Bulletin of Environment, Pharmacology and Life Sciences
Bull. Env. Pharmacol. Life Sci., Vol 7 [SPL 1] 2018 : 119-124

Online ISSN 2277-1808
Journal's URL:http://www.bepls.com
CODEN: BEPLAD
Global Impact Factor 0.876
Universal Impact Factor 0.9804
NAAS Rating 4.95

ORIGINAL ARTICLE **OPEN ACCESS**

Effect Of Different Post-Harvest Packaging Treatments On Shelf-Life Of Banana Var. Grand Naine

M.R.Bhanusree[1], S.K.Ghosh[2],K. Ravi Kumar[2], C.P. Suresh[4], and S. Chakravarty[3*]
[1]Regional Research Sub Station (Old Alluvial Zone), Mathurapur, Malda, West Bengal- 732203, [2]Uttar Banga Krishi Viswavidyalaya, Pundibari, Coochbehar, [3]Dept. of Forestry, Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, [4]North Eastern Hill University, Tura, Meghalaya-794 001, India
E-mail: ravikuna2050@gmail.com; c_drsumit@yahoo.com*

ABSTRACT
An experiment was carried out at Postharvest laboratory of Uttar Banga Krishi Viswavidyalaya, Pundibari, West Bengal. Fruits treated with $KMnO_4$ + wax coating kept in unperforated polythene cover under ambient conditions was recorded highest green-life (17.31 days), yellow-life (7.62 days) and shelf-life (24.93 days) when compared to control. The chlorophyll content was also highest in the same treatment on 3rd day (3.86 mg/100g) degraded upto 1.48 mg/100g on 18th day whereas in control it was recorded 3.12 mg/100g on 3rd day and degraded to 1.15 mg/100g on 9th day only. Similarly, the ripening percentage, fruit retention & PLW were also best in case of fruits treated with $KMnO_4$ + wax coating kept in unperforated polythene cover (T_3) when compared to control.
***Key words**: Physical Parameters, Banana and Post-harvest treatments*

Received 22.05.2018 Revised 29.06.2018 Accepted 03.07.2018

INTRODUCTION

Consumers use visual quality to purchase freshly produce fruits usually that is blemish-free (Shanmugasundaran and Manavalan, 2002). Indian fruit processing industry is able to utilize less than 2 % of the produce annually and about 30-40 % of fruits and vegetables are lost due to improper post-harvest handling (estimated to ₹ 40,000 crores/year) (Uma, 2008). Post-harvest losses in banana are due to improper handling, transport, storage and marketing as they are constantly subjected to spoilage caused by bruising, senescence and microbial decay while they remain in market channels. Fruit green life is a major post-harvest attribute on which conservation of commodity chain depends and thus it is highly desirable to delay or postpone the ripening and senescence until they are to be consumed (Ramana *et al*., 1989). Banana green life thus must be optimized for terai region to fit the transport and market requirement.

Banana is a climacteric and ethylene dependent fruit for ripening. It is highly perishable with post-harvest losses of 30-40 % warranting storage between harvesting and consumption (Salunkhe and Desai, 1984). Use of film packaging, packing in polyethylene bags or newspaper, $KMnO_4$ and wax emulsion coating of fruits can delay on set of ripening thereby extending its storage life (Philippe *et al.,* 2010). In this connection, the suitability and application of different types of pre-and post-harvest approaches for Grand Naine was tested to ensure achieving its complete post-harvest quality and reduce losses hand in hand.

MATERIALS AND METHODS

This experiment was conducted in the laboratory of the Department of Pomology and Post-harvest Technology of Uttar Banga Krishi Viswavidyalaya, Pundibari, West Bengal during 2013-14. The treatments (14) are Un-perforated & perforated polyethylene bag and news paper wrapping in combination with $KMnO_4$& Wax coating along with control (No packing) replicated thrice in Completely Randomized Block Design (CRD).

Mature banana bunches of uniform size, shape and colour was carefully harvested and carried to the laboratory to avoid any abrasions or mechanical injury to fruit during harvest from plant crop. Hands

were washed in normal water to remove latex, latex stains, soil particles and floral remnants. After washing, hands were dipped in 1000 ppm carbendazim (50 % w p) for 10 minutes to control post-harvest fruit rot (Datar and Ghule, 1988). After washing the hands were dried under shade for three hours until no water particles were visible on fruit surface. The individual hands were then packed and kept at room temperature for their quality assessment at an interval of every three days. Wax coating used was 5 % while 5 g $KMnO_4$ was impregnated in blotting paper and placed in plastic trays. Total number of Fruits per treatment is 90. The significance of results of the data was subjected to analysis of variance given by Gomez and Gomez (1984) employing the Indostat (Version-7.1) software package.

RESULTS AND DISCUSSION

The effect of post-harvest packaging treatments on green, yellow and shelf life of banana var. Grand Naine is given in table 1.Green, yellow and shelf life improved significantly with the packaging treatments (11.87-17.31, 6.01-7.62 and 18.06-24.93 days over the no packaging control (8.01&8.10, 4.21). Only three packaging treatments had an average shelf life of 24 days, two treatments had 21 days, seven treatments had 18 days and fruits under control had an average shelf life of only 12 days. Green, yellow and shelf life was longest when the fruits were dipped in $KMnO_4$; wax coated and then packaged in un-perforated polyethylene bags i.e. shelf life doubled as compared to the unpackaged/untreated control and its difference was significant with all other packaging treatments. The other packaging treatments which also doubled the shelf life as compared to control was $KMnO_4$+ wax coating + perforated polyethylene bag packaging (24.78 days) and $KMnO_4$ + un-perforated polyethylene bags packaging (24.42 days).

Packaging the fruits with either perforated or un-perforated newspaper with or without combination of $KMnO_4$ and wax coating extended the shelf life up to about six days only (18.06-18.95 days) as compared to unpackaged/untreated control. The delay in shelf life with newspaper wrapping stored under open air could be due to retarded respiration as a result of modified atmosphere (O_2 depletion and CO_2 accumulation) by the packaging materials (Zewter *et al*., 2012). This was further improved by the polyethylene packaging indicating development of improved atmosphere modification resulting in extended shelf life of the fruits (Zewter *et al*., 2012).Polyethylene packaging without perforations and perforated polyethylene packaging with or without $KMnO_4$ extended the shelf life up to 8-9 days (20.27-21.75 days as compared to control. Wax act as a physical barrier on banana skin which might reduced water loss from banana by transpiration and other means extending its shelf life (Macwan *et al*., 2014). Thus, in terai region of West Bengal banana fruits var. Grand Naine fruits can be stored up to 24-25 days by creating modified atmospheric condition using polyethylene bags but before packaging fruits must be dipped in potassium permanganate and wax coated.Preventing build-up of ethylene around produce is among the methods in use to delay ripening of bananas (Zewter *et al*., 2012). This is achieved through the use of agents that absorb ethylene such as potassium permanganate (Shaun and Ferris, 1997).

The fruits coated with wax and wrapped in all treatment combination of newspaper initially on start of storage on day 3rd of storage had maximum content of chlorophyll in the range of 3.07-3.54 that reduced to 1.30-2.13 per 100g on 12th day i.e. six days before ripening. Similarly packaging with un-perforated polyethylene bagging and perforated polyethylene bagging with or without potassium permanganate had maximum chlorophyll content of 3.25-3.56 which decreased to 1.33-1.47 per 100 g six days before ripening i.e. on 15th day of storage. Similarly the packaging treatments of perforated polyethylene bagging with $KmnO_4$ and un-perforated polyethylene bagging either with $KmnO_4$ or $KmnO_4$ + wax coating turned the fruits completely yellow or ripened on 24thday of storage was estimated with maximum chlorophyll content of 3.75-3.86 that reduced to 1.24-1.26 per 100 g six days before ripening. This means that these treatments had extended the green life of the stored fruits significantly over other packaging treatments as is evidenced from green life of the fruits presented in table 1 thereby also extending the shelf life significantly. This was due to modified atmospheric conditions created by these packaging treatments with reduced O_2 and increased CO_2 concentration inside the storage environment reducing respiration and ethylene production (Seymour*et al*., 1987).

The quantum of ripening of fruits kept under observation progressed during the storage period was significantly influenced by different packaging treatments in comparison with no packaging control is presented in (table 1). It was observed that fruits under control initiated and completed ripening earlier than the packaged fruits. These fruits started ripening on 6th day with 30.8 % and completed ripening on 12th day of storage with cent per cent ripened fruits. On 9th day of storage all the packaging treatments initiated ripening with ripened fruits in the range of 6.7-30.0 % except polyethylene bagging with or with perforations in combination with $KmnO_4$ and wax coating which is significantly lower than the ripened fruits of the control treatment (69.6 %). On 12th day ripening initiated with the packaging treatments that did not ripened on 9th day with 13.7 & 15.2 % ripened fruits which was significantly lower than other packaging treatment that initiated ripening on 9th day of storage (28.9-64.9 %).

Table 1: Effect of post-harvest packaging treatments on green, yellow & shelf life (days), chlorophyll content (mg/100g) and ripening (%) of banana fruit var. Grand Naine.

Treatment	Green life	Yellow life	Shelf life	Chlorophyll content (mg/100g)						Ripening (%)						
				Day 3	Day 6	Day 9	Day 12	Day 15	Day 18	Day 6	Day 9	Day 12	Day 15	Day 18	Day 21	Day 24
UPB	14.39	6.82	21.21	3.56	3.44	2.86	2.31	1.34	*	0.0	11.8 (20.0)	30.2 (33.3)	51.7 (46.0)	93.2 (74.9)	100.0 (90.0)	*
UPB+K	16.96	7.46	24.42	3.75	3.63	3.12	2.50	1.77	1.26	0.0	6.7 (15.0)	30.3 (33.4)	38.7 (38.4)	54.4 (47.5)	90.3 (72.8)	100.0
UPB+K +WC	17.31	7.62	24.93	3.86	3.75	3.36	2.65	2.13	1.48	0.0	0.0	13.7 (21.7)	21.8 (27.8)	48.6 (44.2)	89.8 (71.3)	100.0
PPB	13.41	6.86	20.27	3.25	3.24	2.63	2.33	1.33		0.0	12.8 (20.9)	35.9 (36.8)	56.9 (48.9)	95.4 (77.6)	100.0 (90.0)	*
PPB+K	14.82	6.93	21.75	3.42	3.38	2.83	2.39	1.47		0.0	7.9 (16.3)	28.9 (32.5)	50.8 (45.5)	96.6 (79.4)	100.0 (90.0)	*
PPB+K +WC	17.26	7.53	24.78	3.79	3.55	3.10	2.61	2.00	1.24	0.0	0.0	15.2 (22.9)	30.8 (33.7)	52.1 (46.2)	88.1 (70.2)	100.0
NU	11.87	6.25	18.13	3.21	2.67	2.38	1.30	*	*	0.0	30.0 (33.2)	61.5 (51.6)	89.6 (71.2)	100.0 (90.0)	*	*
NU+K	11.94	6.50	18.44	3.25	2.85	2.56	2.07	*	*	0.0	23.4 (28.9)	58.2 (49.7)	85.5 (67.6)	100.0 (90.0)	*	*
NU+K+ WC	12.23	6.72	18.95	3.54	3.25	2.67	2.13	*	*	0.0	16.9 (24.2)	51.7 (45.9)	81.8 (64.7)	100.0 (90.0)	*	*
NP	11.92	6.15	18.07	3.07	2.53	2.22	1.24	*	*	0.0	26.8 (31.1)	64.9 (53.7)	98.5 (82.9)	100.0 (90.0)	*	*
NP+K	12.10	6.33	18.43	3.17	2.64	2.34	1.51	*	*	0.0	23.3 (28.9)	62.5 (52.2)	95.6 (77.9)	100.0 (90.0)	*	*
NP+K+ WC	12.27	6.63	18.90	3.32	3.05	2.57	2.06	*	*	0.0	18.2 (25.2)	54.9 (47.8)	89.9 (71.5)	100.0 (90.0)	*	*
WC	12.05	6.01	18.06	3.36	3.04	2.53	1.71	*	*	0.0	30.0 (25.2)	54.9 (47.8)	99.2 (84.9)	100.0 (90.0)	*	*
Control	8.01	4.21	12.22	3.12	2.33	1.15	*	*	*	30.8 (26.2)[1]	69.6 (56.5)	100.0 (90.0)	*	*	*	*
CD P=0.05	**0.42**	**0.12**	**0.39**	**0.07**	**0.04**	**0.06**	**0.08**	**0.08**	**0.08**	**-**	**1.80**	**0.89**	**0.80**	**0.18**	**4.41**	**-**
CV	**1.9**	**1.1**	**3.5**	**1.2**	**0.8**	**4.2**	**2.4**	**2.8**	**3.0**	**-**	**4.5**	**1.1**	**1.0**	**0.2**	**4.8**	**-**
S.Em ±	**0.14**	**0.04**	**0.13**	**0.02**	**0.02**	**0.02**	**0.03**	**0.03**	**0.02**	**-**	**0.62**	**0.31**	**0.4**	**0.1**	**2.12**	**-**

UPB – un-perforated polyethylene bag; PPB- perforated polyethylene bag; NU- newspaper un-perforated; NU- newspaper perforated; K- $KMnO_4$; WC- wax coating

On 15th day of storage, wax coated and all treatment combination of newspaper had 81.8-99.2 % in and 86.6-99.9 % fruits had ripened which was significantly higher than that recorded with all the treatment combinations of polyethylene bags (21.8-56.9 %). On 18th day of storage wax coated fruits and fruits wrapped with all treatment combination of newspaper had cent per cent ripened fruits whereas ripened fruits in all the treatment combinations of polyethylene bagging were in the range of 48.6-96.6 %. On day 21st of storage all the fruits packed in un-perforated polyethylene bags and perforated polyethylene bags with or without $KmnO_4$ ripened while 88.1-90.3 % fruits ripened which got completely ripened on 24th day of storage. The ripening observations clearly indicate that polyethylene bagging irrespective of perforations or not had significantly slower ripening process than the wax coatings or newspaper wrappings with or without perforations throughout the storage process because of effective modified atmosphere created by the former inside the storage medium. Modified or controlled atmospheric (MA/CA) condition techniques that affects banana physiology is used to delay and manage ripening include temperature control and relative humidity management, modified atmosphere storage, ethylene removal or inhibition of ethylene action through chemical means (Parsons *et al*., 1964; Shashirekha *et al*., 2007)

The packaging treatments which improved the shelf life or delayed ripening process also improved retention or reduced spoilage. The controlled fruits ripened fast thus also had accelerated spoilage rate or less retained fruits. On its ripening at 12th day only 41.4 fruits respectively could be retained which reduced at a faster rate throughout its storage period than the packaged treatment and also the retained fruit at all days of observation was significantly lesser than the packaged treatments which had cent per cent retention till 9th day of their storage. Banana fruits were reported to retain freshness, firmness and greenness longer even up to 30 days when stored in polyethylene bags (Osman and Abu-Goukh, 2008; Sarla*et al*., 2013).

From 12th day to last day of storage i.e. 24th day all the treatment combinations of polyethylene bagging had significantly higher retention or lesser spoilage than the wax coating and all the treatment combinations of newspaper wrapping. On 21st day of storage fruit retention reduced to less than 50 % with polyethylene bagging with or without perforations and also with combination of perforated polyethylene bagging and potassium permanganate but the fruit retention was still higher than 60 %with polyethylene bagging with or without perforations combined with $KMnO_4$ + wax coating and also with combination of un-perforated polyethylene bagging and $KMnO_4$ (74.3, 78.2 & 69.6 %. Only polyethylene bagging with or without perforation in combination with $KMnO_4$ + wax coating had fruit retention of more than 50 % on final day of storage i.e. 24th day with 52.5 & 56.5 %. It was also observed that combining only potassium permanganate with these packaging materials significantly enhanced retention which further significantly improves retention if fruits are also wax coated with this combination then when these packaging materials were used alone. This was because $KMnO_4$ increased firmness and greenness (i.e. retarded ripening) and reduced decay or spoilage (Rao and Chundawat, 1988).

The data on physiological loss in weight presented in table 2. The fruits under control i.e. kept as such in ambient environment ripened on 12 days of storage. The fruits coated with only wax and those wrapped in either perforated or un-perforated newspaper in combination with either $KMnO_4$ or $KMnO_4$ and wax coating ripened on 18 days of storing. Fruits packed in perforated polyethylene bagging and un-perforated polyethylene bagging with or without $KMnO_4$ treatment ripened on 21 days of storing. The fruits those ripened on 24 days of storing were packed in un-perforated polyethylene bags in combination with $KMnO_4$ with or without wax coating and perforated polyethylene bags in combination with $KMnO_4$ and wax coating.

Gradual physiological loss in weight of plant of banana var. Grand Naine fruits after subjecting to different post-harvest treatments during its storage period is given in table 2.All these treatments had significantly lesser weight loss compared to no packaging control throughout the storage period. The weight loss however increased gradually as the storage duration extended till 24th day of storage (though all treatments did not continue up to 24 days from the day of storing as their fruits ripened well ahead). However, the increase had been at a reduced rate in all the treated fruits as compared to unpackaged/no-treated control.

The fruits coated with only wax and packed in newspaper in combination with either potassium permanganate or potassium permanganate and wax coating had accelerated rate of weight loss and recorded peak loss up to about 20 % with completion of ripening earlier by six days i.e. on 18th day of storage while fruits under control had peak weight loss 14-17 % on ripening i.e. on 12th day of storage. The fruits ripened on 21st day of storage have its final weight loss of 13-16 % were packed in un-perforated polyethylene bags and perforated polyethylene bags with or without potassium permanganate dipping.

Table 2: Effect of post-harvest packaging treatments on fruit retention (%) and Physiological loss in weight (%)of banana var. Grand Naine.

	Fruit retention (%)							Physiological loss in weight (%)							
Treatment	**Day 6**	**Day 9**	**Day 12**	**Day 15**	**Day 18**	**Day 21**	**Day 24**	**Day 3**	**Day 6**	**Day 9**	**Day 12**	**Day 15**	**Day 18**	**Day 21**	**Day 24**
UPB	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	83.3 (65.7)	60.9 (51.3)	48.3 (44.0)	*	1.39	2.37	4.24	4.93	5.59	9.41	14.26	*
UPB+K	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	86.6 (73.8)	79.9 (63.3)	69.6 (56.5)	49.6 (44.8)	1.35	2.34	4.08	4.93	5.47	8.88	13.23	14.6
UPB+K+WC	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	86.3 (68.3)	78.2 (62.2)	56.5 (48.7)	1.33	2.24	3.14	3.93	5.35	8.15	11.86	12.3
PPB	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	80.0 (63.4)	54.5 (47.6)	43.1 (41.0)	*	1.77	3.58	4.82	6.61	7.73	13.10	18.19	*
PPB+K	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	83.3 (65.9)	64.5 (53.4)	49.1 (44.5)	*	1.57	2.86	4.43	6.45	7.35	12.49	16.53	*
PPB+K+WC	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	84.8 (67.0)	74.3 (59.5)	52.5 (46.4)	1.45	2.61	4.36	6.02	6.95	12.45	16.45	17.3
NU	100.0 (90.0)	100.0 (90.0)	77.8 (61.8)	73.7 (59.1)	45.4 (42.4)	*	*	2.48	4.24	7.16	9.40	10.27	17.16	*	*
NU+K	100.0 (90.0)	100.0 (90.0)	86.1 (68.1)	80.5 (63.2)	41.2 (39.9)	*	*	2.39	4.08	6.76	9.29	10.15	17.23	*	*
NU+K+WC	100.0 (90.0)	100.0 (90.0)	90.0 (71.6)	82.1 (63.3)	48.3 (44.0)	*	*	2.12	3.66	6.56	8.74	9.99	17.31	*	*
NP	100.0 (90.0)	100.0 (90.0)	80.5 (63.8)	70.3 (56.9)	35.2 (36.4)	*	*	2.56	4.50	7.68	9.71	11.29	17.95	*	*
NP+K	100.0 (90.0)	100.0 (90.0)	85.6 (67.7)	74.7 (59.8)	39.2 (38.8)	*	*	2.44	4.43	7.27	9.33	10.23	16.26	*	*
NP+K+WC	100.0 (90.0)	100.0 (90.0)	88.5 (70.1)	81.8 (62.5)	45.3 (42.3)	*	*	2.18	4.33	7.23	9.25	11.54	15.18	*	*
WC	100.0 (90.0)	100.0 (90.0)	75.0 (60.0)	72.2 (58.2)	39.4 (38.8)	*	*	2.57	4.53	7.32	9.82	10.57	18.45	*	*
Control	96.6 (79.4)[1]	65.4 (54.0)	41.4 (40.1)	*	*	*	*	2.60	5.23	10.65	17.25	*	*	*	*
CD P=0.05	**0.01**	**0.46**	**0.19**	**0.62**	**2.04**	**0.66**	**0.99**	**0.05**	**0.06**	**0.06**	**0.85**	**0.11**	**0.16**	**0.05**	**-**
CV	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**1.2**	**0.1**	**0.8**	**1.4**	**0.7**	**0.5**	**0.2**	**-**
S.Em ±	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**0.01**	**0.02**	**0.03**	**0.29**	**0.03**	**0.04**	**0.02**	**-**

UPB – un-perforated polyethylene bag; PPB- perforated polyethylene bag; NU- newspaper un-perforated; NU newspaper perforated; K- $KMnO_4$;

WC– wax coating; *complete ripening of the stored fruits; [1]values in parenthesis are angular transformed values

Packaging $KMnO_4$ dipped and wax coated banana fruits in un-perforated polyethylene bags was the best treatment that had significantly lesser weight reduction throughout the storage period as compared to all other treatments. The final weight loss i.e. at 24th day of storage recorded with this packaging treatment was 12.3 as compared to 14.6 & 14.5 % weight loss on 24th day fruits packed in un-perforated polyethylene bags treated with potassium permanganate and perforated polyethylene bags treated with potassium permanganate along with wax coating, respectively. This indicates that this packaging treatment had retained maximum moisture during its storage period or prevented moisture loss due to wax coating. This was due to maintained minimum turbulence inside the modified packaging environment from the ambient environment due to its un-perforated polyethylene shielding during its storage period keeping the fruit fresher and maintaining its palatability or edible qualities while vice versa was true for other treatments. These other treatments were fruits not packaged/treated, coated with wax only and packed with newspaper and polyethylene bags in combination with either potassium permanganate or wax coating lost maximum moisture during storage period and even ripened earlier i.e. on 12-21 days of storing.Bananas are highly susceptible for softening due to physiological loss in weight during ripening which results in spoilage of the fruits (Chauhan *et al*., 2006).

Polymeric film packaging has been extensively used to reduce water loss for minimizing physiological loss in weight of the stored fruits (Agnihotri and Ram, 1971).As was also observed in this study several workers also have reported that bananas packed in polyethylene packages had the lowest weight loss, followed by those in perforated ones, whereas the unpacked fruits had the highest weight loss (Kumar and Brahmachari, 2006).

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