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Effect of different Post-harvest Packaging Treatments on Shelf-life and Quality of Banana var. Grand Naine

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ABSTRACT: An experiment was carried out to investigate the effect of different packaging materials on shelf life and quality of banana fruits at Postharvest laboratory of Uttar Banga Krishi Viswavidyalaya, Pundibari, West Bengal. The experimental treatments were Un-perforated & perforated polyethylene bag and news paper wrapping in combination with $KMnO_4$ & Wax coating along with control. The experiment was laid out in a complete randomized design (CRD) with three replications. 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 titrable acidity was also highest in the same treatment on 3rd day (0.94 and 0.99) degraded up to (0.26 and 0.29 %) on 24th day whereas in control it was recorded (0.68 and 0.63) on 3rd day and degraded to (0.36 and 0.35%) on 12th day only. Similarly, the sugar acid ratio was also best in case of fruits treated with $KMnO_4$ + wax coating kept in unperforated polythene cover (T_3) and $KMnO_4$ + wax coating kept in perforated polythene cover when compared to control.

Keywords: Physical Parameters, shelf life, Banana, Packing material and Post-harvest treatments.

INTRODUCTION

Banana (*Musa* spp) is a member of Musacea family and native to south east Africa. It is the most popular fresh fruit all over the world and its name comes from the Arabic word 'banan', which means finger. Banana is a large perennial herb with leaf sheaths that form the trunk like pseudostem. They vary in height from 1.5-8 m (Hailu *et al*., 2014). Banana is a very popular fruit due to its low price and high nutritive value. It is consumed both in fresh and cooked form both as ripe and raw fruit. Banana is a rich source of carbohydrate and is rich in vitamins particularly B. It is also a good source of potassium, phosphorus, calcium and magnesium. The fruit is easy to digest, free from fat and cholesterol. It helps in reducing the risk of heart diseases when used regularly and is recommended for patients suffering from high blood pressure, and kidney disorders. Processed products, such as chips, banana puree, jam, jelly, juice, wine and halwa can be made from the fruit. Banana can be utilized for the production of edible vaccine against Hepatitis-B virus (HBV). The plant based vaccine for HBV from edible banana seems to be an economical alternative for human healthcare by many scholars. The total area under banana in the world is 11.13 million ha, producing 97.38 million tons of banana and plantains. India is the largest producer of banana in the world, contributing 24 % to the global production with a total area of 0.565 million ha and production 19.1 million tons reported for the year 2011 (FAO, 2011).

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 Rs. 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). Generally, significant proportion of banana fruits have been lost in India due to lack of awareness on effect of packaging materials on shelf life and quality of harvested banana fruit. Hence, it is necessary to assess the effect of different packaging materials on quality and shelf life of banana 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 newspaper 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 5g $KMnO_4$ 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.

Table 1: Effect of post-harvest packaging treatments on green, yellow and shelf life (days) of banana fruit var. Grand Naine.

Treatment	Green life		Yellow life		Shelf life	
	Plant	Ratoon	Plant	Ratoon	Plant	Ratoon
UPB	14.39	14.75	6.82	6.75	21.21	21.50
UPB+K	16.96	17.12	7.46	7.15	24.42	24.27
UPB+K+WC	17.31	17.28	7.62	7.35	24.93	24.62
PPB	13.41	14.51	6.86	6.64	20.27	21.15
PPB+K	14.82	14.77	6.93	6.66	21.75	21.44
PPB+K+WC	17.26	17.16	7.53	7.24	24.78	24.40
NU	11.87	12.08	6.25	6.10	18.13	18.17
NU+K	11.94	12.10	6.50	6.55	18.44	18.65
NU+K+WC	12.23	12.19	6.72	6.55	18.95	18.74
NP	11.92	12.07	6.15	6.05	18.07	18.12
NP+K	12.10	12.12	6.33	6.34	18.43	18.46
NP+K+WC	12.27	12.16	6.63	6.48	18.90	18.65
WC	12.05	12.05	6.01	6.26	18.06	18.31
Control	8.01	8.10	4.21	4.14	12.22	12.24
CD $_{P=0.05}$	**0.42**	**0.04**	**0.12**	**0.06**	**0.39**	**0.08**
CV	**1.9**	**0.2**	**1.1**	**0.5**	**3.5**	**1.0**
S.Em±	**0.14**	**0.02**	**0.04**	**0.02**	**0.13**	**0.04**

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

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; Abdullah *et al.,* 2016). 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 influence of different packaging treatments on titrable acidity of Grand Naine banana fruits is presented in Table 2 and was significantly influenced by these treatments. Titratable acidity of ripening banana also decreased gradually from a maximum on day of storage to a minimum on completion of ripening. The pattern of increase and fall of titrable acidity after reaching peak was similar to that of sugars and TSS. This could be associated to ripening stages of the banana fruits which were influenced by the storage treatments (Zewter *et al*., 2012). TA increased to its peak which coincided with the accumulation of ethylene and ripening and then started to decline afterwards (Hernandez *et al*., 2006). As the control fruits ripened faster on 12th day of storage, titratable acidity also decreased at a faster rate than the packaged fruits which ripened slowly having an extended ripening period of 6-12 days over the ripening of control fruits. The control fruits had significantly lower titratable acidity throughout its ripening period as compared to the packaged fruits. The maximum titratable acidity estimated for plant and ratoon control fruit on day 3 of storage was 0.68 and 0.63 %, respectively which reduced to 0.36 and 0.35 %, respectively on ripening. Correspondingly the range of maximum and minimum values of titratable acidity of fruits coated with only wax and packed in all treatment combinations of newspaper which ripened on 18th day of storage was 0.74-0.94 % & 0.36-0.40 % for plant crop and 0.91-0.99 % & 0.34-0.39 % for ratoon crop. Similarly, maximum and minimum titratable acidity of fruits packed on un-perforated polyethylene bags and also in perforated polyethylene bags with or without potassium permanganate which ripened on 21st day of storage estimated was 0.87-0.89 % & 0.35-0.38 % and 0.94-0.96 % & 0.32-0.34 % respectively.

Table 2: Effect of post-harvest packaging treatments on titrable acidity (%) of banana fruits var. Grand Naine.

Treatment	Day 3		Day 6		Day 9		Day 12		Day 15		Day 18		Day 21		Day 24	
	P	R	P	R	P	R	P	R	P	R	P	R	P	R	P	R
UPB	0.89	0.95	0.77	0.79	0.63	0.73	0.64	0.71	0.60	0.67	0.40	0.39	0.35	0.32	*	*
UPB+K	0.87	0.97	0.82	0.81	0.69	0.80	0.64	0.73	0.60	0.68	0.42	0.42	0.36	0.33	0.25	0.32
UPB+K+WC	0.94	0.99	0.84	0.85	0.71	0.82	0.68	0.75	0.64	0.69	0.44	0.44	0.38	0.34	0.26	0.29
PPB	0.88	0.96	0.75	0.78	0.62	0.73	0.60	0.70	0.56	0.60	0.39	0.37	0.36	0.32	*	*
PPB+K	0.87	0.94	0.75	0.82	0.63	0.74	0.61	0.71	0.60	0.62	0.42	0.42	0.38	0.34	*	*
PPB+K+WC	0.90	0.96	0.80	0.82	0.66	0.77	0.65	0.72	0.64	0.64	0.43	0.42	0.38	0.35	0.25	0.32
NU	0.85	0.92	0.70	0.71	0.61	0.72	0.58	0.63	0.54	0.54	0.36	0.34	*	*	*	*
NU+K	0.74	0.91	0.73	0.72	0.63	0.72	0.62	0.66	0.60	0.57	0.36	0.35	*	*	*	*
NU+K+WC	0.81	0.93	0.74	0.78	0.63	0.73	0.63	0.69	0.63	0.59	0.40	0.39	*	*	*	*
NP	0.84	0.92	0.72	0.73	0.59	0.67	0.55	0.55	0.55	0.53	0.39	0.37	*	*	*	*
NP+K	0.85	0.94	0.71	0.74	0.61	0.71	0.57	0.57	0.58	0.56	0.36	0.35	*	*	*	*
NP+K+WC	0.86	0.95	0.74	0.75	0.63	0.72	0.63	0.59	0.60	0.58	0.40	0.38	*	*	*	*
WC	0.83	0.92	0.69	0.73	0.53	0.64	0.62	0.63	0.56	0.55	0.36	0.35	*	*	*	*
Control	0.68	0.63	0.52	0.60	0.47	0.53	0.36	0.35	*	*	*	*	*	*	*	*
CD $_{P=0.05}$	**0.05**	**0.04**	**0.04**	**0.02**	**0.01**	**0.02**	**0.012**	**0.01**	**0.03**	**0.016**	**0.024**	**0.013**	**0.02**	**0.012**	**-**	**-**
CV	**3.6**	**3.0**	**2.7**	**1.3**	**1.9**	**2.0**	**1.2**	**0.8**	**1.5**	**1.3**	**3.1**	**2.2**	**1.5**	**1.8**	**-**	**-**
S.Em±	**0.02**	**0.01**	**0.01**	**0.04**	**0.01**	**0.04**	**0.04**	**0.01**	**0.01**	**0.01**	**0.01**	**0.04**	**0.04**	**0.04**	**-**	**-**

P- plant crop; R- ratoon crop; 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 fruit.

Finally, the best packaging treatments in terms of longest ripening period (perforated polyethylene bagging in combination with $KMnO_4$ along with wax coating and un-perforated polyethylene bagging either with $KMnO_4$ or $KMnO_4$ with wax coating) had ripened fruits on 24th day of storage was estimated with 0.25-0.26 % and 0.29-0.32 % titratable acidity which reduced from its initial values of 0.87-0.94 and 0.96-0.99 % in plant and ratoon crop, respectively on day 3 of storage. This clearly indicates that the polyethylene bagging either perforated or un-perforated in combination with potassium permanganate alone or potassium permanganate + wax coating was the best packaging treatment in terms minimizing the acidity of the banana fruits or increasing sweetness of the fruits by delaying the ripening process or extending storage period. This can be explained in terms of final acidity of the control fruits on ripening which was 0.35-0.36 % while with these treatment combinations of polyethylene bagging with potassium permanganate and wax coating the acidity was even lower with only 0.25-0.32% which was due to extension of ripening period by 12 days that reduced the acidity to minimum possible meaning that the packaging had improved the fruit quality along with extending the ripening period. Lengthening the ripening process increases the time of ripening metabolism to further decrease the acidity as compared to control or other packaging treatments. On ripening, fruits having minimum acidity mean maximum sweetness of the fruits or maximum palatable quality. Earlier studies also reported similar decreasing trend of acidity under all the storage conditions and especially with $KMnO_4$ (Waskar and Roy 1992; Narayana *et al*., 2002; Kumar and Brahmachari 2006).

Sugar acid ratio is the proportion of sugar to acidity in the fruit and as sugar and acidity was significantly influenced by the different packaging treatments so was the sugar acid ratio and obviously the ratio increased as ripening progressed from a minimum at start of ripening to a maximum on ripening indicating gradual decrease of acidity to gradual increase of sweetness (Table 3). The ratio of the control fruits was significantly higher throughout its ripening period than the packaged fruits and has reached the peak sweetness (61.86 in plant crop and 66.40 in ratoon crop) from an initial of 12.25 and 13.71, respectively on 3rd day of storage, faster than the packaged fruits i.e. on 12th day. Correspondingly for packaged treatments up to 12th day of storage this ratio increased from 3.37-5.09 to 16.94-24.50 in plant crop and 4.09-4.93 to 17.35-27.21 in ratoon crop. This clearly indicates that ratio increased at faster rate in the control fruits than the packaged fruits. Moreover, the trend of progress of sugar acid ratio and the influence of packaging on it in comparison to control fruits were similar as was also exhibited by sugar content and acidity of the fruits.

Polyethylene bagging has been extensively used for storage to enhance fruit quality (Kader, 1988; Purvis, 1983). Rapid increment in the total and reducing sugar as well as rapid decrease in starch contents of fruits stored in open air could be due to faster ripening process which converts starch into sugar, while the slower rate in packaged, bagged and covered fruits could be due to the effects of packaging, bagging and covering in delaying the ripening process (Dong *et al*., 2001, 2002; Morrelli and Kader 2002; Golding *et al*., 2005; Mebratu and Muneda 2019). The chemical control of the post-harvest wastage has become an integral part of the handling and successful marketing of bananas extending shelf life and maintaining desirable qualities like sugars, acidity and ascorbic acids in the fruits (Tongthieng and Sangchote 1993; Borkar *et al*., 2008; Bhalerao *et al*., 2010; Macwan *et al*., 2014). The packed fruits recorded with smallest changes in total soluble sugars, ascorbic, acid and TSS/acid (Magdaline *et al*., 1999).

Table 3: Effect of post-harvest packaging treatments on sugar acid ratio of ripening banana fruits var. Grand Naine.

Treatment	Day 3		Day 6		Day 9		Day 12		Day 15		Day 18		Day 21		Day 24	
	P	R	P	R	P	R	P	R	P	R	P	R	P	R	P	R
UPB	4.0	4.4	8.1	10.1	13.2	13.1	18.4	18.6	26.0	26.8	52.0	57.1	63.1	73.3	*	*
UPB+K	4.0	4.2	7.7	9.3	12.5	11.7	18.0	17.9	25.0	25.6	47.3	51.6	62.0	69.5	88.8	71.6
UPB+K+WC	3.4	4.1	7.5	8.7	11.7	11.5	16.9	17.3	24.1	25.2	45.8	49.1	57.9	67.4	86.9	79.1
PPB	4.1	4.6	9.5	10.3	13.6	13.5	20.6	19.9	29.8	30.4	54.2	61.3	61.2	71.8	*	*
PPB+K	4.1	4.7	9.0	9.8	13.2	13.1	20.1	19.1	27.5	29.5	50.5	54.2	58.9	68.2	*	*
PPB+K+WC	3.8	4.6	8.5	9.8	12.5	12.6	18.4	18.7	24.6	27.4	49.2	53.5	58.6	66.5	90.0	71.1
NU	4.5	4.8	10.5	11.8	14.5	16.0	21.9	23.7	30.8	34.5	57.5	65.3	*	*	*	*
NU+K	5.1	4.9	9.8	11.6	14.1	15.8	20.6	22.2	27.2	32.2	58.2	63.3	*	*	*	*
NU+K+WC	4.5	4.8	9.5	10.5	13.9	15.5	19.8	21.0	26.0	33.1	50.1	56.8	*	*	*	*
NP	4.7	4.9	10.3	11.8	15.9	17.2	24.5	27.2	32.3	36.6	55.01	61.9	*	*	*	*
NP+K	4.5	4.8	10.4	11.7	15.2	16.6	23.8	26.1	30.0	34.5	59.6	66.7	*	*	*	*
NP+K+WC	4.5	4.7	9.9	11.4	14.4	16.4	20.9	24.7	29.1	33.2	55.0	61.3	*	*	*	*
WC	4.3	4.7	10.6	11.8	17.4	18.7	20.7	22.9	31.3	35.7	59.2	65.8	*	*	*	*
Control	12.2	13.7	18.8	20.5	31.6	30.7	61.9	66.4	*	*	*	*	*	*	*	*
CD $_{P=0.05}$	0.3	0.2	0.4	0.2	0.4	0.5	0.4	0.3	5.2	1.7	0.8	2.1	1.6	2.2	-	-
CV	3.6	2.9	2.8	1.3	1.9	2.0	1.2	0.8	1.5	1.3	3.1	2.2	1.5	1.8	-	-
S.Em$\pm$	0.09	0.08	0.15	0.08	0.15	0.17	0.15	0.11	0.24	0.23	0.95	0.73	0.51	0.71	-	-

P- plant crop; R- ratoon crop; 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.

Similar results with regard to shelf life and other quality parameters of banana fruits like TSS, contents of reducing sugars, non-reducing sugars and starch, and titratable acidity at 6, 12 and 18 days after treatment were obtained with only waxing of fruits or in combination of other chemicals stored in polythene bags as was obtained in this study was also reported by (Rao and Rao 1979; Desai *et al.*, 1989; Vijaya Raju, 1989; Shaikh *et al.*, 1991; Devi and Arumugam 2005). Reduction of respiration rate and ethylene production as a result of coating with edible films has also been reported for banana (Banks, 1984). Delay in increment of all quality traits of fruits stored in polyethylene bags fortified with $KMnO_4$ along with wax coating of fruits was due to slowed ripening up to 24 days as a result of modified atmospheric conditions irrespective of perforations or not. The delay in increase of the sugars by inclusion of $KMnO_4$ in the polyethylene was attributed to the ethylene removal and inhibition effect of $KMnO_4$ (Jobling, 2000) thereby delaying climacteric respiration triggering effects of ethylene (Wills *et al.*, 1998; Mattheis *et al.*, 2003). Fruits stored in polyethylene bags in combination with $KMnO_4$ had delayed decline in sugar content which could related to delay in ripening as $KMnO_4$ reacts with ethylene and limit its catalytic role on respiration (Shaun and Ferris, 1997). With polyethylene bags having more control over the gas exchange with the surrounding air, the levels of CO_2 and O_2 around the fruits had further slowed down conversion of starch to sugars (Zewter *et al.*, 2012; Rahman *et al.,* 2020).

CONCLUSION

Under ambient conditions and without any post-harvest storage treatments Grand Naine fruits could be stored up to 12 days. However, using different post-harvest packaging treatments can extended shelf lifeup to 24 days along with improved quality and increased fruit shelf life (green + yellow life) during storage through increased sugar acid ratio, thus it is recommended to create a modified atmospheric condition of the storage environment by packaging the fruits in polyethylene bags with or without perforations but fortifying the bagging with potassium permanganate and wax coating of the stored fruits.

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Conflicts of Interest. None.

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