



Evaluation of Ethylene Usage and Effects of Temperature, Humidity, and Lights on the Ripening of Banana (*Musa spp*)

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ABSTRACT

Introduction: Banana as a basic food plays an important role in improving food security. This plant has a special value due to its short fruiting time and economic profitability. Banana tree is widely cultivated in developing and tropical countries and is considered one of the most important fruit trees in the world. Banana is climacteric fruits. Most of the fruits are ripened on the tree, but for export we need to harvest and store unripe. The aim of this study is to evaluate the use of ethylene and the effect of different temperatures, humidity and light on the ripening of bananas.

Materials and Method: This study was carried out in the laboratory of Sar-e-Pol Higher Education Institute from 7 Nov to 28 Dec 2022, in order to obtain the best conditions for the quick ripening of bananas. Non-scratch bananas were randomly purchased from market. They were separated in pairs and put to the place that was already prepared for testing, and subjected to different treatments and kept for 48 hours in a dark and warm place with a temperature of 18 °C.

Findings: The findings of this research show that the bananas treated with ethylene, ripen earlier than the control bananas at different temperatures. The effect of 18 and 22°C temperatures in 3 to 4 days and 24°C temperatures in 1 to 2 days was observed. Bananas that were ripened at a high temperature were sweeter and had less smell than those that were ripened at a lower temperature. Bananas that were kept at a relative humidity of 70 percent and above ripened later than the bananas that were kept at a relative humidity of less than 70 percent. High and low relative humidity has less effect on the inside quality of the banana, but has a direct effect on attractiveness and color. Bananas that were ripened in bright light were sweeter and yellower in color than those in the dark.

Conclusion: Based on the findings of this research, the use of chemical substances (ethylene), temperature, humidity and light for the ripening of unripe bananas has a direct effect on its attractiveness and quality.

Keywords: Ethylene, Temperature, Humidity, Light, Banana

INTRODUCTION

There are many growing, important and valuable plants in tropical regions of the world, among them banana (*Musa spp*) has a special position due to its short fruiting time and economic profitability (Koran Khan et al., 2012). Banana plant with the scientific name of *Musa spp* belongs to the Musaceae family, which has different diploid (AA), triploid (AAA, ABB, AAB) and tetraploid (AAAA) forms, and each of them are cultivated in different climates (Kulkarni et al., 2011). This plant is cultivated in 1200 elevation. It can grow in temperatures of 10 to 40°C with high relative humidity, but the best temperature for the growth and development of this plant is 15 to 35°C. If the weather is cold, the growth and development, needs more time. 1700 mm of annual rainfall is needed for proper growth and development.

Banana as a basic food plays a role in improving food security (Sabohi & Jamnia, 2007). Due to its low-fat and high energy content, it is very useful for strengthening the bones of children and the elderly. It is also estimated that 100 million people use bananas as their main source of energy (Thomson et al., 2001). Banana is widely cultivated in developing and tropical countries and is considered one of the most important fruit trees in the world (Koran Khan et al., 2012). It can be harvested throughout the year. Most of the fruits ripen on the top of the tree, and some of them are harvested unripe and need to be stored for ripening (Soltani et al., 2013).

Ripening of bananas is one of the important economic concerns after harvest (Rabaya et al., 2017). It is not easy to determine the degree of ripeness of the fruit, especially the color of the fruit has nothing to do with its ripeness. Certainly, skilled and experienced people can determine the degree of ripening of the product (Soltani et al., 2013). Accordingly, banana is a fruit that ripens after harvest due to the continuous production of ethylene. Ethylene is a plant hormone, a natural-colored gas, which is responsible for many processes; it is including ripening, and is also known as de-greening, on the other hand, it is a natural process without chemical substances (Ranvira et al., 2020). Ripening is a process that includes physiological, biochemical, and organoleptic changes in fruits to obtain the desired taste, color, aroma and smell. During the ripening process, the color changes from green to yellow due to pigments. Two compounds are responsible for it, chlorophyll and carotenoid. When the ripening process begins, chlorophylls begin to break down and simultaneously the fruits become yellow due to carotenoids.

In addition to the pectin decomposition process, the soft fruit flesh and its sweetness increase due to the decomposition of starch into simple sugars such as fructose into glucose. The increase in sweetness, the softness of the skin and the yellowing of the skin are the organoleptic changes that occur during the ripening process. Usually, Bananas are harvested at the immature stage. To reduce this time of maturation, people tend to use artificial methods. Many methods have been introduced to determine the ripening, which can be named mechanical (firmness), acoustic, machine vision, radio frequency methods, etc (Soltani et al., 2013). They also use chemicals such as ethylene, calcium carbide, acetylene, propylene, phosphoric acid, glycol and ethanol for the ripening of banana. The ancient people in Sri Lanka used smoke to increase the temperature for the ripening of banana (Ranvira et al., 2020). Research shows that heat storage affects ripening. Keeping the banana at a temperature of 14 to 30 °C increases the ripening speed and softens faster. Temperatures below 14°C can cause irregular ripening due to chilling damage.

Control of relative humidity in the postharvest environment relative humidity promotes fruit spoilage by as important as the control of temperature. Generally, there is an inverse relationship between the water loss by fruit and the relative humidity of the storage environment. Low relative humidity has been shown to increase weight loss while high increasing diseases. There is conflicting observations on the effect of humidity on respiration, ethylene production and ripening of Banana fruits. Relative humidity can affect the occurrence of some physiological disorders and uniformity in ripening (Ahamad et al., 2006). Banana ripening including several physiological changes such as change in color from green to yellow, starch degradation, increase in soluble sugar content, increase in aroma compounds and texture loss, which substantially affect the consumer appeal. Therefore, the effect of environmental condition such as temperature, humidity, and atmospheric composition on the ripening of banana fruit during postharvest handling has been extensively studied and optimized for different varieties (Ozdemir, 2016).

Most of the research has pointed out the speed of ripening and shelf life of banana. However, there are no published studies in the field of measuring different temperatures, light and humidity. Therefore, the current research is based on a simple traditional method, which has investigated the feasibility of ethylene stimulation, high and low temperature, light and different humidity in detecting the ripeness of the banana.

MATERIALS AND METHODS

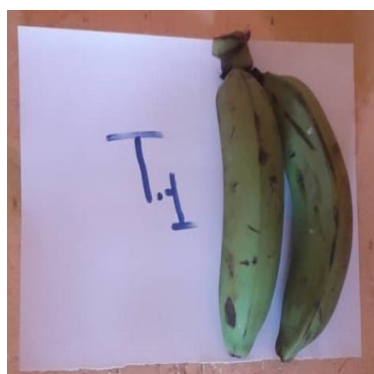
This study was carried out in the laboratory of Sar-e-Pol Higher Education Institute from 7 Nov to 28 Dec 2022, in order to obtain the best conditions for quickly ripening of banana with several dozen green and unripe bananas. Bananas without scratches and cuts were randomly purchased from banana importers in Sar-e-pol city. They were separated in pairs and put to the place that was already prepared for testing, and subjected to 24 treatments. Among them, five were treated with ethylene (Ahamad et al., 2006). They were kept for 48 hours in a dark and warm place with a temperature of 18 °C. After 48 hours, the bananas were placed under different conditions of humidity, light and heat, as shown in Table 1.

Table (1): Variables, treatments and different types of heat, percentage of relative humidity and type of light.

Variables	Treatments					
Ethylene	T1	T2	T3	T4	T5	T6 (control) *
Heat (°C)	22	18	24	24	18	20
Relative humidity (%)	60-65	65-70	70-75	75-80	80-85	65-70
Light/dark	electricity light	electricity light	dark	dark	normal light	normal light

*: T6 is the control treatment placed in normal room temperature, humidity and light.

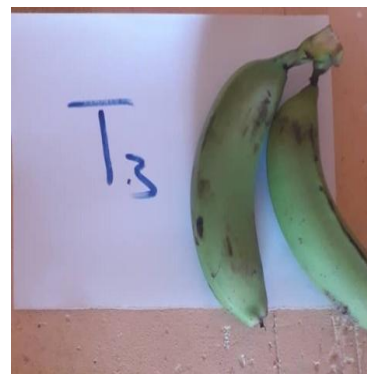
In addition to Table 1, the order treatments are shown in the following pictures (1-6).



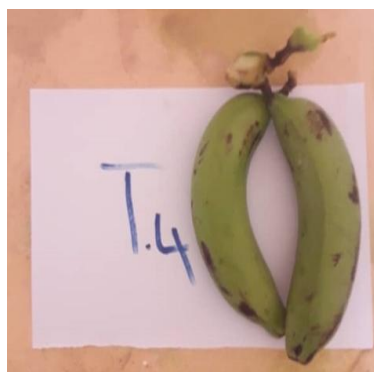
Picture (1)



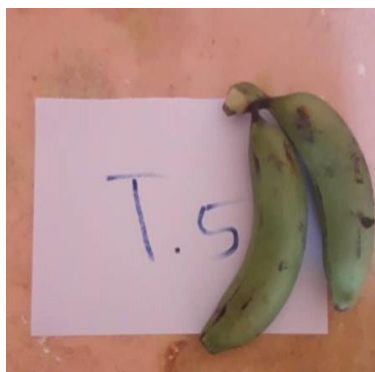
Picture (2)



Picture (3)



Picture (4)



Picture (5)

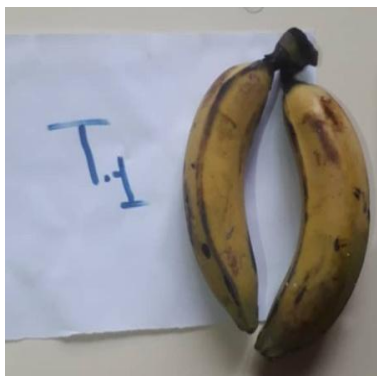


Picture (6)

Therefore, in this research, we sensitively and objectively checked the quality of the fruit after every two hours and the changes occurred until full ripeness. The temperature was set with an electric heater and a two-season air condition for the treatments and was measured by a simple digital thermometer. The humidity required for treatments is controlled by sprinkling water and its percentage is measured by a digital hygrometer. Banana treatments were adjusted and checked in different lights (electricity light source, darkness and normal light).

RESULTS AND DISCUSSION

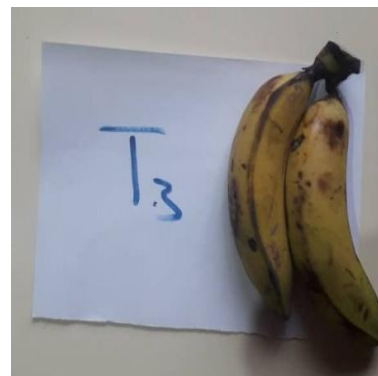
Since the study was done in the laboratory and after full color development and ripening, the fruit was evaluated by six scientific research members of Sar-e-pol Institute of Higher Education based on color development, attractiveness, end part color, end part green percentage, taste, juiciness, smell and softness of the banana flesh. The results of them are shown in pictures (7-12) and Table 2.



Picture (7)



Picture (8)



Picture (9)



Picture (10)



Picture (11)



Picture (12)

Table (2): Banana color, attractiveness, end part color, skin thickness, taste, juiciness, smell and softness of the meat.

Treatments	Parameters							
	Fruit color	Fruit Attractiveness	Color of end of fruit	Peel thickness	Fruit taste	Fruit juicy	Fruit smell	Flesh softness
T1	greenish yellow	semi fresh	greenish yellow	medium	Sweet	semi - juicy	-	soft
T2	yellow	Fresh	yellow	medium	Sweet	semi - juicy	-	semi hard
T3	greenish yellow	Fresh	greenish yellow	Thin	Sweet	juicy	+	semi hard

T4	yellow	Fresh	yellow	Thin	very sweet	juicy	+	soft
T5	greenish yellow	Fresh	greenish yellow	medium	sweet	semi - juicy	+	semi hard
T6	greenish yellow	Un-fresh	greenish yellow	Thick	not sweet	dry	-	hard
-Means no smell and + denoted smell.								

According to (Table 2), the color of the banana is 66.67 percent is greenish yellow and 33.33 percent is yellow. Banana attractiveness: 66.66% fresh, 16.66% semi-fresh and control treatment 16.66% dry. The color of the end of the banana is 50% yellow and 50% greenish yellow. Banana skin thickness: 33.34% was thin, 50% was partially thin and control treatment was 16.66% thick. Banana taste: 16.66% very sweet, 33.34% sweet and 50% slightly sweet. Juiciness of banana: 33.34% juicy, 50% semi-juicy and control treatment was 16.66% dry. The smell of banana is 50% low smell, 33.34% medium smell and 16.66% odorless. Softness of banana meat: 33.34% was soft, 50% was semi-soft and control treatment was 16.66% hard. In order to better display the evaluation of the study, refer to Figure 1.

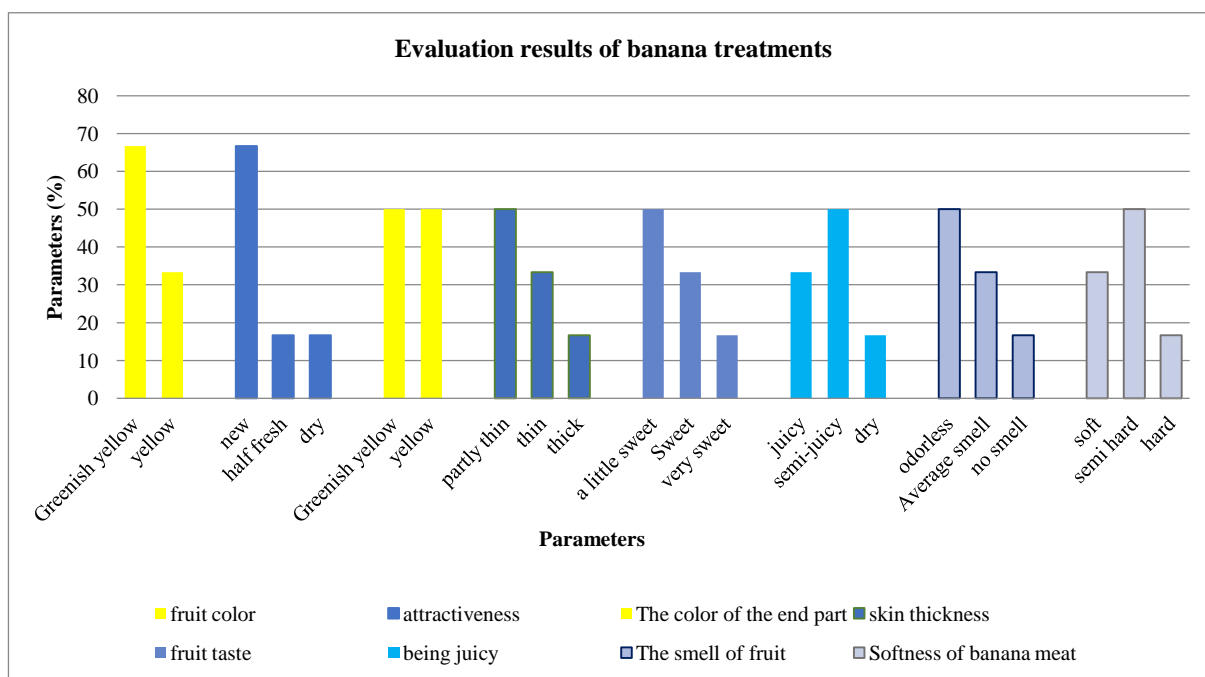


Figure 1. The results of the judges' evaluation of banana treatments

The bananas treated with ethylene at different temperatures reached earlier than the control. Interactions between ethylene and temperatures of 18 and 22°C were visible in three to four days. But this difference was observed at 24°C for one to two days. The results of this research are synonymous with the findings of (Bouzayen, 2006) stating that climacteric fruits produce ethylene during their ripening (Bouzayen, 2006). As the ripening process progresses, the production of ethylene increased significantly (Bapat et al., 2010).

The bananas treated with ethylene at high temperature were more yellow and softer than the control tubers that were protected at low temperature. Thompson (2019) states that the softening of banana during its ripening is based on three factors: first, the conversion of starch into simple sugars, second, the breakdown of pectin materials, and third, the movement of water from the skin to the flesh of the fruit. Judges' subjective evaluation showed that the bananas treated with ethylene had a better taste at a temperature of 24. The bananas that were

ripened at a high temperature were sweeter than the bananas that were ripened at a lower temperature, and the smell. The judges gave the highest points to the bananas that were considered at temperatures of 22 and 24°C and the lowest points to the bananas that were reached at 18°C and were a little harder.

The opinion of the judges about the attractiveness of bananas was that, in the eyes of customers, the color of bananas is used to decide on the quality, sweetness and softness inside. The bananas ripened at higher temperatures with ethylene treatment achieved the highest score for acceptability. The reason was clear: they had a good flavor, sweetness and less astringency. Bananas ripened at lower temperature were significantly firmer but still had acceptable flavor. Therefore, low temperature (18°C) can be used to achieve firmer bananas which might reduce mechanical damage during handling because a firmer fruit would be better able to withstand rough handling during marketing (Thompson, 2008).

The bananas that were exposed to different percentages of relative humidity showed different reactions. Bananas that were stored at 70% or higher relative humidity reached later than those that were kept at relative humidity lower than 70%. The results of the findings of Ahmad et al. (2006) showed that the acceleration of ripening and ripening at lower moisture levels is related to the rate of ethylene production (Ahmad et al., 2006). Bananas ripened in high humidity were slightly greener and sweeter than bananas that were ripened in lower humidity. Bananas that were ripened in medium and high relative humidity had the same taste according to the judges and they determined the minimum scores for their attractiveness. The evaluations showed that medium and high relative humidity did not affect the quality inside the bananas, but it had a direct effect on the attractiveness and color of the bananas and excessive weight loss in lower humidity causes the bananas to appear wrinkled and black, these results are synonymous with the findings of Ghebresslassie (2003).

In fruits, chemical interactions are carried out by the enzymes like amylase, glycosidase, phosphorylase, and sucrose synthase, and as a result, it increases the level of soluble sugars, mainly sucrose, glucose, and fructose (Duran-Soria et al, 2020). Therefore, the bananas that were placed under white light lost more weight than the bananas that were placed in the dark. This may be due to the opening and closing of the stomata, which causes the temperature difference to reduce the weight of the banana. The judges reported; bananas ripened in white light were sweeter and yellower in color than bananas ripened in the dark. This case is synonymous with the research of Ding et al. (2007). They showed that the decomposition of the thylakoid membrane and chlorophyll of the banana color by chlorophyllase and oxidase enzymes and the green color of the banana is gradually destroyed and yellow pigments appear (Ding et al., 2007). According to the evaluation of the judges, the bananas that were ripened in white light were softer, juicier and more attractive than those that were ripened in the dark.

CONCLUSION

In this research, the impacts of ethylene, different temperature, light and relative humidity were investigated on banana fruits. The evaluations showed that understanding the ripening characteristics of banana fruit is complex and influenced by several factors. Results illustrated that the color of the fruit has no relationship with the ripeness flesh. The use of chemical substances (ethylene), temperature, light and humidity have direct effects on the ripening of banana and its quality.

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