Tree-aspects Based Variation in Physiochemical Components of Acid Lime (*Citrus aurantifolia* Swingle) Fruits in Nepal.

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ABSTRACT

The main objective of this study is, to determine the variation of fruit quality at different sides of the tree. Total of 15 bearing trees were selected randomly (5 trees per site) from three different agro ecological domain representing terai (<600masl), mid-hill (600 to 1200masl) and high-hill (>1200m asl) areas and samples were collected from the selected trees. Randomly ten fruits (from east, west, canopy-centre, north and south sides) were collected from each tree and analyzed for amount of vitamin C (ascorbic acid), TSS, TA and juice. The parameters varied significantly according to the agro ecological zones.

Key words: Ascorbic acid, agro-ecological zone, TSS, TA, juice.

INTRODUCTION

Acid Lime (*Citrus aurantifolia* Swingle) is one of the important commercial fruits, which has been cultivated in 60 out of 75 districts of Nepal (NCRP, 2006). Citrus, including acid lime is considered as high value commodity and has given number one priority by Master Plan for Horticulture Development (MOA, 1990). The cultivation of acid lime is scattered from terai to high hills and east to west in Nepal. The total area under citrus cultivation is about 26,681ha, out of which acid lime (*Citrus aurantifolia*) covers 4,183ha. Within the citrus species, acid lime ranks third after Mandarin and Sweet orange in terms of area and production. Total annual fruit production of acid lime in Nepal is recorded at 20,492 mt with productivity of 8.4 mt/ha (MOAC, 2008). In Nepal, Eastern Development Region (EDR) has the highest area and production (7,987mt) of acid lime. It is used for juice, desert, pickle and other medicinal purpose.

The organic acid component of acid lime juice is primarily composed of citric acid. The soluble solid of the juice consists mainly of sugar and citric acid. According to Soot and Cameron (1961b) total acid content in acid lime juice varied from 5 to 7.5%, and total soluble solids from 5.5 to 8.5%. The acid content in juice plays an important role in determining the quality of a variety as well as maturity indices of the fruit (Koehlar et al., 2003). In citrus species, amount of organic acid is genetically controlled (Fang et al., 1997). In his report, a seedless variety of lime (Chakradhar) contains 60-66 percent juice in fresh fruit and 118.2-140.8 mg/100g vitamin C and 8.3-9.1% citric acid in juice. Ascorbic acid (Vit C) is one of the most important vitamins found in acid lime juice. Fruit contents of ascorbic acid, juice, TSS and TA are influenced by variety, cultural practice, maturity, soil, climate, fruit growth stage and bearing side of the tree (Nagy Steven, 1980), and they are important parameters to determine fruit quality. Fruiting side of the tree is one of the important factors that determines the quality of fruits. Producers, consumers and traders have a very limited knowledge in this aspect. It is necessary to study the variation of fruit quality at different side of the tree for processing and marketing. Therefore, the main objectives

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of this study was to determine the contents of vitamin C, TSS, TA and juice in acid lime fruits fruited at different sides of trees. Findings of the study will help to select the best quality of lime fruits for commercialization and industrial uses.

MATERIALS AND METHODS

Fruit sample collection

A total of 15 bearing trees were selected randomly (5 tree per site) from three different agro ecological domain (Table-1), representing Terai (<600m asl), mid-hill (600 to 1200m asl) and high-hill (>1200m asl) areas. Total of 150 fruit-samples were collected from three sites. Randomly ten fruits from each of the trees (2 fruits from each of the tree sides namely east, west, north, south and canopy-centre) were collected. The study was arranged in RCBD design. All the bearing sides of the treess are treatments with individual trees in a site treated as replications. Data were analyzed in M Stat C software package.

Table 1: Fruit sample and locational details of fruit sample collection sites.

High-hill (>1200masl)			Mid-hill (600-1200masl)			Terai (< 600masl)		
Plant #	Altitude (m)	Location	Plant#	Altitude (m)	Location	Plant#	Altitude (m)	Location
LT-1	1750	Fachmara-7	LD-6	1181	Bodhe-1	LM-11	135	Sunpur-2
LT-2	1710	Fachmara-9	LD-7	1180	Belhara-1	LM-12	135	Sunpur-2
LT-3	1655	Fachmara-9	LD-8	1175	Belhara-1	LM-13	125	Pathari-2
LT-4	1485	Fachamara-1	LD-9	1130	Belhara-3	LM-14	125	Pathari-2
LT-5	1410	Fachamara-8	LD-10	1130	Belhara-1	LM-15	125	Pathari-2

Note: LT= Lime Terhathum, LD= Lime Dhankuta, LM= Lime Morang

Chemical composition analysis

Juice was extracted and juice percent were measured on the basis of fruit weight. Titrable acids (TA) and Vitamin C were analyzed in the Post Harvest Technology and Research Unit laboratory, Khumaltar, Lalitpur. Total soluble solids (TSS) were measured with the help of Refractometer. Two milliliter of juice was titrated with 0.2N sodium hydroxide to phenophthalein endpoint, and content of titrable acid was calculated using following formula (Ranganna, 1995).

$$TA\% = \frac{\text{Volume of titrate x Normality of titrate x Eq. Wt. of citric acid}}{\text{Volume of Sample x 1000}} \times 100$$

Likewiae, vitamin C (ascorbic acid) was determined by the 2,6-dichlorophenol indophenols titration method and calculated by the following formula (Jonsan, 1966).

$$\text{Vitamin C (mg/100 ml juice)} = \frac{\text{Titer x Dye factor (0.122) x Vol. made up (100ml)}}{\text{ml of aliquot (3ml) x wt of sample (g)}} \times 100$$

RESULTS

Ascorbic acid

High variation of ascorbic acid in the fruits was observed in the different sides of bearing trees and across the agro-ecological zones. The amount of ascorbic acid was found to increase in the high-hills as compared to terai zone. Highest ascorbic acid (79.6mg) per 100ml juice was observed in south side fruits in high-hill, where the

lowest ascorbic acid (62.8mg) showed up in north side fruits. Mid-hill samples showed highest ascorbic acid content of 69.9mg in south side fruits and a lowest content of 55.1 mg in canopy-centre fruits. Likewise, terai samples showed highest content of ascorbic acid (58.7mg) in north side fruits and the lowest (41.8mg) in canopy-centre fruits. Among the total samples, average content of ascorbic acid was highest in high-hills (68.3mg) followed by mid-hills (62.2mg) and terai (49.7mg) samples (Table, 2). The coefficient of variation among trees is higher in terai (14.7%) and lower (3.88%) in high-hills, whereas such among fruiting aspects was observed non-significant in all the ecological zones.

Juice

Variations in juice contents were observed in the fruit samples from different aspects of the trees. In general, lowest juice contents were observed in the fruits from canopy-center or north aspect. Variation in juice percent was observed according to the agro ecological zones as well. Average amount of juice was highest (44.3%) in terai samples followed by high-hills (40%) and mid-hill (39.9%) samples. The coefficient of variation is higher (8.9%) in mid-hills and lowest (5.73%) in terai (Table, 2).

Table 2. Physicochemical characteristics of acid lime fruits as per the aspect of the tree.

Aspect	Vit.C mg/100ml juice			Juice%			TSS%			TA%		
	High hill	Mid hill	terai	High hill	Mid hill	terai	High hill	Mid hill	terai	High hill	Mid hill	terai
East	63.3	62.5	43.1	40.8	40.3	45.0	7.5	7.4	8.1	7.2	7.1	6.8
West	68.3	61.5	49.1	38.1	39.6	41.7	7.6	7.7	7.8	7.1	7.3	7.0
North	63.4	62.8	58.7	40.5	41.0	39.3	7.6	7.7	8.3	7.2	7.2	7.4
South	79.6	69.9	55.5	43.9	43.0	45.7	8.2	7.9	7.7	7.9	7.5	7.0
Centre	62.8	55.1	41.8	36.6	35.6	39.9	7.3	7.5	7.3	7.0	7.1	6.7
Mean	68.3	62.2	49.7	40.0	39.9	44.3	7.6	7.7	7.8	7.3	7.2	7.0
F Test	NS	NS	NS	NS	NS	NS	NS	NS	**	**	**	NS
CV %	3.88	8.24	14.70	8.38	8.90	5.73	3.90	3.81	5.06	3.69	4.51	3.06

Note: NS= non significant, **= Significant at 0.05 level, CV= coefficient vriations.

Total soluble solid (TSS) and Titrable acid (TA)

Variation in the percent of TSS and TA was observed in the fruits from different side of bearing trees. In high hill samples, highest amount of TSS 8.2% was observed in fruits from southern side fruits and lowest 7.3% in fruits from canopy-centre. Similar result was observed in mid-hills samples. In terai, highest TSS was 8.3% observed in north side fruits and lowest 7.3% in canopy-centre fruits. Variation of TSS percent was observed according to the agroecological zone. Average amount of TSS was 7.8% in terai samples followed by the samplesI in mid hill (7.7%) and in high-hills (7.6%). The coefficient of variation was 5.06% in terai and 3.81% in mid-hills. Similarly in high-hill samples, highest amount of TA (7.9%) was observed in south aspect fruits and lowest (7.1%) in canopy-centre samples. Similar result was observed in mid-hills samples. In terai highest TA was observed 7.4% in north side fruits and lowest was 6.7% in centre fruits. Variation of TSS percent was observed according to the agro ecological zone. Average amount of TA was highest 7.3 % in high hills samples followed by 7.2% in mid hill and 7.0% in terai samples. The coefficient variation is higher was 4.51% in mid hills and lowest 3.06% in terai (Table, 2). No significant result in TA percent in terai sample whereas highly significant result in TA percent was observed in high and mid hills.

DISCUSSION

In general the contents of ascorbic acid, juice, TSS and TA were higher in the south side fruits in high and mid-hill. However, higher contents of ascorbic acid, TSS and TA were found in north side fruit in terai. There is no significant effect of fruiting sides in ascorbic acid and juice percent. Physicochemical composition of the fruits especially ascorbic acid, TSS and TA depends on the maturity stage and exposure to sun light. Generally good sun shine is received in the southern side of trees. Fruits from the north side and canopy-centre of the tree have considerably low sunshine and poor quality of fruits. In sweet orange fruits the exterior (sunlight) part contained more vitamin C and sugar with significant correlation between sucrose and ascorbic acid content (Izumi et al, 1988). Green colour orange has less vitamin C than the colored orange, when harvested at the same time. Fruits grown on the south side of the tree have higher acidity than fruit on the other side (Hattari et al, 1959). Fruits exposed on sun light have significantly higher ascorbic acid content (Sinclair, 1984).

Jawharlal et al, (1992) reported that juice content of 50-52%, acidity of 6.2-6.9%, TSS of 6.2-8% could be used as index of harvesting maturity in acid lime. The juice percent in the fruit increased continuously with some fluctuation, and the maximum value of 51.1% was attained at maturity (Hitalmani and Rao, 1970). In Andra Pradesh, juice and citric acid standards for acid lime fruits are 45-58% and 6.7-7.7% resectively. Sidappa (1952) reported that the acid lime grown in South India had average juice percentage from 45-58% of acidity from 6.2-7.6% in maturity and on average 12 seeds per fruit. A significant positive relation of seed number with fruit weight was reported. The size of fruit may not be a reliable criteria for maturity depending on the bearing and nutrient status of the plant. Fruits are matured even in the small size. Round shape, thin peel, less number of seed and high contents of juice and acids are the major characteristics of good quality lime fruit (Paudyal and Shrestha, 2003). The side of a tree affects the maturity of fruits due to uneven sunlight (Gill et al., 1985). Acid content decreased with rise in temperature during fruit development stage (Dhillan and Singh, 1993). Under the tropical (hot and humid) condition, level of TSS increases due to high vegetative growth. In subtropical condition, fruits have good color, smooth surface and high TA due to low humidity and good sunshine. Whereas in humid zone, fruits are juicy and having thick peel and rough surface (Hayes, 1975).

CONCLUSION

Highest ascorbic acid was observed in south side and lowest in north side fruits in high and mid-hill samples. Whereas, in terai higher ascorbic acid was observed in north side fruits, and it was lower in the canopy-centre fruits. Average content of ascorbic acid was highest in high-hill followed by mid-hill and terai. Higher contents of juice, TSS and TA were observed in south side fruits and lower contents of those in canopy-centre samples in high-hill samples. Similar result was observed in mid-hill samples. However, higher contents of TSS and TA were observed in north side fruits and lower contents of those in canopy-centre fruits in terai. Variation in TSS percentage was also observed according to the agro ecological zones. Average amount of TSS was higher in terai samples followed by mid-hill and high-hill samples in order. Results of this study proves that quality fruits in lime trees are fruited in the southern aspect in the mid and high hills and northern aspect in terai.

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