Tropical Agricultural Research Vol. 11 1999, 74-85

Quality of Mangoes as Affected by Stage of Maturity

R. Amarakoon, K.H. Sarananda[1] and D.C.K. Illeperuma[2]

Postgraduate Institute of Agriculture
University of Peradeniya
Peradeniya, Sri Lanka

ABSTRACT. *Immature harvesting, latex burn and poor postharvest handling practices result in high postharvest losses of mango. The present study was carried out to develop subjective and objective methods of maturity indices for 'Karuthacolomban', 'Velleicolomban' and 'Willard'. Fruits were harvested at 10, 11, 12 and 13 weeks after flowering and subjected to float/sink test. They were also analysed for physical appearance such as colour and shape, and chemical composition such as total soluble solids and titratable acidity. A sensory evaluation test was conducted for ripened fruits after each stage of maturity. Effect of latex on the severity of disease development was also studied by recording the disease index and visual quality rating.*

The results revealed that peel colour development could be used as an index for 'Willard' to determine the harvest maturity. Conversion of dark green to light green with maturity cannot be considered as a reliable index for the other two varieties. Raising of shoulders with maturity is a better indicator of maturity than peel colour development, and it could be used as a reliable index to harvest all three varieties. However, for 'Karuthacolomban' and 'Velleicolomban', experience is required to identify the correct stage for selective harvesting. Though the mature fruits of 'Willard' and 'Velleicolomban' answered the float test, 'Karuthacolomban' did not respond consistently. Therefore, this test could be recommended for identifying the correct stage of maturity of 'Willard' and 'Velleicolomban'. The mean value of total soluble solids (TSS) recorded from 'Karuthacolomban' and 'Velleicolomban' cultivars harvested 13 weeks after flowering was 18°Brix, while titratable acidity was recorded as 0.3%. The TSS and TA of 'Willard' were similar to the above results at the 12th week after flowering. The fruits harvested before the optimum stage of maturity contained significantly lower

---

1 Food Research Unit, P.O. Box 53, Department of Agriculture, Peradeniya, Sri Lanka.

2 Department of Food Science and Technology, Faculty of Agriculture, University of Peradeniya, Peradeniya, Sri Lanka.

($p<0.05$) TSS, higher TA and poorer sensory properties than that of matured fruits.

'Karuthacolomban' was found to be more susceptible to stem end rot than 'Velleicolomban'. Removal of latex by washing did not minimize the disease incidence. Thus, it could be recommended that 'Velleicolomban' and 'Karuthacolomban' be harvested with stalk attached so as to prevent latex drip damage on skin and minimize incidence of disease.

INTRODUCTION

Mango (*Mangifera indica l.)* is one of the six major fruit crops in the world. The world production of mango is over 15 million tonnes per annum. Sri Lanka accounts for about 0.4% of total world production and is the 20th largest producer in the world (Warburton, 1993). Because of the delicious taste, characteristic flavour and high content of certain nutrients such as vitamins A, B and C and fibre, the world demand for mango increases annually. Compared to the other major fruits such as banana and apples few postharvest and biochemical studies have been reported for mango (Prinsely, 1986). Though the demand for mango is high in the export market, there is a limited supply mainly due to lack of established technologies on harvesting, handling, transport, storage and ripening. In Sri Lanka the postharvest loss reported for mango is about 40-60% (Wilson Wijeratnam, 1994). As such, reducing postharvest loss is of vital importance.

In Sri Lanka, it is a common practice to harvest mango in a single picking which includes more immature fruits than mature fruits. Immature mangoes do not ripen naturally. Artificial stimulated ripening could result in poor quality mango fruit. Therefore, harvesting at optimum stage of maturity using maturity indices is extremely important. In different countries numerous studies have been carried out to determine the optimum stage of maturity for harvesting of mango fruit. The criteria used were based on physical characters, chemical constituents and respiratory pattern.

The most important postharvest diseases of mango are anthracnose (*Colletotrichum gloesporiodes*) and stem end rot (*Botryodiploidia theobromae*). Identification of the causes and the measures to control these diseases is important to reduce postharvest loss of mango. Mechanical damage has been reported as one of the major causes for these diseases because it predisposes the fruit to microbial infection. Therefore, it is required to handle fruits carefully during harvesting, grading, packing and transport.

This study was carried out to develop subjective and objective maturity indices for commercially important local cultivars 'Karuthacolomban', 'Velleicolomban' and 'Willard' to identify the effect of latex on postharvest diseases of mango.

METHODOLOGY

Collection of samples

The fruits were harvested from Maha Illupallama research station and Gannoruwa farm. 'Karuthacolomban', 'Velleicolomban' and 'Willard' were used for the study. Three trees from each cultivar were tagged at flowering stage, and the fruits were harvested at 10 weeks after flowering in weekly intervals depending on the variety.

Development of maturity indices

Physical appearance such as colour and shape were recorded at each stage of harvest. Shape of the fruits was observed visually using degree of raising shoulders as described by Wardlaw and Leonard (1936). The fruits were placed in a bucket of water, and number of floats and sinks for each variety was counted separately.

Chemical parameters such as total soluble solids and titratable acidity were measured as given below at each stage of maturity. Middle part of the mesocarp of mango was macerated in a mortar and pestle, and the pulp was filtered through a muslin cloth. Total soluble solid content of the juice was directly measured using a hand refractometer and reported as °Brix. For determination of titratable acidity, 1 ml of pulp extract was diluted in 10 ml distilled water and titrated against 0.1 N NaOH using phenolpthalene as an indicator. Titratable acidity was expressed as percentage citric acid (Rangana, 1986).

A sensory evaluation test was conducted for ripe fruits after each stage of maturity. The fruits were tested for colour, aroma, off odour, balance of sweetness and sourness, taste, astringency and overall acceptability using a trained panel. The centre parts of the mesocarp were cut in to cubes and served in salad cups with three digit random number codes. The panelists were given an unstructured line scale of 10 cm with anchored points for each attribute varying from "not at all" to "very much".

Effect of latex on the severity of diseases

The fruits were harvested by using the following methods twelve weeks after of flowering. The fruit with stalk and no latex, without stalk and with latex and without stalk and no latex (washed) were allowed to ripe. The fruits were tested for diseases using a disease index (0-4), *i.e.*: 0 = no disease, 1 = 1-10% disease, 2 = 11-20% disease, 3 = 21-30% disease, 4 = 31% over disease, and visual quality rating using a scale (1-9) *i.e.*: 1 = none edible, 3 = edible, cannot be sold, 5 = fair, defects moderate, 7 = good, slight defects and 9 = excellent were recorded.

Experimental design and analysis

A complete randomised block design was used with three replicates. The data were subjected to variance analysis using the SAS package. Least square means procedure was used to separate treatment means when differences were significant ($P<0.05$).

The sensory evaluation data were analyzed by Friedman test using the Minitab statistical package.

RESULTS AND DISCUSSION

Morphological features

The change of morphological characters of 'Karuthacolomban', 'Velleicolomban' and 'Willard' as recorded by degree of raising shoulders is shown in Table 1. It could be seen that mangoes with different harvest maturity varied in shape. Thus, the fruits could be categorised into three stages of maturity; immature, half-mature and fully mature based on the morphological characteristics. The immature fruits had the shoulders below the pedicel insertion whereas the half-mature fruits had the shoulders in line with the stem. The fully mature fruits had out grown shoulders, which were more prominent in 'Willard' than that in 'Karuthacolomban' and 'Velleicolomban'. However, out grown shoulders could still be used to determine the stage of maturity of 'Willard' and 'Karuthacolomban'. Similar observations were made for 'Jullie' and 'Tommy Atkins' mangoes (Wardlaw and Leonard, 1936).

Table 1. Percentage fruits grouped on position of shoulder at each stage of maturity in three cultivars of mango.

Stage of maturity	% Position of shoulder		
	Below pedicel insertion	In-line with stem	Out grown
Karuthacolomban			
1	100[a]	0[c]	0[c]
2	90[a]	10[b]	0[c]
3	4[b]	86[a]	10[b]
4	0[c]	15[b]	85[a]
Velleicolomban			
1	100[a]	0[b]	0[b]
2	100[a]	0[b]	0[b]
3	54[b]	46[a]	0[b]
4	0[c]	40[a]	60[a]
Willard			
1	100[a]	0[c]	0[c]
2	60[b]	40[b]	0[c]
3	0[c]	80[a]	20[b]
4	0[c]	0[c]	100[a]

Treatment means in a column having a common letter(s) are not significantly different by Duncan Multiple Range Test 5%.

Peel colour

Development of red peel colour observed for 'Willard' at optimum stages of maturity could be used as an index to determine the stage of harvesting. Similar observations were made for 'Haden' variety by Malevski *et al.* (1977). Even though development of light green colour at latter stages of maturities was observed for 'Karuthacolomban', it was difficult to use it as an index as the change in colour was not easily identifiable. Neither formation of pigments nor disappearance of green colour was noted in 'Velleicolomban' during maturation. As such, peel colour could not be used as an index to determine the stage of maturity of 'Velleicolomban'.

During ripening of the fruits harvested at the optimum stage of maturity, a marked increase in the intensity of yellow colour and reddish yellow colour were observed for 'Karuthacolomban' and 'Willard' respectively. The disappearance of chlorophyll from the peel and change of colour from green to red are closely linked to the respiratory climacteric. These changes are due to destruction of chlorophyll thereby revealing the carotene and xanthophyll (Biale and Young, 1962).

Float/sink test

The percentage floaters harvested at different maturity stages are given in Table 2. It is evident that a significant decline in percentage floaters may be observed with the increase in maturity. The percentage floaters in the case of 'Velleicolomban' and 'Willard' decreased with maturity. However, no significant reduction in percentage floaters with maturity was noted for 'Karuthacolomban'. Mukerjee (1953) examined several physical, morphological and chemical parameters of Indian varieties of mango and suggested that grading based on specific gravity (water sinkers > 1.0) as the most reliable method for maturity estimation. Coronel (1983) reported float/sink test as a reliable method for sorting of 'Carabao' variety according to maturity. Harkness and Cobin (1951) showed that the fruits of 'Haden' variety with a specific gravity > 1 were suitable for picking. These studies show that the applicability of the float/sink test in determination of maturity depends on the variety. The total soluble solid content of ripe mangoes harvested at different stages of maturity is shown in Table 2. At the maturity stage 4, a significant increase in °Brix was noted, suggesting that the fruits could be harvested at that stage to obtain high sensory attributes. This shows that the lowest percentage floaters and the highest TSS coincides with the maturity stage 4, suggesting that 'Willard' fruits could be harvested at this

Table 2. Mean percentage floaters, total soluble solids (TSS) and percentage titratable acidity (% TA) of three varieties of green and ripened mangoes harvested at different stages of maturity.

Variety	Stage of maturity	% Floaters	TSS (Brix)		% TA	
			Green	Ripe	Green	Ripe
Karuthacolomban	1	98[a]	5.50[d]	13.00[d]	2.50[a]	0.30[a]
	2	95[a]	7.00[c]	13.80[c]	2.30[a]	0.24[b]
	3	94[b]	7.50[d]	15.00[b]	2.00[b]	0.24[b]
	4	94[b]	7.96[a]	19.00[a]	2.50[a]	0.18[c]
	LSD 0.05	4.14	0.24	0.30	0.25	0.01
Velleicolomban	1	100[a]	5.20[c]	11.80[d]	2.40[a]	1.03[a]
	2	77[b]	6.70[b]	15.40[c]	2.10[b]	1.00[a]
	3	64[c]	7.00[a]	16.00[b]	1.90[a]	0.30[b]
	4	20[d]	7.00[a]	18.00[a]	1.10[d]	0.30[b]
	LSD 0.05	6.30	0.13	0.19	0.19	0.10
Willard	1	100[a]	5.00[d]	13.50[d]	1.72[a]	0.35[a]
	2	60[b]	6.40[c]	15.70[c]	0.79[d]	0.30[b]
	3	36[c]	7.90[b]	18.50[b]	0.91[c]	0.23[a]
	4	3[d]	13.00[a]	19.00[a]	0.95[b]	0.21[c]
	LSD 0.05	3.35	0.19	0.17	0.29	0.03

Each data point represents the mean of three samples. Means with the same letters are not significantly different by Duncan Multiple Range Test 5%.

stage to obtain the optimum maturity. The variety 'Velleicolomban' also showed similar results. Even though the TSS content of 'Karuthacolomban' increased with maturity, there was no significant reduction in the percentage floaters as the fruit matured. This indicates that the sink/float test could not

be used to determine the stage of maturity of 'Karuthacolomban'. Similar observations have been made by Del Mundo *et al.*, 1984 for some other varieties of mango.

Chemical constituents

Table 2 gives the TSS content and % TA of unripe and ripe fruits harvested at different stages of maturity. It is evident that the TSS content increases and % TA decreases with maturity. This is supported by the evidence that the fruits harvested at mature and half-mature stages had higher TSS and lower TA than the immature fruits (Medlicott *et al.*, 1986). Decrease in acidity is due to changes of organic acids, particularly dicarboxylic and tricarboxylic acid in the kreb cycle (Biale and Young, 1962).

'Karuthacolomban' showed the lowest % TA at the 4th stage of maturity. The % TA of the other two varieties was almost the same at the 3rd and 4th stages of maturity. The TSS content of all three varieties increased gradually and reached the maximum value at the 4th stage of maturity. However, for 'Willard', it did not change significantly at the 3rd and 4th stages of maturity. This implies that 'Willard' attains its optimum quality in the 12th week after flowering, and the other two varieties take a longer time to attain the optimum quality. Thus, 'Willard' could be harvested at the 3rd stage and 'Karuthacolomban' and 'Velleicolomban' at the 4th stage of maturity.

Sensory evaluation

The sensory quality attributes of three mango varieties harvested at different maturity stages and ripened naturally are given in Table 3. Except for flesh colour and off odour, the sensory attributes of all three varieties were significant at p=0.05 level. The results revealed that sensory attributes were affected by the stage of maturity. The Friedman rank sum test showed that the highest values for all the quality attributes of ripe 'Karuthacolomban' were obtained for the fruits harvested at the 4th stage of maturity. Similarly 'Velleicolomban' showed the highest rank sum values for the fruits harvested at the 3rd and 4th stages of maturity. However, for 'Willard' rank sum values for fruits harvested at the 3rd and 4th stages of maturity were not significantly different at p=0.05. These results reveal that the fruits harvested at the optimum maturity stage develop better sensory quality attributes than that of the half-mature or immature fruits. This is due to the fact that normal physico-chemical changes do not occur during ripening of immature fruits.

Table 3. Mean scores of sensory evaluation of ripened mango harvested at different stages of maturity.

Variety	Maturity stage	Colour	Aroma	Off odour	Taste	Balance in sweetness/ sourness	Acceptability
Karuthacolomban							
	1	5	5	14	5	5	5
	2	11	10	13	10	10	10
	3	16	16	9	16	17	20
	4	18	18	14	19	18	15
	P=	0.007	0.005	0.564	0.003	0.004	0.002
Velleicolomban							
	1	7	5	13	6	5	6
	2	10	11	12	9	11	9
	3	15	17	16	18	16	19
	4	17	17	4	17	18	17
	P=	0.061	0.008	0.392	0.006	0.007	0.005
Willard							
	1	7	6	17	5	5	5
	2	9	9	11	10	10	10
	3	16	19	9	18	18	19
	4	18	16	12	17	18	16
	P=	0.07	0.005	0.301	0.004	0.025	0.03

Each rank # sum data was obtained by the mean percentage value given by the total of five trained panelists.

Therefore, it is imperative that different varieties of mangoes be harvested at specific times after fruit set to facilitate the maximum development of quality attributes.

The minimum length of time taken for maturity of fruits varies between 85-95 days after fruit set, but appears to be dependent on the variety and climatic conditions. Since mango trees flower over several weeks and set

fruit at different times, analyses of physico-chemical characteristics would not be useful in determining the proper maturity stage for harvesting from one plantation or even from one tree on commercial basis. Medlicott *et al.*, 1986 also reported the difficulty in identifying the proper maturity stages based on physico-chemical characteristics, for 'Tommy Atkins' varieties. However, physico-chemical properties characteristics could be used if flower induction is practised.

Table 4. Disease index (DI) and visual quality rating (VQR) of two varieties of mango in relation to method of harvesting and washing immediately after harvesting.

Variety	Harvest condition	DI	VQR
Velleicolomban			
	with latex and no peduncle	3.23[a]	0.66[c]
	without latex and with peduncle	0.50[b]	8.50[a]
	washed and no peduncle	2.00[c]	4.16[b]
	LSD 0.05	0.87	1.23
Karuthacolomban			
	with latex and no peduncle	3.50[b]	1.00[b]
	without latex and with peduncle	0.83[c]	8.16[a]
	washed and no peduncle	3.83[a]	0.66[c]
	LSD 0.05	1.37	2.55

Each date point represents the mean of 15 fruits. Means with the same letter in a column of a cultivar are not significantly different by Duncan Multiple Range Test 5%.
Disease index (0-4), *i.e.*: 0 = no disease. 1 = 1-10% disease, 2 = 11-20% disease. 3 = 21-30% disease. 4 = 31% over disease, and visual quality rating using a scale (1-9) *i.e.*: 1 = none edible, 3 = edible, cannot be sold, 5 = fair, defects moderate. 7 = good, slight defects and 9 = excellent.

Effect of latex

Mature fruits of 'Velleicolomban' and 'Karuthacolomban' were harvested with and without the stalk attached, and the disease index (DI) and

visual quality rating (VQR) were recorded. It is revealed that the method of harvesting had a significant effect on development of postharvest diseases. Table 4 shows that the lowest DI and the highest VQR are recorded for fruits harvested with the stalk attached. This may be due to the absence of latex exudates, which could damage the skin and thereby make entry points for pathogens. Moreover, stress ethylene produced by burnt tissue could stimulate spore germination and appresoria formation of pathogenic fungi causing a higher incidence of disease infection (Flaishman and Kallattukudy, 1994).

If improved harvesting techniques are not adopted, mangoes are separated from stem at the least resistant point (naturally falling point) where the latex exudation is maximum. Thus, washing of fruits is practised to remove latex. However, the present results show that washing increased DI when compared with the control. This effect was more prominent in 'Karuthacolomban' than in 'Velleicolomban'. Therefore, harvesting with the stalk attached could be recommended for extending the postharvest life of mangoes.

REFERENCES

Biale, J.B. and Young, R.E. (1962). The biochemistry of fruit maturation. Endeavour. 21: 164-174.

Coronel, R.E. (1983). Varietal improvement. *In*: State of the Art Mango Research Crops Series No. 3. 10-3. Phillipine Council for Agriculture and Resources Research and Development. Los Banos, Laguna, Phillipines.

Del Mundo, C.R., Lizada, M.C.C., Mendazoa, D.B. and Garica, N.L. (1984). Indices for harvest maturity in 'Carabao' mangoes. Postharvest Res. Notes. 1: 11-2.

Flaishman, M.A. and Kollattukudy, P.E. (1994). Timing of fungal invasion using host's ripening hormone as a signal. Proc. Natl. Acad. Sci. USA. 91: 6579-6585.

Harkness, R.N. and Cobin, M. (1951). The 'Florida' mango forum. pp. 141.

Malevski, Y., Gomez Brito, L., Peleg, M. and Selberg, M. (1977). External colour as maturity index of mango. J. Fd. Sci. 5: 1318-1316.

Medlicott, A.P., Bhogal, M. and Reynolds, S.B. (1986). Changes in the peel pigmentation during ripening of mango fruit (*Mangifera indica* L. var. 'Tommy Atkins'). Ann. App. Biol. 109: 651-656.

Mukerjee, P.K. (1953). The mango- its botany cultivation, uses and future improvement, especially as observed in India. Econ. Bot. 7: 130-62.

Prinsely, T.R. (1986). Mangoes in the Carribean. Production and postharvest treatments. CSC Technical Publication Service.

Rangana, S. (1986). Manual of fruits and vegetables products. Tata McGraw Hill Publishing Co. Ltd., New Delhi.

Warburton, W.S. (1993). Elimination of *Colletotrichum gloesporoides* from mango planting stock. Report on a study visit to Sri Lanka. Project No: 54. Natural Resource Institute, U.K.

Wardlaw, C.W. and Leonard, R.E. (1936). The storage of west Indian mangoes. Imp. Coll. Trop. Agri. (Trinidad). Low temperature. Res. Stn. Mem. 3.

Wilson Wijeratnam, R.S. (1994). Post harvest handling procedures, Principles and practices. Personal Communication.