

## Short communication

# Influence of harvesting maturity and low temperature storage on shelf-life and physico-chemical quality of banana cv. Grand Naine

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### ABSTRACT

A study was undertaken to assess the effect of maturity and storage temperature on shelf-life and quality of banana cv. Grand Naine. Treatments comprised of three different maturity stages, viz., 75, 90, 100% and four storage temperatures, viz., 12, 14, 16°C and ambient temperature. Results revealed that fruits harvested at 75% maturity and stored at 12°C had a shelf-life of 45 days. Whereas, 100% mature fruits kept at ambient temperature could be retained for only 10 days. Banana fruits harvested at 75% maturity and stored at 12°C showed more firmness and minimum physiological loss in weight and titrable acidity compared to other treatments during the storage. However, fruits harvested at 100% maturity and kept at ambient temperature recorded the highest values for total soluble solids (22.30°Brix) and total sugars (22.05%) on 13<sup>th</sup> day of storage.

**Key words:** Banana, maturity, storage temperature, shelf-life, quality.

India is the largest consumer and producer of banana contributing about 25 per cent to the global production. In India, banana covered about 830 thousand hectares in the year 2010-11 with a production of 29,780 thousands MT and a productivity of 35.9 MT/ha (Anon, 1). Gujarat is the third largest producer of banana in the country, next to Tamil Nadu and Maharashtra. A study by ASSOCHAM in 2013, revealed that India incurred post harvest losses worth Rs. 2 lakh crores owing to the absence of modern cold storage facilities, absence of food processing units and a callous attitude towards post harvest losses (Anon, 2). Post harvest losses vary among commodities, production areas and seasons. As per a survey conducted by Davara and Patel (3) the total post-harvest losses in banana at different levels in Gujarat were 15.43%.

This investigation was carried out at the Regional Horticultural Research Station and Post Harvest Technology Centre of ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari. Thirty-six healthy inflorescences were selected randomly just after emergence. Stage of harvesting was determined on the basis of number of days taken to maturity after inflorescence emergence. Based on the above criteria in cv. Grand Naine 100 days from shooting (flowering) to harvest was determined as the time required for full maturity and it was fixed as 100% maturity. Accordingly, 90 and 75 days after shooting were considered as the duration required attain 90 and 75% maturity stage. The hands were separated from bunches and kept in cold storage at 12, 14 and 16°C

and under ambient conditions (34°C temperature and 70% RH). The shelf-life was calculated by counting the number of days taken from harvesting to attain optimum marketing quality. Physiological loss in weight (PLW), firmness, total soluble solids, titrable acidity and total sugars were recorded every third day. Fruit firmness was tested by a pocket penetrometer (Fruit Tester FT 327). Total soluble solids were measured using a hand refractometer. Titrable acidity and total sugars were estimated as per the methods suggested by Ranganna (9). The experiment was laid out in CRD with factorial concept up to the 19<sup>th</sup> day of storage. Subsequently, CRD was employed till the 34<sup>th</sup> day of experimentation. On the 37<sup>th</sup>, 40<sup>th</sup> and 43<sup>rd</sup> day of the investigation, only average means were considered for interpretation.

Results indicated a significant effect of maturity levels and storage temperatures on all parameters studied. Fruits harvested at 75% maturity and held at 12°C could be stored for 45 days (Table 1). Whereas, 100% mature fruits kept at ambient temperature could be retained for only 10 days. Fruits harvested at different maturity levels when stored at ambient temperature had more or less the same shelf-life. At ambient temperature, the respiration rate was higher which hastened ripening as compared to low temperature storage. This is in agreement with the findings of Hossain *et al.* (5) who reported 30 days of shelf-life for bananas stored at 14°C.

As ripening progressed, the physiological loss in weight increased (Table 2). The maximum PLW was observed in 100% mature fruits stored at ambient temperature (on 13<sup>th</sup> day). This might be due to rapid

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**Table 1.** Interaction effect of maturity and storage temperature on the shelf-life of banana cv. Grand Naine.

Treatment	Shelf-life (days)
75% maturity + 12°C	45.0
75% maturity + 14°C	40.0
75% maturity + 16°C	28.0
75% maturity + ambient temp.	13.0
90% maturity + 12°C	37.0
90% maturity + 14°C	35.0
90% maturity + 16°C	22.0
90% maturity + ambient temp.	12.0
100% maturity + 12°C	34.0
100% maturity + 14°C	28.0
100% maturity + 16°C	19.0
100% maturity + ambient temp.	10.0
CD <sub>0.05</sub>	
Interaction (Maturity × temp.)	0.74

ripening in late harvested fruits as compared to early harvested fruits. This can also be attributed to greater evapo-transpiration and respiration rates at higher temperatures as previously reported by Lebibet *et al.* (6). Fruits harvested at 75% maturity and stored at 12°C recorded the lowest PLW up to the 43<sup>rd</sup> day of storage. The physiological metabolism in fruits of different maturity levels slowed down when held at low temperature, which resulted in lower PLW as compared to those kept at ambient temperature. These results are in line with those of Narayana and Mustafa (8) in banana cv. Karpuravalli.

Results also revealed a steady reduction in firmness during the course of the investigation regardless of maturity levels and storage temperatures (Table 3). The maximum firmness was observed in fruits harvested at 75% maturity and stored at 12°C throughout the storage period. Whereas, the minimum fruit firmness was recorded in fruits harvested at 100% maturity and kept at ambient temperature. Fruits of 75% maturity were harvested 25 days earlier than fruits of 100% maturity and therefore had better firmness. Thompson (13) stated that softening of banana fruits during ripening is associated with the conversion of starch to sugars, breakdown of pectin substances and movement of water from the peel of the banana to its pulp during ripening. Higher weight loss and greater TSS in fruits harvested at 100% maturity and kept at ambient temperature support the above possibilities. Similar observations were also reported by Nagaraju and Reddy (7).

**Table 2.** Interaction effect of maturity and storage temperature on PLW (%) of banana cv. Grand Naine.

Treatment	Storage period (No. of days)													
	4 <sup>th</sup>	7 <sup>th</sup>	10 <sup>th</sup>	13 <sup>th</sup>	16 <sup>th</sup>	19 <sup>th</sup>	22 <sup>nd</sup> *	25 <sup>th</sup> *	28 <sup>th</sup> *	31 <sup>st</sup> *	34 <sup>th</sup> *	37 <sup>th</sup>	40 <sup>th</sup>	43 <sup>rd</sup>
75% maturity + 12°C	1.41	2.41	3.72	4.92	6.33	7.69	8.37	9.12	10.05	11.41	12.67	13.91	15.06	17.32
75% maturity + 14°C	1.52	2.75	4.26	5.46	6.61	7.83	8.95	10.05	11.21	12.37	13.52	15.81	17.3	**
75% maturity + 16°C	1.66	2.88	4.76	5.66	6.72	8.01	9.41	10.25	11.5	**	**	**	**	**
75% maturity + ambient temp.	3.28	7.06	11.94	15.67	**	**	**	**	**	**	**	**	**	**
90% maturity + 12°C	1.45	2.54	4.20	5.35	6.58	7.73	8.89	10.07	11.41	12.62	13.76	16.43	**	**
90% maturity + 14°C	1.65	2.79	4.58	5.75	6.82	7.93	8.98	10.71	11.74	12.88	14.59	**	**	**
90% maturity + 16°C	1.75	3.63	4.95	6.12	7.07	8.44	9.67	**	**	**	**	**	**	**
90% maturity + ambient temp.	3.53	7.74	11.84	17.41	**	**	**	**	**	**	**	**	**	**
100% maturity + 12°C	1.47	2.74	5.20	5.87	7.25	8.37	9.93	11.37	13.32	14.14	16.42	**	**	**
100% maturity + 14°C	1.82	2.92	5.19	6.57	8.00	8.84	10.36	11.41	13.63	**	**	**	**	**
100% maturity + 16°C	1.99	3.92	5.45	7.11	9.02	11.30	**	**	**	**	**	**	**	**
100% maturity + ambient temp.	3.81	8.05	11.91	18.23	**	**	**	**	**	**	**	**	**	**
CD <sub>0.05</sub>	0.16	0.34	0.55	0.56	0.49	0.59	0.63	0.72	0.65	0.81	0.82	--	--	--

\*\*Fruits were not available for analysis because of over ripening

**Table 3.** Interaction effect of maturity and storage temperature on fruit firmness (kg/cm<sup>2</sup>) of banana cv. Grand Naine.

Treatment	Storage period (No. of days)													
	4 <sup>th</sup>	7 <sup>th</sup>	10 <sup>th</sup>	13 <sup>th</sup>	16 <sup>th</sup>	19 <sup>th</sup>	22 <sup>nd*</sup>	25 <sup>th*</sup>	28 <sup>th*</sup>	31 <sup>st*</sup>	34 <sup>th*</sup>	37 <sup>th</sup>	40 <sup>th</sup>	43 <sup>rd</sup>
75% maturity + 12°C	17.20	16.17	15.57	14.50	13.40	17.20	12.50	11.40	10.33	8.80	6.67	5.17	4.43	3.27
75% maturity + 14°C	17.10	16.10	15.17	13.90	12.80	17.10	11.67	10.20	9.70	7.53	5.57	4	3	**
75% maturity + 16°C	17.10	15.73	13.87	11.50	9.73	17.10	8.20	6.53	4.90	**	**	**	**	**
75% maturity + ambient temp.	10.90	6.30	3.77	**	**	**	**	**	**	**	**	**	**	**
90% maturity + 12°C	16.77	15.70	14.70	13.47	12.67	16.77	11.37	10.37	7.93	6.33	4.47	3.10	**	**
90% maturity + 14°C	16.80	15.63	14.47	13.23	12.60	16.80	9.77	7.90	5.60	4.57	3.43	**	**	**
90% maturity + 16°C	16.60	15.37	14.03	10.93	6.80	16.60	4.63	**	**	**	**	**	**	**
90% maturity + ambient temp.	10.60	6.00	3.23	**	**	**	**	**	**	**	**	**	**	**
100% maturity + 12°C	15.50	14.73	13.53	11.83	10.13	15.50	8.37	5.67	4.73	3.57	2.47	**	**	**
100% maturity + 14°C	15.27	14.50	12.53	10.6	8.67	15.27	6.60	5.17	3.47	**	**	**	**	**
100% maturity + 16°C	14.57	10.50	6.73	5.3	4.00	14.57	**	**	**	**	**	**	**	**
100% maturity + ambient temp.	9.57	4.33	2.57	**	**	**	**	**	**	**	**	**	**	**
CD <sub>0.05</sub>	NS	0.33	0.43	0.33	0.39	0.41	0.39	0.42	0.28	0.43	0.27	--	--	--

\*\*Fruits were not available for analysis because of over ripening

A progressive increase in TSS across all treatments was observed during ripening (Table 4). The maximum TSS was observed in 100% mature fruits held at ambient temperature up to 13<sup>th</sup> day of storage. This can be attributed to higher respiration rates at ambient temperature and subsequent conversion of starch into simple sugars during ripening. Similar findings were observed by Deca and Harmine (4). The minimum TSS was noticed in fruits harvested at 75% maturity and stored at 12°C. These results corroborated the findings of Salvador *et al.* (10). An increase in the level of TSS proportionate to the maturity level was earlier reported by Narayana and Mustaffa (8).

In all treatments, the amount of titrable acidity increased as ripening progressed (Table 5). The minimum titrable acidity was recorded in fruits harvested at 75% maturity and stored at 12°C. Fruits harvested at 100% maturity and kept at ambient temperature showed the maximum titrable acidity. Titrable acidity increased gradually until the fruits reached full ripe stage. Tapre and Jain (11) also reported an increase in titrable acidity during the course of banana ripening. The maximum total sugars were observed in the fruits of 100% maturity kept at ambient temperature on 13<sup>th</sup> day (Table 6). The minimum total sugars were observed in 75% mature fruits stored at 12°C. Trakulnaleumsai *et al.* (14) also noted an increase in total sugars when banana was stored at ambient temperature as compared to 12°C. The observed increment in total sugars could be due to the hydrolysis of starch into sugar as ripening progressed (Terra *et al.*, 12). In bananas, starch hydrolysis and sugar synthesis are normally complete on reaching full ripeness (Salavador *et al.*, 10). Fruits stored at low temperature (16, 14 and 12°C) did not exhibit any symptom of chilling injury.

Thus, for local markets, fruits of banana cv. Grand Naine should be harvested at 100% maturity and kept at ambient temperature. However, for distant markets banana should be harvested between 75-90% maturity and stored at 12-14°C.

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**Table 4.** Interaction effect of maturity and storage temperature on total soluble solids (°Brix) of banana cv. Grand Naine.

Treatment	Storage period (No. of days)													
	4 <sup>th</sup>	7 <sup>th</sup>	10 <sup>th</sup>	13 <sup>th</sup>	16 <sup>th</sup>	19 <sup>th</sup>	22 <sup>nd</sup>	25 <sup>th</sup>	28 <sup>th</sup>	31 <sup>st</sup>	34 <sup>th</sup>	37 <sup>th</sup>	40 <sup>th</sup>	43 <sup>rd</sup>
75% maturity + 12°C	3.43	3.77	4.50	5.40	6.10	6.53	7.07	7.57	7.9	9.73	11.47	14.50	18.73	22.4
75% maturity + 14°C	3.57	4.13	5.17	5.77	6.23	7.23	8.30	9.50	14.7	17.07	20.53	21.53	22.60	**
75% maturity + 16°C	4.07	4.70	5.87	6.60	7.67	11.60	18.80	21.37	22.23	**	**	**	**	**
75% maturity + ambient temp.	4.87	5.33	10.07	21.63	**	**	**	**	**	**	**	**	**	**
90% maturity + 12°C	3.67	4.27	4.80	5.57	6.50	6.90	8.37	8.70	13.73	15.37	19.87	22.27	**	**
90% maturity + 14°C	3.97	4.43	5.30	5.83	6.73	7.43	12.07	15.33	20.03	21.10	22.70	**	**	**
90% maturity + 16°C	4.20	4.87	6.20	10.00	17.47	20.50	22.20	**	**	**	**	**	**	**
90% maturity + ambient temp.	5.33	8.77	14.23	22.20	**	**	**	**	**	**	**	**	**	**
100% maturity + 12°C	3.93	4.40	5.27	5.83	6.50	7.23	9.17	10.50	14.6	18.83	22.23	**	**	**
100% maturity + 14°C	4.17	4.63	5.73	6.33	8.30	12.00	19.10	19.83	21.77	**	**	**	**	**
100% maturity + 16°C	4.50	5.23	6.87	12.57	19.20	21.67	**	**	**	**	**	**	**	**
100% maturity + ambient temp.	6.50	9.63	19.63	22.30	**	**	**	**	**	**	**	**	**	**
CD <sub>0.05</sub>	0.40	0.50	0.57	0.57	0.54	0.58	0.52	0.75	0.46	0.75	0.37	--	--	--

\*Data was analyzed using Complete Randomized Design (CRD); \*\*Fruits were not available for analysis because of over ripening

**Table 5.** Interaction effect of maturity and storage temperature on titratable acidity (%) of banana cv. Grand Naine.

Treatment	Storage period (No. of days)													
	4 <sup>th</sup>	7 <sup>th</sup>	10 <sup>th</sup>	13 <sup>th</sup>	16 <sup>th</sup>	19 <sup>th</sup>	22 <sup>nd</sup>	25 <sup>th</sup>	28 <sup>th</sup>	31 <sup>st</sup>	34 <sup>th</sup>	37 <sup>th</sup>	40 <sup>th</sup>	43 <sup>rd</sup>
75% maturity + 12°C	0.088	0.096	0.144	0.152	0.192	0.240	0.272	0.304	0.320	0.368	0.416	0.46	0.51	0.54
75% maturity + 14°C	0.096	0.136	0.168	0.176	0.240	0.272	0.320	0.352	0.384	0.408	0.432	0.50	0.54	**
75% maturity + 16°C	0.096	0.152	0.216	0.232	0.256	0.336	0.408	0.464	0.512	**	**	**	**	**
75% maturity + ambient temp.	0.104	0.168	0.280	0.416	**	**	**	**	**	**	**	**	**	**
90% maturity + 12°C	0.096	0.144	0.152	0.192	0.224	0.256	0.312	0.392	0.416	0.456	0.488	0.54	**	**
90% maturity + 14°C	0.120	0.160	0.192	0.224	0.264	0.296	0.344	0.424	0.464	0.488	0.544	**	**	**
90% maturity + 16°C	0.136	0.168	0.224	0.241	0.320	0.344	0.440	**	**	**	**	**	**	**
90% maturity + ambient temp.	0.160	0.192	0.296	0.440	**	**	**	**	**	**	**	**	**	**
100% maturity + 12°C	0.120	0.160	0.192	0.208	0.272	0.296	0.352	0.424	0.440	0.464	0.533	**	**	**
100% maturity + 14°C	0.144	0.168	0.216	0.240	0.288	0.360	0.416	0.440	0.520	**	**	**	**	**
100% maturity + 16°C	0.152	0.200	0.240	0.264	0.360	0.472	**	**	**	**	**	**	**	**
100% maturity + ambient temp.	0.168	0.232	0.304	0.504	**	**	**	**	**	**	**	**	**	**
CD <sub>0.05</sub>	0.015	0.017	0.015	0.027	0.025	0.036	0.029	0.037	0.028	0.028	0.045	--	--	--

\*Data was analyzed using Complete Randomized Design (CRD); \*\*Fruits were not available for analysis because of over ripening

**Table 6.** Interaction effect of maturity and storage temperature on total sugars (%) of banana cv. Grand Naine.

Treatment	Storage period (No. of days)													
	4 <sup>th</sup>	7 <sup>th</sup>	10 <sup>th</sup>	13 <sup>th</sup>	16 <sup>th</sup>	19 <sup>th</sup>	22 <sup>nd</sup>	25 <sup>th</sup>	28 <sup>th</sup>	31 <sup>st</sup>	34 <sup>th</sup>	37 <sup>th</sup>	40 <sup>th</sup>	43 <sup>rd</sup>
75% maturity + 12°C	3.11	3.63	3.98	4.22	4.38	4.88	5.34	5.92	7.21	7.71	8.35	11.82	17.58	23.38
75% maturity + 14°C	3.65	3.82	4.12	4.44	4.70	5.28	5.96	9.72	12.46	15.69	21.56	25.28	25.45	**
75% maturity + 16°C	3.72	4.10	4.25	4.59	5.05	10.33	16.78	19.81	23.54	**	**	**	**	**
75% maturity + ambient temp.	4.07	4.31	9.78	20.51	**	**	**	**	**	**	**	**	**	**
90% maturity + 12°C	3.58	3.74	4.11	4.42	5.49	6.04	8.34	9.15	11.29	12.32	18.10	22.22	**	**
90% maturity + 14°C	3.74	3.93	4.40	4.60	5.77	6.29	9.35	15.89	18.16	23.09	25.77	**	**	**
90% maturity + 16°C	3.78	4.26	4.61	7.81	15.70	16.45	23.19	**	**	**	**	**	**	**
90% maturity + ambient temp.	4.40	4.86	10.71	21.08	**	**	**	**	**	**	**	**	**	**
100% maturity + 12°C	3.61	3.87	4.55	5.12	7.69	7.71	9.21	12.61	16.4	19.17	23.00	**	**	**
100% maturity + 14°C	3.93	4.14	4.88	4.87	8.33	11.43	21.09	23.07	25.42	**	**	**	**	**
100% maturity + 16°C	4.23	4.69	5.43	14.06	16.23	23.04	**	**	**	**	**	**	**	**
100% maturity + ambient temp.	5.03	5.52	16.07	22.35	**	**	**	**	**	**	**	**	**	**
CD at 5%	0.25	0.20	0.51	0.61	0.46	0.57	0.84	0.59	0.88	1.20	1.58	--	--	--

\*\*Fruits were not available for analysis because of over ripening

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