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Fruit Growth and Proximate Composition of *Dilllenia indica* Linn.

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ABSTRACT

***Dillenia indica* Linn. is an important minor fruit of Dilleniaceae. It is commonly known as 'Chalta' in Bangladesh. Botanically, chalta is a pseudo fruit where the persistent and fleshy calyx with interior ovary forms the prominent edible part. Though eaten fresh, the fruit is usually cooked and it can be made into juice, jam, jelly, pickles and chutney. Fruit growth and nutritional composition of chalta were investigated at the Botanical Garden of Bangladesh Agricultural University, Mymensingh (24º26' and 24^{0}54' N and 90^{0}15' and 90^{0}30' E) between August and October, 2011 to ascertain the horticultural harvesting stage of fruit. Flowers were tagged at first opening (days after flowering) and fruit growth was investigated up to harvest maturity. Fruit size (length and diameter), and growth of calyx were investigated at 7-days interval up to 77 days after flowering. Calyx and fruit size, and fruit weight were gradually increased with increasing ages, up to 77 days after flowering. However, the increment between 75 and 77 days after flowering appeared non-significant. Hence, the fruit harvesting age was set at 75 days after flowering. The fruit length and diameter (9.50 and 11.51 cm, respectively) were attained at 75 days after flowering. The length, breadth, and thickness of individual sepal (9.94, 9.28, and 2.20 cm, respectively) were obtained at 75 days after flowering. The fresh and dry weights of calyx (480.53 and 163.73 g, respectively) were also recorded at 75 days after flowering. The calyx of 75 days aged contained appreciable amount of crude protein, crude fibre, crude fat, ash, and total carbohydrate (5.70, 32.02, 3.34, 4.61, and 51.22%, respectively). It might be concluded that harvest maturity of chalta attained around two and a half months from flowering when fruits turn into yellowish green colour with average fruit fresh weight of 523 g.**

Key words: *Dillenia indica,* fruit growth, harvest maturity, nutrient composition.

INTRODUCTION

Dillenia indica Linn. is an evergreen large shrub or small to medium- sized tree belongs to family Dilleniaceae. It is commonly known as 'Chalta or Hargesa' (Dipal and Priti 2013) and 'Chalita' (Talukdar *et al.,* 2012). It grows all over the Bangladesh (Parvin *et al.,* 2009) and widely distributed in South-east Asia (Ramesh *et al.,* 2008). It is a spreading tree and has beautiful white fragrant flowers, toothed leaves, and globose fruits with small brown seeds (Janick and Paull 2008). Flowering occurs in July-August and fruit ripens in November-December (Dipal and Priti 2013). Fruits of chalta are globose, 10–15 cm in diameter, indehiscent, persistent sepals, fleshy and slightly swollen (Dipal and Priti, 2013). The fruit of chalta is a special type, where the enlarged persistent fleshy calyx forms the predominant edible part (Bose *et al.,* 2002). The ripe fruits are widely used in the flavoring curries and preparation of jam and jelly (Sunil *et al.,* 2011; Kumar *et al.,* 2011) and good beverages, jam, jelly, pickles and chutney can be prepared (Saikia and Dutta 1995). Fruits are nutritionally rich and contain (per 100 g of edible portion) calories 59, fibre 2.1-2.5 g, fat 0.2-0.34 g, protein 0.8 g, ash 3.54 g, phosphorus 26 mg, calcium 16 mg (Neog and Mohan 1993; Saikia and Dutta 1995). Chalta possess many medicinal properties and it is reputed as a cooling beverage in fever, expectorant in cough mixture, tonic, laxative and astringent (Maniruzzaman and Samhita 1993).

Assessment of fruit maturity indices is important to ensure sensory traits (flavour, colour, aroma, and texture) and nutritional quality, and increase postharvest shelf life. Appropriate maturity indices also facilitate scheduling of harvest and packing operations and marketing of products (Dhatt and Mahajan, 2007). Horticultural maturity is the stage of development at which a plant or plant part possesses the prerequisites for use by consumers for a particular purpose i.e. ready for harvest (Dhatt and Mahajan 2007). A given commodity may be horticultural mature at any stage of development. Horticultural maturity of chalta fruits is considered when they attained a desirable size with good fibre content for making juice, jam, jelly, pickles and chutney, whereas physiological maturity commences at maximum seed dry weight. In general, fruit maturation is accompanied by significant changes in external appearance. Any fruit picked either early or too late is more susceptible to physiological disorders or has a shorter shelf life than fruit picked at the proper maturity (Kader, 1999). A couple of researches on growth of minor fruits such as in cowphal (*Garcinia cowa*) (Roy *et al.,* 2010), china cherry (*Muntingia calabura*) (Rahman *et al.,* 2010), deshi and bilati gab (Hasan *et al.,* 2014) has performed and

only one report on chalta in Bangladesh (Hasan *et al.*, 2015) is available. Hence, the current study was conducted (i) to investigate the fruit growth of chalta at different ages; and (ii) to determine the nutritional value (proximate composition) of the fruit. Overall objective was to ascertain the right stage of fruit harvest i.e. horticultural maturity.

MATERIALS AND METHODS

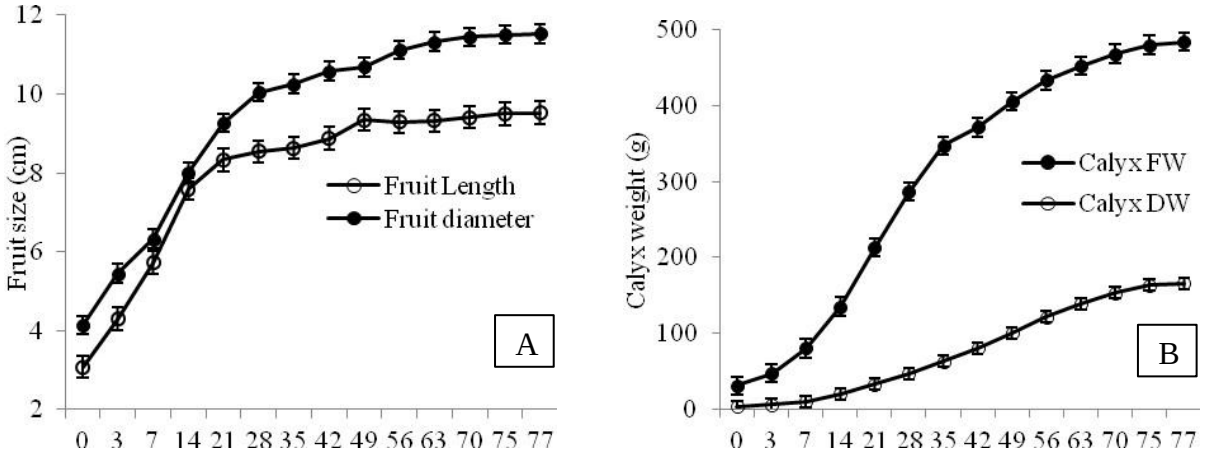
Three chalta trees were selected at Botanical Garden and Faculty of Veterinary Science in the Bangladesh Agricultural University campus, Mymensingh to study the fruit growth during August to October, 2011. Different coloured woolen threads were loosely fastened in the pedicel of flowers to record fruit age at 0, 3, 7, 14, 21, 28, 35, 42, 49, 56, 63, 70, 75 and 77 days after first opening of flowers (DAF). At each DAF, at least 15 fruits (five each from three replicates) were harvested. Fruit length and diameter were measured by ruler. The length and breadth of calyx were also recorded by ruler, while calyx thickness was measured by slide calipers. The sepal was divided into two equal halves and thickness was determined from the maximum thickened middle portion. Fresh weight of freshly harvested fruits were recorded and then shelled and the seeds were separated. The dry weight of calyx and seed were recorded after oven drying (80 ± 2^0C) till constant weight. The absolute growth rate, AGR= $\{(W_2-W_1) \div (T_2-T_1)\}$ of calyx was also calculated, where W and T represent fresh weight and time of fruit harvest, respectively. The proximate constituents: crude protein (CP), crude fibre (CF), ether extract (EE) or crude fat, ash, and nitrogen free extract (NFE) or total carbohydrate of calyx were determined at four (42, 56, 75, and 77) DAFs (AOAC, 1990). The Completely Randomized Design (CRD) was followed with three replications. Different ages i.e. DAFs were used as treatment in analyzing the data. The program MSTAT-C (Russell, 1986) was used to analyze the data. The mean differences were compared by least significant difference (LSD) test (Gomez and Gomez 1984).

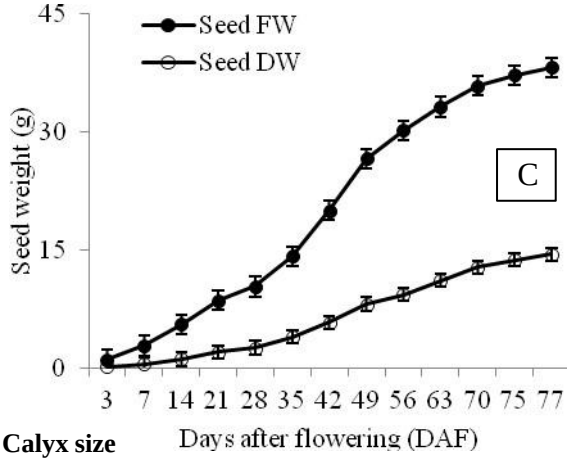
RESULT AND DISCUSSION

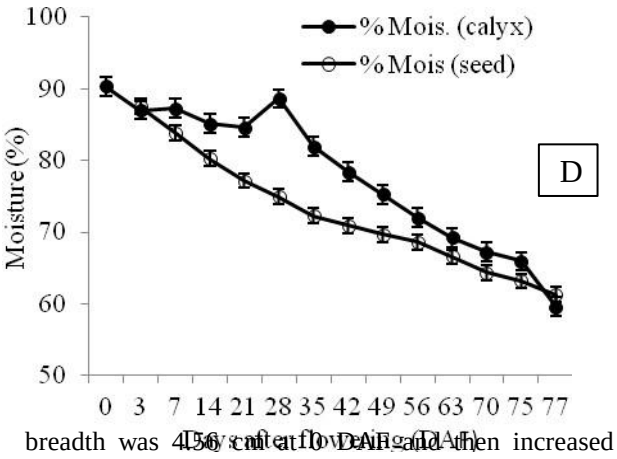
Fruit size

Fruit length and diameter followed sigmoid growth pattern and increased with increasing ages (days after flowering, DAF) (Fig. 1A). The length was 3.08 cm at first day of flower opening and grew rapidly and reached 7.59 cm at 14 DAF. After that, fruit length increased gradually and reached maximum at 77 DAF (9.53 cm). Fruit diameter also followed almost similar pattern to that of length but at higher rate. At initial stage (0 DAF), it was 4.14 cm and increased very rapidly up to 28 DAF (10.05 cm) and then gradually increased towards horticultural maturity (11.54 cm) (Fig. 1A). Sigmoid growth pattern in *Dillenia* fruits was also observed by Bose *et al.,* (2002) and Das *et al.,* (2011). The present result regarding fruit diameter is in partial conformity with the report of Bose *et al.,* (2002) who reported that fruit diameter of chalta ranged from 10 to 15 cm. Talukdar *et al.,* (2012) reported that fruit diameter of *Dillenia indica* ranged from 7.5 to 10 cm which also agrees the present finding. The increase in fruit diameter can be attributed to an increase in the size of the cells and accumulation of carbohydrates and mucilage in the intercellular spaces in fruit (Bollard 1970).

Fig. 1. Changes in fruit size (A), calyx and seed weight (B, C) and moisture (%) in chalta at different ages (DAF). Vertical bars indicate $lsd_{0.05}$.







Calyx size

Significant variation was observed in case of calyx size (length, breadth and thickness) at different ages (DAF) (Table 1). Like fruit size and weight, the length, breadth, and thickness of calyx also attained maximum value at horticultural mature stage i.e. at 77 DAF (Table 1). Calyx length was 5.17 cm at first day of flowering followed by rapid increase up to 28 DAF (8.36 cm). Thereafter, length increased gradually towards picking period and attained an average of 9.96 cm (between 75 and 77 DAF) (Table 1). Calyx breadth was 4.56 cm at 0 DAF and then increased sharply up to 42 DAF (8.63 cm) followed by gradual but slow increase towards horticultural maturity with an average of 9.29 cm (between 75 and 77 DAF) (Table 1). At initial stage (0 DAF) calyx thickness was 0.49 cm followed by gradual increase up to 7 DAF and thereafter attained maximum rate between 14 and 28 DAF (average of 1.24 cm). At later stage of growth, thickness increased slowly towards picking period with an average size of 2.22 cm (between 75 and 77 DAF) (Table 1).

Table 1. Variation in calyx size, calyx: to fruit ration, and absolute growth rate (AGR) of chalta at different ages (days after flowering, DAF)

DAF	Calyx size (cm)			Calyx: Fruit	DAF (AGR)	AGR of calyx (gd^{-1})
	Length	Breadth	Thickness			
0	5.17m	4.56m	0.49l	1.00a	-	-
3	5.36l	4.64l	0.55k	0.98ab	0-3	0.49i
7	5.54k	5.26k	0.71j	0.96ab	3-7	1.01h
14	5.90j	6.16j	0.84i	0.96ab	7-14	1.48g
21	6.95i	6.83i	1.22h	0.96ab	14-21	1.79f
28	8.36h	7.57h	1.67g	0.97ab	21-28	2.01e
35	8.51g	8.02g	1.77f	0.96ab	28-35	2.28d
42	9.08f	8.63f	1.92e	0.95ab	35-42	2.51c
49	9.25e	8.82e	2.01d	0.94b	42-49	2.86b
56	9.42d	9.01d	2.09c	0.94b	49-56	3.02a
63	9.57c	9.11c	2.14bc	0.93b	56-63	2.53c
70	9.72b	9.20b	2.18ab	0.93b	63-70	2.05e
75	9.94a	9.28a	2.20a	0.93b	70-75	1.45g
77	9.98a	9.30a	2.23a	0.93b	75-77	1.03h
$lsd_{0.05}$	**0.05**	**0.08**	**0.05**	**0.05**	**-**	**0.12**
Sig. level	**	**	**	*	-	**
CV (%)	**0.40**	**0.56**	**1.67**	**1.88**	-	**3.85**

In each column, figures bearing uncommon letter(s) are significantly different at P≤0.05. Each figure is the mean of 15 fruits (5 fruit × 3 replications). **= Significant at 1% level of probability, *= Significant at 5% level of probability.

Calyx weight

Calyx fresh weight followed a typical sigmoid pattern while dry weight followed almost a linear pattern (Fig. 1B). Fresh weight of calyx was 30.89 g at first day of flowering and increased very rapidly up to 35 DAF (347.83 g) followed by a gradual increase up to harvest maturity with maximum weight of 484.42 g. Calyx dry weight was 2.97 g at first day of opening and linearly increased to 165.79 g towards harvestable stage (Fig. 1B).

Seed weight

Like calyx weight, seed fresh weight also followed a sigmoid pattern while dry weight followed almost a linear pattern (Fig. 1C). Seed fresh weight was 1.03 g at 0 DAF and increased linearly up to 10.32 g (28 DAF) followed by a sharp increase till 49 DAF (26.60 g). After that, fresh weight again increased gradually towards maturity 38.21 g. Seed dry weight was 0.12 g at first day of flowering and then increased almost linearly to 14.41 g at harvestable condition (Fig. 1C).

Fruit (calyx and seed) weight attained maximum at 77 DAF (523 g). The present result regarding fruit weight is in partial conformity with the report of Bose *et al.,* (2002) who reported that single fruit weight of *Dillenia* ranged between 400 and 600g.

Moisture of calyx and seed

Moisture content of both calyx and seed decreased with increasing ages (DAF) (Fig. 1D). Initially, moisture content of calyx was highest at 0 DAF (90.37%) and then decreased gradually up to 21 DAF (average of 86.02%) followed by an increase at 28 DAF (88.66%). Later on, moisture content of calyx again decreased gradually and reached the minimum at 77 DAF (59.58%). Highest seed moisture was found at 3 DAF (87.51%) and lowest (61.27%) recorded at 77 DAF (Fig. 1D). The decrease in moisture content towards harvesting maturity might be due to an increase in fibre content and dry matter accumulation in calyx (Bose *et al.,* 2002).

Calyx to fruit ratio

Calyx to fruit ratio was statistically significant at different ages (DAF) (Table 1). It was maximum (1.00) at 0 DAF followed by gradual decrease up to 42 DAF (average of 0.96) and minimum value was recorded between 63 and 77 (average of 0.63). Decreased calyx to fruit ratio with increasing ages might be due to increase in seed weight along with high accumulation of mucilage pulp in seeds towards harvest period. Decreased pulp to fruit ratio with increasing ages after flowering was reported in *Garcinia cowa* (Roy *et al.,* 2010).

Fruit absolute growth rate (AGR)

Effect of ages (days after flowering, DAF) on AGR of fruit was significant ($P \leq 0.05$) in chalta (Table 1). The AGR increased gradually with the advancement of ages and showed greater between 49 and 56 DAF (average of 3.02 g/day). After that AGR again declined towards maturity. AGR of calyx was not highest at horticultural mature stage which indicates that it may not be used a reliable index of fruit harvest.

Proximate Composition of calyx

Calyx of chalta showed significant variation in terms of crude fibre, ash and nitrogen free extract content (Table 2). Maximum crude protein and ash content (5.90% and 20.25%, respectively) were found at 42 DAF while highest ether extract and total carbohydrate (3.55% and 54.76%, respectively) were recorded at 56 DAF (Table 2). Crude fibre content was maximum (33.95%) at right harvest stage of fruit i.e. 77 DAF. Proximate composition is considered as a predictor of fruit maturity in terms of nutritional quality (Roy *et al.,* 2010; Rahman *et al.,* 2010; Hasan *et al.,* 2014). Edible calyx of 77 DAF contained crude protein, crude fibre and crude fat (5.64, 33.95 and 3.33%, respectively) but according to Neog and Mohan (1993), and Saikia and Dutta (1995) *Dillenia* fruits contained protein (0.8%), fibre (2.1-2.5%) and fat (0.2-0.34%). These variations in proximate composition might be due to different maturity stages, cultivars, climate etc. However, calyx of 77 DAF aged contained 4.74% ash which is in partial conformity with Neog and Mohan (1993); Saikia and Dutta (1995) who reported about 3.54 g ash content per 100 g of edible portion. In case of *Dacryodes edulis*, the amount of crude protein and carbohydrate of fruits varied during various maturation stages and the fully matured fruits contained lowest value (5.13, and 16.07%, for protein and carbohydrate respectively) (Majesty *et al.,* 2012). Therefore, the calyx of chalta possesses appreciable nutrition in terms of proximate composition.

Table 2. Proximate composition (crude protein-CP, crude fibre-CF, ether extract-EE, ash and total carbohydrate-NFE) of calyx of chalta at different ages (days after flowering, DAF)

DAF	% Proximate Constituents				
	CP	CF	EE	Ash	NFE
42	5.90	20.93d	3.23	2.25c	47.33d
56	5.80	22.22c	3.55	4.58b	54.76a
75	5.70	32.02b	3.34	4.61b	51.22b
77	5.64	33.95a	3.33	4.74a	48.71c
$lsd_{0.05}$	**0.42**	**0.55**	**0.42**	**0.11**	**1.23**
Sig. level	**NS**	**	**NS**	**	**
CV (%)	**3.62**	**1.01**	**6.33**	**0.69**	**1.22**

In each column, figures bearing uncommon letter(s) are significantly different at P≤0.05. Each figure is the mean of 15 fruits (5 fruit × 3 replications). **= Significant at 1% level of probability, NS= Non significant.

Fruits of chalta require about 160 days reaching the stages of harvest maturity (Das *et al.*, 2011). But under Bangladesh contest, around two and a half months duration is required from flowering to fruit harvesting. This variation might have occurred due to variety and climatic factor. Changes in visual appearance of fruits have also been reported in China cherry (Rahman *et al.*, 2010), cowphal (Roy *et al.*, 2010) and deshi and bilati gab (Hasan *et al.*, 2014) to ascertain fruit maturity stage. Around two and a half months from flowering, the chalta fruits developed yellowish green colour (observation). Such future study on visual indices may be important.

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