugar (Table 49).

Non-reducing sugar content: It was found that fruits of the accession no. ACS FJ1 had 1.68% non-reducing sugar (Table 49).

Table 49. Fruit pH, vitamin C, titratable acidity, total sugar, reducing sugar and non-reducing sugar of lukluki germplasm

Germplasm	**pH**	**Vitamin C (mg/100g)**	**Titratable acidity (%)**	**Total sugar (%)**	**Reducing sugar (%)**	**Non-reducing sugar (%)**
ACS FJ1	3.55	15.21	2.32	3.83	2.15	1.68

Nutritional Status of Lukluki

Nutritional constituents of lukluki accession ACS FJ1 were determined in the laboratory. Results shows that fruits of accession ACS FJ1 contained 27.43 mg/100g sodium (Na), 150.73 mg/100g potassium (K), 88.17mg/100g calcium (Ca), 48.12mg/100g magnesium (Mg), 0.91mg/100g iron (Fe), 0.48mg/100g copper (Cu), 14.30mg/100g manganese (Mn) and 1.65mg/100g zinc (Zn) (Table 50).
Table 50. Nutritional constituents of lukluki germplasm

Germplasm	Na (mg/ 100g)	K(mg/ 100g)	Ca (mg/ 100g)	Mg (mg/ 100g)	Fe (mg/ 100g)	Cu (mg/ 100g)	Mn (mg/ 100g)	Zn (mg/ 100g)
ACS FJ1	27.43	150.73	88.17	48.12	0.91	0.48	14.30	1.65

g) Gutgutia (*Protium serratum)*

Gutgutia (*Protium serratum)* is a medium tree belongs to family Burseraceae. It is distributed in Bhutan, Combodia, India and Mymanmar. In Bangladesh, it is found in the forests of Chittagong Hill Tracts, Cox's Bazar, Sylhet, Moulavibazar districts. One accession of Gutgutia germplasm was collected from Bandarban district and it is stated as ACS PS1.

Morphological Characters of Gutgutia:

Leaf Characteristics: Leaves are compound, oblong-lanceolate, lateral veins are prominent on both surface, light green to dark green in colour.

Leaf shape: Leaves are categorized as oblong (Plate 61).

Plate 61. Leaf shape of gutgutia germplasm **Plate 62.** Leaf margin of gutgutia germplasm

Young leaf color: Young leaves are mainly light green.

Mature leaf color: Mature leaves are mainly dark green.

Leaf margin: Leaf margin is mainly catagorized as serrate (Plate 62).

Leaf apex: Leaf apex is categorized as acuminate (Plate 63a).

Leaf base: Leaf base is categorized broadly as cuneate (Plate 63b) .

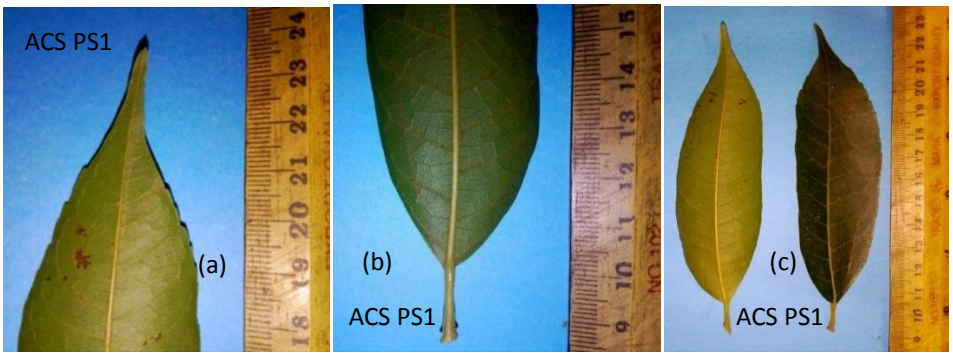


Plate 63. Leaf apex (a), base (b) and length (c) of gutgutia germplasm

Leaf length: Leaf length was found 13.87 cm (Plate 63c, Table 51).
Leaf width: Leaf width was found 4.46 cm (Table 51).
Petiole length: Petiole length was found 1.27 cm (Table 51).
Petiole width: Petiole width was found 0.28 cm (Table 51).
Leaf area: Leaf area was found 23.78 cm^2 (Table 51).

Table 51. Leaf length, width, petiole length, width and leaf area of gutgutia germplasm

Germplasm	Leaf length (cm)	Leaf width (cm)	Petiole length (cm)	Petiole width (cm)	Leaf area (cm^2)
ACS PS1	13.87	4.46	1.27	0.28	23.78

Flower Characteristics: Flowers are unisexual, male and female flowers produce on different plant.
Male flower: Male flowers are in axillary racemes, 0.2 to 0.25 cm long, 4-5 sepals, 5 petals, stamens 5 (Plate 64).
Female flower: The green to light green female flowers have 4-5 sepals, ovate in shape, petals 5, ovary are broadly ovoid in shape (Plate 65).

Plate 64. Male flower of gutgutia gerplasm

Plate 65. Female flower of gutgutia gerplasm

Bearing habit: They are categorized as regular bearing.
Number of sepals: The female flowers have 4-5 sepals.
Sepal color: Color of sepals ranges from light green to dark green.
Petal color: Color of petals is light green.
Number of petals: The female flower has 5 petals.
Length of petals: The length of petals was 0.15 to 0.2 cm.
Width of petals: The width of petals was 0.1 to 0.15 cm.
Length of sepals: The length of sepals was 0.1 to 0.15 cm.
Width of sepals: The width of sepals was less than 0.1 cm.
Pedicel length: Pedicel length was found 0.15 to 0.2 cm.
Flower position: They are categorized as axillary.

Fruit Characteristics: Fruits are flattened globose in shape, sometimes round brown to dark in colour
Fruit shape: Fruits are flattened globose in shape (Plate 66).

Plate 66. Fruit shapes of Indian red pear germplasm

Fruit color: Immature fruits are green color and ripe fruits are reddish brown (Plate 66).
Fruit weight: The average fruit weight was found 4.34 gm (Table 52).
Fruit length: The average fruit length was found 2.11 cm (Plate 67a, Table 52).

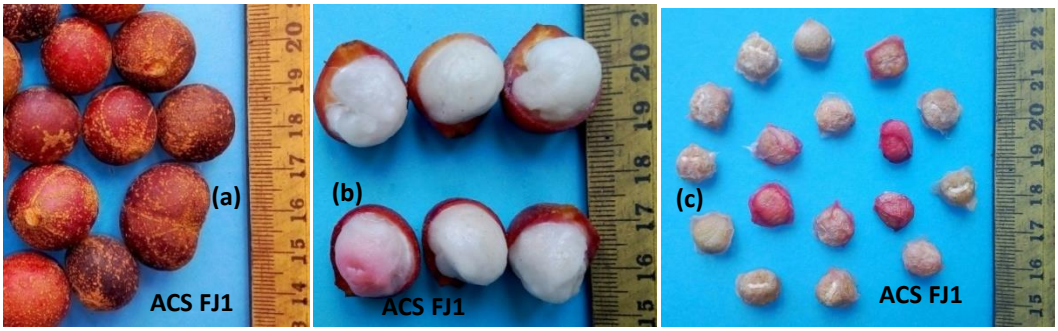


Plate 67. Fruit length (a), flesh color (b) and seed (c) of gutgutia germplasm

Fruit width: The average fruit width was found 1.73 cm (Table 52).
Flesh colour: The flesh of fruits is whitish (Plate 67b).

Table 52. Fruit weight, length, width, TSS, moisture% and dry matter% of gutgutia germplasm

Germplasm	Fruit weight (gm)	Fruit length (cm)	Fruit width (cm)	TSS (%)	Moisture (%)	Dry matter (%)
ACS PS1	4.34	2.11	1.73	17	85.25	14.75

Seed Characteristics:

Seed color: Seeds are mainly whitishin colour (Plate 67c).
Seed number: They bears single seed in each fruit (Table 53).
Seed weight: The average seed weight was found 1.89 gm (Table 53).
Seed length: The average seed length was found 0.83 cm (Table 53).
Seed width: The average seed width was found 0.74 cm (Table 53).

Table 53. Number of seed, seed weight, length and width of gutgutia germplasm

Germplasm	No. of seed	Seed weight (gm)	Seed length (cm)	Seed width (cm)
ACS PS1	1	1.89	0.83	0.74

Biochemical Compounds of Gutgutia

The following biochemical compounds of gutgutia ACS PS1 were determined at the laboratory. Results shows that gutgutia accession ACS PS1 contained 17 % total soluble solids (TSS), 85.25% moisture, 14.25% dry matter (Table 52), pH 2.82, ascorbic acid (Vitamin C) 21.74mg/100g, titratable acidity 10.55%, Total sugar content 0.16%, Reducing sugar 0.09% and Non-reducing sugar 0.07% (Table 54).

Table 54. Biochemical compounds of gutgutia germplasm

Germplasm	pH	Vitamin C (mg/100g)	Titratable acidity (%)	Total sugar (%)	Reducing sugar (%)	Non-reducing sugar (%)
ACS PS1	2.82	21.74	10.55	0.16	0.09	0.07

Nutritional Status of Gutgutia:

Nutritional constitutions of gutgutia accession ACS PS1 were determined at the laboratory. Results shows that gutgutia ACS PS1 contained 28.17mg/100g sodium (Na), 190.91mg/100g potassium (K), 112.12mg/100g calcium (Ca), 92.74mg/100g magnesium (Mg), 0.95mg/100g iron (Fe), 1.40mg/100g copper (Cu), 5.57mg/100g manganese (Mn) and 2.08 mg/100g zinc (Zn) (Table 55).

Table 55. Nutritional constituents of gutgutia germplasm

Germplasm	Na(mg/ 100g)	K (mg/ 100g)	Ca (mg/ 100g)	Mg (mg/ 100g)	Fe (mg/ 100g)	Cu (mg/ 100g)	Mn (mg/ 100g)	Zn (mg/ 100g)
ACS PS1	28.17	190.91	112.12	97.24	0.95	1.40	5.57	2.08

Comparison of some biochemical and mineral nutrients among the test minor fruits:

Among the minor fruits maximum vitamin C content (21.74 mg/100g) was obtained from gutgutia followed by monkey jack (20.86 mg/100g) and the minimum vitamin C (5.73 mg/10g) found from velvet apple. In case of K content, it was observed that river ebony contained highest K (258.35 mg/100g) followed by velvet apple (238.51 mg/100gm) and the lowest in monkey jack (65.14 mg/100g).

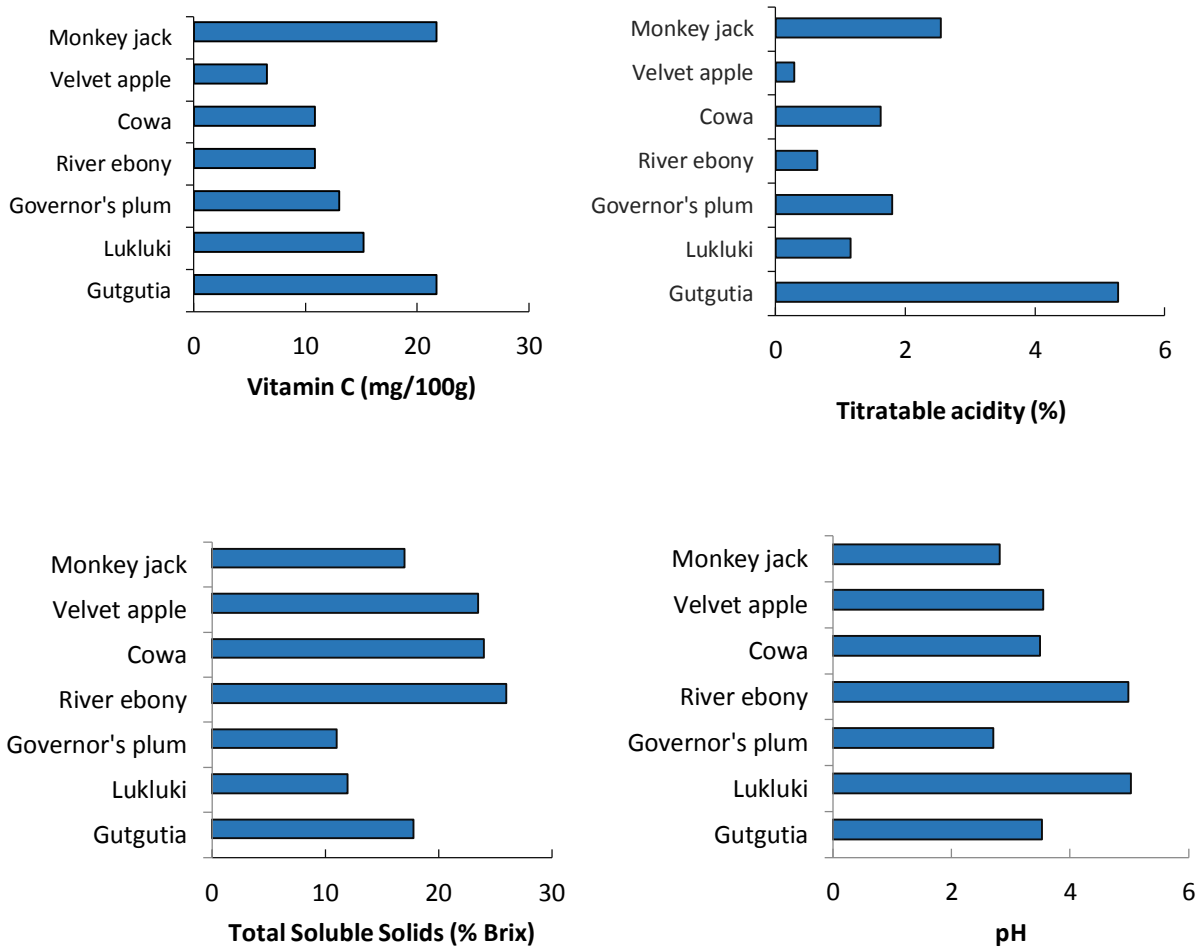


Figure 1. Ascorbic acid (Vitamin C), Titratable acidity, Total Soluble Solids (TSS) and pH contents of test minor fruits

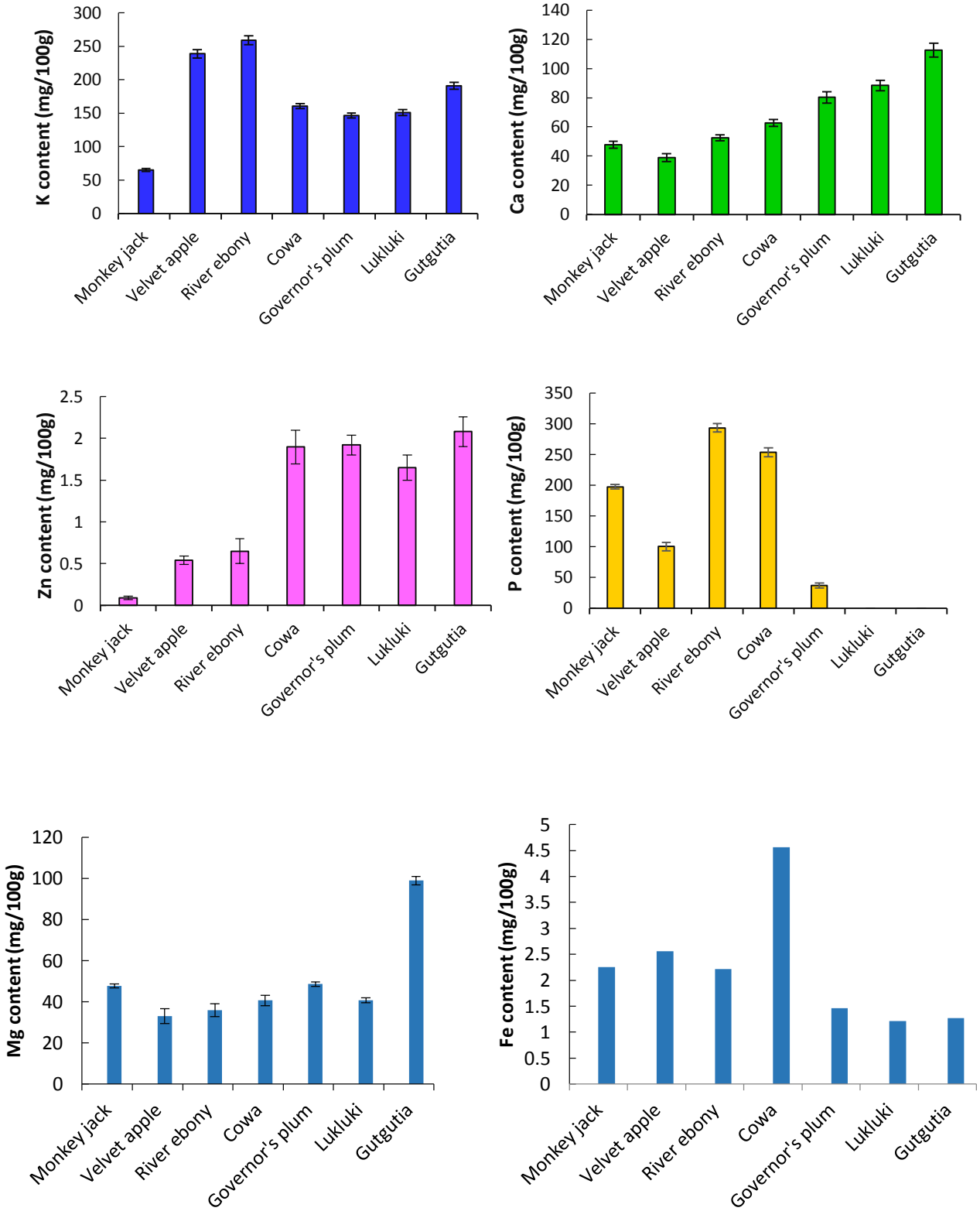


Figure 2. Potassium , Calcium, Zinc, Phosphorus, Magnesium and Iron contents of test minor fruits

11. Research highlight/findings (Bullet point – max 10 nos.): _____ _____

i) It was observed that each of germplasm in each fruit species bears significantly different morphological features and nutritional status;

ii) Maximum vitamin C content (21.74 mg/100g) was obtained from gutgutia followed by monkey jack (20.86 mg/100g) and minimum (5.73 mg/10g) from velvet apple;

iii) Among the test minor fruits gutgutia contained highest amount Ca (112.59 mg/100g), Mg (98.88 mg/100g) and Zn (2.08 mg/100g) while river ebony contained maximum amount P (293.47 mg/100g) and K (258.68 mg/100g) as compared to other minor fruits;

iv) It can be concluded that the selected minor fruits have tremendous potentiality in human nutrition and soci-economic development of Bangladesh. The documented information could be useful for varietal development of minor fruits.

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B. Implementation Position

1. Procurement:

Description of equipment and capital items	PP Target		Achievement		Remarks
	Phy (#)	Fin (Tk)	Phy (#)	Fin (Tk)	
(a) Office equipment	Desktop computer Laser printer Scanner	85,000.00	Desktop computer Laser printer Scanner	85,000.00	Timely procured
(b) Lab &field equipment	Chlorophyll meter (Dualex) , Digital refractometer, Slide calipers	365,000.00	Chlorophyll meter (Dualex) , Digital refractometer, Slide calipers	365,000.00	Timely procured
(c) Other capital items	-	-	-	-	-

2. Establishment/renovation facilities: Not applicable

Description of facilities	Newly established		Upgraded/refurbished		Remarks
	PP Target	Achievement	PP Target	Achievement	

3. Training/study tour/ seminar/workshop/conference organized: Not applicable

Description	Number of participant			Duration (Days/weeks/ months)	Remarks
	Male	Female	Total		
(a) Training					
(b) Workshop					

C. Financial and physical progress

Fig in Tk

Items of expenditure/activities	Total approved budget	Fund received	Actual expenditure	Balance/ unspent	Physical progress (%)	Reasons for deviation
A. Contractual staff salary	305580	305580	305580	-	100	-
B. Field research/lab expenses and supplies	380420	380420	380520	-	100	-
C. Operating expenses	125000	125000	125000	-	100	-
D. Vehicle hire and fuel, oil & maintenance	134000	134000	134000	-	100	-
E. Training/workshop/seminar etc.	-	-	-	-	-	-
F. Publications and printing	75000	15000	15000	60000		Fund is not released
G. Miscellaneous	30000	30000	30000	-	100	
H. Capital expenses	450000	450000	450000	-	100	
Total	**1500,000**	**1440,000**	**1440,000**	**60,000**		

D. Achievement of Sub-project by objectives: (Tangible form)

Specific objectives of the sub-project	Major technical activities performed in respect of the set objectives	Output (i.e. product obtained, visible, measurable)	Outcome (short term effect of the research)
i) Collect and conserve important minor fruits from coastal and hilly areas of Bangladesh	Seven minor fruit germplasm have been collected from coastal and hilly areas of Bangladesh	Collected minor fruit germplasm have been conserved at BAU-GPC	Test minor fruits are conserved for multiplication
ii) Characterize the morphological features, biochemical and nutritional status of collected minor fruits from coastal and hilly areas of Bangladesh	Morphological features have been characterized. Biochemical and nutritional status of collected minor fruits were determined	Information on morphological, biochemical and nutritional quality of minor fruit have been presented in final report	Quality and potential ability of test minor fruits assessed towards further improvement aiming nutritional security
iii) Document the information for future use in varietal improvement also protect these local landraces from piracy	Data on morphological features, biochemical and nutritional quality of test minor fruits have presented in final report.	A well written report has been prepared for future use in varietal development	Test minor fruits are protected from biopiracy

E. Materials Development/Publication made under the Sub-project:

Publication	Number of publication		Remarks (e.g. paper title, name of journal, conference name, etc.)
	Under preparation	Completed and published	
Technology bulletin/ booklet/leaflet/flyer etc.			
Journal publication **(Conference Abstract)**		01	**Title-** "Morphological Characterization of Velvet apple (*Diospyros discolor* Willd.) Germplasm of Bangladesh" **Conference name-** ***5th International Symposium on Minor Fruits, Medicinal and Aromatic Plants"*** held on 4-6 September, 2019 at the Institute for Agro Technology and Rural Sciences, University of Colombo, Weligattha, Sri Lanka.
Information development			
Other publications, if any **(MS thesis)**		01	Studies on morphological, biochemical and nutritional status of different velvet apple (*Diospyros discolor*Willd.) germplasm

F. Technology/Knowledge generation/Policy Support (as applied):

i. Generation of technology (Commodity & Non-commodity)

Not Applicable

ii. **Generation of new knowledge that help in developing more technology in future**

The nutritional values of seven minor fruits are assessed highlighting their potentiality for production and role in nutrition security

iii. Technology transferred that help increased agricultural productivity and farmers' income

Not Applicable

iv. Policy Support

Policy makers may undertake protection program following the nutrition values as per present study which would help ultimately improve nutrition status in target areas.

G. Information regarding Desk and Field Monitoring

i) Desk Monitoring [description & output of consultation meeting, monitoring workshops/seminars etc.):

- A desk monitoring was done by PIU-BARC-NATP-2 team on 07.03.2018 that was Headed by Dr. Mian Sayeed Hassan, Director, PIU, BARC. The team were highly satisfied on the progress of the project work
- Research progress was also presented in the six month Progress Workshop (26 February, 2018) held on 26 February, 2018 at BARC Auditorium.
- Research work was presented in the Annual Workshop (10-13, September) on 12 September, 2018 at BARC Auditorium.

ii) Field Monitoring (time & No. of visit, Team visit and output):

- Two internal field monitoring were conducted by Bangladesh Agricultural University Research System (BAURES) team on 3 March, 2018 and 17 May, 2018. Members of the monitoring team expressed their opinion as highly satisfied.

H. Lesson Learned/Challenges (if any)

i) Coastal and hilly areas are the hub of different minor fruit germplasm
ii) Minor fruits are rich in ascorbic acid and some minerals
iii) They are potential for raising production followed by people's nutrition

I. Challenges (if any)

Signature of the Principal Investigator
Date ……

Seal

Counter signature of the Head of the organization/authorized representative
Date ……..
Seal