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DETERMINATION OF MATURITY INDICES OF BER (*Zizyphus Mauritiana* Lam.) VAR. BARI KUL-2

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Abstract

A study was conducted at Fruit Research Farm and Postharvest Technology Laboratory of Horticulture Research Centre, Bangladesh Agricultural Research Institute during the period from October 2009 to February 2010 to determine the maturity indices of ber. The ber variety BARI Kul-2 was selected for conducting the study. Ber fruits were tagged at fruit setting stage and harvested at 90, 100, 110, 120 days after fruit set (treatments). The physicochemical characters like fruit weight and size, specific gravity, TSS (%), sugar (%), acidity (%), pulp-stone ratio, TSS-acid ratio, sugar-acid ratio as well as subjective sensory attributes like fruit colour and texture, and storage traits like storage life, physiological weight loss (%), ripening status and decay, browning and shriveling (%) of harvested fruits were evaluated for determining the proper stage of commercial maturity. The fruit weight, TSS (%), pulp-stone ratio, TSS/acid ratio, sugar-acid ratio and specific gravity of BARI Kul-2 were found 24.33g, 15.60, 15.66, 39.72, 16.14 and 0.98, respectively, at 110 days after fruit set. Considering all the physical and chemical characters matching with subjective parameters, fruits of BARI Kul-2 was found commercially mature after 110 days of fruit set when the fruits turned into light greenish yellow to greenish yellow colour and specific gravity less than 1.00.

Introduction

Ber (*Zizyphus mauritiana* Lam.) or Indian jujube belongs to the genus *Zizyphus* of the family *Rhamnaceae* or buckthorn family which has about 50 genera and more than 600 species (Pareek, 1983). It is an important fruit in Bangladesh. This fruit is very popular among the people of all social strata for its nourishing value and good taste and lower price. Ber is one of the most nutritious fruits with medicinal value. It is one of the richest sources of Vitamin C, next to aonla and guava but better than citrus fruits and apple (Bal and Uppal, 1992).

The word 'Maturity' of a crop refers to an assessment of physiological development which is of two types; physiological maturity and commercial

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maturity (Shewfelt and Prussia, 1993). Physiological maturity is described as "the stage of development when a plant or plant part will continue ontogeny even if detached" whereas commercial maturity is defined as "the stage of development when a plant or plant part possess the prerequisites for utilization by the consumer for a particular purposes" (Watada *et al*., 1984). Maturity is an integral component of quality, especially in the context of commercial maturity (Will *et al*., 1998). On the other hand 'Index' is the sign or indication of the readiness of fruits for harvest according to consumer's choice (Bautista, 1990). Index is of two types-subjective and objective. The former includes colour, size, changes in appearance, feel, sound, smell etc., whereas, the objective indices include chemical constituents, dry matter content, age, weight, length, breadth or diameter etc. Horticultural maturity is equals to commercial maturity. In case of fruit, it is usually refers to the stage when it possesses the necessary characters preferred by the consumers.

Harvesting of fruits at proper stage of maturity is very much important both for maintaining quality and marketing. Ripening of fruit may take place either before or after harvest, but it is generally accepted that postharvest ripening of ber only occurs if the fruit is sufficiently mature when picked. Immature fruits do not have satisfactory sweetness and taste. Overmature fruits, on the other hand, lose their attractiveness and crispiness and became slimy in texture within a very short time (Pareek, 2001). Abbas (1997) stated that fruit colour, percentage of titrable acids and total soluble solids are the most important maturity indices shown for ber fruits grown in Basrah region, but research in India indicates that the specific gravity of the fruit and fruit colour are more suitable indices (Bal, 1980; Bal and Singh, 1978; Bhatia and Gupta, 1985; Bal and Uppal, 1992).

Bangladesh Agricultural Research Institute released a ber variety named BARI Kul-2 in 2002. It is a heavy bearer good quality variety having potentials to commercial cultivation. In view to providing information to growers to harvest at proper stage for better marketing, maturity indices of the variety should be standardized. Therefore, the present study was undertaken to determine the proper stage of maturity in view to find out proper time of harvesting of BARI Kul-2.

Materials and Method

The experiment was conducted on existing ber orchard at Fruit Research Farm and Postharvest Technology laboratory of Horticulture Research Centre, Bangladesh Agricultural Research Institute (BARI) during the period from October 2009 to February 2010. Three trees were selected, each of which was considered as a replication. The selected trees were of 6 years old with approximately uniform growth and size, under same management practices. The trees were fertilized with 25 kg well decomposed cowdung, 750g Urea, 600g

TSP and 600g MP in two split of doses at the end of May and beginning of November with light irrigation (Islam, 2005; Hossain *et al*., 2009). The experiment was laid out in Randomized Completely Block Design (RCBD) with three replications. Fruits were tagged at fruit setting stage and harvested at 90, 100, 110, 120 and 130 days after fruit set (treatments). Two hundred fruits from each tree were plucked randomly for studying different physical, biochemical and quality characteristics. Then these were carried to the laboratory of Postharvest Technology Section, and analyzed for physical and chemical characters on the day of harvesting. One hundred fruits were kept at ambient condition for storage studies. Sensory evaluation was done by panel of judges consisting of five members both for fresh harvested fruits as well as stored ones.

Physical Characters: Weights of fruit and stone were measured by electrical balance. Length, breadth and circumference of fruit were recorded by slide caliper and scale. Pulp-stone ratio was calculated from the following formula:

Pulp-stone ratio = (Fruit weight-stone weight)/Stone weight

Chemical analysis: The biochemical and nutritional parameters were determined by the methods described in the Manual of Analysis of Fruit and Vegetable products (Rangana, 1986). Acidity, vitamin-C and TSS (%) were determined at the day of fruit harvesting. Acidity by treating against standard NaOH solution, ascorbic acid by 2, 6- Diclorophenol-Indophenol Visual Titration Method and TSS (%) by brix meter were determined. These methods were conducted according to Rangana (1986).

Storage studies: Physiological loss in weight (PLW), storage life and physical appearance of harvested fruits were evaluated for storage potentiality. The weight loss (%) and storage life were evaluated as follows:

Physiological loss in weight (%): It was determined by periodic weighing of ber fruits and expressed as percentage of its initial weight by following formula:

$$\%PLW = \frac{W_0 - W_1}{W_0} X100$$

Where, PLW = Physiological loss in weight

W_0 = Initial weight of ber fruits kept for storage (on the day of harvesting)

W_1 = Final weight of ber fruits on selected days after harvesting

Storage life (Day): The storage life of fruits was determined by judging the non-marketability parameters like decay or damaging, shriveling, skin browning, ripening status, odd-flavour etc. at ambient condition.

Sensory evaluation: Sensory evaluation was done both for fresh as well as stored fruits after 3 and 6 days of storage. The physico-morphological qualities

like skin colour, pulp texture and taste were evaluated by a panel of judges consisting of 5 members of scientific personnel. They were asked to evaluate the traits by a scoring rate on a 9- point hedonic scale, i.e. 9=Like extremely, 8=Like very much, 7=Like moderately, 6=Like slightly, 5=Neither like nor dislike, 4=Dislike slightly, 3=Dislike moderately, 2=Dislike very much and 1=Dislike extremely. The different preferences as indicated by scores were evaluated by statistical methods.

Statistical analysis: A two way analysis of variances (ANOVA) was done for different parameters by using statistical method (MSTAT C). The mean separation was done by Duncan's Multiple Range Test (DMRT).

Results and Discussion

Significant variation was found both on physical and chemical characters of fruits as well as storage life and quality attributes.

Physical characters

Weight, length, breadth, and circumference of fruit, stone weight, pulp-stone ratio and specific gravity, all the characters differed significantly (Tables 1 & 2). Fruit weight was found maximum (28.60g) after 130 days of fruit set followed by 120 (26.53g) and 110 days (24.33g). On the contrary, the fruits harvested 90 days after fruit set had the minimum weight (14.41g) among the selected five days of harvesting. Fruit length (4.18 cm), breadth (3.61 cm), and circumference (11.57 cm) were found maximum at 130 days but these were statistically similar with the fruits harvested at110 and 120 days (4.04 and 4.16 for length, 3.44 and 3.55 cm for breadth and 11.25 and 11.43 cm for circumference, respectively). The lowest length, breadth and circumference of fruits were recorded from the fruits harvested 90 days after fruit set. Pulp-stone ratio was computed high (17.75) from the fruits harvested 130 days after fruit set while it was recorded minimum (11.21) at 90 days. Moderate pulp-stone ratio was obtained from the fruits harvested at 110 and 120 days after fruit set (15.66 and 16.81, respectively). Fruits harvested at 110,120 and 130 days after fruit set had the specific gravity <1 (0.98, 0.95 and 0.93, respectively) whereas it was calculated >1 from the fruits harvested at 90 and 100 days after fruit set (1.04 to 1.01, respectively). Bal and Uppal (1992) reported that the best indicator for judging the maturity of ber fruit is that the specific gravity should be less than one. Specific gravity at harvest maturity in Kaithli, Gola and Umran variety were observed as 0.88, 0.93 and 0.81 respectively, in India (Bhatia and Gupta, 1985).

Table 1. Physical characteristics of ber fruits var. BARI Kul-2 influenced by days to maturity.

Days after fruit set (Maturity)	Fruit weight (g)	Fruit length (cm)	Fruit breadth (cm)	Fruit circum-ference (cm)	Stone weight (g)	Pulp-Stone ratio	Specific gravity
90	14.41 e	3.25 c	2.83 c	9.13 c	1.18 d	11.21d	1.04 a
100	19.82 d	3.69 b	3.15 b	10.74 b	1.33 c	13.90 c	1.01 ab
110	24.33 c	4.04 a	3.44 a	11.25 a	1.46 b	15.66 b	0.98 ab
120	26.53 b	4.16 a	3.55 a	11.43 a	1.49 ab	16.81 ab	0.95 ab
130	28.60 a	4.18 a	3.61a	11.57 a	1.52 a	17.75 a	0.93 b
CV (%)	2.74	1.82	2.78	1.13	1.76	2.98	1.77

In a column, the means with same letter are not significantly different at 1% level by DMRT

Table 2. Chemical characteristics of ber fruits var. BARI Kul-2 influenced by days to maturity.

Days after fruit set (Maturity)	TSS	Total sugar	Acidity	TSS/Acid ratio	Sugar/Acid ratio	Vitamin C (mg/100g pulp)
90	10.40 c	4.83 c	0.49 a	21.29 d	9.96 c	44.67 d
100	13.07 b	5.83 b	0.42 ab	31.18 cd	14.06 c	64.13 c
110	15.60 a	6.40 b	0.40 abc	39.72 bc	16.14 bc	73.22 bc
120	16.17 a	7.80 a	0.35 bc	46.91 b	22.65 ab	110.40 a
130	16.73 a	8.70 a	0.27 c	61.63 a	29.14 a	83.40 b
CV (%)	4.54	5.13	11.37	11.19	14.58	8.79

In a column, the means with same letter are not significantly different at 1% level by DMRT

Chemical characters

Significant variation was found among the fruits harvested at different days for chemical traits like total soluble solids, total sugar, acidity, TSS-acid ratio, sugar-acid ratio and Vitamin C (Table 2). The highest TSS (16.73%) was recorded from the fruits harvested at 130 days after fruit set which was statistically similar to those of 110 (15.60%) and 120 days (16.17%). Though the total sugar increased with days to maturity, it was statistically similar at 120

and 130 days (7.80 and 8.70%, respectively). Acidity decreased gradually from 90 days to 130 days. It was computed maximum (0.49%) from the fruits harvested at 90 days after fruit set while it was found minimum (0.27%) in 130 days. The highest TSS-acid ratio (61.63) was obtained from the fruits harvested at 130 days followed by 120 days (46.91). Sugar/acid ratio was calculated maximum (29.14) at 130 days. The highest vitamin C (110.4 mg/100g) was obtained from the fruits harvested 120 days followed by 130 days (83.40 mg/100g). Fruits harvested at 90 days after fruit set had the lowest amount of vitamin C (44.67 mg/100g pulp). Vitamin C content was found to be reported high at the early ripening stage in Chinese jujube by Kuliev and Akhundov (1975) and Bi *et al*. (1990).

Sensory evaluation

The acceptability scores for colour and taste were obtained high both by the fruits harvested at 110 and 120 days after fruit set (Table 3). These were 8.83 and 8.23 for colour and taste for the fruits harvested at 120 days after fruit set, however, statistically similar to those (8.67 and 8.17, respectively) of the fruits harvested at 110 days after fruit set. The preference score for texture was obtained high (8.77) by the fruits harvested at 120 days after fruit set followed by 130 and 110 days after fruit set (7.93 and 7.60, respectively). The lowest scores for colour (5.77), texture (4.83) and taste (5.33) were obtained by the fruits harvested at 90 days after fruit set. The preference scores for colour, texture, and taste were found to be decreased with increasing of storage time (Table 3). On 3rd day of storage, the highest score (7.00) for colour was got by the fruits harvested at 110 days after fruit set. On the same day, the scores for texture and taste were found not to be vary significantly among the fruits harvested at 110, 120 and 130 days after fruit set. The acceptability scores of colour, texture and taste declined in all cases on 6th days of storage (Table 3). On the same day, the fruits harvested at 130 days after fruit set had the lower scores for colour (3.10) and taste 4.00), though it got statistically similar score (4.60) for texture of the fruits of 100, 110 and 120 days (4.44, 5.10 and 4.87, respectively) after fruit set. On 6th day of storage, fruits harvested 90 days after fruit set lost their scores drastically as 3.10, 1.63 and 3.23 for colour, texture and taste, respectively (Table 3). The lower scores both for fresh and storage ones of the fruits harvested at 90 and 110 days after set indicate its non-acceptability or less acceptability of proper maturity. On the other hand, it was got lower by the fruits harvested at130 days after fruit set, both at fresh and succeeding storage time, probably because of over maturity.

Table 3. Sensory evaluation of ber fruits var. BARI Kul-2 influenced by days to maturity.

(Preference score: 1-9)

Days after fruit set (Maturity)	Colour			Texture			Taste		
	Storage periods (Days)			Storage periods (Days)			Storage periods (Days)		
	0	3	6	0	3	6	0	3	6
90	5.77 c	3.53 c	3.10 c	4.83 c	2.43 c	1.63 b	5.33 c	4.00 b	3.23 c
100	7.27 b	5.60 b	4.77 a	5.43 c	5.06 b	4.44 a	7.40 b	6.50 a	4.93 ab
110	8.67 a	7.00 a	4.00 b	7.60 b	6.60 a	5.10 a	8.17 a	6.60 a	5.43 a
120	8.83 a	6.60 ab	4.93 a	8.77 a	7.07 a	4.87 a	8.23 a	7.40 a	4.05 bc
130	7.47 b	5.60 b	3.10 c	7.93 ab	6.40 a	4.60 a	7.60 ab	6.47 a	4.00 bc
CV (%)	5.36	8.38	6.26	4.03	5.23	6.25	3.52	8.78	8.46

In a column, the means with same letter are not significantly different at 1% level by DMRT.

Storage attributes

Storage life: Fruits harvested at 110 days after fruit set had the highest storage life (4.50 days) followed by that of 120 days (3.83 days) while it was the lowest (2.00 days) when the fruits were harvested at 90 days after fruit set (Table 4). From Table 4 and 5, it revealed that the best storage life was recorded from the fruits harvested at onset of ripening followed by prior to onset of ripening i.e. colour turning stage. On the contrary, fruits harvested at green or fully ripe stage had short storage life. Several authors also mentioned similar opinion (Abbas, 1997; Al-Niami *et al*. 1989). Though jujube is usually stated as non-climacteric fruit (Kader, 1992), Chinese jujube (*Zizyphus jujuba* Mill. non Lam.) were found to be lie in those group experimentally (Kader *et al.*, 1982), however, some varieties of ber or Indian jujube (*Zizyphus mauritiana* Lam.) was found to shown climacteric behaviour as they produced more CO_2 and ethylene during ripening compare to those of mature green stage (Abbas and Saggar, 1989; Abbas, 1997), and hence the storage life of ber was found to be short likewise to many other tropical fruits (Abbas, 1997). Depending of cultivar and storage conditions, it may vary from 4 to 15 days (Pareek, 2001). Jain *et al*. (1979) had reported lower storage life in Umran fruits, i.e for 3 days in open baskets and 6 days in earthen pots. Similarly, Siddiqui and Gupta (1990) could store Umran fruits for only 3 days in wooden boxes. A longer storage life of 10 days, however reported for Umran variety by Jawanda *et al*. (1980a, b). Owing to low respiration rate, fruits of Umran variety were found to suitable for prolonged storage when harvested at

mature-golden yellow stage (Singh *et al*., 1981). In Bangladesh, Islam (2007) observed 4 to 5 days of storage life for different cultivars of ber grown in Rajshahi region. In fact, the short storage life of BARI Kul-2 was considered in this study due the fact mostly of its rapid browning tendency of fruit skin, i.e. pericarp browning within 2 to 5 days of storage at ambient condition (Table 4).

Physiological loss in weight (%): No significant variation was found in physiological loss in weight of stored ber till 3 days of storage (Table 4). However, it was recorded higher (12.53%) on 3rd day from the fruits harvested at 90 days after fruit set. On 6th day of storage, the maximum weight loss (40.50%) was recorded from the fruits harvested at 90 days after fruit set. It was recorded lesser on that day both from the fruits harvested at110 and 120 days after fruit set (18.83% and 16.87%, respectively). In comparison to others, the fruits harvested at 130 days after fruit set had less weight loss both on 3rd and 6th day of storage though it reached to14.73% at latter (Table 4).

Skin blemish: The pericarp of ber was found to becoming brown and shrivel with storage time. The skin of the fruits got blemish through browning, shriveling and undesirable changes. It lowered the preference of the fruits as fresh consumption. The nature and extent of skin blemish in storage were found to be different with maturity differences. At 3 days of storage, the maximum (55.30%) skin blemish was recorded from the fruits harvested at 90 days after fruit set. On the contrary, it was found less (37.97) on the fruits harvested at 110 days after fruit set which was statistically similar (38.63%) to those of 120 days. At 6 days of storage, the skin blemish was found to be increased in all cases. However, it was comparatively less (56.30%) on the fruits harvested at 110 days after fruit set which was statistically not different (59.30%) with those of the fruits harvested at 120 days (Table 4). The skin blemish was recorded high (94.07) from the fruits harvested at 90 days after fruit set. It was statistically similar (90.50%) to those of the fruits of 100 days. The blemish of fruit skin of the fruits of 130 days was also more on 3 (48.10%) and 6 days (77.73%) of storage (Table 4). It could be mentioned that shriveling was found to be appeared earlier mostly on the fruits harvested by 90 days after fruit set whereas browning was exhibited more by the fruits harvested at 130 days. The quick browning of the fruits of latter might be indicating of possible accumulation of degraded polyphenol or increase of tannin in pericarp area of fruit. Decrease of total phenolics with fruit maturity in jujube was reported by Pandey *et al*. (1990) whereas tannin content was found to be increased during ripening by Calderia (1967).

Table 4. Storage life, physiological loss in weight (PLW) and skin blemish of ber fruits var. BARI Kul-2 influenced by storage periods at ambient condition.

Days after fruit set (Maturity)	Storage life	PLW (%)			Skin blemish (%)		
		Storage periods (Days)			Storage periods (Days)		
		0	3	6	0	3	6
90	2.00 c	-	12.53	40.50 a	-	55.30 a	94.07 a
100	2. 67 bc	-	9.40	27.63 b	-	53.93 a	90.50 a
110	4.50 a	-	8.83	18.83 bc	-	37.97 c	56.30 b
120	3.83 ab	-	8.27	16.87 bc	-	38.63 c	59.30 b
130	3.17 a-c	-	7.97	14.73 c	-	48.10 b	77.73 ab
CV (%)	16.82		19.00	15.99		16.11	20.25

In a column, the means with same letter are not significantly different at 1% level by DMRT

Subjective maturity parameters and quality attributes

Fruits were found attractive and properly ripe having light greenish yellow to greenish yellow skin with good taste and flavour when harvested 110 and 120 days after fruit set (Table 5). It retained acceptable appearance on 3 days of storage (Table 6). Fruits harvested at 90 days did not ripen properly. Though the fruits harvested at 130 days were fully ripe and attractive, it became overripe and skin of the fruit turned into brown which was unattractive at 3 days of storage (Table 5 and 6). At 6 days of storage, all the harvested fruits of 130 days after fruit set lost their acceptance of quality severely as fresh consumption. However, fruits harvested at 110 and 120 days after fruit set retained some acceptance of quality till the aforesaid time (Table 6). To obtain good organoleptic quality, Siddiqui and Gupta (1990) recommended harvesting fruits at green-yellow for Kaithli, green-mature or green-yellow or yellow for Gola variety of India. Singh *et al*. (1981) observed that fruits of cultivar Umran developed good organoleptic quality at mature-golden yellow stage. However, Pareek (2001) reported that ber fruits could be harvested at mature-green and mature-golden yellow stages depending on cultivar, distance from market, and expected postharvest uses. At the fully ripe stage, the fruits develop poor organoleptic quality but might be suitable for dehydration.

Table 5. Subjective maturity parameters and quality attributes of ber fruits var. BARI Kul-2 on the day of harvesting as harvested at different days after fruit set.

	Maturity parameters		Quality attributes		
Days after fruit set (Maturity)	Skin colour	Pulp texture	Taste	Attractiveness of fruits on the day of harvesting	Ripening status
90	Green	Less crispy	Not good; astringent	Not attractive	Unripe
100	Light green	Less crispy	Acceptable; slightly astringent	Not so Attractive	Prior to onset of ripening
110	Light Greenish yellow	Crispy	Very good; less astringent	Very much attractive	Onset of ripening
120	Greenish yellow	Crispy	Very good; less astringent	Very much attractive	Fully ripe
130	Full yellow to fully yellow with partially Brownish	Crispy	Good; astringency reduced, taste also reduced	Less attractive	Fully ripe to little bit over ripe

Table 6. Quality attributes of ber fruits var. BARI Kul-2 during storage pertaining to harvested at different days after fruit set.

Days after fruit set (Maturity)	Storage periods							
	At 3 days				At 6 days			
	Physical appearance	Pulp texture	Taste	Ripening status	Physical appearance	Pulp texture	Taste	Ripening status
90	Green, severely Shriveled	Insipid	Unpleasant	Unripe	Green, severely Shriveled	Insipid	Not good	Unripe
100	Dull Green, moderately Shriveled	Insipid	Unpleasant	Not ripe properly	Pale green, severely shriveled	Insipid	Not good	Not ripe properly
110	Skin not so shriveled and colour turns into dull yellow	Less crispy	Acceptable	Ripe properly and flavour still acceptable	Skin shriveled and colour turns into brownish	Crispy-ness fall down	Moderately acceptable	Becoming Over ripe
120	Skin not so shriveled but colour turns into brownish	Medium crispy	Acceptable	Fully ripe and flavour still acceptable	Skin shriveled and colour turns into brownish	Crispy-ness fall down	Moderately acceptable	Becoming Over ripe
130	Skin becoming shriveled and colour turns into brown	Less crispy	Moderately acceptable	Over ripe and flavour becoming unacceptable	Skin severely shriveled and colour turns into deep brown or light tan	More fall down of crispyness	Not acceptable	Over ripe and presence of odd-flavour

Conclusion

Considering physical and chemical characters, sensory attributes and storage behaviour of fruits, it might be concluded that BARI Kul-2 was found horticulturally mature between 110 to 120 days after fruit set. The fruits of BARI Kul-2 were found as greenish yellow and crispy in texture having TSS 15.60-16.17%; pulp-stone ratio 15.66-16.81, TSS-acid ratio 39.72-46.91, sugar-acid ratio 16.14-22.65 and specific gravity 0.98-0.95 while 24.33-26.53g in weight as properly matured. The higher storage life (4.50 days) was recorded from BARI Kul-2 when harvested at 110 days having less decay, browning and shriveling of fruits during storage.

Recommendation

It could be mentioned here that ber fruits could not be mature at a time and several picking may need for total harvesting. Therefore, it would be wise to harvest fruit at colour turning stage rather than mature green or over ripe stage for better storage life with good quality. Regarding this, the selected days to harvest for BARI Kul-2 were found to lie between 110 to 120 days after fruit set i.e. 5 to 15 February at the study area of Bangladesh.

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