Relating Ethylene Production and Banana Ripeness

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Abstract

Does fruit ripeness have an effect on the amount of ethylene produced? In this experiment, ethylene production between unripe and ripe bananas was investigated by looking at the ripening speeds of tomatoes exposed to them. Ripening, a process that affects color and texture in fruit over time (Alexander, 2002) is promoted by ethylene, a natural gas produced by fruits (Khan, 2017). Ripening speeds were measured through the percentage of red color in the tomatoes over a two-week period, with the hypothesis stating that if unripe bananas produce more ethylene than ripe bananas, then there will be a greater change in red color percentage in the tomatoes over a two-week period. Statistical tests showed that there was no difference in the means of red color percentage between the tomatoes paired with unripe or ripe bananas, and therefore, there was insufficient evidence to suggest a difference in the amount of ethylene produced by unripe and ripe bananas.

Introduction

The stage of ripeness is a major factor in the decision to pick, purchase, and consume fruit. For example, bananas are usually harvested when they are mature but not fully ripe, as the time it takes for them to be relocated and sold will allow them to ripe (Thompson, 1995). Bananas are very often bought when they are green, once again to allow time for them to ripe, which will cause them to become sweeter (Cordenunsi-Lysenko, 2019).

Different fruits display different evidence of ripening. Color change is common, as seen in fruits such as bananas and tomatoes. Bananas start off green, and as they ripen, they turn yellow and brown spots develop (Adebayo, 2016). Tomatoes are also green initially, turning a deep red color as then ripen (Bhandari, 2016). On the other hand, some fruits lack color change but undergo texture transformation as they ripen. Avocados are such fruits, as during the ripening process, their originally hard texture gradually softens, while they only get slightly darker (Lin, 2020).

As we can see, ripening is a process that can affect color, texture, and flavor of fruit over time (Alexander, 2002). Ripening is promoted by ethylene, a colorless gas produced in bananas and tomatoes that acts naturally as a plant hormone (Khan, 2017). It controls the internal processes and growth in plants and fruits, and in this case, hastens the speed of ripening (Pierik, 2006). Thus, a commonly known method to quicker ripening of fruits is to store them next to each other, allowing for the effects of the produced ethylene to speed up the process.

In this experiment, the difference of ethylene production amounts between ripe and unripe bananas will be investigated. Tomatoes will be grouped with unripe and ripe bananas to determine if unripe bananas produce more ethylene than ripe bananas. The amount of ethylene produced will be estimated through the recording of the changes in red color percentage (representing ripening speed) in the tomatoes over a two-week period. The hypothesis for this experiment is as follows: if unripe bananas produce more ethylene than ripe bananas, then the tomatoes grouped with the unripe bananas will have greater rate of increase in red color percentage, and therefore faster ripening speeds. The motivation for this experiment is to attain a greater understanding of ethylene production and interaction of fruits at different stages of ripeness.

Methods

Materials

Before conducting the experiment, the necessary materials were gathered. The list of materials included:

- Nine green, large tomatoes (not cherry tomatoes)
- Three green bananas
- Three yellow bananas
- Nine Ziploc bags
- Masking tape

In order to ensure similarity (or as close as possible to) between fruits, certain criteria were kept in mind when they were picked. First, all the fruits were bought from the same store in batches under the same label. The green tomatoes were picked from a group of tomatoes labelled “Field Tomatoes”, and the bananas were chosen from the same group of bananas. Second, the fruits were chosen with as much color similarity as possible. For the bananas, the most visually green bunch of bananas were chosen, and same for the yellow bananas. As they were attached by the stems, they were considered to be the same color, and therefore, the same stage of ripeness. For the tomatoes, since they were already detached from the vines, the tomatoes that were perceived to be most green were chosen.

Preparation

To start, a green tomato was inserted into each Ziploc bag. Next, the three green bananas were separated at the stems and each was inserted into a different bag. Similarly, the

process was repeated with the yellow bananas. At this point, all nine Ziploc bags were filled, with three Ziploc bags each containing a green banana and a tomato, three Ziploc bags with a yellow banana and a tomato, and three Ziploc bags with just a tomato. Lastly, each Ziploc bag was labelled; Unripe 1, 2 and 3 respectively for the bags with the green bananas, Ripe 1, 2 and 3 respectively for the bags with the yellow bananas, and Control 1, 2, and 3 respectively for the bags with just the tomatoes.

Data Collection

The colors of the tomatoes were recorded every day around afternoon, for a period of two weeks. The colors were determined using ColorGrab, an Android application created by Loomatix, through pictures taken using the phone's camera. All pictures were taken in the same room under the same lighting conditions to make sure that the colors were not affected by different shades of lighting. Additionally, a 1 cm by 1 cm square was outlined using masking tape on each tomato to define a more specific area in which to take a picture of, as the colors could potentially be different in various parts of the tomatoes.

Through ColorGrab, specific hex codes (unique combinations of 6 numbers and letters for specific colors) were shown for the respective colors, which were recorded to an Excel spreadsheet. After the two-week period, all the hex codes were converted to their red percentages using the Color-Hex website (https://www.color-hex.com).

Data Analyses

With the red percentage data, a line graph was made to visualize the changes in color with respect to the time. Afterwards, the data was analyzed through a Two-Way ANOVA as

there were two independent variables (time and banana ripeness). A Tukey's Test was then used to determine the significance of the results in each category.

Results

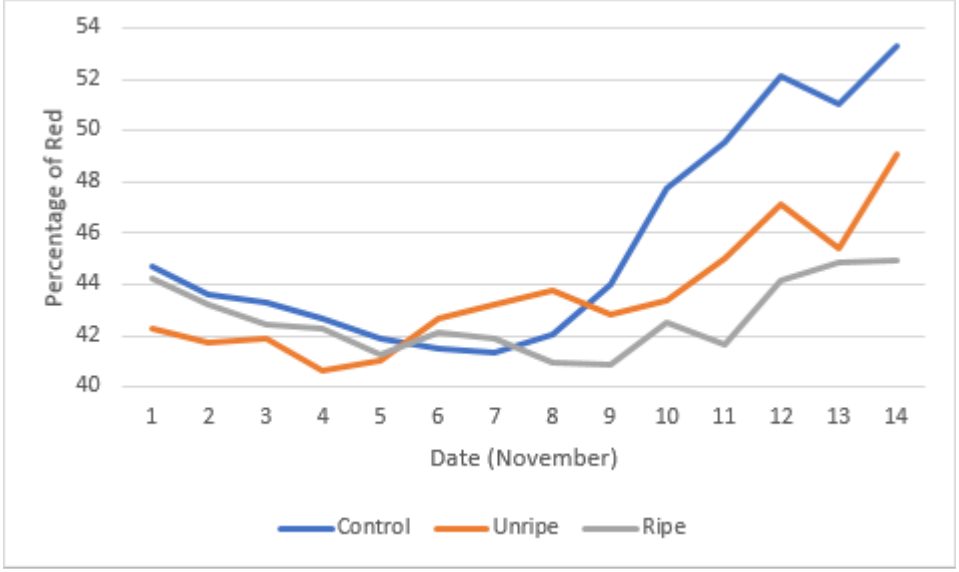

Figure 1: Average red percentage of tomatoes in the Control, Unripe, and Ripe groups with respect to time. Tomatoes in the control group were unexposed to extraneous ethylene produced by bananas, while tomatoes in the unripe and ripe groups were exposed to ethylene produced by unripe and ripe bananas respectively.

Figure 2: Average color gradient of tomatoes in the Control, Unripe, and Ripe groups over time.

Discussion

Altogether, the tomatoes in the control group were found to ripen quicker than the tomatoes grouped with the bananas (Fig. 1). Visually, the color matched the data, as the tomatoes in the control group were clearly the reddest (Fig. 2). When subjected through a Two-Way ANOVA, the null hypothesis, which states that the means between the three groups are the same, was rejected as the p-value of 0.000102 is less than 0.05. Consequently, a Tukey's Test was performed to further investigate the significance between the means of the groups. It was found that the means were significantly different when comparing between the Unripe group to the Control group as well as the Ripe group to the Control group, as the absolute differences between the averages of the red color percentage (2.0 and 2.9) were greater than the critical value (1.6). However, the difference between the means of the Unripe group when compared to the Ripe group were found to be insignificant, as the absolute difference (0.9) was less than the critical value (1.6). Therefore, while there is enough evidence to suggest that lone tomatoes ripen faster than tomatoes grouped with bananas, there is not enough evidence to suggest a difference in ripening speed between tomatoes grouped with unripe and ripe bananas; thus, there is not enough evidence to suggest a difference in the amount of ethylene produced between unripe and ripe bananas.

Even though steps were taken to ensure similarity between fruit and experimental conditions, there were still certain factors that could have affected the results. First, while the bananas were picked at the same time (as evidenced by the connected stems), the tomatoes could have been picked at different times. The tomatoes perceived to be the greenest were chosen, hence, their stages of ripeness could vary. Second, despite taking pictures of the tomatoes in the same room under the same lighting conditions, the brightness was varied due

to potential shadows and focus of the camera. Thus, this could cause inaccuracy in the color detected. Third, in addition to increasing ripening speed, ethylene also causes browning and overly softening (Saltveit, 1999). In this experiment, the red percentage of the tomatoes could be attributed to these detriments, as the they had displayed browning and softening.

When relating these results to the hypothesis, the amount of ethylene produced is considered equal in both the unripe and ripe bananas due to the indifference in ripening speeds of the respective tomatoes. However, this does not explain why the lone tomatoes ripened faster than those grouped with bananas. Logically, the ethylene released from the combination of both fruits should be greater than from just one tomato. One explanation could be due to the response to exogenous ethylene. In another study investigating gene expression of ethylene in tomato development, it was found that some genes in tomatoes that require ethylene for their expression did not express when exposed to exogenous ethylene (Lincoln, 1987). When considering the increased exogenous ethylene produced by the bananas, perhaps abnormal gene expression could be a reason for the outcome.

Further research could be done on this topic. The same experiment could be repeated while addressing the aforementioned factors that affected the results. Moreover, different fruits could be tested to explore ripeness versus ethylene production. Additionally, as both the bananas and the tomatoes were ripening in this experiment, further research could implement a steady source of ethylene released, and potentially test the effects of exogenous ethylene not produced by the fruit itself.

Conclusion

There was no difference found between the speeds of ripening between the tomatoes grouped with the unripe bananas and the tomatoes grouped with the ripe bananas, and therefore, there is not enough evidence to suggest a difference in the amount of ethylene produced by unripe and ripe bananas.

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