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Fruit maturation and associated changes in 'Mosambi' orange (*Citrus sinensis*)

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ABSTRACT

Fruit maturity changes in terms of physico-chemical, physiological, and sensory characteristics of monsoon-blossom crop of 'Mosambi' orange grown under sub-humid tropical climate of central India were studied. Rapid increase in fruit diameter, volume and weight was recorded from 180 to 220 days after fruit set, however, the growth was slow thereafter up to 250 days. Maximum diameter was 8.42 cm, while maximum weight was 253.28 g after 240 and 250 days, respectively. Fruit firmness, peel thickness, peel and rag percentage decreased, while peel colour, TSS/acid ratio and juice content increased from 180 to 250 days. Vitamin 'C' content was 56.60 mg/100 ml after 180 days and decreased to 52 mg/100 ml as fruit matured. After 240 days, TSS : acid ratio was 16.63 with 12.82% TSS and 0.78% titratable acids. The *p*H of the juice increased with fruit maturity. Fruits developed acceptable flavour and appearance after 240 days. 'L' and chroma values rose and hue angle (h°) declined with maturation and fruit colour turned yellow after 250 days. Chlorophyll ('a', 'b' and total) content dropped and total carotenoides in rind flavedo increased significantly. Reducing and total sugars in juice increased. Total phenols in flavedo increased up to 210 days and then declined. Fructose, glucose and sucrose increased in juice with fruit maturity and were in the ratio of 1:2:2 at 240 days. Xylose and maltose were present in trace amounts and ribose was not detected. Respiratory rate declined with fruit maturity confirming non-climacteric nature of 'Mosambi' fruit.

Key words: *Citrus sinensis*, Climate, Maturity, Monsoon-blossom fruit, 'Mosambi' orange

'Mosambi' orange [*Citrus sinensis* (L.) Osbeck] is one of the most important commercial citrus fruits grown in central India with a total area of 41 018 ha and annual production nearly of 0.4 million tonnes (Shinde and Kulkarni 2000). Under tropical sub-humid (monsoon-type) climatic conditions of central India, trees flower during three main flushes, viz spring blossom (*'ambia'*), monsoon blossom (*'mrig'*) and autumn blossom (*'hasta'*). Monsoon and autumn flushes are due to drought (by withholding irrigation) induced dormancy while spring flush is due to winter dormancy. From commercial point of view, monsoon-blossom (June–July) is important as its fruits are harvested in dry months of summer (March–April) when demand is maximum. Fruits of this crop also need to be stored to avoid glut in the market. There is no information and data on physiological, physical, biochemical and sensory attributes of 'Mosambi' orange fruit of monsoon-blossom crop grown in the country. The knowledge of changes during fruit development and maturity with respect to physiological, physical, biochemical and sensory characteristics is a pre-requisite to harvesting intended for fresh fruit market, storage and processing. The present study was undertaken to examine these changes in maturity-related attributes of 'Mosambi' orange fruit from monsoon-blossom crop grown under sub-humid tropical climate. The objective was also to determine suitable standards of maturity indices for optimum harvesting stage keeping in view the above needs.

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MATERIALS AND METHODS

Uniformly growing 12-year old budded trees of 'Mosambi' orange on rough lemon rootstock planted at 6 m×6 m distance under normal agro-climatic conditions were identified in a orchard near Nagpur (20.2°N latitude and 79.1°E longitude; nearly 300 m altitude) during 2005–06. Five (replicates) trees growing on medium black soil were selected. During flowering of 'Mrig' crop (monsoon blossom) season, at the time of petal-fall (fruit set), fruit-lets were tagged on 5 July. The weather data during growing season were recorded and diurnal variation as well as heat unit summation were calculated. Fifty fruits (10 fruits/tree were sampled from all canopy positions at 1–2 m height) were taken from sixth month (180 days from fruit set) onwards for recording observations on physical, biochemical,

physiological and organoleptic parameters. Sampling was done after 180 (5 January), 190 (15 January), 200 (25 January), 210 (5 February), 220 (15 February), 230 (25 February), 240 (6 March), and 250 days (15 March), after fruit set. Fruit length or height (stem end to stylar end), equatorial diameter and peel thickness were measured with vernier callipers and weight was recorded. Fruit height to diameter ratio was calculated. Fruit volume (cm^3) was measured by water displacement. Firmness was determined in kg force with pressure tester (Effigy 011 model) having 8 mm head and expressed in Newton (N). Rind colour was measured with colour difference meter (Colorgard systems/ 05, Pacific Scientific, USA) at the equatorial plane in CIE System as 'L' (lightness or darkness 0, black; 100, white), 'a' (green/red hue component) and 'b' (yellow/blue hue component) values. The 'a' and 'b' co-ordinates were transferred in to hue angle 'h°' (arc tangent b/a) and saturation index 'chroma,' $\sqrt{a^2 + b^2}$ (McGuire 1992). The juice squeezed by reamer was weighed and expressed as per cent juice content. Fruits were hand-peeled, the peel and rag were weighed separately and expressed as percentage of fruit weight. Total soluble solids (TSS) in juice were measured with hand refractometer and corrected for temperature while titratable acidity (expressed as anhydrous citric acid) and ascorbic acid content were estimated following titrimetric methods (AOAC 1985). Juice *p*H was measured with digital *p*H meter. TSS : titratable acidity ratio as a maturity index was calculated. The organoleptic (sensory) characteristics such as fruit appearance and flavour were evaluated in a preference test by the trained 15-member panel (Heintz and Kader 1983) using 9-point hedonic scale. For sweetness and sourness, scale of 1–5 (score 1, not sweet or not sour; 5, very sweet or very sour) was used. Chlorophyll ('a', 'b' and total) content (Sadasivam and Manickam 1996) and total carotenoids (Ting and Rouseff 1986) in rind flavedo were determined by spectrophotometric methods. Total phenol content in rind flavedo was determined by spectrophotometric method using Folin-Ciocalteau reagent (Sadasivam and Manickam 1996)). For total sugar estimation in fruit juice, phenol sulphuric acid method described by Dubois *et al.* (1956) was followed. Reducing sugars in juice were determined following Nelson-Somogyi method (Sadasivam and Manickam 1996). The external and internal condition of the fruit and overall appearance were also recorded visually. Soluble sugars in juice were determined in two samples at each interval by HPLC method (Ting and Rouseff 1986) using Shimadzu Class VP HPLC system. Acetonitrile and deionized water in ratio of 75: 25 was the mobile phase with flow rate of 1 ml/min. Refractive index detector and Shim-pack amine (PNH_2–10) column were used. Twenty microlitre sample and standards were injected after filtering through syringe filter (0.20 mm). Standard sugars, viz D-fructose, D (+)glucose, sucrose, D (+)xylose, ribose and maltose (Sigma–Aldrich Co., St. Louise, MO 63178, USA) were used to determine and confirm retention times and peaks. Respiration rate was measured with Infrared CO_2 analyzer (Amtek model CD-3A) at each sampling interval by flushing fresh air (100 ml/min) over approximately one kg fruit held in air tight glass jar to measure per cent CO_2 and estimated as mg CO_2/kg/hr.

Data were subjected to Analysis of Variance (ANOVA) using randomized design (Steel and Torrie 1980). The treatment means were compared with LSDs calculated at $P = 0.05$.

RESULTS AND DISCUSSION

Changes in physico-chemical characteristics

Rapid increase in diameter, volume and weight of 'Mosambi' fruit was recorded from 180 days onwards till 220 days after fruit set. The growth was however slow thereafter up to 250 days (Table 1) and fruit diameter increased significantly between 180 and 220 days of fruit set. Maximum fruit diameter (8.42 cm) was recorded after 240 days, while maximum weight (253.28 g) was recorded after 250 days however, there was no significant difference in weight and diameter of fruit between the intervals after 220 days up to

Table 1 Changes in physical quality attributes of 'Mosambi' sweet orange during maturation

Days after fruit set	Fruit weight (g)	Fruit height (cm)	Fruit diameter (cm)	H/D* ratio	Fruit volume (cm^3)	Fruit firmness (N)	Peel thickness (cm)	Peel (%)	Rag (%)
180	161.62	7.02	7.09	0.98	178.61	115.52	0.82	42.74	35.83
190	190.66	7.49	7.52	0.99	205.08	106.97	0.74	41.71	34.04
200	194.52	7.54	7.65	0.99	213.27	91.84	0.73	41.54	31.16
210	223.86	8.04	8.28	0.97	258.20	87.41	0.74	41.46	29.59
220	247.90	8.02	8.38	0.95	267.31	77.22	0.72	41.01	30.28
230	249.56	8.01	8.40	0.95	268.00	74.39	0.73	38.01	26.91
240	250.40	7.92	8.42	0.94	267.62	74.58	0.69	35.65	25.80
250	253.28	7.94	8.36	0.94	269.83	74.64	0.69	33.80	24.52
SE of Means ±	5.51	0.10	0.10	0.01	7.02	1.90	0.04	0.67	0.70
CD (*P*=0.05)	15.91	0.28	0.28	0.04	20.27	5.48	0.12	1.96	2.08

*H/D, Height to equatorial diameter ratio

250 days. Fruit height: equatorial diameter ratio was 0.98 indicating near spherical shape of the fruit at 180 days (six months after fruit set). As the fruits matured they became globose in shape with higher equatorial diameter relative to the height which was evident from decrease in height: diameter ratio (0.94) after 240 days. Fruit volume was 178.61 cm^3 at 180 days and increased significantly to 267.31 cm^3 at 220 days with marginal increase thereafter. Fruit firmness (measure of resistance to rind puncture) decreased gradually with advancement in maturity and finally remained almost constant at nearly 74 N around 240 days indicating no change in firmness between 230 and 250 days. Fruit peel thickness decreased from 0.82 cm after 180 day to 0.69 cm after 240 days. Peel percentage declined from 42.74% at 180 days to 33.80% at 250 days. Similarly, rag percentage also decreased.

Significant increase was recorded in juice content between 230 days and 240 days (Table 2). Six months after fruit set (5 January) 'Mosambi' fruits had 21.38% juice which almost doubled to 40.93% after nearly eight-and-half months (15 March). Increase in juice content of acid lime (*Citrus aurantifolia* Swingle) (Ladaniya and Shyam Singh 2000) and 'Nagpur' mandarin (*Citrus reticulata* Blanco) (Ladaniya 1996) fruit have also been recorded with maturity. Increase in juice content between 240 and 250 days was non-significant. Fruits could not be sampled beyond 250 days as the grower harvested remaining fruit fearing drop in juice content. Juice content of 'Nagpur' mandarin fruits has been shown to decline after attainment of acceptable maturity (Ladaniya 1996). This is the reason why fruits are not retained on the tree by the growers beyond market maturity in tropical region of central India. In contrast to this, sweet oranges grown in cool sub-tropical climate can be retained for three to five months after maturity (Reuther and Rios-Castano 1969). Total soluble solids increased very slowly, with non-significant difference between 180 and 210 days after fruitset. At 220 days, there was a significant increase in soluble solids content (11.66%). As the fruit matured, TSS content increased to 12.82% at 240 days. Sharp decline in titratable acidity

Table 2 Changes in juice percentage, total soluble solids, titratable acidity, TSS: acidity ratio, juice *p*H, ascorbic acid, reducing sugars and total sugars of 'Mosambi' orange during maturation

Days after fruit set	Juice (%)	TSS (%)	Titratable acidity (%)	TSS/acidity ratio	*p*H	Ascorbic acid (mg/100 ml)	Reducing sugars (%)	Total sugars (%)
180	21.38	10.48	2.02	5.21	2.92	56.60	4.27	5.52
190	23.22	10.76	1.58	6.81	3.22	53.40	5.03	5.70
200	26.50	11.28	1.24	9.08	3.27	55.20	6.00	6.49
210	28.72	10.98	1.14	9.71	3.20	50.70	5.90	8.89
220	31.84	11.66	0.92	12.74	3.17	50.81	5.30	9.74
230	35.81	12.18	0.83	14.67	3.55	51.40	5.58	10.23
240	39.53	12.82	0.78	16.63	3.56	52.90	6.85	10.48
250	40.93	12.88	0.71	18.14	3.66	52.70	7.05	10.88
SE for means ±	0.49	0.21	0.04	0.47	0.06	1.20	0.26	0.32
CD (*P*=0.05)	1.41	0.63	0.12	1.35	0.18	3.47	0.76	0.93

Table 3 Monthly temperature, heat unit summation, relative humidity, sunshine and rainfall during growth and maturation of 'Mosambi' orange

Month	Temperature (°C)				Heat unit summation*	Relative humidity (%)	Sunshine (hr/day)	Rainfall (mm)
	Maximum	Minimum	Diurnal difference	Mean monthly temperature				
July 2005	32.98	24.38	8.62	28.68	404.4	84.66	6.55	129.9
August	29.05	22.02	7.03	25.53	403.9	91.65	1.56	266.4
September	32.82	22.42	10.40	27.62	453.6	88.45	6.25	52.00
October	35.06	19.04	16.02	27.05	451.0	90.62	10.08	22.00
November	32.00	13.52	18.48	22.76	307.8	81.67	8.77	0.00
December	31.67	13.42	18.25	22.54	311.2	75.92	7.18	0.00
January 2006	29.68	12.38	17.30	21.03	264.6	73.46	10.64	0.00
February	32.12	15.52	16.40	23.82	316.19	72.00	8.96	14.10
March	35.83	17.35	18.42	26.59	211.3	60.75	9.27	15.00
					Total 3 214.5			Total 500.3

*Heat unit summation (degree days) calculated as °C mean temperature above 12.5°C (minimum temperature for citrus growth) multiplied by days in month from 5 July to 15 March

was recorded from 2.02% at 180 days to 0.78% at 240 days. Consequently, TSS:acid ratio increased significantly at each sampling interval with ratio of 16.63 and 18.14 after 240 and 250 days, respectively. Khokhar and Sharma (1984) observed that in 'Blood Red' orange grown under semi-arid sub-tropical climate of Haryana, soluble solids increased from mid-September (5.5%) until January (11.3%), while titratable acidity decreased from 1.19% to 0.64% recording highest TSS/Acid ratio (17.65 : 1) in the first week of January. Increase in maximum temperature from January to March (Table 3) must be responsible for rapid decline in acidity from 2.02% after 180 days to 0.78% after 240 days in 'Mosambi' orange in the present study. Rapid maturity of fruit with faster accumulation of sugars and drop in acidity was recorded in hot tropical climate of Cartagena (Colombia), whereas accumulation of solids coupled with drop in acidity was quite slow in cool arid and semi-arid sub-tropical climate of California. In fact, acids remained in the range of 1–1.5% when 'Valencia' fruit matured in sub-tropical climate (Reuther and Rios-Castano 1969). The *p*H of juice of 'Mosambi' orange increased gradually from 2.92 to 3.66 which was consistent with drop in acidity.

Ascorbic acid content declined as the fruit matured but the drop was not significant after 210 days (Table 2). In fact ascorbic acid content increased slightly after 210 days although rise was not significant. Reducing and total sugars also increased during maturity of 'Mosambi' fruit. Soluble solids of juice were mainly constituted of soluble sugars, acids, vitamins and other soluble constituents as it was evident from changes mainly in total sugars and soluble solids. Sugars accounted for 50% of soluble solids at 180 days, which increased to 84% at 250 days.

Rind colour (visual and pigment content) of 'Mosambi' fruit changed significantly with advancing maturity (Table 4). 'L' value indicating lightness increased significantly, while 'a' co-ordinate (indicating green when negative and red when positive) also changed with decline in negative value thus confirming fading of green colour. The values of 'b' co-ordinate (indicating yellow colour when positive) increased significantly indicating increasing intensity of yellow colour with maturity. Hue angle (h°) declined from 119.42° at 180 days to 85.46° at 250 days, while chroma value increased significantly indicating saturation of yellow colour. Chlorophyll 'a' of rind was higher than chlorophyll 'b' at the interval of 180 days. Both chlorophyll 'a' and 'b' decreased with fruit maturity; the loss in chlorophyll 'b' being slower than that in Chlorophyll 'a'. Chlorophyll 'b' was reported to be tightly bound with protein and less subject to enzymatic breakdown than chlorophyll 'a' (Jahn and Young 1976) Total chlorophyll content dropped from 129.40 mg/g at 180 days to 6.80 mg/g at 250 days. At 180 days after fruit set total carotenoid content of the rind was not more than 0.66 mg/100 g. With maturity of fruit, carotenoid content increased significantly to 2.64 mg/100 g after 250 days. Mehta and Bajaj (1984) reported that total carotenoid content was 7.6 and 6.1 mg/100 g in rind of 'Kinnow' and 'Blood Red' orange, respectively at Ludhiana, Punjab during fruit maturation in December–January. In north India, citrus fruits develop attractive reddish orange colour due to higher total carotenoids in rind while in tropical climate of central India fruits develop colour of relatively low intensity. In present study, 'Mosambi' fruit rind was found to develop light yellow colour during February-March when mean minimum temperature was 12–17°C. Meredith and Young (1969) found that 15/5°C (day/night) temperature stimulated carotenoid production in Blood orange, while 35°/30°C temperature decreased production of carotenoids. Temperatures from 15–20°C were found optimum for production of maximum colour in citrus rind (Wheaton and Stewart 1973). In present study, 'Mosambi' fruits remained green up to December and with increased diurnal variation in January through March (from 180 to 250 days), fruit surface and juice colour (visual) were pale yellow. Deep yellow colour with slight orange tinge was observed at 250 days in fruits, particularly on the top of the canopy. Grierson *et al.* (1982) reported that low night temperature stress to citrus fruits produced internal ethylene in quantities large enough to destroy chlorophyll and promote development of carotenoids. Total phenolics of the

Table 4 Changes in colour, chlorophyll, carotenoids and total phenol content of 'Mosambi' orange flavedo during maturation

Days after fruit set	Hunter colour value			Hue angle (h°)	Chroma	Chlorophyll 'a,' (mg/g)	Chlorophyll 'b,' (mg/g)	Total chlorophyll (mg/g)	Total carotenoids (mg/100 g)	Total phenols (g/100 g)
	'L'	'a'	'b'							
180	56.87	–16.92	30.44	119.42	34.51	91.80	37.60	129.40	0.66	0.22
190	63.41	–18.00	39.42	114.94	43.42	30.60	15.00	50.40	1.48	0.26
200	70.42	–16.63	48.55	109.10	51.42	27.00	11.80	35.80	1.60	0.21
210	71.64	–15.56	45.82	108.78	48.41	21.60	10.60	33.80	2.14	0.36
220	70.20	–14.32	49.59	106.20	53.48	14.80	10.20	18.60	2.34	0.32
230	72.96	–8.51	54.91	99.37	55.82	7.60	4.90	14.80	2.57	0.32
240	72.60	–7.46	56.54	97.60	57.06	5.36	3.00	8.00	2.61	0.30
250	76.22	5.01	62.22	85.46	62.56	5.20	2.98	6.80	2.64	0.33
SE for means±	1.44	1.30	2.05	1.80	1.85	1.49	0.85	2.49	0.12	0.01
CD (P = 0.05)	4.15	3.74	5.91	5.20	5.35	4.31	2.47	7.18	0.36	0.12

Table 5 Changes in soluble sugars of 'Mosambi' orange juice during maturation

Days after fruit set	Fructose (%)	Glucose (%)	Sucrose (%)	Xylose (%)	Maltose (%)	Total (%)
180	1.30	1.10	1.70	0.52	0.14	4.76
190	1.90	1.30	1.80	0.05		5.05
200	2.30	2.40	1.50			6.20
210	3.50	2.90	2.35	0.025		8.77
220	3.82	2.60	2.40			8.82
230	4.18	2.61	3.00		0.16	9.95
240	1.98	4.81	3.61			10.40
250	1.80	4.70	4.00			10.50

'Mosambi' fruit flavedo increased significantly up to 210 days and then declined. Phenolics were 0.22 g/100 g flavedo at 180 days and increased to 0.36 g/100 g at 210 days before dropping to 0.33 g at 250 days.

Changes in soluble sugars of juice

Soluble sugars of juice increased as the fruit matured (Table 5). Fructose, glucose and sucrose were prominent sugars while xylose and maltose were found in trace amounts. Ribose sugar was not detected. Glucose increased continuously from 1.1% at 180 days to 4.81% at 240 days and then declined slightly, while fructose increased up to 230 days. Sucrose, a primary non-reducing disaccharide sugar which is derived from fructose and glucose, increased considerably between 230 and 250 days resulting in increased sweetness as evident from sweetness score during that period (Table 6). Reduction in fructose at 240 and 250 days could be due to its utilization in synthesis of sucrose which increased with fruit maturity. Glucose also recorded increase between intervals of 230 and 240 days and then declined. Xylose content was 0.52% at 180 days which declined to 0.025% at 210 days and thereafter this sugar was not detected. Maltose was detected at180 days (0.14%) and 230 day (0.16%). The ratio of fructose: glucose: sucrose was reported to be 1: 1: 2 in 'Valencia' orange (Ting and Attaway 1971) while in the present study these sugars in 'Mosambi' fruit were present in ratio of around 1 : 2 : 2 at 240 days. This difference could be attributed to difference in maturity stage of fruit or agro-climatic conditions or variety.

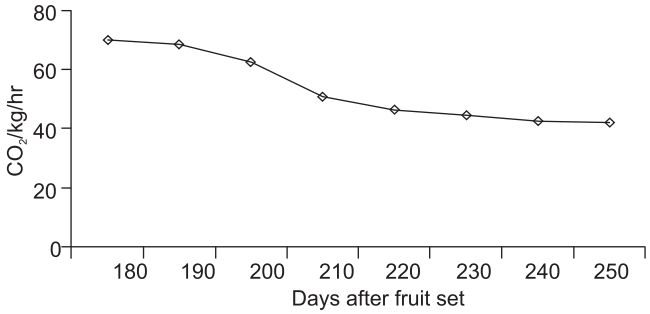

Fig 1 Respiration rate of 'Mosambi' orange at maturation

Changes in respiration rate of fruit

Respiration rate was quite high (nearly 70 mg CO_2/kg/hr) at180 days after fruit set and slowly declined as the fruit matured with 41.80 mg CO_2/kg/hr at 250 days (Fig 1). This respiratory trend during advancing fruit maturity confirmed the non-climacteric nature of 'Mosambi' orange.

Changes in organoleptic characteristics

'Sourness' score declined significantly from 4.16 to 1.60 with concomitant increase in 'sweetness' score from 1.64 to 4.16 (on 1–5 scale) at 180 and 250 days, respectively (Table 5). Flavour score increased from 6.08 (on 1–9 hedonic scale) after 180 days to 7.84 after 250 days. Appearance score also recorded significant rise from 6.44 at 180 days to 8.24 at 250 days which was attributed to development of pale yellow colour. Total soluble solids (TSS) and titratable acidity (TA) contribute to orange fruit flavour (Pehrson and Ivans 1988). Minimum threshold of legal maturity for California oranges is TSS/TA ratio of 8:1. The organoleptic test indicated that consumers did not like sour fruits. For freshly squeezed Florida orange juice minimum TSS standard is 11°Brix and TSS/TA ratio is 12.5 with maximum ratio of 19.5 (Fellers 1990). As observed in the present study, TSS content of 12.82% and TSS : acidity ratio 16.63 coupled with desired sweetness (4.00) and flavour (7.76) score, 'Mosambi' fruit resulted in good palatability and acceptability at 240 days.

In present study, duration of 2 to 2 and1/2 months represented maturation of 'Mosambi' fruit from 180 days to 250 days where leveling-off of growth coincided with increase in soluble solids, flavour and sweetness and drop in acidity, sourness and fruit firmness. Total time required for growth and maturation of 'Mosambi' fruit from fruit set to

Table 6 Organoleptic evaluation of 'Mosambi' orange during maturation

Days after fruit set	Sourness (scale 1–5)	Sweetness (scale 1–5)	Flavour (scale 1–9)	Appearance (scale 1–9)
180	4.16	1.64	6.08	6.44
190	3.16	2.44	6.20	6.32
200	2.60	3.40	6.84	6.72
210	2.24	3.12	6.84	6.92
220	2.04	3.36	6.82	7.12
230	2.08	3.48	7.68	7.72
240	1.80	4.00	7.76	8.04
250	1.60	4.16	7.84	8.24
SE of means ±	0.16	0.16	0.16	0.20
CD (P = 0.05)	0.47	0.48	0.47	0.57

Sourness scale 1–5 (1, Not sour; 2, slightly sour; 3, moderately sour; 4, sour; 5, very sour) Sweetness scale 1–5 (1, Not sweet; 2, slightly sweet; 3, moderately sweet; 4, sweet; 5, very sweet). Flavour and appearance, hedonic scale 1– 9 (1, Dislike extremely; 2, dislike very much; 3, dislike moderately; 4,dislike slightly 5, neither like nor dislike; 6, like slightly ; 7, like moderately ; 8, like very much; 9, like extremely)

acceptable palatability was 240 days. Reuther and Rios-Castano (1969) reported that 'Valencia' fruits matured within six to seven months under low land tropics (Cartagena, Colombia) while it took 14 months under arid sub-tropical and coastal climate (Santa Paula, California, USA). Around Nagpur, because of higher temperatures (21–28°C mean monthly temperature) and sub-humid climate (RH 72–91%), 'Mosambi' fruit growth and maturation were faster with accumulated temperature more than 3000 heat unit (HU) summation (Table 6). This is consistent with heat unit concept that minimum range (1 000–1 400 HU) results in poor growth rate and rate increases until above 6 000HU (Mendel 1969).

It was concluded that considering fruit growth pattern, TSS content, TSS:acid ratio and sensory attributes, 'Mosambi' orange fruits intended for storage and fresh market can be harvested at 240 days after fruit set under sub-humid (monsoon type) climate of central India. For processing purpose, harvesting will be ideal at 250 days when maximum TSS (12.88%), TSS:acid ratio (18.14) and juice content (40.93%) are obtained.

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