Ascorbic Acid and Potassium Aluminum Sulfate Solutions in Shelf-Life of Philippine Banana Lakatan (Musa acuminata) Species

Liwayway H. Acero
Department of Natural Sciences, San Beda College, Manila Philippines
Email: lilyacero1@yahoo.com

***Abstract*—There are a lot of studies using physico-chemical methods on prolonging shelf-life of bananas. However no published studies conducted on the low cost method of prolonging shelf-life of bananas in Philippine setting. This study focuses on the simple chemical methods that can immediately be used by banana farmers and retailers on how to prolong the shelf-life of *Musa acuminata*. Three treatments (control-no immersion, 50g/l Potassium Aluminum Sulfate, 50g/l ascorbic acid as immersing solution) with three groups (10 minutes, 20 minutes and 30 minutes) was used in this study. Initial weight, average number of ripening days, final weight and cost analysis per treatment was computed. Result showed (significant difference) that the longest ripening days was obtained in treatments and groups immersed (10, 20, 30) in T2 (50g/l Potassium Aluminum sulfate and water solution). Treatment 2 also revealed the highest average final weight after 22 days of shelf-life and the cost of production was also minimal.**

***Index Terms*—musa acuminata, potassium aluminum sulfate, ascorbic acid**

I. Introduction

Banana is not far from coconut as the tree of life owing to its many uses. Aside from being eaten fresh, the ripe fruit can also be processed into jam, candies, and purees. On the other hand, the unripe bananas may be processed into starch and chips. Banana extracts can also be processed into wine, catsup and vinegar. In some areas, especially in the provinces, the banana leaves are believed to be medicinal and can heal open-skin to wounds faster. Aside from being used as packing materials in markets and other areas of trade, the banana leaves are also used for cooking purposes. The same thing goes with the banana blossom, which is an important ingredient in some special Filipino dishes. When dried, banana blossoms have an export market. Like abaca, the banana fiber can be made into ropes, sacks and mats. The banana peel is also being utilized as a material for making paper and paper boards [1].

The Philippines belongs to the region considered the “origin” of the banana plant, hence, bananas thrive very well in the country’s warm and humid climate. *Lakatan* is the variety most widely grown by small-hold banana growers in Northern Luzon, along with *Saba, Latundan, and Bungulan* [2].

Banana is a climacteric fruit. It is usually harvested once they have reached maturity which then undergoes rapid ripening during transit and storage. *Lakatan bananas* if keep in low temperature (18-20 degrees Centigrade) will ripe at 18 days. But if keep in room temperature (25-28 degrees Centigrade) in tropical countries, will ripen on the 5th day as shown in Fig. 1 [3].

The Philippine banana industry is currently one of the top agricultural export earners. The increasing demand worldwide has resulted in greater expansion of area planted to banana, including those in environmentally critical places. Current high chemical input technologies used in banana production have been documented to have significant environmental and public health costs. Second-grade or reject bananas result from is handling of the fruit. They have scars or blemishes caused by fungus, damaged neck, or knife cuts. Sometimes rejection occurs when the fruits do not reach the required size for export. Second-grade bananas, comprising 5% of total production, is normally sold, while rejected fruits are either given away, sold as animal feed, used in the production of puree for baby food, or disposed of in the plantations large open-air dump [4].

Color stage at shelf life and color homogeneity, will result in increased sales, faster rotation and higher profits. Ethylene concentration and air volume in storage areas are the factors that influence shelf-life of *lakatan* [5].

In the Philippines the common method to prolong the shelf-life of banana is by lowering the temperature of the storage area. Provision of facilities for refrigeration entails big capital for the farmers. Thus the author conceptualized a means of prolonging ripening of bananas by low cost scheme, to enable the banana farmers prolong the ripening of their products to increase production

The use of a chemical that oxidizes ethylene to carbon dioxide and water can help banana growers to lessen the cost of production thereby increasing profit. These products may absorb ethylene and extend storage life to some degree but the efficient destruction of ethylene requires large contact surface areas.

Manuscript received January 13, 2015; revised May 3, 2015.

doi: 10.18178/ijfe.1.1.34-38

There are many uses of Ascorbic acid in humans, animals and plants as part of their nutrition. However no studies conducted on the use of ascorbic acid to prolong the shelf-life of bananas. Ascorbic acid has many applications in the food industry. It is used as preservatives in the processed meats and removal of fungus in nuts. It is used to reduce browning in fruits and vegetables; as a processing aid and to reduce nitrosamine formation in cured and raw meat products; to reduce the oxidation of fats and lipids; and as a dough conditioner [6]. Fungi (molds) in nuts that are already roasted can be removed by rinsing it with water and ascorbic acid solution [7]. Covering the nuts with water and Vitamin C powder about ¼ teaspoon for 5 minutes detoxifies it [7]. Ascorbic acid (vitamin C) is an antioxidant that keeps fruit from darkening and enhances destruction of bacteria during drying. A mixture of 2 1/2 tablespoons (34 grams) of pure ascorbic acid crystals into one quart (1000 milliliters) of cold water prevents darkening of fruits [8].

Potassium Aluminum Sulfate locally known as *Tawas* in the Philippines is non-toxic and is used to cure canker sores. Alum shortened the duration of healing on Recurrent aphthous ulceration with lack of any side effects [9]. Potassium Aluminum Sulfate solution can also be used to prolong shelf-life of tomatoes. The *tawas*-water solution was more effective for overripe tomatoes [10].

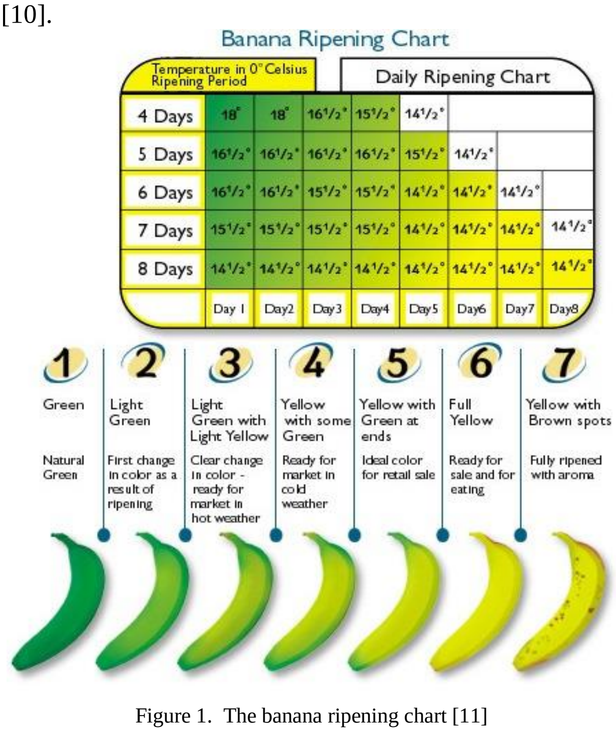

Figure 1. The banana ripening chart [11]

A. Objectives of the Study

This study will help Banana growers and retailers to prolong shelf life of their products using affordable methods thereby increase productivity. Specifically it will determine the shelf life of *lakatan bananas* immerse in Potassium Aluminum Sulfate and ascorbic acid solutions with different immersion time. It also seeks to find out the final weight at ripening. Identify low cost methods on how to prolong shelf life of their products.

II. Materials and Methods

A. Materials

This research employed experimental research method with 3 treatments and 3 groups. Ninety unripe *lakatan* bananas were used. Each treatment was grouped into three and subject to different immersion time (10 minutes, 20 minutes and 30 minutes). Treatment 1, composed of 30 bananas, weighing 2,191 grams as the control. Treatment 2, 30 bananas weighing 2,191 grams and was immersed in 50g/l solution of Potassium aluminum sulfate and tap water. Treatment 3, 30 bananas weighing 2,184 grams was immersed in 50g/l solution of ascorbic acid and tap water. Prior to the conduct of the study materials such as plastic basin, plastic crates as containers, powdered potassium aluminum sulfate, ascorbic acid and digital weighing scale, graduated cylinder, and tap water were prepared.

B. Methods

1) The lakatan bananas

Six point fifty seven (6.57) kilos of *lakatan* bananas was purchased from the same bunch and same source in Davao, Philippines. It was transported to Pasay Manila Philippines and on the experimental site (Makati, Philippines).

2) Preparation of solutions

Using a graduated cylinder and weighing scale the following solutions were prepared; treatment 1 (control) just wash with tap water, treatment 2, 50g/l solution of potassium aluminum sulfate and tap water, treatment 3, 50g/l solution of ascorbic acid and tap water.

3) Grouping of bananas

The banana hands, cut out from the bunch, were washed in clean in flowing water, to remove the dirt and dust that accumulate, as well as the latex that exudes from the cut surface of the bunch. Aside from the three treatments with methods and different solutions, each treatment was grouped into three. *Lakatan* bananas in T2 and T3 was immersed in different solutions as shown in Table I and Fig. 2. The experiment was conducted in a room whose temperature, ranges from 22-30 degrees centigrade.

TABLE I. Experimental Layout

T1G1 737 grams	T2G1 725grams immersed in (50g/l of Potassium Aluminum Sulfate) for 10 minutes	T3G1 721grams banana immersed in 50g/l of ascorbic acid for 10 minutes
T1G2 728 grams	T2G2 733grams immersed in 50g/l of Potassium Aluminum Sulfate for 20 minutes	T3G2 731grams immersed in 50g/l of ascorbic acid for 20 minutes
T1G3 726grams	T2G3 733grams immersed in 50g/l of Potassium Aluminum Sulfate for 30 minutes	T3G3 732grams immersed in 50g/l of ascorbic acid for 30 minutes

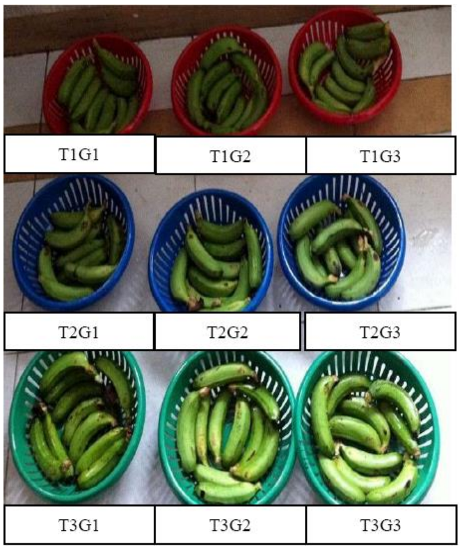

Figure 2. Bananas arranged in experimental lay-out

Each treatment was immersed on the different solutions as what was indicated in the experimental set-up (Fig. 3).

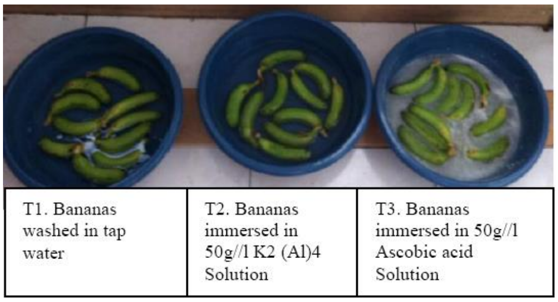

Figure 3. Bananas in different solutions

4) Data gathered

To obtain accurate result, observation was done daily. The following data needed to support the claims in this study are as follows; Average initial weight in grams of the bananas per group per treatment. Number and weight of bananas that ripened after 10 days and every 3 days thereafter. Final weight in grams observation was also recorded. Cost per treatment was also computed. Two-way factorial ANOVA was employed to determine degree of significance among the treatments. Least Significant Difference test was used to identify what treatment is significant over the other.

III. Results and Discussion

A. Average Initial Weight in Grams

Prior to the conduct of the study ninety green bananas was randomly assigned. Each treatment and group comprised of 10 bananas. Table II shows the average initial weight in grams. T1 (control) and T2 (50g/l of Potassium Aluminum Sulfate) had a mean weight of 73 grams andT3 (50g/l of Ascorbic acid) had a mean weight of 73.07 grams. The difference in their mean weight is negligible which means that it is treated equal on the start of the study, to avoid bias on the result.

TABLE II. Initial Weight of Bananas

	G1	G2	G3	Total	Mean
T1-control-no immersion	737	728	726	2191	73
T2 (50g/l. Potassium Aluminum Phosphate)	725	733	733	2191	73
T3 (50g/l. Ascorbic Acid	729	731	732	2192	73.07

B. Number of Bananas That Ripened after 10, 13, 16, 19 and 22 Days after Harvest.

Unripe banana shows a low level of ethylene, a natural plant hormone that regulates every facets of plant growth. During ripening stage, higher ethylene production induces higher metabolic rates of starch to sugar conversion; chlorophyll degradation and unmasking of carotenoids, thus the green bananas progressively turns yellow and dark coloured.

Contrary to the normal ripening process which is 5-7 days after harvesting, bananas starts to ripen (when the peel turns yellow) after 10 days and every three days thereafter. Table III displays the number of bananas that ripened from 10 days after harvest and every 3 days thereafter. Fig. 4 and Fig. 5 are pictures of ripened banana at 10 days and 19 days. Table IV shows that the longest average ripening days was obtained in T2 (17.6 days), followed by T3 (17 days) and the shortest in T1 (15.23 days). ANOVA and LSD test revealed that bananas in T2, (all groups) are significant over T1 and T3. The result implies that immersion of green *lakatan* bananas in 50g/l Potassium Aluminum Sulfate and water could prolong its shelf-life from 5-8 days to 17.6 days. The antioxidant content of *Alum* oxidizes ethylene to carbon dioxide and water, limiting the increase in ethylene that speeds up fruit ripening.

TABLE III. Number of Bananas That Ripened from 10-22 Days after Harvest

	Group 1					Group 2					Group 3				
	10 days	13 days	16 days	19 days	22 days	10 days	13 days	16 days	19 days	22 days	10 days	13 days	16 days	19 days	22 days
T1	7	0	1	2	0	3	0	3	2	2	4	1	0	4	2
T2	3	3	1	1	2	1	0	2	4	3	0	0	0	8	2
T3	3	0	1	4	2	3	1	0	4	2	0	1	3	4	2

Banana crown browning can be prevented or reduced using suitable antioxidants which is present in some safe chemicals. The most important of these chemicals are aluminum potassium sulphate [12] .The best antioxidants in reducing crown browning were thiourea and potassium aluminum sulfate which are sulfur-containing compounds and had an antioxidant activity. Banana hands stored at 14 ℃ had significantly less crown browning as compared to those kept at 35℃ because the lower temperature reduced the activity of polyphenoloxidase enzyme which is responsible for banana crown browning [13].

Similar mild treatments has been employed with fresh cut bananas or shelf life enhancement by the combined action of chemical dip with 1% (w/v) calcium chloride, 0.75% (w/v) ascorbic acid and 0.75% (w/v) cysteine and/or combined with a Carrageenan coating and/or combined with controlled atmosphere (3% O_2+10% CO_2) [14].

TABLE IV. AVERAGE RIPENING IN DAYS

	G1	G2	G3	total	Mean
T1	12.4	16	17.3	45.7	15.23^a
T2	14.8	18.4	19.6	52.8	17.6^b
T3	16.6	16.3	18.1	51	17^a

Legend; Mean with the same superscript are not significant *at p =.05*
Mean with different superscript are significant at p =.05

ANOVA						
S.V	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	9.082	2	4.5411	$3.056^{n.s}$	0.156	6.944
Columns	21.282	2	10.641	$7.161^{\#}$	0.047	6.944
Error	5.944	4	1.4861			
Total	36.308	8				

Legend; **significant at p=.05*
n.s = not significant at p=.05

Figure 4. Bananas at 10 days after harvest

Figure 5. Bananas at 19 days after harvest

C. Final Weight in Grams

Final weight as shown in Table V was obtained by weighing the bananas as soon as it got ripe. Bananas in T2 had the highest final weight in grams, with a mean of 63.6 grams, followed by bananas in T1 with a mean of 62.57 grams. The least was in T3 with a mean weight of 59.4 grams. No significant difference was obtained in the Analysis of variance. The result means that the final weight was not affected by the different solutions.

Ethylene gas is released by the chemical reactions involved in the ripening process. This results in a slight weight loss. More importantly, the banana skin and the inside of the banana become softer and more permeable to water loss. The ripening process also releases other volatile compounds into the air. All of the evaporations result in weight loss, which is a consequence of the ripening process.

Banana is one of many fruits that undergo ripening. Ripening is a physiological maturation catalyzed by the plant hormone ethylene (C_2H_4). Ethylene starts a cascade of reactions leading to a respiratory climacteric (basically a brief but significant spike in respiration). Carbohydrates are used as substrate, hence the decrease in weight. Thus there is a direct correlation between weight loss and ripening. However, weight loss is also a cause of the ripening process. During the climacteric, ethylene is produced in *situ* as one product of respiration. This induces the production of more ethylene, which further ratchets up the process [15].

TABLE V. FINAL WEIGHT IN GRAMS

	G1	G2	G3	Total	Mean
T1-control-no immersion	646	625	606	1877	62.57
T2 (50 g/l. Potassium Aluminum Phosphate)	629	663	615	1907	63.6
T3 (50 g/l. Ascorbic Acid	599	586	598	1781	59.4

ANOVA						
SV	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	2790.2	2	1395.1	3.843	0.117	6.944
Columns	672.2	2	336.1	0.926	0.467	6.944
Error	1451.8	4	362.95			
Total	4914.2	8				

Legend; *n.s = not significant at p=.05*

TABLE VI. COST PER TREATMENT

Item	T1	T2	T3
1.Cost of Bananas	PhP57.63	PhP57.63	PhP57.65
2.Cost of chemicals	PhP00.00	PhP 5.00	PhP25.00
3.plastic basket	PhP15.00	Ph15.00	Ph15.00
4.plastic basin	PhP15.00	Ph15.00	Ph15.00
5.depreciation of digital balance	PhP 5.25	PhP 5.25	PhP 5.25
TOTAL	PhP92.88	PhP98.15	PhP142.90

D. Cost per Treatment

Table VI displays the cost per treatment incurred in this study. T1 had the lowest cost per treatment

(PhP92.88). T1 is the control which means no additional chemicals was added. T2 follows (PhP98.15) and the biggest cost per treatment is in T3 (PhP142.90). Ascorbic acid is more expensive than Potassium Aluminum Sulfate. Thus, the researcher would like to recommend the use of Potassium Aluminum sulfate solution as immersing solution for unripe *lakatan* bananas in areas where refrigeration is very expensive.

IV. Conclusion

Growers and retailers of climacteric plants like banana in tropical countries are beset by rapid ripening of their products. This study focuses on the low cost methods in prolonging the shelf-life of Lakatan banana. The result expressed that the shelf-life of Philippine banana-*lakatan* species could be prolonged by using non expensive method, like the immersion of bananas for 10, 20 or 30 minutes in 50g/l Potassium Aluminum Sulfate, in areas where refrigeration is not possible. In remote areas where electricity is not yet present, banana farmers could prolong the ripening process by the using Potassium Aluminum Sulfate as immersing solution, thereby increasing profit. A follow-up study on the use of this solution on other tropical fruits with peel should be conducted.

Acknowledgment

The author acknowledges her invaluable Professors from University of the Philippines-Open University, Dr. Ricardo Bagarinao and Prof. Sol Marie Hidalgo. Administrators and professor of the College of Arts and Sciences, San Beda College Manila; Dr. Tessie R. Da Jose-Dean, Dr. Christian Bryan Bustamante Vice-Dean, Dr. Fedeliz S. Tuy, Associate Vice-Dean for their encouragement.

References

[1] D. P. Lejano, "The future brightens for Philippine banana," *BAR Research and Development Digest*, vol. 11, no. 1, pp. 1, Jan.-Mar. 2009.

[2] T. K. Lim, *Edible Medicinal and Non-Medicinal Plant*s, Springer Science and Business Media, 2012. ch. 7, pp. 495.

[3] Esguerra, *et al.*, "Regulation of ripening and disease control in Lakatan and Latundan bananas," Post Harvest Seed Sciences Division, Crop Science Cluster, College of Agriculture, University of the Philippines Los Banos Laguna, Apr. 2001, pp. 1.

[4] R. P. Calderon and A. C. Rola, "Assessing benefits and costs of commercial banana production in the Philippines," Institute of Planning and Policy Studies, College of Public Affairs, University of the Philippines Los Banos Laguna, vol. 3, no. 7, pp. 8-9, 2003.

[5] M. Madrid, "Improved banana ripening results in 25-33% more sales at retail: Find out how," *Fruit Profits*, *EU, North Africa and Latin America*, vol. 1, no. 1, pp. 1, 2011.

[6] Takeda. (2014). Vitamin C in food processing. Takeda Canada Vitamin and Food. Inc. Takeda U.S.A Inc. [Online]. 1(1). pp. 1. Available: http://www.mratcliffe.com/images/vcb.pdf

[7] H. Clark, *Moldy Foods and Aflatoxin*, World Press and Athualpa, 2015. ch. 3, pp. 381-395.

[8] P. Kendall and J. Sofos. (Aug. 2014). Drying fruits. Colorado State University, Extension Division. [Online]. 1(1). pp. 1. Available: http://www.ext.colostate.edu/pubs/foodnut/09309.html.

[9] J. Tagreed, *et al.*, "Evaluation of the efficacy of alum suspension in treatment of recurrent ulcerative," *Science Journal*, vol. 17, no. 2, pp. 70-71, 2005.

[10] M. Cemanes and P. Gabornes, "Firming and shelf life of tomatoes as affected by alum (Tawas) and lime (Apog) treatment," Leyte National High School, Leyte Philippines, 2013.

[11] (2014). All about ripening. Isopan Insulation Pvt. Ltd., India. [Online]. 1(1). pp. 1. Available: http://isopaninsulation.com/technologies/banana-ripening

[12] E. Ismail, *et al*., Effects of antioxidants and dehandling methods under different temperature levels on control of banana crown browning. *Research Gate Journal*. [Online]. 1(1). pp. 1. Available: http://www.researchgate.net/publication/237564629_Effects_of_Antioxidants_and_Dehanding_Methods_under_Different_Temperature_Levels_on_Control_of_Banana_Crown_Browning.

[13] L. Hag and G. M. Mortuza, "Control of banana fruit rots by Alum," *Agricultural Research Corporation Sudan*, vol. 32, no. 2, pp. 70-71, 1996.

[14] Bico, *et al*., "Chemical dips and edible coatings to retard softening and browning of fresh-cut banana," *International Journal of Postharvest Technology and Innovation*, vol. 2, no. 1, pp. 13-24, 2010.

[15] T. Durham, "Banana mass and ripening," Newton and Ask A. Scientist, Argonne National Laboratory's Educational Program, Argonne, Illinois, USA, 2011.

Liwayway H. Acero is a member of Asia Pacific Chemistry, Biology, Environment, Engineering Society, editorial member for Global Science and Technology Forum. Educational background: Doctor of Education major in Educational Management from Palawan State University on March 2003. She conducted her dissertation as research student at Okayama University Graduate School of Education in Japan on March to June 2000. She got her diploma in science teaching -major in biology in 2009 from the University of the Philippines-Open University in Los Banos Laguna. She received her Master of Science degree in agricultural education major in agricultural education minor in Plant Science (Agronomy) from the Western Philippines University in Aborlan, Palawan, Philippines on April 1993. She got her Bachelor of Science degree in Agriculture (*cum laude*), major in Animal science and minor in Plant Science (agronomy) from the Western Philippines University in Aborlan, Palawan Philippines on April 1986.

She is an associate professor and the chairperson of the Department of Natural Sciences, College of Arts & Science in San Beda College, Mendiola, Manila, Philippines. Prior to her employment in San Beda College in Manila, she had served as professor for 20 years in Western Philippines University in Puerto Princesa City, Palawan, Philippines. She handled several administrative works aside from teaching profession. She served as assistant dean of Western Philippines University, Puerto-Princesa Campus, and Director for Instruction, Department Chairperson of the Education Department chairperson of the Agribusiness Department & chairperson for the thesis committee.

She had 8 publications. Six of which are international publications.