Selection of Sweet Orange (*Citrus sinensis* Osbeck) Varieties for Production Period Expansion

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ABSTRACT

Harvesting season of sweet orange in Nepal is very narrow (January-February) since most plantations are composed of mid-season variety. Therefore, a variety evaluation study was carried out at National Citrus Research Programme, Dhankuta to select early, mid and late maturing varieties for the mid-hill ecological region of the country to extend harvesting duration. Fourteen varieties evaluated in this study exhibited large variations on fruit characters and maturity periods. Varieties with three types of fruit shapes: oblate, spheroids and ellipsoid were recorded. Fruit weight ranged from 101±8.6 in Dhankuta Junar to 157.7±22.1 g in Shamauti, and pulp percent varied from 51.1±5.1 as in Mosambi to 69.7±3.6 in Navelencia. Navelencia and Washington Navel were seedless varieties, while Mosambi had more than 20 seeds/ fruit. Percentage of juice content in the fruits of Leu Gim Gong and Hamlin was around 39 percent while it was only 26.2 percent in Mosambi. TSS ranged from 9.0 to 11.4 ^{0} Brix, and total acids from 1.1 to 1.6 percent among the varieties. Navelencia and Washington Navel matured during November-December. Pineapple, Malta Blood Red, Shamauti, Mosambi, Vanelle, Dhankuta Junar, Rubi, White Taker and Hamlin were mid-season varieties maturing during January-February. Valencia, Sevelle Common and Leu Gim Gong matured around March-April. Based on maturity period and fruit characters Washington Navel was selected for early season, Pineapple and Hamlin for mid season and Valencia for late season production. By commercialization of presently selected early and late varieties, production period of sweet orange in Nepal can be extended at least for six months compared to two months at present.

Key words: sweet orange varieties, maturity period, Valencia Late, Washington Navel

INTRODUCTION

Sweet orange (*Citrus sinensis* (L.) Osbeck) occupies first position among citrus fruit crops in area coverage and production in the world. According to FAO (2006), world's total area under citrus cultivation is nearly 7.4 million hectare of which 3.7 million hectare is under sweet orange cultivation, and sweet orange shares about 57.8 % of the global total citrus fruit production. This crop has been grown in most of the citrus growing countries, but Brazil, Unites States of America, China, Mexico, Spain and India are the leading sweet orange producing countries of the world.

About 35 thousand ton of sweet orange fruit was produced in Nepal in 2004 from 5254 hectare of orchards (FDD, 2005). It is the second important citrus species of Nepal after mandarin sharing about 20 and 23 % of total citrus area and production respectively. The two districts: Ramechhap and Sindhuli account nearly 56 percent of total sweet orange production of Nepal. Most sweet orange plantations in Nepal are composed of a local variety (Junar). It is a mid-season variety maturing during January-February, a normal

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season of sweet orange production in Nepal. In the other months, sweet orange is imported from India to meet market demand. Several exotic sweet orange varieties were introduced into Nepal after 1970s, but their evaluation was not carried out systematically in the past. Limited studies, whatever, were carried out, were focused mainly on mother plant and rootstock selection and propagation techniques (HDP, 1996). As a result, varieties for different seasons are completely lacking in Nepalese citriculture, which has resulted in a very narrow harvesting period (Jan.-Feb.). Therefore, a variety evaluation study was carried out to select superior early and late maturing varieties of sweet orange especially for mid-hill region of Nepal.

MATERIALS AND METHODS

A total of 14 sweet orange varieties (Table 1) established at research orchard of National Citrus Research Programme, Dhankuta (1350 m altitude) were evaluated for horticultural characters in 2002 and 2003. Among the varieties Junar was a local selection and the rest were exotic varieties introduced from India. All the varieties were grafted on rough lemon (*Citrus jambhiri*) rootstocks and the tree ranged in age from 20 to 30 years. It is important to compare the fruit quality of the varieties at similar maturity stage. So, first of all initiation of maturity period was determined. For this, in the first year of evaluation, fruits of selected trees of each variety were observed for color development from mid October (beginning of Kartik). When most fruits started to turn yellow color, fruit samples (two fruits/tree) were evaluated for TSS, TA and their ratio in weekly interval. Same fruit samples were also used for organoleptic test. The fruits were found sweet enough for fresh consumption when ratio of TSS and TA crossed 7:1 level. So, the time at which this ratio was recorded was considered as initiation of maturity period for that variety. Fifteen days after the initiation of maturity period, fruit characters such as fruit apex and base shape, rind texture, skin color, fruit weight, seed number, rind, pulp and juice percent, total soluble solids (TSS), total acids (TA) and TSS/TA ratio were recorded. These traits are least affected by external environment and are also important from market point of view. Fruit samples (10 fruits/tree) were randomly collected from all directions of the tree. Shapes of fruit, apex-shape, base-shape and rind texture were determined following the Citrus Descriptors (IPGRI, 1999). TSS was recorded by hand refractometer. Two milliliter of fruit juice was titrated with 0.1 N sodium hydroxide (NaOH) solution to Phenophthalein end point and percentage of TA was calculated using formula of Rangana (2002). Percentage of rind, pulp and juice was calculated based on fruit weight. Means of two years data with standard deviations within variety were used for comparison.

RESULT AND DISCUSSIONS

Quantitative fruit characters

Average fruit size ranged from 101.8 to 157.7 g among varieties (table 1). Shamauti produced biggest fruits (157.7 ± 22.1 g) whereas; Dhankuta Junar (101.8±8.6 g) and Lue Gim Gong (104.4 ± 14.9 g) had small sized fruits. Lower rind percentages were recorded in Navelencia (30.2%), Hamlin (31.1%), Lue Gim Gong (31.7%) and Washington Navel (32.6%). On the other hand pulp percentages in the fruit of these varieties were high. The varieties with high rind percentage (thick rind) such as Mosambi and Malta Blood Red had low pulp content in the fruits.

Washington Navel and Navelencia were seedless (Fig. 2); Pineapple, Shamauti, Sevelle Common, Vanelle, Lue Gim Gong and Hamlin had low number (3-5) of seeds per fruit. Valencia, Rubi and Whitetaker were moderately seeded (5-9 seeds/fruit). Dhankuta Junar and Malta Blood Red had 7-14 seeds in a fruit whereas Mosambi had very high number (20.3 ± 4.2) of seeds per fruit (table 1). Juice content in fruit was low in Mosambi (26.2%) and Malta Blood Red (28.5%). Fruits of Lue Gim Gong (39.6%), Hamblin (38.6%) and Navencia (35.7 %) were more juicy. TSS ranged from 9 to 11.4 ^{0} Brix, TA from 1.1 to 1.6 and TSS/TA ratio from 7.2 to 9.1. Karkara and Lakhapal (2000) also noted wide variation on fruit characters among sweet orange varieties.

Qualitative fruit characters

Fruit characters such as fruit shape and texture are important factors for market acceptance. Three types of fruit shape namely spheroid (nearly equal height and diameter), oblate (height less than diameter) and ellipsoid (height greater than diameter) were recorded. Fruits of Washington Navel were oblate; Shamauti and Vanelle had ellipsoid fruits while other 11 varieties produced spheroid fruits (table 2). Citrus traders were found to prefer spheroid and oblate type of fruits because such fruits are easy to adjust in layer during packaging (personnel communication with local traders). Two types of fruit bases and apices (truncate or convex) were found in the varieties (Table 2). Rind surface in all the varieties except in Mosambi was smooth. Fruit rind in Mosambi was grooved which was very prominent at basal end. On horticultural point of view sweet oranges are classified into four groups namely navel, common, pigmented and acidless (Spiegel-Roy and Goldschmidt, 1996). Except acidless, other three types of sweet oranges were identified in this study. Washington Navel and Navelencia were navel type with small secondary fruit embedded in the apex of the main fruit. Malta Blood Red was pigmented or blood type since the fruit pulp at full maturity was pink in color due to development of anthocynin pigment. All other varieties were common or blond oranges. Acidless or sugar oranges have very less acid in fruit juice generally less than 0.2%. Fruit juice analysis (Table 1) showed that all the 14 varieties had more than 1% acid confirming that none of these varieties were acidless type.

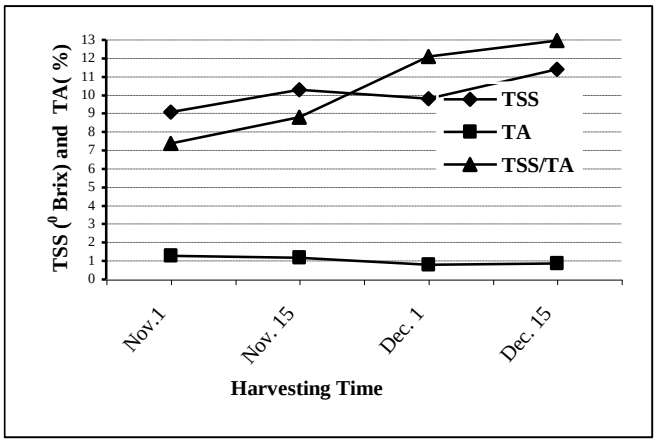

Figure 1. Change in TSS, TA and TSS/TA ratio over time in Washington Navel sweet orange

Maturity period

As mentioned above, fruit samples were used for organoleptic test and, TSS and TA analysis after fruit rind stated to develop yellow color. It was found that when TSS/TA ratio crossed above 7:1, sweet orange fruits were sweet enough in organoleptic test. So, TSS/TA ratio of 7 has been considered as indicator of initiation of maturity and harvesting time in sweet orange in mid-hill condition of Nepal. Based on maturity period the varieties were classified into three groups: early (maturing from November), mid-season (maturing from January) and late (maturing from March). Washington Navel and Navelencia were early varieties; Valencia, Sevelle Common and Lue Gim Gong were late maturing varieties and rest of the varieties were found mid-season maturing type (table 2). The TSS/TA ratio in mid and late season varieties was less than 5

and fruits were sour in taste even after one month of full yellow color development on rind surface (data not presented). On the other hand, fruits of early maturing varieties like Washington Navel were sweet and TSS/TA ratio crossed 7 even when only about 50% of the fruit rind had turned to yellow color. Cool temperature enhances yellow color development by accelerating the process of chlorophyll degradation and carotinoids build up in citrus fruits. Therefore, poor color development in early varieties could be attributed to relatively high temperature during the maturity period of such varieties. Differences in date of maturation between early and late cultivars are believed to reflect differences in heat unit requirements. Late cultivars require a larger sum of heat units than early cultivars for maturation (Reuther, 1973).

Citrus fruits are non-climacteric in nature meaning that changes in fruit texture and composition during maturation takes place in a slow and gradual manner. Maturation of citrus fruit is characterized by gradual changes in juice content and some of its constituents (Eaks, 1970). On one hand there is a decline in TA brought about by decomposition of citric acid, a major organic acid of citrus juice. On the other hand, there is an increase in sugars, usually expressed as TSS. With acidity declining and sugars increasing towards maturation, the TSS/TA ratio, commonly used as 'maturity index' in most countries, starts to increase (Spiegel-Roy and Goldschmidt, 1996). But in Nepal, development of yellow color in rind surface is a commonly used indicator of maturity in sweet orange. The result of present study revealed that color development only might not be the true indicator of maturity since it may depend on several factors like variety, climate and season. TSS/TA ratio of 8 has been used as maturity and harvesting index of sweet orange in USA (CCPP, 2004). But considering mild subtropical type of production climate of Nepal where reduction of acid in citrus fruits is slow and slightly acid blended taste preferences of Nepalese consumers, TSS/TA ratio of 7 has been suggested as the indicator of harvesting time of sweet orange for Nepal.

Figure.2. Seedless fruits of Washington Navel with prominent navel at stylar end

Selection of varieties

As mentioned earlier, there was diversity among the varieties on maturity period from November to April, and varieties were broadly grouped into early, mid and late maturing types. So, an attempt was also made to select superior varieties for each maturity group. For selection, varieties within each maturity group were compared on fruit size, rind, pulp and juice percent, seed number, TSS, TA, TSS/TA ratio and other observation made during evaluation.

Washington Navel and Navelencia were early maturing varieties. Both the varieties were very similar in most fruit characters. But compared to Washington Navel, very high rate of post bloom fruit drop was observed in Navelencia. So, Washington Navel was selected for early season production. On the first week of November (third week of Kartik), TSS/TA ratio in Washington Navel was 7.37:1 (Fig. 1), and taste was adequately sweet for fresh consumption. It confirms that this variety started to mature from the beginning of November at 1350 m elevation. It is likely that this variety may mature 1-2 weeks earlier at

lower (1000-1200 m) altitude because of availability of higher amount of heat unit and sunshine there.

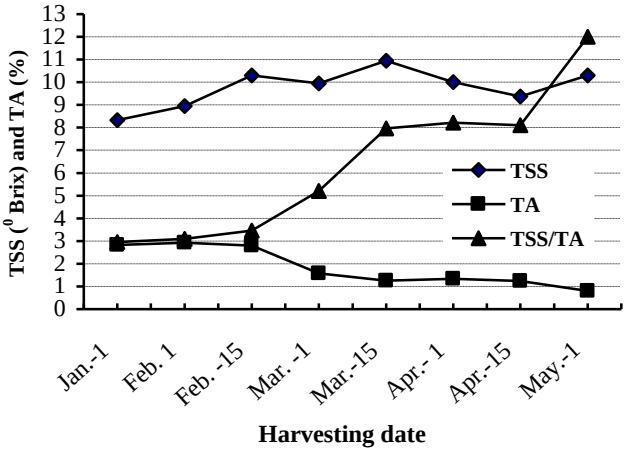

Figure 3. Change in TSS, TA and TSS/TA ratio in Valencia Late variety

Nine varieties found maturing during January – February are considered as mid or normal season varieties in Nepal. The TSS/TA ratio of these varieties crossed 7 in the beginning of January (mid Paush). Junar is a mid-season and predominantly cultivated local variety of Nepal. However, present study showed that Hamlin and Pineapple are superior to Junar in most of the fruit characters such as high pulp and juice and low rind and seed content (table 1). So, in addition to Junar, Hamlin and Pineapple are also recommended for mid-season production. Disseminating these to farmers would help in improving fruit quality of sweet orange in Nepal. The fruit quality of Mosambi, a popular commercial variety in India, was found very poor (low pulp and juice percent, highly seeded and thick rind) in mid-hill condition of Nepal. It suggests the need of location specific varieties for quality fruit production. .

Figure 4. Overlapping of fruit maturity and flowering in Valencia Late sweet orange

Late maturing varieties: Valencia, Sevelle Common and Lue Gim Gong were very similar in all characters except that fruits of Valencia were bigger in size possibly due to better tree health. It is likely that these varieties could have been originated as clonal progenies of same variety but given different names in different countries. According to Hodson (1967), Lue Gim Gong is a nucellar selection of Valencia. The acid content was high (>2.8%) and taste was sour in late varieties until mid-February. After mid-February, acid content started to decrease with slight increase in TSS, which resulted in sharp increase in TSS/TA ratio. Fruits of Valencia started to mature (TSS/TA > 7) from the second week of March (Fig. 3) and can be harvested until the end of April. In this variety, maturity of fruits overlapped the development of new bloom (Fig. 4) and the fruits stored remarkably well on the trees without major loss in quality.

Narrow genetic base resulting by the use of single variety could be very vulnerable for biotic and abiotic stresses. To reduce such vulnerability and provide choices on quality to consumers, most countries use more than one variety. For example, in India varieties like

Mosambi, Sathguthi, Jaffa, Valencia and Malta (Singh, et al., 2002) and in USA Pineapple, Cara Cara, Lane Late, Washington Navel, Autumn Gold and Summer Gold (Kahn et al., 2000) are recommended, and are being cultivated in commercial level. Commercialization of presently selected early and late season varieties can broaden the genetic base of sweet orange, and is also appropriate technique for expanding harvesting season in Nepal, where storage facilities are inadequate and expensive.

CONCLUSION

Sweet orange, the second important citrus fruit crop of Nepal, has been cultivated in mid-hill region of the country. At present harvesting duration of this crop is very narrow (January-February) because of the use of single variety: Junar. Hence a variety evaluation study was undertaken to select superior varieties for different harvesting seasons.

Wide variations were noted on fruit characters such as fruit shape and size, seed number, pulp percent, juice, TSS and TA content, TSS/TA ratio and maturity season among the 14 varietiesevaluated. Navelencia and Washington Navel were early maturing (November-December) and seedless. Pineapple, Shamauti, Rubi, White Taker, Hamlin, Dhankuta Junar, Vanelle, Mosambi and Malta Blood Red were mid-season maturing (January-February) varieties, whereas Sevelle Common, Lue Gim Gong and Valencia were late

Table 1. Quantitative fruit characters of 14 sweet orange varieties

Variety	Fruit Weigh (gm)	Rind (%)	Pulp (%)	Seed No.	Juice (%)	TSS (^{0} Brix)	TA (%)	TSS/TA
Pineapple	136.2 (±13.6)	39.6 (±2.7)	62.0 (±1.6)	2.6 (±1.5)	36.7 (±2.7)	10.3 (±0.3)	1.3 (±0.1)	8.2 (±0.6)
Washington Navel	144.1 (±28.7)	32.6 (±1.4)	67.2 (1.4)	0.8 (±0.8)	35.3 (±1.6)	11.4 (±0.6)	1.4 (±0.1)	8.4 (±0.8)
Malta Blood Red	130.0 (±25.9)	44.4 (±6.2)	53.9 (±6.0)	10.5 (±4.0)	28.5 (±7.5)	10.3 (±1.0)	1.6 (0.3)	7.5 (±0.9)
Shamauti	157.7 (±22.1)	35.6 (±3.2)	64.0 (±3.3)	3.7 (±2.1)	30.6 (±3.0)	10.8 (±0.6)	1.4 (±0.1)	7.9 (±1.0)
Mosambi	120.8 (±16.4)	46.0 (±5.4)	51.1 (±5.1)	20.3 (±4.2)	26.2 (±5.6)	9.0 (±0.7)	1.2 (±0.2)	7.6 (±1.3)
Sevelle Common	111.0 (±10.1)	34.0 (±5.1)	65.0 (±5.0)	4.8 (±2.3)	34.6 (±4.7)	9.9 (±0.6)	1.3 (±0.2)	7.5 (±1.1)
Valencia	124.5 (±20.7)	34.2 (±2.1)	64.7 (±2.2)	5.3 (±1.9)	35.3 (±2.6)	10.0 (±0.8)	1.2 (±0.2)	8.4 (±0.9)
Navelencia	148.0 (±40.7)	30.2 (±3.7)	69.7 (±3.6)	0.6 (±0.9)	38.4 (±3.6)	10.2 (±0.5)	1.1 (±0.2)	9.1 (±1.3)
Vanelle	124.5 (±20.7)	34.3 (±8.4)	65.0 (±8.4)	4.5 (±2.0)	36.3 (±8.1)	10.6 (±1.0)	1.3 (±0.1)	8.7 (±0.7)
Dhankuta Junar	101.8 (±8.6)	37.2 (±4.0)	60.1 (±3.9)	10.2 (±3.4)	34.0 (±3.2)	9.9 (±1.2)	1.2 (±0.6)	8.2 (±2.2)
Rubi	113.9 (±24.6)	36.8 (±8.1)	62.0 (±7.7)	7.7 (±4.1)	32.8 (±11.1)	11.1 (±2.0)	1.4 (±0.2)	8.3 (±1.8)
Lue Gim Gong	104.4 (±14.9)	31.7 (±2.6)	67.2 (±2.7)	4.8 (±1.4)	39.6 (±3.3)	9.6 (±1.0)	1.3 (±0.2)	7.5 (±1.3)
White Taker	132.9 (±18.2)	34.1 (±6.0)	64.7 (±6.4)	8.5 (±3.0)	37.5 (±4.4)	9.0 (±0.8)	1.2 (±0.3)	7.9 (±1.8)
Hamlin	151.5 (±21.2)	31.1 (±4.6)	68.3 (±4.7)	4.4 (±2.5)	38.6 (±4.5)	9.1 (±0.2)	1.3 (±0.1)	7.2 (±0.8)

season maturing (March-April) varieties. Based on maturity period and other fruit characters Washington Navel has been selected for early season, Pineapple and Hamlin for mid-season and Valencia for late season production.

Commercialization of the varieties selected by this study especially those of early and late maturing types can extend harvesting period of sweet orange at least for six months (November-April) in comparison to about two months (January-February) at present. Sweet orange fruits can be stored up to three months under low temperature (6-8 ^{0} C) and high humidity (90-95%) condition, which can be met easily under cellar stores in mid-hill of Nepal. Thus, availability of locally produced sweet orange fruits can be extended further two months by storing the late maturing varieties in cellar stores.

Table 2. Qualitative fruit characteristics of sweet orange varieties

Variety	Fruit Shape	Base shape	Apex shape	Stylar end	Maturity period
Pineapple	sheroid	tuncate	convex	closed	Jan.-Feb.
Washington Navel	obate	convex	truncate	open-navel	Nov.-Dec.
Malta Blood Red	sheroid	tuncate	truncate	closed	Jan.- Feb.
Shamauti	elipsoid	tuncate	convex	closed	Jan.- Feb.
Mosambi	sheroid	convex	convex	closed	Jan.- Feb.
Sevelle common	sheroid	truncate	convex	closed	Mar.-Apr.
Valencia	sheroid	truncate	convex	closed	Mar.–Apr.
Navelencia	sheroid	convex	truncate	open- navel	Nov.– Dec.
Vanelle	elipsoid	tuncate	convex	closed	Jan.- Feb.
Dhankuta Junar	sheroid	convex	truncate	closed	Jan.- Feb.
Ruby	sheroid	convex	truncate	closed	Jan.- Feb.
Lue Gim Gong	sheroid	tuncate	convex	Slightly open	Mar.–Apr.
White taker	sheroid	convex	convex	closed	Jan.- Feb.
Hamlin	sheroid	truncate	convex	closed	Jan.- Feb.

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