Emir. J. Food Agric. 2014. 26 (3): 229-237
doi: 10.9755/ejfa.v26i3.15853
http://www.ejfa.info/

FOOD SCIENCE AND NUTRITION

The effects of ethephon on the ripening of Vietnamese Latundan bananas (*Musa sapientum*)

Quoc Le Pham Tan*, An Huynh Thi Truong, Lam Le Thanh, Ly Le Thi Hong and Suong Nguyen Thi Tuyet

Institute of Biotechnology and Food Biotechnology, Industrial University of Ho Chi Minh City, Vietnam

Abstract

Nowadays, there are many types of chemicals that have the ability to mature and affect the quality of banana fruit. The purpose of this study is to investigate the influence of ethephon (2-chloroethyl phosphonic acid) on the ripening of Latundan bananas (*Musa Sapientum*). Latundan bananas are the most common fruit in Vietnam and other Asian countries; they have high protein and sugar levels. The samples were soaked into ethephon at different concentrations of 0, 1.0, 1.5, 2.0, 2.5 and 3.0% (v/v), it were stored in plastic crates covered with canvas, storage temperature at 31±2.3°C, humidity 71±11.37 %. The evaluation criteria used in this study were ripe ratio, weight loss, reducing sugar content, acidity, sensory evaluation and residual ethephon content of the Latundan bananas after ripening. The results showed that when Latundan bananas were soaked in ethephon at solution concentration of 2.5% (v/v) have the ability to ripen quickly, equally and have beautiful colors on the surface of the peel. In addition, the sensory qualities of bananas that are soaked in ethephon do not create discomfort for the consumers. Currently, in Vietnam, there is no regulation for the maximum content of ethephon permitted in bananas. We hope that the Ministry of public Health will issue the maximum amount of permitted ethephon residues in bananas.

Key words: Ethephon, Latundan bananas, *Musa sapientum*, Storage, Reducing sugar

Introduction

In Vietnam, Latundan bananas (*Musa Sapientum*) is a tropical fruit, small, short, and round. When it ripens, the peel is yellow, thin, and its meat is delicious. Bananas were very popular in Europe, especially in Germany and France (Tran, 1998). In terms of nutrition, bananas were more valuable than potato and are the same as meat. Every 100g can create 100 calories and help us digested easily. Besides that, bananas contained a large amount of vitamins, especially vitamins A and vitamin C (Tran, 2011). When the fruit ripens, it also creates a certain amount of ethylene but not as high as the ripe fruit by chemicals such as calcium carbide, ethephon. They are commonly applied on wholesale markets and by the fruit processing industry to accelerate postharvest ripening of fruit (Mahayothee et al., 2007; Korsak and Park, 2010). Thus, the use of these ripening agents was necessary to shorten preservation time.

Nowadays, ethephon or ethrel is used in many fields such as plant growth regulators to release ethylene that makes defoliation, reduce postharvest losses (Pham, 2005) and improve colour development of fruit (Zhou et al., 2010). Because ethylene was released from this compounds in the postharvest phase as well as endogenous ethylene accelerated ripening and subsequent senescence of fruit tissues by stimulating physiological processes such as respiration, softening and chlorophyll degradation, yellowing peel (Chesworth et al., 1998). Recently, there are many different opinions about the toxicity of ethephon make the user worried (Nguyen et al., 1999), for instance ethephon is irritant to the skin or the eyes but is not a skin sensitizer, it was not a carcinogen and is classified by IARC (International Agency for Research on Cancer) as group D (not carcinogenic to humans) and FAO pointed out a maximum allowable daily intake for ethephon at 0.05 mg/kg body weight/day (Bui, 2007). Using ethephon in Vietnam is quite new and an unpromulgated law about the impact of chemicals residues on ripening bananas. Therefore, the objective of this study is to research some effects of ethephon on the ripening process of bananas, we can be active in storage

Received 25 August 2013; Revised 07 October 2013; Accepted 20 October 2013; Published Online 15 November 2013

*Corresponding Author

Quoc Le Pham Tan
Institute of Biotechnology and Food Biotechnology, Industrial University of Ho Chi Minh City, Vietnam

Email: lephamtanquoc@yahoo.com

process and avoid effecting of residue ethephon on consumers.

Materials and Method

Materials

Latundan bananas are harvested in Long Khanh province, Vietnam. It is harvested time after approximately 90-95 days after flowering. The length of fruit is from 6 to 7.5 cm, diameter of fruit (in the middle of the body) from 2.5 - 2.8 cm. The banana samples achieved level 1 (Figure 2).

Ethephon are in liquid form, transparent, light yellow and made in China.

Research Methodology

Ripe Latundan bananas processing

The processing of Latudan banana follows the steps below:

Bananas → Sorting → Washing → Soaking → Keeping dry → Preserving

Bananas are kept in plastic baskets covered with canvas at storage temperature of 31±2.3°C, humidity 71±11.37%.

Analysis methods

The percentage (%) of weight loss was measured by electronic scales; the mass loss rate based on the volume of the preservation process results over the volumes initially.

The glucose examination was determined by a glucometer Cleverchek (Germany) and calculated thus:

$$\%\ \text{Glucose} = x * 10^{-3} * 180 * \frac{V}{1000 * m} * 100$$

(Quoc et al., 2013)

x: The concentration of glucose displays on the glucometer (mmol/L)

180: Molecular mass of glucose

m: Mass of fruit (g)

V: The dilution of solution (ml)

The total acidity value was determined by (AOAC 942.15, 2000). Titration acidity was performed by NaOH 0.1 N with phenolphthalein 0.1% as an indicator and expressed in grams (g) of total acidity per 100 g of fruit.

Residue examination of ethephon on bananas was determined by gas chromatography-mass spectrophotometer (GC–MS) (TCVN 8668, 2011). It was expressed in milligrams (mg) of ethephon per 1 kg of fruit.

Different testing on sensory evaluation: pair comparison test – the simple difference test (or the same/different test) (Lawless et al., 2010).

Data analysis

Each sample had weight of 520±8 g, corresponding to 15 units; repeated three times. Data would be analyzed by Statgraphics software (Centurion XV) with confidence interval p_{value}=0.05.

Results and Discussion

Effect of ethephon concentration solution on Latundan bananas maturity and weight loss versus preservation time

In Table 1, the ripening process takes place on the samples with different ethephon concentration from 1.0 to 3.0%, but not equally. Ripe rates increased correspondence with preservation time. In the period from 48 - 60 hours, the soaking samples ripened rapidly. After 60 hours, ripen rate was quite equal, especially at a concentration of 3.0%, the rate of ripening has reached 100%, higher than all of the samples are soaked ethephon. At 72 hours, all sample ripen over 80%, had specific aroma and yellow colour. During preservation time, ethephon is released and create ethylene to stimulate the ripening process of bananas. The more amount of ethylene released, the ripening process was more quickly (Le et al., 2008). After 84 hours, ripe ratio of the sample with ethephon reduced, samples without ethephon treatment start to ripen from 60 to 156 hour (Figure 1). It shows that ethephon agents make the ripening time shortened and created beautiful colors on the surface of the bananas peel. Ripening rate was evaluated based on banana colour chart of Isopan Insulation PVT LTD – India (2011), ripen bananas have to achieve from level 4 to 7 (Figure 2). The ripe rate in samples with 2.5 % ethephon treatment was the most highest, uniform and stable.

Water content of fruit makes up about 60% of the body's weight (Sandra et al., 1997); the banana samples in research can achieve 74.7-78%. Consequently, it was very difficult to preserve fruits in normal condition; they cannot avoid the weight loss. The process of evaporation was the main reason to reduce the volume and weight of fruits and vegetables (Ton et al., 2008). Overall, bananas are soaked or not with ethephon, the weight loss has increased by time. In the early period, the loss in volume change insignificantly, the water loss is slowly about 0-4%. Starting at 36 hours, samples with ethephon treatment are superior (especially at a concentration 1.5%) to white samples on the weight loss. The weight loss increased correspondingly with the preservation time, it achieved the maximum value from 17.9-18.9% after 108 hours (Table 2). After that, all samples with ethephon treatment were absolutely damaged. And after 108 hours, the weight loss of samples without ethephon treatment decreased slightly, it was totally damaged at 168 hours (Figure 3).

Table 1. Percentage of ripe Latundan bananas (%) versus the preservation time.

Hours (h)	Concentration of ethephon (%, v/v)					
	0	1.0	1.5	2.0	2.5	3.0
0	0.00±0.00 A	0.00±0.00 A	0.00±0.00 A	0.00±0.00 A	0.00±0.00 A	0.00±0.00 A
12	0.00±0.00 A	0.00±0.00 A	0.00±0.00 A	0.00±0.00 A	0.00±0.00 A	0.00±0.00 A
24	0.00±0.00 A	0.00±0.00 A	0.00±0.00 A	0.00±0.00 A	0.00±0.00 A	0.00±0.00 A
36	0.00±0.00 A	0.00±0.00 A	0.00±0.00 A	0.00±0.00 A	0.00±0.00 A	0.00±0.00 A
48	0.00±0.00 Aa	53.33±6.67 Bc	26.67±6.67 Bb	55.56±10.18 Cc	6.67±11.55 Aa	62.22±3.85 Dc
60	77.78±10.18 Dab	80±13.33 Cab	55.55±20.37 Cb	57.78±10.18 Ca	64.45±20.37 Ca	100±0.00 Fb
72	95.56±7.7 Eb	86.67±6.67 Ca	97.78±3.85 Eb	95.55±3.85 Eb	100±0.00 Db	100±0.00 Fb
84	100±0.00 Eb	80±11.55 Ca	95.55±3.85 DEb	93.33±6.67 Eb	97.8±3.85 Db	91.11±3.85 Eb
96	100±0.00 Ee	75.55±3.85 Cbc	84.44±7.7 Dcd	68.89±10.18 Db	91.11±7.7 Dde	55.56±7.7 Ca
108	100±0.00 Ec	8.89±3.85 Aab	0.00±0.00 Aa	13.33±6.67 Bb	31.11±13.88 Bc	17.78±3.85 Bb
120	95.56±7.7 Ea	–	–	–	–	–
132	73.33±10.64 Da	–	–	–	–	–
144	33.33±13.34 Ca	–	–	–	–	–
156	17.78±16.78 Ba	–	–	–	–	–

Various capital letters in the same column are significant difference at the level of p=5%.
Various lowercase letters in the same row are significant difference at the level of p=5%.

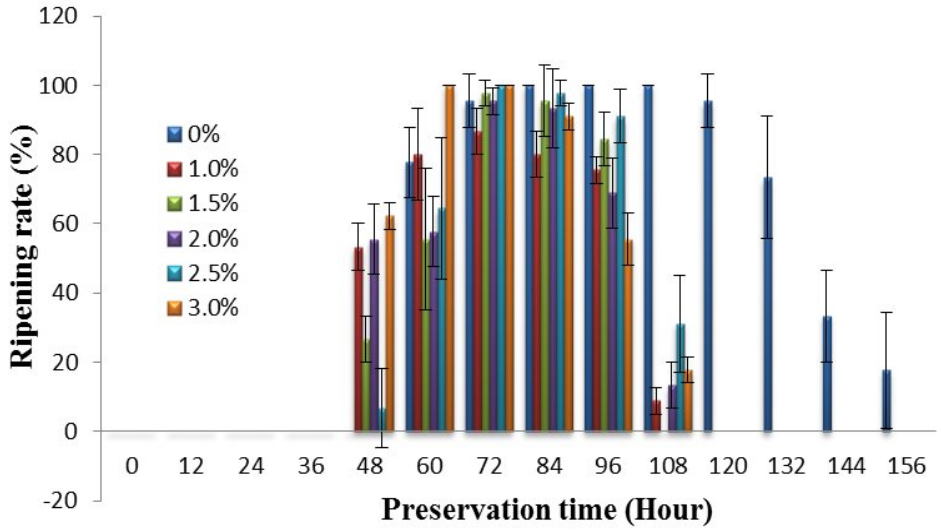
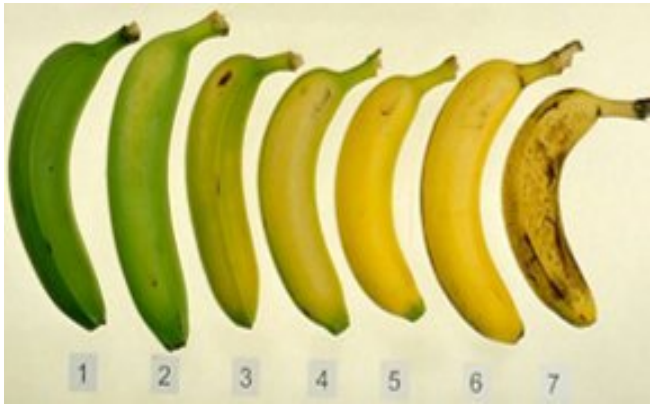


Figure 1. Changes in rate of ripe Latundan bananas with preservation time



1.Evenly green; common color after harvesting
2.Light green; color of bananas treated by gas
3.More green than yellow; ready for wholesale supply
4.More yellow than green; recommended for retail outlets
5.Ideal color for sale
6.Fully ripe bananas ready for consumption
7.Over ripe; diffuse brown spots

Figure 2. Levels of banana ripening.

Table 2. Weight loss (%) according to storage time.

Hours (h)	Concentration of ethephon (%, v/v)					
	0	1.0	1.5	2.0	2.5	3.0
12	1.60±0.56 Abc	2.23±1.44 ABc	1.62±0.6 Abc	0.67±1.15 Aab	0.00±0.00 Aa	1.93±0.09 Abc
24	3.81±3.24 ABCa	3.49±1.97 Ba	3.55±0.65 Ba	3.12±1.23 Ba	1.97±0.02 Ba	4.20±1.58 Ba
36	6.05±2.96 BCa	6.68±1.99 Ca	7.40±0.64 Ca	6.18±0.93 Ca	5.59±0.51 Ca	6.43±1.25 Ca
48	7.66±3.17 BCDa	7.93±1.54 Ca	8.68±0.84 Ca	8.00±1.1 CDa	7.23±1.06 Da	8.36±1.3 CDa
60	9.58±3.14 CDEa	11.12±0.76 Da	11.27±0.89 Da	9.81±0.65 DEa	8.87±0.9 Ea	10.28±1.36 DEa
72	11.19±2.57 DEFa	12.04±1.15 DEa	12.22±1.14 Da	11.69±1.22 EFa	10.52±1.08 Fa	11.55±1.94 Ea
84	13.43±3.08 EFGa	14.27±1.34 EFa	14.47±0.79 Ea	13.54±1.3 Fa	13.15±1 Ga	14.75±0.86 Fa
96	15.99±4.27 GHa	16.45±0.5 FGa	17.68±1.34 Fa	16.32±2.27 Ga	15.79±0.84 Ha	16.65±0.64 FGa
108	17.92±3.34 Ha	18.64±1.18 Ga	19.9±1.67 Ga	18.13±1.81 Ga	18.09±1.36 Ia	18.22±1.58 Ga
120	17.55±3.21 GHa	–	–	–	–	–
132	16.67±0.68 GHa	–	–	–	–	–
144	15.7±0.59 GHa	–	–	–	–	–
156	15.27±0.93 FGHa	–	–	–	–	–

Various capital letters in the same column are significant difference at the level of p=5%.
Various lowercase letters in the same row are significant difference at the level of p=5%.

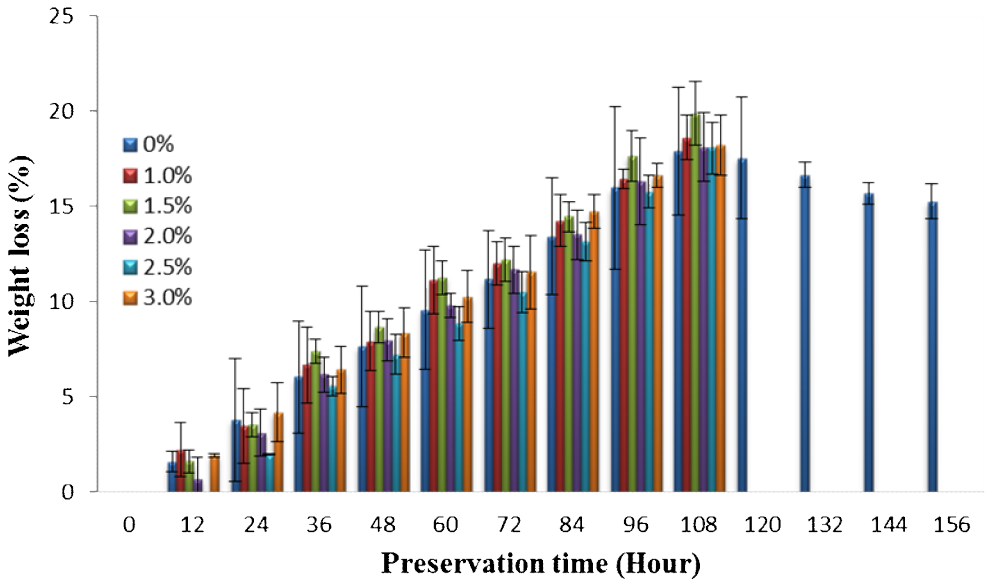


Figure 3. Changes in value of the weight loss with preservation time.

Effect of ethephon concentration solution on reducing sugar and total acidity versus in preservation time

Table 3. Amount of glucose (%) of bananas versus the preservation time.

Hours (h)	Concentration of ethephon (%, v/v)					
	0	1.0	1.5	2.0	2.5	3.0
0	0.12±0.02 Aa	0.13±0.03 Aa	0.12±0.03 Aa	0.13±0.02 Aa	0.12±0.02 Aa	0.13±0.03 Aa
12	0.78±0.03 Bd	0.28±0.05 Ab	0.39±0.02 Bc	0.20±0.01 Aa	0.20±0.01 Aa	0.21±0.03 Ba
24	0.71±0.02 Bc	0.85±0.17 Bd	0.84±0.07 Ccd	0.56±0.01 Bb	0.50±0.03 Bab	0.40±0.02 Ca
36	1.21±0.06 Ca	2.24±0.17 Cc	2.31±0.05 Dcd	2.47±0.04 Ce	1.83±0.03 Cb	2.44±0.18 Gde
48	1.76±0.03 Da	2.64±0.17 Dd	2.80±0.12 Ed	2.69±0.13 Cd	2.16±0.02 Db	2.43±0.15 Gc
60	5.21±0.13 Fe	3.80±0.19 Eb	4.75±0.09 Gd	3.45±0.11 Ea	4.39±0.07 Gc	4.73±0.11 Gd
72	4.73±0.06 Eb	5.44±0.21 Fc	5.66±0.29 Hc	3.96±0.15 Fa	4.73±0.11 Hb	5.69±0.37 Dc
84	8.06±0.14 Ge	5.70±0.12 FGa	6.73±0.06 Ic	5.60±0.07 Ga	7.68±0.11 Id	6.36±0.04 Fb
96	5.27±0.11 Fd	3.70±0.05 Eab	4.50±0.16 Fc	5.88±0.31 He	3.95±0.11 Fb	3.60±0.11 Ea
108	5.14±0.12 Fd	5.95±0.5 Ge	2.75±0.14 Ea	3.11±0.09 Dab	3.62±0.37 Ec	3.56±0.06 Ebc

Various capital letters in the same column are significant difference at the level of p=5%.
Various lowercase letters in the same row are significant difference at the level of p=5%.

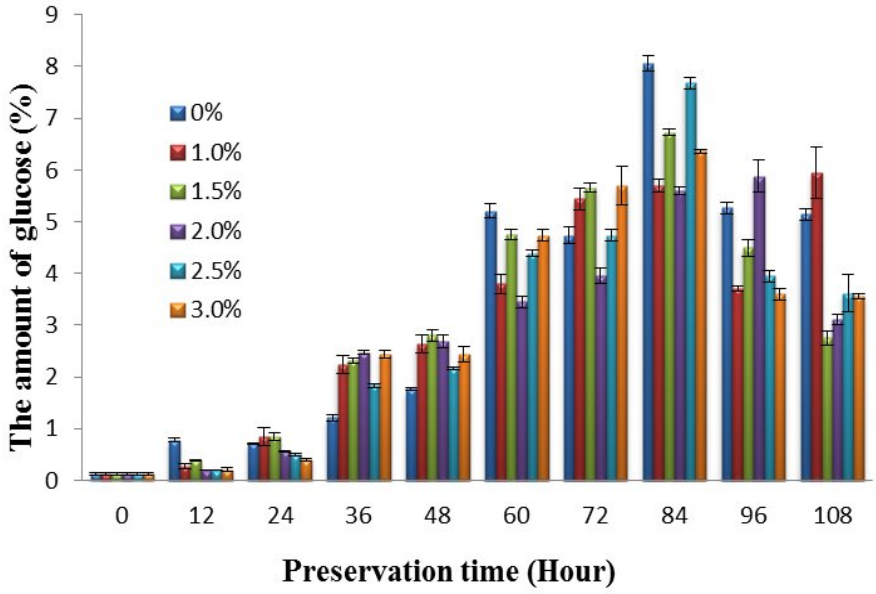


Figure 4. Changes in value of the content of glucose with preservation time.

In table 3, the sugar content increased slowly in storage time. This means that in the postharvest ripening process, fruits would produce the reducing sugar content more than the consumption sugar content during the ripening process (Le et al., 2008). The reducing sugar content in all samples at the first period was very low and stable, then increased gradually with storage time, then declined sharply. At 36 and 48 hours, all forms of sugar increased approximate three times from 0.85 to 2.80% in comparison with 24 hours. The highest growth was in the period from 60 to 84 hours with all samples. The highest sugar content without ethephon treatment samples was 8.06% and 7.68% correspondence an ethephon treatment samples at 2.5%, raised approximate four times the reducing sugar content in 36 hours (Figure 4).

At 96 hours in the ripening process, after maximum sugar content, bananas sugar content began to decline and was used for the respiratory process. Therefore, the sugar content decreased.

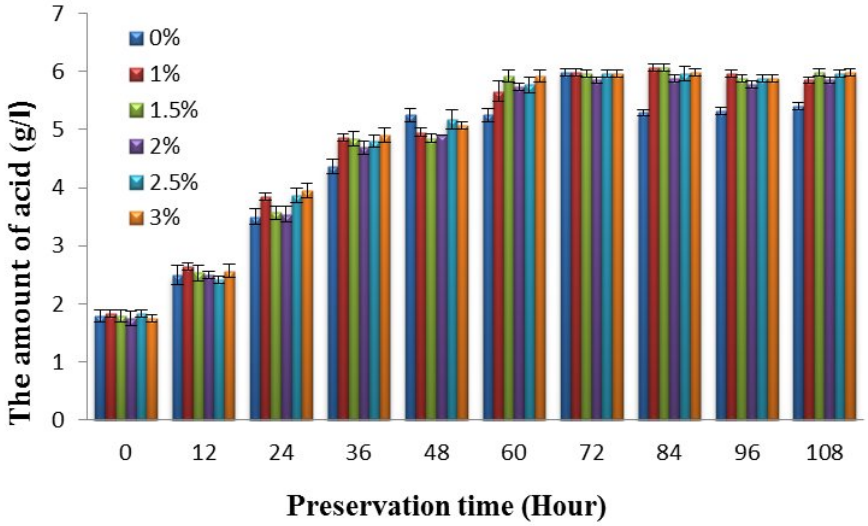


Figure 5. Changes in value of the total acidity with preservation time.

Table 4. Variation of the total acid content (g/l) over time preserved.

Hours (h)	Concentration of ethephon (%, v/v)					
	0	1.0	1.5	2.0	2.5	3.0
0	1.79±0.11 Aa	1.83±0.06 Aa	1.79±0.11 Aa	1.75±0.13 Aa	1.83±0.06 Aa	1.75±0.06 Aa
12	2.50±0.17 Bab	2.64±0.06 Bb	2.53±0.13 Bad	2.50±0.06 Bab	2.42±0.06 Ba	2.57±0.11 Bab
24	3.50±0.13 Ca	3.84±0.06 Cb	3.57±0.12 Ca	3.54±0.13 Ca	3.87±0.13 Cb	3.95±0.13 Cb
36	4.36±0.12 Da	4.87±0.06 Dbc	4.84±0.13 Dbc	4.69±0.11 Db	4.80±0.11 Dbc	4.91±0.12 Dc
48	5.25±0.11 Ec	4.95±0.07 Dab	4.95±0.07 Dab	4.91±0.00 Ea	5.18±0.17 Ec	5.07±0.06 Ebc
60	5.25±0.11 Ed	5.66±0.17 Eab	5.92±0.11 EFab	5.74±0.06 Fa	5.77±0.13 Fcd	5.92±0.11 Fbc
72	5.99±0.06 Fb	5.99±0.06 Gb	5.96±0.06 EFab	5.85±0.06 FGa	5.96±0.06 Gab	5.96±0.06 Fab
84	5.29±0.06 Ea	6.07±0.06 Gc	6.07±0.06 Fc	5.88±0.06 Gb	5.96±0.13 Gbc	5.99±0.06 Fbc
96	5.32±0.06 Ea	5.96±0.06 FGc	5.88±0.06 Ebc	5.77±0.06 FGb	5.88±0.06 FGbc	5.88±0.06 Fbc
108	5.40±0.06 Ea	5.85±0.06 Fb	5.99±0.06 EFc	5.85±0.06 FGb	5.96±0.06 Gbc	5.99±0.06 Fc

Various capital letters in the same column are significant difference at the level of p=5%.
Various lowercase letters in the same row are significant difference at the level of p=5%.

In figure 5, acid levels increased slowly during the preservation time from 0 to 60 hours. The sample without ethephon treatment was lower than the sample with ethephon treatment almost times. The amount of acid did not show much of that variability in the sample with ethephon treatment, but it had the significant difference with non ethephon treatment samples (Table 4). Bananas changed to ripening process, so damage process began to appear at the same time. The internal enzyme systems of bananas along with the development of microbial fermentation takes place strongly, combined with the aerobic respiration and under the effect of ethylene from ethephon, the bananas will ripen quickly (Ton et al., 2008).

Through the survey, we found that banana samples with ethephon concentration of 2.5% (v/v) have the high ratio of ripe fruit, high reducing sugar content, low weight loss, equal ripening and delicious taste during the speeding about 60 - 72 hours (Figure 7 and 8).

Testing residue ethephon content on Latundan bananas

After the preservation time about 60-72 hour, the ethephon residues in Latundan bananas were 23.0 ppm (mg/kg). The concentration of ethephon residues in fruits will decrease over preservation time because ethephon could be hygroscopic and released ethylene (Tran, 2000).

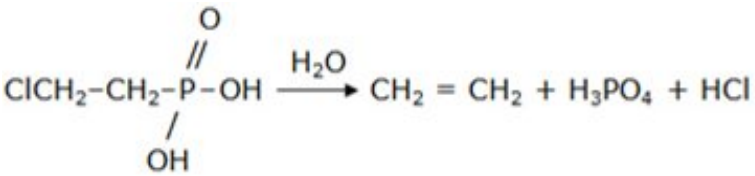


Figure 6. Decomposition of ethylene from ethephon.

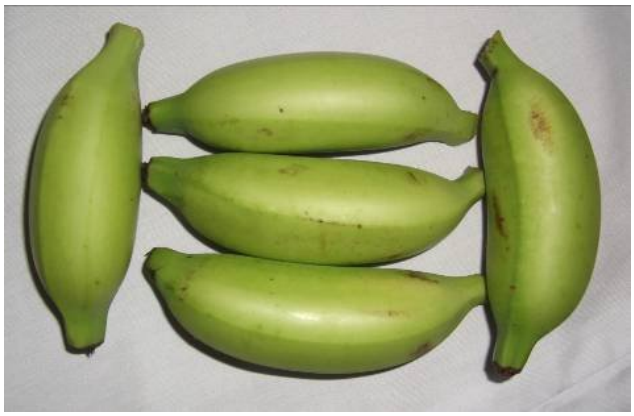


Figure 7. Latundan bananas before soaking in ethephon solution.

Figure 8. Latundan bananas after soaking in 2.5% ethephon solution.

Table 5. Responding summary of participants.

Subjects responded	Subjects required		Total
	Matched pairs AA or BB	Unmatched pairs AB or BA	
Same	6	4	10
Different	7	7	14
Total	13	11	24

A: Samples soaked into ethephon solution
B: Samples did not soaked into ethephon solution
$\chi^2 = 0.231$ $\chi^2_{cri} = 2.71$

$\chi^2 < \chi^2_{cri}$, consumers can not recognize the banana samples for soaking and not soaking into ethephon solution. In other words, two samples (A and B) are the same as statistically significant at the level of p=5 %.

Sensory evaluation of Latundan bananas after soaking in ethephon solution

Using 24 participants who have evaluated the similarities and differences of the samples of bananas with ethephon 2.5%, preservation time 72 hours and bananas which were bought in the local market and have the similar ripen. Result shows in Table 5.

Conclusion

At an ethephon concentration solution of 2.5% (v/v), preservation time from 60 to 72 hours, Latundan bananas ripened equally, low weight loss, high reducing glucose content, minor changes on total acidity and the rate of ripe fruit was over 80%. Consumers did not realize the differences of bananas after soaking into the ethephon solution. But the ethephon residues were high, that may affect the consumer's health. From this context, authors proposed to define rules about ethephon residues on bananas to Vietnam government.

References

AOAC. 2000. Official method of Analysis. 17th ed. Association of Official Analytical Chemists, Gainthersbug, MD, USA.

Bui, Q. Q. 2007. Ethephon and Jackfruit. Palo Alto, California.

Chesworth, J. M., T. Stuchbury and J. R. Scaife. 1998. An introduction to agricultural biochemistry. Chapman & Hall, London, UK. pp. 388–392.

Isopan Insulation (India). 2011. Banana colour chart.

Korsak, T. and Y. S. Park. 2010. Ethylene metabolism and bioactive compounds in ethylene-treated 'Hayward' kiwifruit during ripening. J. Hortic. Env. Biotechnol. 51(2):89–94.

Lawless, H. T., H. Heymann. 2010. Sensory evaluation of food – Principles and practices. International Thomson publishing.

Le, V. T., T. H. Nguyen, T. L. B. Hoang, L. H. Quan. 2008. Fruits and vegetables: Processing and preservation technology. Science and Technics Publishing House, Ha Noi, Vietnam.

Mahayothee, B., S. Neidhart, W. Mühlbauer and R. Carle. 2007. Effects of calcium carbide and 2-chloroethylphosphonic acid on fruit quality of Thai mangoes under various postharvest ripening regimes. Eur. J. Hortic. Sci. 72:171–178.

Nguyen, Q. T., M. K. Nguyen and H. P. Tran. 1999. Ethylene and its applications in agriculture. Agricultural Publishing House, Vietnam.

Pham, V. C. 2005. Control methods of growth, development, flowering and fertilization of fruit trees. Agricultural Publishing House, Vietnam.

Quoc, L. P. T., L. T. Cam, V. N. Anh, D. V. Thai and D. T. Bich. 2013. Research the influence of ethephon on the ripe ambarella (*Spondias dulcis* L.). Ann. Food Sci. Technol 14(1):27-33.

Sandra, B. and H. Kim. 1997. Water content of fruits and vegetables. Educational programs of the Kentucky Cooperative Extension Service. p.129

TCVN. 2011. Fruits – Determination of ethephon residue by gas chromatography (GC). Official method of Analysis, Ho Chi Minh, Vietnam.

Ton, N. M. N., T. T. T. Tran and V. V. M. Le. 2008. Fruits and vegetables processing technology, Volume 1, Vietnam National University. Ho Chi Minh City Publishing House, Vietnam.

Tran, H. P. 2000. Initial results of Ethrel application in agriculture. Research collection of science and technology, Vietnam.

Tran, T. T. 1998. Fruit-tree. Agricultural Publishing House, Vietnam.

Tran, T. N. 2011. Analyze the genetic diversity of bananas in Lamdong by molecular biological methods. Master dissertation, Dalat University, Faculty Biology, Vietnam.

Zhou, J. Y., C. D. Sun, L. L. Zhang, X. Dai, C. J. Xu and K. S. Chen. 2010. Preferential accumulation of orange-colored carotenoids in Ponkan (*Citrus reticulata*) fruit peel following postharvest application of ethylene or ethephon. Sci. Hortic. 126:229–235.