Cercetări Agronomice în Moldova
Vol. XLV , No. 4 (152) / 2012

RESEARCH REGARDING THE INFLUENCE OF ETHEPHON ON THE RIPE ACEROLA (*MALPIGHIA GLABRA* L.)

L.P.T. QUOC[1]*, C.P. DAT[1], A.T. HANG[1], T.H. MI[1], L.T.T. NGA[1]

*E-mail: lephamtanquoc@yahoo.com

Received September 19, 2012

ABSTRACT. These days, there are many types of chemicals which have ability to hasten the ripe fruit and affect the quality of fruits like calcium carbide, ethylene, acetylene, gibberellic acid. The objective of this research determines the influence of ethephon (2-chloroethyl phosphonic acid or ethrel) on the ripe acerolas (*Malpighia glabra* L.). Because the acerolas are the common fruit in Vietnam and another Asia countries, it had a lot of water and high nutrition, especially reducing sugars and acid ascorbic. The acerolas samples was soaked into ethephon solution at concentrations of 0, 1, 1.5, 2 and 2.5 % (v/v), then preserved in basket covered with cloth in conditions: temperature 30±1.4 ^{o}C, relative humidity 72±10 %. The use of specifications for evaluating were the percentage of ripe fruits, weight loss, the content of reducing sugar, total acidity and sensory evaluation of acerolas. The results showed that acerolas soaked into concentration of 2 % (v/v) ethephon have stimulated fruits that were the quick and uniform maturity; peel of acerolas was very smooth, red and characteristic flavour. Consumers are not unpleasant with the sensory evaluation quality of fruits soaked with ethephon. The ethephon residue in fruit after treatment did not harm in consumer's health and it was absolutely suitable for the food law in Vietnam.

Key words: Ethephon; 2-chloroethyl phosphonic acid; Ethrel; Acerolas; Maturity.

INTRODUCTION

Acerola (*Malpighia glabra* L.*)* is a tropical fruit in the family *Malpighiaceae*. Acerolas had a bright red drupe, is 1–3 cm in diameter with weight of 3–5 g. The fruit peel was glossy, thin, soft and easily damage. It was cultivated in the south Vietnam with the high yield. Acerola had a lot of water and the high nutrition so it was raw material in beverage processing and was the main fruit for dessert with vietnamese (vi.wikipedia.org, 2009). In Vietnam,

[1] Institute of Biotechnology and Food Technology, Industrial University of Ho Chi Minh City, Ho Chi Minh City, Vietnam

it was usually preserved at normal condition in the local market store in .

Mature fruits produce a certain amount of ethylene which does not make uniform maturation in a batch. Therefore, a solution of chemical treatment is necessary. Ethephon (ethrel) was known as a plant growth regulator which decomposes into ethylene. It stimulates defoliation, ripe evenly fruit, decreasing preservation time and minimizing post-harvest losses (Pham, 2005).

Recently, there have been many mixed opinions on the toxicity of ethephon that confused the customers (Nguyen *et al*., 1999). It was classified as an organophosphate pesticide and was registered with EPA (US Environmental Protection Agency) since 1973 as a plant growth regulator used to promote fruit ripening and flower induction. 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 ethephone at 0.05 mg/kg body weight/day (Bui, 2007). In addition, using ethephon solution in ripe fruit was quite new and having no article for the influence of this chemical on the ripe acerolas. Nevertheless, ethephon could be hygroscopic and released ethylene during storage. Thus, ethephon could hasten the ripe acerolas and the ethephon residues did not affect the health of consumers with the tiny dose. Therefore, we conducted to research this subject.

MATERIALS AND METHOD

Materials

Acerolas are harvested in Go Cong, Ben Tre province, Vietnam. Fruits will be harvested after approximately 25 days from the date simultaneously bloom. Harvested fruits are 20.5±1.87 mm in diameter with weight 4 – 6 g/fruit.

Ethephon are in liquid form, pale yellow color, transparent and from China.

Method

Ripe acerolas processing

Acerolas → Shorting → Washing→ Soaking → Keeping dry → Preserving

Acerolas were preserved into a basket covered with a cloth at temperature 30±1.4 ^{o}C and relative humidity 72±10 %.

Analysis method

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

The concentration of reducing sugar was determined by Lane – Eynon method. We used glucose solution 1%, the mixture of Fehling A and B. Sugars will discoloration of methylene blue indicator, which is the end of the reaction. Content of reducing sugars was expressed in percentage (%) of fruit mass.

The total acidity value was determined by (AOAC 942.15, 2007). Titration acidity was performed by NaOH 0.1 N with phenolphatalein 0.1% as an indicator and expressed in grams (g) of total acidity per 100 g of fruit.

Residue examination of ethephon on acerolas was determined by gas chromatography–mass spectrophotometer

(GC – MS) (AOAC 2007.01, 2007). 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 and Heymann, 2010).

Data analysis

Each sample of acerolas had weight of 250 g, corresponding to 55–60 units, repeated three times. Data would be analyzed by Statgraphics program (Centurion XV) with confidence interval p=0.05.

RESULTS AND DISCUSSION

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

In *Table 1,* the percentage of ripe acerolas at different concentrations increased corresponding to incubation time. In particular, the samples soaked with ethephon solution at higher concentration resulted in higher ripening rate and faster ripening time than those without ethephon treatment. At time 50 and 60 hours, the soaking sample in 2 and 2.5% of ethephon solution obtained the highest ripening grade, however, these samples decreased due to the spoilage. The samples at these concentrations matured quite equally, had specific aroma and dark red color. It is proved that ethephon was decomposed to release ethylene which promotes the ripening process of acerolas. The more ethylene was decomposed, the ripe fruit promoted fast (Le *et al*., 2008). The ripening rate of soaking samples in 2% of ethephon increased approximately 35% after 50 hours and 20% after 60 hours compared to those without ethephon treatment. However, at time 70 hours, the samples without ethephon treatment reached the highest ripening rate (75.85%) (*Fig. 1*).

During post harvest ripening, weight loss rate increased over the preservation time because the respiratory plant process released carbon dioxide, water and consumes glucose. In addition, acerolas have high water content 85-95%, the evaporation process may be one of the main reasons causing weight loss of fruits (Ton, 2008). For the first 40 hours, the weight loss was inconsiderable. From 40 to 80 hours, the weight loss increased rapidly (*Table 2*). At the time of 40 incubation hours, the weight loss of acerolas increased nearly two times when comparing with the time 30 hours. And at the time 50 hours, the weight loss raised approximate three times when comparing with the time 40 hours. The weight loss slowed from the time 50 to 60 hours. After 60 hours of incubation, the weight loss increase dramatically, particularly the samples soaked with 2.5% of ethephon. The weight reduction was slow in samples with 2% ethephon treatment when comparing with remaining samples (*Fig. 2*).

Table 1 - Percentage of ripe acerolas (%) versus the preservation time

Hour	Conc. (%,v/v)				
	0	1	1.5	2	2.5
10	0.00 ± 0.00 Aa	0.00± 0.00 Aa	0.00± 0.00 Aa	0.00± 0.00 Aa	0.00± 0.00 Aa
20	0.00 ± 0.00 Aa	0.00± 0.00 Aa	3.70± 3.21 Aab	3.64± 4.81 Aab	8.02± 4.08 Bb
30	6.35± 3.70 Ba	15.93± 2.61 Bb	38.68± 2.61 Bc	41.82± 1.82 Bcd	44.09± 1.44 Cd
40	30.44± 2.05 Ca	50.31± 0.54 Cb	65.69± 4.00 Cc	72.73± 1.82 Cd	75.77± 1.75 Dd
50	48.86± 1.81 Da	71.78± 0.40 Db	82.82± 0.92 Dc	83.03± 1.05 Dc	85.73± 0.72 Ed
60	65.53± 0.99 Ea	81.59± 0.51 Db	84.67± 0.93 Dbc	86.67± 1.05 Dcd	89.51± 4.09 Ed
70	75.85± 0.17 Fab	78.55± 1.54 Eb	76.11± 2.71 Eab	73.94± 2.10 Ca	67.65± 2.89 Fc
80	43.22± 7.17 Dab	39.33± 3.86 Ba	41.74± 1.70 Bab	48.48± 3.78 Eb	43.47± 2.46 Cab
90	5.09± 5.00 ABa	0.00± 0.00 Ab	0.00± 0.00 Ab	0.00± 0.00 Ab	0.00± 0.00 Ab

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%.

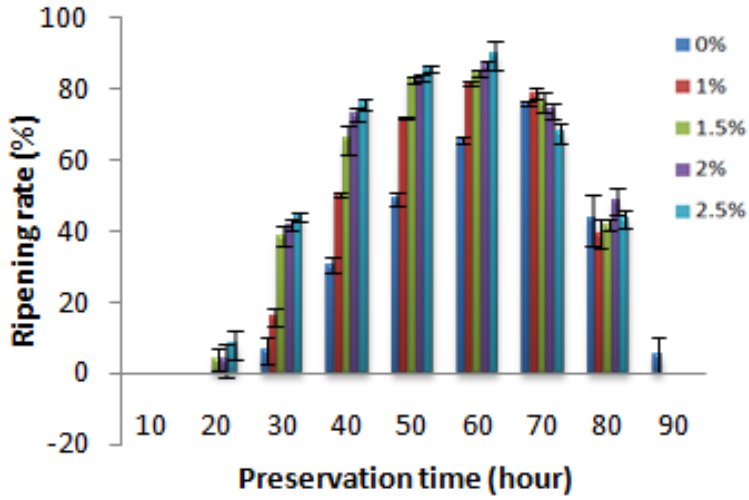

Figure 1 - The ripe acerolas rate (%) versus the preservation time

Table 2 - The weight loss (%) versus the preservation time

Hour	Conc.(%,v/v)				
	0	1	1.5	2	2.5
0	0.00 ± 0.00 Aa	0.00± 0.00 Aa	0.00 ± 0.00 Aa	0.00± 0.00 Aa	0.00± 0.00 Aa
10	0.67 ± 0.23 ABa	0.53 ±0.46 Aba	0.67 ± 0.23 Ba	0.67 ± 0.23 ABa	0.27 ± 0.23 ABa
20	0.80 ± 0.00 ABa	0.53 ± 0.23 Aba	0.67 ± 0.23 Ba	0.53 ± 0.23 ABa	0.53 ± 0.23 ABCa
30	1.20 ± 0.01 Ba	1.20 ± 0.01 Ba	1.33 ± 0.23 Ca	1.32 ± 0.60 Ba	0.93 ± 0.23 BCa
40	2.14 ± 0.24 Ca	2.40 ± 0.68 Ca	1.47 ± 0.23 Cb	2.65 ± 0.22 Ca	1.33 ± 0.23 Cb
50	7.48 ± 0.61 Da	6.39 ± 0.43 Dab	6.39± 0.69 Dab	5.96 ± 0.77 Db	6.64 ± 0.61 Dab
60	8.01 ± 0.43 Da	6.93 ± 0.26 Dbc	6.79 ± 0.40 Dbc	6.49 ± 0.45 Dc	7.57 ± 0.69 Eab
70	9.48 ± 0.85 Ea	12.78 ± 0.80 Eb	11.19 ± 0.40 Ec	10.99 ± 1.16 Eac	13.81 ± 0.92 Fb
80	12.28 ± 0.90 Fa	15.31 ± 1.00 Fbc	14.380 ± 0.37 Fb	14.04 ± 1.21 Fb	16.60 ± 0.82 Gc

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%.

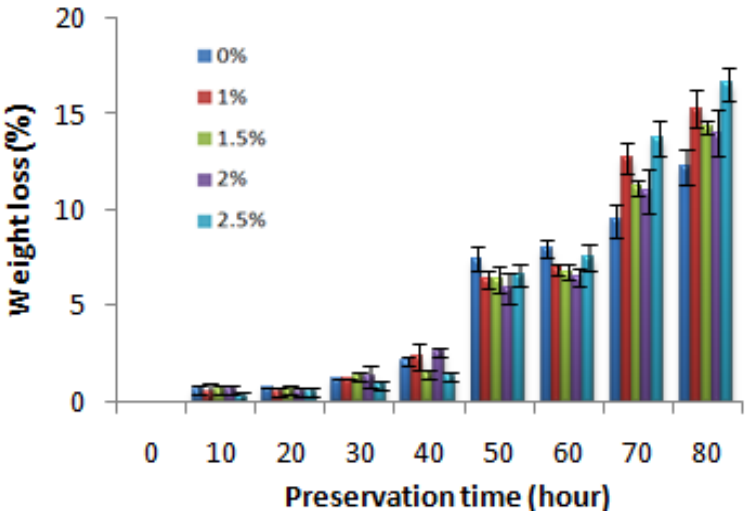

Figure 2 - The weight loss (%) versus the preservation time

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

The amount of reducing sugar in fruits tended to decrease slowly during preservation time. The fruits would produce more amount of reducing sugar than that of consumed sugar during ripening process (Le *et al.,* 2008; Tran, 2004). In *Table 3*, the samples without ethephon treatment, the quantity of reducing sugar fluctuated slightly and increased gradually at greater ethephon concentrations. The samples treated with 2.5% of ethephon after 30 hours, the amount of reducing sugar grew quite strongly (8.43%). Otherwise, this amount varied unstably and decreased rapidly, from 6.86% after 40 hours to 4.9% after 60 hours. Acerolas in this phase began to spoil which caused high respiration to consume much amount sugar (Ton, 2008). The treatment sample with 2% of ethephon, amount of reducing sugar did not increased rapidly when comparing with 2.5% of ethephon (reached 8.43% after 40 hours); in return, this amount had longer stability and slower reduction (retained 6.67% after 60 hours) (*Fig. 3*).

Table 3 - Amount of reducing sugar (%) versus preservation time

Hour	Conc.(%,v/v)				
	0	1	1.5	2	2.5
0	4.71 ± 0.59 Aa	4.71 ± 0.00 Aa	4.51 ± 0.68 Aa	4.71 ± 0.59 Aba	4.71 ± 0.59 Aa
10	4.90± 0.34 ABa	5.10 ± 0.34 ABa	4.90± 0.34 Aa	4.9± 0.34 ABa	5.49± 0.34 BCa
20	5.10 ± 0.34 ABa	5.49± 0.34 BCab	6.08± 0.34 Bbc	5.88± 0.59 CDb	6.67± 0.34 Dc
30	5.49± 0.34 BCa	5.69± 0.34 Bca	7.65± 0.59 CDb	8.24± 0.59 FGb	8.43± 0.34 Eb
40	6.08± 0.34 Ca	7.06± 0.59 Eb	8.24± 0.59 Dc	8.43± 0.34 Gc	6.86± 0.34 Dab
50	6.86± 0.34 Da	8.24± 0.59 Fb	7.84± 0.68 CDb	7.45± 0.34 EFab	5.88± 0.59 Cc
60	7.45± 0.34 Da	6.67± 0.34 Deb	7.25± 0.34 Cab	6.67± 0.34 DEb	4.9± 0.34 ABc
70	7.06 ±0.59 Da	6.08± 0.34 Cab	6.08± 0.34 Bab	5.49± 0.90 BCbc	4.51± 0.34 Ac
80	6.86± 0.34 Da	5.1± 0.68 Abc	5.88± 0.59 Bb	4.51± 0.34 Ac	4.31± 0.34 Ac

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%.

EFFECT OF ETHEPHON ON THE RIPE ACEROLAS

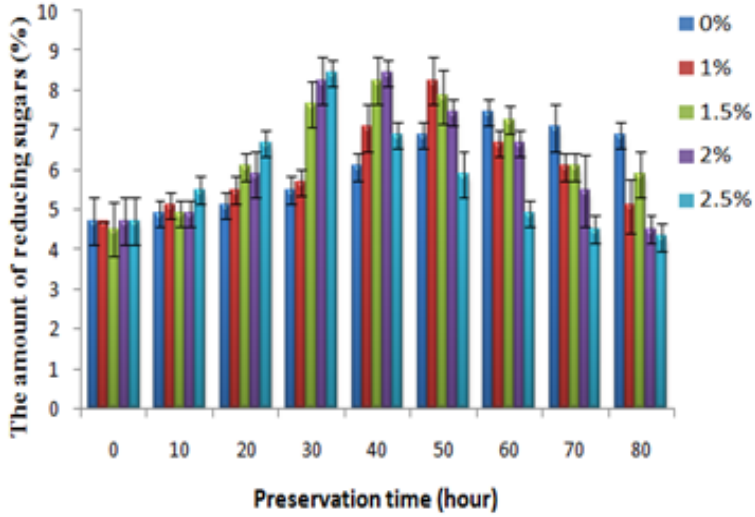

Figure 3 - Amount of reducing sugar (%) of acerolas versus the preservation time

Table 4 - Amount of total acidity value (g/l) versus the preservation time

Hour	Conc.(%,v/v)				
	0	1	1.5	2	2.5
0	3.164 ±0.06 Aa	3.127 ±0 Aa	3.127 ±0.11 Aa	3.201 ±0.06 Aa	3.238 ±0.11 Aa
10	2.941 ±0.06 BCa	3.052 ±0.13 Aba	2.941 ±0.06 ABb	3.052 ±0.06 ABc	3.015 ±0.11 Bc
20	2.903 ±0.22 Cb	2.866 ±0.32 Aba	2.829 ±0.06 BCa	2.903 ±0.11 BCb	2.866 ±0.06 BCa
30	2.829 ±0.13 CDab	2.792 ±0.11 Bca	2.829 ±0.26 BCab	2.972 ±0.11 CDa	2.754±0.17 CDa
40	2.792 ±0.11 CDab	2.754 ±0.13 Cb	2.754 ±0.13 BCb	2.717 ±0.06 Db	2.606 ±0.13 Dc
50	2.717 ±0.28 CDa	2.717 ±0.06 Cda	2.68 ±0.11 CDa	2.606 ±0.06 DEa	2.308 ±0.13 Eb
60	2.643 ±0.06 DEa	2.457 ±0.22 Dea	2.531 ±0.06 Da	2.494 ±0.23 Ea	2.122 ±0.11 EFb
70	2.419 ±0.06 EFa	2.196 ±0.06 Efb	2.271 ±0.06 Eb	2.084 ±0.06 Fc	2.01 ±0 Fc
80	2.271 ±0.06 Fa	2.084 ±0.13 Fb	2.047 ±0.06 Fb	2.084 ±0.06 Fb	2.047 ±0.06 Fb

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%.

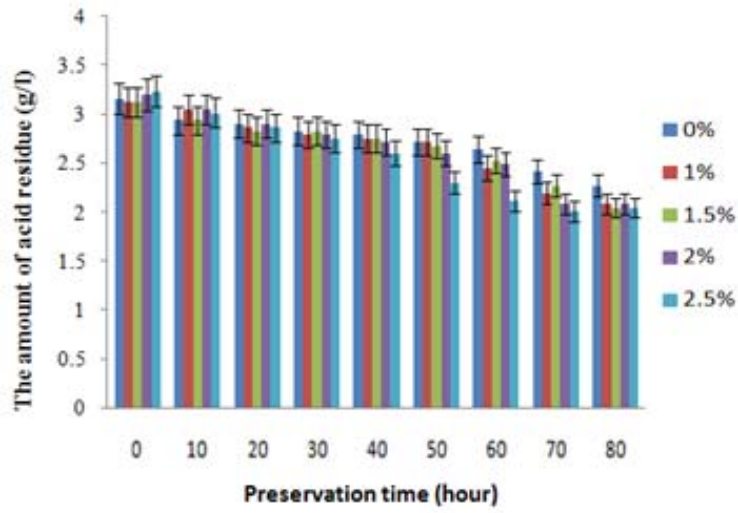

Figure 4 - Amount of total acidity value (g/l) of acerolas versus the preservation time

In *Table 4*, the total acidity value in acerolas tended to decrease during the preservation time. It are the major respiratory substrates, utilized higher than others and could decrease to 50% during fruit formation. Reducing amount of total acidity in ripe fruits results as increasing of cell membrane penetration lead acid to diffuse into cells, this process released some derivatives of malic acid, which would convert into soluble sugar (Le *et al.,* 2008; Tran, 2004). The amount of total acidity in 0% of ethephon sample decreased at the least and was significant different at level of p=5% when comparing with the remaining samples. Amount total acidity of all samples treated with ethephon changed inconsiderably (*Fig. 4*). Acerolas changed to ripening process, so damage process began to appear at the same time.

In this research, the samples treated with 2% of ethephon solution which had high ripening rate and reducing sugar amount, low weight loss, ripening evenly and having good sensory evaluation after incubation time from 50 to 60 hours.

Testing the ethephon residue on the acerolas

After the preservation time from 50 to 60 hour, the ethephon residue on acerolas was covariant when comparing its with the ethephon concentration solution (*Table 5*). However, ethephon residue will reduce over preservation time cause ethephon could be hygroscopic and released ethylene (Tran, 2000) (*Fig. 5*). Nevertheless, residues on samples still remain in the permitted range (in accordance with the current regulation of Vietnam–Circular No. 68/2012/TT-BNNPTNT).

Table 5 - The ethephon residue on the acerolas (mg/kg)

Ethephon concentration in soaking solution (%,v/v)	1	1.5	2	2.5
Ethephon residue on the acerolas (mg/kg)	0.0715 ± 0.011^{a}	0.0825 ± 0.005^{ab}	0.11 ± 0.013^{bc}	0.12 ± 0.014^{c}

Various small lowercase letters are significant difference at the level of p=5%.

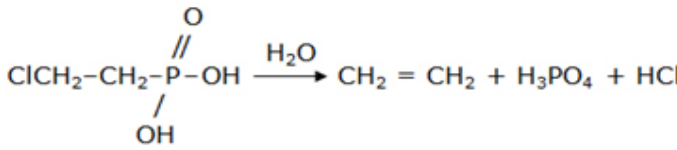

Figure 5 - Ethylene was formed from ethephon (Tran, 2000)

Sensory evaluation of acerolas after soaking in ethephon solution

We used 24 participants who have evaluated the similarities and differences of the samples of acerola which are not soaked (*Figs. 6 and 7*), were bought in the local market and soaked into ethephon solutions with the preservation time 50 hour. Result was presented in *Table 6*.

$\chi^2 < \chi^2_{cri}$, consumers were unable to differentiate the soaking and not soaking samples into ethephon solution. In other words, these two samples (A and B) are the similar at the level of p=5%.

Figure 6 - Acerolas before soaking in ethephon solution

Figure 7 - Acerolas after soaking in ethephon solution

Table 6 - Responding summary of participants

Sample order	Quantity of samples	Response	
		Similar	Different
AA	6	4	2
AB	6	3	3
BB	6	5	1
BA	6	4	2

A: samples soaked into ethephon solution
B: samples did not soaked into ethephon solution
$\chi^2 = 0.75$ $\chi^2_{cri} = 2.71$

CONCLUSIONS

At an ethephon concentration of 2%, acerolas were preserved in about 50–60 hours, they had an uniform maturity, low weight loss, high reducing sugar, minor changes on total acidity.

The ethephon residues on acerolas was in the safe range for health of consumers. Consumers did not realize the differences of acerolas after soaking into the ethephon solution.

Acerolas which are hastened to ripe by using ethephon with small cost (2 USD per 500 ml of ethephon); while generate a considerable efficiency of commercial value (Ethephon can be dilute to 25 liters). This cost is likely acceptable in Vietnam.

REFERENCES

Bui Quoc Quang, 2007 - Ethephon and Jackfruit, Palo Alto, California.

Lawless H.T., Heymann Hildegarde, 2010 - Sensory evaluation of food. Principles and practices. International Thomson Publishing House.

Le Van Tan, Nguyen Thi Hien, Hoang Thi Le Bang, Quan Le Ha, 2008 - Fruits and vegetables-processing and preservation technology. Science and Technics Publishing House, Ha Noi, Vietnam.

Nguyen Quang Thach, Nguyen Manh Khai, Tran Hanh Phuc, 1999 - Ethylene and its applications in agriculture. Agricultural Publishing House, Vietnam.

Pham Van Con, 2005 - Control methods of growth, development, flowering and fertilization of fruit trees. Agricultural Publishing House, Vietnam.

Ton Nu Minh Nguyet, 2008 - Fruits and vegetables processing technology, Volume 1, Vietnam National University. Ho Chi Minh City Publishing House, Vienam.

Tran Hanh Phuc, 2000 - Initial results of Ethrel application in agriculture. Research collection of science and technology, Vietnam.

Tran Minh Tam, 2004 - Post-harvest: Agricultural produce processing and storing. Agricultural Publishing House, Vietnam.

xxx, 2009 - www.vi.wikipedia.org /wiki /S%C6%A1_ri