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Evaluation of newly developed mango (*Mangifera indica*) hybrids for their storage behaviour and peel colour

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ABSTRACT

Time required for ripening, post ripening life, cumulative physiological loss in weight during storage, peel colour and sensory quality of newly developed 12 mango (*Mangifera indica* L.) hybrids were compared with the important mango hybrids 'Pusa Arunima' and 'Amrapali'. Among hybrids, 'Pusa Arunima' and 'H 3-2' took longer time for ripening (6.2 and 6.4 days, respectively) while hybrids 'H 4-12' and 'H 2-14' ripened faster (3.8 and 4.0 days, respectively). Total post-harvest life was maximum in hybrid 'H 3-2' (9.8 days), followed by 'Pusa Arunima' (9.4 days). Mango hybrids, namely 'H 1-11', 'H 2-13' and 'H 13-7' showed more than 10% cumulative physiological loss in weight on day 6 of storage. However, in 'H 3-2' and check variety 'Pusa Arunima' the cumulative physiological loss in weight was less than 11% even up to day 9 of storage. Other hybrids like 'H 1-1', 'H 1-6', 'H 4-12', 'H 11-2', 'H 2-6' and 'H 1-5' had more than 10% cumulative physiological loss in weight on day 7 of storage. The spoilage was also less in hybrids 'H 3-2', 'H 2-13', 'H 1-1' and 'Pusa Arunima'. Hybrids 'H 1-1', 'H 1-6', 'H 4-12' and 'H 11-2' excelled over 'Pusa Arunima' in terms of redness of peel of ripe fruits. With regard to sensory quality, hybrid 'H 1-6' and 'H 1-1' scored better in overall acceptability as compared to other hybrids, 'Pusa Arunima' and 'Amrapali'.

Key words: Cumulative physiological loss in weight, Mango hybrids, Peel colour, Storage, Sensory quality

Mango (*Mangifera indica* L.) commonly called as 'King of fruits' in India is considered to be a very important fruit in the world market due to its excellent flavour, attractive fragrance, beautiful colour, delicious taste and health-promoting properties (Rathore *et al*. 2007). In India, about 30 cultivars are being grown commercially occupying about 2.31 million ha area with an annual production of 12.75 million tonnes (NHB 2008–09). Since mango is a climateric fruit, it is harvested at full maturity and allowed to ripen after harvesting. The time required for ripening is controlled genetically and hence, it is a varietal character. Being a climacteric fruit, it has a very short shelf-life and reaches its respiration peak of ripening process on 3rd or 4th day after harvesting at ambient temperature (Narayana *et al*. 1996). Emphasis of mango breeding programmes has now shifted to the development of varieties preferably having red peel colour and suitable for export. Now-a-days, non-destructive techniques for quality evaluation have gained popularity. Determination of maturity in mango has been correlated with various physical characteristics like skin colour, shape, size and shoulder colour using near infrared (NIR) spectroscopy, visual spectral analysis, acoustic and ultrasound techniques as well as colour measurement (Jha *et al*. 2006, Jha *et al*. 2007). Efforts are now underway to produce new hybrids having desirable qualities with attractive skin colour, so that they will occupy a better position in the international trade. As a result of exhaustive hybridization work carried out at the Institute during last few decades, number of new hybrids have been evolved having coloured peel with fruit quality matching closely to the international requirement. The present investigation was carried out to determine the time required for ripening, peel colour changes and shelf-life of the new hybrids in comparison to the existing hybrids 'Pusa Arunima' and 'Amrapali'.

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MATERIALS AND METHODS

An experiment was carried out to evaluate new mango hybrids developed at Division of Fruits and Horticultural Technology of the Institute. Out of 12 mango hybrids, 11 were obtained by crossing 'Amrapali' as female parent with 'Sensation' ('H 1-1', 'H 1-6', 'H 1-11', 'H 1-5', 'H 11-2',

'H 3-2', 'H 13-7' and 'H 13-8'), 'Lal Sundari' ('H 2-6') and 'Alphonso' ('H 2-14') as male donor parent, whereas hybrid 'H4-12' was obtained from the cross 'Dushehari'× 'Sensation' and hybrid 'H 2-13' was derived from the cross 'H 27 N' × 'H 71'. New hybrids were compared for their storage behaviour and sensory qualities with the commercial varieties 'Pusa Arunima' ('Amrapali'× 'Sensation') and 'Amrapali' ('Dushehari'×'Neelum') developed at the Division and released for its commercial cultivation. Mature fruits of different hybrids were procured from the mango hybrid evaluation block of the Institute. The fruits were sorted out for uniform maturity by dipping in plain water. The fruits floating in water were considered immature and discarded. The selected fruits of different hybrids were stored at ambient temperature (28–31 ºC) and were used for further study.

Twentyfive fruits were marked in each lot and their initial weights were recorded and subsequently, they were weighed on alternate days. Cumulative physiological loss in weight was calculated and expressed in per cent. The stored fruits were observed daily for any change in peel colour, softening and development of characteristic flavour and aroma. Time taken for more than 75% of the fruits in a lot to develop characteristic colour and flavour was recorded as the time taken for ripening by that hybrid or variety and expressed in days. During recording of cumulative physiological loss in weight, the fruits were checked for rotting and infected fruits were counted and discarded. Based on the number of rotten fruits, the spoilage was expressed in per cent. The fruits ripened to optimum condition under each lot were kept further, to study the post ripening life. When two or more fruits showed the symptoms of over ripening by shriveling and over softening, that duration was considered as the optimum shelf-life of that hybrid and expressed in days. The sum of time taken for ripening and post ripening life was taken as total post harvest life of the hybrid.

The fruit surface colour was measured using a ColorTec-PCM. The measurements are expressed in terms of chromaticity coordinates L, a, b where L measures lightness and varies from 100 for perfect white to zero for black, approximately as the eye would evaluate it. The chromaticity dimensions 'a' measures redness when positive, greyness when zero and greenness when negative, and 'b' measures yellowness when positive, greyness when zero and blueness when negative. The colorimeter was calibrated with standard black and white calibration tiles. The nose cone was kept in complete contact with the mango surface to prevent leakage of light emitted by the colorimeter.

The fruits ripened to optimum condition were subjected to sensory evaluation by a panel of 10 judges. The evaluation was carried out on a 9-point hedonic scale based on the principles of sensory evaluation (Amerine *et al*. 1965) for their colour, taste, flavour, texture and overall acceptability.

The experiment was laid out in completely randomized design having 14 mango genotypes with 25 replications. The data were analyzed using analysis of variance (ANOVA) as suggested by Gomez and Gomez (1984). Valid conclusions were drawn only on significant differences between treatment means at the $P \leq 0.05$ level of probability.

RESULTS AND DISCUSSION

Storage behaviour

Significant differences were observed in cumulative physiological loss in weight of different hybrids. On the day 2 of storage lowest cumulative physiological loss in weight was observed in 'H 3-2' (1.01%), followed by 'H 1-5' (2.86%). At the end of storage period, least cumulative physiological loss in weight was found in 'H 3-2' (10.65%) which had non-significant differences with cumulative physiological loss in weight observed in check mango hybrid 'Pusa Arunima' (10.88%). The highest cumulative physiological loss in weight was observed in hybrid 'H 2-14' (20.37%) on day 7 of storage. It was interesting to note that three mango hybrids, namely 'H 1-11', 'H 2-13' and 'H 13-7' showed more than 10% cumulative physiological loss in weight on day 6 of storage. However, In 'H 3-2' and check variety 'Pusa Arunima' even up to day 9 of storage the cumulative physiological loss in weight was less than 11%. Other hybrids like 'H 1-1', 'H 1-6', 'H 4-12', 'H 11-2', 'H 2-6', 'H 1-5' and the parental cultivar 'Amrapali' had more than 10% cumulative physiological loss in weight on day 7 of storage. The differential response of mango hybrids for cumulative physiological loss in weight might be attributed to their genotypic effect. Less cumulative physiological loss in weight observed in mango hybrid 'H 3-2' and check variety' Pusa Arunima' may be attributed to comparatively thicker peel of these hybrids. Our results suggest that newly developed mango hybrids may be stored at room temperature for 5 to 9 days without any appreciable loss in the fruit quality. Moreover, the storage life of 'H 3-2' on the basis of cumulative physiological loss in weight was found to be best among these hybrids.

The time taken for ripening of different hybrids varied significantly (LSD = 0.18, $P \leq 0.05$) (Table 1). Time required for ripening ranged from 3.8 days in 'H 4-12' to 6.4 days in 'H 3-2'. Hybrid 'H 3-2' took longer time (6.4 days) for ripening which had non-significant difference with 'Pusa Arunima' (6.2 days). The days required for ripening in rest of the hybrids and 'Amrapali' ranged between 4 and 5 days. The post ripening life of fruits of mango hybrids ranged from 2.1 days ('H 13-8', 'H 2-13' and 'H 1-11') to 3.5 days in 'H 3-2' which had significantly higher post ripening life than 'Pusa Arunima' (3.1 days) and 'Amrapali' (2.7 days). However more than three days post-ripening life was also observed in hybrids, namely 'H 1-1', 'H 1-6', 'H 2-14'and 'H 13-7'. Among 14 mango genotypes, the total shelf-life was found to be maximum for 'H 3-2' (9.8 days), followed by 'Pusa Arunima' (9.4 days), whereas minimum in 'H 2-13'

Table 1 Storage behaviour of different mango hybrids

Hybrid	Time for ripening (days)	Post-ripening life (days)	Total life (days)	Spoilage (%)	TSS of ripened fruit (°B)	Peel colour					
						Unripe			Ripe		
						L	a	b	L	a	b
Amrapali	4.1	2.7	6.8	14.3	22.1	43.28	–2.07	14.17	55.73	0.91	23.59
'Pusa Arunima'	6.2	3.1	9.4	3.2	19.6	27.22	2.72	12.35	30.59	8.18	11.22
'H 1-6'	4.2	3.1	7.2	8.5	21.3	26.99	2.89	2.58	33.69	16.69	20.61
'H 2-14'	4.0	3.2	7.3	14.4	19.4	45.13	1.13	17.07	48.21	6.32	28.03
'H 13-7'	4.3	3.4	7.6	11.1	19.1	40.54	3.03	11.72	46.01	13.44	34.68
'H 13-8'	4.8	2.1	6.8	10.1	18.6	40.13	–2.86	16.07	37.94	12.86	22.06
'H 4-12'	3.8	2.9	6.7	5.0	20.4	28.95	13.13	13.60	43.41	15.04	36.12
'H 1-1'	4.4	3.4	7.8	2.1	19.5	37.53	4.01	17.68	47.03	18.79	33.57
'H 11-2'	5.2	2.3	7.4	3.4	17.0	28.66	9.59	5.32	30.64	14.48	8.39
'H 2-13'	4.1	2.1	6.2	2.1	19.1	34.06	–4.35	14.22	36.89	–2.27	22.63
'H 1-11'	4.5	2.1	6.6	12.5	18.1	42.20	–1.42	20.03	38.94	–0.77	25.31
'H 2-6'	4.4	2.9	7.2	10.5	19.4	39.92	2.44	16.77	41.03	5.54	31.29
'H 1-5'	4.6	2.3	7.0	3.6	20.2	41.87	1.29	17.44	40.17	1.93	20.59
'H 3-2'	6.4	3.5	9.8	2.1	18.5	35.44	6.34	10.36	38.83	8.58	21.31
LSD ($P \leq 0.05$)	0.18	0.16	0.32	0.87	0.30	1.53	0.46	1.68	1.59	1.37	1.77

L, Lightness/darkness; a, greenness (–ve)/ redness (+ve); b, blueness (–ve) /yellowness (+ve)

(6.2 days). The spoilage was least (2.1%) in hybrids 'H 3-2', 'H 2-13' and 'H 1-1'), followed by 'Pusa Arunima' (3.2%) and 'H 11-2' (3.4%). Maximum spoilage percentage was observed in hybrid 'H 2-14' (14.4%) which had non-significant differences with 'Amrapali' (14.3%). It was also observed that fruits of hybrids 'Amrapali'×'Sensation' had comparatively better shelf-life than the hybrids developed by crossing 'Amrapali' with male donor parent 'Lal Sundari'. It might be attributed to the better shelf-life of 'Sensation' (an exotic coloured variety) which was used as male donor parent in development of coloured mango hybrids. Keeping in view the highly heterozygous nature of mango, the differential response in terms of shelf-life of hybrids was very obvious.

Peel colour

The loss of green colour was the most obvious change in mango, which was probably due to the physico-chemical changes by degradation of the chlorophyll and increase in the carotenoid and anthocyanin pigments during storage. The brightness index 'L' shows the intensity of fruit colour and low value of 'L' indicates a dark peel. In unripe fruits of mango hybrids, it ranged from 26.99 ('H 1-6') to 45.13('H 2-14'). However, in fully ripened fruits it ranged from 30.59 ('Pusa Arunima') to 55.73 ('Amrapali'). The data on lightness of fruits clearly suggest that in majority of hybrids fruits

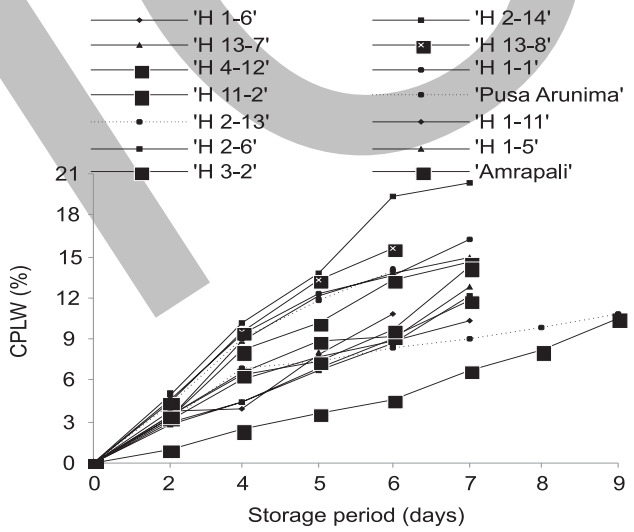

Fig 1 Cumulative physiological loss in weight (CPLW) of mango hybrids during ripening and storage

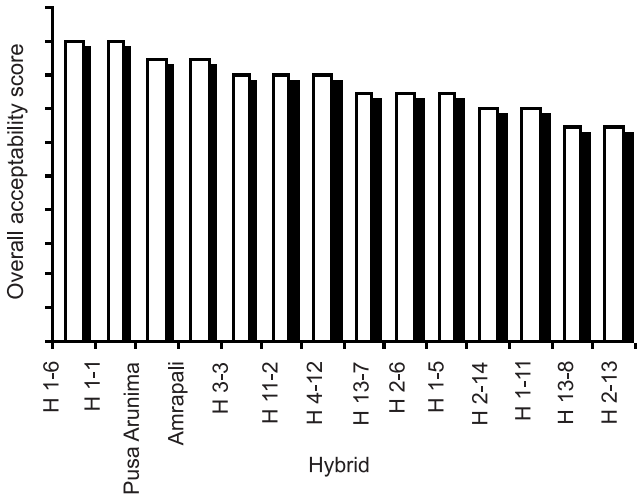

Fig 2 Overall acceptability scores of mango hybrids

became lighter in colour after ripening except in 'H 1-11' and 'H 13-8' where ripened fruits had slightly darker colour than unripe ones. However, in hybrid 'H 1-5' lightness of fruit was almost same in unripe and ripe conditions. The hybrids which do not follow this unique trend remained green even after ripening.

The value of chromaticity parameter 'a' indicates the high blush colour affecting the cosmetic appearance. Mango fruits having sufficient red blush on peel are preferred in the international trade. In the ripened stage, red colour development in peel was maximum in the hybrid 'H 1-1' (18.79) (Fig 1), followed by 'H 1-6' (16.69), 'H 4-12' (15.04) and 'H 11-2' (14.48) as indicated by high and positive 'a' values of ripe fruits (Table 1). By comparing the 'a' value of unripe but mature fruits of 'H 1-6' (2.89) and 'H 1-1' (4.01) with 'a' value of ripened fruits of these hybrids, it is clearly evident that during ripening of 'H 1-6' and 'H 1-1', redness of fruit increased 5.78 and 4.68 folds, respectively. However in unripe but mature condition the redness of fruit was maximum in 'H 4-12' (13.13), followed by 'H 11-2' (9.59). This clearly suggests that fruits of 'H 4-12' and 'H 11-2' had redness in unripe conditions which further increased during ripening. By comparing newly developed mango hybrids with coloured variety 'Pusa Arunima', hybrids 'H 1-1', 'H 1-6', 'H 4-12' and 'H 11-2' excelled over 'Pusa Arunima' in terms of redness of peel of ripe fruits, whereas, 'H 3-2' (8.58) had non-significant difference for 'a' value as compared to 'Pusa Arunima' (8.18). Hybrids 'H 2-13'and 'H 1-11' had least 'a' value for peel after ripening as indicated by negative values of 'a' suggesting partly the green colour of the peel.

The values of 'b' which indicates yellowness of fruit, ranged from 8.39 ('H 11-2') to 36.12 ('H 4-12') in the ripened fruits. From consumer's point of view, mango fruits having red blush on yellow peel is most preferred than red blush on green peel. It was interesting to note that hybrids, viz 'H 1-1', 'H 1-6' and 'H 4-12', had higher values of 'a' and 'b' than 'Pusa Arunima' (check). However, in 'H 11-2' the 'b' value was comparatively lower than 'Pusa Arunima'. All these hybrids showed better peel colour than 'Pusa Arunima'.

Sensory analysis

Quality is the ultimate criterion of the desirability of any product. A detailed assessment of the organoleptic qualities in terms of colour/appearance, taste, aroma, flavour revealed significant variation amongst the different mango hybrids studied. Hybrids 'H 1-6' (9.0) and 'H 1-1' (9.0) scored better than 'Pusa Arunima' (8.5) and 'Amrapali' (8.5) for overall acceptability (Fig 2). However, overall acceptability of 'H 3-2', 'H 4-12' and 'H 11-2' hybrids were at par with 'Pusa Arunima' and ' Amrapali'. Least scores (6.5) were obtained for hybrids 'H 2-13' and 'H 13-8'. In the various quality attribute tests, the first evaluation goes to colour, followed by taste, flavour and texture. Higher score noted for 'H 1-6' and 'H 1-1' may be attributed to their better appearance due to red blush on the peel. Ripened fruits of theses hybrids were also liked more by the panelists.

From these studies, it may be concluded that in terms of storage 'H 3-2' was better than 'Pusa Arunima' and 'Amrapali'. However, overall acceptability was higher for 'H 1-1' and 'H 1-6' compared to other hybrids, 'Pusa Arunima' and 'Amrapali'. Moreover estimation of fruit quality based on 'L', 'a' and 'b' system describing co-ordinates of colour is useful in marketing and monitoring consumer preferences and may be used as a non- destructive technique for estimation of fruit quality.

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