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CHANGES IN PHYSICO-CHEMICAL PROPERTIES OF *ASSAM* LEMON (*CITRUS LIMON* BURM.) AT DIFFERENT STAGES OF FRUIT GROWTH AND DEVELOPMENT

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ABSTRACT
An experiment was undertaken under mid hills of Meghalaya, India, in order to study the changes in physico-chemical properties of *Assam* lemon at different stages of fruit growth and development. The present study significantly showed that fruits harvested at 120 to 130 days after fruit set developed acceptable physico-chemical qualities with optimum fruit weight (109.28 to 112.95 g), fruit size (Length = ≥ 81.05mm, Breadth = ≥50.13mm), specific gravity (0.97 to 1.01), juice content (37.68 to 41.23 %), TSS (≥6.3 °Brix), titratable acidity (4.18 to 4.35%), ascorbic acid (≥32.41 mg/100g), TSS: acidity (≥1.51) and these may be considered as the most reliable maturity indices for taking harvest decision in *Assam* lemon fruit.

INTRODUCTION

Citrus is the third most important fruit crop in India, after banana and mango. Citrus in India is grown in 0.48 million ha area with a total production of 4.27 million tonnes (Kumar *et al.*, 2013). *Citrus limon* are important cultivars of lemon in India originating in Southeast Asia, China, and the Malayan Archipelago. The fruit is rich in vitamin C which helps the body to fight off infections and also to prevent or treat scurvy (Umadevi *et al.*, 2011). *Assam* lemon (*Citrus limon* Burm.) is a seedless lemon cultivar which is widely grown in north-eastern states of India. Being an acidic fruit, it is mostly used for flavouring vegetable dishes, fish, meat and salads besides preparation of refreshing cold drinks, cordials and marmalades. Physico-chemical qualities and storage life of fruits would depend on various physiological and biological changes which occur during fruit growth, development and maturity. Such information is useful to assess the stage of maturity for harvesting of the fruit. Fruits picked at the wrong stage of maturity may develop physiological disorders in storage and may exhibit poor dessert quality. Therefore, the objective of the experiment is to investigate and identify the right stage of harvesting in *Assam* lemon under the mid hills conditions of Meghalaya.

MATERIALS AND METHODS

An experiment was conducted at the Experimental Farm of the Division of Agro-forestry, ICAR Research Complex for NEH Region, Barapani, Umiam-793103, Meghalaya during the year 2008-2009. The experiment was laid out in completely randomized design and was replicated three times (Snedecor and Cochran, 1967). The flowers were tagged prior to fruit set and 20 fruits per replication were collected at 15 days interval up to 90 days after fruit set (DAF) and at 10 days interval from 90 DAF onwards for physical and chemical analysis. Physical parameters of the fruit were taken in terms of fruit length (mm), fruit breadth (mm), rind thickness (mm), length from pith to albedo (mm), fruit weight (g), specific gravity, juice content (%) and peel colour. Fruit length, fruit breadth, rind thickness and length from pith to albedo (LPA) were measured with digital vernier caliper, fruit weight with electronic balance, and specific gravity as weight per unit volume of the fruits (Shivasankar and Kumar, 1999). The juice was measured with the help of graduated cylinder and then expressed into percentage. The fruit peel colours were measured using a Hunter Lab Color Quest XE colorimeter (Mc Guire, 1992). Colour measurements were expressed in terms of L, a, b and colour difference (ΔE) values, where, L is a measure of lightness on a scale ranging from 0 (black) to 100 (white); +a denotes redness (Positive values), -a indicates greenness (Negative values); +b denotes yellowness (Positive values) and –b indicates blueness (Negative values) respectively. The fruit

quality parameters were studied in terms of total soluble solids (^{0}Brix), titratable acidity (%), ascorbic acid (mg/100g) and TSS:acid ratio. Total soluble solid (TSS) was determined with the help of digital refractometer. Acidity and ascorbic acid content of the fruit were estimated following the standard procedures described by AOAC (1995).

RESULTS AND DISCUSSION

Physical characteristics

Physical attributes of *Assam* lemon at different stages of fruit growth and development is presented in Table 1 and Table 2. The fruit weight of *Assam* lemon showed double sigmoid pattern of growth. These observations had confirmed the earlier findings of Josan *et al.* (1988) and Sema and Sanyal (2003a). The increase in fruit weight, fruit length, fruit breadth and length from pith to albedo was prominent and significant from the initial stages of development i.e.30 up to 150 DAF. The change in the above parameters could be attributed to an increase in the size of the cell and accumulation of food substances in the intercellular spaces in fruit (Bollard, 1970). The fruit showed rapid increase in rind thickness in the first stage of growth (6.17 mm till 60 DAF) and then declined with maturity (3.50 mm at 150 DAF). Increase in rind thickness in the early stage was characterized by high metabolic rate (Bain, 1958). Specific gravity was higher in the beginning (1.48 at 30 DAF) and declined with the progress of fruit development, which was in agreement with the results of Sema and Sanyal (2003a). The specific gravity could swing either way (decrease or increase) depending upon the relative increases or decreases in weight and volume since the rates of these two attributes govern the specific gravity. Accumulation of juice was significantly influenced by the age of fruit. The juice percentage increased gradually till the last date of observation (150 DAF) which was in agreement with the finding of Ladaniya and Singh (2000) in *Kagzi* lime. The increase might be accounted mainly for the accumulation of water and solutes to the juice vesicles. Fruit peel colour in terms of L, a, b and ΔE values increased significantly with the advancement of fruit development *i.e.* L (36.10 to 61.21), a (-5.67 to -3.31), b (10.70 to 29.67) and ΔE (1.02 to 31.56) from 30 up to 150 DAF (Table 2). This was perhaps due to the increased accumulation of total carotenoids and degradation of chlorophyll (Miller *et al.*, 1940). Similar results were also observed by Deka *et al.* (2006) in *Khasi* mandarin.

Chemical characteristics

The quality attributes in terms of TSS, acidity, TSS:acid ratio and ascorbic acid were depicted in Table 3. TSS significantly decreased with the advancement of fruit growth (6.73^0 Brix to 5.57^0 Brix) with 5.93^0 Brix at 130 DAF. The higher value of TSS

Table 2: Changes in fruit peel colour of *Assam* lemon at different stages of fruit growth and development

DAF	L	a	b	ΔE
15	-	-	-	-
30	36.10	-5.67	10.70	1.02
45	37.49	-6.17	11.40	2.08
60	40.64	-7.76	14.73	6.50
75	40.18	-7.50	14.09	5.63
90	38.27	-7.58	13.24	3.87
110	38.33	-7.32	13.37	3.92
120	46.08	-7.95	18.34	12.87
130	59.82	-4.60	26.18	28.36
140	57.12	-1.22	26.64	27.19
150	61.21	-3.31	29.67	31.56
S.Em ±	2.55	1.22	1.64	3.02
$CD_{0.05}$	7.52	3.59	4.84	8.90

DAF = Days after fruit set

Table 3: Changes in chemical parameters of *Assam* lemon at different stages of fruit growth and development

DAF	TSS (^{0}Brix)	Titratable Acidity (%)	Ascorbic Acid (mg/100g)	TSS: acidity
15	-	-	-	-
30	6.73	1.17	90.45	6.06
45	6.57	1.96	56.45	3.59
60	6.53	3.65	51.39	1.79
75	6.50	3.82	51.39	1.71
90	6.47	3.86	44.45	1.68
110	6.37	3.97	36.11	1.60
120	6.30	4.18	32.41	1.51
130	5.93	4.35	30.56	1.36
140	5.93	4.46	27.78	1.33
150	5.57	4.86	11.11	1.16
S.Em ±	0.12	0.21	3.47	0.35
$CD_{0.05}$	0.36	0.62	10.23	1.03

DAF = Days after fruit set

Table 1: Changes in physical characteristics of *Assam* lemon at different stages of fruit growth and development

DAF	Fruit Weight (g)	Fruit Length(mm)	Fruit Breadth(mm)	Specific Gravity	Rind Thickness(mm)	LPA (mm)	Juice (%)
15	0.42	16.72	5.97	1.41	-	-	-
30	12.53	44.84	21.22	1.48	5.52	6.26	-
45	37.44	68.54	32.96	1.08	5.80	7.13	12.26
60	62.87	74.09	40.70	0.97	6.17	9.87	28.80
75	66.62	76.04	41.92	0.97	5.92	14.39	29.25
90	68.32	78.97	40.51	0.97	4.93	14.77	33.44
110	100.07	79.10	48.28	0.94	4.82	17.69	35.02
120	109.28	81.05	50.13	0.97	4.34	18.35	37.68
130	112.95	82.06	48.98	1.01	3.90	20.02	41.23
140	125.00	82.99	51.97	1.06	3.56	20.19	41.75
150	146.51	92.04	57.38	1.21	3.50	20.25	41.83
S.Em ±	13.42	5.77	1.75	0.09	0.23	0.99	3.93
$CD_{0.05}$	39.36	16.93	5.13	0.28	0.68	2.92	11.67

DAF = Days after fruit set

at the initial stage of fruit growth might be due to more accumulation of sugar which later converts to organic acids. The level of acidity was found to increase significantly with the advancement of fruit growth and development (1.17% to 4.86%) with optimum acidity content 4.35% at 130 DAF. Increase in citric acid during fruit development might be due to higher synthesis of acid in juice vesicles by enzymatic action (Ricevuto, 1933). Similar finding was also reported by Ladaniya and Singh (2000) in *Kagzi* lime. The TSS: acid ratio was found to decrease significantly with increasing fruit growth and development with maximum (6.06) at 30 DAF and minimum (1.16) at 150 DAF. Decrease in TSS: acid ratio might be attributed to relatively higher rates of accumulation of acids coupled with rapid decrease in TSS. The level of ascorbic acid content remained high in immature fruit and gradually declined with the advancement of fruit growth (Ascorbic acid content at 30, 130 and 150 DAF is 90.45, 30.56 and 11.11 mg/100g respectively). The decline in ascorbic acid during the course of maturation could be due to its utilization in certain metabolic process. The present results were in conformity with the findings of Sema and Sanyal (2003b) in *Assam* lemon.

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