Chapter 6

Changes of Nutrient Content and Fruit Components During Fruit Development

Introduction

Loss of nutrients from soil occurs mainly through crop removals. It is important to know whether these nutrients are adequately replenished. Nutrients are mainly converted to organic compound by metabolic processes. The stocks of nutrients in leaves are consequently distributed to young leaves, branches, roots and fruits (see Results in Chapter 5) for growth development (Supakamnerd, 2001; Kumlung *et al*., 2003). The young fruits behave as sinks, meanwhile leaves are source of nutrients (Menzel *et al*., 1988). Tangerine fruit growth is demonstrated as simple sigmoid curve (Lima and Davies, 1984; Issarkraisila, 1984). The development of fruit can be divided into three major stages: cell division (I), cell enlargement (II) and fruit maturation (III) (Kale and Adsule, 1995). The most important factors affecting growth and quality of the fruits are irrigation and fertilization. Fruits require amount of nutrients differently at each stage of fruit development (Supakamnerd, 2001). The objective of this study is to determine growth, quality and nutrient contents in tangerine fruit at different stages.

Materials and Methods

The experiment was conducted at a private orchard at Mae Soon Noi subdistrict, Fang district of Chiang Mai province during April 2005 – April 2006. Five-year-old tangerine cv. Sainampueng trees were selected for the study. The completely randomized design was used with 4 treatments which were fruit age at 2 (sampled on April 21, 2005), 5 (sampled on July 15, 2005), 8 (sampled on October 27, 2005) and 10 (sampled on December 24, 2005) month-old. Each treatment consisted of 5 replicates and each tree represented for one replicate.

The 5 tangerine fruits were sampled according to schedule. Observatory parameters consisted of such fruit qualities as fruit size (vernier calliper), fruit weight (electronic machine), peel thickness (vernier calliper), peel colour (limit colour cascade), total soluble solids (TSS; pocket refract meter ATAGO-Pelete PR 101), vitamin C (iodate titration), juice percentage, pH of juice (pH meter), tritratable acidity (TA; 0.1 $\overline{N}$ NaOH, phenol phthalein 1%) and juice colour (limit colour cascade). Five randomly chosen fruits per tree were analyzed in each treatment.

The peel and flesh of fruits were dried in hot air oven at 72 $^{\circ}$C for 5 days. The nutrient concentration in juice, peel and flesh were determined (by the procedures) as previously described in Chapter 4.

The data were statistically analyzed by using ANOVA. A least significant difference (LSD) was applied to test the effects of treatments when the F-test was statistically significant at $p \leq 0.05$.

Results and Discussion

1. Fruit growth

Fruit size was increased 2.4, 1.3 and none of change times from 2- to 5-month-old fruits, 5- to 8-month-old fruits and 8- to 10-month-old fruits, respectively (Table 6.1). While fruit weight was increased 8.8, 2 and none of change times from 2- to 5-month-old fruits, 5- to 8-month-old fruits and 8- to 10-month-old fruits, respectively. Contrastively, thickness of peel was decreased when fruit age increased.

It was showed that the fruit aged 5 to 8 months gave the highest rate of the fruit growth. The growth of the citrus fruit is customarily divided in three stages: cell division (I), cell enlargement (II) and fruit maturation (III) (Guardiola and Garcia-Luis, 2000; Holtzhausen, 1982; Kale and Adsule, 1995). The initial growth of the fruit is characterized by an increase in the thickness of the pericarp as a result of cell division which lasts for several weeks after petal fall (Guardiola and Garcia-Luis, 2000). This is followed by a phase of cell enlargement characterized by the vacuolization of the juice sacs, the marked increase in the size of the locules and a significant reduction in peel (pericarp) thickness (Kuraoka, 1962; Guardiola and Garcia-Luis, 2000). Most of the growth of the fruit is done during the phase of cell enlargement (3- to 8-month-old fruits).

The colour of peel was changed from green to greenish yellow at 8- to 10-month-old fruits. In the fruit maturation, chlorophyll pigments are disappeared from the flavedo and carotenoid pigments are revealed (Charles and Coggins, 1986).

2. Fruit quality

Total soluble solids were increased 13.7 and 5.3 % from 5- to 8-month-old fruits and 8- to 10-month-old fruits (Table 6.1). Vitamin C was increased 5.1 and 3.1 % from 5- to 8-month-old fruits and 8- to 10-month-old fruits. Juice percentage was increased 29.8 and 8.9 % from 5- to 8-month-old fruits and 8- to 10-month-old fruits. The pH of juice was increased 0.42 and 0.02 % from 5- to 8-month-old fruits and 8- to 10-month-old fruits.

Total soluble solids, vitamin C, juice percentage and pH of juice were increased by about 13.7, 5.1, 29.8 and 0.42 %, respectively as the fruit age 5 to 8 months (Table 6.1). They were increased as the fruit age 8 to 10 months by about 5.3, 3.1, 8.9 and 0.02 %, respectively.

Contrastively, TA of juice was decreased when fruit aged increased. The colour of juice was changed from yellow to reddish yellow at 8- to 10-month-old fruits.

It is shown that the fruit age 5 to 8 months gave the highest rate of the fruit quality as well as fruit growth. The juice percentage and sugar content initially increase to reach a maximum value at the beginning of the cell enlargement phase and remain nearly constant until maturation (Kale and Adsule, 1995; Guardiola and Garcia-Luis, 2000). And the concentration of organic acids decreases as the fruit maturation (Kimbell, 1984; Charles and Coggins, 1986; Kale and Adsule, 1995).

Table 6.1 Fruit size, fruit weight, thickness of peel, peel colour, total soluble solids (TSS), vitamin C, juice percentage, pH of juice, titratable acidity (TA) and juice colour of tangerine cv. Sainampueng fruit at different ages.

Fruit age (month)	Fruit size[1/] (cm)	Fruit weight [1/] (g)	Thickness of peel [1/] (mm)	Peel colour	TSS [1/] ($^{\circ}$Brix)	Vitamin C [1/] (mg/ 100 ml)	Juice percentage [1/]	pH of juice[1/]	TA [1/] (%)	Juice colour
2	2.16 c	8.52 c	3.40 a	8.6 GY[2/]	-	-	-	-	-	-
5	5.20 b	74.86 b	3.18 a	8.3 GY	7.90 b	16.6 c	24.5 c	3.92 b	3.06 a	7.4 Y[3/]
8	6.64 a	150.16 a	2.33 b	7.4 GY	9.15 a	21.7 b	54.3 b	4.34 a	1.01 b	5.4 Y
10	6.73 a	158.02 a	2.06 c	5.4 GY	9.66 a	24.8 a	63.2 a	4.36 a	0.69 c	9.2 YR[4/]
$LSD_{0.05}$	0.24	14.43	0.24	-	0.67	2.98	3.85	0.11	0.29	-
% CV	3.45	10.99	11.71	-	5.48	9.16	4.57	1.87	3.45	-

[1/] Means followed by different letters within columns are significantly different at the 5 % level by $LSD_{0.05}$

[2/] GY was ratio of yellow and green

[3/] Y was level of yellow

[4/] YR was ratio of red and yellow

3. Nutrient contents

The contents of N, P, Ca, Mg, Mn, Cu, Zn and B in fruit were increased by about 3.2, 5.2, 2.9, 1.9, 4.3, 5.5, 3.5 and 2.6 times, respectively as the fruit aged 2 to 5 months (Table 6.2). Afterward, they were increase by about 2.0, 1.3, 1.6, 2.1, 1.8, 2.3, 3.0 and 2.0 times, respectively as the fruit aged 5 to 8 months. Lastly, they became static as the fruit aged 8 to 10 months. While as, the content of K and Fe were increased when fruit aged increased. The content of K was increased 3.2, 2 and 1 time from 2- to 5-month-old fruits, 5- to 8-month-old fruits and 8- to 10-month-old fruits, respectively. While Fe content was increased 5.6, 1.7 and 1.5 time from 2- to 5-month-old fruits, 5- to 8-month-old fruits and 8- to 10-month-old fruits, respectively.

The content of K increased in 10 months because the farmer believes that apply potassium at fruit aged 9 to 10 months while affecting the fruit quality (Locascio *et al.*, 1990; Guler, 1997). It increases TSS, vitamin C and juice percentage but decreases TA (Kimbell, 1984; Charles and Coggins, 1986; Kale and Adsule, 1995).

The most nutrients became static at the fruit aged 8 to 10 months because the nutrients did not transfer to fruit. The observation showed that the branch with harvest mature fruit would show the flushing leaves. But it was impossible in bearing twig with fruit development. Therefore, the nutrient content in fruit did not have significant convertibility.

Fruit growth results from the accumulation of nutrients may be useful in fruit development. The increasing content of nutrients in fruit totally affects fruit size, fruit weight, TSS, vitamin C, juice percentage and pH of juice.

Table 6.2 Nutrient contents in tangerine cv. Sainampueng fruit at different ages.

Fruit age (month)	N [1/] (mg/fruit)	P [1/] (mg/fruit)	K [1/] (mg/fruit)	Ca [1/] (mg/fruit)	Mg [1/] (mg/fruit)	Fe [1/] (mg/fruit)	Mn [1/] (mg/fruit)	Cu [1/] (mg/fruit)	Zn [1/] (mg/fruit)	B [1/] (mg/fruit)
2	15.9 c	2.2 c	15.3 d	10.7 c	2.6 c	0.021 d	0.012 c	0.020 c	0.013 c	0.024 c
5	50.6 b	11.4 b	48.2 c	31.4 b	4.9 b	0.118 c	0.052 b	0.110 b	0.045 b	0.063 b
8	102.8 a	15.0 a	94.6 b	51.2 a	10.1 a	0.203 b	0.091 a	0.248 a	0.135 a	0.125 a
10	97.6 a	15.0 a	129.2 a	47.4 a	10.9 a	0.309 a	0.082 a	0.259 a	0.120 a	0.120 a
$LSD_{0.05}$	25.09	2..69	23.42	8.37	1.01	0.069	0.018	0.024	0.016	0.017
% CV	7.68	6.34	9.48	8.62	7.16	9.87	10.14	9.26	6.85	6.91

[1/] Means followed by different letters within columns are significantly different at the 5 % level by $LSD_{0.05}$

Conclusions and Recommendations

From the 2- to 5-month-old period, it was found that the growth rate of fruit size define rise while in 5- to 8-month-old fruits apparently determines in increasing TSS, vitamin C, juice percentage and pH of juice.