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ORIGINAL ARTICLE

Identification and conservation of elite wood apple (*Feronia limonia* L.) genotypes from West Bengal

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ABSTRACT
A study was conducted to identify the elite wood apple germplasm among its natural population from different locations of Nadia district of West Bengal. Wood apple trees in 20 different locations were initially screened for their fruit quality characters out of which 10 quality germplasm were selected for detailed studies including flowering, fruiting and fruit bio-chemical properties. The 10 different elite class germplasm were evaluated for characters like peak and second flowering season, peak and second fruiting season, overall abundance of flowering andfruiting, fruit shape, fruit length, fruit diameter, seeds per fruit, fruit weight, pulp weight, edible pulp percentage, shell thickness, tss, titratable acidity, total sugar, reducing sugar and ascorbic acid. It was found that the Acc. 5 (Karimpur) and Acc. 9 (Chakdah) fruits are large in size, profuse flowering and fruiting, high pulp percentage and thin shell thickness. Both the accessions have late fruit maturity time and can overcome market glut situation when huge amount of fruits are already available. Beside that it have a high TSS, titratable acidity, total sugar, reducing sugar and high ascorbic acid content. Hence, the following germplasm can be conserved by asexual propagation and can be harnessed in future breeding programs.
Keywords*: accessions, kathbel, monkey fruit, characterization, wood-apple.*

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INTRODUCTION

Wood apple belongs to the family Rutaceae and is botanically known as *Feronia limonia*L. It is also known as curd fruit, monkey fruit and kathbel. It is believed to have originated from sub-tropical plains of India [1] and prefers a dry climate for optimum flowering and fruiting. It can be well grown in drought prone and semi-arid regions. The productive age of plant is believed to be 12-70 years [2]. The fruit is rarely grown commercially in India but has enormous potential to be a major fruit. It is a climate resilient fruit crop and can tolerate extreme dry conditions during flowering and fruit set[3]. The tree is believed to be naturally tolerant to biotic and abiotic stress. At the same time it can tolerate wet condition during fruit set [3]. This fruit can grow in fallow and barren waste land which is even devoid of essential elements as well [4]. Wood apple is a moderate sized tree which is slow growing and is deciduous in nature [5].

Juice prepared from wood apple have superb thirst quenching capability and have tremendous potential to be an important crop for beverage processing. Traditionally in Indian homes, wood apple is even consumed raw and is preferred because of its exquisite flavour and perfect sour-sweet blend. Wood apple is also used to prepare processed products like chutney, jam and jelly [6].

Wood apple is a miraculous fruit with enormous nutrients and phytochemicals contributing to its medicinal properties [7]. Wood apple fruits contain a innumerable amount of phytochemicals such as polyphenols, vitamins, saponins, coumarins, amino acids, tri-terpenoids, phytosterols, tannins, tyramine derivatives, etc [8]. Wood apple have several beneficial nutritional and medicinal properties. In Indian traditional system of medicine, wood apple is known to cure diseases like dysentery, diarrhea, asthma, wounds, tumors, hepatitis and cardiac debility [9]. Wood apple is known to possess excellent amount of

nutrients which many fruits are lacking. It is having significant amount of Vitamin A, Vitamin B_1 and Vitamin B_2. It have trace amount of vitamin C as well [10]. Wood apple fruit is an enormous source of anti-oxidants and has potential to scavenge free radicals in human body [11].Both ripe and unripe wood apple fruit is known to possess excellent medicinal properties. Ripe fruit is known to cure liver problems and is good for heart. It has good cholesterol lowering potential as well. Unripe fruit is having enormous potential to cure diarrhea and dysentery. Ripe fruit consumption can reduce problems and cure in longer run the problems associated with gums and teeth, hiccough, sore throat and diseases of the gums [12]. Ripe fruit, leaves, stem, bark and root of wood apple also have anti-venomous capability against snake bite [13]. The essential oils which are extracted from wood apple fruits and seeds are effective against 12 bacteria causing human disease [14]. Senthilkumar and Venkatesalu, (2013)[15]also reported anti-microbial activity of wood apple. Fruit pulp of wood apple is also known to possess antipyretic, anti-inflammatory and analgesic activity [16]

Even juice extracted from young leaves of wood apple when consumed solely or with milk can cure intestinal problems associated with worms. It is also good against piles. Wood apple fruit have anti-tumor property. Mishra *et. al,* [17] also reported anti-ulcer property of wood apple. The pulp of wood apple when used for the preparation of face cream can remove lesions and small spots from the skin [18]. Fruits are also known to be larvicidal property and can kill insect larvae [19]. Wood apple is believed to be hepato-protectant with some adaptogenic activity like cleansing of blood impurities, leucorrhoea, dyspepsia and jaundice [6]. Acidic hetero-polysaccharide extract of wood apple fruit surprisingly exhibited cell growth inhibition of in-vivo Ehrlich ascites carcinoma [20]. Wood apple fruits and seeds are also known to be anti-diabetic [21].

There is limited information on the germplasm of wood apple for selection of superior characters. Germplasm collection is a basic and very important step of improvement in any crop [22, 23, 24]. Genetic variability is considered one of the most desired components for selection of the best performing parents for further use in breeding programme. By natural selection and spontaneous mutation, some trees growing in roadside and homestead might have several desirable properties and marvelous fruit characteristics which the consumer wants in the market. In our study an attempt has been made to visit local villages and identify the wood apple trees with exceptional characters based on flowering, fruiting and bio-chemical properties of the fruit. Later the trees with superior traits can be multiplicated and conserved for future research.

MATERIAL AND METHODS

Initial survey was done in Nadia district of West Bengal to identify and select 20 trees from distinct locations. The trees were of age between 12 - 25 years and were vegetative vigorous. These trees were geographically tagged and in the 1st year, fruits from 20 trees were collected. Out of the 20 different trees, 10 best accessions based on initial fruit quality were identified which were shortlisted for further studies about flowering, fruiting and detailed physio-chemical properties. The studies about flowering and fruiting properties were done in the location of the trees itself whereas the bio-chemical properties of the fruits were studied in Post Graduate Laboratory, Department of Post harvest technology, BCKV, Mohanpur. Final studies on 10 best accessions were done in Shantipur, Gede, Kalyani, Krishnanagar, Karimpur, Haringhata, Ranaghat, Nabadwip, Chakdah and Palashiwhich were named as Acc-1, Acc-2 to Acc. 10 respectively. The design of the experiment was Randomized Block Design (RBD) with 10 accessions as ten different treatments and 3 replications each.

Number of flowering and fruiting flushes, peak flowering time, peak fruiting season, second fruiting season, overall abundance of flowering and flower colour were determined based on researcher regular observation and opinion of local people. The fruit dimension was measured by Vernier calipers. Fruit weight as average of 10 fruits by using electronic weighing balance. Pulp percentage was determined on the basis of total pulp weight with comparison to total fruit weight. Total soluble solid (TSS) was estimated by using the hand refractometer. Bio-chemical assessment of the fruits like the titratable acidity (TA), ascorbic acid content, reducing sugar and total sugar (TS) was done by method suggested by Association of Analytical chemists [25].

RESULTS AND DISCUSSION

Flowering and fruiting characters

Table 1 highlights the flowering characteristics of different wood apple accessions collected from Nadia district of West Bengal. All the 10-accession studied have habit of flowering twice a year. Flowering was in two flushes in all the accessions studied. The peak season of flowering was at early monsoon days which were early-June to mid-July. The time for second flowering was in the spring which wasearly

February to early March in all the accession. The peak fruiting season was dry summer days which were mid-Aprilto late-May. The second fruiting was during early winter (early October to late November) in all accessions. Quite exceptionally, the ACC-5, ACC-8 and ACC-10 have very late fruiting both in main fruiting season and off season as well. Overall abundance of flowering was profuse in ACC- 1, ACC-2, ACC-4, ACC-5, ACC-7, ACC-9 and ACC-10 and moderate in ACC-3, ACC-6 and ACC-8. Overall abundance of fruiting was profuse in ACC- 1, ACC-3, ACC-4, ACC-5, ACC-6, ACC-9 and ACC-10 and moderate in ACC-2, ACC-7 and ACC-8. The flower colour is pale whitish green in all the accessions. The fruit shape is Round in all the accessions except ACC- 3 and ACC-5 where the fruits are flattened round.

Table 1:Flowering characteristics of different wood apple accessions

Accessions	Peak flowering time	Peak fruiting season	Second flowering season	Second fruiting season	Overall abundance of flowering	Overall abundance of fruiting	Fruit shape
Acc. 1	Mid June	Early May	Mid February	Late October	Profuse	Profuse	Round
Acc. 2	Late June	Early May	Early February	Mid October	Profuse	Moderate	Round
Acc. 3	Late June	Early May	Mid February	Early November	Moderate	Profuse	Flattened round
Acc. 4	Early June	Mid April	Early February	Early October	Profuse	Profuse	Round
Acc. 5	Early July	Mid May	Early March	Late November	Profuse	Profuse	Flattened round
Acc. 6	Mid June	Mid April	Mid February	Late October	Moderate	Profuse	Round
Acc. 7	Early July	Late May	Late February	Mid November	Profuse	Moderate	Round
Acc. 8	Mid June	Late April	Early February	Mid October	Moderate	Moderate	Round
Acc. 9	Late June	Mid May	Mid February	Mid November	Profuse	Profuse	Round
Acc. 10	Mid July	Late May	Mid February	Early November	Profuse	Profuse	Round

Fruit characteristics

Table 2 represents the fruiting characteristics of different wood apple accessions. It can be observed from the table that fruit length was highest in case of ACC-5 (8.89 cm) followed by ACC-9 (7.96 cm), ACC-3 (6.98 cm), ACC-6 (6.78 cm), ACC-10 (6.48 cm) and ACC-4 (6.25 cm). A very low fruit length was observed in ACC-2 (5.82 cm) followed by ACC-7 (5.96 cm) and ACC-8 (5.85 cm). Fruit diameter at the basal end was highest in ACC-5 (9.04 cm) followed by ACC-9 (7.49 cm), ACC-6 (6.68 cm), ACC-10 (6.50 cm), ACC-1 (6.42 cm) and ACC-4 (6.26 cm). Least fruit diameter was observed in ACC-8 (5.72 cm), ACC-2 (5.83 cm) and ACC-7 (5.86 cm). Seeds per fruit in wood apple were maximum in ACC-10 followed by ACC-8, ACC-3, ACC-6, ACC-7 and ACC-4 which were 312.33, 291.67, 242.67, 241.67, 240.67 and 232.33 respectively. These results are similar to the findings of Singh *et. al*., [26].

The weight of fruit was maximum in case of ACC-9 (283.08 g) followed by ACC-5 (281.30 g), ACC-3 (226.08 g), ACC-10 (205.05 g) and ACC-6 (200.07 g). A very low fruit weight were observed in ACC-4 (102.47 g) followed by ACC-2 (157.67 g), ACC-8 (161.67 g) and ACC-7 (165.33 g). Pulp weight was highest in ACC-4 (188.33 g) followed by ACC-9 (184.67 g) and ACC-5 (177.33 g). Low pulp weight was observed in ACC-2 (77.67 g) followed by ACC-8 (80.33 g) and ACC-7 (94.33 g). Pulp percentage was highest in ACC. 9 followed by ACC-5 which were 65.33% and 63.08% respectively. Pulp percentage was lowest in ACC. 2 followed by ACC-8 which were 49.26% and 49.72% respectively. Shell thickness was maximum in ACC-7 (0.43 cm) followed by ACC-1 (0.41 cm), Acc. 2 (0.40 cm), Acc. 3 (0.40 cm) and Acc. 4 (0.40 cm). Comparatively, thinner shell of 0.33 cm and 0.36 cm was observed in Acc. 5 and Acc. 9 respectively. A thicker rind can ensure minimum bruise and injuries to the fruits and a thinner shell might be more profitable on consumer's aspect. These results are similar to the findings of Singh *et. al*., [26].

Table 2:Fruiting characteristics of different wood apple accessions

Accessions	Fruit length (cm)	Fruit diameter (cm)	Seeds per fruit	Fruit weight (g)	Pulp weight (g)	Edible pulp percentage (%)	Shell thickness (cm)
Acc. 1	6.40	6.42	191.67	176.16	101.33	57.54	0.41
Acc. 2	5.82	5.83	218.67	157.67	77.67	49.26	0.40
Acc. 3	6.98	7.11	242.67	226.08	130.33	57.50	0.40
Acc. 4	6.25	6.26	232.33	102.47	188.33	54.40	0.40
Acc. 5	8.89	9.04	185.67	281.30	177.33	63.08	0.33
Acc. 6	6.78	6.68	241.67	200.07	117.40	58.67	0.37
Acc. 7	5.96	5.86	240.67	165.33	94.33	57.06	0.43
Acc. 8	5.85	5.72	291.67	161.67	80.33	49.72	0.38
Acc. 9	7.96	7.49	177.33	283.08	184.67	65.33	0.36
Acc. 10	6.48	6.50	312.33	205.05	118.67	57.99	0.38
C.D. at 5%	0.17	0.48	25.63	12.41	10.27	4.07	0.02
S.Em. (±)	0.05	0.16	8.56	4.15	3.43	1.36	0.01
C.V.	1.42	4.14	6.35	3.51	5.02	4.13	2.99

Bio-chemical characteristics

Bio-chemical properties of different wood apple accessions are described in table 3. From the table we can find that highest value of TSS was observed in Acc. 9 (18.43^{0}B) and ACC-5 (17.87 ^{0}B). A low TSS was observed in fruits from ACC-2 (13.63 ^{0}B), ACC-8 (14.27 ^{0}B) and ACC-7 (14.57 ^{0}B).Titratable acidity in the fruits showed huge variation among the 10 accessions. Highest Titratable acidity (%) was observed in Acc. 1 (5.48 %) followed by Acc. 8 (5.18 %), Acc. 5 (5.15 %), Acc. 4 (5.11 %), ACC-10 (5.08 %) and Acc. 2 (5.05 %). A very low Titratable acidity was observed in ACC. 7 (3.55 %) followed by ACC. 6 (3.74 %) and ACC. 3 (3.97 %). TSS and Titratable acidity of the fruits were observed similar to that of Sharma *et. al*., (2014).Highest amount of total sugar was observed in ACC. 9 (17.33 %) followed by Acc. 5 (16.30 %) and ACC. 10 (16.30 %). Lower amount of total sugar was observed in Acc. 2 (11.63 %) followed by ACC. 8 (12.30 %), ACC. 7 (12.43 %) and ACC. 6 (13.43 %). Highest value of reducing sugar was observed in ACC. 9 (6.49 %) followed by ACC. 5 (6.22 %) and ACC. 10 (5.98 %). Lowest value of reducing sugar was observed in ACC. 2 (4.61 %) followed by ACC. 7 (5.02 %), ACC. 8 (5.07 %), ACC. 1 (5.12 %) and ACC. 6 (5.31%). Total sugar and reducing sugar of the fruits were observed similar to that of Kumar and Deen, (2017)[4].

Highest amount of ascorbic acid content was observed in ACC. 9 (18.43 mg/100g) followed by ACC. 5 (17.76 mg/100g), ACC. 7 (16.31 mg/100g) and ACC-10 (16.20 mg/100g). Lowest amount of ascorbic acid was observed in ACC. 1 (11.99 mg/100g) followed by ACC. 8 (12.07 mg/100g), ACC. 3 (12.78 mg/100g), ACC. 2 (13.14 mg/100g) and ACC. 4 (13.73 mg/100g).Ascorbic acid content in wood apple is similar to that of Singh *et. al*., [26].

Table 3:Bio-chemical properties of different wood apple accessions

Accessions	TSS (^{0}B)	Titratable acidity (%)	Total Sugar (%)	Reducing Sugar (%)	Ascorbic acid (mg/100g)
Acc. 1	16.33	5.48	14.20	5.12	11.99
Acc. 2	13.63	5.05	11.63	4.61	13.14
Acc. 3	16.90	3.55	14.63	5.69	12.78
Acc. 4	16.93	5.11	14.94	5.45	13.73
Acc. 5	17.87	5.15	16.30	6.22	17.76
Acc. 6	15.47	3.74	13.43	5.31	15.30
Acc. 7	14.57	3.97	12.43	5.02	16.31
Acc. 8	14.27	5.18	12.30	5.07	12.07
Acc. 9	18.43	4.33	17.33	6.49	18.43
Acc. 10	16.60	5.08	15.10	5.98	16.20
C.D. at 5%	0.22	0.22	0.48	0.25	0.27
S.Em. (±)	0.07	0.07	0.16	0.08	0.09
C.V.	0.80	2.71	1.96	2.65	1.07

CONCLUSION

Keeping in view all the above results, it was found that the Acc. 5 (Karimpur) and Acc. 9 (Chakdah) flower profusely, fruits are large in size and fruits have high pulp percentage and thin shell thickness. Both the accessions have late fruit maturity time and can overcome market glut situation when huge amount of fruits are already available. Nevertheless, they have a high TSS, titratable acidity, total sugar, reducing sugar and high ascorbic acid content. Hence, the following germplasm can be conserved by asexual propagation and can be harnessed in future breeding programs.

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CONFLICT OF INTERESTS

The authors have declared no conflict of interest.

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