Indian J. Hort. 69(4), December 2012: 578-585

Effect of cultivar, harvesting stage and storage period on the quality of mango during natural ripening

S.N. Jha*, P. Jaiswal, K. Narsaiah, R. Sharma, R. Kumar, A. Basedia and P.P. Kaur
Agricultural Structures and Environmental Control Division, Central Institute of Post-harvest Engineering & Technology, Ludhiana 141004, Punjab

ABSTRACT

Physico-chemical characteristics, *viz*., total soluble solids (TSS), pH, dry matter (DM) and overall acceptability scores (OA) of nine major Indian mango cultivars at different harvesting stages were studied during natural ripening. Mangoes were kept in a single layer at ambient room conditions (26-38°C, RH 60-70%) for ten days and were taken randomly at an interval of two days for quality assessment. Parameters like TSS and pulp pH showed significant increase while, DM declined significantly with storage period. The early harvested mangoes did not ripen well with OA score of less than 6 except Alphanso from Maharashtra, whereas; mangoes harvested at mid and late stages ripened well and resulted into higher sensory scores. Statistically significant scores were observed in late harvested mangoes. There was significant variation in OA scores of early, mid and late harvested mangoes.

Key words: Mango, ripening, storage, quality, maturity.

INTRODUCTION

Mango (*Mangifera indica* L.) is one of the most important tropical fruits relished for its succulence, exotic flavour and delicious taste. Mangoes are harvested at hard green stage after it reaches physiological maturity (Jha *et al.*, 8). Harvest maturity was found to be the most important determinant of storage life and final fruit quality (Jha *et al.*, 6; Jha and Matsuoka, 19). The onset of climacteric rise in mango fruit depends on the harvesting stage and storage conditions (Joas *et al.*, 9). It affects the ripening process (Saranwong *et al.*, 14) and thus, the final flavour of the ripened fruit (Bender *et al.*, 1). The variability of fruit harvest can lead to wide variations in physiological parameters (Tijskens *et al.*, 18). This in turn causes variation in sugar content, pH and dry matter, which can be correlated with the consumer's perception of maturity (Schmilowitch *et al.*, 15). Fruits picked before physiological maturity does not ripen properly (Medlicott *et al.*, 12) resulting into poor eating experience (Subedi and Walsh, 16). Therefore, each fruit develops according to its own agronomic history and harvesting stage (Lechaudel and Jaos, 11). The objective of this investigation was to study the effect of harvesting stage (early, mid and late) on physico-chemical and sensory quality parameters to mark the optimum harvesting/ maturity stage indicators for different mango cultivars under study.

*Corresponding author's E-mail: snjha_ciphet@yahoo.co.in

MATERIALS AND METHODS

Nine mango cultivars (Alphanso = A, Banganapalli = B, Chausa = C, Dashehari = D, Kesar = K, Langra = L, Maldah = M, Mallika = M and Neelam = N) were selected for sampling from orchards of different Indian states by following randomized block design (Jha *et al.* 7). Fruits were manually harvested at three different dates (first, second and third) based on growers' experience and previous findings (Jha *et al*., 4, 5, 6, 8) (Table 1). Thereafter, fruits were transported to laboratory within 48 h in ventilated corrugated fibre board boxes containing partially frozen gel packs placed in-between the two layers of mangoes to minimize the quality losses. Mangoes free from any external injury were sorted and stored under ambient conditions (26-38ºC, RH 60-70%) for natural ripening and were evaluated at an interval of 0, 2, 4, 6, 8 and 10 days of storage for sensory and physico-chemical properties.

Mango juice was extracted by centrifuging (Eltek MP-400R, Electrocraft, Mumbai) the macerated pulp at 15,000 rpm for 5 min. The TSS and pH (Jaiswal *et al.*, 3) of the juice was measured using hand held digital refractometer (Pal-1, Atago, Japan range 0-53°Brix, least count 0.2°Brix) and digital pH meter (ThermoFisher Scientific Inc., Singapore), respectively. Dry matter content of the mango pulp was determined using hot air oven method before subjected to sensory evaluation. The sensory attributes were scored using 9 point Hedonic scale (Liked extremely = 9, Liked very much = 8, Liked

Table 1. Sampling schedule and abbreviations used for mango cultivars harvested from different locations.

Cultivar	Place of procurement	Abbreviations used	Stage of harvesting		
			Early	Mid	Late
Alphonso	Karnataka	AK	23rd March	2nd May	23rd May
	Maharashtra	AM	2nd May	1st June	15th June
Banganapalli	Andhra Pradesh	BA	6th April	2nd May	5th June
	Orissa	BO	9th April	11th May	5th June
Chausa	Punjab	CP	20th June	29th June	10th July
	Uttar Pradesh	CU	29th June	7th July	19th July
Dashehri	Punjab	DP	16th June	20th June	6th July
	Uttar Pradesh	DU	20th June	29th June	7th July
Kesar	Gujarat	KG	24th April	14th May	5th June
	Maharashtra	KM	24th April	14th May	5th June
Langra	Uttar Pradesh	LU	20th May	15th June	29th June
Maldah	Bihar	MB	21st May	15th June	6th July
Mallika	Orissa	MO	9th April	29th April	16th May
Neelam	Tamilnadu	NT	27th March	23rd April	3rd June

Table 2. Tests of significance for TSS, pH, DM and OA scores of mango cultivars at different harvesting stages and storage period.

Parameter	Effects	SS	DF	MS	$F_{Calculated}$
TSS	Harvesting stage (H)	5777.7	2	2888.8	202.9*
	Cultivar (C)	7713.9	13	593.4	41.6*
	Storage period (S)	10776.7	5	2155.3	151.4*
	H × C	5494.8	26	211.3	14.8*
	C × S	740.3	10	74.0	5.2*
	H × S	3621.1	65	55.7	3.9*
	H × C × S	6072.9	130	46.7	3.2*
pH	Harvesting stage (H)	293.03	2	146.5	1603.3*
	Cultivar (C)	533.43	13	41.0	449.0*
	Storage period (S)	197.54	5	39.5	432.3*
	H × C	73.86	26	2.8	31.1*
	C × S	19.62	10	1.9	21.5*
	H × S	96.82	65	1.4	16.3*
	H × C × S	112.32	130	0.8	9.5*
TA	Harvesting stage (H)	3631	2	1815.4	0.5*
	Cultivar (C)	49403	13	3800.2	1.1*
	Storage period (S)	15456	5	3091.1	0.9*
	H × C	90076	26	3464.4	1.0*
	C × S	34334	10	3433.3	1.0*
	H × S	219054	65	3370.0	0.9*

contd...

Table 2 contd...

Parameter	Effects	SS	DF	MS	$F_{Calculated}$
	H × C × S	444471	130	2419.0	1.0*
DM	Harvesting stage (H)	964.5	2	482.3	109.6*
	Cultivar (C)	5760.5	13	443.1	100.7*
	Storage period (S)	836.6	5	167.3	38.0*
	H × C	7207.0	26	277.2	63.0*
	C × S	515.2	10	51.5	11.7*
	H × S	2798.2	65	43.0	9.8*
	H × C × S	5805.5	130	44.7	10.2*
OA	Harvesting stage (H)	129.3	2	64.6	138.1*
	Cultivar (C)	169.2	13	13.0	27.8*
	Storage period (S)	40.2	5	8.1	17.2*
	H × C	153.9	26	5.9	12.6*
	C × S	135.0	65	2.1	4.4*
	H × S	39.5	10	3.9	8.4*
	H × C × S	310.4	130	2.3	5.0*

SS = Sum of squares, DF = Degrees of freedom, MS = Mean sum of squares, $F_{Calculated}$ = Calculated F value, * = Significant at $p \geq 0.05$.

moderately = 7, Liked slightly = 6, Neither liked nor disliked = 5, Disliked slightly = 4, Disliked moderately = 3, Disliked very much = 2, Disliked extremely = 1) by a panel of 10 sensory judges with equal number of male and female members. The significance of cultivars, harvesting stage and storage period was calculated by analysis of variance (ANOVA) at $p \geq 0.05$ using AgRes software. Treatments were replicated thrice and average values of each parameter were recorded.

RESULTS AND DISCUSSION

The late harvested mangoes exhibited higher TSS in almost all cultivars during ripening except cultivars Chausa Punjab, Dashehri Uttar Pradesh, Langra Uttar Pradesh and Neelam TamilNadu, whereas it was higher in early and mid harvested ones (Fig. 1) probably due to over ripening of late harvested samples. Similar results were reported by Joas *et al.* (9), Jha *et al.* (6), and Saranwong *et al.* (14). The increase in TSS during natural ripening could be attributed to breakdown of starch into soluble sugars. Krishnamurthy *et al.* (10) reported complete hydrolysis of starch into sucrose and glucose during ripening along with proportional increase in TSS. Similar increase in TSS was observed in green mature Alphanso (Doreyappa and Huddar, 2). Harvesting stage significantly affected TSS during storage. Cultivar specific variations in TSS content were recorded (Table 2). The interactions between harvesting stage, storage period and cultivar were also significant.

Higher pulp pH was observed in late harvested mangoes in all cultivars during ripening except cultivars Banganapalli Odisha, Dashehri Punjab, Langra Uttar Pradesh, Maldah Bihar and Neelam Tamil Nadu, whereas pH of mid harvested ones superseded the late samples after 6th day (Fig. 2). This might be attributed to decline in acid content due to conversion into sugars and their further utilization in metabolic process (Doreyappa and Huddar, 2). Joas *et al.* (9) also observed higher pH in the late harvested mangoes. An earlier report (Doreyappa and Huddar, 2) also demonstrated an increase in pH of mango during ripening at room temperature. ANOVA indicated that pH and interactions between harvesting stage, storage period and cultivar were significantly changing with storage period and harvesting stage (Table 2).

Higher DM was observed in late harvested mangoes, except in cv. Alphanso Maharashtra, Dashehri Punjab, Banganapalli Andhra Pradesh, Dashehri Uttar Pradesh, Maldah Bihar and Neelam TamilNadu, whereas it was higher in early and mid harvested ones (Fig. 3). Saranwong *et al.* (14) observed higher dry matter in late harvested mango than that of early ones. The increase in DM suggests accumulation of organic substances

Table 3. Overall acceptability scores of different mango at different harvesting stages.

Cultivar	Place of procurement	Abbreviation	Harvesting stage		
			Early	Mid	Late
Alphonso	Karnataka	AK	4.07^{u}	4.72^{st}	3.76^{u}
	Maharashtra	AM	$5.55^{hijklmn}$	$5.27l^{mnop}$	$5.47^{hijklmno}$
Banganapalli	Andhra Pradesh	BA	6.18^{defg}	$5.55^{hijklmn}$	6.98^{b}
	Orissa	BO	5.30^{klmnop}	5.68^{defg}	6.18^{defg}
Chausa	Punjab	CP	5.11^{nopqrs}	5.13^{nopqs}	5.90^{efgh}
	Uttar Pradesh	CU	5.70^{hijkl}	5.80^{fghij}	6.34^{cde}
Dashehri	Punjab	DP	5.03^{opqrst}	5.61^{hijklm}	6.34^{cde}
	Uttar Pradesh	DU	$5.25l^{mnopq}$	5.81^{fghi}	6.74^{bc}
Kesar	Gujarat	KG	4.49^{t}	$5.38^{ijklmnop}$	7.16^{b}
	Maharashtra	KM	4.75^{rst}	5.31^{klmnop}	7.84^{a}
Langra	Uttar Pradesh	LU	4.94^{pqrst}	5.74^{ghijk}	5.86^{fgh}
Maldah	Bihar	MB	5.62^{hijkl}	$5.53^{hijklmn}$	6.51^{cd}
Mallika	Orissa	MO	$5.32^{ijklmno}$	4.81^{qrst}	6.23^{def}
Neelam	Tamilnadu	NT	$5.36^{jklmnop}$	$5.47^{hijklmno}$	5.17^{mnopqr}

*Values followed by the same letters are not significantly different at $p \geq 0.05$

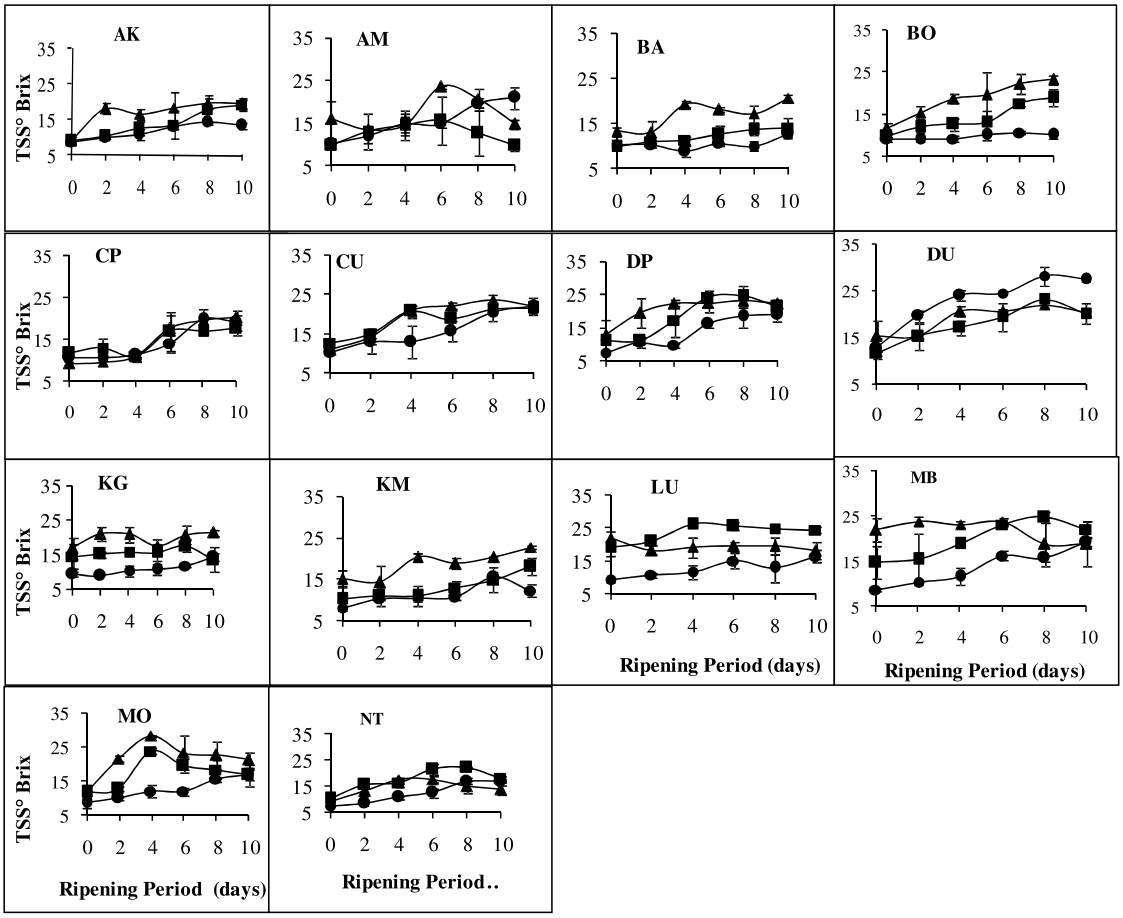

Fig. 1. Variations in total soluble solids (TSS) of mango cultivars harvested at different maturity stages, Early (●), Mid (■) and Late (▲) during natural ripening.

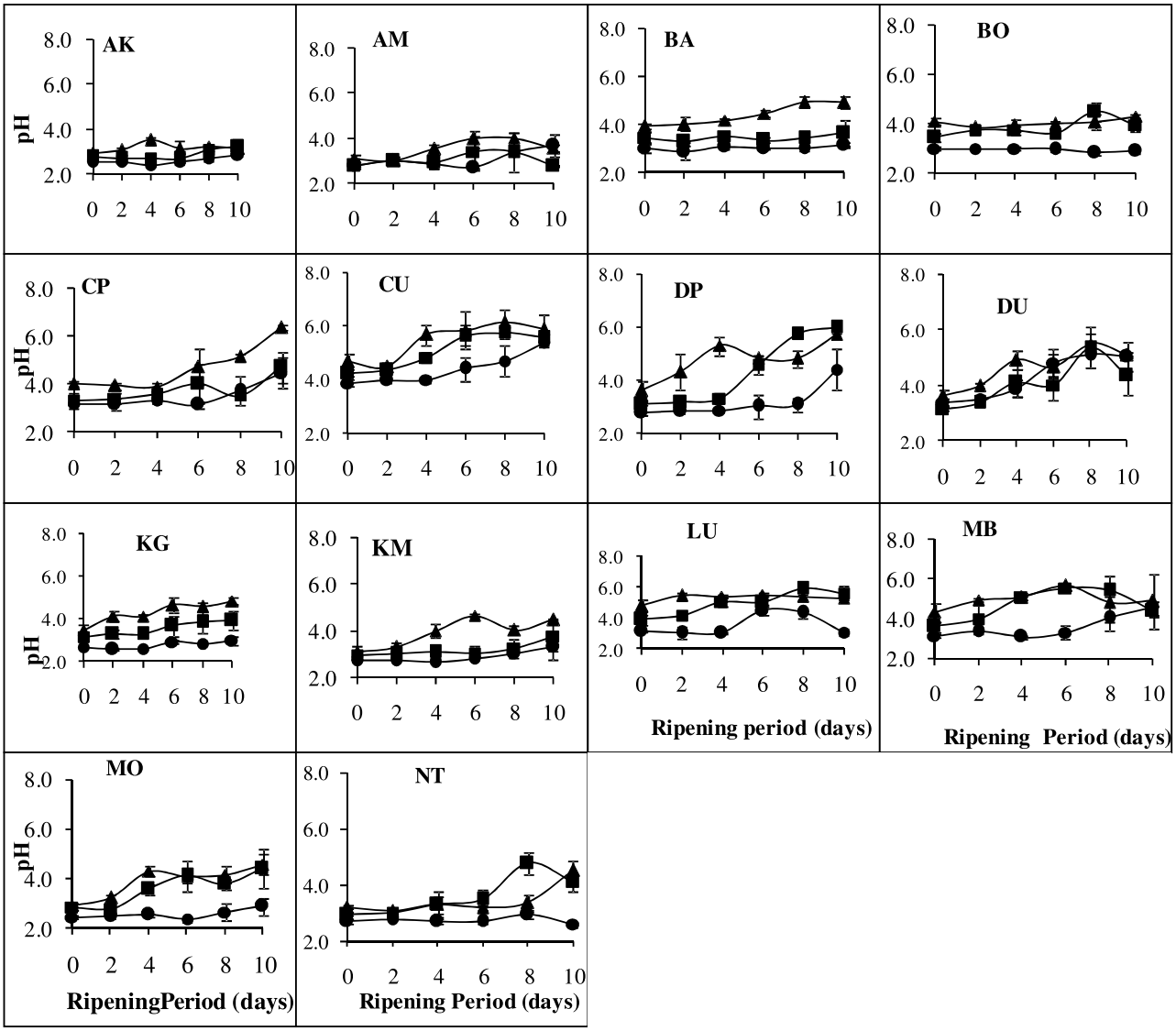

Fig. 2. Variations in pH of mango cultivars harvested at different maturity stages, Early (●), Mid (■) and Late (▲) during natural ripening.

needed for completing the ripening process due to significant enzymatic activity of starch breakdown and sugar synthesis (Tandon and Kalra, 17). The DM however did not vary widely during ripening except cvs. Alphanso Maharashtra, Kesar Gujarat, Kesar Maharashtra and Langra Uttar Pradesh. In cvs. Alphanso Maharashtra, DM increased in early harvested mangoes while it decreased in mid and late harvested ones during ripening. Subedi and Walsh (16) also reported absence of significant variation in DM during natural ripening. ANOVA indicated that the decline in DM with storage at early, mid and late harvesting stages was statistically significant. The interaction between harvesting stage, cultivar and storage period was also found to be statistically significant in declining the dry matter content (Table 2).

The OA scores increased initially during ripening period but, later on sensory scores declined (Fig. 4). OA scores however, were always higher for late harvested mangoes except Langra Uttar Pradesh and Neelam Tamil Nadu. The increase in OA scores might be due to on setting of climacteric phase and decrease might be due to over ripening (Sabato *et al.*, 13). OA scores of mangoes harvested at early stage did not vary widely due to immature stage and thus, did not ripen well (Medlicott *et al.*, 12). Saranwong *et al.* (14) also observed that mangoes

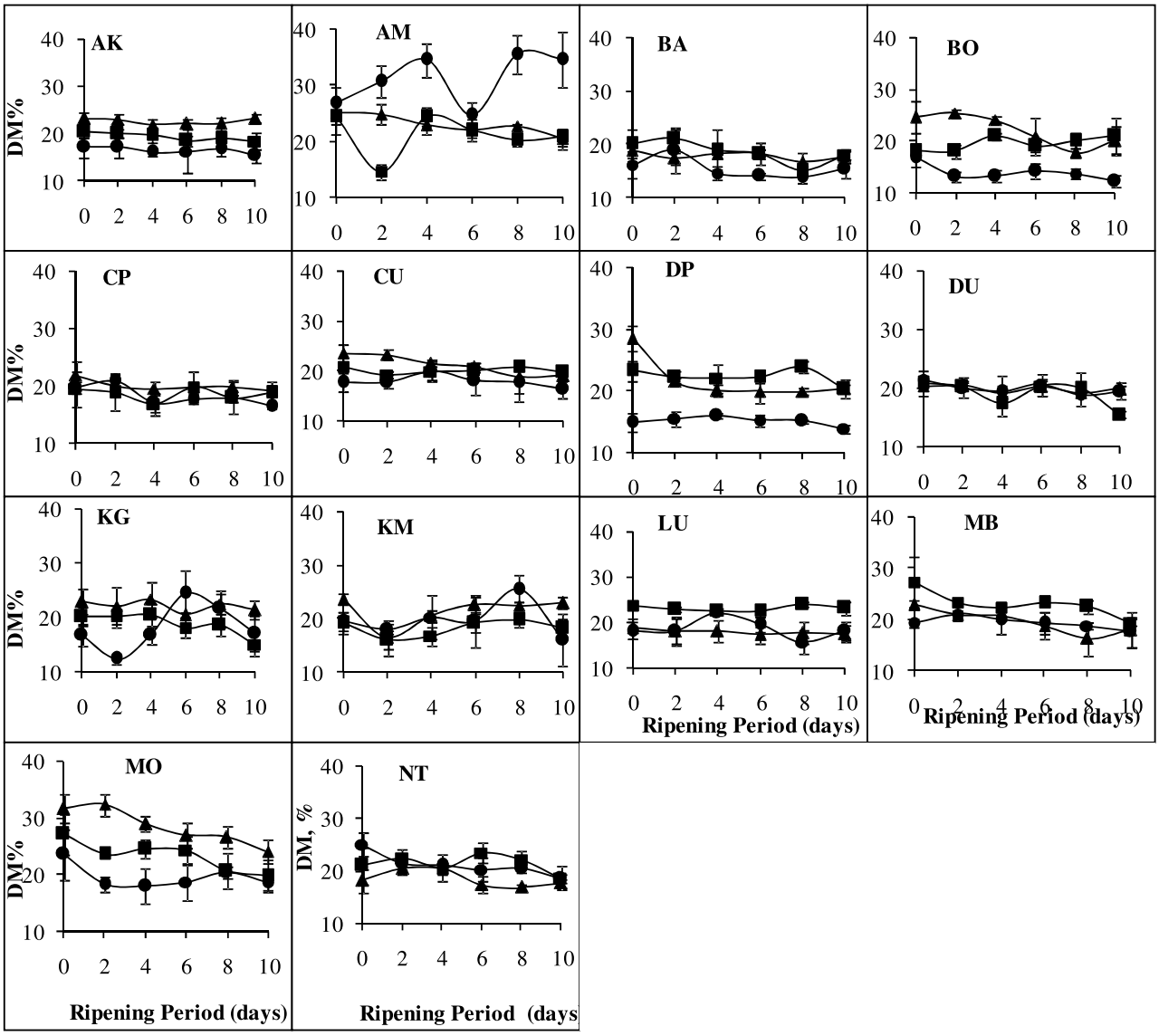

Fig. 3. Variations in DM of mango cultivars harvested at different maturity stages, Early (●), Mid (■) and Late (▲) during natural ripening.

harvested at late stage ripened well and lead to better eating quality than the mangoes harvested at early stage. A multiple range test using LSD (AgRes) indicated that OA score in late harvested mangoes was significantly higher than early and mid harvesting except for few mango varieties (Alphanso Karnataka and Neelam Tamilnadu) (Table 3). In cv. Alphanso Karnataka, the OA score was found to be significantly higher in mid harvesting stage as compared to early and late harvesting. The OA scores of cv. Alphanso Maharashtra did not show much variation in early, mid and late harvesting. In cv. Banganapalli Andhra Pradesh, OA score was higher in late and early harvested mangoes as compared to mid harvesting. In rest of the cultivars (Banganapalli Odisha, Chausa Punjab, Chausa Uttar Pradesh, Dashehri Punjab, Dashehri Uttar Pradesh, Kesar Gujarat, Kesar Maharashtra, Langra Uttar Pradesh, Maldah Bihar), the OA score was found to be highest in late harvested mangoes followed by mid and early harvested mangoes, except for cv. Mallika Odisha, where the OA score was observed to be significant in late harvested mangoes, followed by early and mid harvested mangoes. However, in cv. Neelam TamilNadu, no significant variation was observed in early and mid harvested mangoes. OA

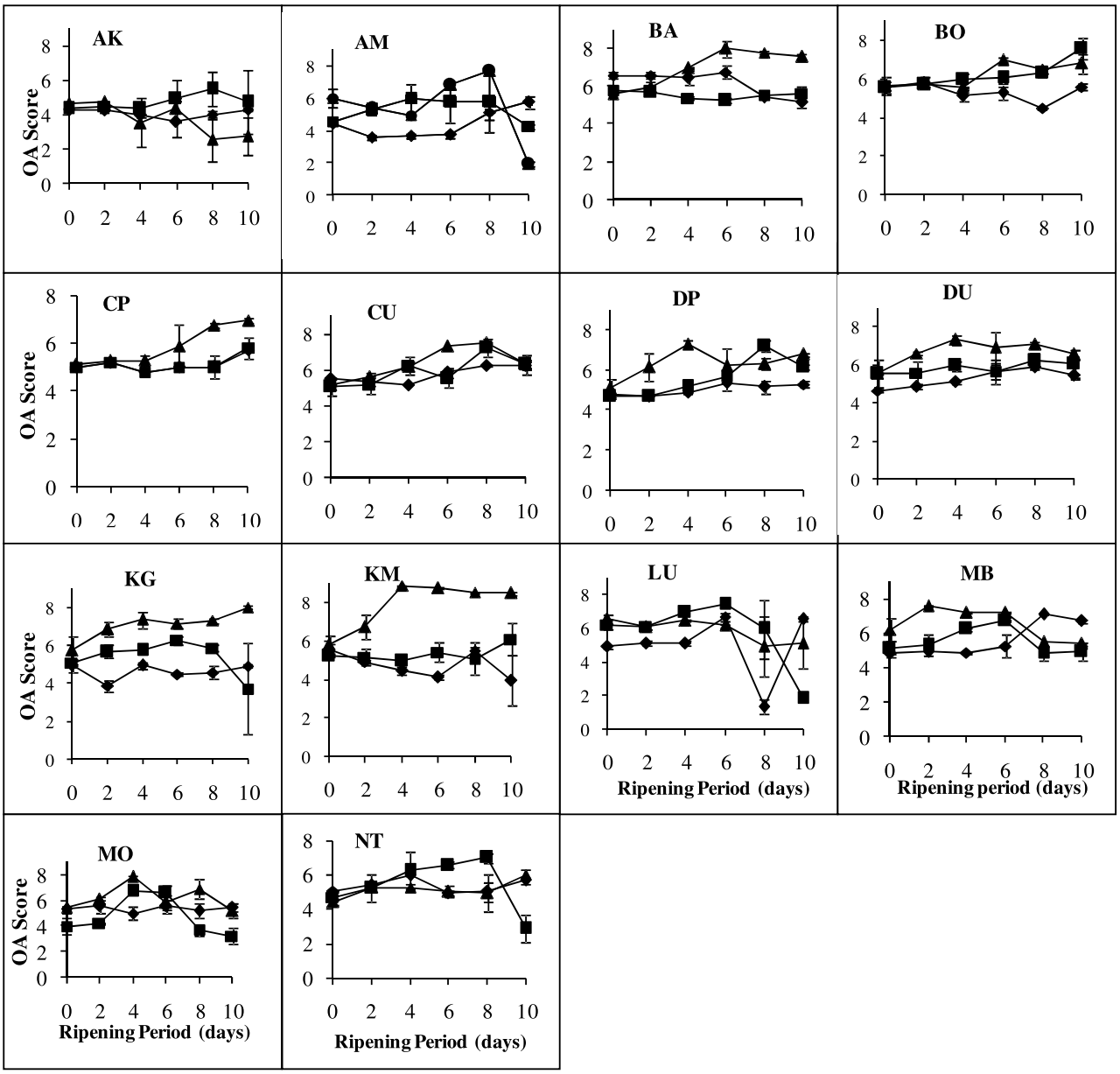

Fig. 4. Variations in OA of mango cultivars harvested at different maturity stages, Early (●), Mid (■) and Late (▲) during natural ripening.

score can serve as markers for optimum harvesting stage of specific mango cultivars. Non destructive monitoring of physico-chemical profile of mangoes on day of highest acceptability may pave the way for labeling the peak eating quality.

ACKNOWLEDGEMENTS

This research was supported by the National Agricultural Innovation Project (NAIP), Indian Council of Agricultural Research (ICAR) through its subproject (Code number - C1030).

REFERENCES

1. Bender, R.J., Brecht, J.K., Baldwin, E.A. and Maludo, T.M.M. 2000. Aroma volatiles of mature-green and tree-ripe 'Tommy Atkins' mangoes after controlled atmosphere vs. air storage. *HortSci*. **35**: 684-86.

2. Doreyappa, G.I.N. and Huddar, A.G. 2001. Studies on ripening changes in mango fruits. *J. Food Sci. Tech*. **38**: 135-37.

3. Jaiswal, P., Jha, S.N. and Bhardwaj, R. 2012. Non-destructive prediction of quality of intact banana using spectroscopy. *Scientia Hort.* **135**: 14-22.

4. Jha, S.N., Jaiswal, P., Sharma, R., Narsaiah, K., Kaur, P.P. and Singh, A.K. 2011. Textural properties of mango cultivars during ripening. *J. Fd. Sci. Tech*. DOI 10.1007/s13197-011-0431-z.

5. Jha, S.N., Jaiswal, P., Kaur, P.P., Narsaiah, K., Singh, A.K., Kumar, R. and Bhardwaj, R. 2012. Relationship between sensory and textural attributes during ripening of mango. *Fd. Bioprocess Tech*. DOI 10.1007/s11947-011-0720-6

6. Jha, S.N., Chopra, S. and Kingsly, A.R.P. 2007. Modeling of colour values for nondestructive evaluation of maturity of mango. *J. Fd. Engg*. **78**: 22-26.

7. Jha, S.N., Jaiswal, P., Narsaiah, K., Bhardwaj, R., Sharma, R., Kumar, R. and Basediya, A.L. 2010. Postharvest microflora on major cultivars of Indian mangoes. *Scientia Hort*. **125**: 617-21.

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

9. Joas, J., Caro, Y. and Lechaudel, M. 2009. Comparison of postharvest changes in mango using a ripening class index for different carbon supplies and harvest dates. *Postharvest Biol. Tech*. **54**: 25-31.

10. Krishnamurthy, G.V., Jain, N.L. and Bhatia, B.S. 1960. Changes in the physico-chemical composition of mango during ripening after picking. *Fd. Sci.* **9**: 277-79.

11. Lechaudel, M. and Joas, J. 2006. Quality and maturation of mango fruits of cv. Cogshell in relation to harvest date and carbon supply. *Australian J. Agric. Res*. **57**: 419-26.

12. Medlicott, A.P., Reynolds, S.B., New, S.W. and Thompson, A.K. 1988. Harvest maturity effects on mango fruit ripening. *Trop. Agric*. **65**: 153-57.

13. Sabato, S.F., Da silva, J.M., Da cruz, J.N., Salmieri, S., Rela, P.R. and Lacroix, M. 2009. Study of physical-chemical and sensorial properties of irradiated Tommy Atkins mangoes in an international consignment. *Fd. Control*, **20**: 284-88.

14. Saranwong, S., Sornsrivichai, J. and Kawano, S. 2004. Prediction of ripe stage eating quality of mango fruit from its harvest quality measured nondestructively by near infrared spectroscopy. *Postharvest Biol. Tech*. **31**: 137-45.

15. Schmilovitch, Z., Mizrach, A., Hoffman, A., Egozi, H. and Fuchs, Y. 2000. Determination of mango physiological indices by near infrared spectroscopy. *Postharvest Biol. Tech*. **19**: 245-52.

16. Subedi, P.P. and Walsh, K.B. 2009. Non-invasive techniques for measurement of fresh fruit firmness. *Postharvest Biol. Tech*. **51**: 297-304.

17. Tandon, D.K. and Kalra, S.K. 1983. Changes in sugars, starch and amylase activity during development of mango fruit cv. Dashehri. *J. Hort. Sci*. **58**: 449-53.

18. Tijskens, I.M.M., Konopacki, P. and Simcic, M. 2003. Biological variance, burden or benefit. *Postharvest Biol. Tech*. **27**: 15-25.

19. Jha, S.N. and Matsuoka, T. 2002. Surface gloss and weight of eggplant during storage, *Biosystems Engg*. 81: 407-12.

Received : July, 2011; Revised : May, 2012;
Accepted : September, 2012