Available online at www.ijpab.com

DOI: http://dx.doi.org/10.18782/2320-7051.2520

ISSN: 2320 – 7051

Int. J. Pure App. Biosci. **5 (1):** 601-612 (2017)

Research Article

International Journal of Pure & Applied Bioscience

OPEN ACCESS

Studies on Physical Changes in Fruit Development of Sweet Orange (*Citrus sinensis* (L.) Osbeck)

Abhishek[1], Kumatkar, R. B.[1], Vinita Rajput[1*] and Ravika[2]

[1]Department of Horticulture

[2]Department of Genetics and Plant Breeding

College of Agriculture, CCS Haryana Agricultural University, Hisar, Haryana-125 004

*Corresponding Author E-mail: rockingeverytime@gmail.com

Received: 12.01.2017 | Revised: 20.01.2017 | Accepted: 23.01.2017

ABSTRACT

The present investigation was carried out at Experimental Orchard, Department of Horticulture, CCS Haryana Agricultural University, Hisar during the year 2014-15. There were four varieties viz., Jaffa, Blood Red, Pineapple and Mosambi which were subjected for different observations. Rapid increase in fruit weight, fruit volume, fruit length and fruit diameter was recorded during initial period of development followed by a slow rate of increase and maximum values was attained on 15th November in Mosambi, 30th November in Jaffa and Pineapple and 15th December in Blood Red after which they tended to decrease slightly. Cultivar Pineapple exhibited maximum average value for these growth parameters. Specific gravity showed a decreasing trend during initial stages and increased in later period of development. Peel thickness, peel and rag content showed a continuous decrease during fruit development, however, rag content started increasing after 15th November in Mosambi, 30th November in Jaffa and Pineapple and 15th December in Blood Red. Number of healthy and aborted seeds were varied in each cultivar and found maximum in Mosambi followed by Pineapple, Blood Red and Jaffa. Juice contentof the fruit increased continuously with the advancement of season and were found maximum on 15th November in Mosambi, 30th November in Jaffa and Pineapple and 15th December in Blood Red after which it started decreasing.

Key words: *sweet orange, physical parameters, fruit development, maturity.*

INTRODUCTION

Citrus is one of the most important fruit crop which ranks third in area and production after banana and mango in India. It belongs to family Rutaceae. Citrus fruit species are grown under varying agro-climatic conditions of India except high hilly temperate regions. Among citrus groups, sweet orange is most popular in north western India and it has net area of 3.35 lakh ha with total production of 38.86 lakh tonnes which is highest among these groups in India[13].

Cite this article: Abhishek, Kumatkar, R.B., Rajput, V. and Ravika, Studies on Physical Changes in Fruit Development of Sweet Orange (*Citrus sinensis* (L.) Osbeck), *Int. J. Pure App. Biosci.* **5(1):** 601-612 (2017). doi: http://dx.doi.org/10.18782/2320-7051.2520

It require a dry and arid conditions coupled with distinct summer and winter season, with low rainfall, like those available in Punjab, Haryana, Deccan regions of Maharashtra, some parts of Gujarat, Northern districts of old Andhra Pradesh. It accounts for more than 80 per cent of citrus processing industry. Sweet orange cultivars Jaffa, Pineapple, Blood Red and Mosambi are grown in Haryana and Punjab. The cultivation of citrus fruits in the North-Western States of India has steadily increased over the past few years due to their high productivity and adaptability to various agro-climatic regions. These fruits are not only delicious and refreshing but also provide vitamins and minerals. Their richness in ascorbic acid (vitamin C) and many other essential minerals *viz*, iron, calcium, phosphorus, magnesium and potassium is very well recognized.

It is a common experience to find the contractors harvesting fruits while still immature and green and dumping those in the markets. This is done to realize more money by catching early market. But this practice does incalculable damage to the prestige and image of the fruit industry, besides depressing future demand for fresh fruit. In the interest of overall well-being of the fruit industry and to save our nation from the ill effect of immature fruits on their health, the practice of selling immature fruits need to be curbed. Citrus fruit should be harvested when they are fully ripe and had developed their characteristic flavor and aroma. These do not at all improve in quality after they have been harvested from the tree[2]. The sale of under ripe citrus fruits is prohibited by law in some of the horticulturally advanced countries like the U.S.A., Australia and South Africa. In India, however, there is no restriction on the sale of such fruits and the contractor to whom the fruit crop is usually auctioned, and traders have a free play in the matter. The fruit is picked regardless of its proper stage of maturity and quite often sent to the market in a raw condition. Such fruits, brings a bad name to the producer, and also endanger the health of the consumer. This practice, therefore, requires to be discouraged.

Though harvesting of fruits, in general, at their proper stage of maturity and ripeness is of great importance in all fruits, yet it is of greater significance in citrus fruits. Being non climacteric, these fruits fail to ripen after picking. No doubt, the external rind colour can be changed to yellow by treating with certain chemicals, but in such fruits the proper sweetness and the natural pleasant flavor, characteristic of tree ripe fruit is always lacking. Physico-chemical changes during growth and development of fruits are used as an important criterion for determining the maturity standards and have been used in various fruits such as citrus and mango[10]. Therefore, the present investigation was carried out to study the physical changes takes place during fruit development and to determine the optimum harvesting date of sweet orange cultivars viz., Mosambi, Jaffa, Pineapple and Blood Red under Haryana conditions.

MATERIALS AND METHODS

The present investigation was carried out at the Experimental Orchard of the Department of Horticulture, CCS Haryana Agricultural University, Hisar during 2014-2015.Hisar (Haryana) situated at 215.2 m above sea level with co-ordinates of 29º 10’ N latitude and 75º 46’ E longitudes. It is characterized by semi-arid climate with hot and dry summer and cold winter. The mean monthly maximum and minimum temperatures showed a wide range of fluctuations both during summer and winter months. A maximum temperature of around 47ºC during summer months of May to June and temperature as low as freezing point accompanied by frost on occasions in winter months of December and January have also been recorded in this region. The total rainfall as well as its distribution in the region is subjected to large variations. About 80 per cent of the annual rainfall (about 450 mm) is received during July to September.

Ten years old trees of four important cultivars *viz.* Jaffa, Blood Red, Pineapple and Mosambi which were planted 6 x 6 m apart constituted the plant material. A total twenty

trees, five from each of the four cultivars were selected for the purpose and each tree was considered as one replication. The trees selected were uniform in size and vigor, and were given uniform cultural practices. Irrigation and manuring were carried out as per recommendations. The experiment was laid out in a completely randomized design.

Data on physical parameters was collected at 15 days interval starting when the 70% of the fruits have attained 6.0 cm diameter till the full maturity. Sampling was carried out on the basis of calendar dates. First sample in all cultivars was taken on 15th August and subsequent samples were collected at fortnightly interval up to 30th December in all the four cultivars.

Fruit weight (g) was calculated from randomly selected fruits from the sample picked and weighed on top pan electronic balance.Fruits selected Eearlier were used for measurement of fruit length (cm). For this digital Vernier Callipers was used.Diameter of fruits from each sample was recorded with digital Vernier Callipers and average value was expressed in centimeters (cm).Average volume (cm^3) of fruits was determined by water displacement method with the help of a graduated cylinder. Specific gravity was calculated simply by dividing the weight of fruit by its volume and was expressed in terms of grams per cubic centimetres.The peel thickness was measured with the help of digital Vernier Callipers at the equator of fruit and expressed in millimeters (mm).Number of healthy and aborted seeds of each fruit from the sample of three fruits was counted separately and their average is taken into consideration. Fruits were peeled off and their juice was extracted with simple juice extractor. The juice was weighed with electronic balance and percentage of juice was worked out on the basis of following formulae:

$$\text{Juice content (\%)} = \frac{\text{Juice weight}}{\text{Fruit weight}} \times 100$$

After extraction of juice, the left over residue was considered as rag content. The per cent rag content was calculated by using the formula:

$$\text{Rag content (\%)} = \frac{\text{[Fruit weight - (peel weight + juice weight)]}}{\text{Fruit weight}} \times 100$$

Randomly selected fruits were peeled manually. Peel was weighed with electronic balance and the per cent peel content was calculated by using the formula:

$$\text{Peel content (\%)} = \frac{\text{Peel weight}}{\text{Fruit weight}} \times 100$$

RESULTS AND DISCUSSION

Fruit weight (g)

Data pertaining to fruit weight of the cultivars have been presented in fig 1. Fruit weight increased at a faster rate during the early stage of fruit development i.e. from 15th August to 15th October in Mosambi and up to 30th October in Jaffa, Pineapple and Blood Red. Later on, it increase at a slow rate and attained maximum value on 15th November in Mosambi (169.25 g), 30th November in Jaffa (170.66 g) and Pineapple (184.74 g) and 15th

December in Blood Red (173.46 g). On subsequent observations, there was a slight decrease in fruit weight in all the cultivars. The average weight of Pineapple (161.41 g) was highest among all the four cultivars, while Blood Red (150.10 g), Mosambi (150.31 g) and Jaffa (149.75 g) were at par with each other.

Ladaniya and Mahalle[8] observed rapid increase in fruit weight from 180 days onwards till 220 days after fruit set in Mosambi followed by a slow increase up to 250 days. Kalra*et al.*[6] also observed highest weight in Pineapple (196 g) which was followed by Jaffa (188 g) and Mosambi (183 g). Bhatnagar*et al.*[3] also observed increasing trend of fruit weight with fruit development and reduction after attaining proper maturity in mandarin.

Fruit length (cm) Fruit diameter (cm)

Data regarding change in fruit length during fruit development in four cultivars are presented in fig 2. Data showed that fruit length increased gradually and significantly up to 15th October in all the four cultivars. Maximum fruit length was recorded on 15th November in Mosambi (6.66 cm), 30th November in Jaffa (6.23 cm) and Pineapple (6.60 cm) and 15th December in Blood Red (6.53 cm) after which slight reduction was observed. Average fruit length differed significantly among the four cultivars. It was maximum in Mosambi (6.41 cm) and minimum (5.95 cm) in Jaffa fruits. Similar trend with different value was observed for fruit diameter (fig 3). Average diameter of all the four cultivars differed significantly with each other. It was highest in Pineapple (6.98 cm) followed by Blood Red (6.75 cm), Jaffa (6.70 cm) and Mosambi (6.59).Similar results on change in fruit length and fruit diameter were also observed by Ladaniya and Mahalle[8] in Mosambi orange.

Fruit volume (cm^3)

Data given in fig 4 indicates that fruit volume increased gradually with the advancement of season. The increase in fruit volume was rapid during initial stages of fruit development and thereafter, the rate of increase slowed down. Significant and rapid increase was observed up to 30th September in Jaffa and till 15th October in Mosambi, Pineapple and Blood Red. Fruit volume started declining after attaining maximum value on 15th November in Mosambi (169.52 cm^3), 30th November in Jaffa (174.37 cm^3) and Pineapple (185.54 cm^3) and 15th December in Blood Red (174.32 cm^3). Average maximum fruit volume of Pineapple (164.54 cm^3) was higher than remaining three cultivars. Whereas, Jaffa (156.19 cm^3) and Blood Red (155.77 cm^3) were found at par.

Similar findings were also observed by Bhatnagar*et al.*[3] in mandarin. Ladaniya and Mahalle[8] also observed rapid increase in fruit volume of Mosambi between 180 days onwards till 220 days after fruit set after that it increase at a slow rate up to 250 days.

Specific gravity (g/cm^3)

Data regarding specific gravity (g/cm^3) have been presented in table 1. Initially, when fruits were immature, it showed a decreasing trend in all the four cultivars and on later stages, it started increasing and became constant after 15th November in Mosambi (0.95), 30th November in Jaffa (0.98) and Pineapple (1.00) and 15th December in Blood red (1.00).

In the present investigation, specific gravity showed a decreasing trend during early stages of fruit development in all the four cultivars but it was found to increase thereafter, continuously and became constant after 15th November in Mosambi, 30th November in Jaffa and Pineapple and 15th December in Blood Red. This leads to the conclusion that the increase in volume of sweet orange fruits is more during earlier phase of development as compared to fruit weight and its reverse occurs in later stages. This might be due to an increase in intercellular spaces during maturation. Similar pattern was also observed by by Ladaniya and Mahalle[8] in Mosambi. It has been reported that

the specific gravity is one of the index associated with maturity[5].

Peel/rind thickness (mm)

With the development and maturity of fruits, change in peel thickness was also observed data regarding this is depicted in table 2. With advancement in season, thickness of peel gradually decreased in all the four cultivars and became almost constant after 15th November in Mosambi and 30th November in Jaffa, Blood Red and Pineapple. Maximum average peel thickness (4.46 mm) was recorded in Mosambi which was higher over remaining cultivars whereas, Jaffa (3.66 mm) and Blood Red (3.65) were at par with each other.

The reduction in peel thickness might be due to continuous increase in pulp size of the fruit. Downward trend of peel thickness with advancement of season was also observed by Ladaniya and Mahalle[8] in Mosambi orange and Bhatnagar*et al.*[3] in Nagpur mandarin. Maximum average peel thickness was observed in Mosambi (4.46 mm) followed by Pineapple (3.91) while, Jaffa (3.66 mm) and Blood Red (3.65 mm) were at par with each other. Lal and Sharma[9] also observed maximum peel thickness in Mosambi (0.62 cm) followed by Blood red (0.55 cm), Pineapple (0.53 cm) and Jaffa (0.47 cm).

Number of seeds (healthy and aborted)

Data given in table 3indicates that number of healthy seeds varied from 7.4 to 9.2 in Jaffa, 9 to 11 in Blood Red, 11 to 14.1 in Pineapple and 12 to 15 in Mosambi. Similarly, number of aborted seeds varied from 1.1 to 3 in Jaffa, 1.3 to 3.4 in Blood Red, 1.8 to 3.8 in Pineapple and 2 to 4.2 in Mosambi. Average number of healthy and aborted seeds was highest in Mosambi (13.5 and 3.1) followed by Pineapple (12 and 2.9), Blood Red (10 and 2.3) and Jaffa (8 and 1.9). Number of aborted seeds in Pineapple and Mosambi were at par with each other. Similarly, 15.67 seeds per fruit in Mosambi and 15 in Blood Red were observed by Mohar*et al.*[12] on 15th December and 15th January respectively. Similarly, 12 seeds/fruit were counted in Mosambi, 11 in Blood Red, 10 in Jaffa and 13 in Pineapple in month of December by Kaul*et al*[7].

Juice (%)

With an increase in fruit size, the weight of juice per fruit increased in all the four cultivars (fig 5). Rapid increase in juice content of Mosambi was observed from 30th August to 15th September (26.94% to 32.73%) and again from 15th October to 15th November (35.98% to 41.03%). While, in Jaffa (35.90% to 38.33%) and Pineapple (34.83% to 37.44%), it increases rapidly from 30th October to 15th November. For Blood Red, abrupt increase (34.91% to 39.89%) in juice per cent was observed from 15th to 30th of November. After reaching to its maximum value on 15th November in Mosambi (41.03%), 30th November in Jaffa (39.14%) and Pineapple (38.42%) and 15th December in Blood Red (40.48%), juice percentage started declining. All the cultivars differed significantly among each other in juice content. The average per cent of juice per fruit was highest in Jaffa (36.20%) over Mosambi (35.50%), Pineapple (34.60%) and Blood Red (33.66%).Bhatnagar*et al.*[3] observed increase in juice percentage with the development of fruit up to 2nd fortnight of November in mandarin. Rapid rate of increase in juice content was observed when fruit reached near maturity stage. Ladaniyaand Mahalle[8]also observed rapid increase in juice content of Mosambi between 230 and 240 days after fruit set.

Rag (%)

Data pertaining torag (%) have been presented in table 4. Rag content with slight variations showed a decreasing trend with the development of fruit but on later stages, it showed some increase. It decreased to 37.47% in Jaffa on 15th November and then increased to 39.51% on last sampling date. In Blood Red, it decreased to 36.97% on 30th November and then increased to 38.15% on 30th December. In Pineapple, it decreased from

43.91 to 39.51 per cent (from 15th August to 30th November) and then increased up to 30th December. However, it was minimum on 30th September (38.39%). Rag percentage in Mosambi decreased to 36.33% on 15th November and then increased up to last sampling date.

Rag percentage showed decreasing trend with slight variations at some stages. Decrease in rag content with fruit development was also noticed by Ladaniya and Mahalle[8] in Mosambi. It started increasing after 15th November in Mosambi, 30th November in Jaffa and Pineapple and 15th December in Blood Red. Bakhshi*et al.*[1] in Valencia Late also observed decrease in rag percentage with fruit development and an increase after optimum maturity stage.

Peel/rind content (%)

In all the cultivars (table 5), the percentage of peel decline from first sampling date (15th August) to last sampling date (30th December). On first sampling, it was 27.01% in Jaffa, 30.52% in Blood Red, 28.90% in Pineapple and 31.21% in Mosambi and as maturity advanced it reduced to 21.68% in Jaffa, 21.59% in Blood Red, 21% in Pineapple and 20.99% in Mosambi. Average peel content per fruit was lowest in Jaffa (24.24%) followed by Mosambi (24.76%), Pineapple (24.97%) and Blood Red (25.65%) and it was at par in Pineapple and Mosambi.

Peel content also showed a continuous decreasing trend with the development of fruits in all the cultivar up to last date of sampling. However, decrease was not much pronounced after 15th November in Mosambi, 30th November in Jaffa and Pineapple and 15th December in Blood Red. Average minimum peel content was reported in Jaffa (24.24%) and maximum in Blood Red (25.65%). Bakhshi*et al.*[1] in Valencia Late and Ladaniya and Mahalle[8] in Mosambi also observed decrease in peel content with every delay in date of picking.

Fig. 1: Change in fruit weight (g) during fruit development of sweet orange cultivars

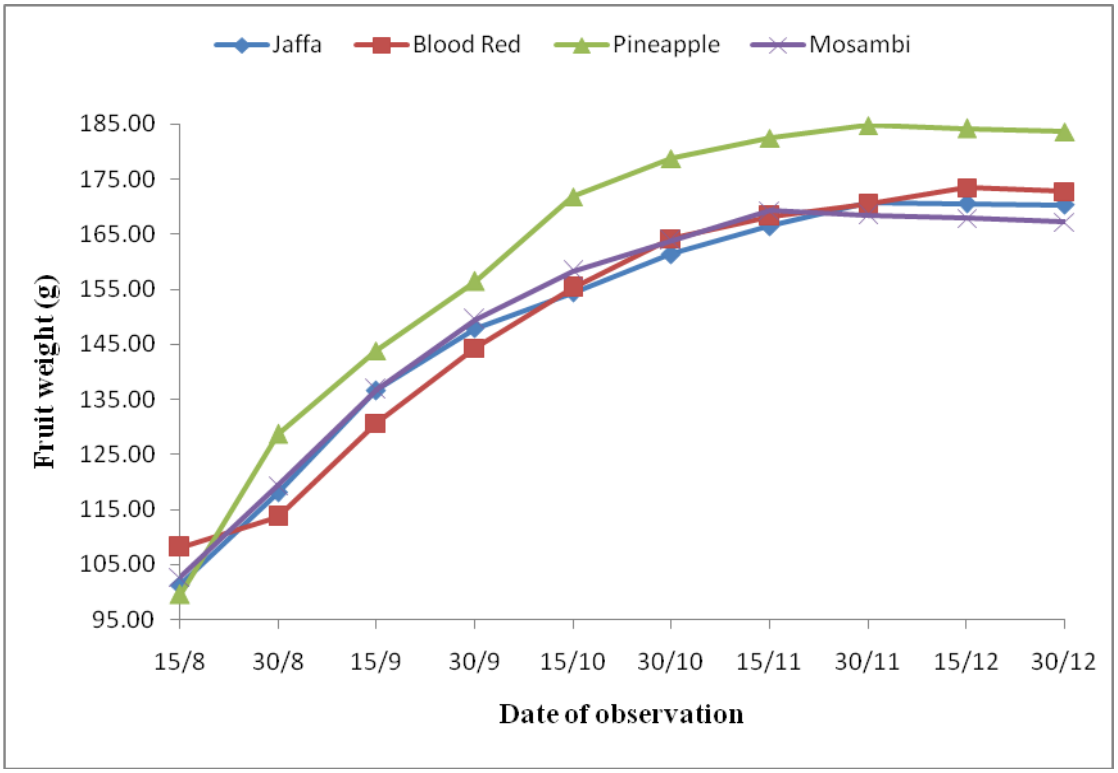

Fig. 2: Change in fruit length (cm) during fruit development of sweet orange cultivars

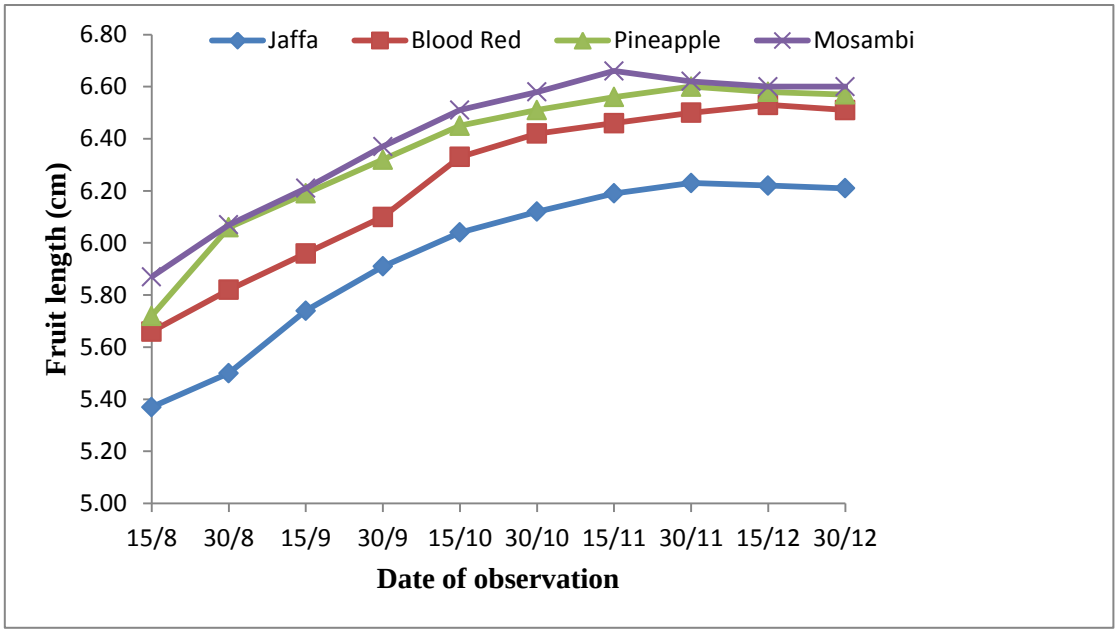

Fig. 3: Change in fruit diameter (cm) during fruit development of sweet orange cultivars

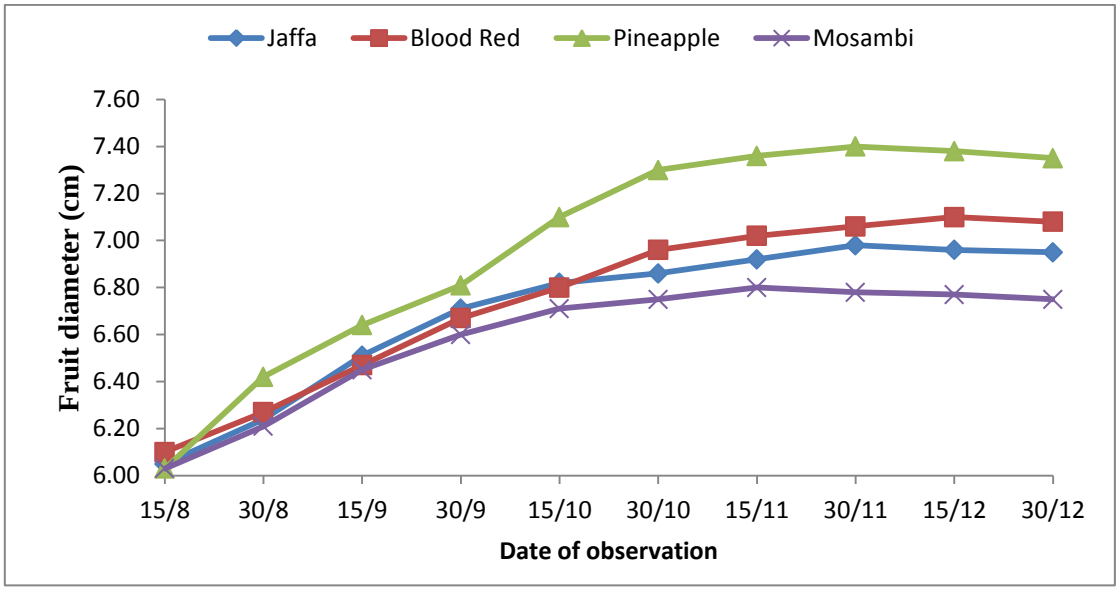

Fig. 4: Change in fruit volume (cm^3) during fruit development of sweet orange cultivars

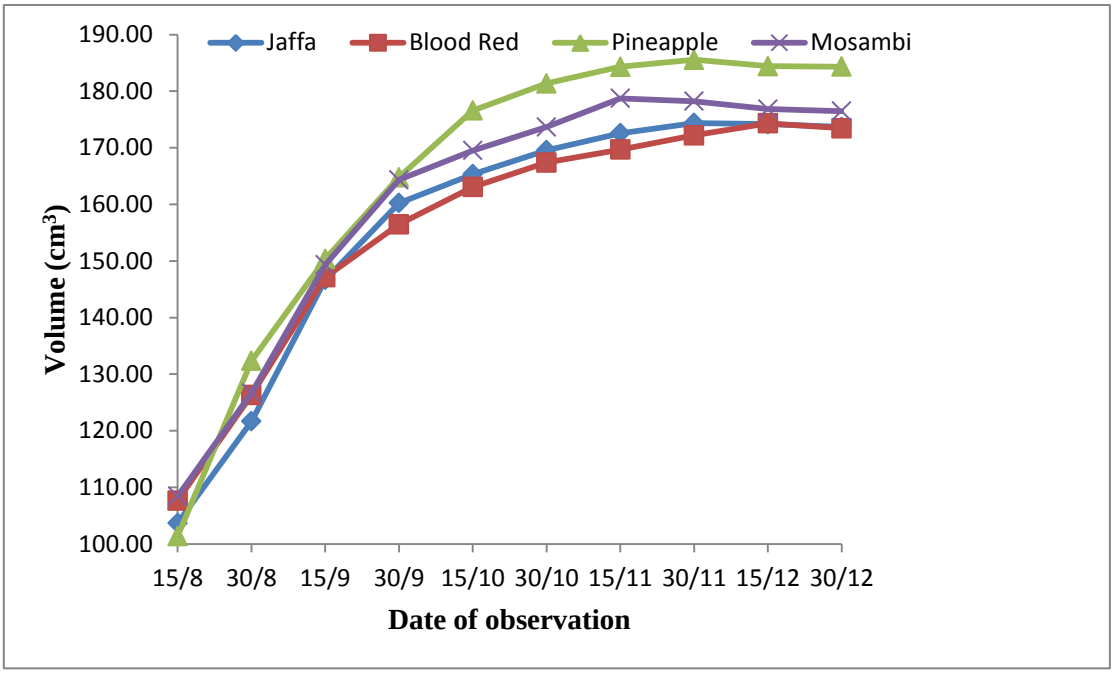

Fig.5: Change in juice (%) during fruit development of sweet orange cultivars

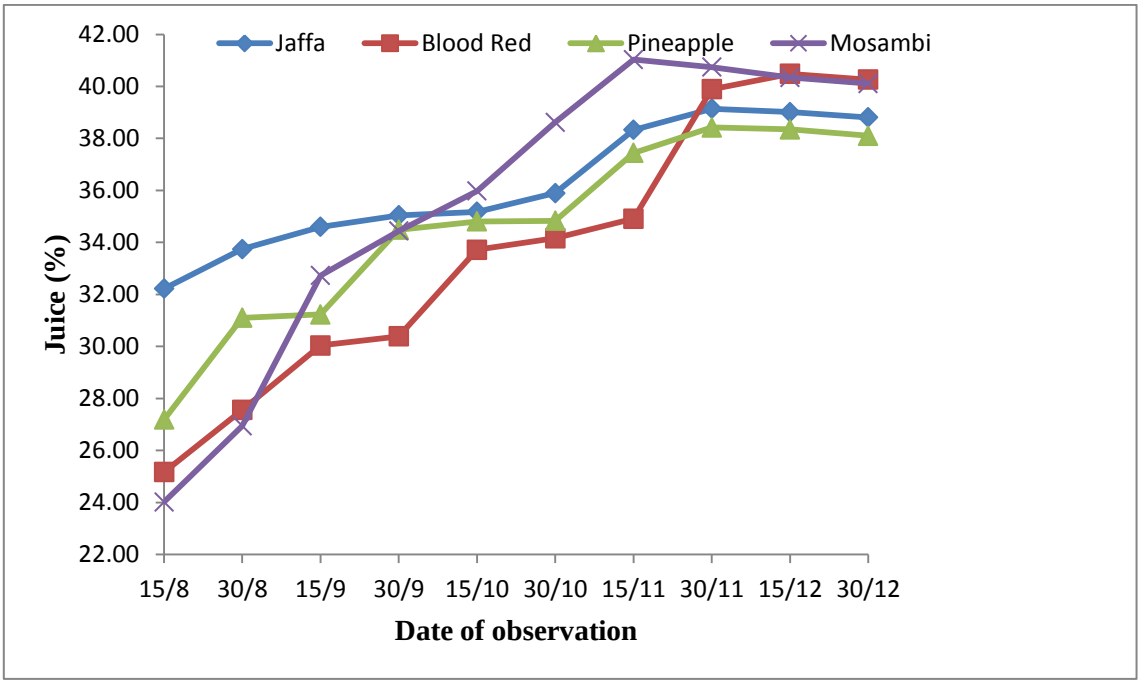

Table 1: Change in specific gravity (g/cm^3) during fruit development of sweet orange cultivars

Date of observation	Cultivars			
	Jaffa	**Blood Red**	**Pineapple**	**Mosambi**
15/8/2014	0.98	1.01	0.98	0.95
30/8/2014	0.97	0.90	0.97	0.94
15/9/2014	0.93	0.89	0.96	0.92
30/9/2014	0.92	0.92	0.95	0.91
15/10/2014	0.93	0.95	0.97	0.93
30/10/2014	0.95	0.98	0.99	0.94
15/11/2014	0.96	0.99	0.99	0.95
30/11/2014	0.98	0.99	1.00	0.95
15/12/2014	0.98	1.00	1.00	0.95
30/12/2014	0.98	1.00	1.00	0.95

Table 2: Change in rind thickness (mm) during fruit development of sweet orange cultivars

Date of Observation	Cultivars			
	Jaffa	**Blood Red**	**Pineapple**	**Mosambi**
15/8/2014	4.09	4.33	4.40	5.08
30/8/2014	3.94	4.21	4.24	4.77
15/9/2014	3.82	3.85	4.13	4.64
30/9/2014	3.70	3.69	4.00	4.57
15/10/2014	3.57	3.47	3.90	4.42
30/10/2014	3.53	3.44	3.78	4.34
15/11/2014	3.52	3.40	3.70	4.22
30/11/2014	3.48	3.38	3.67	4.21
15/12/2014	3.47	3.37	3.65	4.20
30/12/2014	3.46	3.37	3.65	4.20
Mean	**3.66**	**3.65**	**3.91**	**4.46**
CD at 5%	0.13	0.14	0.11	0.12

CD at 5% for comparing difference in cultivars = 0.04

Table 3: Change in Number of healthy (H) and aborted (A) seeds during fruit development of sweet orange cultivars

Date of observation	Cultivars							
	Jaffa		Blood Red		Pineapple		Mosambi	
	H	A	H	A	H	A	H	A
15/8/2014	7.6	2.0	10.7	2.0	13.2	2.5	13.6	3.7
30/8/2014	7.4	3.0	10.2	2.5	12.7	3.2	14.2	3.5
15/9/2014	8.0	1.7	9.8	1.3	14.1	1.8	12.8	4.2
30/9/2014	9.1	1.7	10.5	2.1	12.1	2.4	14.7	2.5
15/10/2014	7.6	1.9	9.8	1.5	10.8	3.6	12.0	3.9
30/10/2014	7.8	1.7	9.6	2.9	11.3	3.2	15.0	2.0
15/11/2014	8.0	2.1	9.5	2.7	12.1	2.3	13.3	2.1
30/11/2014	7.5	2.5	9.0	3.0	11.0	3.5	12.0	3.6
15/12/2014	8.0	1.3	10.0	3.4	11.0	3.8	14.0	2.6
30/12/2014	9.2	1.1	11.0	2.0	12.5	3.0	13.5	2.8
Mean	**8.0**	**1.9**	**10.0**	**2.3**	**12.0**	**2.9**	**13.5**	**3.1**
CD	0.95	0.55	NS	0.77	1.74	0.59	1.60	1.09

CD at 5% for comparing difference in cultivars is 0.4 for healthy seeds and 0.3 for aborted seeds

Table 4: Change in rag (%) during fruit development of sweet orange cultivars

Date of Observation	Cultivars			
	Jaffa	Blood Red	Pineapple	Mosambi
15/8/2014	40.77	44.31	43.91	44.77
30/8/2014	39.56	42.47	40.94	42.16
15/9/2014	38.94	40.40	41.06	39.36
30/9/2014	39.44	42.95	38.39	39.91
15/10/2014	40.82	40.54	39.34	39.78
30/10/2014	39.62	42.13	40.64	38.77
15/11/2014	37.47	41.82	39.56	36.33
30/11/2014	38.48	36.97	39.51	37.81
15/12/2014	39.01	37.22	40.14	38.62
30/12/2014	39.51	38.15	40.90	38.90

Table 5: Change in rind content (%) during fruit development of sweet orange cultivars

Date of Observation	Cultivars			
	Jaffa	**Blood Red**	**Pineapple**	**Mosambi**
15/8/2014	27.01	30.52	28.90	31.21
30/8/2014	26.71	29.97	27.96	30.89
15/9/2014	26.46	29.56	27.72	27.91
30/9/2014	25.52	26.66	27.12	25.66
15/10/2014	24.01	25.75	25.85	24.23
30/10/2014	23.48	23.71	24.53	22.60
15/11/2014	23.20	23.27	23.00	21.64
30/11/2014	22.38	23.14	22.07	21.45
15/12/2014	21.97	22.30	21.51	21.04
30/12/2014	21.68	21.59	21.00	20.99
Mean	**24.24**	**25.65**	**24.97**	**24.76**
CD at 5%	1.86	1.77	2.32	1.88

CD for comparing difference in cultivars = 0.43

CONCLUSION

On the basis of present studies, these cultivars should not be harvested before 15th November (for cv. Mosambi), 30th November (for cv. Jaffa and Pineapple) and 15th December (for cv. Blood Red). It is, however, essential to confirm these findings before final recommendations are made, because these observations are based on the data of only one season and these may be different for different locality depending up on environmental conditions.

Acknowledgement

Authors want to thank the faculty member, non-teaching staff and field assistants of the Department of Horticulture, CCS HAU, Hisar, Haryana, for their technical and moral support.

REFERENCES

1. Bakhshi, J.C., Singh, G. and Singh, K.K., Effect of time of picking on fruit quality and subsequent cropping of Valencia Late variety of sweet orange (*Citrus sinensis*). *Indian J. Hort.* **27:** 63-70 (1967).
2. Bal, J.S. and Chohan, G.S., Studies on fruit quality at maturity and ripening of Kinnow mandarin on different rootstocks. *Indian J. Hort.* **44:** 45-51 (1987).
3. Bhatnagar, P., Singh, J., Jain, M.C., Singh, B., Manmohan, J.R. and Dashora, L.K., Studies on seasonal variations in developing fruits of Nagpur mandarin (*Citrus reticulate* Blanco) under Jhalawar conditions. *Asian J. Hort*. **7(2):** 263-265 (2012).
4. Ghosh, S.N. and Chattopadhyay, N., Performance of sweet orange cultivars under semi-arid region of West Bengal. *Haryana J. Hort.* **27(3):** 153-156 (1998).
5. Harkness, N.W. and Cobin, H., Haden mango maturity observation during 1950. *Proc. Fla. Mango Forum* **10:** 27-82 (1950).
6. Kalra, S.K., Sharma, J.N. and Chohan, G.S. Tree growth, yield and fruit quality of six orange cultivars under arid irrigated regions of Punjab. *Indian J. Hort.* **46(1):** 14-18 (1989).
7. Kaul, M.K., Bhatnagar, P. and Kumar, M., Varietal evaluation trial in *Citrus sinensis*Osbeck. *Indian J. Citriculture* **1(1):** 3-5 (2002).

8. Ladaniya, M.S. and Mahalle, B.C., Fruit maturation and associated changes in Mosambi orange. *IndianJ. Agri. Sci.* **81(6):** 494-499 (2011).
9. Lal, H. and Sharma, R.M., Performance of sweet orange cultivars under Pithoragarh condition. *Punjab Hort. J.* **24(1-4):** 37-45 (1984).
10. Lakshminarayan, S., Subhatra, N.V. and Subramanyam, H., Some aspects of development physiology of mango fruit. *J. Hort. Sci.* **45:** 133-42 (1970).
11. Mathur, M.M. and Godara, P.S. Physico-chemical studies of some citrus species grown in arid irrigated region of Rajasthan. *Haryana J. Hort. Sci.* **19(3-4):** 251-255 (1990).
12. Mohar, T.A., Abbas, M.M., Awan, M.Z., Javed, M.A. and Farooq, A., Performance of different sweet orange varieties under Faisalabad conditions. *J. Agric. Res.* **49(3):** 363-367 (2011).
13. Saxena, M. and Gandhi, C.P., Indian Horticulture Database, National Horticulture Board, Ministry of Agri. Government of India, India (2014).