Annals of Tropical Research 39 (SUPPLEMENT A):55-65 (2017)

Postharvest handling intervention for banana var la tundan grown in the marginal upland in Inopacan, Leyte

Marcelo A. Quevedo[1*], Arsenio D. Ramos[2], Ness Marie Sta. Iglesia[1] and Kris Benzon V. Notarte[3]

ABSTRACT

The study was conducted to evaluate the effectiveness of packaging materials for transport and simple storage techniques of banana fruits planted by the upland farmers of Inopacan, Leyte and to identify and introduce the suitable postharvest intervention for their adoption. The use of plastic crates and rattan basket significantly minimized bruises and scratches of banana fruits during transport compared to plastic sack. Providing lining materials further reduced these injuries during transport. As a result of minimal damage during transport, the shelf life was extended during storage at ambient condition. On the other hand, harvested banana fruits were not stored as these were directly sold to the market during market days (tabo) or directly bought by middle men from the farm. However, in some instances where there is a difficulty in transport due to impassable roads, farmers are obliged to keep the harvested banana for sometime in their homes or collection center. Banana var. 'Latundan' fruits in hands or in bunch stored using MAP (PE bags) with diffusion holes had better postharvest performance, particularly lesser weight reduction, extended ripening (based on peel color changes & firmness), lower incidence and degree of decay and acceptable sensory quality ratings. In contrast, fruits in MAP without diffusion hole had inferior postharvest behavior.

Keywords: marginal upland farmers, postharvest intervention, La' Tundan' banana fruits, quality

INTRODUCTION

Crop production in marginal upland areas is generally associated with low agricultural productivity which could be attributed to low yield due to poor crop

[1] PhilRootcrops, Visayas State University, Visca, Baybay City, Leyte
[2] Department of Horticulture, Visayas State University, Visca, Baybay City, Leyte
[3] Visayas State University, Visca, Baybay City, Leyte

* **Corresponding Author**. Address: PhilRootcrops, Visayas State University, Visca, Baybay City, Leyte; Email:celoque777@yahoo.com
DOI: 10.32945/atr39sa5.2017

performance and high postharvest losses. Bananas are usually planted in marginal uplands which suffered high postharvest losses due to the conditions in the uplands that favor product quality deterioration. Such conditions include poor fertility and inadequate moisture supplies of most soils which indirectly affect the quality and postharvest life of the harvested produce. It was reported that growing fruit vegetables in soil with calcium deficiency could drastically result to physiological disorder, known as blossom end rot (Esguera & Bautista 2007). However, most of the losses occurred during the movement of the produce from the production areas to market or consumers. For example, in Brazil, 40% losses of the total banana production were reported to occur during harvest/transport steps (Brazil 1993). Inappropriate infrastructure and carelessness in the handling of fruits during harvest and post-harvest operations are the main factors that lead to these high loss rates and to a visual appearance denoting low fruit quality (Alves 1984). In Bangladesh, a study showed that of the 25% postharvest losses of banana, 17% was caused by fruit injuries during transport and 8% due to fruit disease (http://daatj.net/index.php?option=com_abook&view=book&catid=3:mastershes es&id=150:postharvest-handling-and-marketing-of-banana-in-the-selected-areas-of-bangladesh&Itemid=4). There is no documented report on the postharvest handling of banana fruits in Region 8, especially those harvested from marginal upland areas, hence, this study was conducted to evaluate the use of different packaging materials during transport from upland growing areas of Inopacan, Leyte to Visayas State University, Baybay City, Leyte, covering a total distance of approximately 17km and to monitor the postharvest behavior of banana fruits during storage at ambient conditions using different storage techniques for possible adaptation by upland marginal farmers in Inopacan, Leyte.

METHODOLOGY

Packaging Materials for Transport of Banana Fruits

Different packaging materials namely: plastic sacks (farmers' practice), rattan basket and plastic crates were used to package banana hands during transport from Barangay Cabulisan, an upland barrio of Inopacan, Leyte. Banana hands of uniform size and maturity were packed in the different packaging materials, with or without lining materials. The packed banana hands in each container (together with the other harvested produce) were loaded in the vehicle and transported to Inopacan market. The experimental fruits were then transferred to an other vehicle and then transported to VSU for monitoring the extent of damage. Immediately after transport, incidence of bruises and scratches were monitored. Those hands that were visually free from damage were stored at ambient condition for shelf life evaluation.

Shelf-life Improvement of Banana Fruits var. 'Latundan'.

In some instances, farmers cannot deliver their harvested banana fruits and other commodities to markets during heavy rains and bad weather conditions because of the difficulty in the maneuver of vehicle and inaccessible slippery and bumpy roads. Hence, some of the harvested fruits turned ripe prior to transport to the market which made them more vulnerable to damage during transport. Methods to minimize ripening of fruits were tried. Modified atmosphere packaging (MAP) of banana var. 'La Tundan' fruit hands was evaluated to control ripening prior to transport. In the first MAP experiment, banana hands were used. Freshly harvested banana var. ”La Tundan” fruit bunches of proper maturity (full round finger) were used. These were carefully dehanded and then the latex was allowed to drain. More or less uniform hands were selected. The selected hands were either stored in MAP, with or without diffusion holes. Diffusion holes were made by making 10 pinpricks (5 in each side of the bag). One hand was placed in each bag and then the mouth was tightly sealed using plastic sealer. Banana hand in the open served as control. The experimental fruits were arranged using CRD with three replications having 3 sample hand/bags per replication. These were stored under ambient condition and were assessed for their postharvest behavior (Figure 1).

Figure 1.The experimental set-up of the banana MAP experiment

In the second MAP experiment, nine freshly harvested banana var. '*Latundan'*fruits' bunches of proper maturity (full round finger) were used. These were procured from Inopacan, Leyte and were carefully transported to the VSU. The bunches were either stored in MAP using polyethylene (PE) bags with or without diffusion holes, or without MAP (control). Diffusion holes were made by making 20 pinpricks (10 in each side of the bag). One bunch was placed in each bag and then the mouth was tightly sealed by tying with rubber strip. The experimental fruits were arranged in CRD with three replications having 3 sample bunches/ bags per replication. These were stored by hanging under ambient condition and were assessed for their postharvest behavior (Figure 2).

Figure 2. The experimental set up of MAP experiment of banana fruit in bunches

The data on physical parameters including weight loss, firmness, peel color, pulp to peel ratio, incidence and severity of decay, visual quality rating, as well as data on chemical parameters such as total soluble solids (TSS) and titratable acidity (TA) were gathered, following standard procedures. Sensory evaluation of ripe fruit was also conducted.

RESULTS AND DICUSSION

Packaging Materials for Transport of Banana Fruits

Packaging materials significantly affected the extent of damage of fruits during transport, especially in rough roads. Bruises and scratches and sometimes, deformities, are inevitable. Incidence of bruises on banana fruits immediately after transport had a wide variation among packaging materials used during transport. The use of rattan baskets and plastic crates significantly reduced the incidence of bruises compared to the use of plastic sacks (normal containers for transport). Addition of lining materials such as dried banana leaves or banana bracts further reduced the incidence of bruises (Table 1).

Table 1. Incidence (%) of bruises in 'La Tundan' banana fruits after transport as influenced by type of containers and lining materials during transport

Packaging material	Provision of lining material		Mean
	Without liners	With liners	
Plastic sack	15.53	12.22	13.88a
Rattan basket	9.45	6.11	7.78b
Plastic crate	10.56	5.56	8.06b
Mean	11.84 a	7.96b	

Means within a column or row followed by the same letter are not significantly different from each other at 0.05 HSD.

Likewise, the incidence of scratches was also reduced significantly by the use of rattan baskets and plastic crates. Addition of lining materials in rattan basket did not significantly reduce further the incidence of scratches. On the other hand, putting lining materials in plastic crates prevented the occurrence of scratches in packed banana fruits (Table 2).

Table 2. Incidence (%) of scratches in La 'Tundan' banana fruits after transport as influenced by type of containers and lining materials during transport

Packaging material	Provision of lining material	
	Without liners	With liners
Plastic sack	15.53a	3.89c
Rattan basket	2.78c	3.33c
Plastic crate	7.78b	0d

Means with the same letter are not significantly different from each other at 0.05 HSD.

The results suggested that the use of appropriate packaging materials during transport is essential to prevent any damage, especially in rough roads. The use of plastic sacks did not protect the fruits against adverse conditions during transport, even when placed with lining materials. Plastic crates and rattan baskets are rigid packaging materials which can protect the fruits during transport and withstand adverse conditions. Providing lining materials can reduce further damages inflicted during transport. Although farmers have not realized the impact of injured fruits, the subsequent storage and utilization of the transported fruits had short shelf life or the fruits are easily ripened/rotten, if not consumed immediately after ripening. The selected fruits that were known to have no visual symptoms of damage had shorter shelf life under ambient condition (Table 3). Those fruits packed in plastic crates during transport had significantly longer shelf life which was about 11 days, compared to 9 days only in both plastic sacks and rattan baskets. The scratches of fruits were prevented when packed with plastic crates. Addition of lining materials in both plastic sacks and rattan baskets significantly improved the shelf life of banana fruits which ranged from 11 to 12 days at ambient conditions. The result implies that the use of appropriate packaging materials during transport not only minimized damage but also lengthened the shelf life of fruits. Though no visible symptoms of damage in the fruits, the internal tissues might have already been affected, thereby affecting the shelf life of the fruits. It is important, therefore, that fruits to be stored should be free from damage.

Table 3. Shelf life (days) of 'La Tundan' banana fruits after transport as influenced by type of containers and lining materials during transport

Packaging material	Provision of lining material	
	Without liners	With liners
Plastic sack	9.00b	11.00a
Rattan basket	9.67b	12.00a
Plastic crate	11.33a	12.67a

Means with the same letter are not significantly different from each other at 0.05 HSD.

Shelf-life Improvement of Banana Fruits var. 'Latundan' using MAP

Physical measurements

Weight loss. MAP using PE significantly reduced weight loss of banana fruits stored under ambient condition for 8 days. MAP with or without diffusion holes were equally effective in minimizing weight loss of the fruit (Table 4). After 8 days of storage, control fruits (unpacked) had 3 times higher percentage weight loss compared to those fruits under MAP. The high relative humidity inside the MAP minimized the loss of moisture and weight which corroborated the findings of Hossain et al (2013).

Table 4. Weight loss (%) of 'La tundan' banana fruits after 10 days of storage

Storage Methods	Days of storage			
	2	4	6	8
T0 (Control)	5.52a	9.05a	12.08a	14.72a
T1 (MAP w/o diffusion holes)	0.28b	1.07b	1.29c	3.00b
T2 (MAP w/diffusion holes)	0.76b	1.69b	2.69b	2.96b

Means with the same letter within a column are not significantly different from each other at 0.05 HSD.

Similar results were obtained in whole banana fruit bunches where those bunches stored in MAP with and without diffusion holes had significantly lower weight loss than the control fruits,12 days after storage (Table 5). Weight loss of fruit bunches stored in MAP with or without diffusion holes and monitored after 17, 20 and 22 days of storage were more or less comparable. The loss of weight was still minimal even after 22 days of storage at ambient condition. Control bunches were terminated after 12 days of storage due to overripening.

Table 5. Weight loss (%) of Latundan banana fruits after 22 days of storage

Storage Methods	Days of storage				
	10	12	17	20	22
T0 (Control)	6.39	11.73a	-	-	-
T1 (MAP w/o diffusion holes)	4.00	3.48b	4.73	5.98	7.06
T2 (MAP w/ 20 diffusion holes)	9.81	2.79b	3.66	2.94	3.92

Pulp to peel ratio. Banana fruits in MAP without diffusion holes had significantly lower pulp to peel ratio than the control fruits, but had comparable pulp to peel ratio with fruits in MAP with diffusion holes (Table 6). The lower pulp to peel ratio of fruits in MAP relative to the control fruits could be a result of delayed ripening. The ratio was higher for fruits that are fully ripened. This could be due to the osmotic transfer of moisture from the peel to the pulp as sugar content of pulp increased. It has been suggested that pulp to peel ratio can be considered as a coefficient of ripeness (Tapre & Jain 2011).

Table 6. Mean average of pulp to peel ratio of 'Latundan' banana fruits after 8 days of storage under ambient condition

Storage Methods	Mean
T0 (Control)	3.06a
T1 (MAP w/o diffusion holes)	2.37b
T2 (MAP w/diffusion holes)	2.62ab

Means with the same are not significantly different from each other at 0.05 HSD.

However, the pulp to peel ratio of banana fruits in bunch were not affected by the three methods of storage because the fruits were already ripe after 22 days of storage (Table 7). Control fruits were already overripe during the sampling, which got a pulp peel ratio that was relatively higher than fruits from the other method of storage.

Table 7. Mean average of pulp to peel ratio of Latundan banana fruits after 22 days of storage

Storage Methods	Mean
T0 (Control)	2.74
T1 (MAP w/o diffusion holes)	2.47
T2 (MAP w/ 20 diffusion holes)	2.50

Peel color. Peel color ratings of banana fruits at 4 sampling periods did not significantly vary among treatments (Table 8). The result, however, indicated that the development of yellow color of the peel of banana fruits in MAP, particularly those in MAP without diffusion holes, was slightly delayed relative to the control fruits. After 8 days of storage, the control fruits had already full yellow peel while those in MAP still had green portions which corroborated the findings of Julianti et al (2012) in Barangan banana. The elevated carbon dioxide inside the MAP delayed the chlorophyll degradation of the peel as a result of inhibition of ethylene action, thereby minimizing the loss of green color.

Table 8. Peel color ratings of banana fruits var. 'Latundan' after 8 days of storage

Storage Methods	Days of storage			
	2	4	6	8
T0 (Control)	1.57	1.57	5.67	6.67
T1 (MAP w/o diffusion holes)	1.00	1.43	2.47	3.07
T2 (MAP w/diffusion holes)	1.00	1.00	3.43	4.93

Color ratings: 1 - green, 2 – first trace of yellow (breaker), 3 – more green than yellow, 4 – more yellow than green, 5 – yellow with green tips, 6 – full yellow (bright)

On the other hand, the peel color ratings of banana fruits in bunch stored in three storage methods were similar after 5 and 10 days of storage, at ambient conditions (Table 9). However, those fruits in bunches stored in MAP with and without diffusion holes had significantly lower color ratings than the control bunches after 12 days of storage at ambient conditions. The fruits were more green than yellow, while the control fruits were already full yellow. The result suggested that when transport of the fruits is difficult due to slippery and impassable roads, bunches of fruits should be placed in MAP rather than dehanded banana fruits to avoid early ripening. The ripening period can be extended up to 12 days of keeping under ambient condition.

Table 9. Peel color ratings of banana fruits var. *'Latundan'* after 12 days of storage

Storage Methods	Days of storage		
	5	10	12
T0 (Control)	1.24	4.00	6.00a
T1 (MAP w/o diffusion holes)	1.00	3.00	3.00b
T2 (MAP w/ 20 diffusion holes)	1.00	2.05	2.67b

Color ratings: 1 - green, 2 – first trace of yellow (breaker), 3 – more green than yellow, 4 – more yellow than green, 5 – yellow with green tips, 6 – full yellow (bright)

Firmness. Fruit firmness was not significantly affected by storage methods (Table 10). In all three sampling periods, however, the rating indicated that fruit softening occurred earlier in control fruits than those in MAP without diffusion holes. After 8 days of storage, the control fruits were already moderately soft, while those in MAP without diffusion holes had only their first perceptible softening. The changes in firmness of banana fruits is attributed to conversion of starch into sugar during ripening, suggesting that those fruits stored in MAP delayed their ripening process (Hossain et al 2013).

Table10.Firmness ratings of banana fruits var. *'Latundan'* after 8 days of storage

Storage Methods	Days of storage		
	4	6	8
T0 (Control)	1.33	3.33	3.33
T1 (MAP w/o diffusion holes)	1.00	1.90	2.00
T2 (MAP w/diffusion holes)	1.00	2.00	3.27

Firmness rating: 1 – firm and hard, 2 – first perceptible softening, 3 – moderately soft, 4 – ripe soft

Decay incidence and severity. The incidence and severity of decay of banana fruits after 8 days of storage did not significantly vary with storage technique (Table 8). Fruits stored using MAP without diffusion hole, however, had numerically higher percentage and severity rating than the control and those in MAP provided with diffusion holes. This result is in contradiction with the result of Hossain et al (2013), where fruits packed in non-perforated bags at low temperature storage exhibited the lowest disease incidence. The slow respiration due to low temperature might be responsible for their results. Our result seemed to indicate that proper balance of 0_2 and CO_2 must be maintained inside the package when placed under ambient condition to avoid heat buildup due to increased respiration. Increased respiration and insufficient ventilation promote condensation inside the package, thereby allowing microbial contamination or growth of pathogens (Holcroft 2015).

Table 11. Incidence (%) and severity decay of banana fruits var. 'Latundan' after 8 days of storage

Storage Methods	Decay (%)	Severity index
	8	8
T0 (Control)	4.44	0.20
T1 (MAP w/o diffusion holes)	11.10	0.93
T2 (MAP w/diffusion holes)	4.45	0.50

Visual Quality. The visual quality ratings of banana fruits stored at 3 methods of storage for 8 days did not significantly vary and were rated either as excellent with no defects, except for fruits stored using MAP without diffusion holes which received lower rating (Good, minor defects) because of the dull yellow color of the peel (Table 12).

Table 12.Visual quality ratings of banana fruits var. 'Latundan' after 8 days of storage

Storage Methods	Days of storage		
	4	6	8
T0 (Control)	9.00	8.40	8.13
T1 (MAP w/o diffusion holes)	8.57	7.90	7.47
T2 (MAP w/diffusion holes)	8.77	8.77	8.33

Chemical Measurements

TSS and TA. The TSS and TA of banana fruits did not vary significantly among methods of storage after 10 days under ambient condition (Table 13). Despite the low pulp peel ratio of those fruits stored in MAP without diffusion holes (which is suggestive of slow ripening process), the TSS and TA of the said fruits were already similar after 10 days of storage, though numerically lower TSS and higher TA.

Table 13.TSS and TA of 'La tundan' banana fruits after 10 days of storage

Storage Methods	TSS (°Brix)	TA (%)
T0 (Control)	16.78	5.20
T1 (MAP w/o diffusion holes)	14.86	7.40
T2 (MAP w/diffusion holes)	16.14	7.16

Sensory Evaluation

All sensory quality attributes of ripe banana fruit subjected to three methods of storage were statistically different except in the flavor, astringency and general acceptability (Table 14). The result, however, clearly indicated that fruits in MAP without diffusion holes received lower scores in almost all attributes, particularly texture and sourness. The delayed and abnormal ripening of the fruits stored in MAP without diffusions holes caused the rejection of the panelists during sensory evaluation. This result implied that although MAP without diffusion holes delayed ripening of fruits, it resulted to poor and abnormal ripening that affected the sensory quality attributes. Hence, proper balance of gases inside MAP must be attained to avoid rejection of the fruits by the consumers. On the other hand, fruits stored in MAP with diffusion holes had more or less similar ratings in all attributes with the control. Ripe fruits from MAP with diffusion holes and the control were given like slightly rating while fruits from MAP without diffusion holes were just given neither like nor dislike rating.

Table 14.Sensory quality ratings of banana fruits var. Latundan after 16 days of storage

Storage Methods	Quality Attributes					
	Texture	Sourness	Sweetness	Banana flavor	Astringency	Gen. Accept.
T0 (Control)	6.68a	6.45a	6.93a	6.99	6.07	6.78
T1 (MAP w/o diffusion holes)	2.35b	2.36b	4.98b	5.02	4.47	5.01
T2 (MAP w/ 20 diffusion holes)	6.91a	6.71a	7.34a	7.31	6.39	7.25

Means followed by the same within a column are not significantly different from each other at 0.05 HSD.

CONCLUSIONS

Plastic sacks as packaging materials are not advisable for use during transport of banana fruits from the marginal uplands in Inopacan, Leyte because they cannot protect the produce from severe damage. It is recommended to use plastic crates or rattan baskets as packaging containers of harvested banana or other commodities because they are rigid and can protect the produce inside during adverse conditions. Addition of lining materials especially in plastic crates further reduced the incidence of damage during transport. Likewise, the shelf life was extended for 2 days when fruits are packed in plastic crates or rattan baskets with lining materials during transport.

In cases where the harvested banana var. '*Latundan*' fruits cannot be transported due to slippery and impassable roads, storage in hands or in bunch using MAP (PE bags) with diffusion holes can be an alternative solution to slow down the ripening process. Fruits stored in MAP with diffusion holes had better postharvest performance, particularly lesser weight reduction, extended ripening (based on peel color changes & firmness), lower incidence and degree of decay and acceptable sensory quality ratings. In contrast, fruits stored in MAP without diffusion holes had inferior postharvest behavior. Control fruits ripened early which is a disadvantage during transport because they are prone to damage infliction.

REFERENCES

Aracena JJ, Sargent SA, Brecht JK & Campbell CA.1993.Environmental factor affecting vascular streaking, a postharvest physiological disorder of cassava root (ManihotesculentaCrantz). *Acta Horticulturae* 343:297-299

Beeching Jr, Han Y, Gomez-Vasquez R, Day RC & Cooper RM.1998. Wound and defense responses in cassava as related to post-harvest physiological deterioration. *Recent Advances in Phytochemistry* 32:231-248

Mvumi B, Matsikira LT & Mutambara J. 2016.

The banana postharvest value chain analysis in Zimbabwe. *British Food Journal* 118(2):272-285

Cagampang GB and Rodriguez FM.1980. Methods Of Analysis For Screening Crops Of Appropriate Qualities. Analytical Services Laboratory, Institute Of Plant Breeding, University of the Philippines, Los Baños

Crentsil D, Gallat S & Bancroft R.1995. Low-Cost Fresh Cassava Root Storage Project achievement to date. In: Proceeding of the Workshop on "Post-harvest Technology Experience in Africa", Accra, 4-8 July 1994. Edited by FAO, Rome

Data ES. 1986. Sweet Potato Storage: Technology Development. In: Root Crop Storage Philippines. Philippine Root Crops research and Training Center, Visayas State College of Agriculture

Hossain MZ, Hassan MK, Hasan GN & Islam MR. 2013. Effects of Modified atmosphere Packaging and Low Temperatures on the Physico-Chemical Changes and Shelf Life of Banana. *Academic Journal of Plant Sciences* 6(1): 19-31. 2013 ISSN 1995-8986

Julianti E, Ridwansyah & Yusraini E. 2012. Effect of Modified atmosphere Packaging on Postharvest Quality of Barangan Banana. *Journal of Food Science and Engineering* 2(2012):38-43