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Evaluation of ripening period, shelf-life, and physiological properties of Sobri (*Musa cavendish*) and Sagor (*Musa oranta*) bananas triggered by ethephon and calcium carbide

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Abstract

The current work emphasis on the influence of using natural and artificial (ethephon and calcium carbide) process on bananas by sensory observation. The objective of the study was to evaluate the ripening period, shelf-life and other physiological properties of bananas using the natural and the artificial method. Ethephon and calcium carbide with different concentrations, heat, and natural process were applied for the evaluation of two banana species. The result shows different shelf-life, ripening period, and physiological properties of both bananas which were monitored through the physical appearance and sensorial analysis. The ripening period and shelf-life were between 2-3.5 days in both bananas treated with ethephon. For calcium carbide treated banana, ripening period evaluated as 2-3 days for Sagor and 3-4 days for Sobri with same shelf-life duration approximately 2-3 days. Ripening period and Shelf-life for heat applied both bananas were about 4-5 and 3-4 days, respectively. Moreover, it is observed that naturally ripening process took 5-6 and 7-8 days for Sagor and Sobri bananas, respectively with the shelf-life of 5-6 days. Bananas (both) treated with ethephon exhibited attractive bright yellow color and stalk color was green for Sagor while it was yellow for Sobri bananas. Calcium carbide treated both bananas had same peel color with different flavor and stalk color. Heat applied both bananas found with same peel color like light yellow, with little flavor and green in stalk color. Overall, the effect of natural process is found to be better with respect to longer shelf-life approximately 5-6 days, attractive flavor, and soft texture than the artificial process. Among artificially ripened bananas the effect of heat process is better with respect to shelf-life around 3-4 days and application of ethephon process is better with respect to physiological properties.

1. Introduction

Banana (Musa acuminata cv. Cavendish) is an economically very important humid fruit belonging to the Musaceae family with numerous diversities (Prabha *et al*., 1998). In 2003 India, Bangladesh, Ecuador, Brazil, and China delivered almost 50% of the total production for about 75% of world production among the top ten banana manufacturing countries (Zhang *et al*., 2005). Banana is the world's fourth paramount food crop which is consumed after rice, wheat, and corn (Mahajan *et al*., 2010). In developing countries, banana is grown in small areas or farms where the contribution is greater in socioeconomic achievement of the farmers due to its large construction period (Omulo *et al.*, 2015). The production of this fruit originates14 months later after planting and can be harvested till next 10 years. Therefore, the constant harvesting of banana offers farmers with endless profit throughout the year (De Beer and Zigawa, 2010).

Another reason for being the best-consumed fruit of banana is its various nutritional values such as vitamins, minerals, and energy all over the world (Adao and Gloria, 2005). Moreover, it is a significant staple food throughout the world. The United Nations Food and Agriculture Organization stated that banana is in fourth position among other supreme crops after the main cereals (FAO, 2010). As banana producing countries Bangladesh ranked 14th position globally and produce around 1 million tons banana each year (Hossain *et al.,* 2016).

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In Asia, India is reflected as the foremost banana producer country (Morton, 1987). According to, Hossain *et al.* (2016), the key areas for banana production in Bangladesh are Gazipur, Narsingdi, Rangpur, Nator, Bogra, Faridpur, Pabna, Khulna, and Noakhali. Banana contains all essential vitamins, minerals, carbohydrates, and dietary fibers (Islam *et al*., 2018). Safe utilization of banana is a noteworthy worry for everybody as the dishonest trader to affix the aging of bananas, is applying different restricted maturing operators, which can cause the genuine medical issue (Siddique *et al*., 2010; Akter and Bari, 2018).

Chemicals are used for the preservation and ripening process in bananas, such as ethephon, calcium carbide (CaC_2), calcium oxide (CaO), and ethylene, (Bari *et al*., 2018). Acetylene acts as a natural ripening agent like ethylene which is produced from chemical reaction between calcium carbide and water and fastens the ripening process (Bari *et al*., 2018). This increasing level of ethylene is responsible to promote the ripening process in fruits like melon, banana and avocado (Bower *et al*., 2002; Siddique *et al*., 2010; Bari *et al*., 2017). Another ethylene creating compound, ethephon, is utilized in post-harvest management because of its fundamental factor to quicken the maturing and shading process in bananas and mangoes (Lakshminarayana *et al*., 1975). It was reported that the sudden increase of ethylene production in fruit indicates the opening of ripening, which represents the rapid increase of the respiration activity (Palomer *et al*., 2005).

Ethephon treatment is popular to increase the degradation process of chlorophyll; moreover, this process is responsible for the expression of pigment namely β-carotene (Basak and Akter, 2018). During ripening period, some alterations observed with the changes of peel color, texture or flavor, synthesis of aromatic compounds, transformation of starch into sugar, lessening of polyphenols and others (Clendennen and May, 1997; Chen and Ramaswamy, 2002). These ripening agents are not only responsible for changing nutritional value but also have hazardous dental health effects (Islam *et al*., 2018). So, the growers and manufacturers, who are associated with fruit business, must have ample knowledge about the perilous effect of these ripening agents. However, this study focused on the effectiveness of ripening process for identifying longer shelf-life and better physiological properties of banana. Moreover, the popular artificially ripening agents ethephon and calcium carbide were utilized to compare with natural process for the evaluation of ripened banana properties.

2. Materials and methods

2.1 Sample preparation

A lab-based observational study was performed in the laboratory of Food Technology and Nutritional Science Department, Mawlana Bhashani Science and Technology University, Santosh, Tangail-1920. A total of two types of banana namely Sagor and Sobri were collected from Tangail in Dhaka. Banana is a popular nutritious fruit among the people and mostly consumed. Well communication system, and higher yield of banana production for commercial purposes, which is supplied in different areas of the country. The duration of the study period was from October 2015 to March 2017.

2.2 Size of samples

The study was conducted in two different batches; batch A and B. Table 1 shows the experimented sample size of both bananas. Total of 640 pieces of bananas were collected for this experimental study. In batch A, there were 160 pieces Sagor bananas and 160 pieces of Sobri bananas. For batch B the amount was similar.

2.3 Sample analysis

The difference of both bananas ripened by using natural and chemical process was evaluated by sensory observation. The evaluation process was performed by a

Table 1. Experimented sample size of bananas

Batch	Group	Concentration	Sagor banana	Sobri banana
A	Group 1	Natural	40	40
	Group 2	Ethephon 1 mL/L	20	20
		Ethephon 2 mL/L	20	20
	Group 3	CaC_2 2 g	20	20
		CaC_2 5 g	20	20
	Group 4	Heat	40	40
B	Group 1	Natural	40	40
	Group 2	Ethephon 1 mL/L	20	20
		Ethephon 2 mL/L	20	20
	Group 3	CaC_2 2 g	20	20
		CaC_2 5 g	20	20
	Group 4	Heat	40	40

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group of trained people consisting of fifteen members. Several physiological properties such as skin and stalk color, ripening period, flavor and shelf-life were also observed by this group.

2.4 Sample application of ripening agents

Ethephon concentration: 1mL/L and 2 mL/L of ethephon concentrations were used in reagent preparation. Some local illegitimate trader applied a concentration of 16-20 mL ethephon per 16-liter water in 1000 pieces bananas for the ripening process. Bananas were cut from bunches and separated into hands and drowned into two different bowls containing 1 mL/L and 2 mL/L ethephon concentration mixed with water. Then the hands of bananas were removed from the water and put them into different cartoon bags.

Calcium carbide reagent: 2 and 5 g of calcium carbide was wrapped in two separate papers (according to local illegitimate businessman application) and dropped into different carton bags containing bananas. They were tied up for the observation and stored in separate rooms.

Control preparation: Control bananas were stored separately in a different cartoon box with straw to ripe naturally. All samples were observed regularly and monitored to write down the changes of smell, skin or stalk color, spot, and other physical properties (Bari *et al*., 2018).

3. Results and discussion

In this study, shelf-life, ripening time, physiological properties of Sobri bananas are monitored by sensory evaluation. Moreover, the result from this experiment is compared with Sagor banana which was completed before this study. During ripening process, chlorophyll degradation revealed the carotenoids pigments from fruit skin and change into golden yellow color. This occurs due to normal respiration process of climate and ethylene gas production at 20-30°C temperature (Yang *et al*., 2009; Bari *et al*., 2018).

3.1 Ripening time

The ripening time of Sobri banana is presented in Table 2. For batch A, 1 mL/L ethephon treated bananas took 3 and half days to ripe completely, on the other hand 2 mL/L ethephon treated bananas took 3 days only. The result showed that for batch B the ripening period of banana was same as batch A banana. Banana treated with 2 g calcium carbide took 4-4.5 days as opposed to 5 g calcium carbide applied banana which took 3-3.5 days to ripe completely. Bananas for batch B took 3-4 days respectively. Bananas that were treated with heat took 4.5 days to ripe completely in comparison to naturally ripened banana took approximately 7-8 days.

Table 2. Ripening time of Sobri banana of different ripening processes.

Group	Ripening process	Ripening Time (day), Sample Type	
		Batch A	Batch B
1	Natural (control)	8	7
2	Ethephon (1 mL/L)	3 and half	3 and half
	Ethephon (2 mL/L)	3	3
3	Calcium Carbide (2 g)	4 and half	4
	Calcium Carbide (5 g)	3 and half	3
4	Heat	4 and half	4 and half

3.2 Shelf- life

The differences in shelf-life between batch A and batch B Sobri banana is presented in Figure 1. Chemicals, heat, and natural process were applied for banana ripening. As shown in Figure 1, 2 mL/L ethephon treated Sobri bananas showed shelf-life ranges from 2 to 3 days and for 1 mL/L ethephon treated bananas it ranges from 3 to 4 days. The shelf-life observed for 2 g calcium carbide treated banana was 3.5 days in batch A and 3 days in batch B. Shelf-life for 5 g calcium carbide treated banana was found as 2 and 3 days for batch A and batch B respectively. Bananas ripened using heat process showed longer shelf-life than those were ripened by using chemicals; 3 days for batch A and 4 days for batch B banana. On the other hand, naturally ripened Sobri bananas for both batches A and B had shelf-life of 5 and 6 days, respectively.

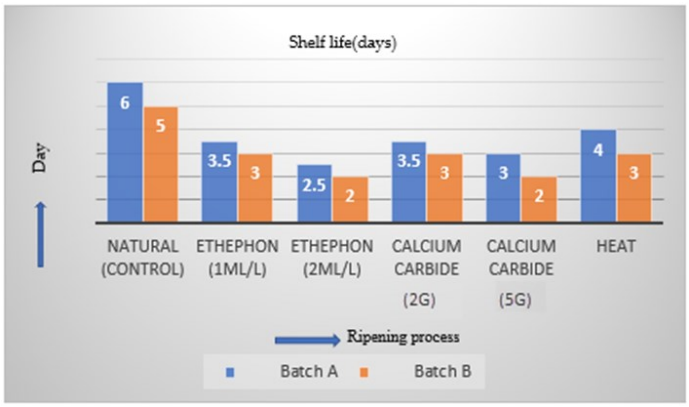

Figure 1. Comparison of the shelf-life between batch A and batch B Sobri bananas

3.3 Peel/skin color

Table 3 represents the color of the banana peel which was treated with 1 mL/L and 2 mL/L ethephon and showed a uniform and attractive yellow color with no spots after ripened completely. For bananas treated with 2 g and 5 g calcium carbide, they developed a uniform bright yellow color after full ripening process. Sobri bananas took 4.5 days to develop color while ripened by using heat process. At the beginning of the ripening

Table 3. The evaluation of different physiological properties of Sobri bananas ripened using chemicals, heat and natural process.

Group	Ripening process	Physiological properties				
		Ripening time (days)	Peel color	Stalk color	Flavor	Shelf-life (days)
1	Natural (control)	7-8	Unattractive, light yellow	Blackish yellow	Nice	5-6
2	Ethephon (1 mL/L)	3 and half	Attractive, uniform, bright yellow	Yellow	Little	3 and half
	Ethephon (2 mL/L)	3	Attractive, uniform, bright yellow	Yellow	Little	2-3
3	CaC_2 (2 g)	4	Uniform, bright yellow	Yellow	Little	3
	CaC_2 (5 g)	3	Uniform, bright yellow	Yellow	Little	2-3
4	Heat	4 and half	Light yellow	Green	Little	3-4

process, banana showed light yellow color where it showed a bright yellow color including spot when ripened completely. Some banana pulp was observed with red spots and hard texture. Naturally ripened bananas had unattractive, light yellow color and pulp became soften when fully ripened.

3.4 Stalk color

The stalk color of ethephon treated bananas for batch A and B was observed as yellow color which is shown in Table 3. Stalk remained fresh and yellow after the full ripening process. Stalk of calcium carbide applied bananas were yellow with rising peel color. After fully ripening process, stalk of banana remained yellow and fresh, but peel became bright yellow. In the beginning stage, the stalk was green color in heat applied bananas and remained fresh even when banana starts to spoil. Moreover, stalk color found as blackish yellow in naturally ripened bananas and became more blackish and shrunk after complete ripening process.

3.5 Flavor of ripened banana

In the beginning stage of ripening, no flavor was observed in bananas treated with ethephon for batch A and B but the flavor was poor in the last stage of ripening. Similarly, no flavor was found in calcium carbide treated bananas at the beginning stage but after fully ripened banana developed little flavor. In case of naturally ripened banana, they showed pleasant flavor when ripened completely.

3.6 Photographic representation of bananas

Figure 2 shows the pictures of ripened Sobri and Sagor banana after using chemicals, heat, and natural process.

Comparison of ripening time and shelf-life between Sobri and Sagor bananas are presented in Table 4. The ripening time of control, ethephon, calcium carbide and heat-treated Sobri bananas were ranged from 7 to 8, 3 to 3.5, 3 to 4 and 4.5 days, respectively. On the other hand, Sagor bananas had 5 to 6, 2 to 3, 2 to 3 and 4 days,

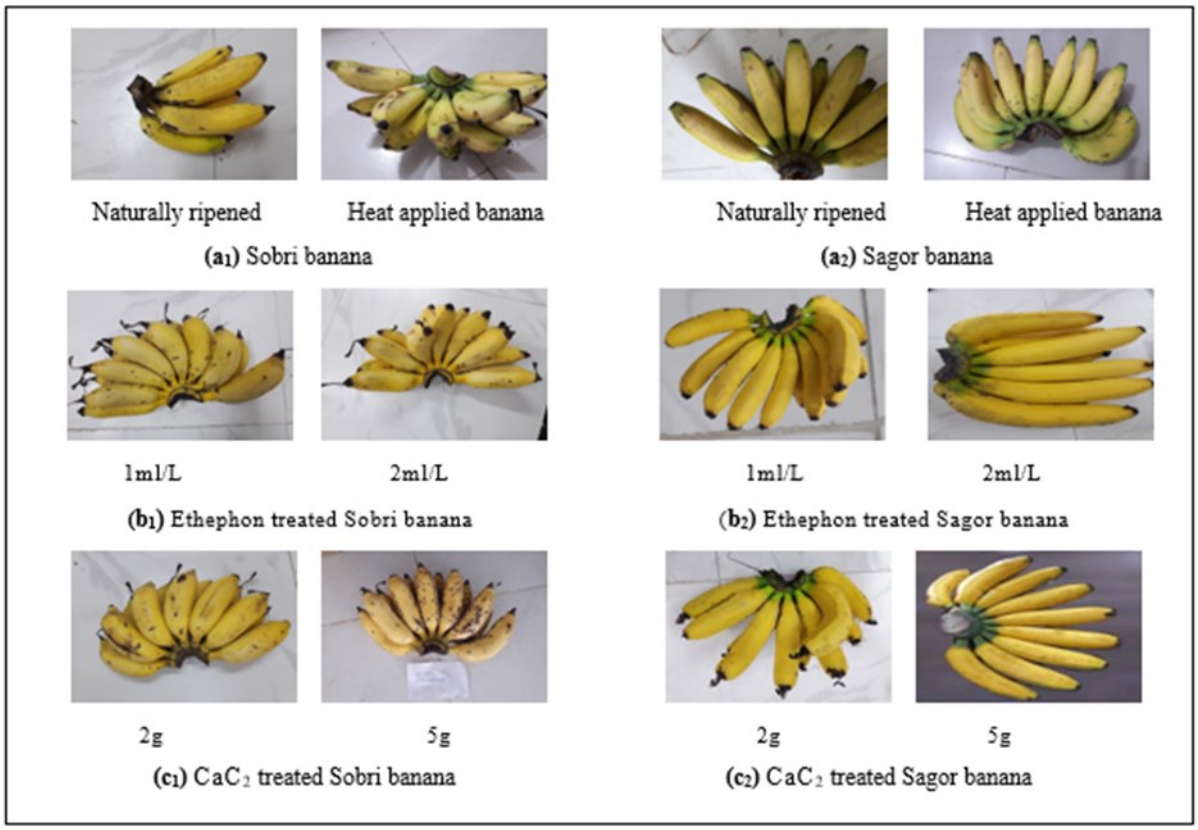

Figure 2. Photographic presentations of Sobri and Sagor bananas using different process.

Table 4. Comparison of ripening time and shelf-life between Sobri and Sagor bananas

Group	Ripening process	Ripening Time (days)				Shelf-life (days)			
		Batch A		Batch B		Batch A		Batch B	
		Sobri	Sagor	Sobri	Sagor	Sobri	Sagor	Sobri	Sagor
1	Natural (control)	8	6-7	7	5-6	6	6	7	5
2	Ethephon (1 mL/L)	3 and half	3	3 and half	3	3 and half	3 and half	3	3
	Ethephon (2 mL/L)	3	2	3	2	2 and half	3	2	2 and half
3	Calcium Carbide (2 g)	4 and half	3	4	3	3 and half	3	3	2 and half
	Calcium Carbide (5 g)	3 and half	2	3	2	3	2 and half	2	2 and half
4	Heat	4 and half	4	4 and half	4	4	4	3	3 and half

Table 5. Comparison of different physiological properties between Sobri and Sagor bananas

Group	Ripening process	Physiological properties of banana					
		Peel color		Stalk color		Flavor	
		Sobri	Sagor	Sobri	Sagor	Sobri	Sagor
1	Natural (control)	Unattractive, light yellow	Unattractive, light yellow	Blackish yellow	Blackish yellow	Nice	Nice
2	Ethephon (1 mL/L)	Attractive, uniform, bright yellow	Attractive, uniform, bright yellow	Yellow	Green	Little	Poor
	Ethephon (2 mL/L)	Attractive, uniform, bright yellow	Attractive, uniform, bright yellow	Yellow	Green	Little	Poor
3	Calcium Carbide (2 g)	Uniform, bright yellow	Uniform, bright yellow	Yellow	Green	Little	Light
	Calcium Carbide (5 g)	Uniform, bright yellow	Uniform, bright yellow	Yellow	Green	Little	Light
4	Heat	Light yellow	Light yellow	Green	Green	Little	Little

respectively. The result showed that Sobri bananas took higher time to ripe than Sagor bananas. It also appeared that for both bananas naturally ripening process took extensive time to ripe than artificially ripened. For the determination of shelf-life, the result revealed that Sobri bananas had higher shelf-life than Sagor bananas. The shelf-life of natural and artificially ripened Sobri was ranged from 6 to 7 and 2 to 4 days exhibited in (Table 4). In case of Sagor bananas it was 5 to 6 and 2 to 3 days.

Dissimilation between several physiologic characteristics such as, skin color, stalk color, and flavor of Sobri and Sagor bananas are determined in this study, which is shown in Table 5. The result showed that peel color and flavor for both bananas ripened by the different processes were same. It is also observed that the stalk color of naturally ripened and heat-treated Sobri bananas was similar to that of Sagor bananas. The stalk color of chemically ripened Sobri bananas was quite comparable to Sagor bananas. For Sobri bananas it was yellow whereas it was green for Sagor bananas. Further research is needed to investigate the reason behind the difference of stalk color of chemically ripened Sobri and Sagor bananas.

4. Conclusion

The difference between natural and artificially ripened bananas has been observed. Bananas were ripened by using heat and different concentrations of ethephon and calcium carbide (CaC_2) reagents. Ethephon treated both Sagor and Sobri bananas showed an attractive bright color (yellow), fresh and soft texture without any spot. The only difference found in both bananas were green stalk color in Sagor and yellow stalk color in Sobri. The results found in calcium carbide applied bananas were bright yellow in color, smooth body texture with little flavor, spotless, and green stalk in Sagor where yellow stalk color in Sobri bananas. Heat -treated banana showed a light-yellow color, fresh texture, and green stalk color without any flavor. On the other hand, naturally ripened banana showed less attractive color including spots, blackish yellow color stalk, and nice flavor. The pulp texture of artificially ripened bananas found hard in the first stage of the ripening process where it was soft in naturally ripened bananas since the beginning stage. To conclude, naturally ripened bananas showed longer shelf-life, nice flavor, and soft texture than ethephon and calcium carbide treated bananas.

Conflict of Interest

The authors declare no conflict of interest.

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References

Adao, R.C. and Glória, M.B. (2005). Bioactive amines and carbohydrate changes during ripening of "Prata" banana (*Musa acuminata* x *M. balbisiana*). *Food Chemistry*, 90(4), 705–711. https://doi.org/10.1016/j.foodchem.2004.05.020

Akter, B. and Bari, L. (2018). Determination of formaldehyde in commercial noodles collected from Dhaka city, Bangladesh, by high performance liquid chromatography. *Annals Food Science and Technology*, 19(2), 341-348.

Bari, L., Akter, B., Talukder, N., Islam, A., Rana, M.S, and Akter, D. (2018). Identification of different physiological properties of sagor bananas ripened by using chemicals, heat, and natural process. *Annals Food Science and Technology*, 19(2), 300-306.

Bari, L., Akter, B., Talukder, S., Shaha, G.K. and Sadia, M.K. (2017). Chemicals used for growth, ripening and storage of lychee in Bangladesh. *Annals Food Science and Technology*, 18(3),463-467.

Basak, P. and Akter, B. (2018). Comprehensive investigation on banana ripening by using natural agents and chemicals. *Annals Food Science and Technology*, 19(2), 307-315.

Bower, J., Holford, P., Latché, A. and Pech, J.C. (2002). Culture conditions and detachment of the fruit influence the effect of ethylene on the climacteric respiration of melon. *Postharvest Biology and Technology*, 26(2), 135–146. https://doi.org/10.1016/S0925-5214(02)00007-8

Chen, C.R. and Ramaswamy, H.S. (2002). Color and texture change kinetics in ripening bananas. *LWT-Food Science and Technology*, 35(5), 415–419. https://doi.org/10.1006/fstl.2001.0875

Clendennen, S.K. and May, G.D. (1997). Differential gene expression in ripening banana fruit. *Plant Physiology*, 115(2), 463-469. https://doi.org/10.1104/pp.115.2.463

De Beer, Z.C. and Sigawa, A. (2010). Banana (*Musa* spp.) Juice Production in South Africa. *Acta Horticulturae,* 879, 233–238. https://doi.org/10.17660/ActaHortic.2010.879.22

FAO. (2010). Review of Food Safety and Quality Related Policies in Bangladesh., p. 1-28. Rome: Food and Agriculture Organization of the United Nations.

Hossain, M.M., Faruq, A. and Ajit, K.M. (2016). Forecasting of Banana Production in Bangladesh. *American Journal of Agricultural and Biological Sciences*, 11(2), 93-99. https://doi.org/10.3844/ajabssp.2016.93.99

Islam, M.N., Imtiaz, M.Y., Alam, S.S., Nowshad, F., Shadman, S.A. and Khan, M.S. (2018). Artificial ripening on banana (*Musa* Spp.) samples: Analyzing ripening agents and change in nutritional parameters. *Cogent Food and Agriculture*, 4(1), 1477232. https://doi.org/10.1080/23311932.2018.1477232

Lakshminarayana, S., Shetty, S. and Krishnaprasad, C.A. (1975). Accelerated ripening of Alphonso mangoes by the application of ethrel. *Tropical Science*, 17, 95-101.

Mahajan, B.V.C., Tajender, K., Gill, M.I.S., Dhaliwal, H.S., Ghuman. B.S. and Chahil, B.S. (2010). Studies on optimization of ripening techniques for banana. *Journal of Food Science and Technology*, 47(3), 315–319. https://doi.org/10.1007/s13197-010-0050-0

Morton, J.F. (Ed.). (1987). Banana. In Fruits of warm climates. Miami, USA: Florida Flair Books.

Omulo, G., Banadda, N. and Kiggundu, N. (2015). Harnessing of banana ripening process for banana juice extraction in Uganda. *Journal of Food Science and Technology*, 6(4), 108-117. https://doi.org/10.14303/ajfst.2015.039

Palomer, X., Roig-Villanova, I., Grima-Calvo, D. and Vendrell, M. (2005). Effects of nitrous oxide (N2O) treatment on the postharvest ripening of banana fruit. *Postharvest Biology and Technology*, 36(2), 167-175. https://doi.org/10.1016/j.postharvbio.2004.12.008

Prabha, T.N. and Bhagyalakshmi, N. (1998). Carbohydrate metabolism in ripening banana fruit. *Phytochemistry*, 48(6), 915-919. https://doi.org/10.1016/S0031-9422(97)00931-X

Siddique, M.W. and Dhua, R.S. (2010). Eating Artificial Ripened Fruit is harmful. *Current Science*, 699(12), 1664-1668. https://doi.org/10.1016/j.foodchem.2008.06.006

Yang, X.T., Zhang, Z.Q., Joyce, D., Huang, X.M., Xu, L.Y. and Pang, X.Q. (2009). Characterization of chlorophyll degradation in banana and plantain during ripening at high temperature. *Food Chemistry*, 114(2), 383–390. https://doi.org/10.1016/j.foodchem.2008.06.006

Zhang, P., Whistler, R.L., Bemiller, J.N. and Bruce, R. (2005). Banana starch: production, physicochemical properties, and digestibility-a review. *Carbohydrate Polymers*, 59(4), 443-458. https://doi.org/10.1016/j.carbpol.2004.10.014

