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The Impact Of Ethylene Application On Ripe Chili Fruits During Storage

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Abstract

Chili is widely consumed fresh. The deterioration of chili fruit during storage was caused by respiration, decreasing water content, mechanical damage, microbial activity, and ethylene hormone activity. This study was aimed to determine the impact of ethylene application on the quality of chili fruit during storage. Ripe chili fruit (*Capsicum annuum* c.v. Neno) was used as genetic material. Treatments were applied in a completely randomized clock design with three replications. Chili fruits were harvested at 80% maturity level. The fruits were dipped in ethylene solution with concentrations: 500 and 1000 ppm for 0, 30, 60, 90, and 120 minutes. The treated chili fruits were stored for six days. Observations were conducted on fruit length, fruit stalk length, fruit weight, fruit flesh thickness, and weight loss. The results showed that exogenous ethylene application to ripe chili fruit at a low dose (500 ppm) did not affect weight loss at one week of storage. However, the application of 1000 ppm for 120 minutes increased the weight loss on the fourth day of storage. This study proves that exogenous ethylene application cannot spontaneously increase ethylene synthesis in non-climacteric fruits.

Keywords: Ethylene, postharvest, ripe chili, weight loss.

Introduction

Chili is one of the horticultural commodities that has a very fluctuating price. Factors that cause chili prices to fluctuate are demand and supply (Anwarudin *et al.*, 2015). The increase in chili prices is due to reduced supply, while demand is constant every day. Fluctuations in chili prices occur because chili production is seasonal, erratic rainfall, production prices, and post-harvest problems such as the length of distribution channels (Farid and Subekti, 2012).

National chili production in 2020 reached 2.77 million tons, an increase of 7.11% (183.96 thousand tons) from 2019. The largest chili producing provinces are East Java (28.28%), West Java (14.32%), and Central Java (11.73%). Total chili consumption of 1.03 million tons in 2020 decreased by 11.88% from the previous year, with the household sector as the main consumption actor. The export value of chili reached US$ 25.18 million, an increase of 69.86% (US$ 10.36 million) from 2019, with the main export destination countries being Saudi Arabia, Nigeria, and Malaysia. The value of chili imports in 2020 decreased to US$ 69.2 million, a decrease of 7.11% (US$ 5.3

million) with the main countries of chili imports being India, China, and South Korea (Central Bureau of Statistics, 2021).

Indonesian people prefer to consume fresh chili peppers. But nowadays, dried chili peppers are also widely used. Fresh chili is highly perishable in open storage conditions (room temperature 26-27 oC). Storage under room temperature conditions results in high weight loss and rapid deterioration of the chemical composition of the chili fruit (Samira *et al*., 2013). Fresh chilies lose water very quickly after harvest and begin to shrivel and change color within a few days (Jain *et al*., 2017). Chili fruits deteriorate rapidly after harvest. The high moisture content in the fruit results in the respiration rate remaining high during storage. High respiration results in accelerated fruit deterioration. The condition of the fruit before storage determines the shelf life. The level of maturity of chili fruit marked by changes in fruit color affects the physio-morphological characteristics of chili. Metabolic changes that occur during the chili ripening process cause changes in taste, color, texture, and aroma (Villa-Rivera and Ochoa-Alejo, 2021).

The classification of chili peppers as non-climacteric fruits is attributed to their distinct ripening patterns, which are characterized by a lack of significant increases in ethylene production and respiration during the ripening process. In contrast, climacteric fruits exhibit a marked increase in these physiological processes, leading to the characteristic softening and color change of the fruit. However, it should be noted that certain chili species have been identified as climacteric intermediates, displaying a hybrid ripening behavior that falls somewhere between the climacteric and non-climacteric categories (Hao *et al*., 2018). The fruit of the chili pepper cultivar (Capsicum annuum var. 'Chooraehong' (*Capsicum frutescens*) is reported as climacteric. Although it is a non-climacteric product, its perishable nature renders chili peppers not durable. The deterioration of chili peppers is due to decreasing moisture content, mechanical damage, evaporation, microbial growth, and the influence of ethylene. The respiration that occurs cannot be stopped. This process leads to a decrease in water content and subsequent decay. Additionally, it provides a conducive environment for bacterial growth, as evidenced by studies conducted by Yanti *et al*. (2018) and Lamona *et al*. (2015). The high water content in red chili peppers triggers the fruit to rot quickly.

Chili is classified as a non-climacteric fruit. Low ethylene content after harvest results in a slow fruit ripening process. Exogenous ethylene application was predicted to increase the rate of fruit ripening. This study aims to determine the response of exogenous ethylene on postharvest chili fruit to fruit weight loss during storage.

Research Method

The postharvest research was conducted at the Plant Breeding Laboratory, Department of Agronomy and Horticulture, IPB. The research was conducted under ambient conditions with a temperature 25 to 27°C and a relative humidity of 60 to 70%.

Plant Materials

The genetic material used was curly red chili fruit of the Neno variety. Chili plants were planted on a plot covered with plastic mulch with a spacing of 40 x 70 cm. Plant maintenance was carried out intensively. A total of 10 fruits were used as samples for each treatment. Samples were chili fruit with an 80% maturity level harvested. The fruits were sorted based on size uniformity and cleaned with running water and aerated.

Experiment Design

The experiment was arranged factorially in a completely randomized group design (RKTL) with 3 replications. The first factor was the dose of etepon: 500 and 1000 ppm. The second factor was etepon application time: 0, 30, 60, 90, and 120 minutes. Initial observations included: fruit length (cm), fruit stalk length (cm), fruit weight (g), and fruit flesh thickness (mm). Further observation was to measure daily fruit weight loss after treatment for one week at room temperature.

Fruit Weight Loss

A total of 10 chili fruits were arranged regularly on a plastic tray. The fruits were stored at room temperature 26-27^{o}C, RH 60-70%. Fruit shrinkage was measured by weighing fruit samples after treatment every day using a digital scale with an accuracy of ±0.01. The measurement results were expressed in grams. The amount of fruit shrinkage was calculated referring to Haile (2018), with the formula:

$$\text{FWL (\%)} = \frac{IW - \text{FW}}{\text{IW}} \text{ x } 100$$

FWL : Fruit Weight Loss
IW : Initial Weight
FW : Final Weight

Data Analysis

The collected data were analyzed for variance. Differences between treatments were detected using the Tukey test at the 0.05 level. All tests were conducted using Minitab software version 16.

Results and Discussion

Fruits Morphology

The results of the analysis of variance (Table 1) showed that different concentrations of etepon had a significant interaction with the duration of application on the length of chili fruit, but had a significant effect on the variable initial fruit weight. All individual chili fruits have similar fruit stalk length and fruit flesh thickness.

The fruit length of the red chili variety Neno ranges from 11.55-15.91 cm, with an initial fruit weight of 2.83-4.98 g. The fruit stalk length was uniform, with an average of 4.75 cm. Fruit flesh thickness averaged 6.3 mm. The curly red chili variety Neno is in high demand because it has a relatively medium level of spiciness.

The classification of chili fruits as green, yellow, or red berries is determined by their ripeness. Each flower contains a single ovary, which is comprised of multiple seeds (Zhigila *et al*., 2014). The pulp consists of an ovary wall, known as the pericarp, which exhibits varying thickness. The fruit interior is divided into two to four carpels, with fragile separating tissue present. A significant number of seeds are attached to the placenta. The fruit's physical characteristics include a round, square, or rectangular shape, with specifications such as thick to elongated and tapered pericarp and thinner walls (O'Donoghue *et al*., 2018). Notably, the vitamin C content of fresh curly red chili has been reported to be 675.66 milligrams per 50 grams, while the content of β-carotene has been documented as 336.66 milligrams per 50 grams (Hasanah *et al*., 2022).

Chili fruits have fruit cavities that limit water-holding capacity. This property, coupled with the fact that water loss from the fruit invariably leads to a diminution of its firmness and overall quality, has a deleterious effect on the fruit's shelf life and market value. The deterioration of chili fruits is marked by the loss of water, the onset of shriveling, discoloration, and the necrotic degeneration of the pericarp (Samira *et al.*, 2013).

Table 1. Results of analysis of variance of curly red chili fruit characters of Neno variety before treatment

Source	df	Mean Square			
		FL (cm)	FSL (cm)	TFF (mm)	IFW (g)
Replication	2	1.3422*	0.0498	0.1442	0.3120
Dosage (a)	1	4.159**	0.0301	0.0648	0.7428*
Time (b)	4	6.1358**	0.0962	0.2905	1.6898**
A x B	4	1.902**	0.0506	0.2236	0.338
Error	18	0.3197	0.1018	0.1768	0.1455
Total	29				
CV		5.65	3.19	4.20	3.81

Numbers followed by signs (*) are significantly different and (**) are significantly different in the F-test at the 0.05 and 0.001 levels. FL: Fruit Lenght; FSL: Fruit Stalk Lenght; TFF: Thickness of Fruit Flesh; IFW: Initial Fruit Weight; CV: Coefficient of Variance

Table 2. Response of different etepon concentrations and application duration to early chili fruit characteristics

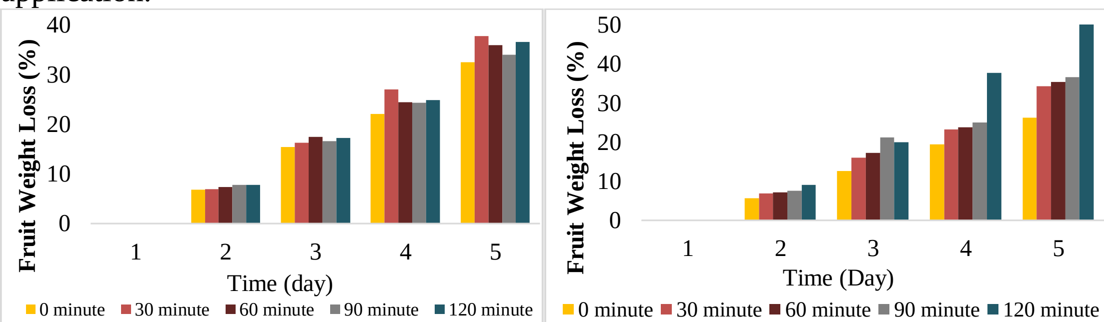
Dosage	Time	Fruit Weight	Length of Fruit Stalk	Thickness of Fruit Flesh	Initial Fruit Weight
(ppm)	(minute)	(cm)	(cm)	(mm)	(g)
500	0	15.91[a]	4.70	6.56	4.98[a]
	30	14.57[ab]	4.73	6.28	4.32[ab]
	60	14.94[ab]	4.78	6.14	3.91[abc]
	90	14.23[b]	4.87	6.45	4.25[ab]
	120	13.69[b]	4.51	6.29	3.77[bc]
1000	0	14.33[ab]	4.97	6.49	4.40[ab]
	30	15.27[ab]	4.96	6.42	4.55[ab]
	60	14.47[ab]	4.68	6.46	3.97[ab]
	90	14.00[b]	4.73	6.30	3.90[abc]
	120	11.55[c]	4.56	5.58	2.83[c]

Numbers followed by the same letter are not significantly different based on the Tukey Test at the 0.05 level.

Weight loss after treatments

As illustrated in Figure 1, the rate of weight loss during storage increased with different etepon concentrations. The duration of etepon application at a low dose (500 ppm) does not affect fruit weight loss. However, the application of etepon at a concentration of 1000 ppm with long application duration (120 seconds) can accelerate rate of ripe chili fruit weight loss during storage. However, the rate of weight loss increased rapidly starting on the fourth day of storage. This suggests that the low dose of etepon application (500 ppm) may not be absorbed or may be lost during the storage process. The application of etepon at 1000 ppm at 120 seconds can be absorbed by the fruit skin within 3 days. This phenomenon proves that the synthesis of ethylene does not occur spontaneously in non-climacteric fruits following treatment with exogenous ethylene. the results of this study are in line with those reported by Krajayklang *et al*. (2000).

The use of etepon on fruit and vegetable products from pre- and post-harvest has been widely reported. The application of etepon on chili plants is usually done through spraying on the plants to homogenize the maturity level of the fruit. In chili fruit, the allowable etepon residue based on Codex Alimentarius standards is 50 mg kg-1 for dried chili and 5 mg kg-1 for fresh chili. Yang *et al*. (2021) reported that the residual level of etepon in curly chili fruit sprayed with doses of 5000 mg/L and 2000 mg/L was 21.18 mg/kg and 18.91 mg/kg, respectively. This residue level decreased with time, thereby supporting the hypothesis that the use of etepon at certain doses on chili fruit is still relatively safe. Moniruzzaman *et al*. (2015) further demonstrated that the optimal timing for harvesting tomato fruits at the ripe green stage, followed by the application of 750 ppm etepon for five minutes, ensures optimal quality for long-distance marketing. Furthermore, the residual levels of 500-1000 ppm ethephon in tomato fruits treated with all ethephon concentrations at 3 and 5 days of storage were found to be below 2 mg/kg, thereby rendering them safe for human consumption. Consequently, the consumption of processed tomatoes should be scheduled after 3 days of etephon application.



Ethepon Dosage at 500 ppm **Ethepon Dosage at 1000 ppm**

Figure 1. Effect of different etepon concentrations and application duration on the weight loss of curly red chili fruits during storage at ambient temperature

As illustrated in Figure 2, the data were stratified into two groups based on all observed variables. The initial group comprises nine treatments, except for the 1000 ppm concentration applied for 120 minutes. The heatmap reveals that the 500 ppm dose of etepon administered for a maximum of 120 seconds resulted in values that were nearly identical to those observed in the low to moderate range of fruit weight loss.

chili peppers are widely consumed fresh. Fruit quality and shelf life were important factors for commercial value. Chili peppers were highly perishable when stored at ambient temperature (26 to 27 °C) (Samira *et al*., 2013). Storage under these conditions leads to significant weight loss and rapid deterioration of the chemical composition of the fruit. Fresh chili peppers lose water very quickly after harvest and start to wilt and change color within a few days (Jain *et al*., 2017). Temperature and

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storage duration have a significant effect on the weight of chili. The weight loss of cayenne pepper was 60.5% after being stored for 15 days at 29 ^{o}C storage (room temperature), with an average chili weight loss of 30%. (Rachmawati *et al*., 2009).

Fruit shrinkage can also occur due to transpiration, respiration, and other reactions. The main factors were high or low temperatures and other unfavorable conditions. Fruit weight loss, otherwise known as fruit deterioration, can also occur due to transpiration, respiration, and other reactions. The decrease in the shelf life of chili was caused by respiration, decreased water content, mechanical damage, microbial activity, and ethylene hormone activity (Nauly, 2016; Yanti et al., 2018). After harvest, water shrinkage occurs so that the quality of the fruit decreases (Megasari & Mutia, 2019; Wulandari et al., 2012).

Treatment	FL	FSL	TFF	IFW	IFWL	FFWL
11	1.395	-0.320	0.950	1.557	-0.619	-0.577
12	0.234	-0.143	-0.051	0.399	-0.441	0.299
23	0.147	-0.452	0.584	-0.211	-0.167	-0.090
24	-0.255	-0.099	0.015	-0.326	0.280	0.114
13	0.559	0.187	-0.555	-0.304	0.050	-0.018
14	-0.060	0.783	0.529	0.282	0.610	-0.335
15	-0.519	-1.555	-0.042	-0.560	0.505	0.097
22	0.838	1.400	0.422	0.817	-0.456	-0.273
21	0.032	1.444	0.698	0.541	-1.811	-1.616
25	-2.371	-1.246	-2.549	-2.196	2.049	2.397

Description: FL: Fruit Length; FSL: Fruit Stalk Length; TFF: Thickness of Fruit Flesh; IFW: Initial Fruit Weight; IFWL: Initial Fruit Weight Loss; FFWL: Final Fruit Weight Loss. Treatment 11: 500 ppm at 0 minutes; 12: 500 ppm at 30 minutes; 13: 500 ppm at 60 minutes; 14: 500 ppm at 90 minutes; 15: 500 ppm at 120 minutes; 21: 1000 at for 0 minutes; 22: 1000 ppm at 30 minutes; 23: 1000 ppm at 60 minutes; 24: 1000 ppm at 90 minutes; 25: 1000 ppm at 120 minutes.

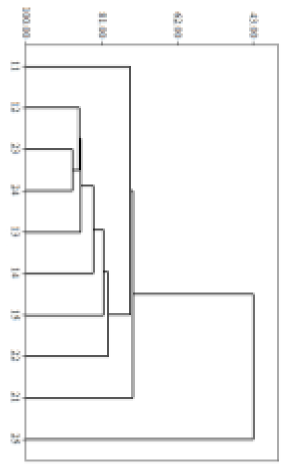

Figure 2. The effects of etepon application treatments on the quality of curly chili fruit during storage at ambient temperature.

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Conclusion

Application of low doses of etepon did not increase the weight loss rate of ripe chili fruits during storage. Application of 1000 ppm etepon for 120 minutes increased the rate of ripe fruit weight loss starting from the fourth day of storage. This study proved that exogenous ethylene application cannot spontaneously increase ethylene synthesis in non-climacteric fruits. To obtain more comprehensive results, further research needs to use more chili cultivars from various species.

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