Identification of Suitable Harvest Date of Okitsuwase Mandarin Under The Mid-Hill Regions of Nepal

B. Chalise[1*], T.B. Pun[2] and U.K. Acharya[3]

[1]*Horticultural Research Station, Rajikot, Jumla*

[2]*Regional Agricultural Research Station, Lumle, Kaski*

[3]*Nepal Agricultural Research Council, Singh Durbar Plaza, Kathmandu*

**Corresponding author: basantchalise@gmail.com*

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Abstract

Studies were carried out during three consecutive years viz. 2012, 2013 and 2014 respectively on Citrus unshiu var. Okitsu Wase. Fruits were taken from 6 years old tree at the starting year at Horticultural Research Station (HRS), Dailekh for identifying the appropriate harvesting time and possible expansion of the production and supply period. Fruit harvesting was done by selecting 5 trees of the similar age. The harvesting was started from 1st September and continued up to the 18th October at 7 days intervals. For every harvesting, two fruits were taken randomly from each tree and evaluated in the fruit laboratory. The total soluble solid (TSS) was recorded by hand refractometer and titratable acidity (TA) by the titration of juice with 0.1N standard solution of sodium hydroxide. Three years studies based on the TSS, TA and TSS:TA ratio (ripening ratio), showed TSS 7.26%, TA 0.98% and TSS:TA ratio 7.40 was recorded during the 7th September indicating appropriate time of harvest. Thus the study revealed that 'Okitsu Wase' variety of Satsuma mandarin under HRS, Dailekh command area and the similar climatic tracts can be harvested from 7th to 14th September. Therefore, supply period of mandarin can promisingly be expanded and fruit production can be promoted in the late fall season (out of season) across subtropical regions of Nepal. As a result consumers will be in position to get mandarin in off-period and citrus growers will catch high price from early harvested fruits.

Keywords: *Citrus unshiu*, *total soluble solid, titratable acidity, sodium hydroxide, refractrometer, ripening ratio*

Introduction

Enormous amount of diversity is common in citrus species as represented by different species and varieties showing unique characteristics in their aesthetic, organoleptic and nutritional properties. Though, there is high diversity in their characteristics, all the citrus fruit show the similar pattern of growth and development (Lado *et al.,* 2014). Citrus fruit exhibit non-climacteric behavior of ripening and should be harvested after the internal maturity has been achieved since no further relevant change in fruit flesh occur after the harvest (El-Otmani and Zacarias, 2014). One or more indices are being considered during the harvesting of the fruits. In the EU, juice content (%), total soluble solid (TSS) and total soluble solid to titratable acidity ratio (ripening ratio) and the proportion of the fruit surface which present the typical coloration of the fruit is considered as the standard for fruit harvesting (UN, 2010). Early maturing mandarin variety or Clementine, internal quality indices for commercial maturity are reached before completing external coloration change. Maturation in the peel and pulp are not coordinated and physiologically both tissues ripen autonomously and independently (Tadeo *et al*., 2008). Therefore, the decision on citrus fruit harvesting and marketing need to be done based on the change in internal chemical composition especially, the sugar and acid, for the fruit rather than the coloration of the skin.

Mandarin (*Citrus reticulata* Blanco) is the most important citrus species of Nepal (APP, 1995). It covers 64.36% (25,123 ha) of the total citrus area (39,035 ha) (MOAD, 2015). Mid-season varieties of mandarin, especially, the local mandarin, are mostly cultivated throughout the mid-hill region stretching from east to the west of the country which ripens in the 1st to 2nd week of November. However, in recent time, some early maturing mandarins were tested and identified as early and can be marketed about two month before than the existing local varieties. Paudyal and Chalise, 2007 reported that in eastern mid-hill region 'Okitsu Wase' mandarin is ready for harvesting in first

week of September. They also reported that in comparison of 'Miyagawa Wase', 'Okitsu Wase' mandarin is about 10 days earlier. Therefore, this investigation was undertaken to identify the appropriate time of harvesting and supply of mandarin from mid-hill regions of Nepal with an aim to make the country self-sustaining in mandarin fruit by expanding the supply period.

Materials and Methods

Citrus unshiu var. 'Okitsu Wase' fruits were harvested at weekly interval from the 1st of September to 18th of October selecting five trees of 6 years at the base year grafted on trifoliate orange. Two fruits were taken randomly from each tree and thus total sample size was 10. Fruits were analytically evaluated at HRS, Dailekh fruit laboratory. Different indices of ripening, mainly the TSS, TA, and TSS:TA ratio were taken into consideration. TSS content of fruits was recorded by hand refractometer and TA by titration with 0.1 N standard solutions of sodium hydroxide and calculated using the following formula.

$$TA\% = \frac{\text{Volume of titrant*} \times \text{Normality of titrant} \times \text{Milliequivalent weight of citric acid**} \times 100}{\text{Volume of sample*}}$$

*Volume of titrant and sample is in milliliter

**Milliequivalent weight of citric acid is 0.064

Results and Discussion

A. Physical parameters

Fruit size

Fruit weight non-significantly varied from 137.30 g harvested on 1st of September to 170.30 g harvested on 14th September with a mean weight of 152.87 g. Similarly, the height of fruit was also found to be non-significantly differentiated from 5.79 cm harvested at 1st September to 6.22 cm harvested on 12th October having the mean height 5.96 cm. Fruit diameter also non-significantly ranged from 6.84 cm harvested on 1st September to 7.31 cm harvested on 28th September respectively (Table 1).

Table 1. Effect of harvesting date on average fruit size of 'Okitsu Wase' mandarin at HRS, Dailekh

Harvesting date	Fruit weight (g)	Fruit height (cm)	Fruit Diameter (cm)
September 1st	137.30	5.79	6.84
September 7th	148.10	5.89	6.87
September 14th	146.20	5.85	6.99
September 21st	151.30	5.91	6.96
September 28th	170.30	6.10	7.31
October 5th	161.20	5.93	7.13
October 12th	155.20	6.22	7.17
October 18th	153.40	5.99	7.15
GM	152.87	5.96	7.05
F Value	1.27NS	0.63 NS	0.98 NS
CV	10.01	5.12	4.05
CD	26.79	0.53	0.49
SEM	8.83	0.17	0.16

CV=Coefficient of variation, CD=Critical difference at probability value 0.05, Treatment means followed by common letter(s) are not significantly different at 5% by DMRT

The size of fruit principally, dependent on the number of fruits retained in the tree, variety and nutrition of the tree. However, this parameter was found statistically non-significant at Dailekh. The average size of 'Okitsu Wase' mandarin fruit produced in western mid-hill regions is presented by the study. Study made by Bourgeois *et al*., 2002 reported 153.3 g of 'Early Armstrong', 154.0 of 'LA Early-R', 164.2 of 'LA Early-S', 161.8 of 'LA Early-C35' and 160.3 of 'LA Early-C-32' variety of Satsuma mandarin. In another study, Rudolvic *et al*., 2014 found 92.94 g in 'Chuhara', 69.98 g in 'Kawano Wase' and 107.96 in 'Owari' variety of Satsuma mandarin. The present finding was also similar with the findings of Jwanda *et al*. (1973), and Bal and Chauhan (1987) who reported decrease in fruit weight with later stage of ripening of Kinnow mandarin. The decreasing fruit weight might be due to catabolic activities in cell and loss of dry matter in the fruit sac.

Juice content and proportion of peel and rag

In Satsuma mandarin harvesting is allowed when the juice content is higher than 40% according to the EU standard (EU, 2011). The juice content in this study was non-significant and was the highest in fruits harvested on 14th of September (59.79%) and lowest on 18th October harvested fruit. In this study, the mean value of the juice content was 56.54%. Present study was also supported by Lado *et al*., 2014 who observed that fruit juice content is related to the ripening process and it increases as fruit matures to reach a maximum value at full maturity and decrease afterward.

Study revealed that the percent proportion of peel was highly significant. Significantly the highest percentage of peel was found in fruits harvested on 12th of October (27.72%) and the lowest on 7th September (20.15%) harvested fruit where, the mean percentage of the peel was 23.14% (Table 2) In present finding, the peel percentage had not shown the clear trend because 'Okitsu wase' mandarin is early maturing variety which was harvested at green peel color stage. However, study made in mandarin by Rokaya *et al.* (2016) reported that percentage weight of peel was low at initial and then gradual increased with the maturity advancement and immediately after peak point of growth it was declined in different altitudes and maturity stages.

Similarly, the rag percentage of the fruit was non-significantly ranged from 15.05% in 18th October harvested fruit to 20.93% in fruit harvested on 28th September with a mean value 19.98% (Table 2). Rokaya *et al*. (2016) in his study on mandarin observed that the percentage of rag was also found significantly declined with the advancement of maturity. They found the highest rag (37.78%) on 11th October harvested fruit whereas 20.65% in 30th November.

Table 2. Effect of harvesting dates on juice content, peel and rag proportion of 'Okitsu Wase' mandarin at HRS, Dailekh

Harvesting date	Juice %	Peel %	Rag %
September 1st	56.27	22.72^{bc}	16.87
September 7th	58.74	20.15^{d}	17.60
September 14th	59.79	21.19^{cd}	16.07
September 21st	57.20	21.69^{cd}	17.82
September 28th	52.67	23.31^{bc}	20.93
October 5th	58.36	24.19^{b}	13.68
October 12th	52.88	27.72^{a}	17.84
October 18th	56.44	24.17^{b}	15.05
GM	56.54	23.14	19.98
F Value	1.26NS	9.92 **	0.95 NS
CV	7.10	5.55	22.61
CD	7.03	2.24	6.72
SEM	2.31	0.74	2.22

CV=Coefficient of variation, CD=Critical difference at probability value 0.05, Treatment means followed by common letter(s) are not significantly different at 5% by DMRT

B. Sugar and acid content

The sugar content of the fruit increases and the organic acid content decreased during the growth of citrus fruit. If the fruit remain intact in the plant for longer time, the concentration of acid decreases however, the sugar content progressively increased.

Total Soluble Solid (TSS)

Lado *et al.,* 2014 described that total soluble solid (TSS) represents about 80% of sugars (mainly glucose, fructose and sucrose), 10% acids (mainly citric, malic and oxalic acids) and 10% nitrogenous compounds (amino acids) in citrus. An increase in sugar is usually accompanied by increase in TSS value which is expressed in ^{0}Brix or Brix%. Measurement of TSS is a practical method for making decision of the harvesting time. In the present study, the value of TSS was found to be increasing from 1st of September which was equal to 6.92%. Significantly the highest value of TSS was recorded on 12th of October (8.34%) which was statistically at par with 18th of October harvest (Table 3). The present finding was also supported by Rokaya *et al*. (2016) who reported that on later stage of maturity of fruit TSS observed higher due to accumulation of sugars, increased level of dehydration and higher light intensity. This finding was also substantiated with the finding of (LARC, 1999), Bhusal (2002) and Ghosh (1993) in mandarin which stated TSS of orange increases with the increase in altitude at the later part of the fruit maturity.

Titratable Acidity (TA)

Unlike sugars, the organic acids concentration decreases with the advancement of the ripening. Citric acid is the major acid constituent and occupies about 70-90% followed by malic acid and oxalic acid (Davies and Albrigo, 1994). In this study the highest acidity percentage was found in early harvested fruit. 1st of September harvested fruit had 1.13% acidity and the 18th of October harvested fruit had the lowest value of acidity i.e. 0.79%. Harvesting on 7th of September and 14th of September statistically had similar acidity. Similarly, harvesting on 14th September and 21st September were statistically at par for their acidity content (Table 3). Present finding was also supported by the findings of Bal and Chauhan (1987) in Kinnow mandarin and Bhusal (2002), Bastakoti and Gautam (2007) and Thapa and Gautam (2002) in mandarin who reported acidity was decreased gradually as the fruits approached maturity.

Ripening Ratio (TSS:TA)

TSS/acid ratio has been considered to be a reliable index of judging maturity of mandarin (Rokaya *et al*., 2016). In case of mandarin, Ladaniya (2001) reported that TSS/acid ratio is more reliable index than the rind color for determining the optimum harvesting time. Due to simple method of quantification of the TSS, TA and TSS/TA ratio has been used worldwide as the main commercial maturity indicator of the citrus fruit. In general, the TSS/TA ratio is at least 6 or higher is acceptable for commercial marketability; however, significant difference may exist depending on the citrus species, varieties and the growing regions as well. The ratio acceptable for commercialization usually range from 7-9:1 for oranges and mandarins to 5-7:1 for grapefruits while this index is not applied in lemon fruit where juice content and essential oils play a vital role on decision of the harvest (Davies and Albrigo, 1994). TSS:TA ratio (ripening ratio) in the present study was highly significant at different dates of harvesting. Significantly the highest ripening ratio was observed on 18th October harvested fruits which were statistically at par with 5th October and 12th October harvested fruits. The lowest ripening ratio was recorded on 1st of September harvested fruit. Harvesting on 7th September (7.40), 14th September (7.68) and and 21st September (8.29) were statistically at par (Table 3). The present finding was similar with the report of Bal and Chauhan (1987) and Jawanda *et al*. (1973) in Kinnow mandarin. The increased TSS could have been due to further synthesis and accumulation of photosynthates in the fruit on the tree. The loss in acidity was reported to be due to normal respiration and conversion to other metabolites (EI-otmani and Coggins, 1991).

Table 3. Effect of harvesting dates on average TSS, TA and ripening ratio of 'Okitsu Wase' mandarin at HRS, Dailekh

Harvesting date	TSS %	TA %	TSS:TA ratio
September 1st	6.92^{f}	1.13^{a}	6.20^{e}
September 7th	7.26^{ef}	0.98^{b}	7.40^{d}
September 14th	7.45^{de}	0.97^{b}	7.68^{d}
September 21st	7.66^{cd}	0.93^{bc}	8.29^{cd}
September 28th	7.93^{bc}	0.90^{cd}	8.93^{bc}
October 5th	8.25^{ab}	0.85^{de}	9.85^{ab}
October 12th	8.34^{a}	0.84^{de}	10.00^{a}
October 18th	8.32^{a}	0.79^{e}	10.58^{a}
GM	7.76	0.93	8.62
F Value	20.5**	30.39**	22.61**
CV	2.62	3.55	6.32
CD	0.35	0.05	0.95
SEM	0.11	0.01	0.31

CV=Coefficient of variation, CD=Critical difference at probability value 0.05, Treatment means followed by common letter(s) are not significantly different at 5% by DMRT

Conclusion

The study revealed that 'Okitsu Wase' variety of Satsuma mandarin under HRS, Dailekh command area and the similar climatic tracts could be harvested from 7th to 14th September based on the maturity index. Therefore, supply period of mandarin could promisingly be expanded and production could be promoted in the late fall season (out of season) across subtropical regions of Nepal.

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Rererences

APP. 1995. Nepal agriculture perspective plan, final report. Agricultural Projects Services Center, Kathmandu, Nepal and John Mellor Associates, Inc., Washington DC, USA. 47 p.

Bal, J.S. and G.S. Chohan.1987. Studies in Fruit Quality at Maturity and Ripening of Kinnow Mandarin on Different Rootstocks. Indian Journal of Horticulture, 44:45-51.

Bastakoti, P. and D.M. Gautam. 2007. Effect of Maturity Stages and Postharvest Stages on Shelf Life and Quality of Mandarin Orange in Modified Cellar Store. Journal of the Institute of Agriculture and Animal Science, 28:65-74.

Bhusal, Y.R. 2002. Improvement of Postharvest Shelf Life of Mandarin Orange (*Citrus reticulata* Blanco). M.Sc. Thesis, IAAS, Rampur.

Bourgeois, W.J., R.J. Constantin and M.J. Falcon. 2002. LA Early: A New Early Marketing Satsuma Mandarin. HortScience 37 (6): 997-998.

Davies, F.S. and L.G. Albrigo. 1994. Fruit quality, harvesting and postharvest technology. *In*: Crop Production Science in Horticulture. Davies, F.S. and L.G. Albrigo (Editors). CAB International. pp. 202-224.

EI-Otmani, M. and C.W. Coggins Jr. 1991. Growth Regulator Effect on Retention of Quality of Stored Cirtus Fruits. Scientia Horticulture, 45:261-272.

El-Otmani, M. and L. Zacarias. 2014. Citrus Postharvest Physiology and Technology. *In*: Postharvest Physiology and Technology: Tropical and Subtropical Fruits. Pareek, S., A.K. Thompson, D. Sivakumar, N. Benkeblia and M. El-Otmani (editors). CAB International Blackwell Publishing.

EU, 2011. Official Journal of the European Union, L157:71-75.

Ghosh, S.P. and R.P. Singh. 1993. Citrus in South Asia. Food and Agriculture Organization (FAO) of the United Nations, Regional Office for Asia and the Pacific.

Jawanda, J.S., J.S. Arora and J.N. Sharma. 1973. Fruit Quality and Maturity Studies of Kinnow Mandarin at Abohar. Punjab Horticulture Journal, 13:3-12.

Ladaniya, M.S. 2001. Post Harvest Technology of Fresh Citrus Fruit. *In*: Singn, S. and Naqvi, S.A.M.H.(editors). Citrus, International Book Distributing Company, Lucknow, 459-473.

Lado, J., M.J. Rodrigo and L. Zacarias. 2014. Maturity indicators and citrus fruit quality. Stewart Postharvast Review 2 (2):1-7.

LARC. 1999. Effect of Altitude and Maturity Stage on Post-harvest Life and Quality of Mandarin Oranges Stored in a Cellar Store. Lumle Agricultural Research Centre, Pokhara.

MOAD. 2015. Statistical information on Nepalese agriculture 2014/2015. Ministry of Agricultural Development, Agri-Business Promotion and Statistics Division, Singha Durbar, Kathmandu, Nepal.

Paudyal, K.P. and B. Chalise. 2007. Evaluation of mandarin (*Citrus unshiu*) varieties for early season production in Nepal. *In*: Proceedings of the 4th National Seminar on Horticulture for Food Security, Employment Generation and Economic Opportunity, Kathmandu, Nepal, January 18-19, 2007. Nepal Horticulture Society.

Radulovic, M., M. Dukic and D. Radulovic. 2014. Agriculture and Forestry 60 (4): 291-298.

Rokaya, P.R., D.R. Baral, D.M. Gautam, A.K.Shrestha and K.P. Paudyal. 2016. Effect of Altitude and Maturity Stages on Quality attributes of Mandarin (Citrus reticulate Blanco). American Journal of Plant Science Vol.7 (6): pp. 958-966

Tadeo, F.R., M. Cercos, J.M. Colmenero-Flores, D.J. Iglesias, M.A, Naranjo, G. Rios, E. Carrera, O. Ruiz-Rivero, I. Lliso, R. Morillon, P. Ollitrault and M. Talon. 2008. Molecular physiology of development and quality of citrus. Advances in Botanical Research, 47: 147-223.

Thapa B.B. and D.M. Gautam. 2002. Preharvest Application of Gibberellic Acid and Maturity Stage on Fruit Quality and Shelf Life of Mandarin Orange. Journal of the Institute of Agriculture and Animal Science, 23:41-47.

UN. 2010. Unece Standard FFV-14. Citrus fruit. New York and Geneva. 12 p.