# EFFECT OF TEMPERATURE ON PHYSIOLOGICAL ACTIVITIES OF TOMATO Cv. 'SAVIOR' DURING POSTHARVEST RIPENING

**Vu Thi Thuy Duong*, Tran Thi Dinh, Tran Thi Lan Huong**

*Faculty of Food Science and Technology, Vietnam National University of Agriculture*

*Email*: thuyduong090692@gmail.com*

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ABSTRACT

The objective of this study was to evaluate the effect of temperature on physiological changes of 'Savior' tomatoes during postharvest ripening. Tomatoes grown in the winter season and summer season were harvested at two maturity stages, mature green and breaker, and ripened at two temperatures, 22°C and 35°C. At the time of harvesting, ethylene production and respiration rate were measuredand then again every two days during the 14 day postharvest ripening process. The results showed that temperature has a great effect on the physiological attributes of tomatoes during postharvest ripening. Ethylene production and respiration rate in tomatoes ripened at 22°C were higher than those ripened at 35°C. Ethylene production was slightly higher in fruits grown in the summer season than those grown in the winter season. Postharvest ripening was inhibited at 35°C.

Keywords: Ethylene production, postharvest ripening, respiration rate, 'Savior', temperature, tomato.

## Ảnh hưởng của nhiệt độ đến các hoạt động sinh lí của cà chua giống Savior trong quá trình chín sau thu hoạch

TÓM TẮT

Nghiên cứu này nhằm đánh giá ảnh hưởng của nhiệt độ đến những biến đổi về sinh lý của cà chua giống Savior trong quá trình rấm chín sau thu hoạch. Cà chua vụ Đông và vụ Hè được thu hái ở 2 độ già 'Mature-green' và 'Breaker', sau đó được rấm chín ở 2 nhiệt độ 22°C và 35°C. Cường độ sản sinh ethylene và cường độ hô hấp được theo dõi tại thời điểm thu hoạch và sau mỗi 2 ngày trong suốt 14 ngày của quá trình rấm chín. Kết quả cho thấy, nhiệt độ có ảnh hưởng lớn đến những biến đổi sinh lý của cà chua Savior trong suốt quá trình chín sau thu hoạch. Cường độ hô hấp và cường độ sản sinh ethylene của cà chua rấm ở 22°C cao hơn ở cà chua được đặt ở 35°C. Cường độ sản sinh ethylene ở cà chua vụ hè cao hơn so với cà chua vụ đông. Quá trình chín sau thu hoạch bị hạn chế ở cà chua rấm ở nhiệt độ cao.

Từ khóa: Cà chua, cường độ hô hấp, cường độ sản sinh ethylene, nhiệt độ, rấm chín sau thu hoạch, "Savior".

## 1. INTRODUCTION

Tomato, *Lycopersiconesculentum*, is one of the most importantvegetable crops of the *Solanaceae* family grown worldwide (Upendra, 2003). Tomato fruit ripening is a complex, genetically programmed process that culminates in dramatic changes in color, texture, flavor, and aroma of the fruit flesh. Fruits with different ripening mechanisms can be divided into two groups: climacteric, in which ripening is accompanied by a peak in respiration and a concomitant burst of ethylene, and non-climacteric, in which respiration shows no dramatic change and ethylene production remains at a very low level. In tomato, it has been shown that ethylene affects the transcription and translation of many ripening-related processes (Giovannoni, 2001). Ethylene is the dominant trigger for ripening in climacteric fruit, and triggers lycopene formation in detached tomatoes (Jeffery *et al.,* 1984).

Temperature is considered to bethe most important environmental factor in the post-harvest life of tomato fruits because it has a tremendous influence on the rate of physiological processes. The conversion of 1-aminocyclopropage-1-carboxylic acid (ACC) to ethylene by the ethylene-forming enzyme is inhibited by high temperatures (Yang, 1990). Field (1985) suggested that high temperatures may interfere with membrane structure, causinganincrease of the activation energy of membrane-bound enzymes and a decline of ethylene synthesis. Biggs *et al.* (1988) noted a similar effect in detached tomato fruits ripened at temperatures above 34°C. Biological reactions generally increase two or three-fold for every 10°C rise in temperature within the range of temperatures normally encountered in the distribution and marketing chain. Waghmare *et al.* (2013) found the respiration rate of fresh cut produce increased 4- to 5-fold higher with an increase in temperature from 10°C to 30°C. At higher temperatures, enzymatic denaturation may occur and reduce the respiration rate (Fonseca, 2002). As shown by Atta-Aly (1992), increasing the storage temperature from 15°C to 30°C significantly increases carbon dioxide production of tomato fruits.

'Savior' is a new tomato variety and one of the most favorable varieties in Vietnam for its high yield performance, good appearance, and excellent eating quality. 'Savior' is also a heat-tolerant and disease-resistant cultivar, making it suitable for growing even in the off season. With these exceptional characteristics of productivity, disease resistance, and adaptability todifferent growing conditions, 'Savior' tomatoes have become an important crop in many localities of the Red River Delta region since 2010 (Dang, 2014). Recently, many research projects looking at cultivation techniques to improve fruiting rate and productivity for 'Savior' tomatoes were announced by scientists. However, studies on postharvest handling and quality changes during fruit ripening are still limited. At present, information on the effects of temperature on the physiological and biochemical changes in 'Savior' tomatoesis not available.

This study aimed to investigate the influence of temperature on the physiological attributes of tomatoes during postharvest ripening in order to provide scientific evidence for postharvest technology, and improve the nutritional value as well as the commercial value of 'Savior' tomatoes after harvest.

## 2. MATERIALS AND METHODS

### 2.1. Materials

Tomato fruits were harvested at a net house belonging to the Fruit and Vegetable Research Institute, Trau Quy, Gia Lam, Hanoi.

To ensure the uniformity in the maturity stage of the tomatoes, flowers that bloomed on the same day were selected and tagged at the time of flowering.Flowers near the top as well as near the roots were removed.

Fruits were harvested at 2 maturity stages according to days after full bloom (DAFB), and also the external coloration degree. The two stages were: mature green stage, when the surface is completely green, and breaker stage, when there is a definite "break" in color from green to tarnish- yellow, pink, or red on less than 10% of the surface, on the bottom of the fruit. Diseased fruits or injured fruits were removed

### 2.2. Experimental design

Tomatoes selected for the experiment were kept in a basket and packed in 3% perforated polypropylene bags. Tomatoes were randomly separated into lots of 150 fruits for each treatment. Three packs (replications) were used for each treatment combination (Table 1) and each pack contained 50 fruits.

Fruits were held in an environmental chamber at two temperatures 22°C and 35°C.

At 22°C, the humidity was 80 - 85%; at 35°C, humidity was 65 - 70%.

**Table 1. Experimental design for tomato 'Savior' fruits**

| Ripening temperature | Maturity stages | Growing seasons |
|---|---|---|
| 22ºC | Mature green (MG) | Summer |
| | | Winter |
| | Breaker (BR) | Summer |
| | | Winter |
| 35ºC | Mature green (MG) | Summer |
| | | Winter |
| | Breaker (BR) | Summer |
| | | Winter |

Fruit samples were taken for analysis every 2 days. Ateach sampling time, three packs (replications) from each treatment were randomly taken.

### 2.3. Measurement method

The ethylene production and respiration rate measurements of the tomatoes were done followingthe methods adopted by Singh (2011). A closed system was used to measure the ethylene production and respiration rates of tomatoes. A known weight of tomatoeswasaddedto an air tight container of known volume. The container was sealed carefully using vacuum grease. A single hole covered with silicon septum was made in the container's lid for the measurement of gas concentration.

The ethylene analyzer model CA56 recorded the ethylene produced. The ethylene was measured in parts per million (ppm) but this was converted to microliters per kilogram per hour ($\mu l.kg^{-1}.h^{-1}$) (Singh, 2013).

The $CO_2$ analyzer model Dual Gas Analyser 250 recorded $CO_2$ production in percentages and these were converted to respiration rates in milliliters of $CO_2$ produced per kilogram per hour (ml $CO_2.kg^{-1}.h^{-1}$) (Singh, 2013).

### 2.4. Data analysis

The Microsoft Excel Program was used to calculate averages. Analysis of variance (ANOVA) was performed using the IRRISTAT 5.0 program. Differences between treatments were analyzed by the least significant difference (LSD) test ($\alpha = 0.05$).

## 3. RESULTS AND DISCUSSION

### 3.1. Effect of temperature on ethylene production of 'Savior' tomatoes during postharvest ripening

Ethylene plays an important role in the initiation and continuation of ripening in all climacteric fruits, including the tomato. Variation of ethylene production during postharvest ripening is presented in Fig. 1.

Fig. 1 shows that temperature had a significant effect on ethylene production of tomatoes, being higher at 22°C than at 35°C. Ethylene production was higher in fruits grown in the summer season than those in the winter season.

In the winter season, the fruits havested at the mature green stage (MG_22) and the breaker stage (BR_22) showed an ethylene production peak when kept at 22°C by 6 days after harvest. The maximum ethylene production was observed in tomatoes at the breaker stage (2.4 $\mu l.kg^{-1}h^{-1}$) (Fig. 1W1,1W2). In the summer season, ethylene production of breaker fruits ripened at 22°C (BR-22) reached the highest point 6 days after harvest (4.89 $\mu l.kg^{-1}h^{-1}$), whereas mature green fruits (MG-22) showed apeak 8 days after harvest (5.07 $\mu l.kg^{-1}.h^{-1}$). The peak of ethylene production of mature green fruits in the summer season was 2.3 times higher than those grown in the winter season (Fig. 1S1, 1S2). After peaking, ethylene production then underwent a continuous decrease during the last days of processing.

In both seasons, the evolution of ethylene production in fruits ripened at 35°C were not significant. Fruits ripened at 35°C were significantly lower in ethylene production compared to fruits ripened at 22°C.

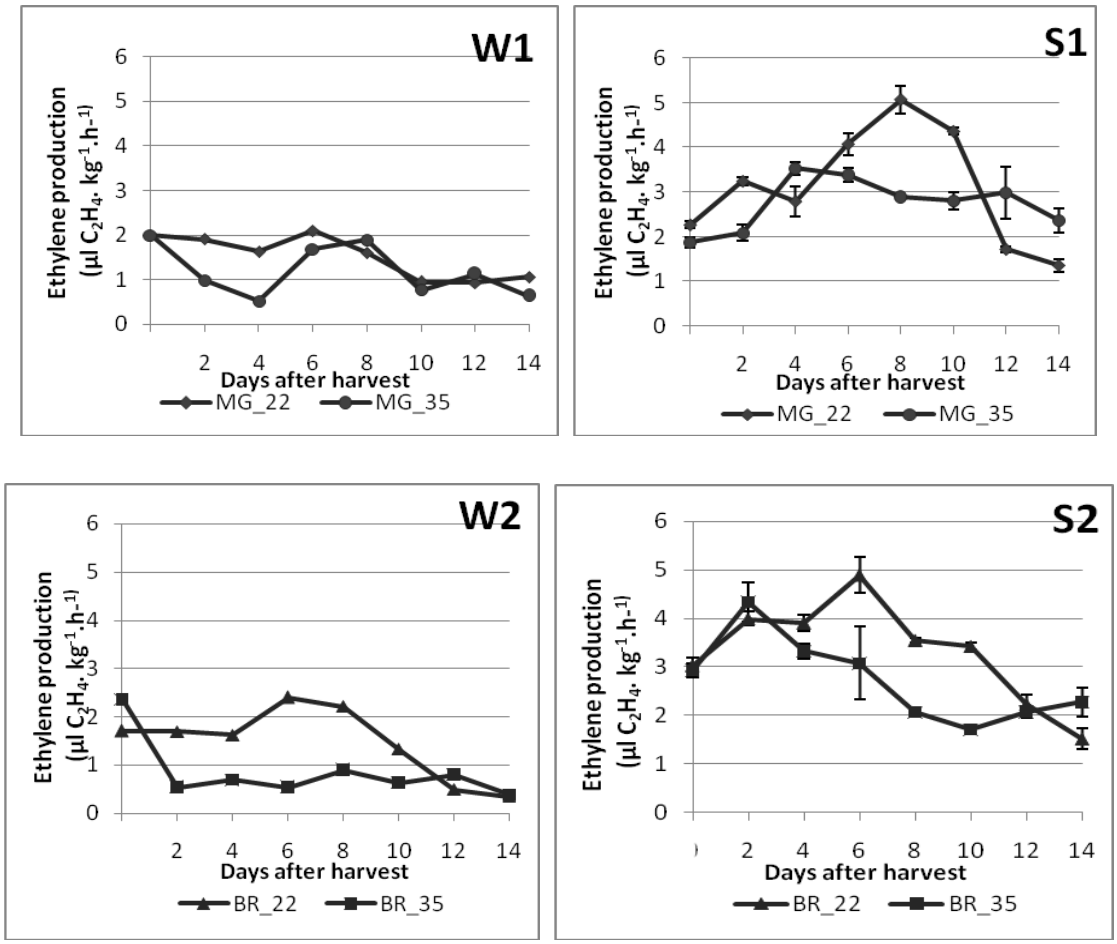


**Fig. 1. Ethylene production of tomato 'Savior' at different postharvest ripening temperature in winter (W1, W2) and summer season (S1, S2)**

These results were confirmed the study by Atta-Aly (1992), which indicated that tomato fruits held at different temperatures from 15°C to 35°C showed maximum ethylene production at 20°C. Ethlene production in breaker tomatoes ripened at 22°C was higher than those ripened at 30°C (Cantwell, 2000). Our resultsare also consistent with the results pointed out by Yang and Cheng (1990), when mature green tomatoes were ripened at 21°C, 30°C, and 37°C, the temperatures of 30°C and 37°C inhibited ethylene production.

Our investigation showed that the evolution of ethylene production of postharvest ripened tomatoes at 22°C was similar with the trend of vine-ripened 'Savior' fruits. The highest value of ethylene production of fruit ripened on-plant and grown in the summer season was achieved when fruit reached the turning stage (4.03 µl.$kg^{-1}h^{-1}$).

Ripening inhibition by high temperatures may be due to an inhibition of endogenous ethylene synthesis and an inhibition of the tissue's ability to respond to the ethylene present. The pathway of ethylene biosynthesis begins with the amino acid methionine (MET). Then, it is converted to S-adenosyl methionine (SAM) by the addition of adenine, and SAM is converted to 1-amino-cyclopropane carboxylic acid (ACC) by the enzyme ACC synthase. The conversion of ACC to ethylene by ethylene-forming-enzyme is inhibited by high temperature (Yang, 1987). Field (1985) suggested that high temperatures may interfere with membrane structure, leading to the increase of the activation energy of membrane-bound enzymes and a decline of ethylene synthesis.

### 3.2. Effect of temperature on respiration rate of 'Savior' tomatoesduring postharvest ripening

Respiration is a normal metabolic activity of living organisms and involves the intake of oxygen to break down glucose for energy production. Tomato is a climacteric fruit displaying a characteristic peak of respiratory activity during ripening. Temperature has been identified as the most important external factor influencing respiration (Singh *et al.*, 2013). The respiration evolution of tomatoes during postharvest ripening is presented in Fig. 2.

From the results of this experiment, temperature had a significant effect on the rate of respiration. Generally, the respiration rates of tomatoes ripened at 22°C were higher than those ripened at 35°C.

As seen in Fig. 2W1 and 2W2, $CO_2$ evolution of tomatoes grown in the winter season and ripened at 22ºC experienced an increase in the first periods, followed by consistent decreases in the next days. The rate of respiration in mature green tomatoes ripened at 22°C reached the maximum (17.97 $ml.kg^{-1}h^{-1}$) after 6 days, then, this value declined for the following examined days.

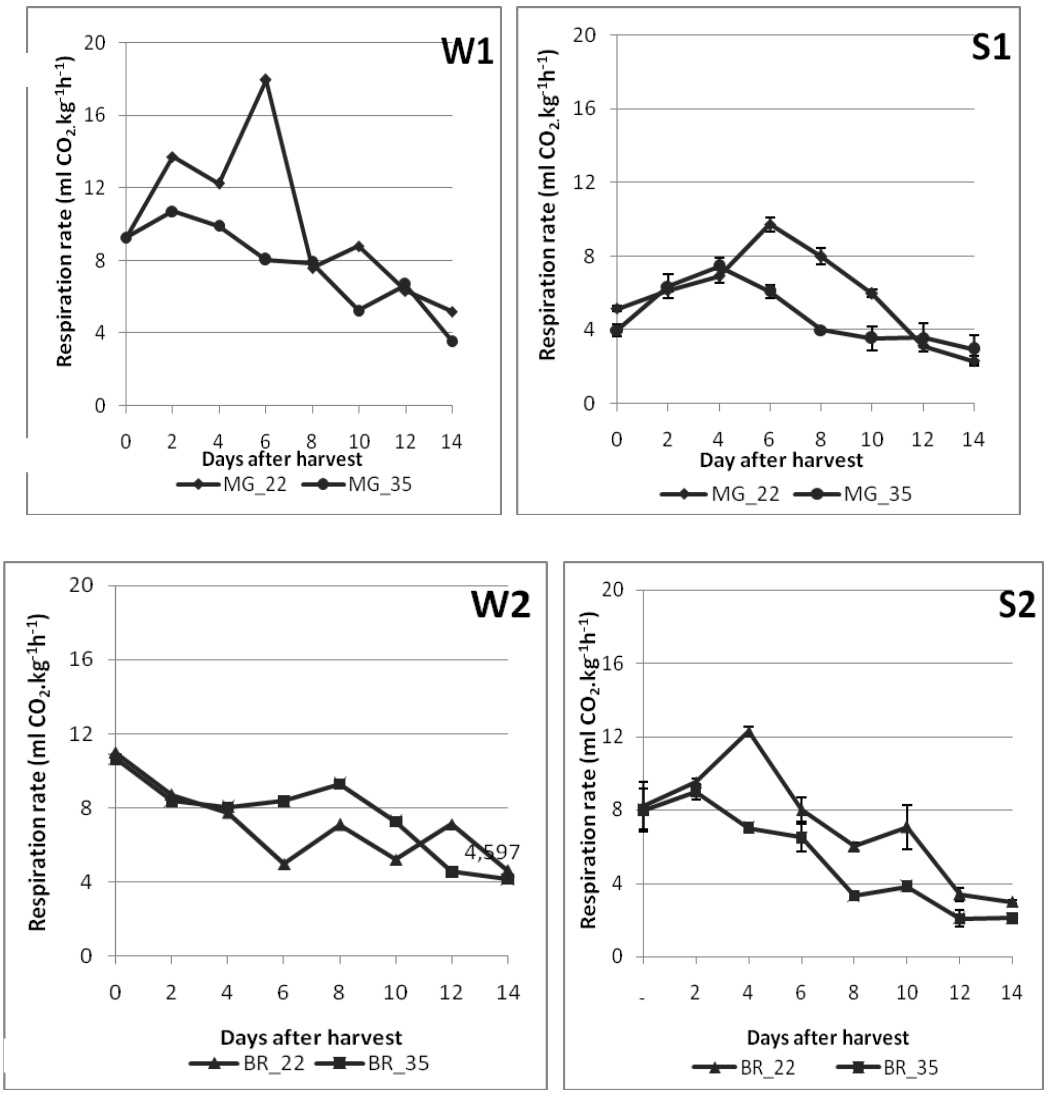


**Fig. 2. Respiration rate of'Savior' tomatoesat different postharvest temperatures in the winter (W1, W2) and summer seasons (S1, S2)**

As the results presented in Fig. 2S1 and 2S2 show, for the summer fruits ripened at 22°C, the respiration rate of fruits at the breaker stage reached the highest point (12.28 $ml.kg^{-1}h^{-1}$) by the $4^{th}$day after harvest. Mature green fruits showed respiratory climacteric after 6 days (7.46 $ml.kg^{-1}h^{-1}$).

For the tomatoes held at 35°C, no marked respiratory climacteric was observed during postharvest ripening.

The respiration rate of tomatoes ripened at 22ºC experienced a trend similar to the evolution of respiration rates of vine-ripened tomatoes grown in the summer season. When tomatoes ripened on-plant, the rate of respiration increased and reached amaximum level at the turning stage, and then decreased when fruits ripened.

Therefore, temperature had a significant effect on the rate of respiration. As shown by Atta-Aly (1992), increasing the storage temperature from 15ºC to 30°C significantly increases carbon dioxide production of tomato fruits. Waghmare*et al.* (2013) found that the respiration rate of fresh cut produce increased 4- to 5-fold higher with an increase in temperature from 10°C to 30°C. However, at higher temperatures, enzymatic denaturation may occur and reduce respiration rates (Fonseca, 2002).

## 4. CONCLUSIONS

Temperature has a significant effect on the physiological attributes of tomatoes during postharvest ripening. Ethylene production and respiration rateswere higher in fruits ripened at 22°C than at 35°C. 'Savior' tomatoes held at 22°C showed a characteristic peak in ethylene production and respiration while this was not observed in fruits held at 35°C. Ethylene production was slightly higher in fruits grown in the summer season than in fruits grown in the winter season. Postharvest ripening was inhibited in fruits ripened at 35°C.

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