EFFECT OF CHEMICAL RIPENING AGENT (ETHEPHON) ON THE NUTRITIONAL AND METAL COMPOSITIONS OF BANANA (PHEE-GYAN-HNGET-PYAW)

MyaThwet Win[1], Khin Lay Naing[2], Myat Myat Thaw[3]

Abstract

Fruit ripening is a natural process which also can be stimulated using different artificial fruit ripening agents. The effect of chemical ripening agent (ethephon) on the nutritional and metal compositions of banana (Phee-gyan-hnget-pyaw) is investigated work. This includes three types of banana (Phee-gyan-hnget-pyaw): natural ripening (untreated), treatment with different dosages of ethephon (250, 500 and 1000 ppm) and market samples. Nutritional values of banana (Phee-gyan-hnget-pyaw) samples were determined by the method of Association of Official Analytical Chemists (AOAC). The moisture content, total ash and fat contents, the protein, crude fiber, carbohydrate and energy values in all samples were measured. The values of reducing sugar and acidity in treated samples were observed to be higher than natural ripening (untreated) sample. Ascorbic acid (vitamin C) contents have been measured by using two methods, the first AOAC's titrimetric method and the second UV-visible spectrophotometry method. It was observed that the amount of ascorbic acid (vitamin C) content was found to be higher in natural ripening (untreated) sample compared with ethephon-treated and market samples. The pH values of all samples were found within the acid range. Some minerals (K, Na, Ca, Mg, Fe, Mn, Zn, Cu, Cd and Pb) were determined by using atomic absorption spectrometer (AAS). Cadmium and lead contents in all samples were not found. Potassium is the highest value in natural (untreated) samples. Phosphorus contents in all samples were determined by using UV-visible spectrophotometer. Phosphorus content gradually increased in all ethephon-treated samples. It was found that the chemically treated banana samples ripened more faster about three times than untreated ones (natural).

Keywords: banana, ethephon, nutritional values, atomic absorption spectrometer, UV-visible spectrophotometer

1. MRes Student (2016-17), Department of Chemistry, University of Yangon & Senior Scientist, Analysis Department, Department of Research and Innovation
2. Dr, Associate Professor, Department of Chemistry, Moehnyin Degree College
3. Dr , Professor, Department of Chemistry, University of Yangon

Introduction

Banana is one of the major crops which are cultivated all over the world. Banana is grown in more than 120 countries throughout the tropical and subtropical regions (Gunasekara*et al*., 2015). Banana is considered as popular stable food for more than 400 million people (Sanjeev and Eswaran, 2008). It is an alternative perennial fruit crop for farmers due to its high economic gains throughout the year. When considering the production, it is the second important crop in the world. India is the largest producer of banana with 23.205 million metric tonnesof annual productions (Kulkarni*et al*., 2011).Banana is one of the most important and common fruits in Myanmar (SeinHla Bo, 2003). It grows in all states and regions of Myanmar and is available all year round. Banana is a number of species or hybrid in the genus *Musa* of the family *Musaceae*. Thirteen *Musa* species including wilds species are widely grown throughout the country.

Banana fruits are wholesome and fairly well balanced source of nutrients containing various mineral salts, high amount of carbohydrates with a little oil and protein (Ahenkora*et al.*, 1997).The medicinal values of banana are higher than the other common tropical and subtropical fruits. Banana is the cheapest as well as one of the most nutritious fruits.

Bananas have long been recognized for their antacid effects that protect against stomach ulcers and ulcer damage. Fresh banana may protect neuron cell against oxidative stress-induced neurotoxicity and may play an important role in reducing the risk of neurodegenerative disorders such as Alzheimer's disease. The fruit is believed to reduce the worm problems in the kids. Bananas contain minerals and other nutrients that promote hair recovery and rehabilitation (Kumar*et al*., 2012).

The plant hormones are extremely important agents in the integration of developmental activities, and they also are concerned importantly in the response of plants to the external physical environment (Moore, 1994). Ethylene is also an important natural plant hormone, used in agriculture to force the ripening of fruits. Ethylene is produced from essentially all parts of higher plants, including leaves, stems, roots, flowers, fruits, tubers and seeds.In higher vascular plants, a relatively simple biosynthetic pathway produces ethylene (Figure. 1). The amino acid methionine (MET) is the

starting point for synthesis. It is converted to S-adenosyl methionine (SAM) by the addition of adenine, and SAM is then converted to 1-amino-cyclopropane carboxylic acid (ACC) by the enzyme ACC synthase. The production of ACC is often the controlling step for ethylenesynthesis. A number of intrinsic (e.g., developmental stage) and extrinsic (e.g., wounding) factors influence this pathway.

The pool of ACC available for ethylene production can be increased by factors which increase ACC synthase activity, reduced by application of growth regulators(e.g., daminozide), or reduced by a side reaction which forms the relatively biologically inert MACC. In the final step, ACC is oxidized by the enzyme ACC oxidase to form ethylene. This oxidation reaction requires the presence of oxygen, and low levels of carbon dioxide activate ACC oxidase. While the level of ACC oxidase activity is usually in excess of what is needed in most tissues, it can show a dramatic increase in activity in ripening fruit and in response to ethylene exposure (Saltveit, 1999).

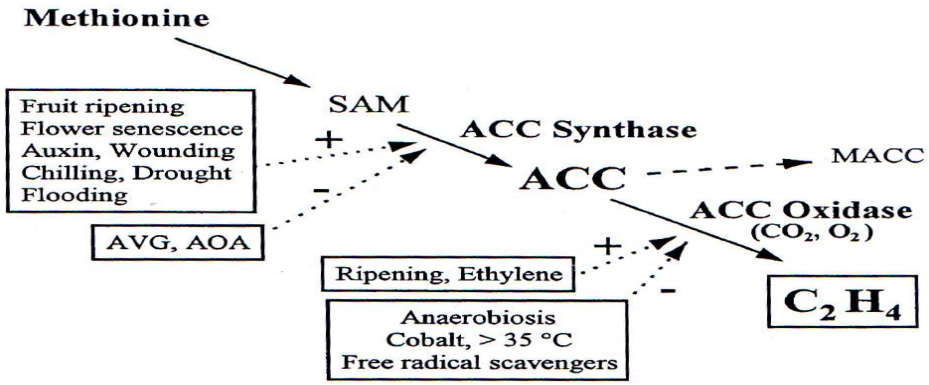
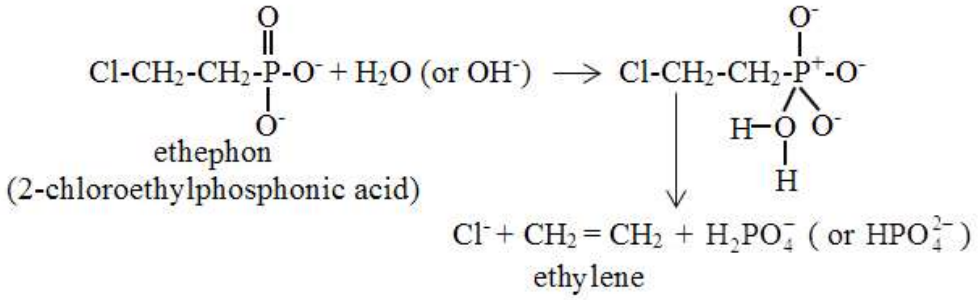


Figure 1: Biosynthesis of ethylene in higher vascular plants. Some of the intrinsic and extrinsic factors that promote (+) or inhibit (-) ethylene (C_2H_4) synthesis in higher vascular plants.

Fruit ripening is a developmentally regulated process resulting from the coordination of numerous biochemical and physiological changes within the fruit tissue that culminates in changes in fruit firmness, color, taste, aroma and texture of fruit flesh (Singh *et al*., 2010). Ripening agents speed up the ripening process. They allow many fruits to be picked prior to full ripening, which is useful. For example, bananas are picked when green and artificially

ripened with specific ripener (Dhembare, 2013). Ethephon, artificial ethylene, ethylene glycol, calcium carbide, carbon monoxide and potassium dihydrogensulfate are major commercially popular artificial ripening agents (Suman *et al*., 2011). Ethephon, 2-chloroethylphosphonic acid, organophosphorus compound is a synthetic plant growth regulator. This class of physiological and biological substance produces similar effects as its endogenous counterparts. Ethephon is used to improve fruit abscission for mechanical harvest, to accelerate post-harvest ripening in fruit, to increase resistance to lodging, to promote or inhibit flowering, to promote maturation and colouring and to enhance sugar content (Hanot *et al*., 2015). Ethephon has been registered with EPA (US Environmental Protection Agency) since 1973 as a plant growth regulator used to promote fruit ripening and flower induction (Bui, 2007). This systemic pesticide translocates into the plant tissues and progressively decomposes to ethylene. Ethylene is the active agent and is associated with various natural physiological processes throughout plant growth and development. Ethephon was found to be the most effective nongaseous ethylene-releasing chemical. Ethephon is a diprotic acid with a phosphonic acid group which provides to this plant growth regulator a high polarity, water solubility and a low volatility. Ethephon is stable in aqueous solution below pH 3.5 and decomposed in ethylene and dihydrogen phosphate under alkali and high temperature conditions (Hanot *et al*., 2015).



Banana is often harvested in a mature but unripe condition, and is subsequently allowed to ripen further. In natural conditions, they ripen slowly, leading to high weight loss, desiccation, ripening is also uneven and fails to develop good colour and aroma. Hence the marketable quality deteriorates. Therefore, normally banana is artificially ripened (Subbaiah *et al*., 2013).The

use of artificial agents may give more acceptable colour than naturally ripened fruits (Hakim *et al*., 2012) but it may increase the risk of contamination of food materials. With the absence of legislation to control the indiscriminate use of harmful ripening agents, research effort is needed to constantly monitor their presence in foods grown locally. This present study is therefore carried out to investigate the effect of chemical ripening agent (Ethephon) on the nutritional and metal compositions of banana (Phee-gyan-hnget-pyaw) by natural (untreated), treatment with different dosages of ethephon (250, 500, 1000 ppm) and market (treated) samples.

Materials and Methods

Collection of Banana Samples and Chemical Ripening Agent

Freshly harvested bunch of green (mature unripe) banana and banana samples treated with chemical ripening agent (ethephon) from market were collected from Minhla Township (Bago Region). The ripening agent (Ethephon 40 %) (Shanghai Huayi Group Co., Ltd., China) used for the study was also bought from the Kyimyindaing market, Kyimyindaing Township (Yangon Region)(Figure 2).

(a) (b) (c)

Figure 2: (a) Banana (Phee-gyan-hnget-pyaw) plant, (b) Banana (Phee-gyan-hnget-pyaw) fruits and (c) Bottle of ethephon (40%)

Preparation of Banana Samples by Treating with Chemical Ripening Agent (Ethephon)

Banana hands were separated from bunches and washed thoroughly with deionized water to remove the contaminations. Two banana hands were used as untreated control fruits (Natural). For each dosage sample, two banana hands were used. These hands were dipped in different concentrations of ripening agent (Ethephon 40 %) solutions(250 ppm, 500 ppm and 1000 ppm) for 15 min. All samples were packed in each ventilated bamboo basket and covered with polyethylene sheet and kept for ripening at room temperature.

Preparation of Banana Samples for Quantitative Analysis

When all the fruits were completely ripened in yellow peel with black spots, fingers were separated from the hands. For each of the all samples, pulp was homogenized with blender. The suspension mixture solution was obtained. Each of the all samples was carried out in triplicate.

Determination of Changes of Ripening Time and Shelf Life

Natural (untreated) and ethephon-treated banana samples were daily monitored for colour changes of the peel indicative of ripening. The stage of ripeness is judged primarily by colour using a 1-7 scale common in the industry. At colour 1, the finger is hard and completely green; No. 2 is green but with some traces of yellow; No. 3 is more green than yellow; No. 4 is more yellow than green; No. 5 is yellow but with traces of green; No. 6 is fully yellow and No. 7 is yellow with black spots (Sogo-Temi*et al*., 2014). The shelf life was calculated by counting the days required to attain the last stage of ripening but up to the stage when fruit remained still acceptable for marketing (Moniruzzaman*et al*., 2015).

Procedure for the Nutritional and Metal Compositions

Nutritional values of all banana samples were determined according to standard methods of Association of Official Analytical Chemists (AOAC, 1990). Water content by oven drying method, ash content by ashing method in a muffle furnace, protein content by micro Kjeldahl's method, crude fiber content by acid-base digestion method, fat content by Soxhlet extraction method, reducing sugar content by Lane-Eynon's method, titratable acidity

content by titrimetric method, pH value by pH meter and ascorbic acid (vitamin C) content by iodometric titration and UV-visible spectrophotometric methods were used.Some mineral and heavy metal contents of the samples were determined by using atomic absorption spectrometer (AAS, Perkin Elmer Analyst 400) and phosphorus contents were determined by using UV-visible spectrophotometer (UV mini-1240, Japan).

Results and Discussion

Changes of Ripening Time and Shelf Life in Natural and Ethephon-Treated Banana (Phee-gyan-hnget-pyaw) Samples

In this research, the fastest colour change indicated by the peel colour to fully yellow with black spots was observed in 1000 ppm ethephon-treated sample in 35 h while the natural (untreated) banana with no ripening agent ripened in 92 h. It was found that the sample with ripening agent accelerated the rate of ripening faster than natural sample. With high treatment (1000 ppm) on fruits required less shelf life (2 days) while lower dosage (250 ppm) required longer shelf life (3 days) indicating high dosage treatment sample reacted rapidly with fruit samples and quick ripening led to spoilage (Figure 3 and Table 1).

A. Finger is hard and completely green

B. Green but with some trace of yellow

C. More green than yellow

D. More yellow than green

E. Yellow but with traces of green

F. Fully yellow

H. Yellow with black spots

Figure 3: Changes of ripening stage of banana by the treatment of ethephon

Table 1. Observation of Ripening Time and Shelf Life in Natural and Ethephon-Treated Samples

No.	Sample	Ripening time (h)							Shelf life (days)
		A	B	C	D	E	F	G	
1.	Natural	_	54	64	72	79	86	92	6
2.	250ppm (ethephon)	–	36	42	48	53	58	63	3
3.	500ppm (ethephon)	–	29	34	39	44	47	49	2.5
4.	1000ppm (ethephon)	–	24	27	29	31	33	35	2

A = Finger is hard and completely green, B = Green but with some traces of yellow, C = More green than yellow, D = More yellow than green, E = Yellow but with traces of green, F = Fully yellow, G = Yellow with black spots

Calibration Curve for Chromate-diphenylcarbazide Complex with respect to Ascorbic Acid Concentration

In this research, the calibration curve was constructed using a series of solutions of ascorbic acid prepared from 100 ppm stock solution. It was found that absorbance of chromium-diphenylcarbazide complex was related to ascorbic acid concentration. By plotting the absorbance determined versus the corresponding concentration range (0.2-1 ppm) the calibration curve was obtained. The concentrations of ascorbic acid in all samples were determined from this curve (Figure 4).

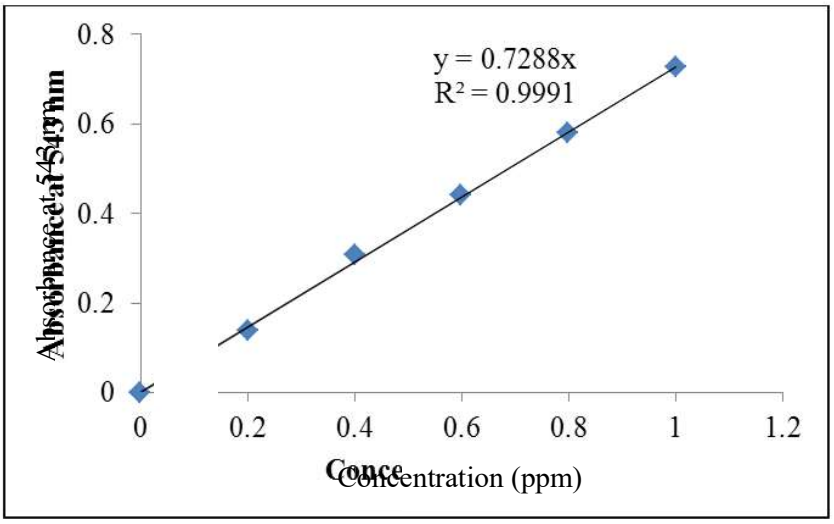


Figure 4: Calibration curve for standard ascorbic acid by UV-visible spectrophotometric method

Standard Calibration Curve for Phosphate

It is necessary to construct a calibration curve from a series of standard solutions(5-100 ppm) for the measurement of phosphorus concentration. In this research, the different absorbance values at 470 nm were obtained for different phosphorus concentrations by using UV-visible spectrophotometer (Vanado-molybdate Colorimetric Method) (Pearson, 1976). It was found that the nature of plot of absorbance vs. concentration of phosphorus was a straight line passing through the original showing that Beer's law was obeyed (Figure 5). Phosphorus contents were determined from this curve.

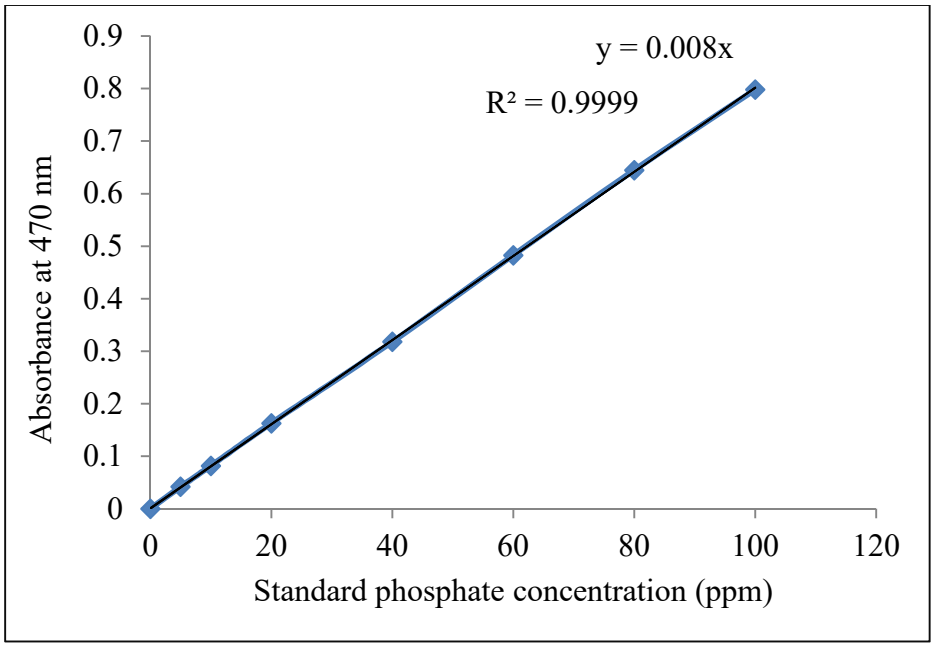


Figure 5: Calibration curve for standard phosphate by spectrophotometric method

Nutritional and Metal Compositions of Natural, Ethephon-Treated and Market Banana (Phee-gyan-hnget-pyaw) Samples

Table 2 shows the nutritional values of natural, ethephon-treated and market banana (Phee-gyan-hnget-pyaw) samples. The water percentage of banana sample was determined by the use of an electric oven at 105 ˚C by drying to obtain constant weight and taking the loss in weight as water.The mean results of water content in natural, (250 ppm, 500 ppm, 1000 ppm) ethephon-treated and market banana samples were found to be 70.69 %, 72.06 %, 72.88 %, 73.90 %, and 73.66 %, respectively(Figure 6). It was found that the water content of all ethephon-treated banana samples were gradually higher than natural (untreated) sample. Water content in banana pulp is observed to increase because of respiratory breakdown of starch to sugar, migration of water from peel to pulp and excess moisture formation (Sen *et al*., 2012; Ayo-omogie*et al*., 2010; Hakim *et al*., 2012). The high percentage of water in chemically treated samples may shortened the shelf life and cause

higher rottenness.The ash percents of all banana samples were found to be in the range of 0.86 – 1.21 %. The amount and composition of ash remained after combustion of fruit material varies considerably according to the part of the fruit, age, treatment etc.

All banana samples contain small amount of protein. It was found that natural (untreated) sample has the maximum content of protein (1.18 %) and market sample has the minimum protein content (0.91 %), whereas the protein content of all ethephon-treated banana samples were less than natural (untreated) sample. This is also in agreement with Adewole and Duruji (2010) who observed a reduction in the protein content during ripening which may be due to reduction of nitrogen during ripening. Crude fiber contents of all banana samples were determined by acid-base digestion method. It was observed that natural (untreated) has slightly higher amount of crude fiber (0.33 %) than the other samples. The higher fiber content in natural sample may be possible due to increase in soluble and insoluble dietary fractions (Khawas*et al*., 2014). It was found that natural sample has slightly high amount of fat (0.05 %) whereas the same fat content (0.03 %) of all ethephon-treated samples were observed. The carbohydrate percentages of all banana samples were calculated by difference. It was observed that carbohydrate content of natural (untreated) sample(26.54 %) was greater than the 1000 ppm ethephon-treated and market samples (23.89 % and 24.25 %)(Figure 7). One of the biochemical changes occurring during ripening is a decrease in carbohydrate content. The starch is degraded by starch degrading enzymes α and β amylases which convert starch to simple sugars (Sogo-Temi*et al*., 2014). It was found that natural (untreated) sample has the highest calorie content (111.33 kcal/ 100 g). Ethephon-treated (1000 ppm) sample has the lowest calorie content (99.71 kcal/ 100 g).

Sugars which possess in their structure free aldehydic or ketonic groups react as weak reducing agents and are termed reducing sugars. These include all the monosaccharides, and the disaccharides maltose, lactose and cellobiose. The highest reducing sugar content (14.44 %) was recorded for market sample. Lower value was observed for natural (untreated) sample. The observed values of reducing sugar (13.02 %, 13.69 %, 14.07 %) for all ethephon-treated samples were gradually higher than natural (untreated)

sample(Figure 8). In another study chemically treated fruits produced higher sugar content due to the increase in soluble pectin, organic acids and hydrolysis of starch to soluble sugars (Hakim *et al.,* 2012).

The titratable acidity of fruit is due to the presence of a mixture of organic acids, whose composition is variable depending on the fruit nature and its maturity. The acids present in the fruits were tartaric, citric, ascorbic, malic and lactic acids. The titratable acidity contents of all banana samples were determined by acid-base titration method. The titratable acidity level was found to be highest in 1000 ppm ethephon-treated sample (0.48 %), while the level was lowest in the natural (untreated) sample (0.35 %). It was reported that high titratable acidity can cause dental erosion, especially among kids (Featherstone *et al*., 2006). Therefore, regular consumption of artificially ripened banana can be hazardous for dental health. Acids play an important role in the post-harvest quality of vegetables, as taste is mainly a balance between sugar and acid contents which is important in evaluation of fruit taste. The changes in titratable acidity and pH of banana indicate a general increase in titratable acidity during ripening (Khawas*et al*., 2014).The pH values of all banana (Phee-gyan-hnget-pyaw) samples were found to be in the acidic range of 4.37-4.69 and pH values of all treated samples were gradually lower than natural (untreated) sample. The decrease in pH of ethephon-treated fruit pulp could be due to increase in titratable acidity during ripening (Kulkarni *et al.,* 2011; Hakim *et al.,* 2012).

The ascorbic acid (vitamin C) contents of natural, ethephon-treated and market samples were determined by iodometric titration and UV-visible spectrophotometric method. In iodometric titration, natural (untreated) sample contained the highest amount of ascorbic acid (12.67 mg/100 g) and the lowest amount was found in the 1000 ppm ethephon-treated sample (6.51 mg/ 100 g) whereas market sample had low level of ascorbic acid amount (6.78 mg/100 g)(Figure 9). In UV-visible spectrophotometric method, ascorbic acid (vitamin C) contents in natural, ethephon-treated and market samples were determined at 543 nm. It was observed that natural (untreated) ripening sample was found to be the highest amount of (13.12 mg/ 100 g). 250, 500 and 1000 ppm ethephon-treated samples and market samples were found to be 9.66 mg/ 100 g, 8.86 mg/ 100 g, 7.17 mg/ 100 g and 6.22 mg/

100g, respectively(Figure 10). According to ripening chemistry, ascorbic acid (vitamin C) decreases with the increase of temperature (Adeyemi and Oladiji, 2009). Ascorbic acid (vitamin C) is also sensitive to oxygen present in the system. Ascorbic acid content of fruits and vegetables decreases even in proper storage treatment due to the prolonged duration (Hakim *et al*., 2012).

Table 2: Comparison of Nutritional Values in Natural, Ethephon-Treated and Market Samples

Sample	Water (%)	Ash (%)	Protein (%)	Fiber (%)	Fat (%)	Carbohyd -rate (%)	Energy value (kcal/100g)	Reducing Sugar (%)	Titratable acidity (%)	pH value	Ascorbic acid[1] (mg/100g)	Ascorbic acid[2] (mg/100g)
S-1	70.69 ± 0.03	1.21 ± 0.02	1.18 ± 0.02	0.33 ± 0.01	0.05 ± 0.02	26.54 ± 0.07	111.33 ± 0.18	13.59 ± 0.02	0.35 ± 0.02	4.62 ± 0.01	12.67 ± 0.02	13.12 ± 0.01
S-2	72.06 ± 0.02	0.96 ± 0.01	1.09 ± 0.03	0.31 ± 0.02	0.03 ± 0.01	25.55 ± 0.04	106.83 ± 0.06	13.02 ± 0.03	0.40 ± 0.01	4.59 ±0.01	9.45 ± 0.01	9.66 ± 0.01
S-3	72.88 ± 0.01	0.91 ± 0.02	0.98 ± 0.02	0.31 ± 0.02	0.03 ± 0.01	24.89 ± 0.01	103.75 ± 0.02	13.69 ± 0.02	0.43 ± 0.02	4.52 ±0.02	8.44 ± 0.01	8.86 ± 0.01
S-4	73.90 ± 0.02	0.91 ± 0.02	0.97 ± 0.02	0.30 ± 0.02	0.03 ± 0.01	23.89 ± 0.03	99.71 ± 0.21	14.07 ± 0.03	0.48 ± 0.02	4.46 ±0.01	6.51 ± 0.01	7.17 ± 0.01
S-5	73.66 ± 0.02	0.86 ± 0.01	0.91 ± 0.01	0.30 ± 0.02	0.02 ± 0.01	24.25 ± 0.02	100.82 ± 0.05	14.44 ±0.02	0.46 ± 0.01	4.37 ±0.02	6.78 ± 0.02	6.22 ± 0.02

S-1= Natural, S-2=250 ppm(ethephon), S-3=500ppm(ethephon), S-4=1000ppm(ethephon), S-5=Market
[1] =Iodometric titration method, [2]=UV–visible spectrophotometric method, Results are expressed as Mean ± S.D, n = 3.

S-1= Natural, S-2=250 ppm(ethephon), S-3=500ppm(ethephon), S-4=1000ppm(ethephon), S-5=Market [1] =Iodometric titration method, [2]=UV–visible spectrophotometric method, Results are expressed as Mean ± S.D, n = 3.

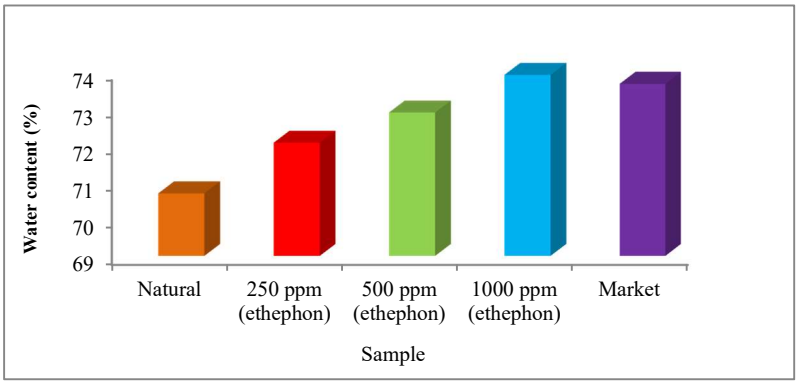


Figure 6: Histogram of water contents in natural, ethephon-treated and market samples

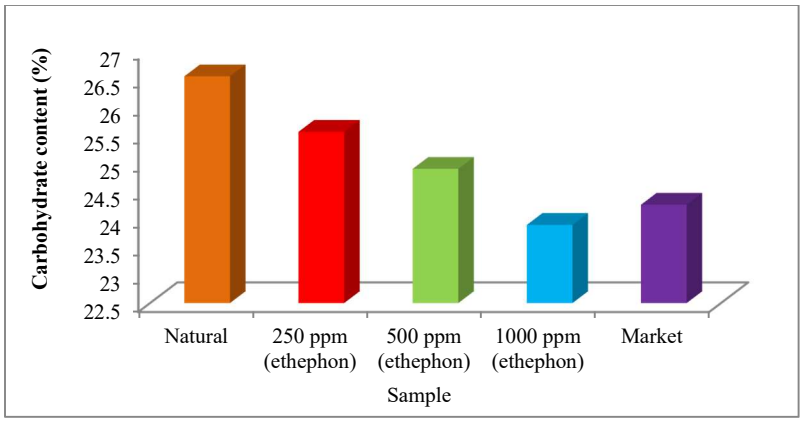
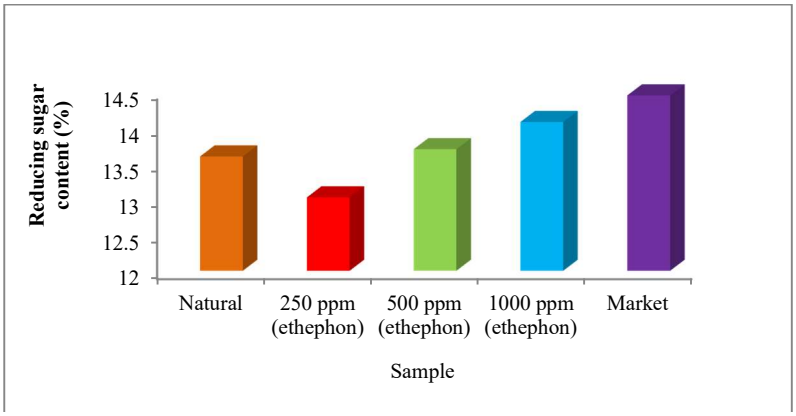


Figure 7: Histogram of carbohydrate contents in natural, ethephon-treated and market samples



Figur 8: Histogram of reducing sugar contents in natural, ethephon-treated and market samples

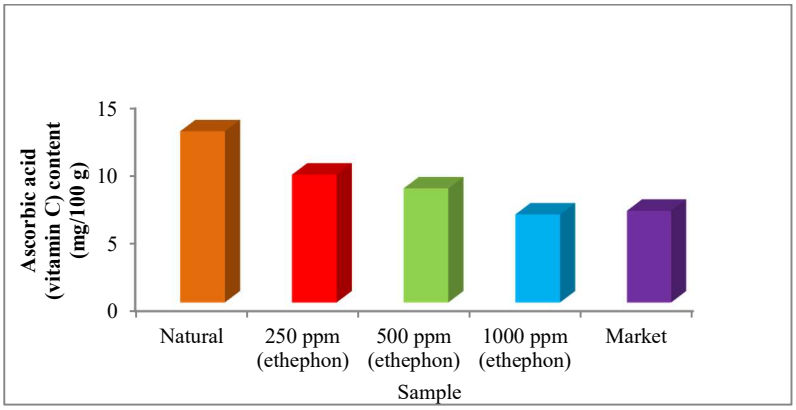


Figure 9: Histogram of ascorbic acid (vitamin C) contents in natural, ethephon-treated andmarket samples by iodometric titration

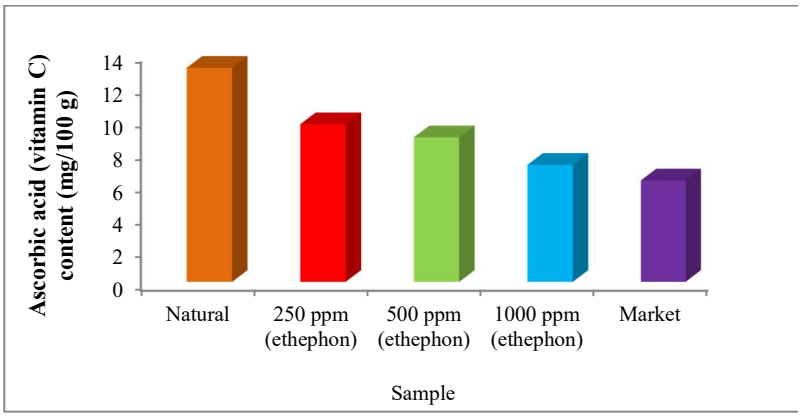


Figure 10: Histogram of ascorbic acid (vitamin C) contents in natural, ethephon-treated and market samples by UV-visible spectrophotometric method

Minerals are important for the various metabolic activities of the living tissue and even more so far the fruit, which exhibits tremendous activity during ripening process. The results of the analysis of some minerals (K, Na, Ca, Mg, P, Fe, Mn, Zn, Cu, Cd and Pb) of all banana (Phee-gyan-hnget-pyaw) samplesare shown in Table 3. In this work, natural (untreated) sample contained the highest content of K followed by Mg, P, Ca, Na, Fe, Zn, Mn and Cu. The mineral contents found in the (250, 500 and 1000 ppm) ethephon-treated and market samples were lower than natural (untreated) sample. Cadmium and lead contents were not found in all samples. In this research work, natural (untreated) sample has the minimum content of phosphorus (38.07 mg/100 g) and market sample has the maximum content of phosphorus (47.01 mg/100 g). Phosphorus contents of 250, 500 and 1000 ppm of ethephon-treated samples were observed to be 39.85, 41.90 and 44.85 mg/ 100 g, respectively. The high amounts of phosphorus in ethephon-treated samples indicate that ethephon is degraded by water resulting in the increase of phosphorus (Hakim *et al*., 2012).

Table 3: Comparison of Mineral Contents in Natural, Ethephon-Treated and Market Samples

Sample	Mineral Contents (mg/100 g)										
	K	Na	Ca	Mg	Fe	Mn	Zn	Cu	P	Cd	Pb
Natural	420.31 ± 0.02	7.38 ± 0.01	29.31 ± 0.01	76.21 ± 0.01	0.84 ± 0.01	0.32 ± 0.02	0.41 ± 0.01	0.17 ± 0.01	38.07 ± 0.02	ND	ND
250 ppm (ethephon)	418.23 ± 0.01	6.54 ± 0.02	27.55 ± 0.03	75.91 ± 0.01	0.79 ± 0.02	0.29 ± 0.02	0.38 ± 0.03	0.15 ± 0.01	39.85 ± 0.02	ND	ND
500 ppm (ethephon)	410.91 ± 0.01	5.73 ± 0.01	26.10 ± 0.02	75.04 ± 0.02	0.79 ± 0.02	0.27 ± 0.02	0.33 ± 0.03	0.12 ± 0.02	41.90 ± 0.02	ND	ND
1000 ppm (ethephon)	409.75 ± 0.01	5.54 ± 0.01	26.06 ± 0.02	74.91 ± 0.02	0.74 ± 0.01	0.26 ± 0.02	0.28 ± 0.02	0.12 ± 0.01	44.85 ± 0.02	ND	ND
Market	394.81 ± 0.01	3.95 ± 0.03	20.29 ± 0.02	74.63 ± 0.03	0.72 ± 0.01	0.24 ± 0.02	0.20 ± 0.02	0.08 ± 0.02	47.01 ± 0.02	ND	ND

ND = not detected, Results are expressed as Mean ± S.D, n = 3.

Conclusion

The current study was an initiation to observe the changes in the basic nutritional parameters upon hindering the natural process of ripening by applying artificial agents. Ripening agent (ethephon) could speed up ripening process than the natural ripening process. This work suggested that the government agencies, scientific communities and any relevant organizations should get involved to follow up the international legislation in monitoring the indiscriminate use of such artificial ripening agents. This research work is of its own merit at least to provide the general guideline. If artificial ripening agent is used the least dosage of about 250 ppm is the highest limit of treatment.

Acknowledgements

The authors would like to thank the Myanmar Academy of Arts and Science for allowing to present this paper and Professor and Head Dr Daw Hla Ngwe, Department of Chemistry, University of Yangon, for her kind encouragement.

References

Adewole, M. B. and Duruji, R. W. (2010). "Quality Assessment of Plantain (*Musa paradisiaca* L.) as Affected by Different Ripening Methods". *African Journal of Biotechnology*, vol. 9(38), pp. 6290-6293

Adeyemi, O. S. and Oladiji, A. T.(2009). "Compositional Changes in Banana (*Musa ssp*.) Fruits during Ripening".*African Journal of Biotechnology*, vol. 8(5), pp. 858-859

Ahenkora, K. M., Key, A., Marfo, K. and Banful, B. (1997)."Nutritional Composition of False Horn *Apantu pa* Plantain during Ripening and Processing".*Afr. Crop Sci. J.,*vol. 5(2), pp. 243-248

AOAC.(1990). *Official Methods of Analysis of the Association of Official Analytical Chemists*. Arlington VA: 15th Ed., Association of Official Analytical Chemists, pp. 1058-10

Ayo-omogie, H. N., Adeyemi, I. A.and Otunola, E. T. (2010). "Effect of Ripening 59 on Some Physiochemical Properties of Cooking Banana (Musa ABB Cardaba) Pulp and Flour".*International Journal of Food Science and Technology,*vol.45, pp. 2605-2611

Bui, Q. Q. (2007). *Ethephon and Jackfruit*. California: Palo Alto, p. 231

Dhembare, A. J. (2013). "Bitter Truth about Fruit with Reference to Artificial Ripener". *Archives of Applied Science Research,* vol. 5(5), pp. 45-54

Featherstone, J. D. B. and Lussi, A.(2006). "Understanding the Chemistry of Dental Erosion, Dental Erosion from Diagnosis to Theory". *Monographs in Oral Science*, vol. 20, pp. 66-67

Gunasekara, S. R. W., Hemamali, K. K. G. U., Dayananada, T. G. and Jayamanne, V. S. (2015)."Post Harvest Quality Analysis of 'EMBUL' Banana Following Artificial Ripening Techniques". *International Journal of Science, Environment and Technology*, vol. 4(6), pp. 1625-1632

Hakim, M. A., Obidul Huq, A. K., Alam, M. A., Saha, B. K.,Formuzul Haque, K. M. and Zaidul, I. S. M. (2012). "Role of Health Hazardous Ethephon in Nutritive Values of Selected Pineapple, Banana and Tomato".*Journal of Food, Agriculture & Environment*, vol. 10(2), pp. 247-251

Hanot, V., Joly,L., Bonnechere, A. and Loco, J. V.(2015). "Rapid Determination of Ethephon in Grapes by Hydrophilic Interaction Chromatography Tandem Mass Spectrometry".*Food Anal. Methods*, vol. 8,pp. 524-530

Khawas, P., Das, A. J., Sit, N.,Badwaik, L. S. and Deka, S. C. (2014). "Nutritional Composition of Culinary *Musa* ABB at Different Stages of Development".*American Journal of Food Science and Technology*, vol. 2(3), pp. 80-87

Kulkarni, S. G., Kudachiker, V. B. and Prakash, M. N. (2011). "Studies on Physico-Chemical Changes during Artificial Ripening of Banana (*Musa sp*) Variety 'ROBUSTA' ". *J. Food SciTechnol*, vol. 48(6), pp. 730-734

Kumar, K. P. S., Bhowmik,D., Duraivel, S. and Umadevi, M. (2012)."Traditional and Medicinal Uses of Banana".*Journal of Pharmacognosy and Phytochemistry*, vol. 1(3), pp. 51-63

Moniruzzaman, M., Khatoon, R., Hossain,M. F. B., Rahman, M. T. and Alam, S. N. (2015). "Influence of Ethephon on Ripening and Quality of Winter Tomato Fruit Harvested at Different Maturity Stages". *Bangladesh J. Agril. Res*., vol. 40(4), pp. 567-580

Moore, T. C. (1994). *Biochemistry and Physiology of Plant Hormones*. New York: 2nd Ed., Narosa Publishing House, pp. 23-25

Pearson, D. (1976). *The Chemical Analysis of Foods*. New York: 7th Ed., Chemical Publishing Co., Inc., pp. 23-24

Saltveit, M. E. (1999). "Effect of Ethylene on Quality of Fresh Fruits and Vegetables". *Postharvest Biology and Technology*, **15**, 279-292

Sanjeev, K. K. and Eswaran, A. (2008)."Efficacy of Micronutrients on Banana *Fusarium* with (*Fusariumoxysporum f. sp. cubense*) and its Synergistic Action with *Trichodermaviride*". *Not. Bot. Hort. Agrobot. Cluj,* vol. 36(1), pp. 52-54

Sein Hla Bo. (2003). *Banana R & D in Myanmar*. Yangon: Ministry of Agriculture and Irrigation, Union of Myanmar, pp. 143-149

Sen, C., Mishra, H. N. and Srivastav, P. P. (2012)."Modified Atmosphere Packaging and Active Packaging of Banana (*Musa spp*): A Review of Control of Ripening and Extension of Shelf Life". *Journal of Stored Products and Post-harvest Research*, vol. 3(9), pp. 122-132

Singh, R., Rastogi, S. and Dwivedi, U. N. (2010)."Phenylpropanoid Metabolism in Ripening Fruits".*Comprehensive Reviews in Food Science and Food Safety*, vol. 9, pp. 398-416

Sogo-Temi, C. M., Idowu, O. A. and Idowu, E. (2014)."Effect of Biological and Chemical Ripening Agents on the Nutritional and Metal Composition of Banana (*Musa*spp)". *J. Appl. Sci. Environ. Manage.*,vol. 18(2), pp. 243-246

Subbaiah, K. V., Jagadeesh,S. L., Thammaiah, N. and Chavan, M. L. (2013). "Changes in Physico-Chemical and Sensory Characteristics of Banana Fruit cv. Grand Naine During Ripening". *Karnataka J. Agric. Sci.,*vol. 26(1), pp. 111-114

Suman, S., Kumud, M. and Thakral, S. (2011)."Application of Apple as Ripening Agent for Banana". *Indian Journal of Natural Products and Resources*, vol. 3(1), pp. 61-64