http://www.pjbs.org

PJBS

ISSN 1028-8880

Pakistan Journal of Biological Sciences

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Pakistan Journal of Biological Sciences 11 (10): 1348-1353, 2008
ISSN 1028-8880

An Analysis on Quality, Colour, Tissue Texture, Total Soluble Solid Content, Titratable Acidity and pH of Santol Fruits (*Sandoricum koetjape* Burm. F.) Merr. Pui Fai Cultivar, Grown in Northern Thailand

P. Chutichudet, Benjawan Chutichudet and S. Kaewsit
Department of Agricultural Technology, Faculty of Technology,
Mahasarakham University, Mahasarakham 44000, Thailand

Abstract: This laboratory experiment was carried out at the Department of Agricultural Technology, Mahasarakham University, Northeast Thailand during June to October 2007. The experiment aimed to search for the most appropriate harvesting age of fruits of Santol orchard plants with respect to colour, tissue texture, total soluble solid content, titratable acidity and pH of Santol fruits. A Randomised Complete Block Design (RCBD) with four replications was used. Each replication consisted of 10 fruits, thus a total of 160 fruits were used. The Santol fruits were harvested at different ages, i.e., 100, 115, 130 and 145 days after full bloom of flowers and these harvested ages were used as treatments, i.e., 100 for T_1 (Control), 115 for T_2, 130 for T_3 and 145 for T_4. The results showed that the most appropriate harvesting date for high quality Santol fruits was found with T_4, i.e., 145 days after full bloom of flowers where Santol fruits of T_4 gave the highest mean values of fruit length, diameter, fresh weight fruit^{-1} of 10.71 cm, 9.31 cm and 399.76 g, respectively. Yellowness of skin colour of fruits was evenly distributed. Total soluble solid content of pericarp, flesh tissue and seeds were highest for T_4 with mean values of 13.93, 15.05 and 18.26^0 brix, respectively. Flesh texture density highly decreased with an increase in numbers of days after full bloom of flowers. Titratable acidity content in fruits was highly decreased with an increase in numbers of days after full bloom of flowers whereas a reverse was found with pH of fruit juices.

Key words: Fruit skin colour, harvesting ages, santol orchard fruits, total soluble solid, titratable acidity

INTRODUCTION

In many tropical countries, there are numbers of tropical fruit trees being grown in different orchard plantations or even those of the villagers' backyards, particularly in Thailand where different kinds of orchard fruits are normally found in most of domestic markets, e.g., jackfruit (*Artocarpus heterophyllus*), rambutan (*Nephelium lappaceum*), mango (*Mangifera indica*), litchi (*Nephelium litchi*), mango-steen (*Garcinia mangostana*), durian (*Durio zibethinus*), longan (*Euphoria longan*), guava (*Psidium guajava*) and many others. The orchard fruits of these crop plants are considered to have its significant role in the Thai economy since most of its annual fruits have been used domestically and some have been exported overseas for a number of decades. The common name of Santol could perhaps derive from Spanish language where the local people who live in Panay Island of the Philippines use to call this orchard plant rather than the Thai people. This orchard plant is commonly known to the Thai people as Kraton thus no English common name has been recorded since it is not found in most of English Dictionaries, e.g., an Oxford English Dictionary, American Webster English Dictionary or even in the Random House English Dictionary, College Edition. The Santol orchard trees could thrive on well in most fertile and well drainage soils in the tropics, particularly Thailand, the Philippines, Indonesia and many other tropical countries (Saimoraka, 2007). In Thailand, the growers of Santol orchard trees obviously used distances within rows and between rows of 8×8 m, respectively. These wide distances being used allowed a single plant to produce a number of branches to cover the ground area with its erected trunk. Thus any large area of plantation may be considered as a forest community. During the past decades when grafting technology reached growers, most growers have chosen to use grafted plants for their plantations rather than planting from matured seeds due to many advantages, e.g., a matter on a true to type of its plant gene, a quicker matured plant and many others. When planted with the use of grafted plants for 2-3 years of growing period, the orchard trees should be able to

Corresponding Author: Dr. Benjawan Chutichudet, Department of Agricultural Technology, Faculty of Technology, Mahasarakham University, Mahasarakham 44000, Thailand

initiate flowers in early March, particularly when grown in the northern region of Thailand. However, with lower latitude near equatorial line then the flowering time could be earlier. In Chiang Rai Province the initiated flowers normally reach its full bloom in late March (approximately 22nd March) and later each flower cluster forms a few numbers of fruits. It may take approximately 100 days from a full bloom of flowers to reach its initial stage of maturity where the matured edible fruits could be harvested for markets. At this harvesting age, individual fruit may possess a sour taste higher than those fruits being harvested later.

It has been advocated that edible Santol fruits possess soft tissue of flesh, delicious and tasty with high amount of antioxidants contents such as β-carotene and some certain amounts of bioactive substances of flavonoid compounds, i.e., catechin, procyanidin B1 and B2. Thus these bioactive substances could provide substantial nutritive values in human nutrition where the substances possess its medicinal properties against human illness such as the healing of Coronary Heart Disease (CHD), the reduction of platelet aggregation, anti-oxidative and anti-carcinogenic substances (Sangkittikomol, 2000; Stoclet *et al*., 2004; Butkhup and Samappito, 2008). Furthermore, it has been stated that Santol fruits could provide anti-oxidants up to 6.5 millimhos 100^{-1} g of fresh weight, whilst in Apple fruits, it could provide up to 2.5 millimhos 100^{-1} of fresh weight only (Burananon, 2007). For the past decades, there has been no published information on appropriate maturity age for the harvest of matured fruits recorded. Therefore, it could be of important value to search for the most appropriate maturity age for growers to harvest their matured fruits of Santol, apart from some analyses on fruit quality in order to attain high quality Santol fruits to supply markets both domestic and overseas.

MATERIALS AND METHODS

This laboratory experiment was carried out at the Department of Agricultural Technology, Faculty of Technology, Mahasarakham University, Mahasarakham, Northeast Thailand during the months of June to October 2007. The fruits of Santol orchard plants were harvested from Prajeenburi Panmai Orchard Farm, Chiang Rai Province, northern region of Thailand. The Santol fruits were harvested from eight years old plants with an average plant height of approximately 7 m above ground level and an average trunk diameter of 15 cm above ground level. The measurements on trunk diameters were made at approximately 30 cm above ground level. The grafted seedlings of Pui Fai cultivar were planted with distances between rows and within rows of 8×8 m, respectively. The Hang Chat soil series (Oxic Paleustults) was used. The experiment was laid in a Randomised Complete Block Design (RCBD) with four replications and each replication consisted of ten fruits. The harvesting ages being used as treatments were: 100 (T_1, Control), 115 (T_2), 130 (T_3) and 145 days (T_4) after full bloom. Thus the experiment consisted of four treatments and each treatment had 40 Santol fruits. At each sampling period, the Santol fruits were carefully harvested at approximately 4 pm (local time) and each individual fruit was wrapped with a soft fibre tissue and all of them were carefully allocated into four cardboard packages with some soft polythene fillers in it to assure no fruit damages occurred during transportation from Chiang Rai to Khon Kaen and eventually to Mahasarakham University (approximately 900 km away from Mahasarakham University). Right after each harvest, a city coach was transported all packages overnight to Khon Kaen and then early in the morning all packages were transferred to a van and started to en-route to Mahasarakham University. Right after its arrival, laboratory work was carried out. The following determinations were made at each sampling period. They include (1) vertical measurements on fruit length (from bottom to top), fruit diameter and average fresh weight of fruits of each replication; (2) measurements on skin colour of fruits with the use of a measurement equipment namely Hunter Lab Model No. 45/0-L, Serial No. 7092, USA. The measurements made were: L* = lightness (black = -100 and white = +100), a* = green or red on skin surface of fruits where - = green and + = yellow, b* = yellowness (- = blue and + = yellow). (3) Tissue texture of flesh, the measurement was carried out with the use of pressure tester Model EPT-1 pressure tester, Lake City Technical Products Inc., Kelowna, BC, Canada where a driller of 11 mm was used. (4) Total soluble solid contents juices being squeezed from fruit skin plus flesh tissue and seeds with the use of distilled water at a ratio between fruit mass and distilled water of 1:3 and measured by a digital refractometer (Atago-Palette PR 101, Atago Co., Ltd., Itabashi-ku, Tokyo, Japan). (5) Titratable acidity with the use of juices described in number 4 with the method of AOAC (1984). (6) The measurement on pH values was carried out with the use of juices described earlier in number 4 and a pH/Ion 510 from Singapore was used. The collected data were statistically analysed using SPSS Computer Program, Version 9 (SPSS, 1999).

RESULTS

Fruit length, fruit diameter and average fresh weight fruit^{-1}: The results showed that an increase in number of

days from full bloom of flowers started from 100 (T_1 control) to 145 days (T_4) highly increased fruit lengths of Santol orchard plants. Fruit lengths ranged from 8.27 to 10.71 cm for T_1 and T_4, respectively (Table 1). Fruit diameters increased from 7.31 to 9.31 cm for T_1 and T_4, respectively. The differences were highly significant. The results on average weights fruit^{-1} were highly increased with values ranged from 218.03 to 399.76 g fruit^{-1} for T_1 and T_4, respectively.

With fruit skin colour, the results showed that changes in fruit skin colour with time were highly significant, i.e., the colour had changed from L* value of darkness of T_1 to the colour of lightness (yellow) of T_4 with values of -49.11 to -36.65, respectively (Table 2). Whilst a* values were also changed from -1.46 to +14.71 for T_1 and T_4, respectively and also b* values of +27.23 to +37.96 for T_1 and T_4, respectively. That is when fruits had advanced in age then the darker colour of T_1 declined to yellowish at 145 days (T_4) after full bloom of flowers. The differences were large and highly significant. Similarly, tissue texture (kg cm^{-2}) was also declined with time where the values decreased from 8.96 to 6.83 for T_1 and T_4, respectively.

Total soluble solid, titratable acidity and pH value of Santol fruits: For total soluble solids (^{0} brix values) of pericarp, flesh tissue and seeds, the results showed that soluble solid content of pericarp highly increased with time where the values ranged from 1.03 to 13.93 for T_1 and T_4, respectively (Table 3). An increase in brix values with time was also found with flesh tissue and seeds where the differences found with each item were highly significant. The highest brix value was found with the tissue in seeds of Santol fruits with a mean value of 18.26 for T_4. A reverse result was found with titratable acidity contents, i.e., an increase in age of fruits highly decreased titratable acidity content where pericarp attained values of 0.33 and 1.05 for T_4 and T_1, respectively. A highly decrease in titratable acidity with time was also found with flesh tissue and seeds. Percentages of titratable acidity of flesh tissue highly decreased from 1.05 to 0.33 for T_1 and T_4, respectively. A similar trend was found with seeds, i.e., the delay in harvesting of fruits highly decreased titratable acidity contents where the values decreased from 2.30 to 0.62% for T_1 and T_4, respectively. With acidity levels (pH), the results showed that pH values of pericarp highly increased from T_1 to T_4 with values ranged

Table 1: Mean values of fruit length, fruit diameter and fresh weight fruit^{-1} of Santol orchard crop harvested at 100 (T_1 Control), 115 (T_2), 130 (T_3) and 145 days after full bloom of flowers, grown in northern region of Thailand

Treatments	Fruit length (cm)	Fruit diameter (cm)	Fresh weight fruit^{-1} (g)
T_1, (Control)	8.27c	7.31c	218.03c
T_2	9.50b	8.80b	336.53b
T_3	10.25ab	9.45a	366.40ab
T_4	10.71a	9.31a	399.76a
F-test	**	**	**
CV (%)	3.66	2.69	6.97
LSD	0.77	0.50	14.44

Letter(s) within columns indicate least significant differences (LSD) at probability, **p = 0.01, CV: Percentage of covariance

Table 2: Mean values of fruit skin colour of L*, a*, b* and tissue texture of flesh of Santol fruits as influenced by treatments, i.e., 100 (T_1), 115 (T_2), 130 (T_3) and 145 (T_4) days after full bloom of flowers

Treatments	L*	a*	b*	Tissue texture (kg cm^{-2})
T_1, (Control)	-49.11c	-1.46d	+27.23c	8.95a
T_2	-45.24bc	+0.87c	+27.72c	8.28a
T_3	-41.66b	+5.84b	+33.60b	6.87b
T_4	-36.65a	+14.71a	+37.96a	6.83b
F-test	**	**	**	**
CV (%)	6.97	25.10	7.24	8.87
LSD	1.34	0.59	1.16	0.36

Letter(s) within columns indicate least significant differences (LSD) at probability, **p = 0.01, CV: Percentage of covariance

Table 3: Total soluble solid (^{0} brix values) and titratable acidity contents found in pericarp, flesh tissue and seeds of Santol fruits as influenced by harvesting dates (treatments)

	Soluble solid (^{0} brix) content			Titratable acidity (%) contents			Acidity levels (pH)		
Treatments	Pericarp	Flesh	Seeds	Pericarp	Flesh	Seeds	Pericarp	Flesh	Seeds
T_1, (Control)	1.03c	1.90d	3.08c	1.05a	2.04a	2.30a	2.38c	2.00c	2.00b
T_2	2.73c	3.80c	4.08c	0.74b	1.36b	1.28b	2.95b	2.83b	2.75a
T_3	8.28b	10.93b	10.93b	0.61bc	0.79c	0.90c	3.33ab	3.00a	3.00a
T_4	13.93a	15.05a	18.26a	0.33c	0.63c	0.62d	3.88a	2.98a	3.05a
F-test	**	**	**	**	**	**	**	**	**
CV (%)	0.57	9.62	20.69	22.72	18.26	9.29	10.35	3.31	9.73
LSD	19.74	0.42	0.77	0.09	0.11	0.05	0.18	0.04	0.13

Letter(s) within columns indicate least significant differences (LSD) at probability, **p = 0.01, CV: Percentage of covariance

from 2.38 to 3.88 for T_1 and T_4, respectively. For flesh tissue pH, the results revealed that, in most cases, an increase in number of days at harvest highly increased pH value of the flesh tissues. However, T_3 and T_4 were similar with values ranged from 2.00 to 3.00 for T_1 and T_3, respectively. Similarly, pH values of seed tissues highly increased with an increase in number of days at harvest with values ranged from 2.00 to 3.05 for T_1 and T_4, respectively.

DISCUSSION

For many countries in the tropical zone like Thailand, the Philippines, Malaysia, Indonesia and many others, Santol crop is known to have its significant role in national economy since its annual fruit production has been enormously distributed, e.g., in Thailand during the 2007, the Thai growers have increased their land areas for Santol plantation up to 5,471 ha due to the high demand for high amount of fruits to be supplied to domestic markets or even overseas. The production of that year reached a figure of 30, 124.84 tonnes (Anonymous, 2007). There are a number of cultivars being accepted by growers in Thailand yet Pui Fai cultivar seems to possess its high popularity among growers than the rest due to its tasty flesh tissue without tannin, large fruit size and high annual fruit production (Duangtong, 1998).

The results of the four harvesting periods (100, 115, 130 and 145 days after full bloom of flowers) showed that fruit length, fruit diameter and average weight fruit^{-1} were highly increased with an increase in number of days after full bloom of flowers. The results suggested that the harvest of fruits at 100 days after full bloom of flowers (T_1, Control) may not be of priority since fruit length, fruit diameter and average weight fruit^{-1} were much smaller than those being harvested later, thus at this maturity age cell division and cell expansion of fruits still continued to develop more rapidly with time. This reason given for the harvest at 100 days after full bloom of flowers (T_1, Control) may be applied to the harvest at 115 days after full bloom of flowers (T_2) since some highly significant differences on growth (fruit length, fruit diameter and average fruit weight) due to treatments were relatively achieved, thus the harvest at day 115 after full bloom of flowers may not be of appropriate period to be harvested. The results found with T_3, i.e., the fruits were harvested at day 130 after full bloom of flowers indicated that fruit length, fruit diameter and average weight fruit^{-1} were similar to those harvested at day 145 after full bloom of flowers. The results indicated that most of the fruits should have reached its maturity stage although some small increases were achieved with T_4 but the differences between the two treatments were not statistically significant. Therefore, the harvest of Santol fruits of T_3, i.e., at 130 days after full bloom of flowers could be the most appropriate period to be harvested if the fruits are to be transported to other far away places or even overseas, i.e., there should be some few weeks more for fruits to attain a high marketable quality. The reason for this may be derived from the harvest of T_4, i.e., even at 145 days after full bloom of flowers yet some small increases on fruit length, fruit diameter and average weight fruit^{-1} were attained although the differences between T_3 and T_4 were not statistically significant. It was noticeable that the increases in fruit length of Santol fruits with time were that of a sigmoid curve where a full maturity of fruits lasted up to 130-140 days after full bloom of flowers as reported by Jeerarat (2002). The increases in weight of mango fruits when matured at an age of 130 to 145 days after full bloom of flowers as reported by Jha *et al.* (2006) were also similar to Santol fruits as found with this work. They stated that the increases in fruit weight of mango up to day 145 after full bloom could have been due to physiological growth of cell expansion in the mango fruits.

With the results on fruit colour, it was found that at 100 days (T_1, Control) the Santol fruits gave L*, a* and b* values of -49.11, -1.46 and +27.23, respectively. The results indicated that the fruits of Santol retained some certain appearances of a light green colour, thus the retaining of light green colour of fruits may not be able to attract eyes of consumers. Francis (1980) stated that fruit colour is an essential indicator on quality of orchard fruits when the fruits reached its maturity then L* value on the lightness of skin colour should be noticeable, i.e., yellowish appearance on the skin of fruits was attained. It was found with Santol fruits of this current work that at 145 days after full bloom of flowers, all Santol fruits turned yellow, i.e., no light green appearance was found. This phenomenon indicated the deterioration of chlorophylls in fruits as reported by Heaton and Marangoni (1996). At 145 days after full bloom of flowers, Santol fruits gave more lightness colour of L* and a* turned to positive value (+). This phenomenon indicated that there had been some appearances of yellowish and red on the skin of fruits where it clarified the presence of carotenoid ($C_{40}H_{56}$) substance on the upper layer of fruit skin. The appearance as such may be used as an indicator or an index for the harvest of orchard fruits as stated by Carlos *et al.* (1994) who carried out the work with the use of Chinese pears (*Pyrus communis*), Ya Li and Seuri cultivars. Mwithiga *et al.* (2007) found with tree tomatoes (*Cyphomandra betaceae*) that fruit colour of L* and b* values declined with time whilst a* values increased where it indicated the rapid ripening of fruits.

For tissue texture of flesh of Santol fruits, the results showed that the harvests at days 100 and 115 (T_1 and T_2), tissue texture densities of flesh of both harvests were similar with a high density of flesh but with the harvests at 130 and 145 days after full bloom of flowers (T_3 and T_4), both harvest dates gave a decline in flesh tissue density and both were similar. This could have been attributed to the advance in maturity age of the Santol fruits, i.e., some enzymes may have some effects on cell wall structures hence the density of flesh was declined resulting in an increase in softness texture of the tissues as reported by Goulao *et al.* (2007). The changes may possibly be attributable to the changes in pectin polymers structures where deterioration of cell wall could have been taken place (Kalra *et al.*, 1995). The changes occurred in matured orchard fruits may include the production of ethylene where a leakage of cell membrane could occur and at the same time structures of pectins hemicelluloses and cellulose may have changed leading to a full maturity of fruits (Huber, 1983; Seymour *et al.*, 1990; Rose *et al.*, 1998; Min-Kyung, 2007).

The results on soluble solid (^{0} brix) in pericarp, flesh tissue and seed of Santol fruits showed that an increase in harvesting dates highly increased brix values of pericarp, flesh tissue and seed of the Santol fruits. The highest brix values of all tested items were attained with T_4. The results indicated that the conversion of carbohydrates to sugars was highest when the Santol fruits reached an age of 145 days after full bloom of flowers. Therefore, at this maturity age, the Santol fruits may have reached its most appropriate harvesting age where a high degree of sweetness was attained and it could possibly attract consumers more than those harvested earlier (Jeerarat, 2002; Jha *et al.*, 2006). Aydin and Kadioglu (2001) reported that an increase in the amounts of pentose and hexose simple sugars could be plentiful when orchard fruits reached its maturity age. However, Ninio *et al.* (2003) reported that soluble sugars in *C. peruvianus* fruits depended most on the translocation of assimilates from source (leaves) to sink (fruits), whilst Suksri (1999) stated that sweetness taste of orchard fruits could only be achieved when the matured orchard trees were applied with a higher rate of potassium (K) than nitrogen (N) provided that soil pH must be within a range between 6 to 6.5 (soil: water by volume). The result on titratable acidity (%) was highly decreased with an increase in harvesting age where a reverse was found with pH values of the three tested items. The advances in maturity ages could possibly be the reason for this phenomenon. The results also indicated the low amount of calcium in fruits of the Santol plants, hence low pH values of the three tested items were attained although there were some highly significant differences found among the four harvesting periods on titratable acidity (%) but relatively small with pH value after the second harvest.

CONCLUSIONS

It was found that the most appropriate harvesting date for Santol fruits was 145 days after full bloom of flowers. At this harvesting date, fruit length, fruit diameter and average fresh weight fruit^{-1} were highly greater than other earlier harvesting dates. An evenly distribution of yellowness of fruit skin was attained with the harvest at 145 days after full bloom of flowers. A highest ^{0} brix value or soluble solid or sugar content was also attained with the harvest at 145 days after full bloom. Titratable acidity % was highly decreased with the advances in the harvesting ages, whilst a reverse was found with pH values of pericarp, flesh tissue and seed.

ACKNOWLEDGMENTS

The authors wish to express their sincere thanks to Mahasarakham University Financial Office for financial assistance, staff members of the Faculty of Technology, particularly the laboratory assistants for their kind assistance and Professor Amnuaysilpa Suksri for his kind assistance in preparing the manuscript and suggestions.

REFERENCES

Anonymous, 2007. Santol orchard plantations in Thailand for the year of 2006: http://production.doac.go.th/estimate/reportP2/reportP2_display.php.

AOAC (Association of Official Analytical Chemists), 1984. Official Methods of Analysis. 14th Edn., Arlington. Virginia, USA., pp: 1200.

Aydin, N. and A. Kadioglu, 2001. Changes in the composition, polyphenol oxidase and peroxidase activities during development and ripening of Medlar fruits (*Mespilus germanica* L.). Bulg. J. Plant Physiol., 27: 85-92.

Butkhup, L. and S. Samappito, 2008. An analysis on Flavonoids contents in Mao Luang fruits of fifteen cultivars (*Antidesma bunius*), grown in Northeast Thailand. Pak. J. Biol. Sci., (In Press).

Carlos, H.C., D. Garner, G.M. Crisosto, G.S. Sibbett and K.R. Day, 1994. Early harvest prevents internal browning in Asian pears. California Agriculture. July-August, pp: 17-19.

Francis, F.J., 1980. Colour quality evaluation in horticultural crops. Hort. Sci., 15: 58-59.

Goulao, L.F., J. Santos, I. De Sousa and C.M. Oliveira, 2007. Patterns of enzymatic activity of cell wall-modify enzymes during growth and ripening of apples. Postharvest Biol. Technol., 43: 307-318.

Heaton, J.W. and A.G. Marangoni, 1996. Chlorophyll degradation in processed foods and senescent plant tissues. Trends Food Sci. Technol., 7: 8-15.

Huber, D.J., 1983. The role of cell wall hydrolysis in fruit softening. Hortic. Rev., 5: 169-219.

Jeerarat, N., 2002. Growth and development of Santol fruits cv. Pui Fai with and without wrapping of fruits against insect pests: Physical appearances. Khon Kaen Univ. J. Sci., 30: 199-211.

Jha, S.N., A.R.P. Kingsly and S. Chopra, 2006. Physical and mechanical properties of mango during growth and storage for determination of maturity. J. Food Eng., 72: 73-76.

Kalra, S.K., D.K. Tandon and B.P. Singh, 1995. Handbook of Fruit Science and Technology. In: Production, Composition, Storage and Processing, Salunkhe, D.K. and S.S. Kadam (Eds.). Marcel Dekker Inc., New York, pp: 123-170.

Min-Kyung, L., 2007. Inhibitory effect of banana polyphenol oxidase during ripening of banana by onion extract and Maillard. Food Chem., 102: 146-149.

Mwithiga, G., M.I. Mukolwe, D. Shitanda and P.N. Karanja, 2007. Evaluation of the effect of ripening on the sensory quality and properties of tamarillo (*Cyphomandra betaceae*) fruits. J. Food Eng., 79: 117-123.

Ninio, R., E. Lewinsohn, Y. Mizrahi and Y. Sitrit, 2003. Changes in sugars, acids and aroma volatiles during ripening of Koubo (*Cereus peruvianus* L. Miller) fruits. J. Agric. Food Chem., 51: 797-801.

Rose, J.K.C., K.A. Hadfield, J.M. Labavitch and A.B. Bennett, 1998. Temporal sequence of cell wall disassembly in rapidly ripening melon fruit. Plant Physiol., 117: 345-361.

Saimoraka, S., 2007. Center for Agricultural Development Profession (Horticulture) of Nakhon Ratchasima Province. http://aopdh06.doac.go.th/kratorn3.htm.

Sangkittikomol, W., 2000. Total amounts of antioxidant substances in vegetables. http://w3.chula.ac.th/college/ahs/ahs-thai/fruitantiox.htm.

Seymour, G.B., I.J. Colquhoun, M.S. Dupont, K.R. Parsley and R.R. Selvendran, 1990. Composition and structural features of cell wall polysaccharides from tomato fruit. Phytochemistry, 29: 725-731.

SPSS, 1999. Base 9.0 for Windows Users Guide. SPSS Inc., USA.

Stoclet, J.C., T. Chataigneau, M. Ndiaye, M.H. Oak, J. El Bedoui, M. Chataigneau and V.B. Schini-Kerth, 2004. Vascular protection by dietary polyphenols. Eur. J. Pharmacol., 500: 299-313.

Suksri, A., 1999. Some Agronomic and Physiological Aspects in Growing Crops in Northeast Thailand. 1st Edn. Khon Kaen University Press, Khon Kaen 40002, Thailand, pp: 212.