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Studies on Physico-chemical characters of Thai Apple ber (*Ziziphus mauritiana* Lamk.) grown in Assam

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Abstract

An experiment was carried out during 2017-19 to study the morpho-physical and bio-chemical characters of Thai Apple ber (*Ziziphus mauritiana* Lamk.) grown in Assam. The leaves of Thai Apple ber fruits collected from different locations of Assam showed elliptic shape with serrate leaf margin, obtuse apex and oblique base. The colour of mature leaves was observed to be dark green. The leaf length, leaf breadth and petiole length of Thai Apple ber fruits shows a great variations among all collection. The plant of Gela Pukhuri and Simen Chapori recorded early flowering and harvesting among the Thai Apple ber plants of other locations in the present study. The fruits of Boitamari (BC-8) recorded longest fruit (5.10cm) while, maximum fruit weight (53.08g) was recorded in BC-1 (Simen Chapori). The shape and surface of seeds was found to be ovate and warty and pulp-stone ratio ranged from 18.76 - 23.28. The biochemical analysis reveals that the quality characters like moisture content, TSS, titratable acidity, TSS-acid ratio and ascorbic acid content differed. Total sugar (6.37 - 7.81%) and reducing sugar (2.44 - 3.06%) contents varied significantly among the Thai Apple ber fruits of different locations. The highest vitamin A (16.08 µg/100g) were found in Gela Pukhuri (BC-3) and highest protein (0.87g/100g) was found in BC-2 (Bongalmora). The calcium and phosphorus contents of the Thai Apple ber fruits ranged from 20.48mg/100g to 23.50mg/100g and 24.08mg/100g to 25.25mg/100g, respectively. It can be concluded that Thai Apple apple ber fruits can successfully be grown under sub-tropical area of Assam. The ber fruits collected from Simen Chapori (BC-1) was found best in terms of biochemical composition i.e. TSS, TSS/ acid ratio, total sugar, reducing sugar and moisture content.

Keywords: *Ziziphus mauritiana* Lamk, Physico-Chemical

Introduction

Ber (*Ziziphus mauritiana* Lamk.) is one of the most ancient and common fruit indigenous to India and China which belongs to family Rhamnaceae and genus *Ziziphus*. It is tetraploid (2n=48). It can be grown well in inferior soil with pH as high as 9.0 in arid and semi-arid regions. It is found growing wild as well as in cultivated forms throughout the warmer regions upto an altitude of 1500 metres above mean sea level (Pareek, 2001) [25]. According to De Candolle (1886) [6], the centre of origin of ber is Central Asia, where it is found growing under varying climatic conditions. Requirement of temperatures ranges from 39-42 °C and it can tolerate temperatures as high as 49-50 °C. However, fruits set are adversely affected at temperatures above 35 °C. Flowering starts in September and completes in November. The harvesting time of fruit varies depending upon varieties; it is generally harvested in the month of December and continues till February in different varieties and in different locations (Reddy, 2017) [29]. The quality of ber fruit produced in Assam region is poor with variable yield as its main reason is due to poor quality of germplasm, poor selection of varieties and poor orchard management by farmers but recent introduction of hybrid ber fruit called as "Thai Apple ber" developed in Thailand is making significant changes in the lives of farmers owing to its profuse bearing, high yielder, fruit colour, quick return and size of the fruits. This hybrid Thailand ber variety is a crossbred between green apple and jujube. Its name signifies size and appearance of green apple fruit and that is the reason it is named as 'Green Apple' or 'Thai Apple Ber'. Its farming is currently trending and it has lots of advantage over traditional ber farming with high economic return and more shelf life. Thai Apple ber fruits are sweet, crispy, juicy and delicious similar to apple. The present investigations were therefore, aimed to generate basic information's on the Physico-chemical characteristics and phenological attributes of Thai Apple ber grown in different condition of Assam.

Materials and Methods

The experiment was carried out in the laboratories of Biswanath College of Agriculture, Assam Agricultural University, during the year 2017-2019. In Assam, hybrid ber varieties such as Thai Apple ber, Taiwan Apple ber, BAU ber and Red Apple ber were introduced recently. The fruits of Thai Apple ber were collected from eight different locations of Assam namely, Simen Chapori (Dhemaji District), Bongalmora (Lakhimpur District), Gela Pukhuri (Biswanath District), Napaam (Sonitpur District), Rowta (Udalguri District), Kamarbandha (Golaghat District), Naharkatia (Dibrugarh District) and Boitamari (Bongaigaon District) and fruits and leaves samples were collected from each location. The observation on morphological, physiological, phenological and biochemical characteristics of the Thai Apple ber fruits were recorded. The experiment was laid out in completely randomized design with eight treatments and three replications. The treatment allotments are as follows: BC-1: Fruits and leaves were collected from Simen Chapori (Dhemaji district); BC-2: Fruits and leaves were collected from Bongalmora (Lakhimpur district); BC-3: Fruits and leaves were collected from Gela Pukhuri (Biswanath district); BC-4: Fruits and leaves were collected from Napaam (Sonitpur district); BC-5: Fruits and leaves were collected from Rowta (Udalguri district); BC-6: Fruits and leaves collected from Kamarbandha (Golaghat district); BC-7: Fruits and leaves were collected from Naharkatia (Dibrugarh district); BC-8: Fruits and leaves were collected from Boitamari (Bongaigaon district). The morphological observations of leaves, fruits and seeds were recorded following the guidelines described in the descriptor published by NBPGR, Pusa Campus, New Delhi (Mahajan *et al.*, 2002)^[21] for ber (*Ziziphus mauritiana* Lamk). The length and diameter of Thai Apple ber fruits were taken with the help of Vernier Calliper. The fruit weight was taken on electronic balance. The volume of Thai Apple ber fruits were determined by water displacement method. The total soluble solids (TSS) of fruit juice of Thai Apple ber was recorded with the help of Pocket Refractometer according to standard procedure as given in AOAC (1986)^[1] in terms of degree Brix ($^{\circ}$ B) at room temperature. The titratable acidity of Thai Apple ber was determined as per the method of Ranganna (1986)^[28] by titrating sample against 0.1 N NaOH using phenolphthalein as an indicator. Sugars, Moisture and Ash content of Thai Apple ber fruit were determined according to AOAC (1980)^[1] method. The ascorbic acid content of Thai Apple ber was estimated by the method of Freed (1966)^[10]. The protein, vitamin A and calcium content of Thai Apple ber fruits were estimated by the method of Lowry *et al.*, (1951)^[19], Srivastava & Kumar, 2007^[34] and Baruah & Barthakur, 1999^[4] respectively. The phosphorus content of collected Thai Apple ber fruits were determined with the help of method described by Saini *et al.*, 2012^[30]. The data was statistically analyzed by using Panse and Sukhatme (1985)^[24] method.

Result and discussion

Leaf characters: It was found that there were no variations in leaf characters *viz.* leaf shape, mature leaf colour, leaf apex, leaf base and leaf margin of Thai Apple ber collected from different locations of Assam are presented in Table no.1 The leaf shape was found to be elliptic while colour of mature leaf of all the samples were dark green in colour. The leaf apex, leaf base and leaf margin were observed to be obtuse, oblique and serrate, respectively. Leaf length, maximum leaf breadth and petiole length differed significantly among the samples collected. Amongst the collections, BC-1 (Simen Chapori) produced longest leaf and maximum leaf breadth of 8.37cm and 4.83 cm, respectively. Similarly, BC-5 (Rowta) produced shortest leaf and leaf breadth *i.e.* 7.77cm and 3.97cm, respectively. The maximum petiole length 0.97cm was found in BC-8 (Boitamari) and shortest petiole length 0.73cm in BC-3 (Gela Pukhuri). The differences in leaf physical characters among the ber collections were probably due to the influence of climatic factors of that particular area. Li *et al.*, (2015) justified earlier that leaf morphology traits had a strong linear relationship with local precipitation and temperature. These findings were in agreement with the study of Dutta (1954)^[9]; Randhawa and Biswas (1966)^[27].

Fruit characters: Fruit size in terms of weight, length, width and fruit shape determine the physical characters of the variety are presented in table no.2. The fruit shape in Thai Apple ber was found to be ovate and oblong. However, there was no variation in colour of mature fruit and pulp. The colour of mature fruit and pulp in all the collections of ber was found to be light green and creamy white. Similarly, no variations were observed in fruit base and apex which was found to be depressed with lightly ridge and fruit apex as round with slight depression. Skin surface in all the collections were found to be smooth glossy except the fruit collected from Napaam (BC-4) which was found to be broadly pointed with depression fruit apex and rough and dull skin surface. Li *et al.* (2016)^[16] reported that climate, soil type and management strategies had an important role in altering the shape of fruits. In the present investigation, the variation in soil type and temperature might have resulted the different shapes, colour of the fruit and pulp. The variety harvested from Simen Chapori (BC-1) exhibited the highest fruit weight (53.08g) while, the lowest (42.22g) was recorded in BC-7 (Naharkatia). The variation among the collections as regard to average fruit weight might be due to inherent characters and climatic adaptability in a particular region. Besides this, the age, vigour of plant and eco-physiological conditions might have also influenced the fruit weight. In the present study, the production of bigger fruits produce by the plants of BC-1 (Simen Chapori) might also be due to higher chlorophyll index values leading higher production of photosynthates enabling the plant to produce bigger fruits. The present finding is in conformity with Mahajan and Dhillon (2000)^[20] and Kumar *et al.* (2014)^[13]. Variations in fruit length and width due to different factors have also been reported by Aulakh *et al.* (2005)^[2]; Dhanumjaya and Subramanyam (2010)^[8].

Table 1: Leaf characters of Thai Apple ber fruits

Treatment	Leaf shape	Leaf apex	Leaf base	Leaf margin	Leaf colour	Leaf length (cm)	Leaf breadth (cm)	Petiole length (cm)
BC-1	Elliptic	Obtuse	Oblique	Serrate	Dark green	8.37	4.83	0.90
BC-2	Elliptic	Obtuse	Oblique	Serrate	Dark green	8.10	4.10	0.87
BC-3	Elliptic	Obtuse	Oblique	Serrate	Dark green	7.90	4.23	0.73
BC-4	Elliptic	Obtuse	Oblique	Serrate	Dark green	7.83	4.27	0.77
BC-5	Elliptic	Obtuse	Oblique	Serrate	Dark green	7.77	3.97	0.83
BC-6	Elliptic	Obtuse	Oblique	Serrate	Dark green	8.13	4.13	0.83

BC-7	Elliptic	Obtuse	Oblique	Serrate	Dark green	8.20	4.13	0.77
BC-8	Elliptic	Obtuse	Oblique	Serrate	Dark green	8.13	4.12	0.97
LSD (P=0.05)	-	-	-	-	-	0.21	0.19	0.09

BC-1: Simen Chapori (Dhemaji district); BC-2: Bongalmora (Lakhimpur district); BC-3: Gela Pukhuri (Biswanath district); BC-4: Napaam (Sonitpur district); BC-5: Rowta (Udalguri district); BC-6: Kamarbandha (Golaghat district); BC-7: Naharkatia (Dibrugarh district); BC-8: Boitamari (Bongaigaon district)

Seed characters: The seed characters include seed shape, seed surface, seed weight, length and pulp-stone ratio which contribute to quality parameters of the fruit. The reduced size of the seed in fruits is considered as one of the desirables characters. In the present study, maximum seed weight (1.97) was recorded in BC-7 (Naharkatia) whereas BC-3 (Gela Pukhuri) produced the longest seed of 2.68cm with minimum pulp-stone ratio (18.76) while BC-4 (Napaam) had the shortest length of seed i.e 2.04 cm. (Table no.3) The decrease in pulp-stone ratio during ripening of fruits in storage indicated that there was an evapotranspiration loss of water from the pulp leading to its decreased weight; however, during ripening on tree, this loss was recouped from the supply of the plant. The variation in seed characters might be due to environmental variation or it might be due to variation in seed size. In the present study, observations on seed characters were in accordance with the Ghosh and Mathew (2002) [11].

Phenological characters: Time of flowering, duration of flowering from first flowering to last flowering and days from fruit set to fruit harvest were observed in Thai Apple ber plants of different location selected for the study. The time of flowering and duration of flowering from first flowering to last flowering varied from location to location in Assam. The early flower initiation was observed in BC-2(Bongalmora), BC-3(Gela Pukhuri) and BC-4 (Napaam) i.e. second week of September while late flowering was observed in BC-1 (Simen Chapori) i.e. fourth week of September. The average duration from first flowering to last flowering for all the Thai Apple ber ranged from 25-30 days. Similarly, days from fruit set to fruit harvest was observed in the range of 60-75 days (Table no.3). The flowering in different time and flower duration might be due to the variation in climatic conditions of the places. Dhaliwal and Bal (1998) [7] opined earlier that fruit set depends on physiological and environmental conditions. Later, Pareek (2001) [25] also reported that environment factors play a significant role to influence the phenotypic relationship.

Table 2: Fruit characters of Thai Apple ber fruits

Treatments	Fruit shape	Fruit Apex	Fruit base	Fruit Length (cm)	Fruit width (cm)	Fruit weight (g)	Pulp colour	Fruit Colour	Skin surface
BC-1	Ovate	Depressed, lightly ridge	Round, lightly ridge	5.00	4.23	53.08	Creamy white	Light green	Smooth glossy
BC-2	Oblong	Depressed, lightly ridge	Round, lightly ridge	4.30	4.07	47.53	Creamy white	Light green	Smooth glossy
BC-3	Oblong	Depressed, lightly ridge	Round, lightly ridge	4.87	3.97	48.23	Creamy white	Light green	Smooth glossy
BC-4	Ovate	Depressed, lightly ridge	Broadly pointed with depression	4.40	4.03	47.27	Creamy white	Light green	Rough and Dull
BC-5	Ovate	Depressed, lightly ridge	Round, lightly ridge	4.03	4.23	46.56	Creamy white	Light green	Smooth glossy
BC-6	Ovate	Depressed, lightly ridge	Round, lightly ridge	4.27	4.07	43.83	Creamy white	Light green	Smooth glossy
BC-7	Oblong	Depressed, lightly ridge	Round, lightly ridge	4.43	4.17	42.22	Creamy white	Light green	Smooth glossy
BC-8	Oblong	Depressed, lightly ridge	Round, lightly ridge	5.10	4.17	44.97	Creamy white	Light green	Smooth glossy
LSD(P=0.05)	-	-	-	0.02	0.10	3.90	-	-	-

BC-1: Simen Chapori (Dhemaji district); BC-2: Bongalmora (Lakhimpur district); BC-3: Gela Pukhuri (Biswanath district); BC-4: Napaam (Sonitpur district); BC-5: Rowta (Udalguri district); BC-6: Kamarbandha (Golaghat district); BC-7: Naharkatia (Dibrugarh district); BC-8: Boitamari (Bongaigaon district)

Table 3: Seed characters and phenological characters of Thai Apple ber fruits

Treatments	Seed shape	Seed surface	Seed Length (cm)	Seed weight (g)	Pulp/ stone ratio	Time of flowering	Duration of flowering (days)	Days from flowering to fruit set (days)
BC-1	Ovate	Warty	2.08	1.07	23.28	4 th week of September	20-25	60-70
BC-2	Ovate	Warty	2.17	1.67	20.60	2 nd week of September	25-30	65-75
BC-3	Ovate	Warty	2.68	1.83	18.76	2 nd week of September	25-30	65-70
BC-4	Ovate	Warty	2.04	1.60	21.09	2 nd week of September	20-30	65-70
BC-5	Ovate	Warty	2.16	1.67	20.09	3 rd week of September	20-30	70-75
BC-6	Ovate	Warty	2.09	1.67	20.31	3 rd week of September	25-30	70-75
BC-7	Ovate	Warty	2.24	1.97	19.53	3 rd week of September	25-30	70-80
BC-8	Ovate	Warty	2.22	1.77	19.69	3 rd week of September	25-30	65-75
LSD(P=0.05)	-	-	0.15	0.16	1.43			

BC-1: Simen Chapori (Dhemaji district); BC-2: Bongalmora (Lakhimpur district); BC-3: Gela Pukhuri (Biswanath district); BC-4: Napaam (Sonitpur district); BC-5: Rowta (Udalguri district); BC-6: Kamarbandha (Golaghat district); BC-7: Naharkatia (Dibrugarh district); BC-8: Boitamari (Bongaigaon district)

Biochemical characters: The total soluble solids content of Thai Apple ber fruits ranged from 10.67 per cent to 13.67 per cent. Fruits collected from Simen Chapori (BC-1) exhibited the highest TSS (13.67 %) followed by BC-5 (Rowta) while lowest TSS content (10.67 %) was found in BC-4 (Napaam). Shukla *et al.* (2007) [33] pointed out that most of the ber cultivars exhibit good level of TSS under hot arid ecosystem and generally dry weather favours enhanced TSS in most of the cultivars. The differences in the values of TSS in the present study could be attributed to seasonal climatic variation in the areas. Titratable acidity of collected samples ranged from 0.35 to 0.44 per cent (Table no.4). Variation in titratable acidity might be due to acids have been converted to sugars and derivatives by the reactions involving the reversal of glycolytic pathway used in the respiration. The present finding is in conformity with Wu *et al.*, (2012) [35]. Similar results were also reported by (Chen *et al.*, 2018) [5] in Chinese jujube. There was variation among the Thai Apple ber fruits in TSS-acid ratio in fruits collected from different localities in the present study. It was observed that TSS-acid ratio ranged from 24.25 to 39.06. Similar levels of TSS-acidity were also reported by Kumari *et al.* (2015) [14]. The data presented in Table no.4 revealed that total sugar content of the fruit harvested from 8 different location of Assam ranged from 6.37 per cent to 7.81 per cent. Similarly, reducing sugar content ranged from 2.44 per cent to 3.06 per cent. The highest total sugar (7.81%) was obtained in fruits of Simen Chapori (BC-1). The variation in sugars content was probably due to agronomic practices and position of fruits on the tree with respect to sunlight. Godi *et al.* (2016) [12] also found variations in the sugar content among different jujube cultivars. The moisture content of Thai Apple ber fruits collected from different locations of Assam ranged from 84.83 per cent to 88.10 per cent as presented in Table no.4. The variation in moisture contents of fruits might be significantly affected by cultivation conditions as reported earlier by Maraghi *et al.*, (2011) [23]. The decrease in moisture content during both on tree as well as in storage could be attributed to evapo-transpiration losses or its utilization during the hydrolysis of insoluble metabolites to soluble metabolites. The present finding was in conformity with work of Chen *et al.*, (2018) [5] in Chinese jujube. Similarly, ascorbic acid content varied from 22.00 mg/100 g to 27.87mg/100 g (Table no.5) in Thai Apple ber fruits collected from different locations of Assam. The accumulation of ascorbic acid was slow during the initial stages of fruit growth and was rapid during subsequent period. The rapid increase in ascorbic acid content might be the result of greater synthesis of glucose-6 phosphate, a precursor of L-ascorbic acid. Kumar (2014) [13] reported that the higher

content of ascorbic acid in litchi might be due to higher sunshine hours during fruit development period. In the present study, variation in sunshine hours in selected areas of Assam from where Thai Apple ber fruits were collected might have resulted variation in the values of ascorbic acid contents. Chen *et al.* (2018) [5] also recorded significant differences on the levels of ascorbic acid in fruits of different districts in China. Vitamin A content was found to have variation among the Thai Apple ber fruits collected from different location under the study. It was observed that Vitamin A content ranged from 14.61 µg/100g to 16.08 µg/100g. Lester (2006) [15] confirmed that variation in phyto-nutrients was inevitable as both genetics and environment influenced the rate of synthesis and degradation of vitamin A in fruits. Ash is the organic residue remaining after the water and organic matter have been removed by heating in the presence of oxidizing agents. In the present study, ash content of Thai Apple ber collected from different locations varied from 2.03 percent to 2.80 percent. However, the ash content of the Thai Apple ber fruits of BC-7, BC-6 and BC-4 were higher than rest of the locations. The variation of soil type and management practices might have lead to variation in ash contents of fruits. The results were in agreement with the findings of Li *et al.*, (2007) and Pareek (2013) [26]. The protein content of Thai Apple ber fruits of BC-2 (Bongalmora) had 0.87g/100g and it was higher than rest of the collections. The decrease in protein content of fruit pulp during development and maturity of ber fruits might be attributed to hydrolysis of protein by increased activity of enzyme protease of the fruit pulp. This increased protease activity could be correlated with the reduced level of proteins during development and maturity of ber fruits. Protein content in ber fruits decreased towards the maturity of fruits. The present finding of the study was in conformity with the results of Sharma and Bawa (1977) [32]. There was a considerable variation in calcium and phosphorus contents of Thai Apple ber fruits collected from different locations of Assam for the study. The results showed that calcium contents ranged from 20.48mg/100g fruits to 23.50mg/100g and phosphorus contents ranged from 24.08mg/100g fruits to 25.25mg/100g in Thai Apple ber fruits (Table no.5). The variation in calcium and phosphorus contents of the fruit might be due to variation in climatic conditions and nutrient status of soil of the growing locations selected for the study. Sharma (1996) [31] observed that calcium content decreased progressively with the advancement of ripening, and it showed a high positive correlation with fruit firmness. The present findings of the study get support from the Morton (1987) [22] and Ara *et al.* (2014).

Table 4: Biochemical characters of Thai Apple ber

Treatments	TSS (%)	Titratable acidity (%)	TSS:acid ratio	Reducing sugar (%)	Total sugar (%)	Moisture content (%)
BC-1	13.67	0.35	39.06	3.06	7.81	88.10
BC-2	11.33	0.42	26.98	2.71	6.73	85.77
BC-3	12.67	0.36	35.19	2.58	6.72	85.53
BC-4	10.67	0.44	24.25	2.64	6.37	87.97
BC-5	13.33	0.35	38.08	2.82	7.45	87.80
BC-6	12.67	0.41	30.90	2.56	7.16	86.80
BC-7	12.33	0.40	30.83	2.71	6.90	84.83
BC-8	12.33	0.42	29.35	2.44	6.88	87.50
LSD (P=0.05)	1.45	0.01	-	0.19	0.65	0.87

BC-1: Simen Chapori (Dhemaji district); BC-2: Bongalmora (Lakhimpur district); BC-3: Gela Pukhuri (Biswanath district); BC-4: Napaam (Sonitpur district); BC-5: Rowta (Udalguri district); BC-6: Kamarbandha (Golaghat district); BC-7: Naharkatia (Dibrugarh district); BC-8: Boitamari (Bongaigaon district)

Table 5: Biochemical characters of Thai Apple ber

Treatments	Ascorbic acid (mg/100g)	Vitamin A (µg/100g)	Ash content (%)	Protein (g/100g)	Calcium (mg/100g)	Phosphorus (mg/100g)
BC-1	27.87	15.08	2.03	0.80	20.48	24.30
BC-2	26.40	14.61	2.37	0.87	20.48	24.42
BC-3	24.53	16.08	2.40	0.76	20.55	24.08
BC-4	26.07	14.85	2.53	0.76	21.40	25.05
BC-5	27.13	15.18	2.30	0.86	21.95	25.25
BC-6	22.00	16.00	2.73	0.75	23.50	25.05
BC-7	25.60	15.15	2.80	0.81	22.87	24.80
BC-8	27.00	14.80	2.33	0.82	21.90	24.82
LSD(P=0.05)	2.00	0.46	0.31	0.05	0.65	0.25

BC-1: Simen Chapori (Dhemaji district); BC-2: Bongalmora (Lakhimpur district); BC-3: Gela Pukhuri (Biswanath district); BC-4: Napaam (Sonitpur district); BC-5: Rowta (Udalguri district); BC-6: Kamarbandha (Golaghat district); BC-7: Naharkatia (Dibrugarh district); BC-8: Boitamari (Bongaigaon district)

Conclusion

The results of the present experiment reveals that a large variation exists in both morphological and biochemical characters of the fruits of Thai Apple ber collected from eight different locations of Assam. The variation in the morphological and biochemical characters of the fruits collected from different locations was highly influenced probably by the climatic conditions prevailing in those respective locations and also influenced by some others factors like soil types and nutrient status and management practices.

Since the present investigation was carried out in few Thai Apple growing locations of Assam only, further study in relation to soil and plant nutrient status, soil moisture content and management practices in the Thai Apple growing areas of Assam might be confirm the variability in morphological and biochemical characters of Thai Apple ber fruits. Again, further study on the molecular level of Thai Apple fruits may also help in different crop improvement programme of this crop.

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