Mango Ripening Procedure – Temperature in the Ripening Room (+/- Ethylene)

Principal Investigator: Dr. Jeffrey K. Brecht
Horticultural Sciences Department
University of Florida
Gainesville, FL

Collaborator: Dennis Khilstadius, Produce Technical Services

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Summary of proposed research (Abstract):

Tommy Atkins, Kent, Keitt and Ataulfo (Honey) mango fruit from the major exporting countries of Mexico, Ecuador, Peru and Brazil were obtained from an importer in Florida throughout the course of one year. We evaluated mango fruit response to ripening temperature with and without ethylene application in terms of appearance, composition, texture, taste and aroma.

Project Objective:

Identify the optimum procedure in terms of temperature and ethylene exposure to achieve the best possible quality ripe mangos for consumers.

Introduction:

Research has shown that ripening mangos in the importing country to provide consumers with ripe/ready-to-eat fruit improves consumer satisfaction and sales. The National Mango Board has been promoting mango ripening to U.S. retailers according to the guidelines in the *Mango Postharvest BMP Manual* and the *Mango Handling and Ripening Protocol*. However, banana ripeners are using temperatures to initiate ripening of mangos that are usually used to ripen bananas (i.e., 60-66°F). This research was conducted to evaluate the effects of the ripening initiation temperature and ethylene exposure on the quality of mangos at the consumer level.

The reason for conducting this research was to compare the quality of mangos when they were fully ripe when their ripening had been initiated (+/- ethylene) during the first 4 days at one of four different temperatures: 60, 65, 70 or 75°F. The ripening temperature that has been recommended by the Mango Board for 10+ years is 68-72°F and in this research all of the fruit were allowed to complete their ripening process at 70°F.

Approach:

Tests were conducted (twice per cultivar) with Kent from Peru, and with Ataulfo/Honey, Keitt, and Tommy Atkins from Mexico. The mangos were exposed to ripening initiation temperatures of 60, 65, 70 or 75°F +/-0.1°F with 95% relative humidity (RH) for 4 days, either with or without initial exposure to 100 ppm ethylene for 24 hours. Following those simulated ripening room treatments, the fruit were transferred to 50°F +/-0.1°F with 95% RH for 4 days to simulate storage at the Distribution Center. After that, completion of ripening was allowed to take in air at 70°F and 95% RH. In order to have fruit from all the treatments ready for tasting on the same day, the fruit from the faster ripening treatments were placed at 50°F and 95% RH when they were ready to eat, until all the fruit were fully ripe (flesh firmness judged subjectively to be around 2-4 lbs-force).

The following measurements were made initially, after 4 days (end of ripening room treatments), after 8 days (end of DC storage) and when fully ripe: (1) Fruit skin and flesh color; (2) Fruit firmness; (2) Juice soluble solids content (°Brix) and titratable acidity. Flesh color under the peel was measured just before measuring fruit firmness. When the fruit were fully ripe, the fruit were also evaluated by an expert panel for sensory quality in terms of appearance, texture, taste and aroma.

Results:

1. Time to Ripen

- Initial ripening at 70 or 75°F resulted in shorter ripening times than 60 or 65°F (70-75°F > 65°F > 60°F)

- Ethylene treatment had little effect on total time to ripen

Table 1. Days to ripen as affected by the initial (4-day) ripening room temperatures and ethylene exposure for 24 hours in the ripening room. [These numbers do not include the days (if any) at 50°F.]

Treatment Temperature (°F)*	Ethylene	Tommy Atkins Test 1 (April, Mexico)	Tommy Atkins Test 2 (June, Mexico)	Kent Test 1 (February, Peru)	Kent Test 2 (March, Peru)	Keitt Test 1 (August, Mexico)	Keitt Test 2 (Sept., Sinaloa, Mexico)	Honey Test 1 (April, Mexico)	Honey Test 2 (May, Mexico)
60	(–)	12	15	12	14	11	9	12	15
	(+)	11	15	12	11	11	9	12	14
65	(–)	12	12	12	11	11	9	12	13
	(+)	12	12	12	11	11	9	12	13
70	(–)	9	10	9	11	9	8	11	12
	(+)	9	10	9	11	9	8	11	12
75	(–)	9	9	9	11	9	8	11	12
	(+)	9	9	9	11	9	8	11	12

*After 4 days at the treatment temperature, the fruit were transferred to 50°F for 4 days to simulate DC storage; then ripening was allowed to continue in air at 70°F, except fruit from the faster ripening treatments were placed at 50°F when they were ready to eat, until all the fruit were fully ripe (2-4 lbs-force).

There was some variation among the different tests and even within the same variety in the number of days it took for the fruit to fully ripen. Generally, the times to ripen were similar and longer for fruit that were initially at 60 or 65°F compared to the fruit that were initially at 70 or 75°F, which also required similar times to ripen. Fruit from the higher ripening initiation temperature treatments (75°F and 70°F with or without ethylene) tended to ripen about 2 to 3 days faster than fruit from the lower temperature treatments.

Using ethylene application to initiate and achieve more uniform mango ripening was found to be effective only occasionally at the lowest ripening initiation temperature and to have minimal effect at the three higher temperatures.

***Note** that some of the number of days for the final evaluations shown in the figures below differ from the longest days to ripen shown in Table 1. These differences are due to the fruit being held for a short additional time at 50°F to facilitate sensory test scheduling.

2. Fruit Softening

- Softening was faster and firmness was more uniform after initial ripening at 70 or 75°F
- Final firmness was unaffected by ripening temperature and ethylene exposure

Figures 1-8 show the fruit firmness on Days 0, 4 and 8, and on the final day when the sensory evaluations were performed.

Note: The conversion of Newtons (N) to pounds-force (lbf) is 4.45 N = 1.0 lbf (divide N by 4.45 to determine lbs-force).

Figure 1. Firmness of the first sample of Tommy Atkins fruit on Days 0, 4 and 8, and on Day 14 when the sensory evaluations were performed.

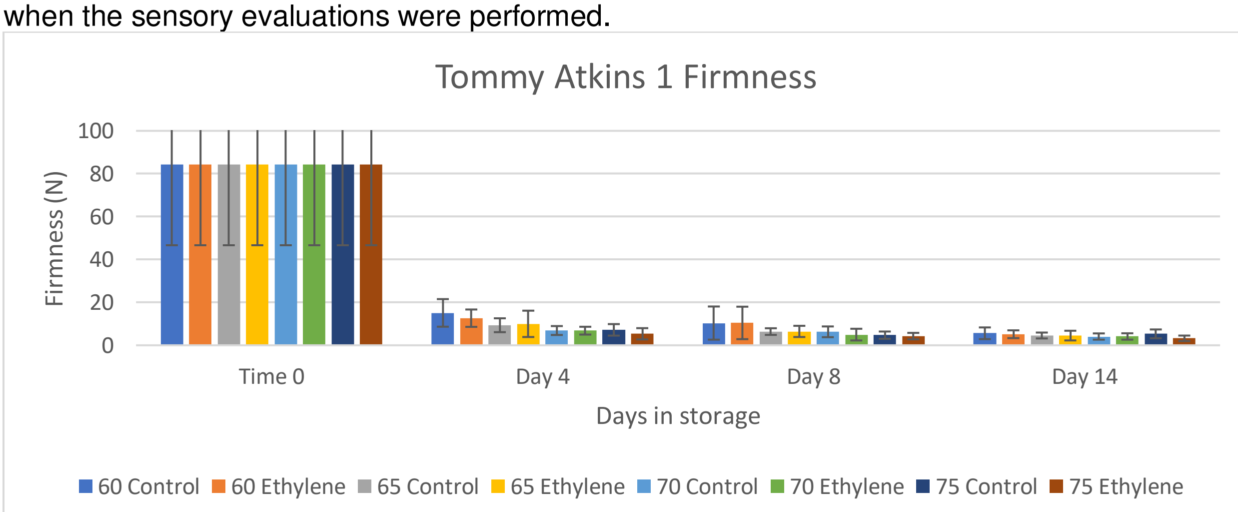


Figure 2. Firmness of the second sample of Tommy Atkins fruit on Days 0, 4 and 8, and on Day 15 when the sensory evaluations were performed.

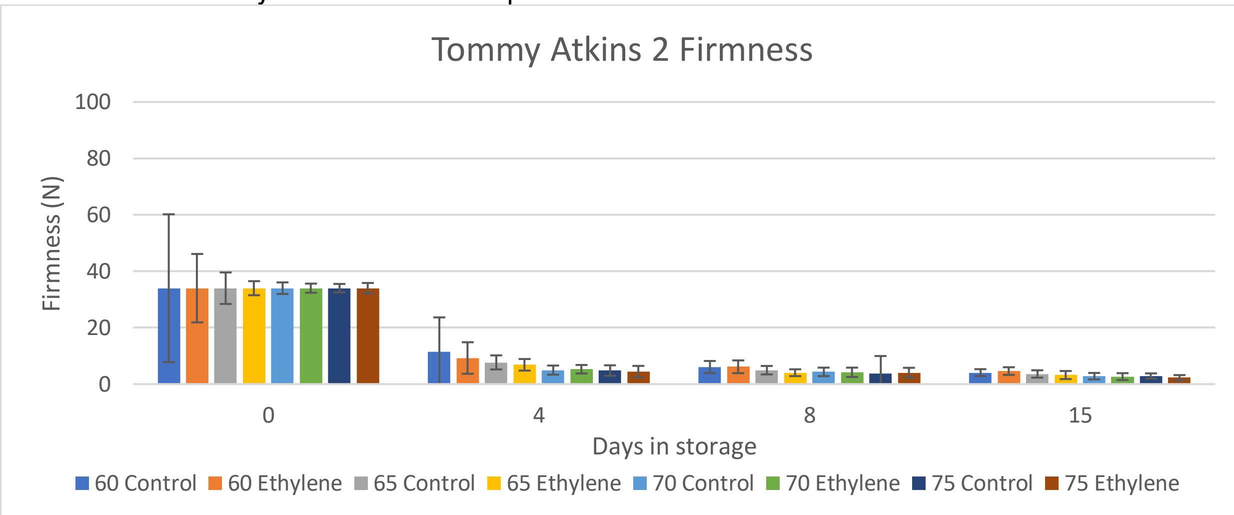


Figure 3. Firmness of the first sample of Kent fruit on Days 0, 4 and 8, and on Day 12 when the sensory evaluations were performed.

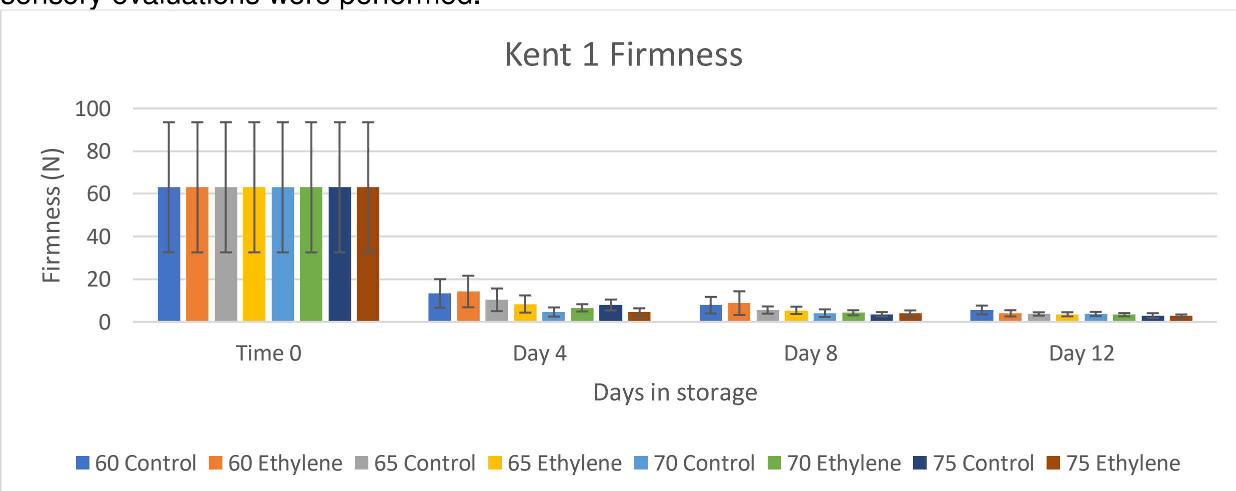


Figure 4. Firmness of the second sample of Kent fruit on Days 0, 4 and 8, and on Day 14 when the sensory evaluations were performed.

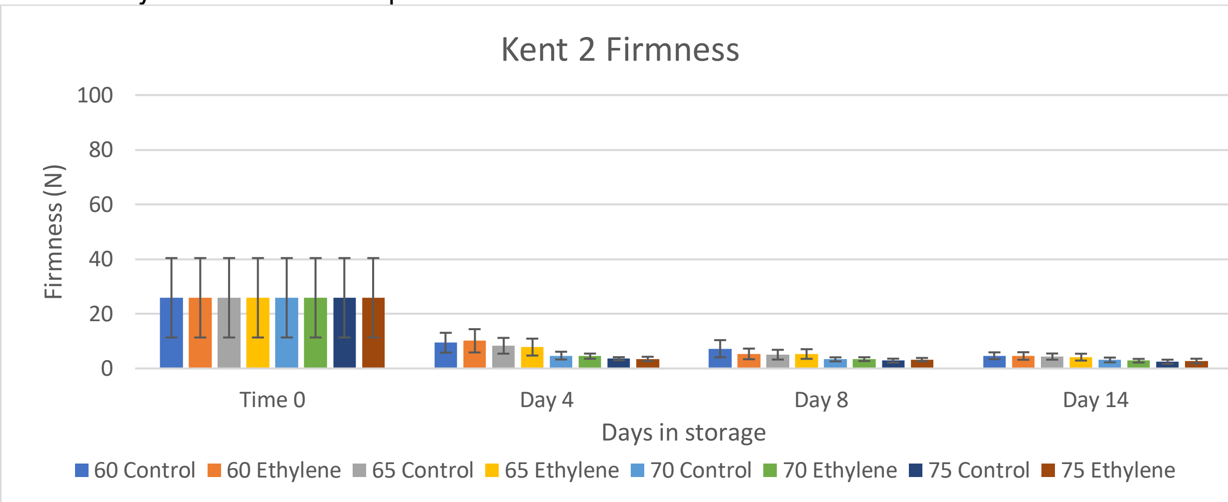


Figure 5. Firmness of the first sample of Keitt fruit on Days 0, 4 and 8, and on Day 11 when the sensory evaluations were performed.

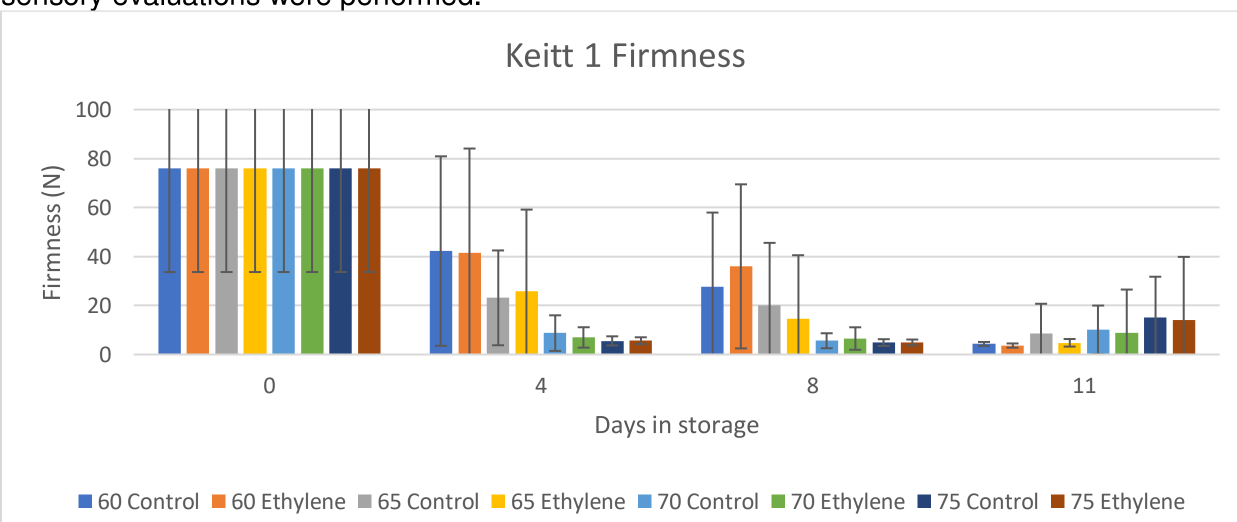


Figure 6. Firmness of the second sample of Keitt fruit on Days 0, 4 and 8, and on Day 9 when the sensory evaluations were performed.

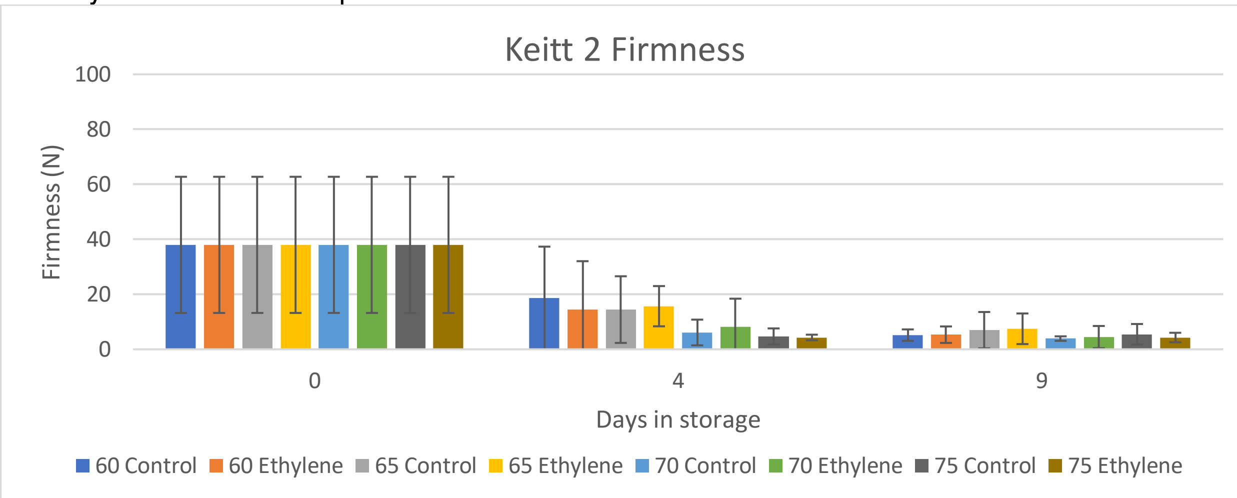


Figure 7. Firmness of the first sample of Honey fruit on Days 0, 4 and 8, and on Day 12 when the sensory evaluations were performed.

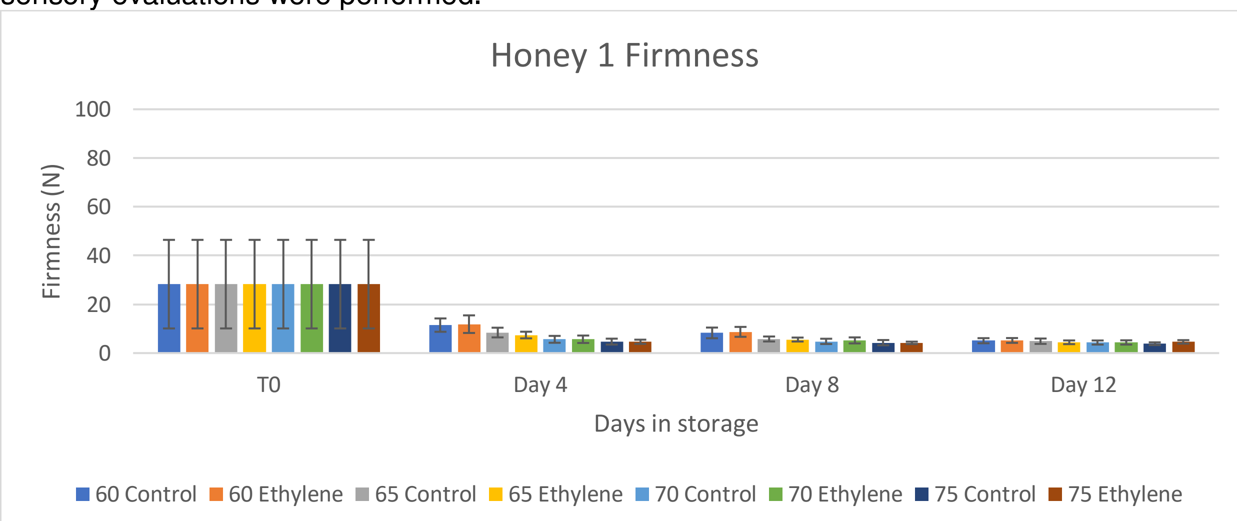
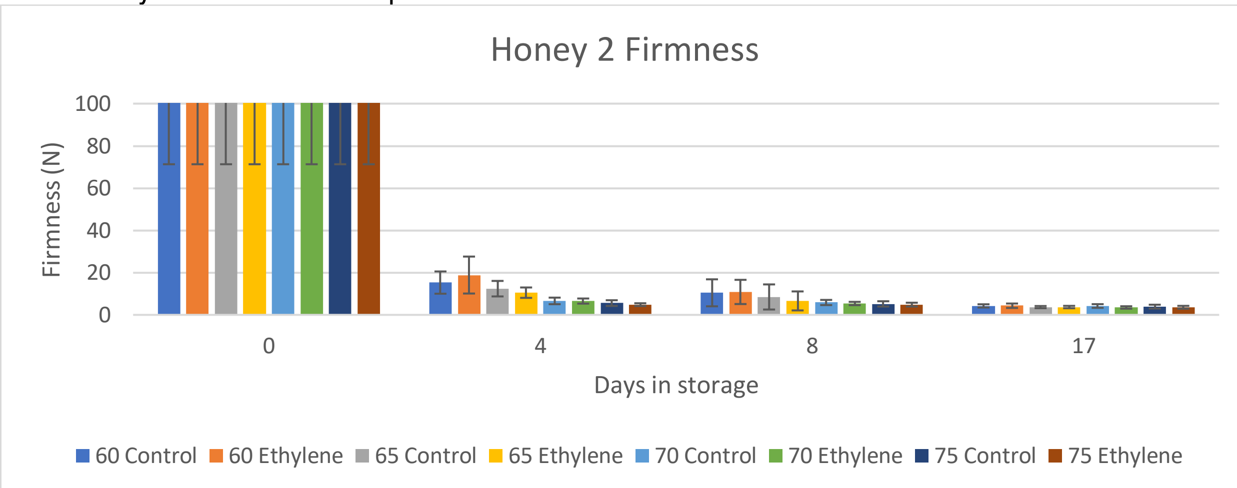


Figure 8. Firmness of the second sample of Honey fruit on Days 0, 4 and 8, and on Day 17 when the sensory evaluations were performed.



Firmness and visual estimates of ripeness agreed with the trend above, showing higher firmness and lower ripeness stages for fruit from the lower ripening initiation temperatures. As time progressed from day 8 to the last day, the firmness and visual ripeness differences between treatments shrank, although the trend remained.

3. Fruit Ripeness (Flesh Color Development)

- Ripeness as shown by flesh color development was not consistently affected by ripening conditions, sometimes showing little change, sometimes developing more after higher initial ripening temperatures

Figures 9-16 show the ripeness stage of the fruit based on internal color development (Stages 1 to 5) on Days 0, 4 and 8, and on the final day when the sensory evaluations were performed.

Figure 9. Ripeness (flesh color development from 1 to 5) of the first sample of Tommy Atkins fruit on Days 0, 4 and 8, and on Day 17 when the sensory evaluations were performed.

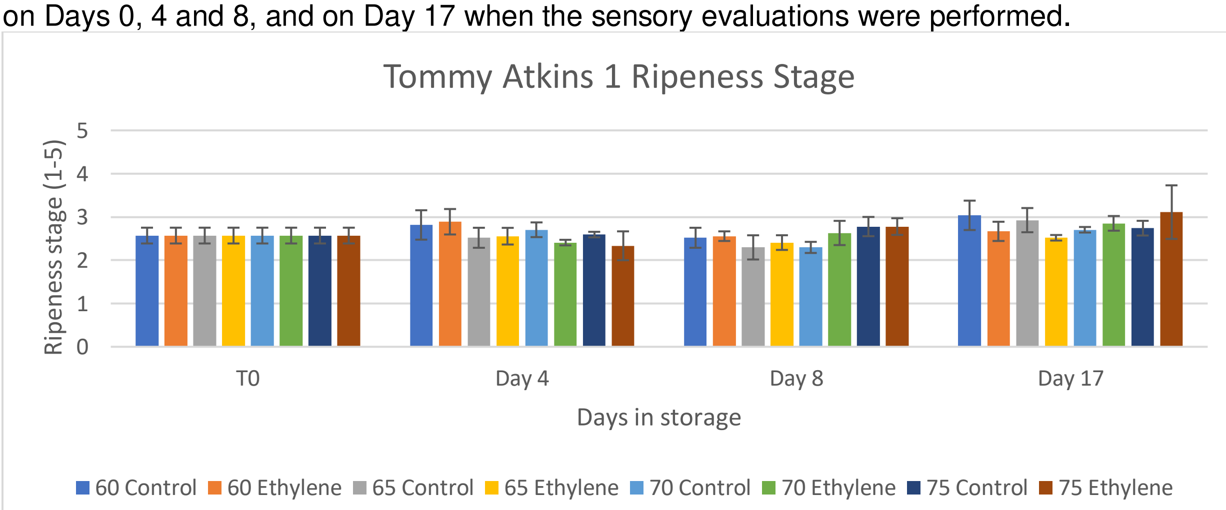


Figure 10. Ripeness (flesh color development from 1 to 5) of the second sample of Tommy Atkins fruit on Days 0, 4 and 8, and on Day 15 when the sensory evaluations were performed.

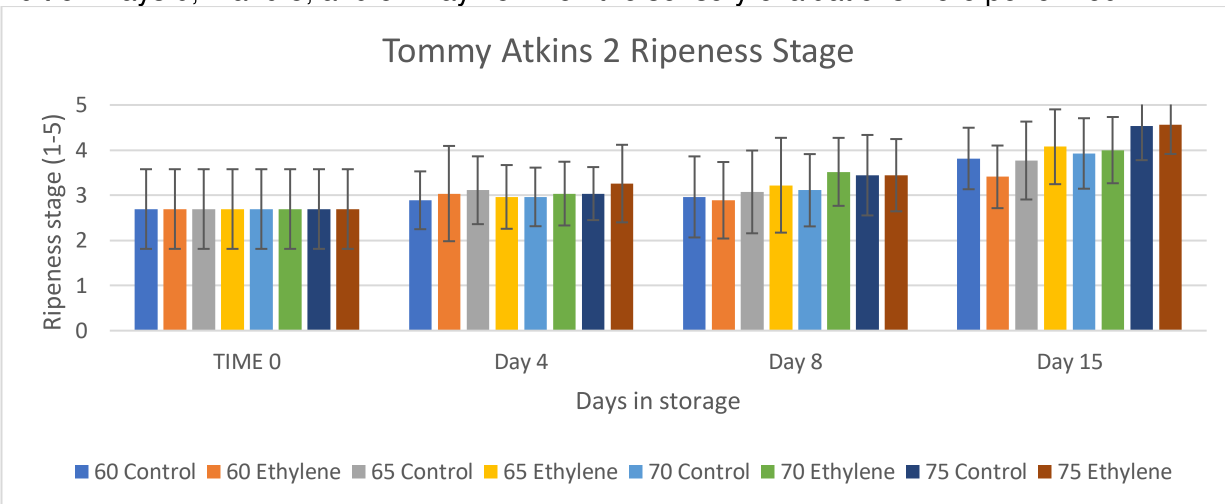


Figure 11. Ripeness (flesh color development from 1 to 5) of the first sample of Kent fruit on Days 0, 4 and 8, and on Day 12 when the sensory evaluations were performed.

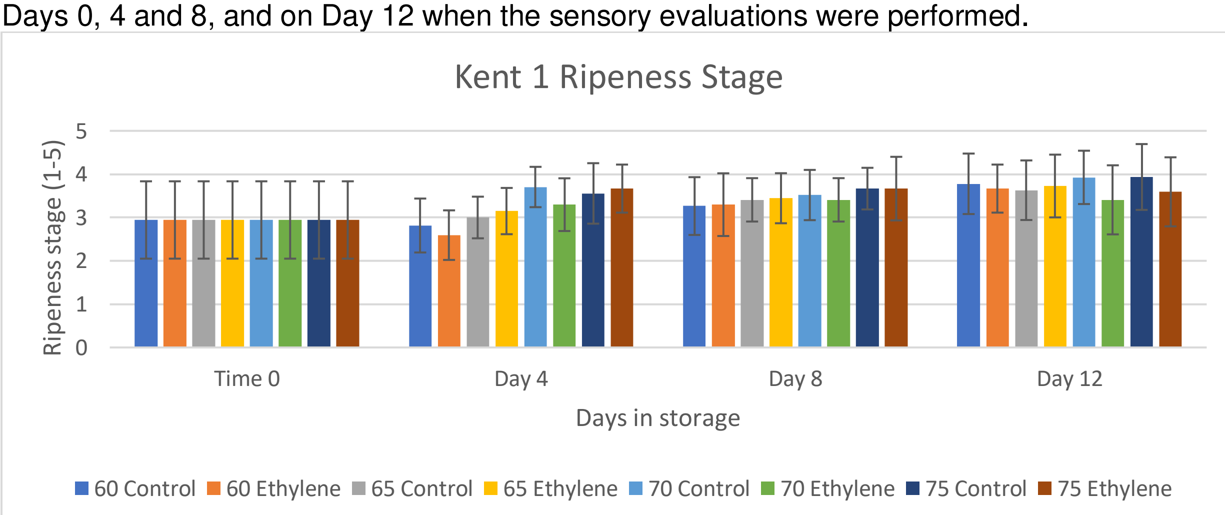


Figure 12. Ripeness (flesh color development from 1 to 5) of the second sample of Kent fruit on Days 0, 4 and 8, and on Day 14 when the sensory evaluations were performed.

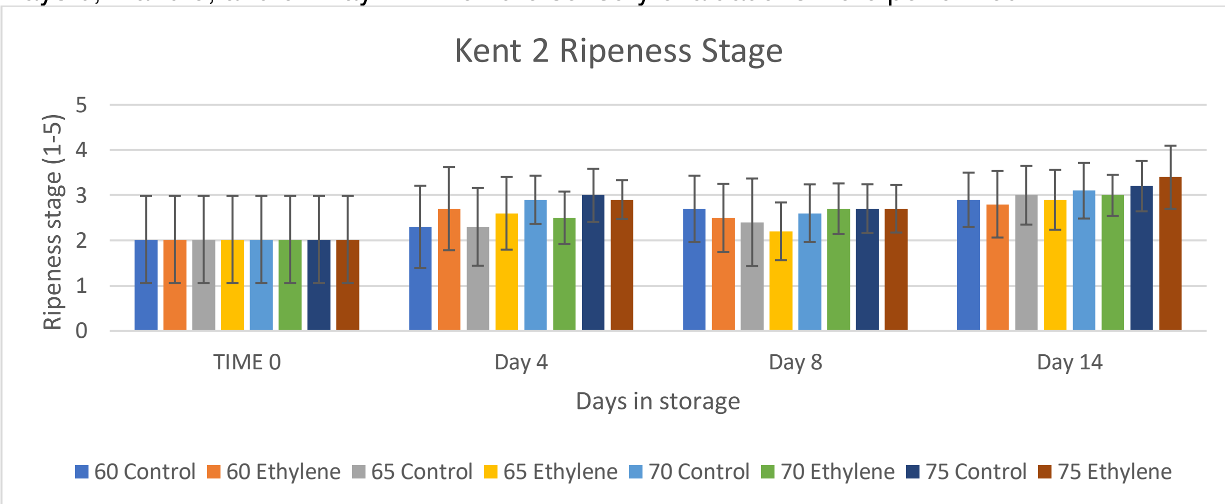


Figure 13. Ripeness (flesh color development from 1 to 5) of the first sample of Keitt fruit on Days 0, 4 and 8, and on Day 11 when the sensory evaluations were performed.

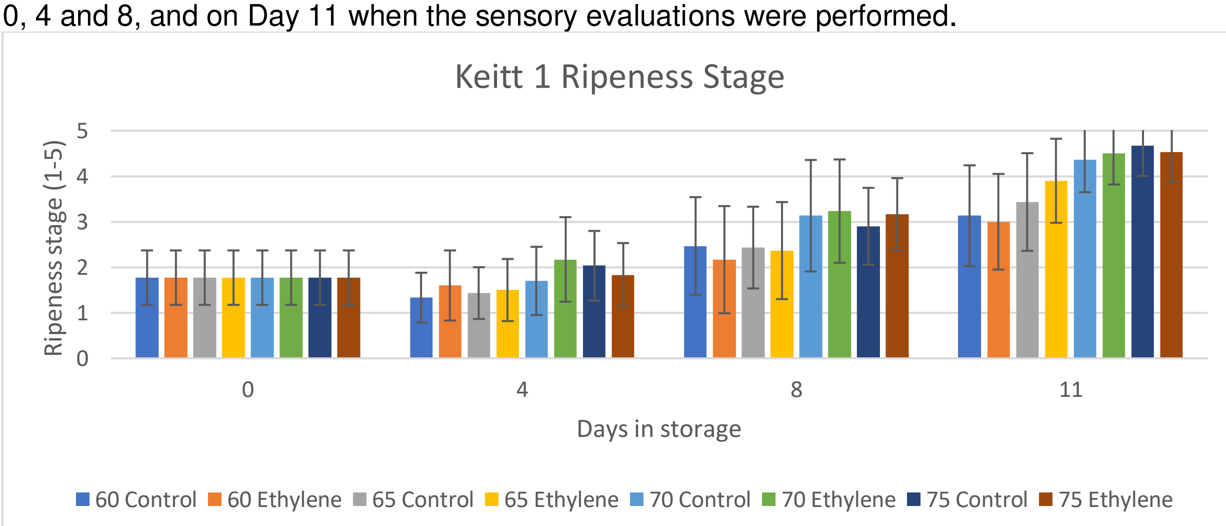


Figure 14. Ripeness (flesh color development from 1 to 5) of the second sample of Keitt fruit on Days 0, 4 and 8, and on Day 9 when the sensory evaluations were performed.

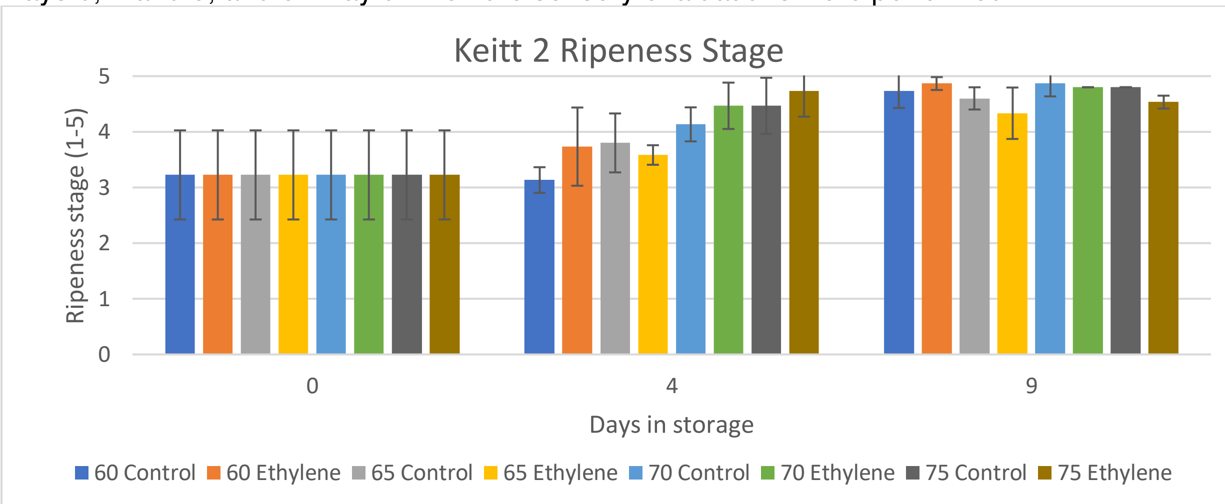


Figure 15. Ripeness (flesh color development from 1 to 5) of the first sample of Honey fruit on Days 0, 4 and 8, and on Day 12 when the sensory evaluations were performed.

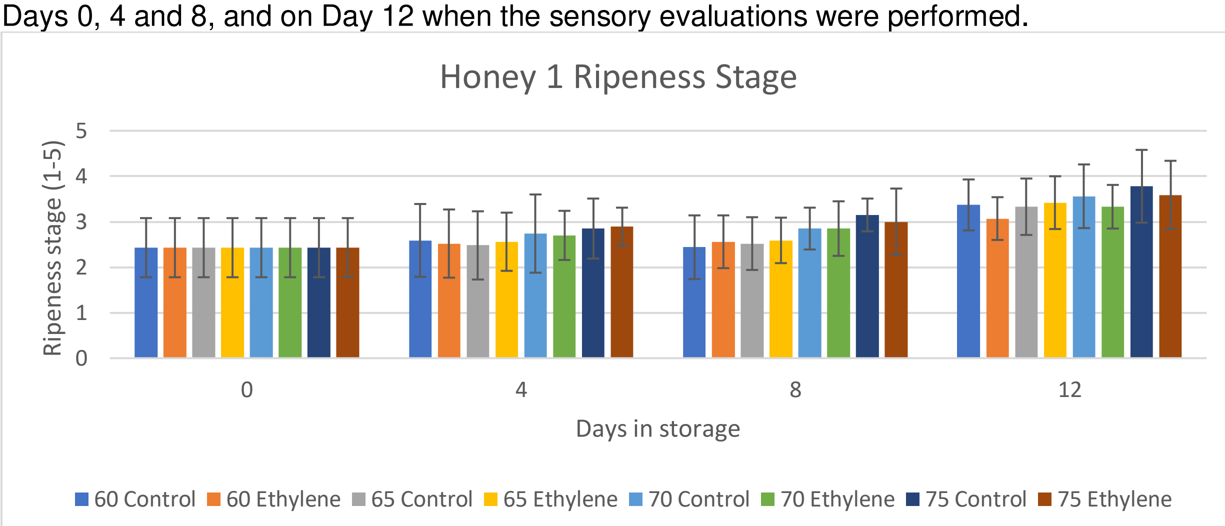
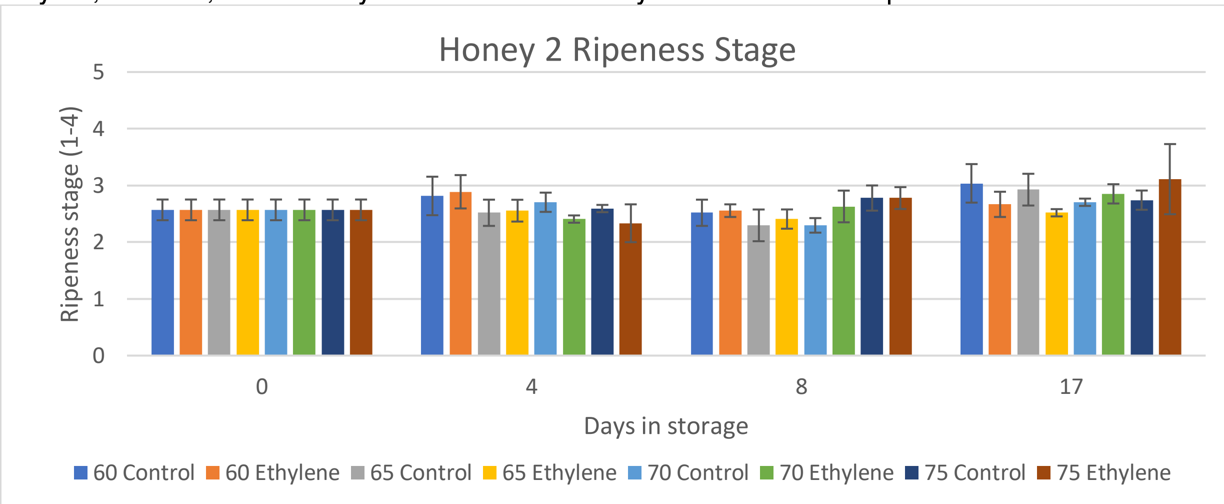


Figure 16. Ripeness (flesh color development from 1 to 5) of the second sample of Honey fruit on Days 0, 4 and 8, and on Day 17 when the sensory evaluations were performed.



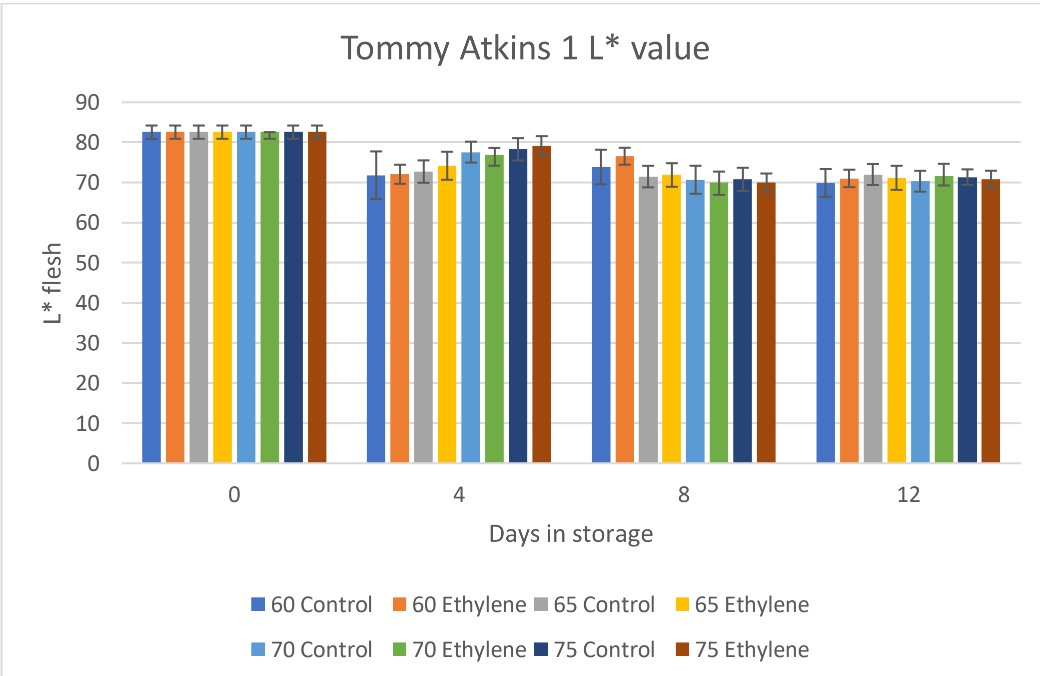
3. Fruit Flesh Color

- Like the ripeness stage changes, subepidermal flesh color changes were minor and mostly unaffected by ripening conditions.

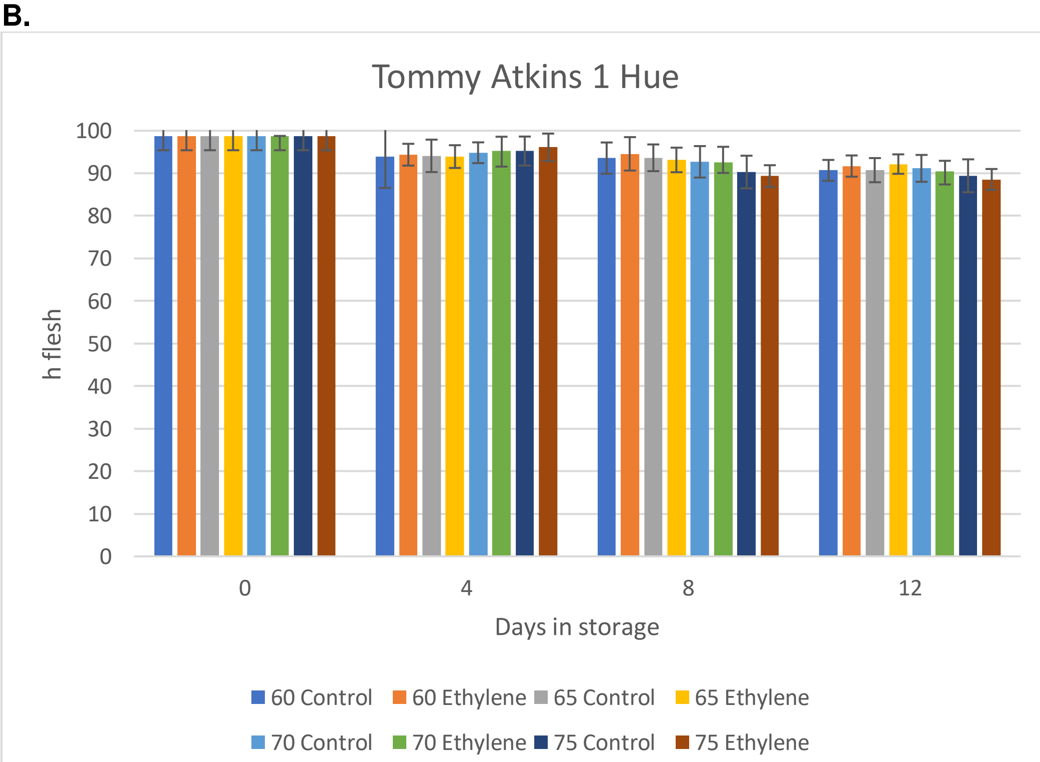
Figures 17-22 show the flesh color of the fruit in terms of colorimeter measurements of the L*, Hue, and Chroma on Days 0, 4 and 8, and on the final day when the sensory evaluations were performed.

Figure 17. Flesh color (**A.** L*, **B.** Hue, and **C.** Chroma) of the first sample of Tommy Atkins fruit on Days 0, 4 and 8, and on Day 12 when the sensory evaluations were performed.

A.



B.



C.

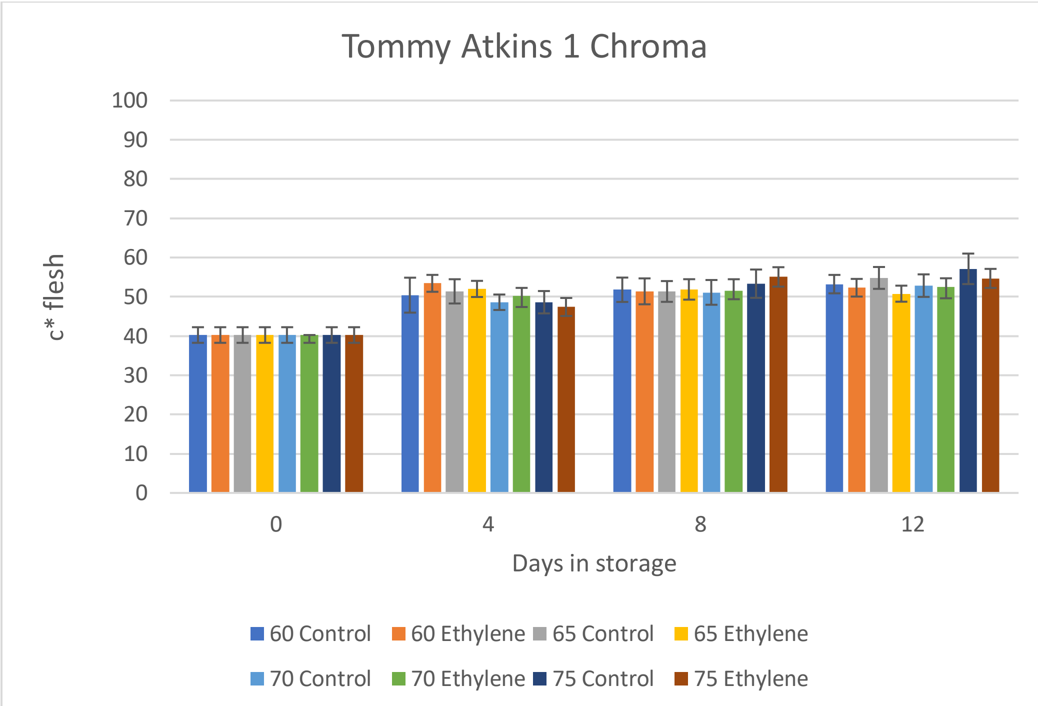
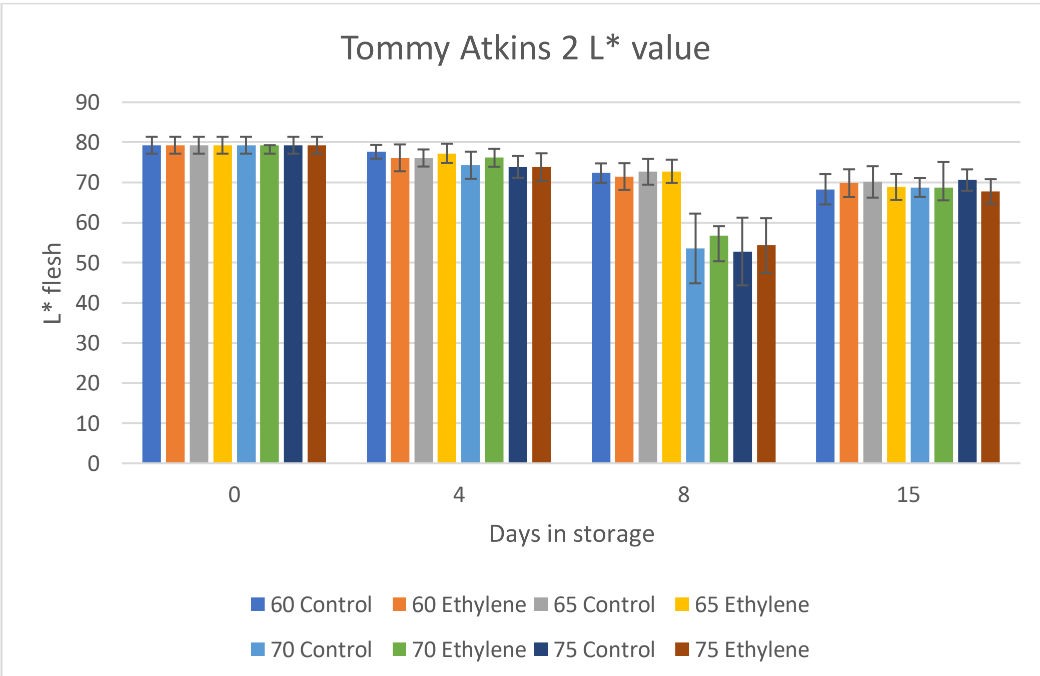
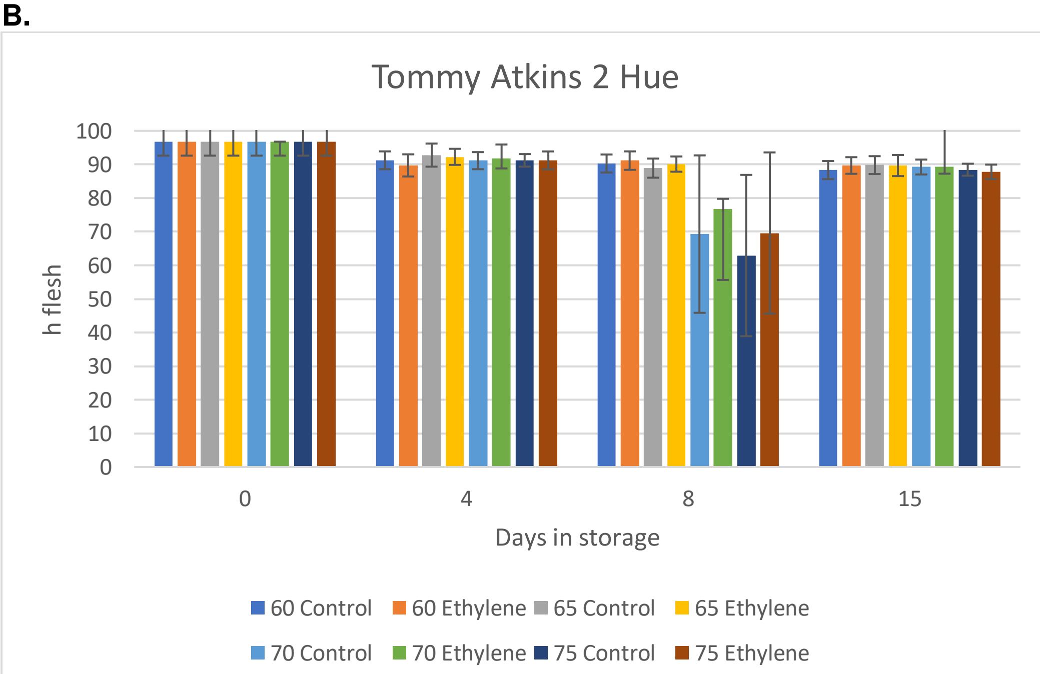

Tommy Atkins 1 Chroma
100
90
80
70
60
50
40
30
20
10
0
c* flesh
0
4
8
12
Days in storage
60 Control
60 Ethylene
65 Control
65 Ethylene
70 Control
70 Ethylene
75 Control
75 Ethylene

Figure 18. Flesh color (**A.** L*, **B.** Hue, and **C.** Chroma) of the second sample of Tommy Atkins fruit on Days 0, 4 and 8, and on Day 15 when the sensory evaluations were performed.

A.



B.



C.

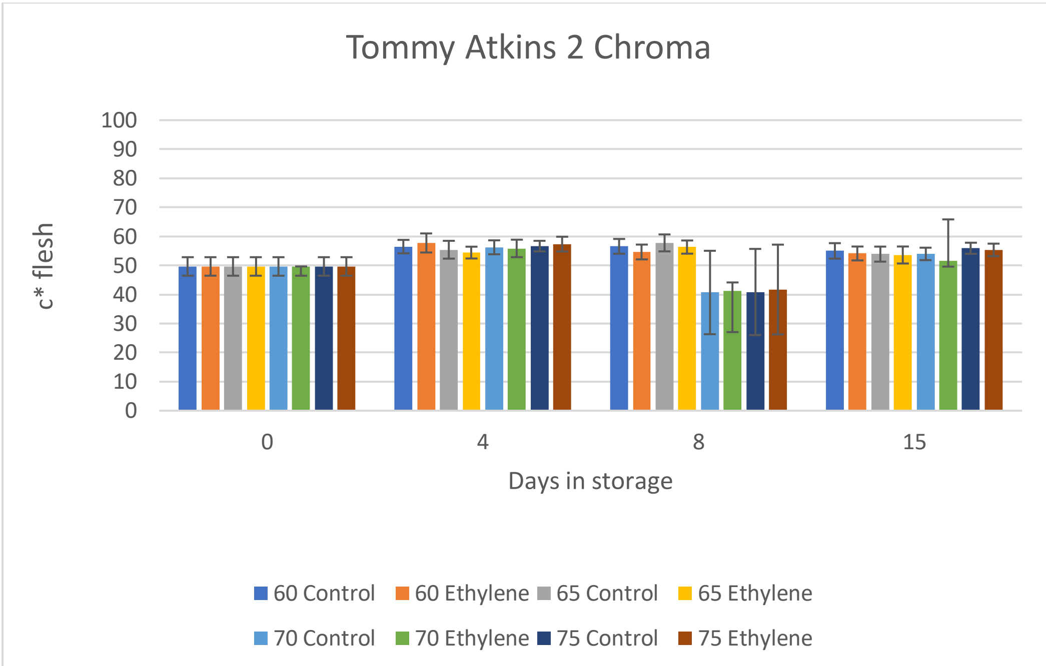
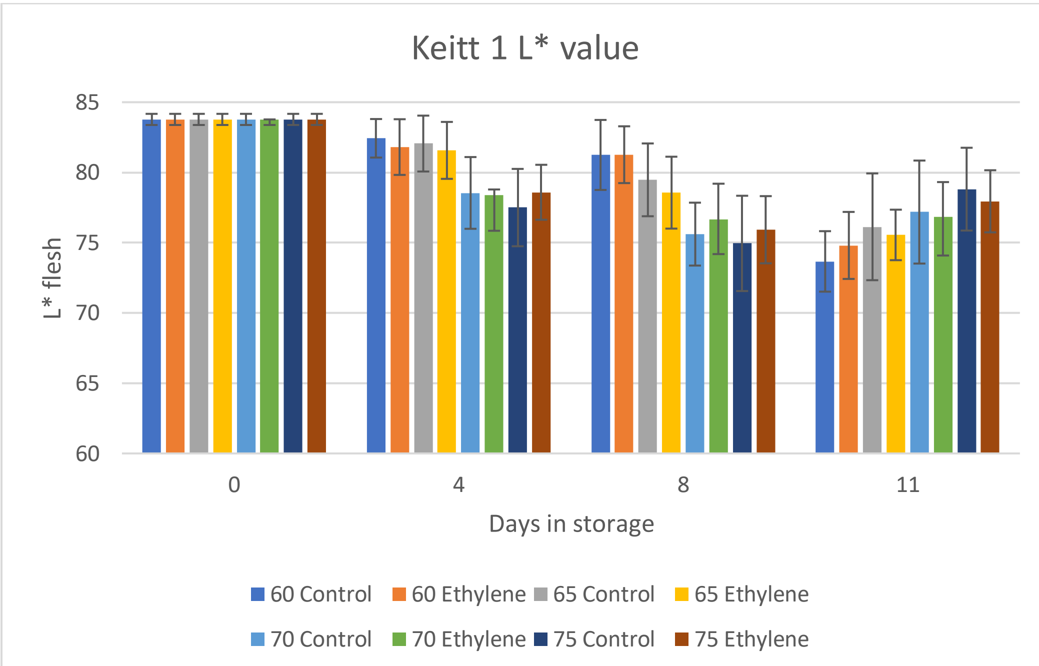
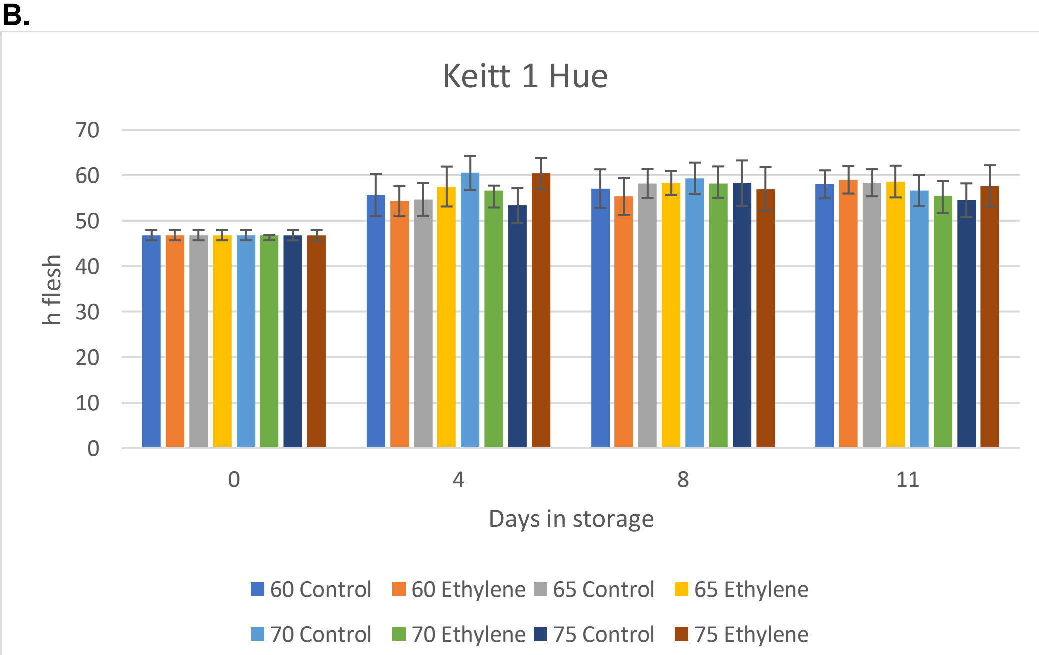

Tommy Atkins 2 Chroma
100
90
80
70
60
50
40
30
20
10
0
c* flesh
0
4
8
15
Days in storage
60 Control
60 Ethylene
65 Control
65 Ethylene
70 Control
70 Ethylene
75 Control
75 Ethylene

Figure 19. Flesh color (**A.** L*, **B.** Hue, and **C.** Chroma) of the first sample of Keitt fruit on Days 0, 4 and 8, and on Day 11 when the sensory evaluations were performed.

A.



B.



C.

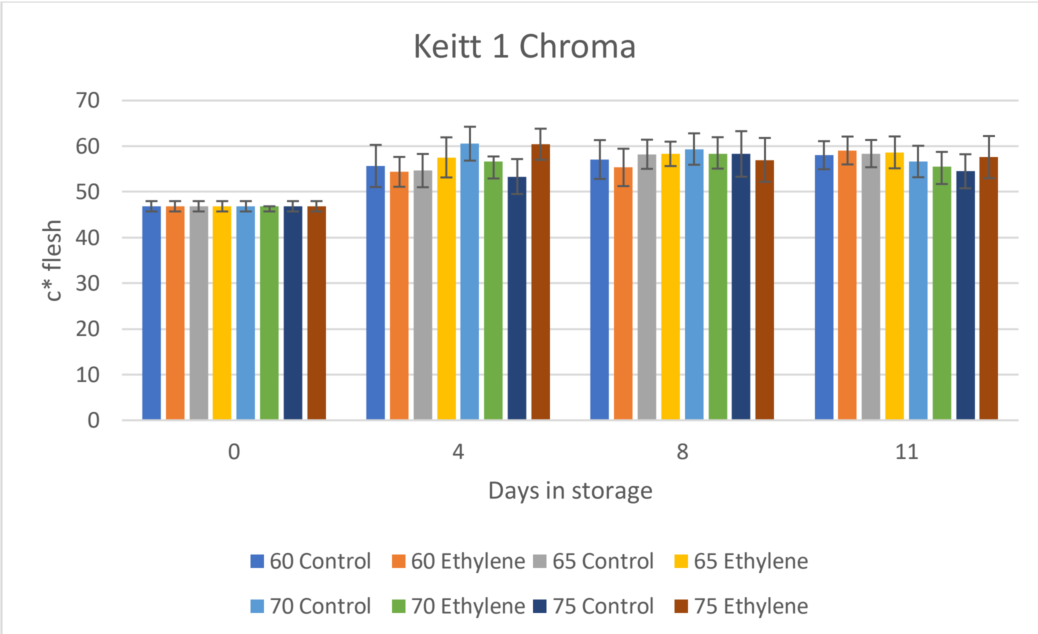
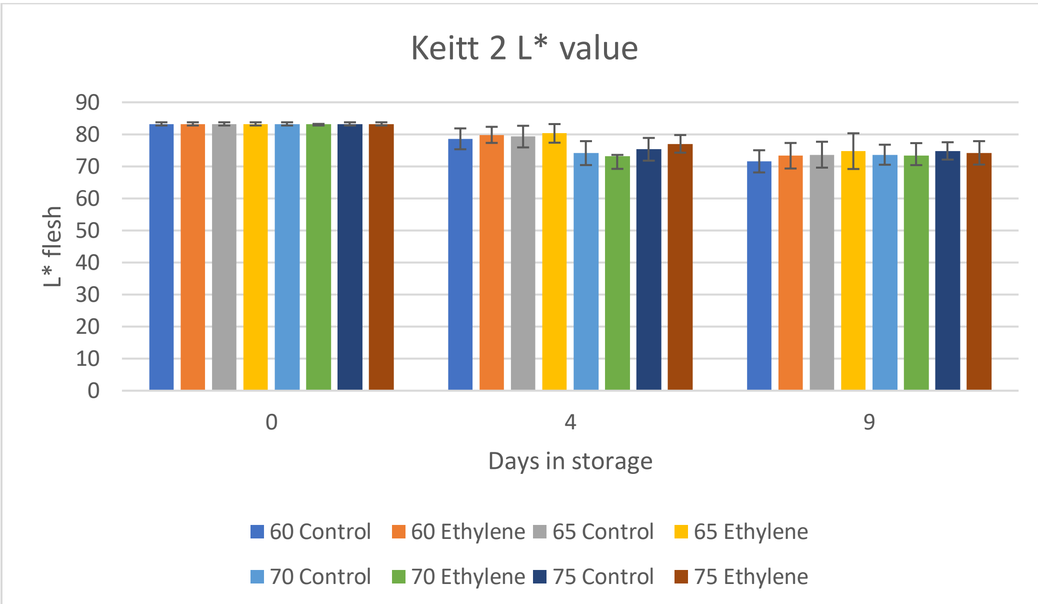
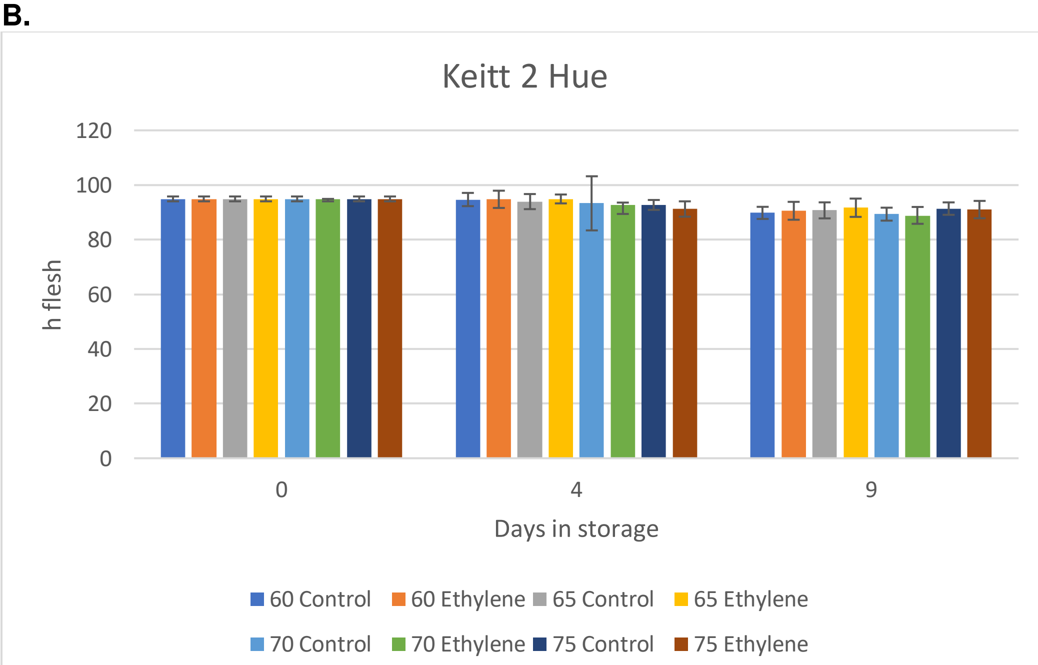

Keitt 1 Chroma
70
60
50
40
30
20
10
0
c* flesh
0
4
8
11
Days in storage
60 Control
60 Ethylene
65 Control
65 Ethylene
70 Control
70 Ethylene
75 Control
75 Ethylene

Figure 20. Flesh color (**A.** L*, **B.** Hue, and **C.** Chroma) of the second sample of Keitt fruit on Days 0, 4 and 8, and on Day 9 when the sensory evaluations were performed.

A.



B.



C.

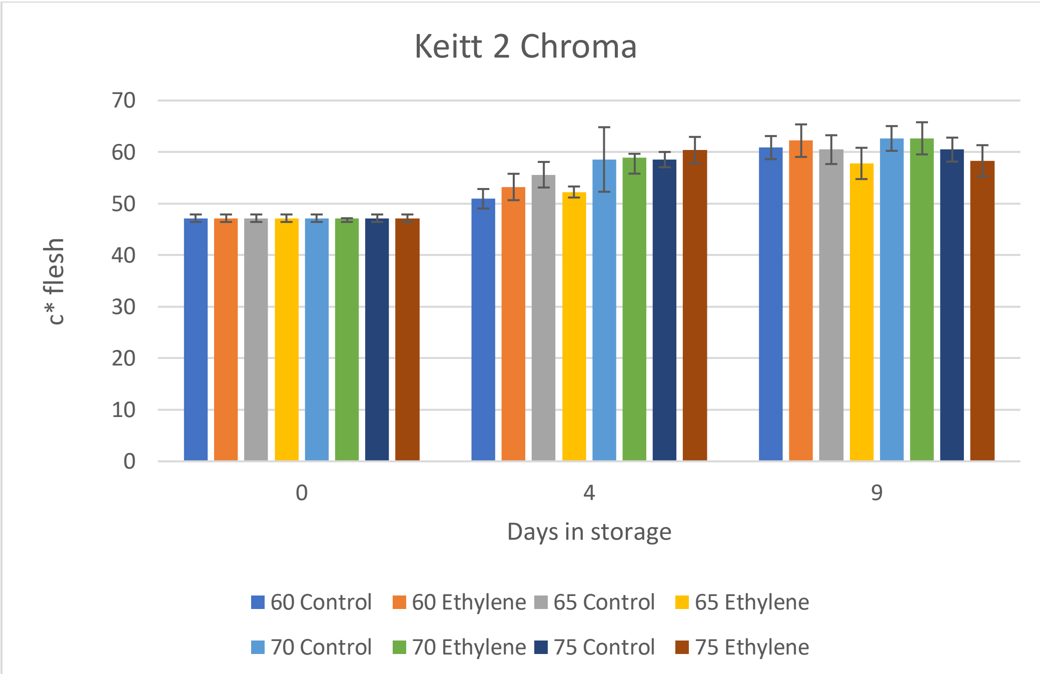
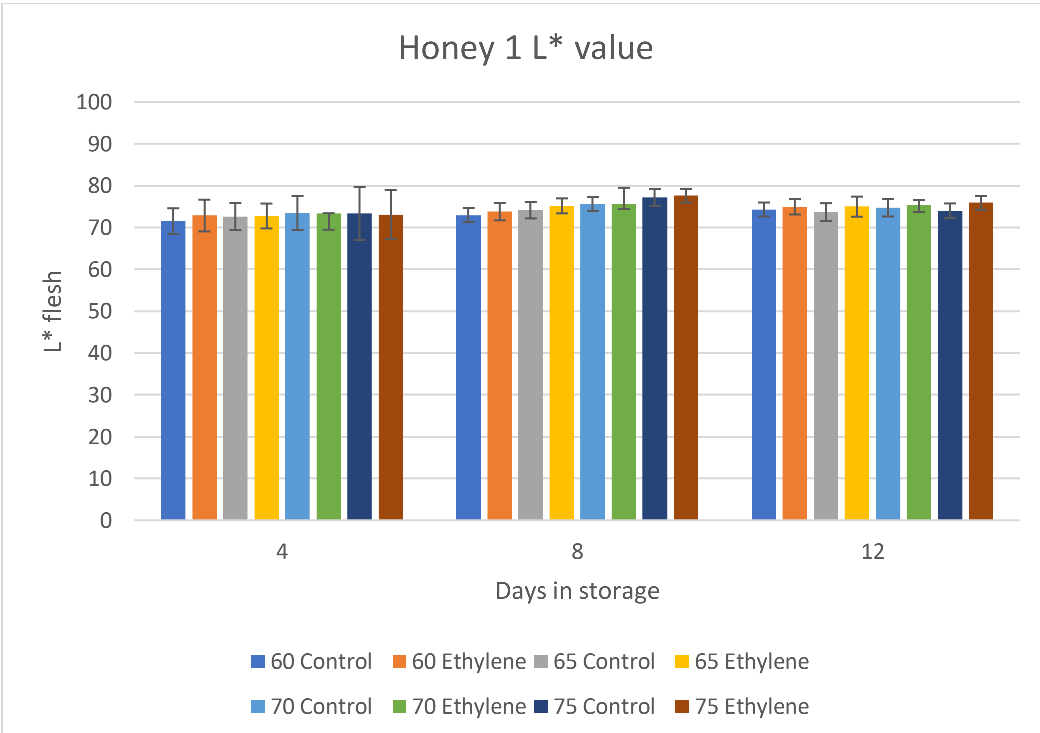
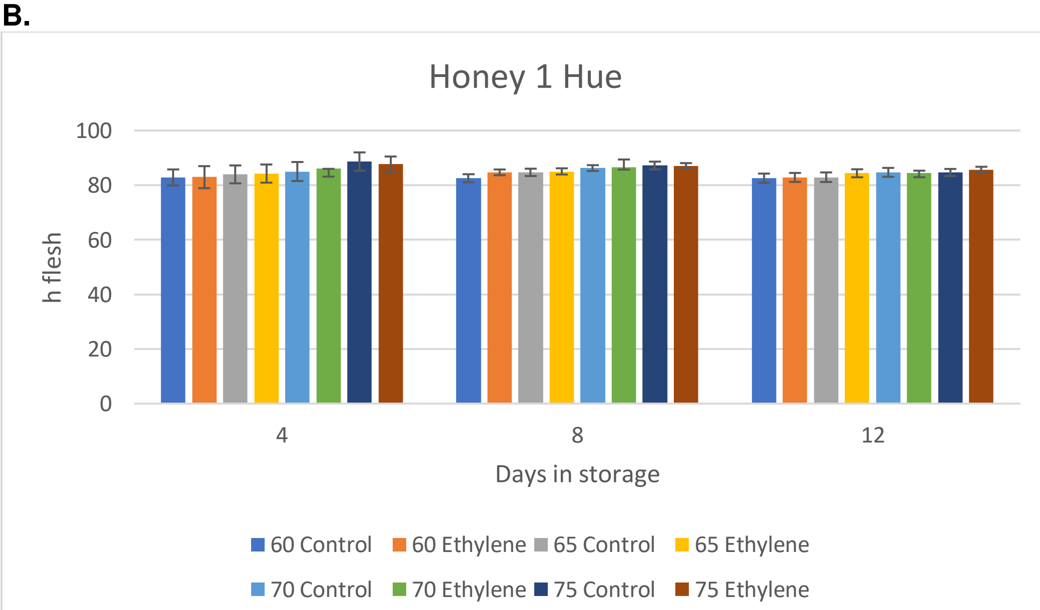

Keitt 2 Chroma
70
60
50
40
30
20
10
0
c* flesh
0
4
9
Days in storage
60 Control
60 Ethylene
65 Control
65 Ethylene
70 Control
70 Ethylene
75 Control
75 Ethylene

Figure 21. Flesh color (**A.** L*, **B.** Hue, and **C.** Chroma) of the first sample of Honey fruit on Days 0, 4 and 8, and on Day 12 when the sensory evaluations were performed.

A.



B.



C.

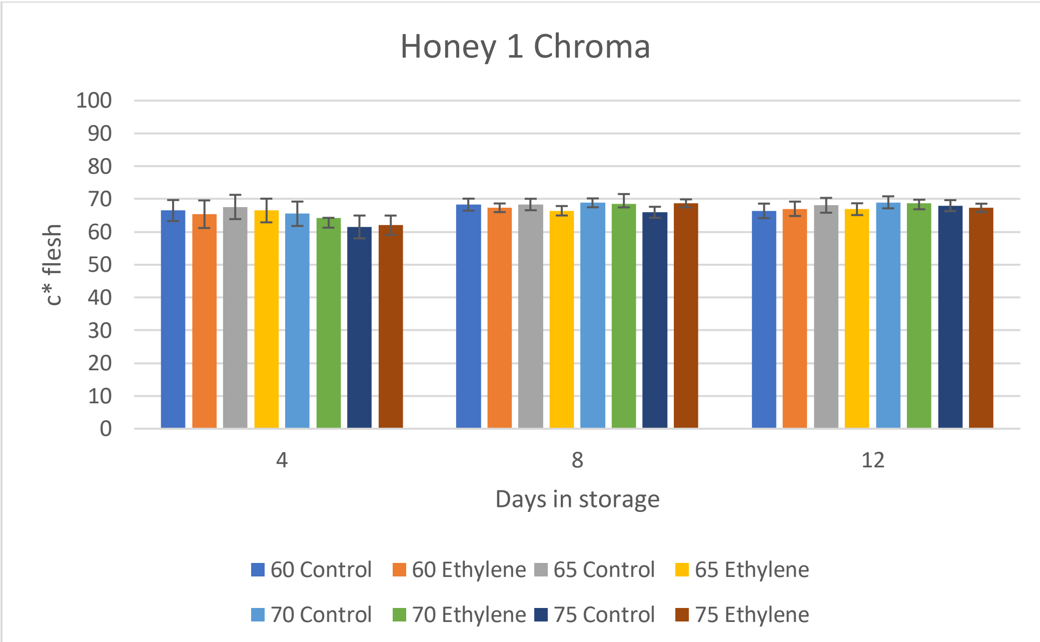
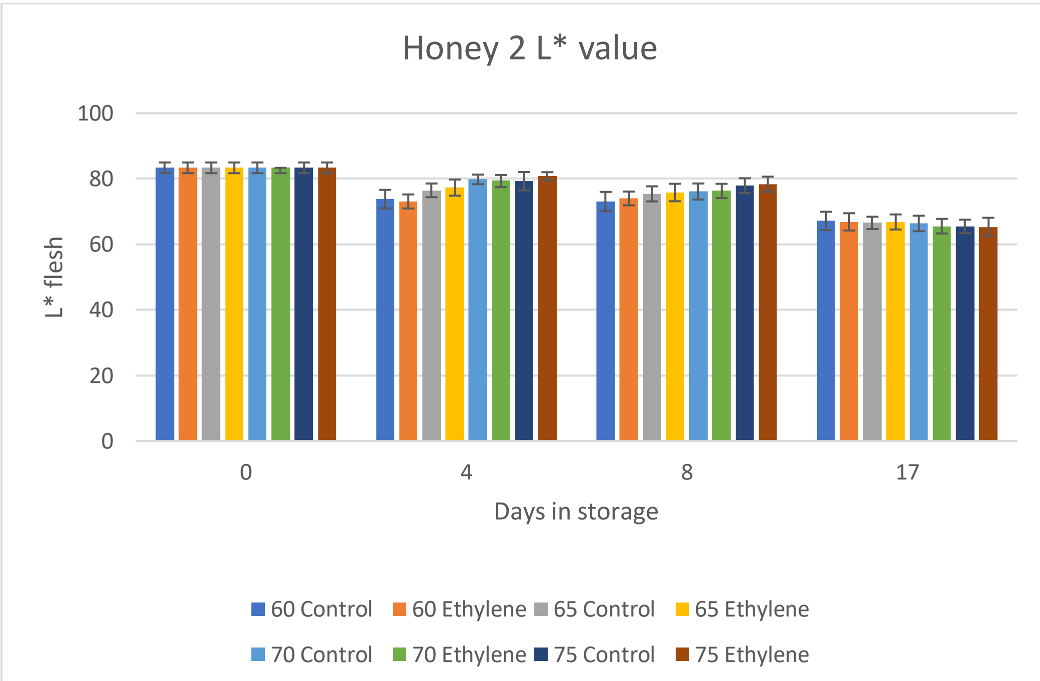
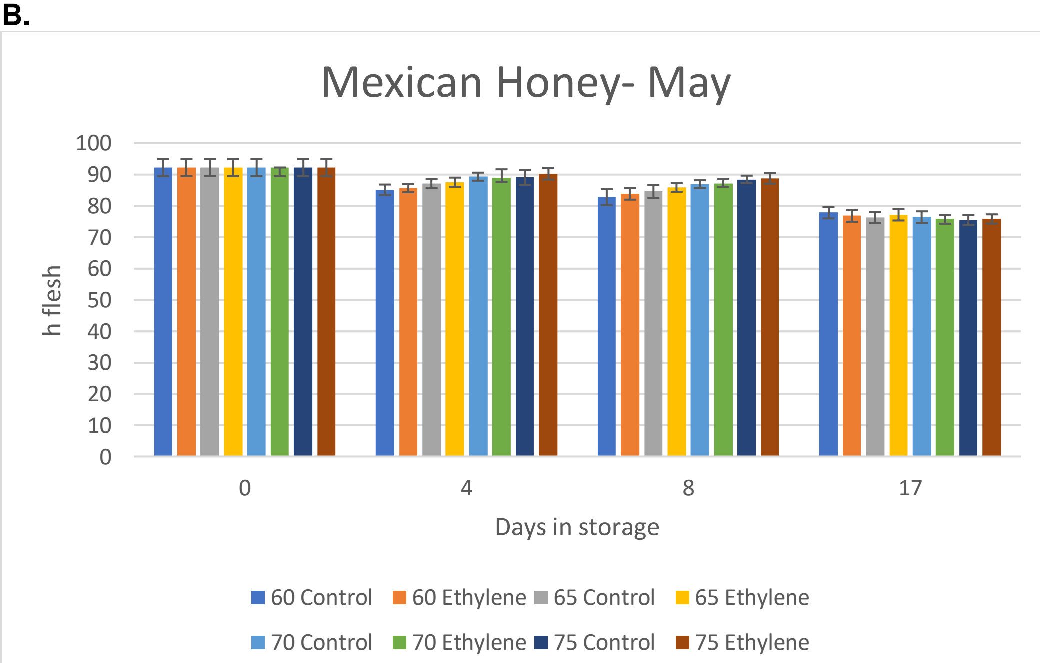

Honey 1 Chroma
100
90
80
70
60
50
40
30
20
10
0
c* flesh
4
8
12
Days in storage
60 Control
60 Ethylene
65 Control
65 Ethylene
70 Control
70 Ethylene
75 Control
75 Ethylene

Figure 22. Flesh color (**A.** L*, **B.** Hue, and **C.** Chroma) of the second sample of Honey fruit on Days 0, 4 and 8, and on Day 17 when the sensory evaluations were performed.

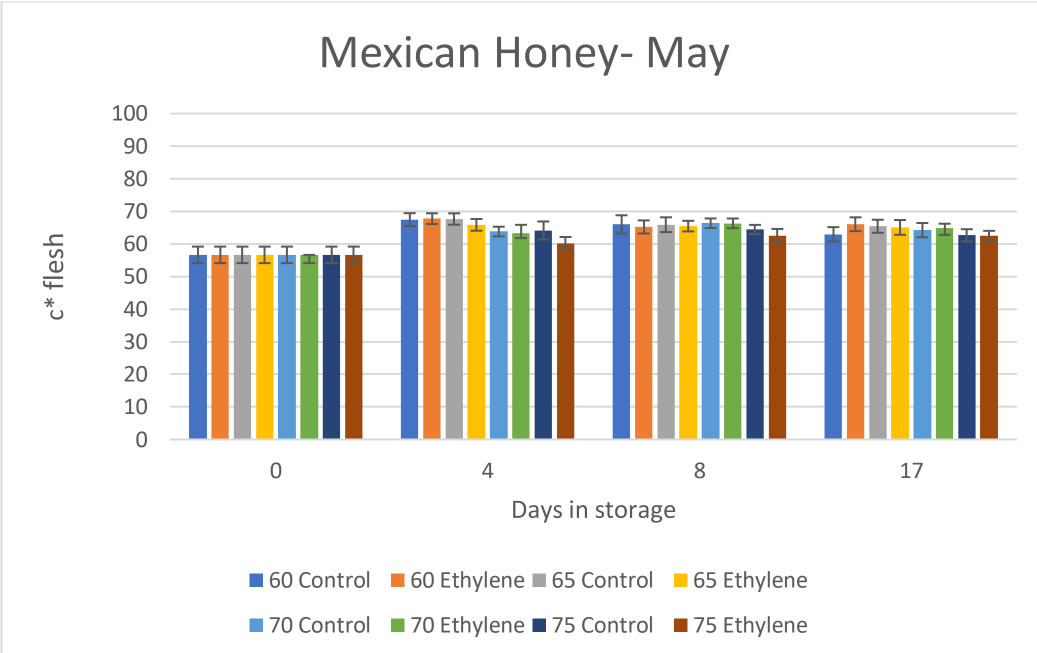
A.



B.



C.



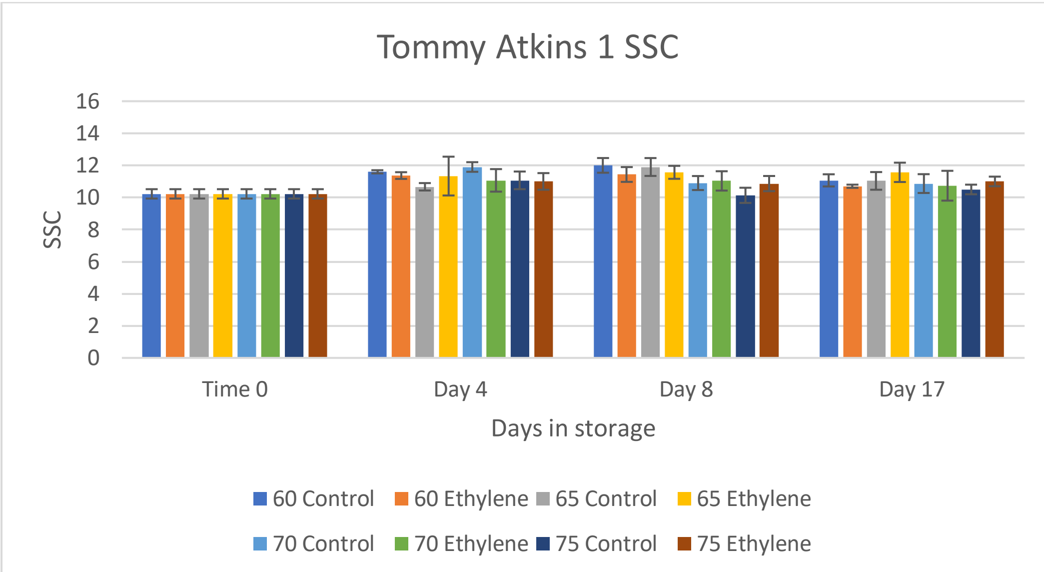
4. Soluble Solids Content (SSC; °Brix) and Total Titratable Acidity (TTA; %)

- SSC changed little or not at all during ripening, but TTA declined substantially – usually more so with higher initial ripening temperatures, resulting in higher SSC/TTA ratios (sweeter taste) with higher initial ripening temperatures

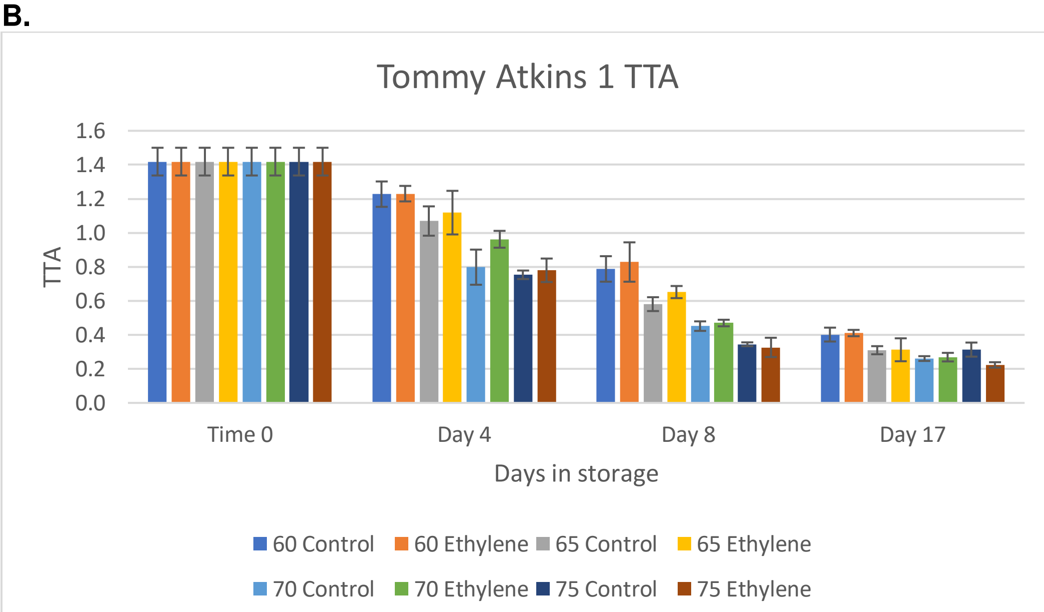
The next eight figures (**Fig. 23 to 30 A, B, C**) show the SSC, TTA, and SSC/TTA ratio on Days 0, 4 and 8, and on the final day when the sensory evaluations were performed.

Figure 23. Composition (**A.** SSC, **B.** TTA, and **C.** SSC/TTA) of the first sample of Tommy Atkins fruit on Days 0, 4 and 8, and on Day 12 when the sensory evaluations were performed.

A.



B.



C.

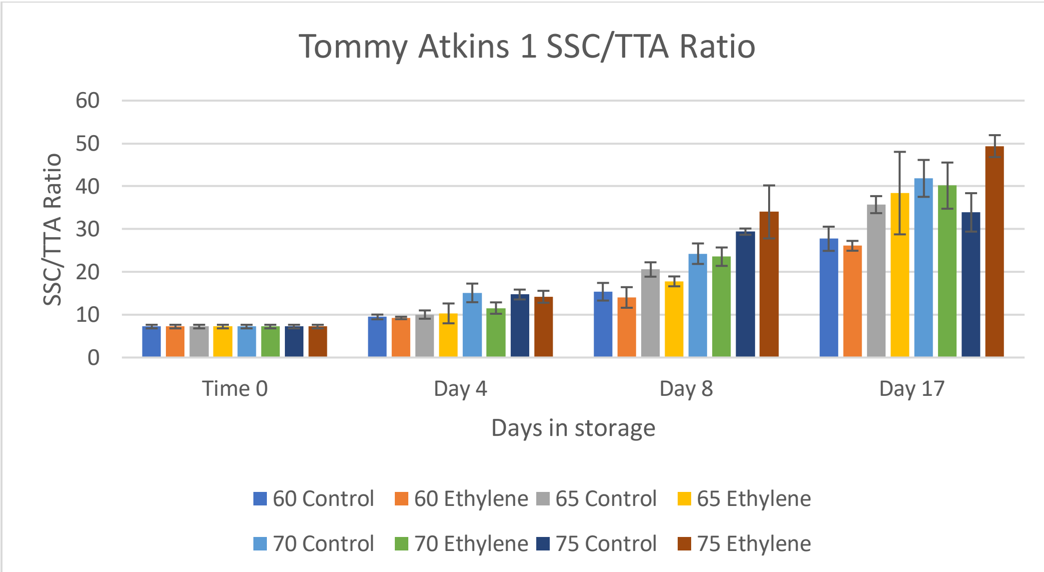
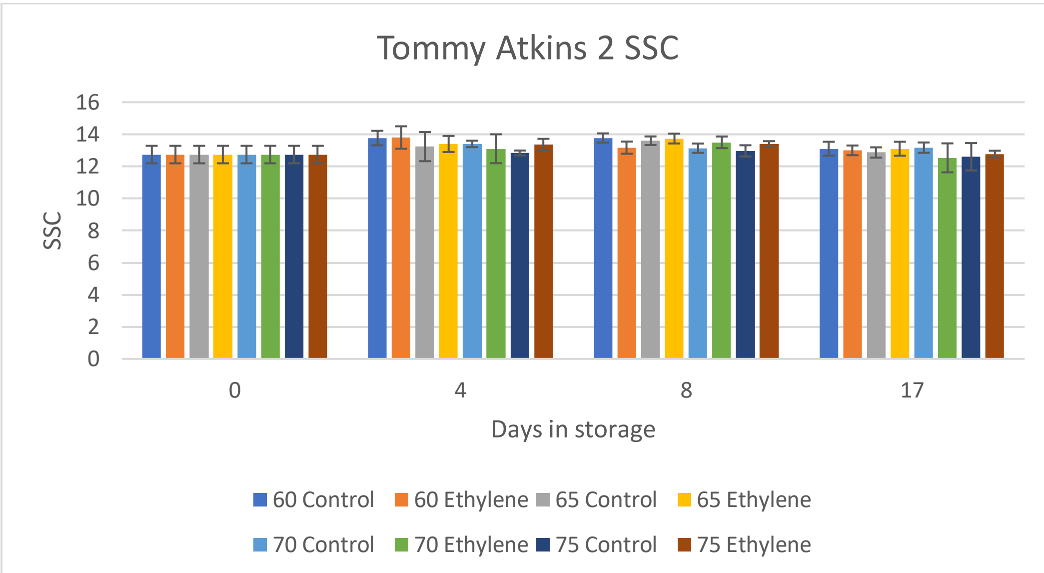
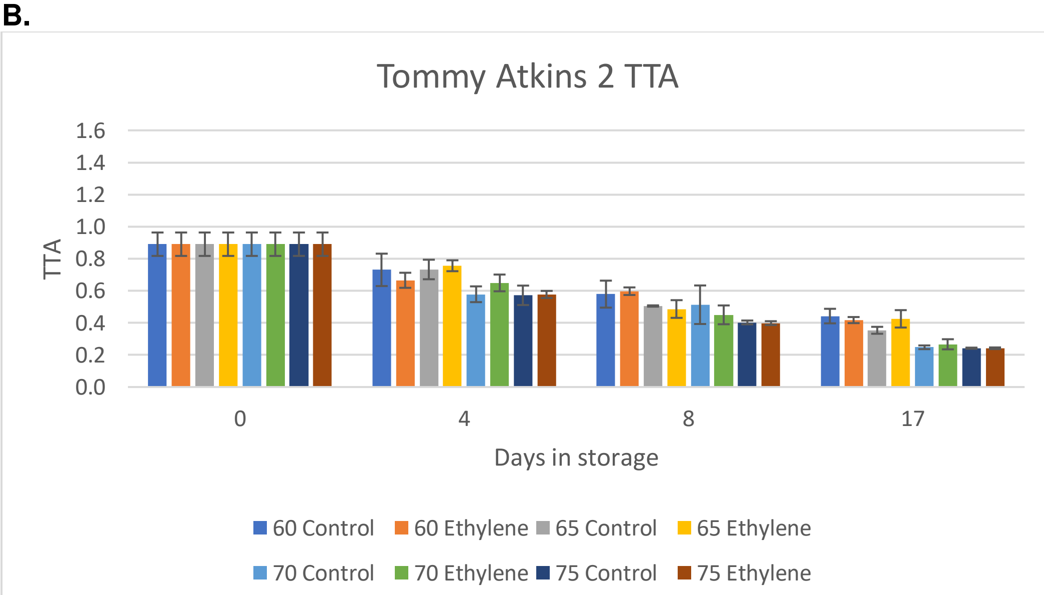

Tommy Atkins 1 SSC/TTA Ratio
60
50
40
30
20
10
0
SSC/TTA Ratio
Time 0
Day 4
Day 8
Day 17
Days in storage
60 Control
60 Ethylene
65 Control
65 Ethylene
70 Control
70 Ethylene
75 Control
75 Ethylene

Figure 24. Composition (**A.** SSC, **B.** TTA, and **C.** SSC/TTA) of the second sample of Tommy Atkins fruit on Days 0, 4 and 8, and on Day 15 when the sensory evaluations were performed.

A.



B.



C.

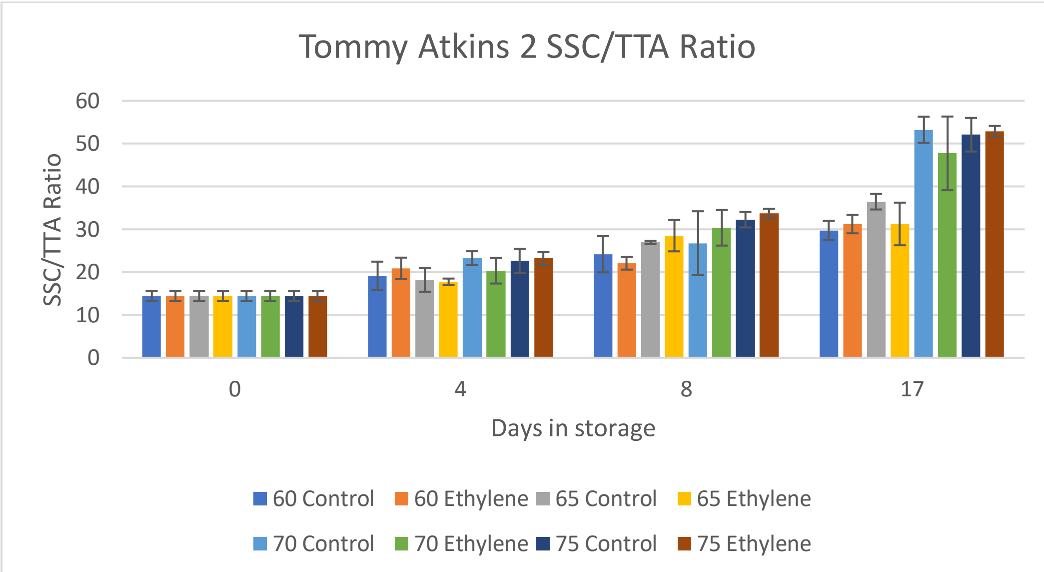
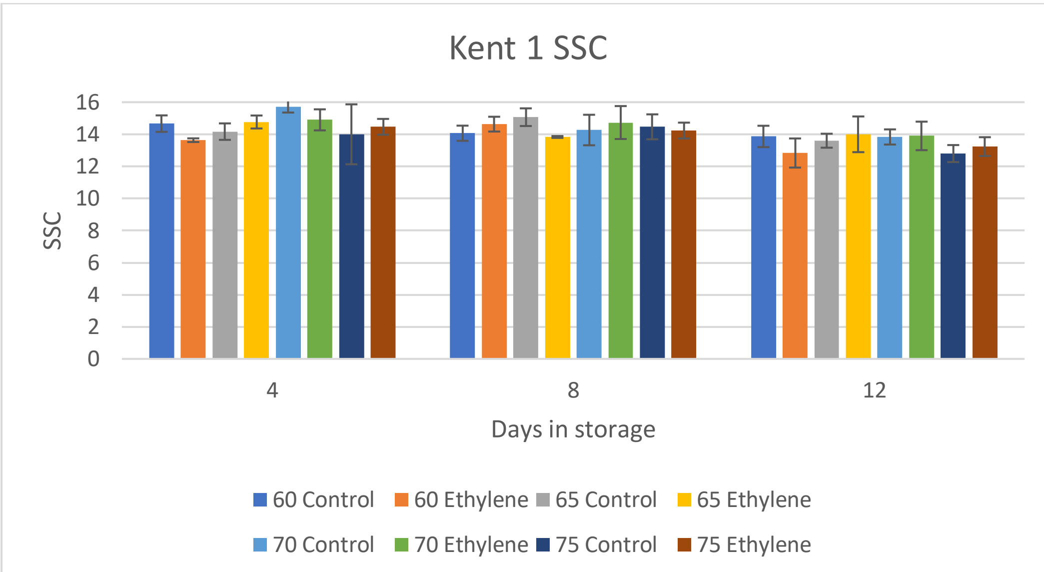
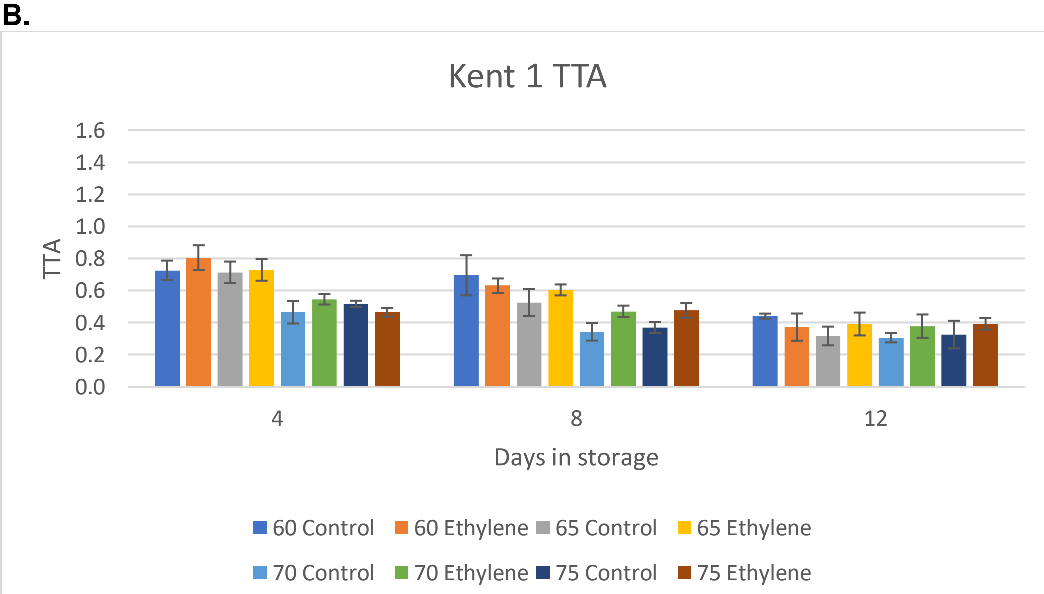

Tommy Atkins 2 SSC/TTA Ratio
SSC/TTA Ratio
0
10
20
30
40
50
60
0
4
8
17
Days in storage
60 Control
60 Ethylene
65 Control
65 Ethylene
70 Control
70 Ethylene
75 Control
75 Ethylene

Figure 25. Composition (**A.** SSC, **B.** TTA, and **C.** SSC/TTA) of the first sample of Kent fruit on Days 0, 4 and 8, and on Day 12 when the sensory evaluations were performed.

A.



B.



C.

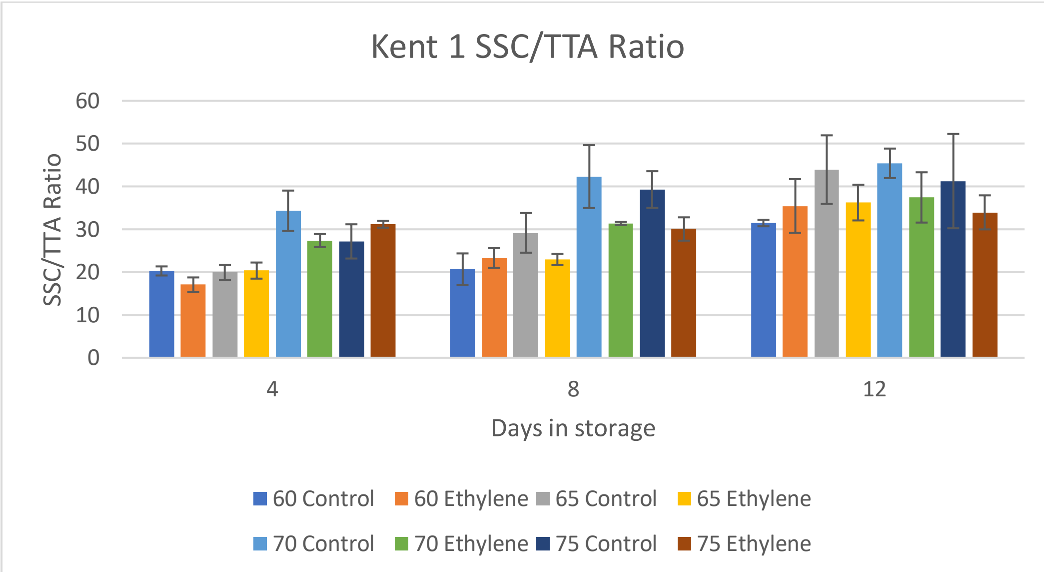
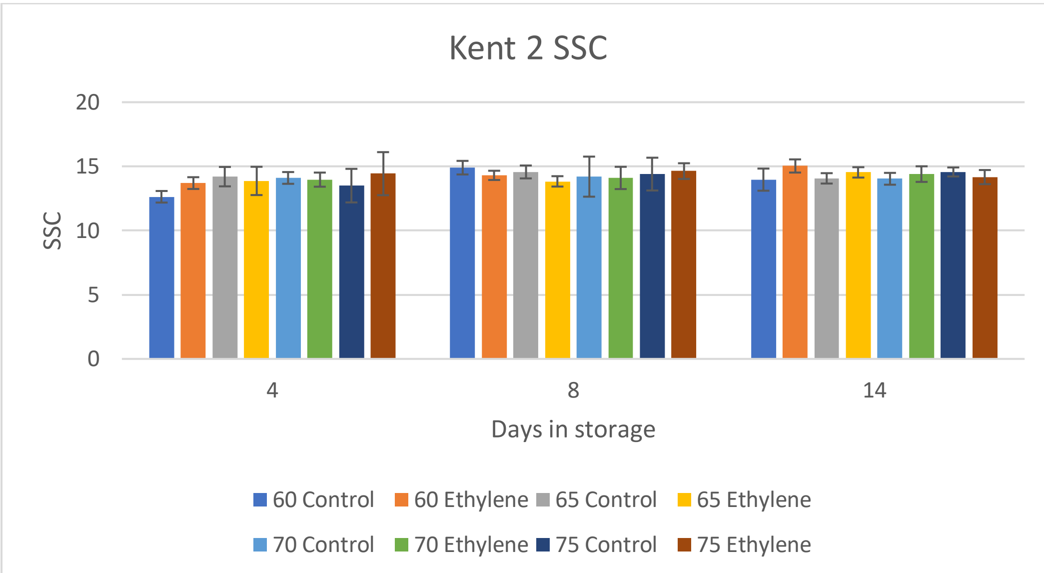
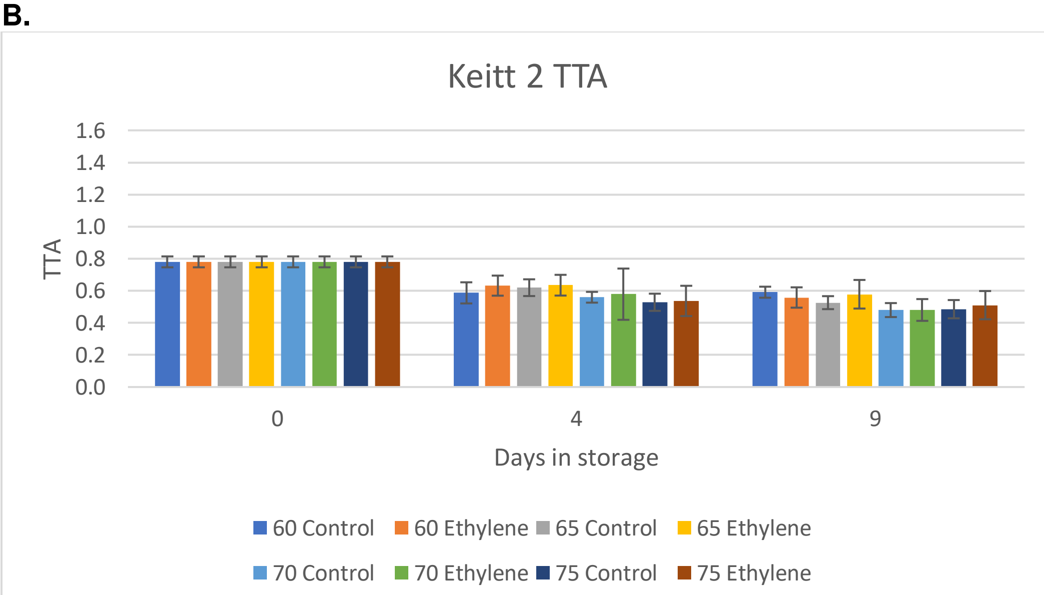

Kent 1 SSC/TTA Ratio
SSC/TTA Ratio
60
50
40
30
20
10
0
4
8
12
Days in storage
60 Control
60 Ethylene
65 Control
65 Ethylene
70 Control
70 Ethylene
75 Control
75 Ethylene

Figure 26. Composition (**A.** SSC, **B.** TTA, and **C.** SSC/TTA) of the second sample of Kent fruit on Days 0, 4 and 8, and on Day 14 when the sensory evaluations were performed.

A.



B.



C.

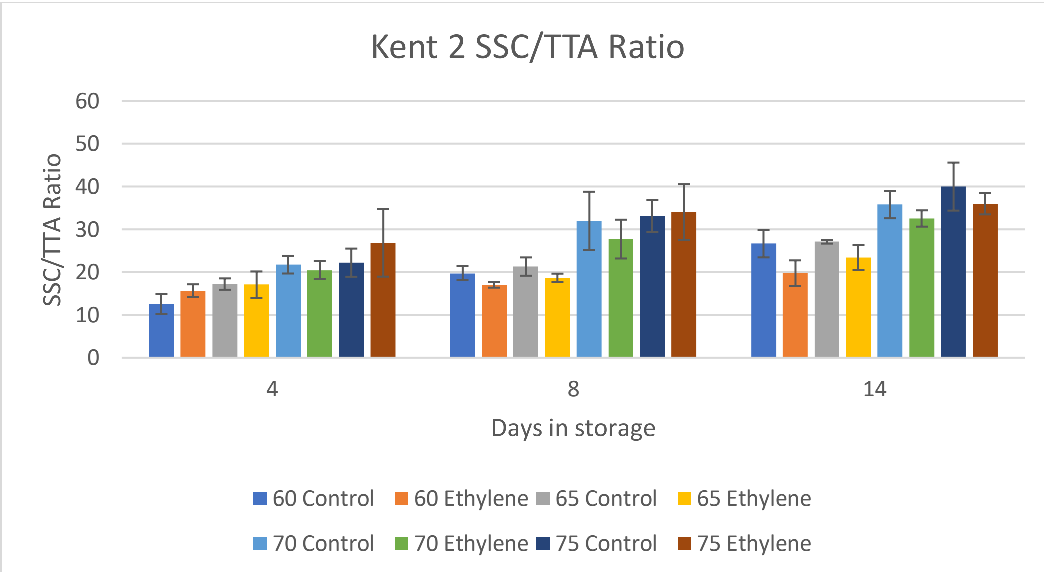
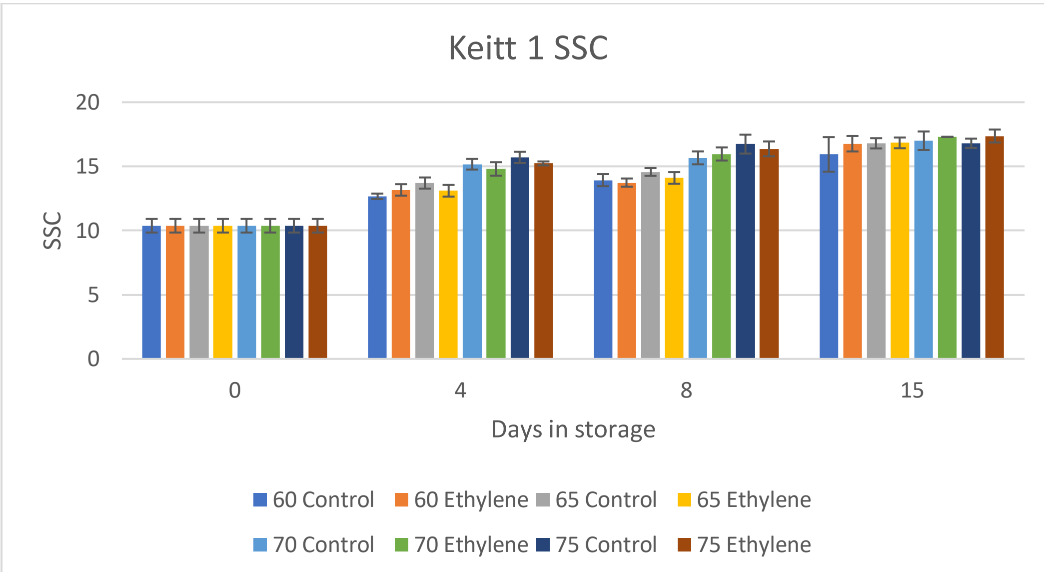
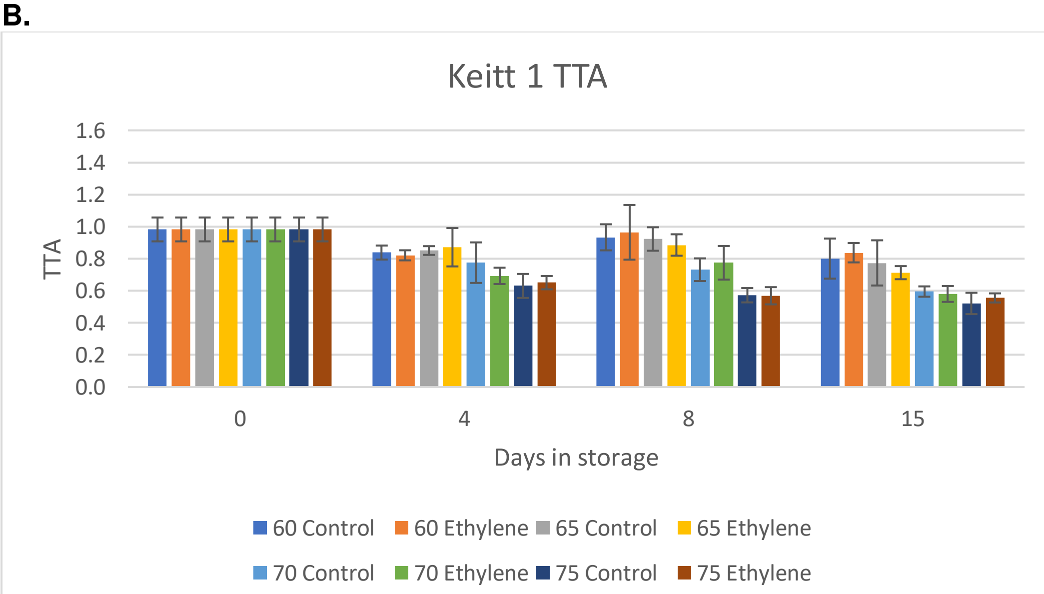

Kent 2 SSC/TTA Ratio
SSC/TTA Ratio
60
50
40
30
20
10
0
4
8
14
Days in storage
60 Control
60 Ethylene
65 Control
65 Ethylene
70 Control
70 Ethylene
75 Control
75 Ethylene

Figure 27. Composition (**A.** SSC, **B.** TTA, and **C.** SSC/TTA) of the first sample of Keitt fruit on Days 0, 4 and 8, and on Day 15 when the sensory evaluations were performed.

A.



B.



C.

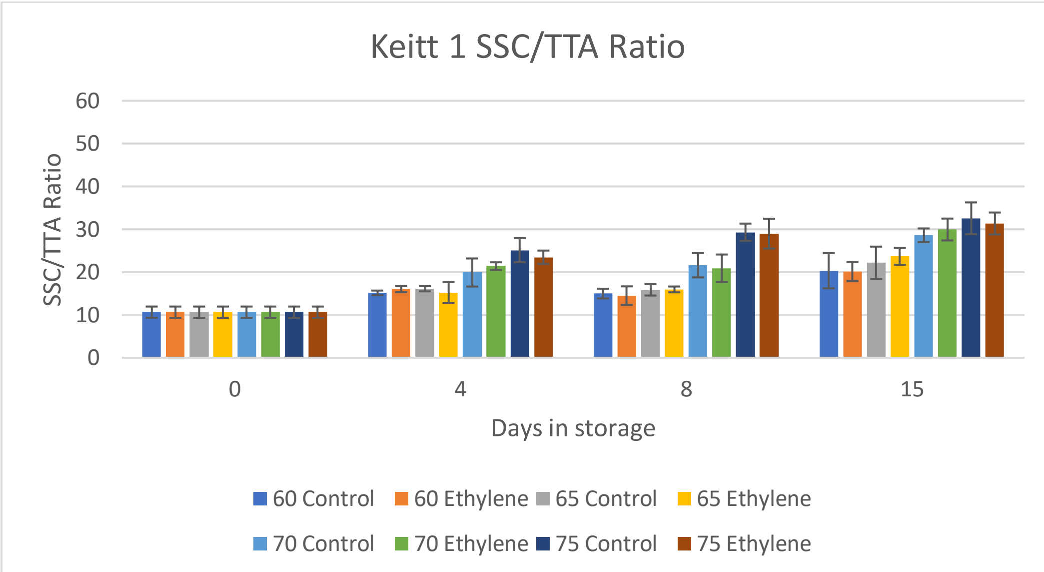
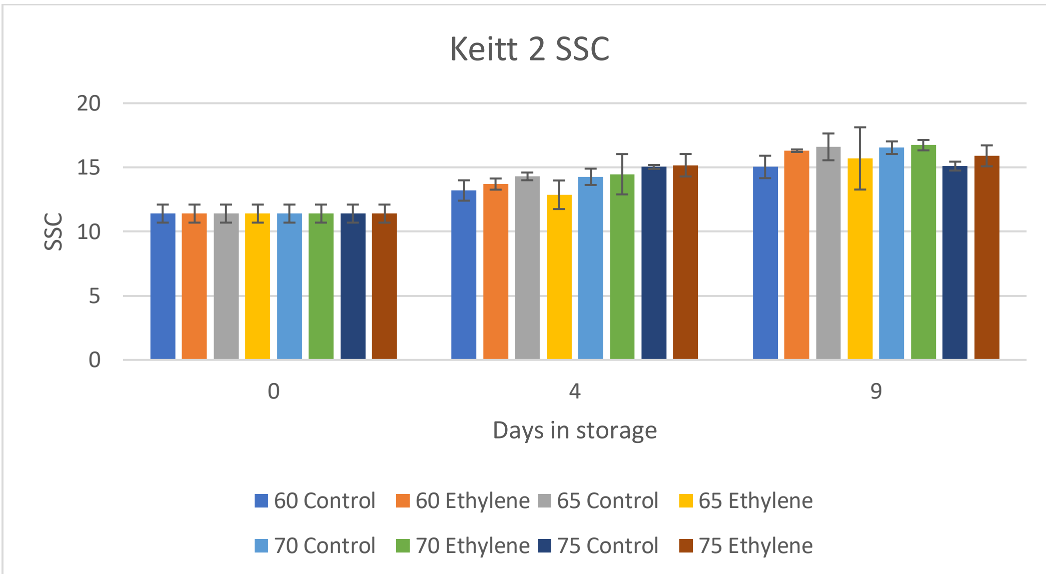
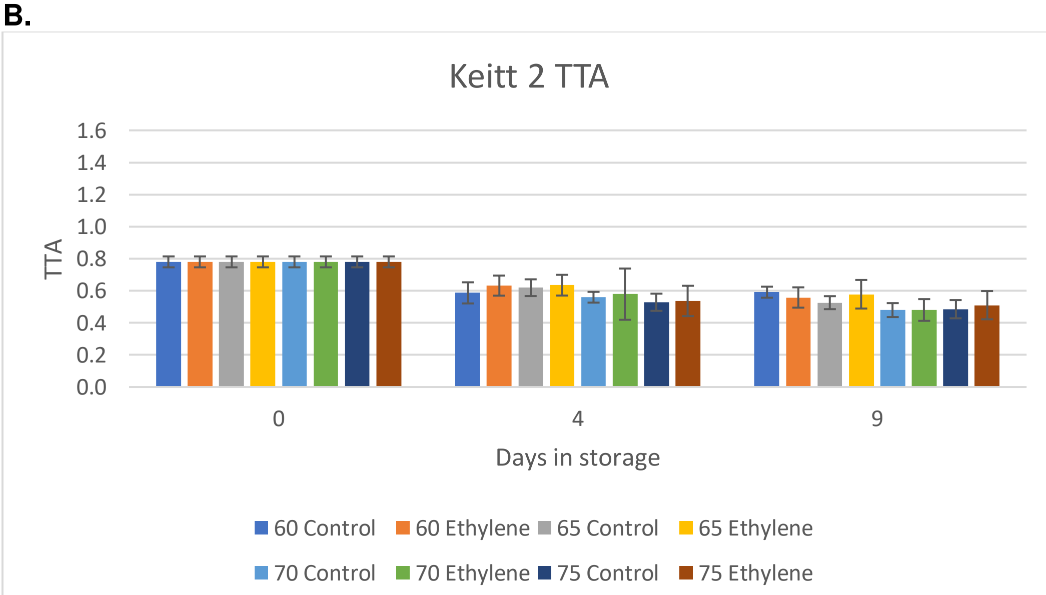

Keitt 1 SSC/TTA Ratio
SSC/TTA Ratio
60
50
40
30
20
10
0
0
4
8
15
Days in storage
60 Control
60 Ethylene
65 Control
65 Ethylene
70 Control
70 Ethylene
75 Control
75 Ethylene

Figure 28. Composition (**A.** SSC, **B.** TTA, and **C.** SSC/TTA) of the second sample of Keitt fruit on Days 0, 4 and 8, and on Day 9 when the sensory evaluations were performed.

A.



B.



C.

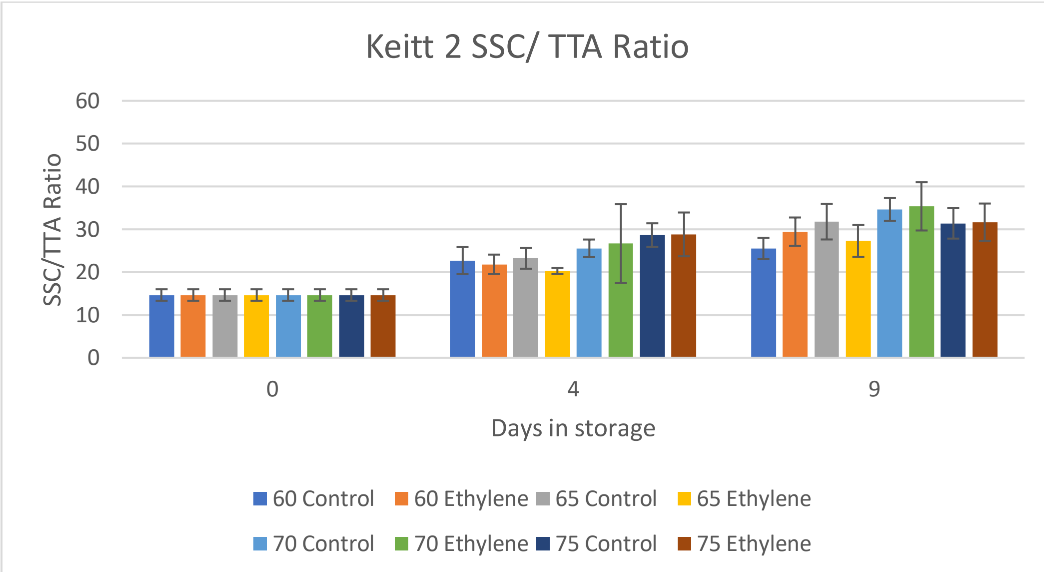
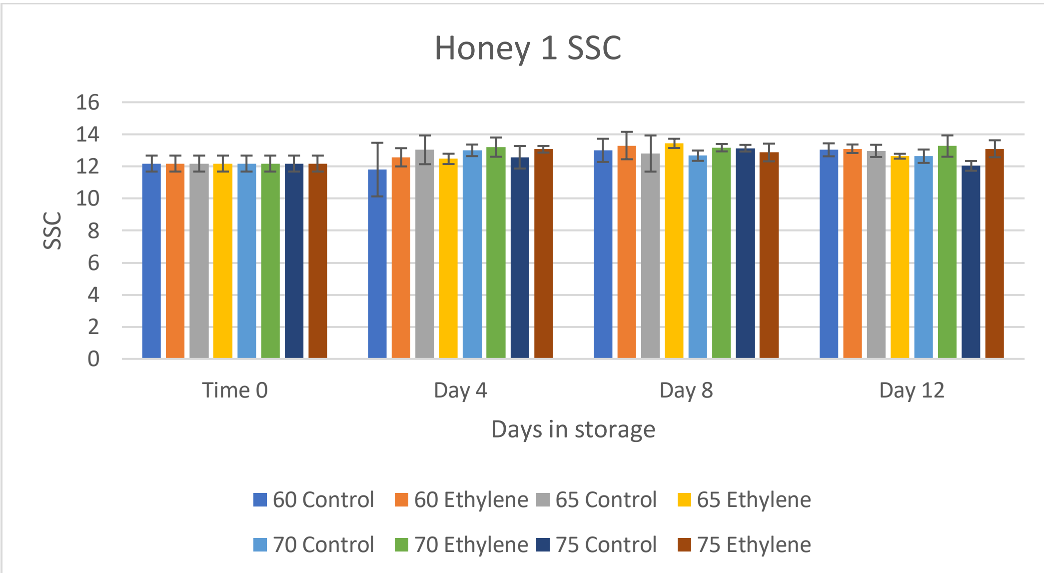
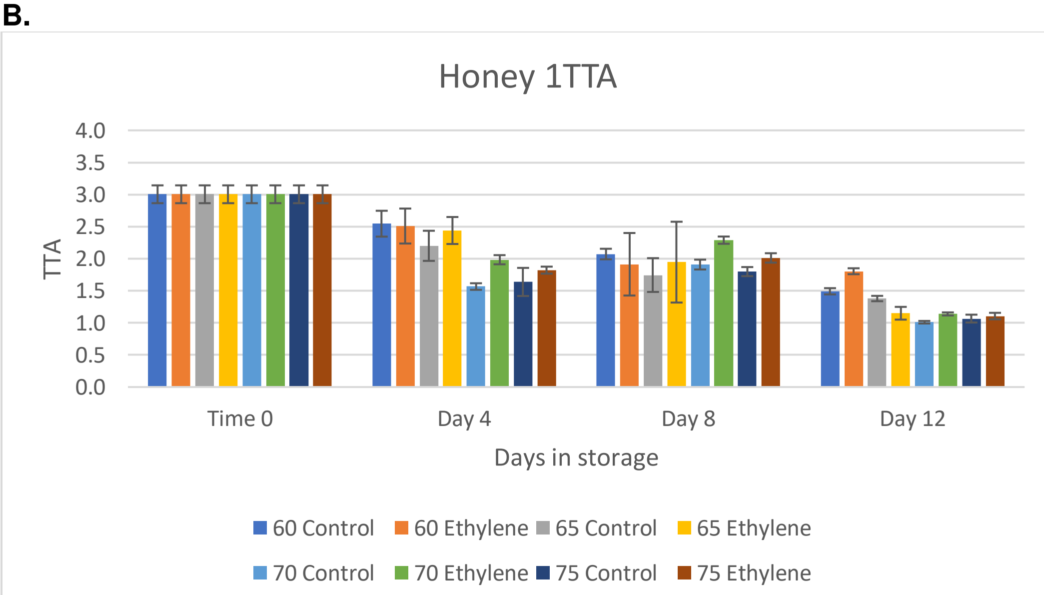

Keitt 2 SSC/ TTA Ratio
60
50
40
30
20
10
0
SSC/TTA Ratio
0
4
9
Days in storage
60 Control
60 Ethylene
65 Control
65 Ethylene
70 Control
70 Ethylene
75 Control
75 Ethylene

Figure 29. Composition (**A.** SSC, **B.** TTA, and **C.** SSC/TTA) of the first sample of Honey fruit on Days 0, 4 and 8, and on Day 12 when the sensory evaluations were performed.

A.



B.



C.

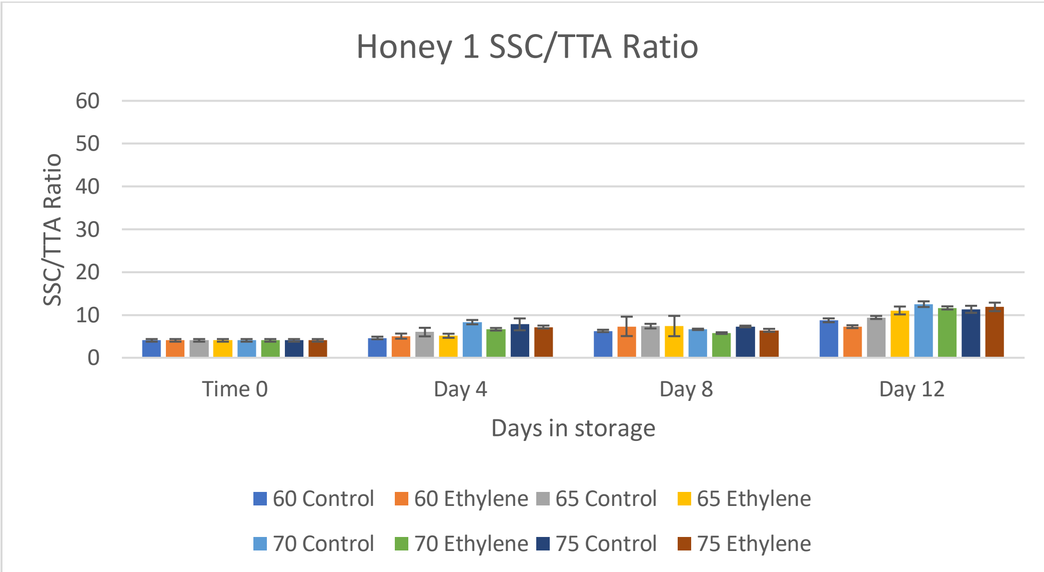
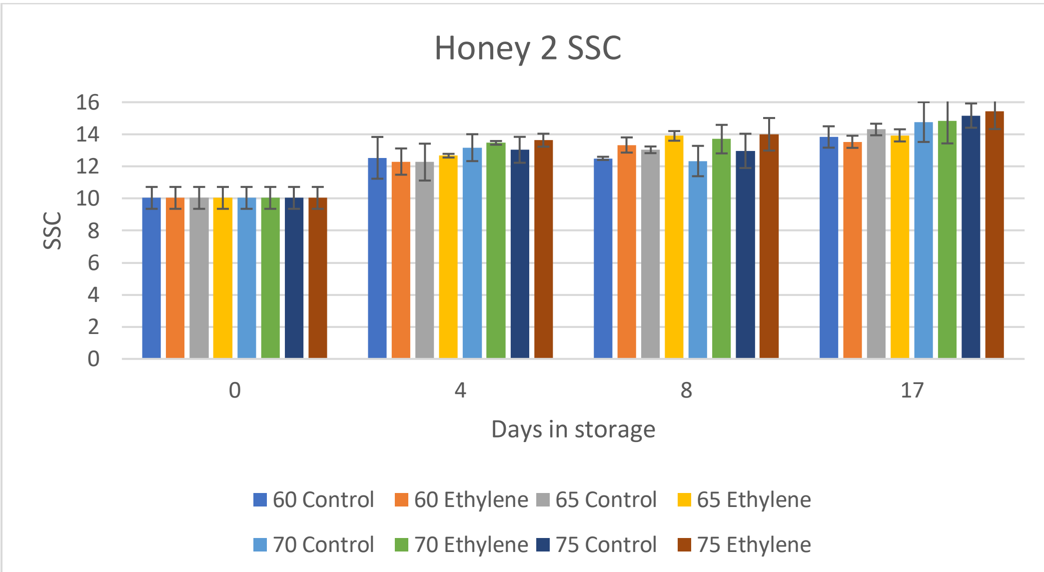
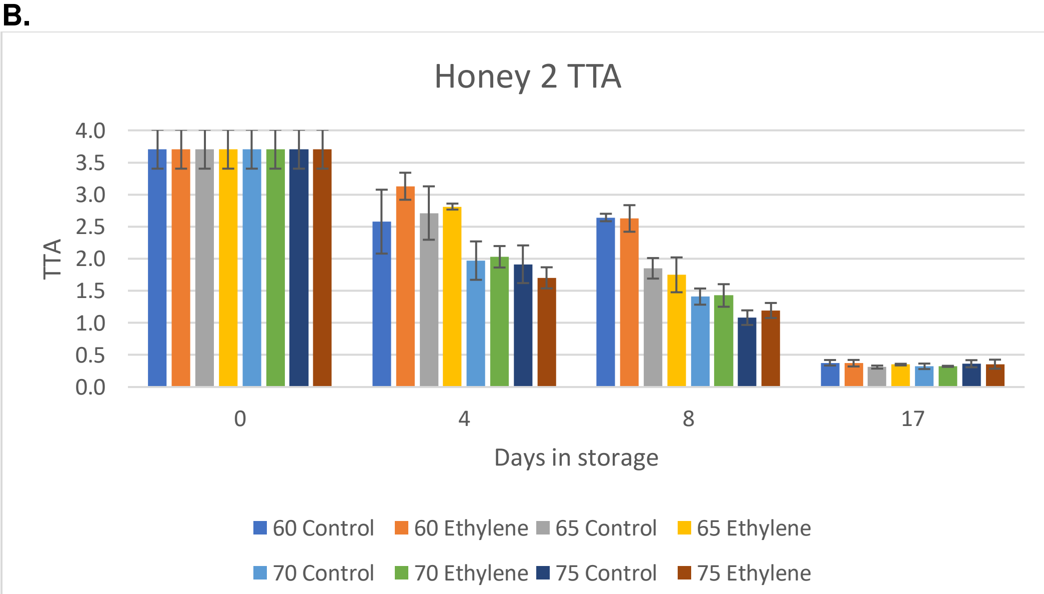

Honey 1 SSC/TTA Ratio
60
50
40
30
20
10
0
SSC/TTA Ratio
Time 0
Day 4
Day 8
Day 12
Days in storage
60 Control
60 Ethylene
65 Control
65 Ethylene
70 Control
70 Ethylene
75 Control
75 Ethylene

Figure 30. Composition (**A.** SSC, **B.** TTA, and **C.** SSC/TTA) of the second sample of Honey fruit on Days 0, 4 and 8, and on Day 17 when the sensory evaluations were performed.

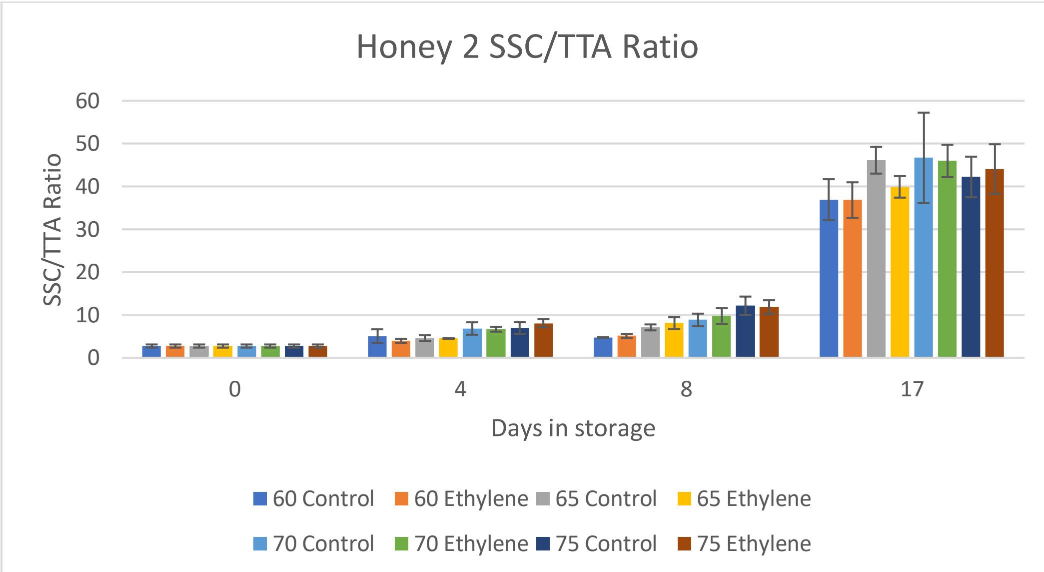
A.



B.



C.



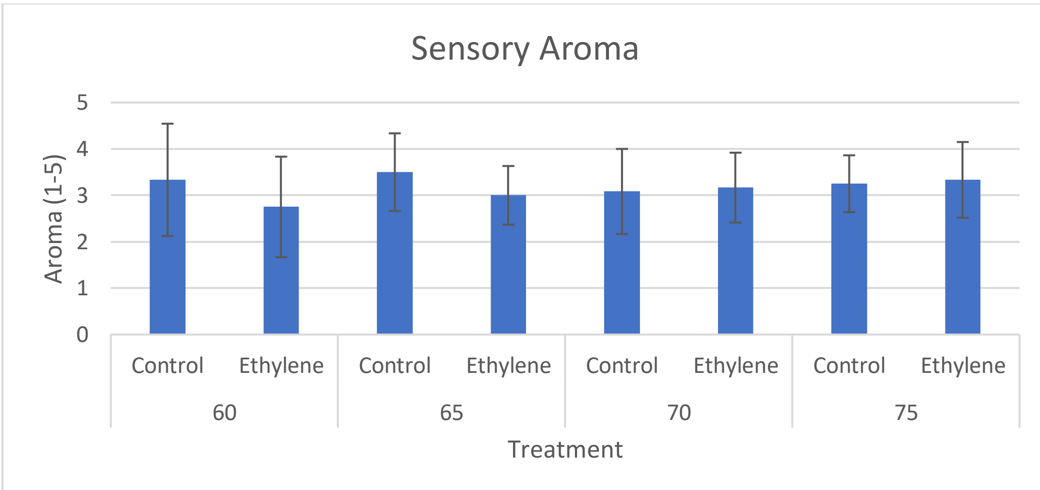
5. Sensory Quality.

- There were no clear-cut effects of the ripening temperature or ethylene on mango sensory quality. However, lower acid taste was recorded for the highest temperature (75°F), and highest acidity was recorded for the lowest temperature (60°F).

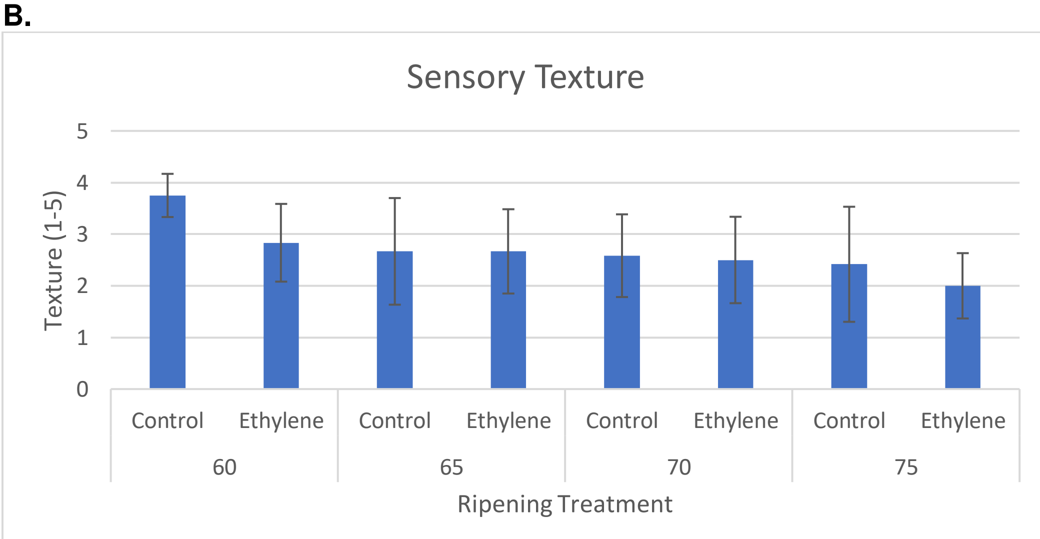
The final eight figures (**Fig. 31 to 38 A, B, C, D, E, F, G**) show the sensory scores for aroma, texture, juiciness, sweetness, acidity, appearance, and overall quality on on the final day when the sensory evaluations were performed.

Figure 31. Sensory quality (**A.** Aroma, **B.** Texture, **C.** Juiciness, **D.** Sweetness, **E.** Acidity, **F.** Appearance, and **G.** Overall Quality) of the first sample of Tommy Atkins fruit on Day 14 when the sensory evaluations were performed.

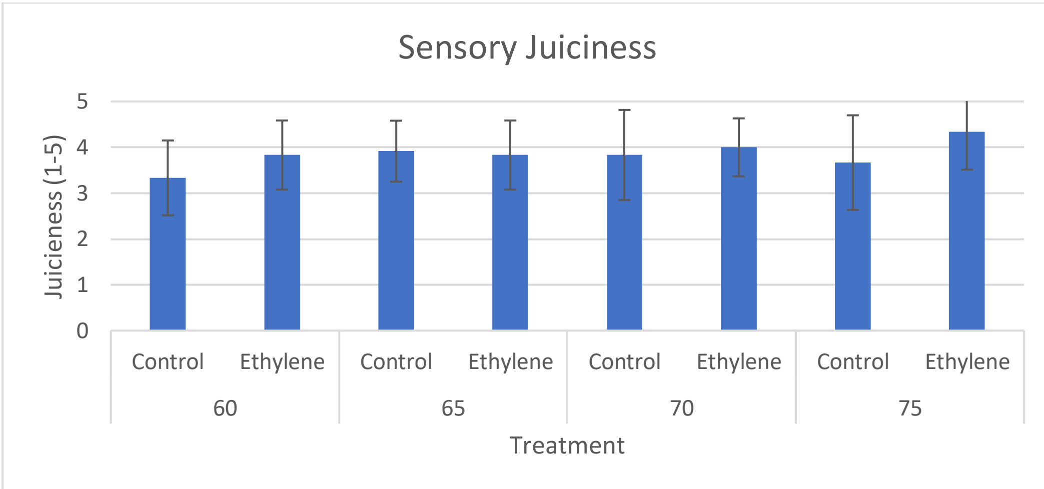
A.



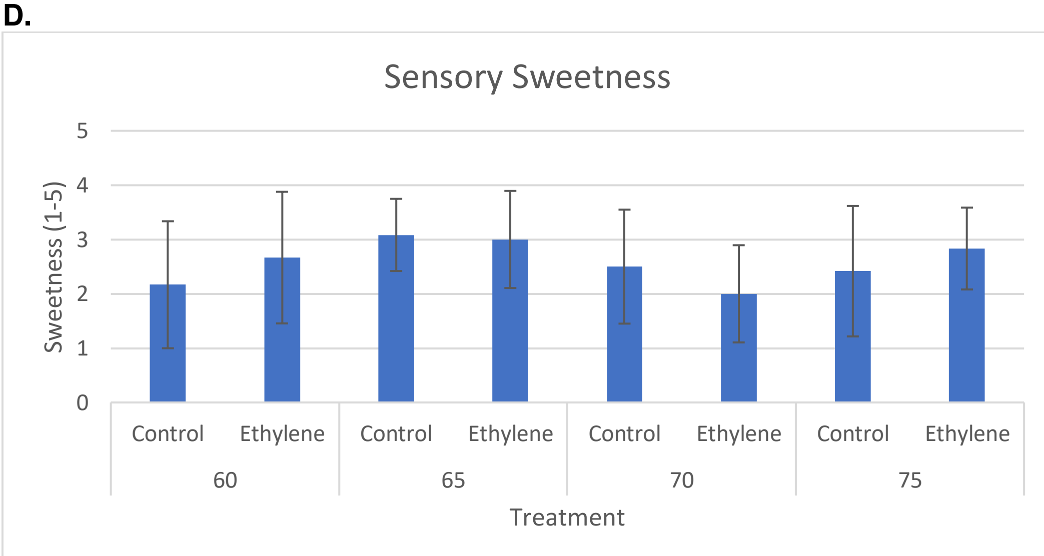
B.



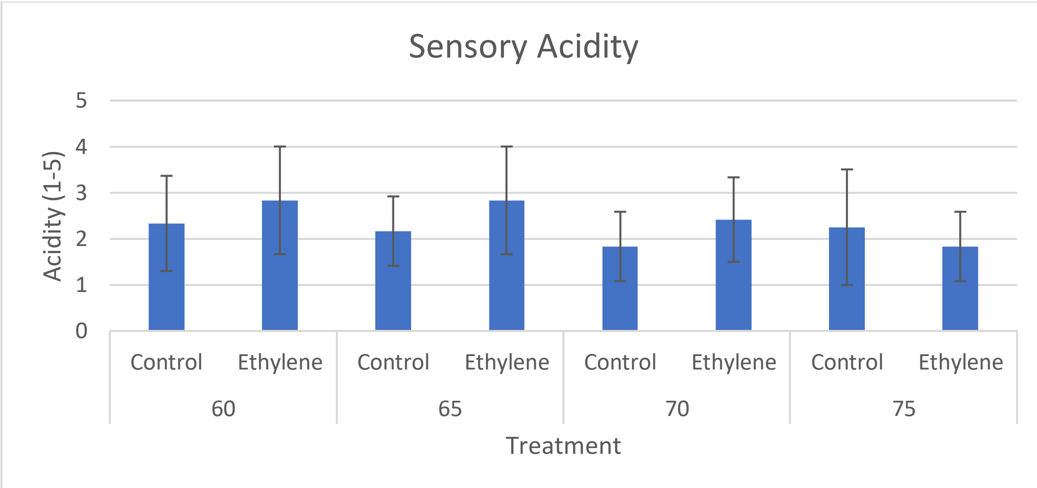
C.


Sensory Juiciness
Juicieness (1-5)
0
1
2
3
4
5
Control
Ethylene
Control
Ethylene
Control
Ethylene
Control
Ethylene
60
65
70
75
Treatment

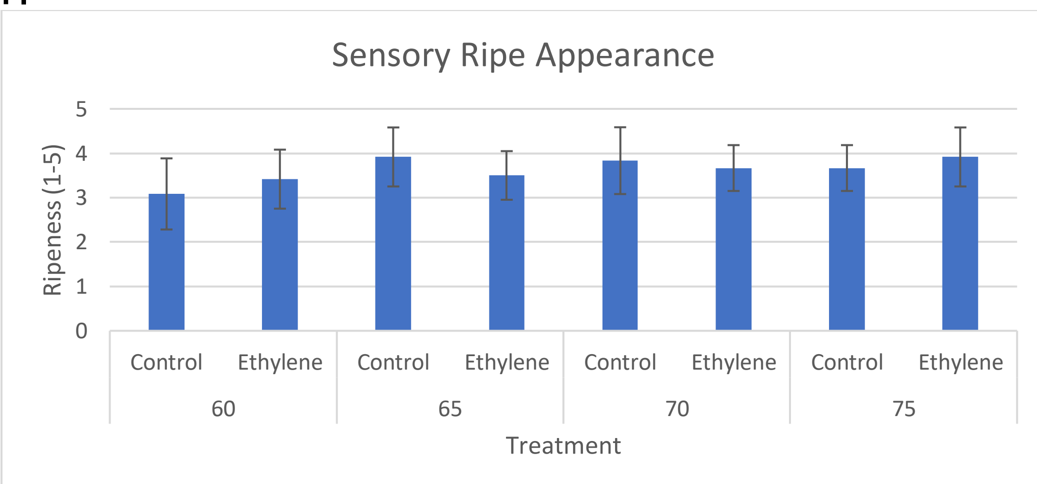
D.


Sensory Sweetness
Sweetness (1-5)
0
1
2
3
4
5
Control
Ethylene
Control
Ethylene
Control
Ethylene
Control
Ethylene
60
65
70
75
Treatment

E.


Sensory Acidity
Acidity (1-5)
0
1
2
3
4
5
Control
Ethylene
Control
Ethylene
Control
Ethylene
Control
Ethylene
60
65
70
75
Treatment

F.


Sensory Ripe Appearance
Ripeness (1-5)
0
1
2
3
4
5
Control
Ethylene
Control
Ethylene
Control
Ethylene
Control
Ethylene
60
65
70
75
Treatment

G.

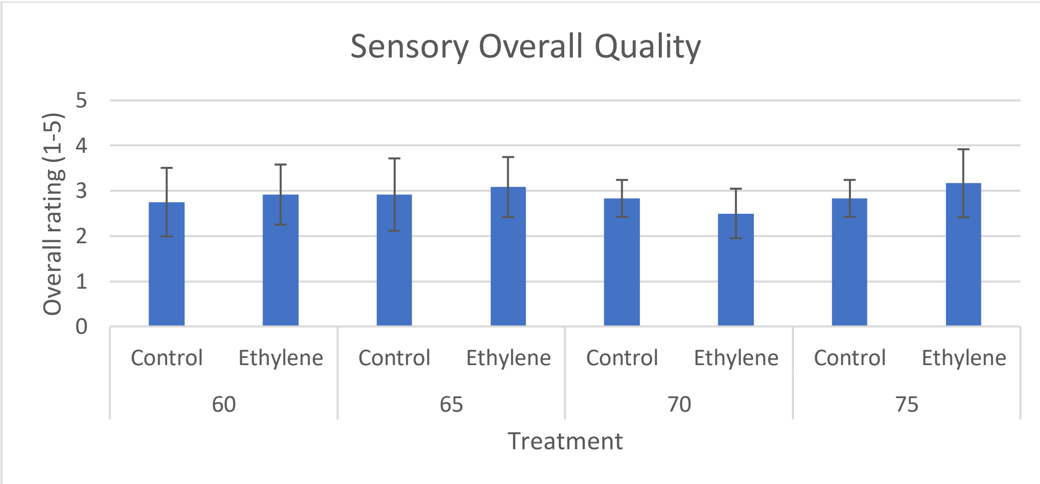
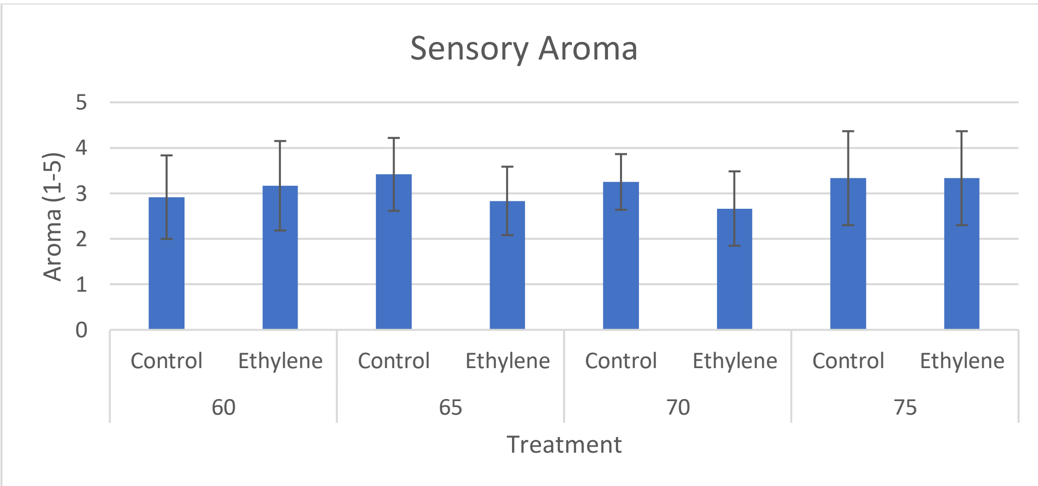
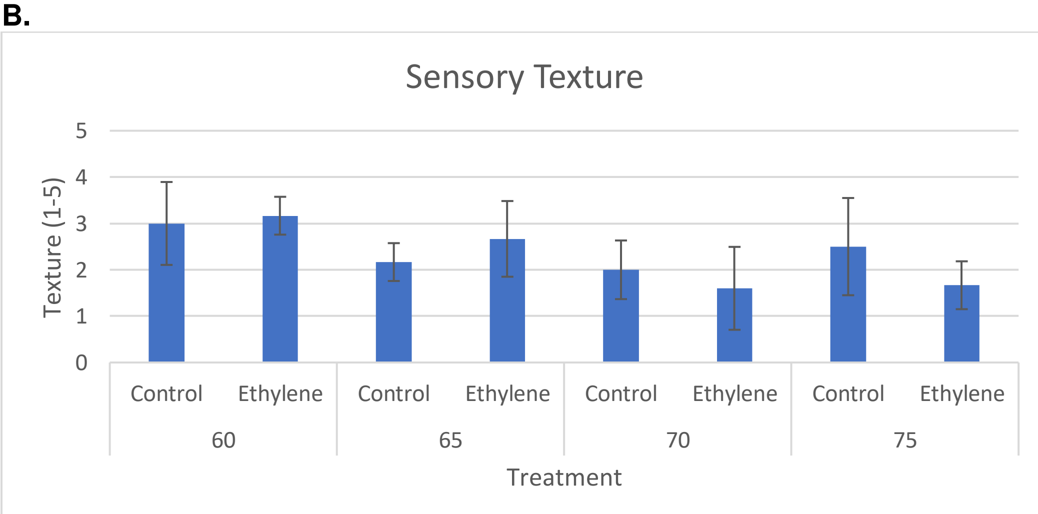

Sensory Overall Quality
Overall rating (1-5)
5
4
3
2
1
0
Control
Ethylene
Control
Ethylene
Control
Ethylene
Control
Ethylene
60
65
70
75
Treatment

Figure 32. Sensory quality (**A.** Aroma, **B.** Texture, **C.** Juiciness, **D.** Sweetness, **E.** Acidity, **F.** Appearance, and **G.** Overall Quality) of the second sample of Tommy Atkins fruit on Day 15 when the sensory evaluations were performed.

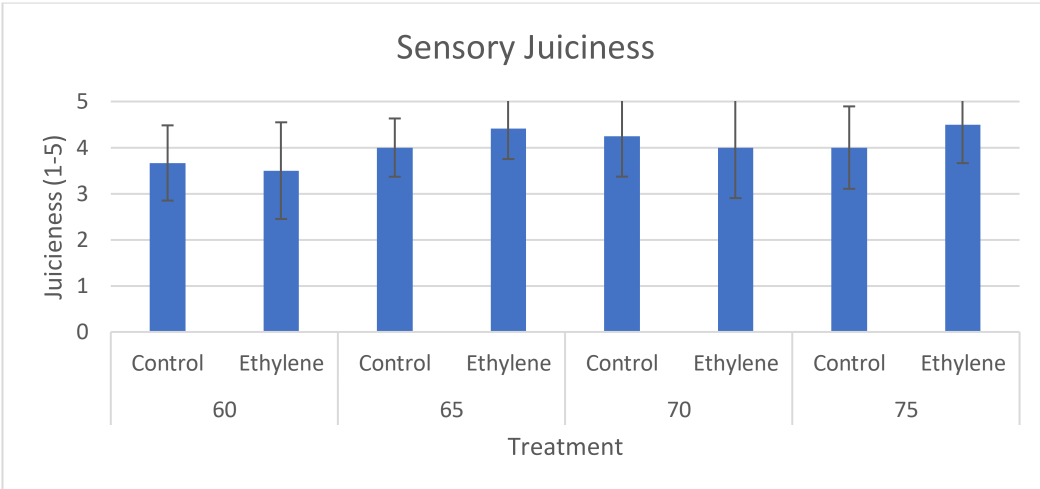
A.



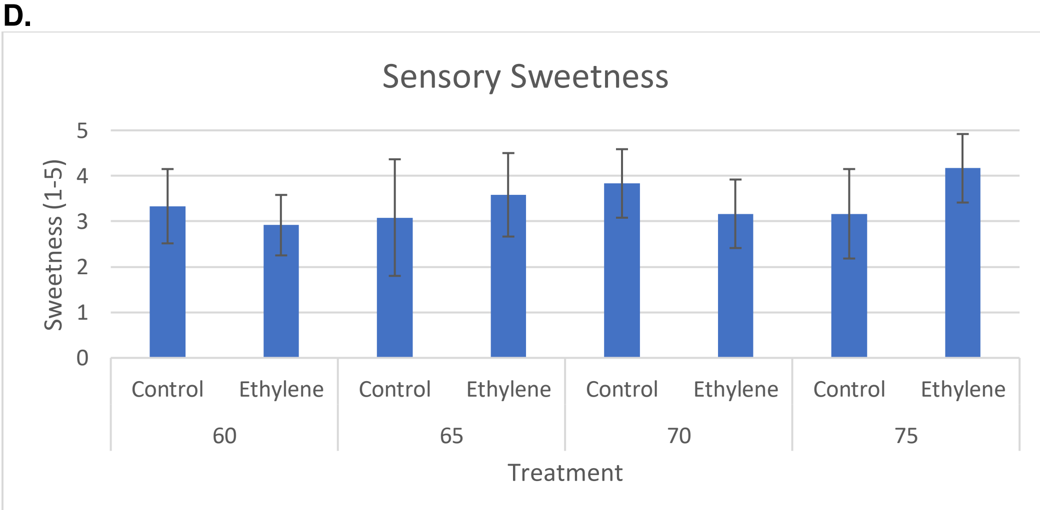
B.



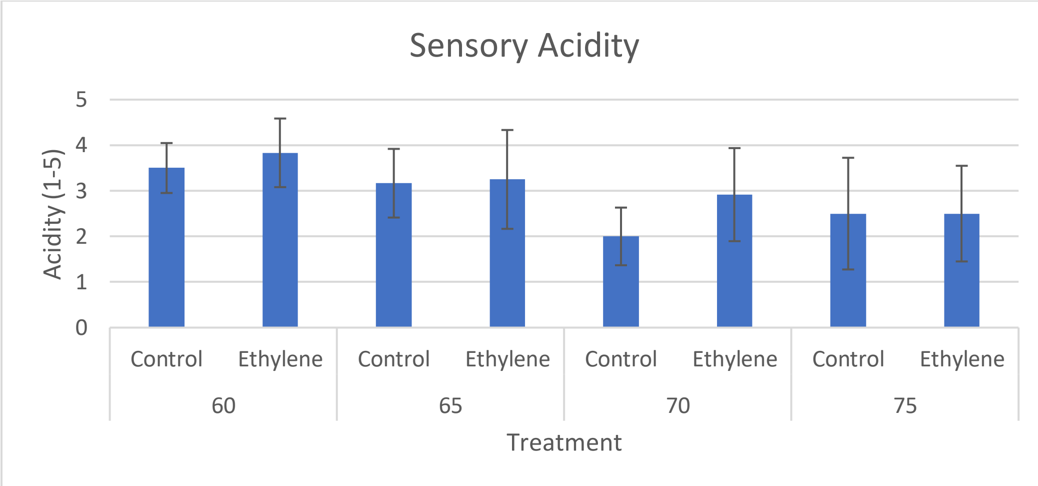
C.


Sensory Juiciness
Juicieness (1-5)
0
1
2
3
4
5
Control
Ethylene
Control
Ethylene
Control
Ethylene
Control
Ethylene
60
65
70
75
Treatment

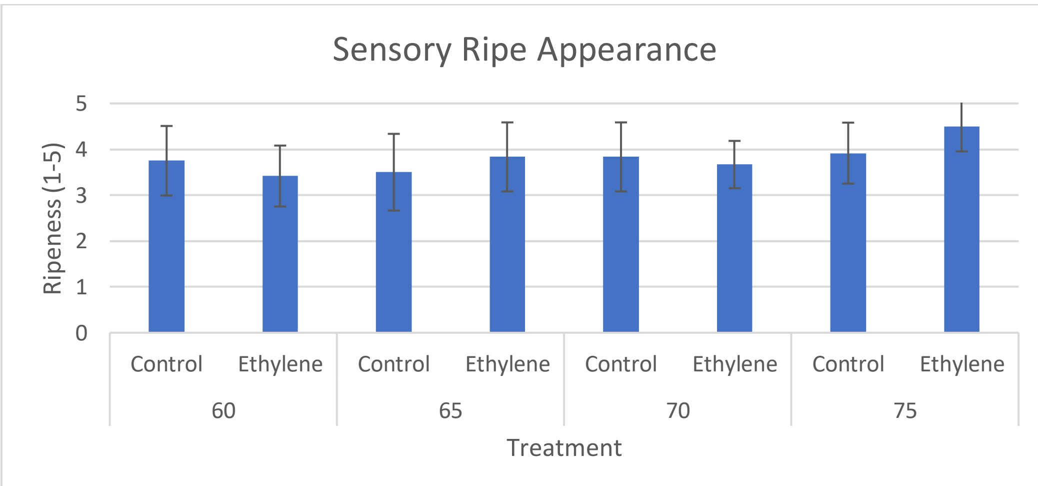
D.


Sensory Sweetness
Sweetness (1-5)
0
1
2
3
4
5
Control
Ethylene
Control
Ethylene
Control
Ethylene
Control
Ethylene
60
65
70
75
Treatment

E.


Sensory Acidity
Acidity (1-5)
5
4
3
2
1
0
Control
Ethylene
Control
Ethylene
Control
Ethylene
Control
Ethylene
60
65
70
75
Treatment

F.


Sensory Ripe Appearance
Ripeness (1-5)
5
4
3
2
1
0
Control
Ethylene
Control
Ethylene
Control
Ethylene
Control
Ethylene
60
65
70
75
Treatment

G.

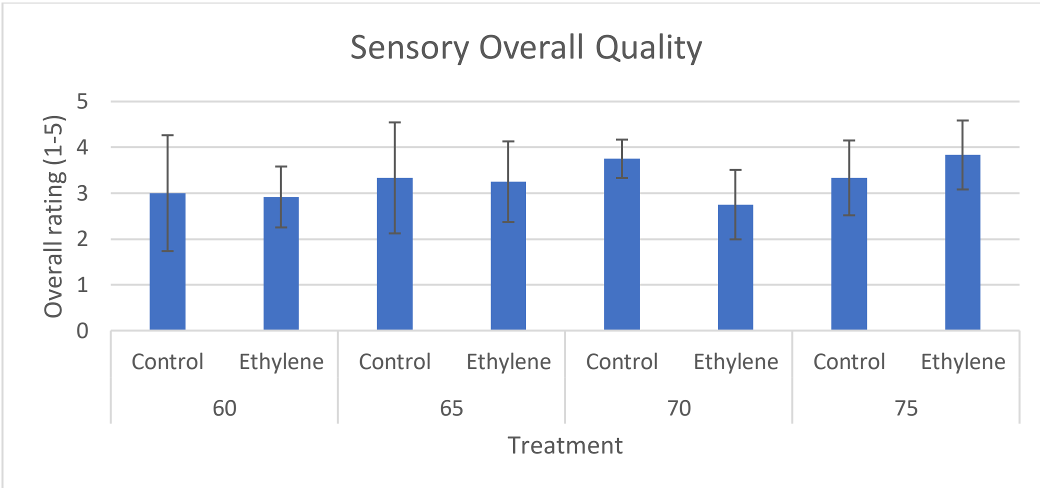
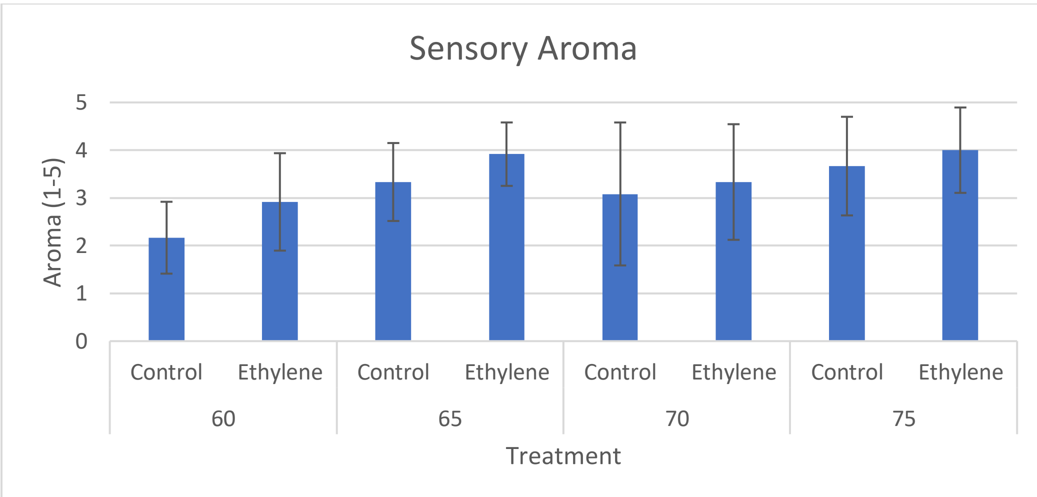
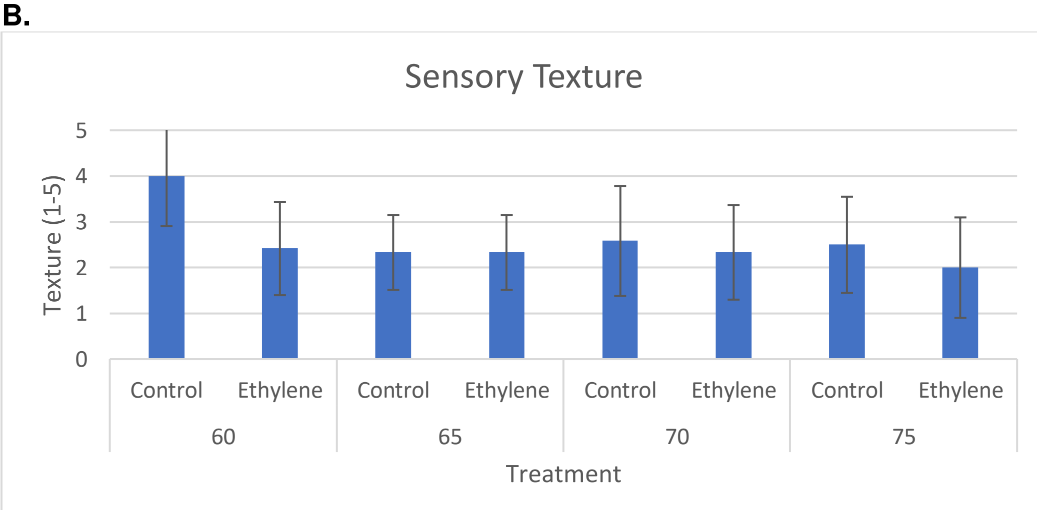

Sensory Overall Quality
Overall rating (1-5)
0
1
2
3
4
5
Control
Ethylene
Control
Ethylene
Control
Ethylene
Control
Ethylene
60
65
70
75
Treatment

Figure 33. Sensory quality (**A.** Aroma, **B.** Texture, **C.** Juiciness, **D.** Sweetness, **E.** Acidity, **F.** Appearance, and **G.** Overall Quality) of the first sample of Kent fruit on Day 12 when the sensory evaluations were performed.

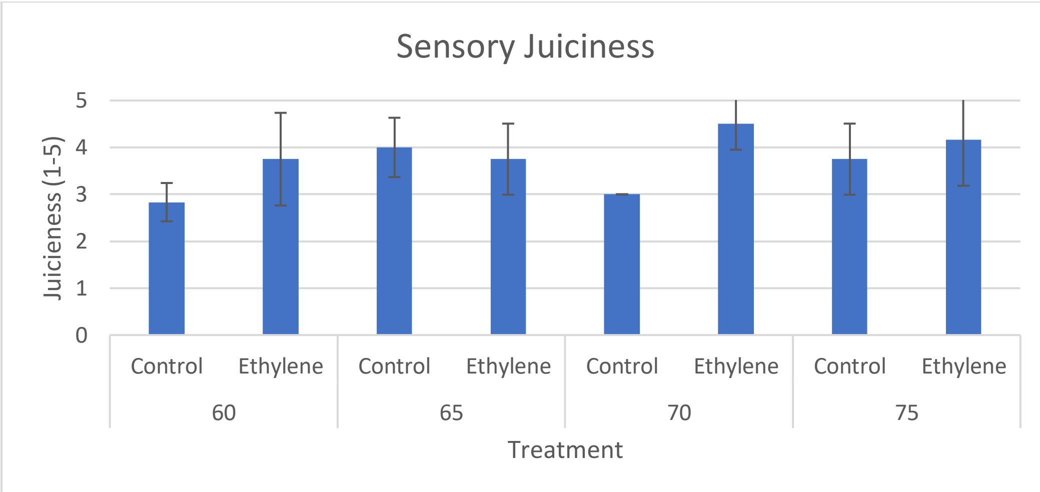
A.



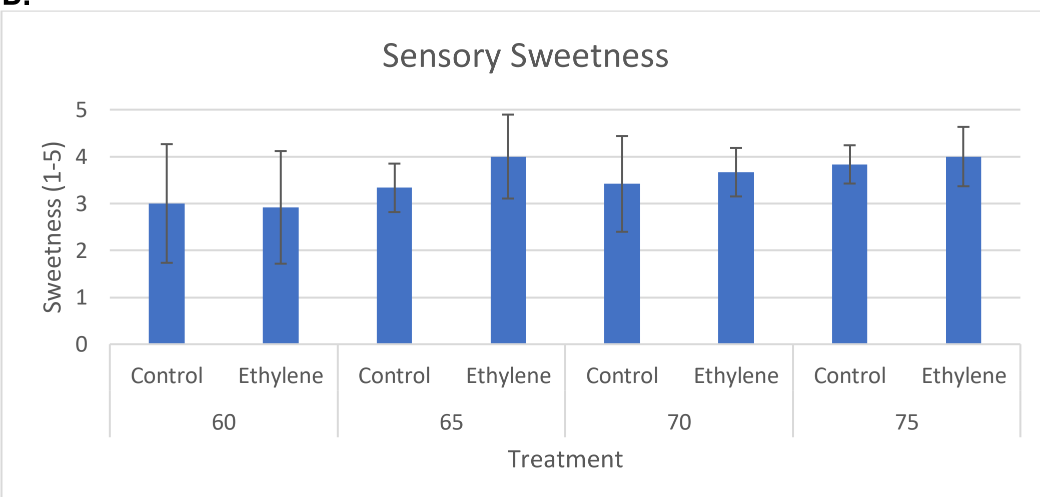
B.



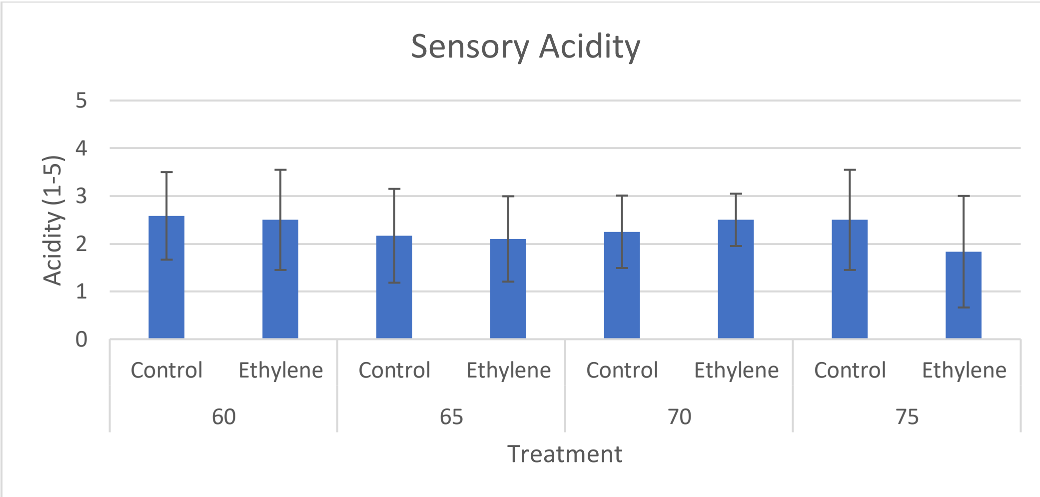
C.


Sensory Juiciness
Juicieness (1-5)
5
4
3
2
1
0
Control
Ethylene
Control
Ethylene
Control
Ethylene
Control
Ethylene
60
65
70
75
Treatment

D.


Sensory Sweetness
Sweetness (1-5)
5
4
3
2
1
0
Control
Ethylene
Control
Ethylene
Control
Ethylene
Control
Ethylene
60
65
70
75
Treatment

E.



F. Ripe Appearance Data Missing

G.

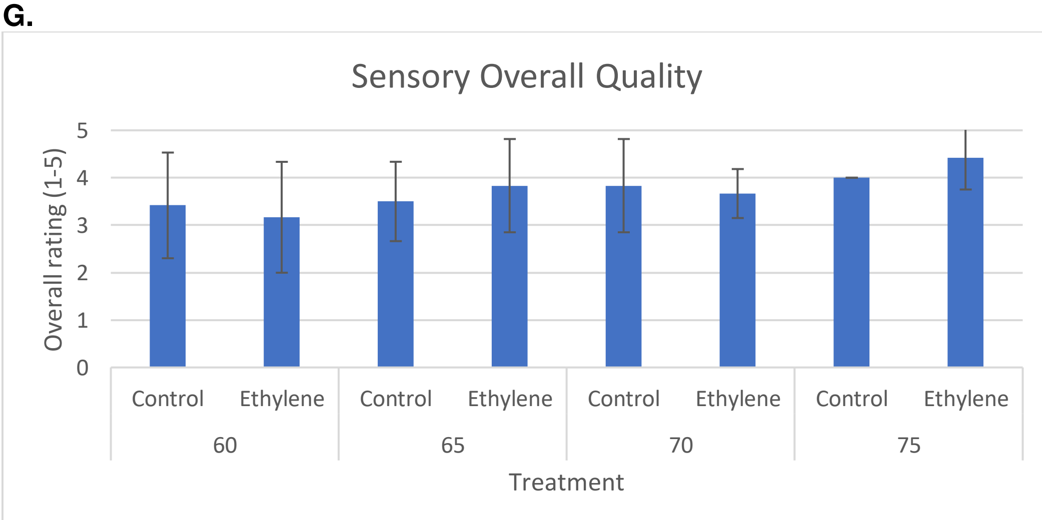
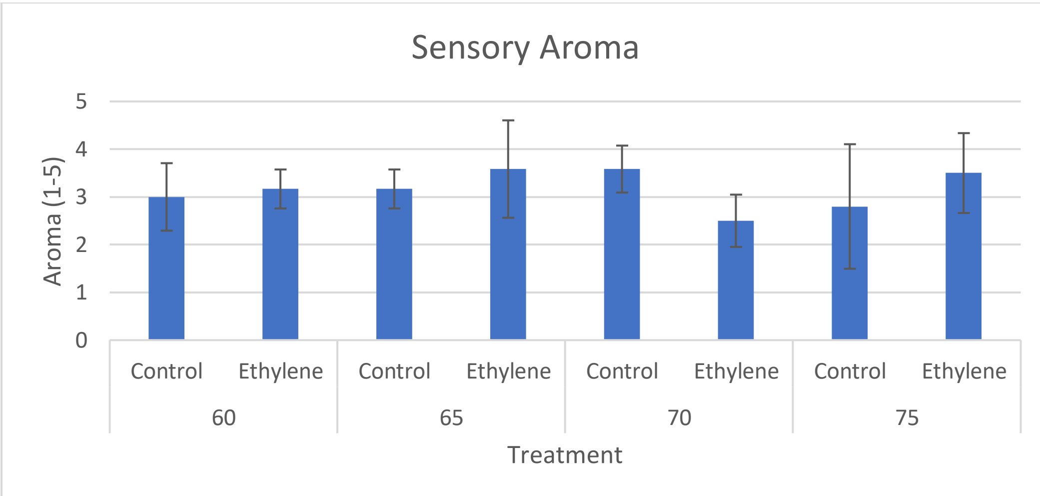
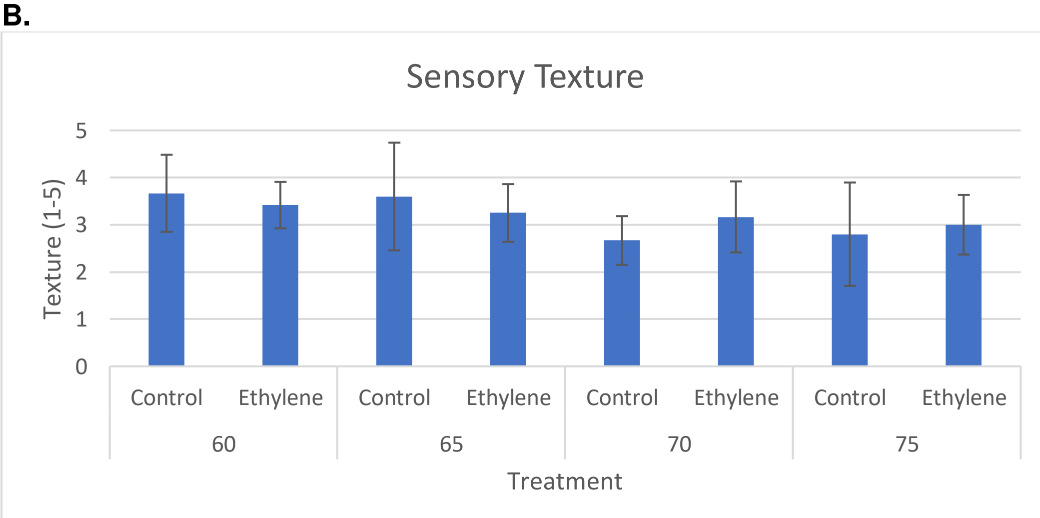


Figure 34. Sensory quality (**A.** Aroma, **B.** Texture, **C.** Juiciness, **D.** Sweetness, **E.** Acidity, **F.** Appearance, and **G.** Overall Quality) of the second sample of Kent fruit on Day 14 when the sensory evaluations were performed.

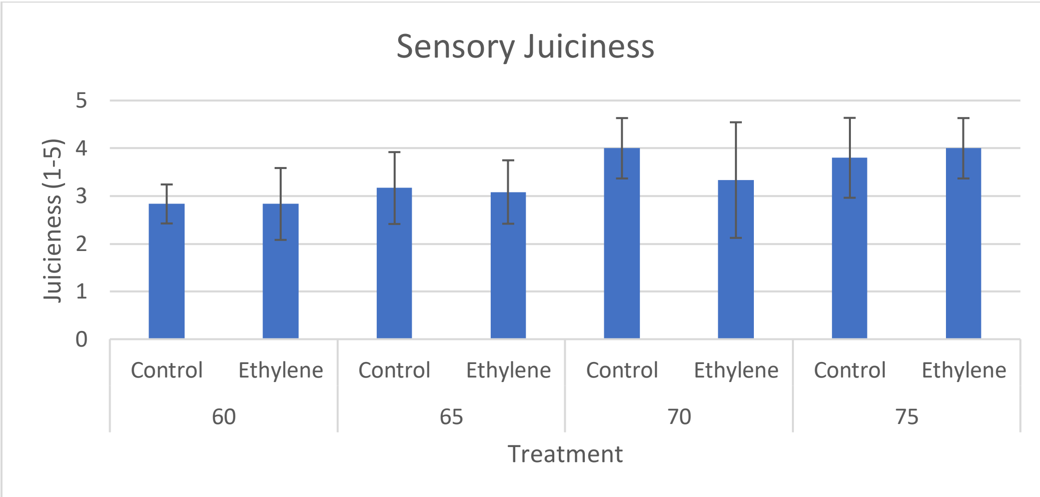
A.



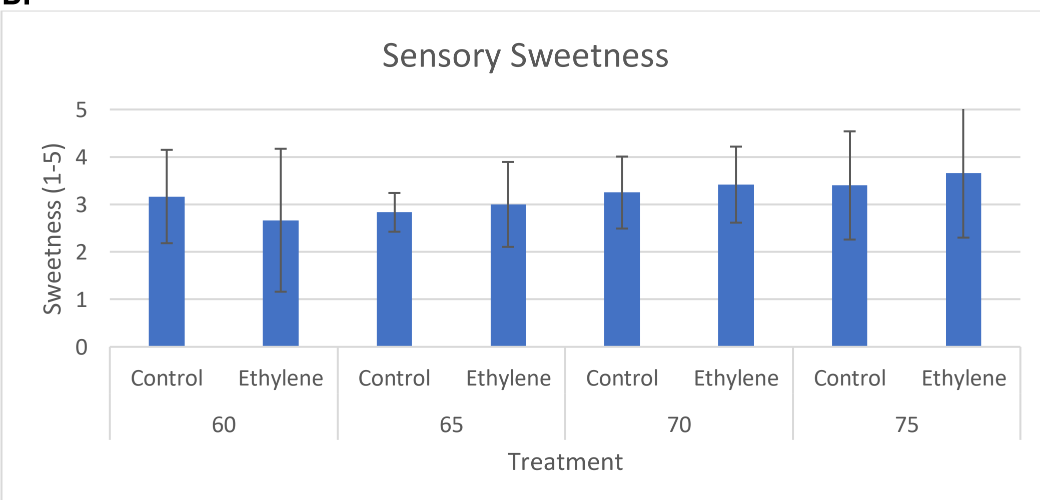
B.



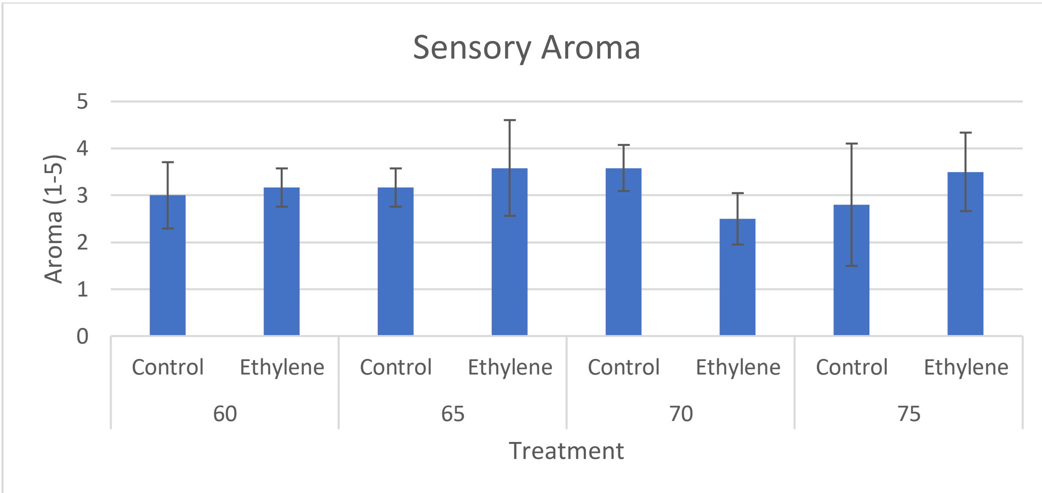
C.


Sensory Juiciness
Juicieness (1-5)
0
1
2
3
4
5
Control
Ethylene
Control
Ethylene
Control
Ethylene
Control
Ethylene
60
65
70
75
Treatment

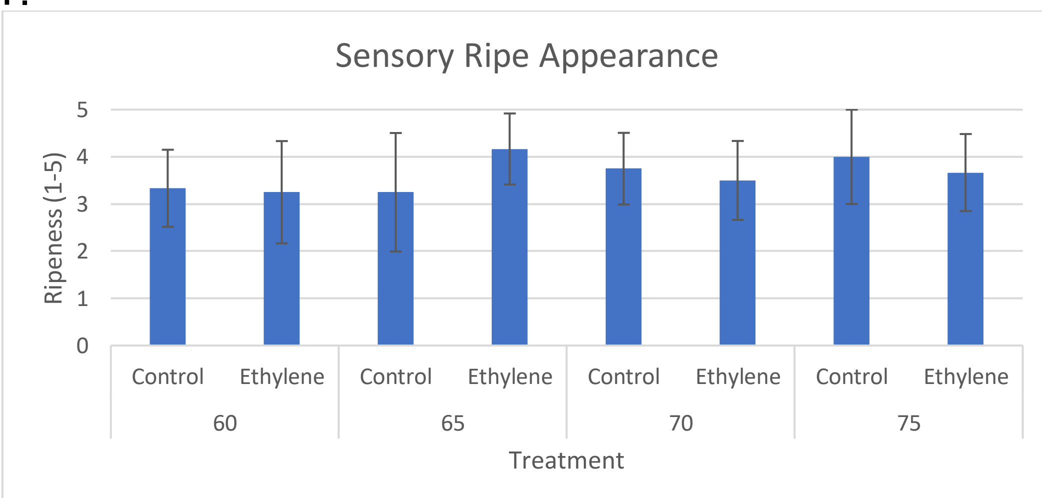
D.


Sensory Sweetness
Sweetness (1-5)
0
1
2
3
4
5
Control
Ethylene
Control
Ethylene
Control
Ethylene
Control
Ethylene
60
65
70
75
Treatment

E.


Sensory Aroma
Aroma (1-5)
0
1
2
3
4
5
Control
Ethylene
60
65
70
75
Treatment

F.


Sensory Ripe Appearance
Ripeness (1-5)
0
1
2
3
4
5
Control
Ethylene
60
65
70
75
Treatment

G.

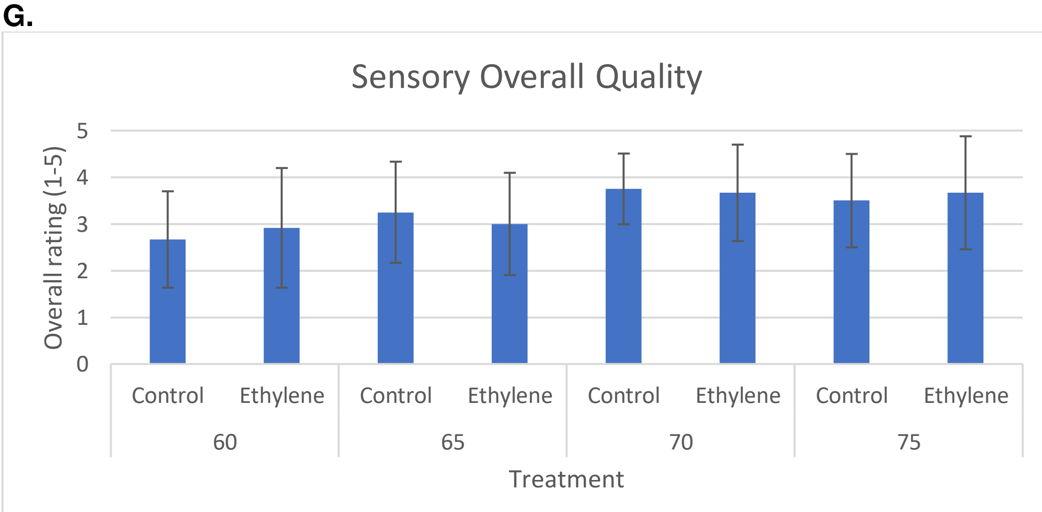
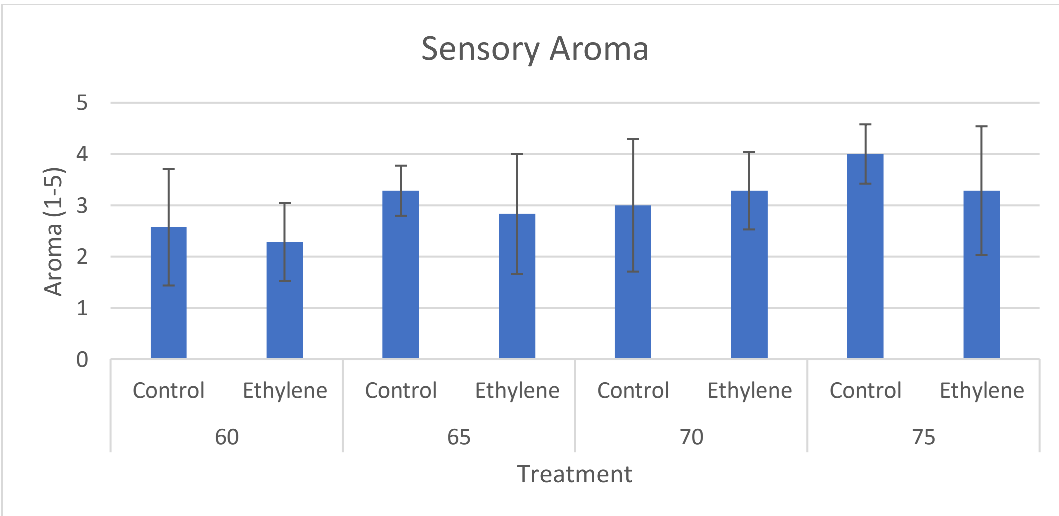
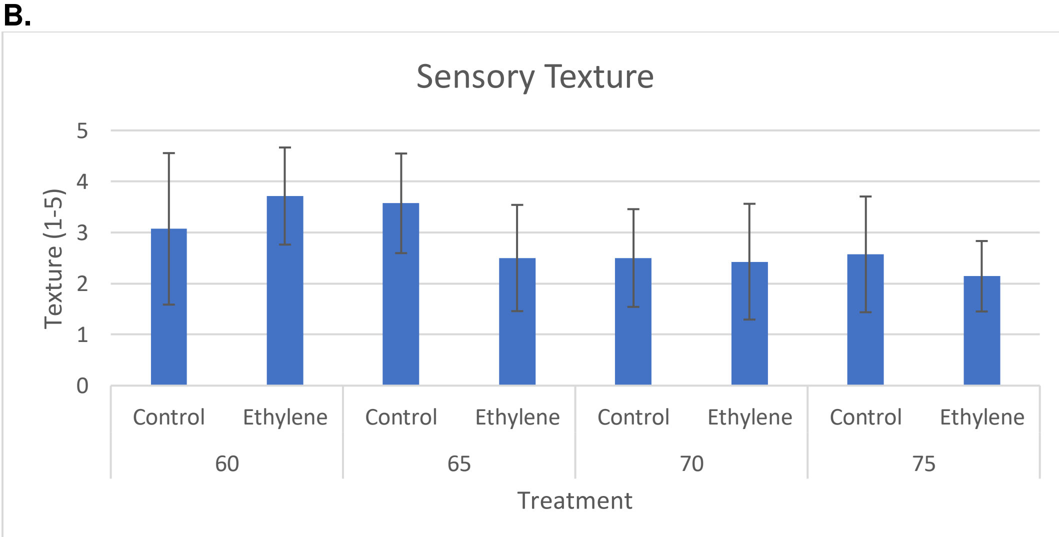

Sensory Overall Quality
Overall rating (1-5)
0
1
2
3
4
5
Control
Ethylene
60
65
70
75
Treatment

Figure 35. Sensory quality (**A.** Aroma, **B.** Texture, **C.** Juiciness, **D.** Sweetness, **E.** Acidity, **F.** Appearance, and **G.** Overall Quality) of the first sample of Keitt fruit on Day 11 when the sensory evaluations were performed.

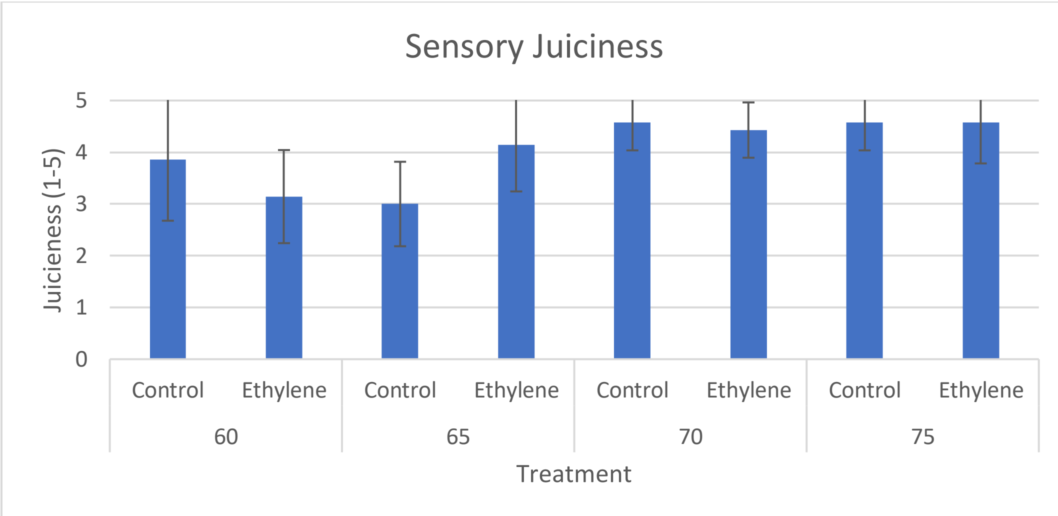
A.



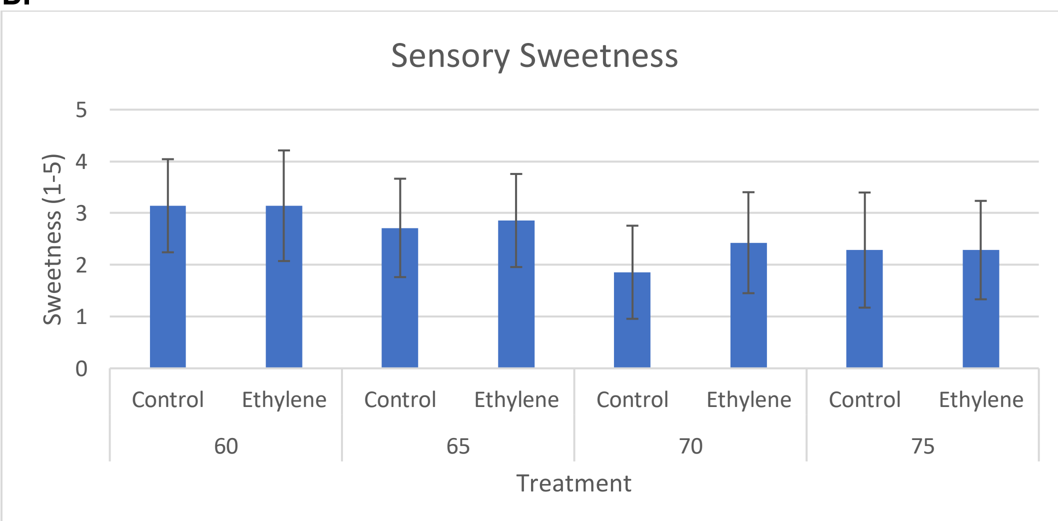
B.



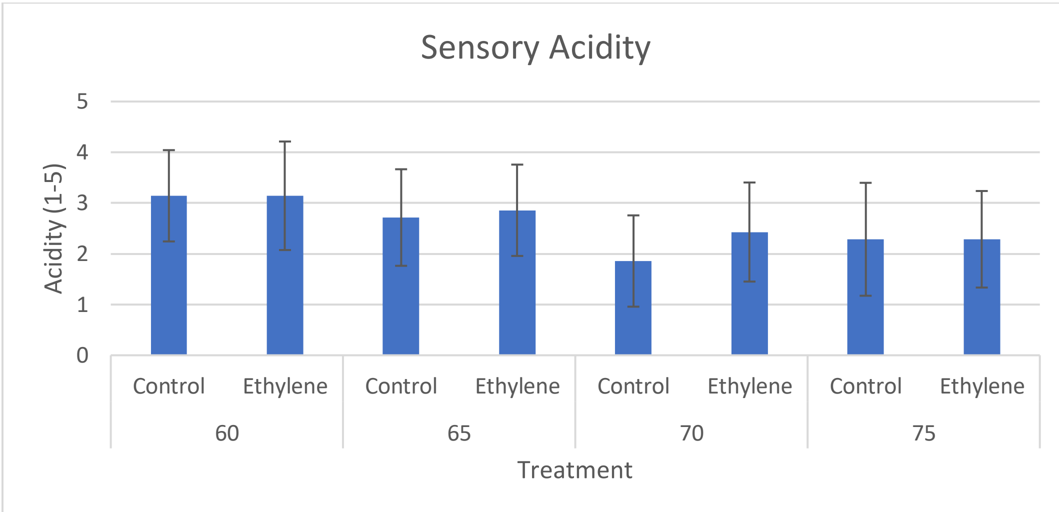
C.


Sensory Juiciness
Juicieness (1-5)
0
1
2
3
4
5
Control
Ethylene
Control
Ethylene
Control
Ethylene
Control
Ethylene
60
65
70
75
Treatment

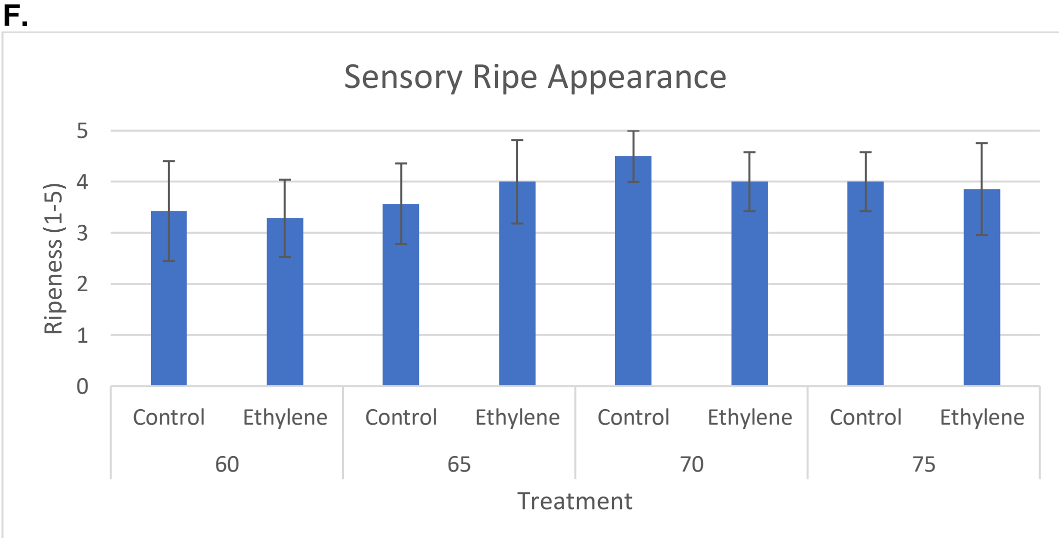
D.


Sensory Sweetness
Sweetness (1-5)
0
1
2
3
4
5
Control
Ethylene
Control
Ethylene
Control
Ethylene
Control
Ethylene
60
65
70
75
Treatment

E.


Sensory Acidity
Acidity (1-5)
5
4
3
2
1
0
Control
Ethylene
Control
Ethylene
Control
Ethylene
Control
Ethylene
60
65
70
75
Treatment

F.


Sensory Ripe Appearance
Ripeness (1-5)
5
4
3
2
1
0
Control
Ethylene
Control
Ethylene
Control
Ethylene
Control
Ethylene
60
65
70
75
Treatment

G.

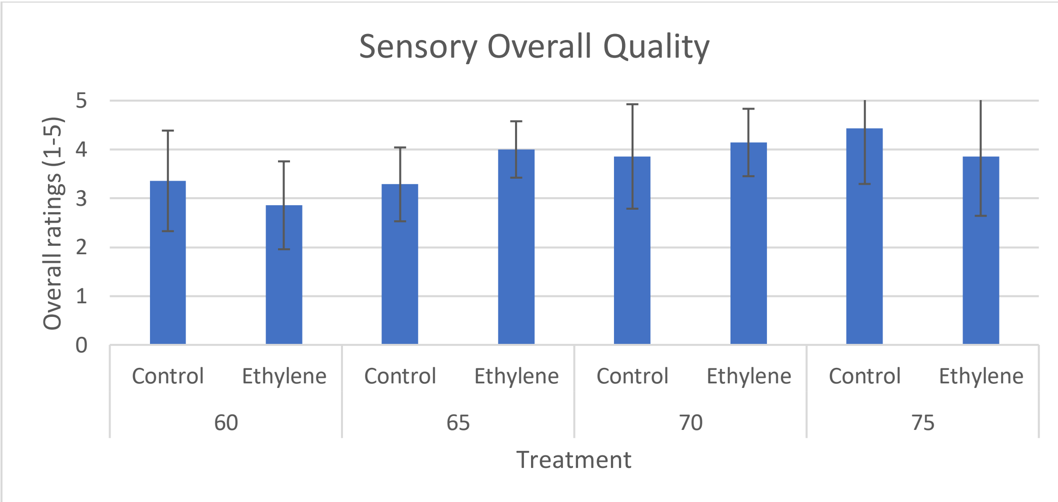
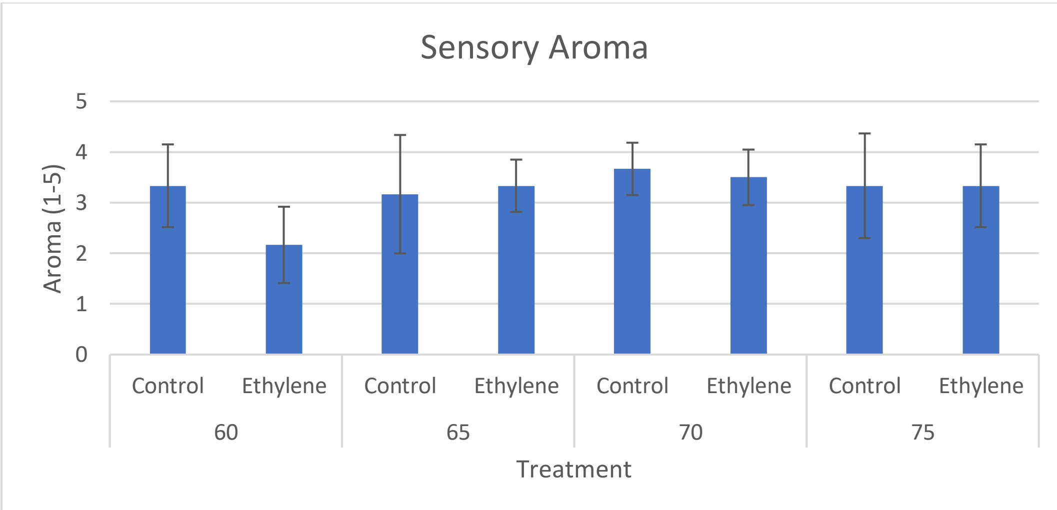
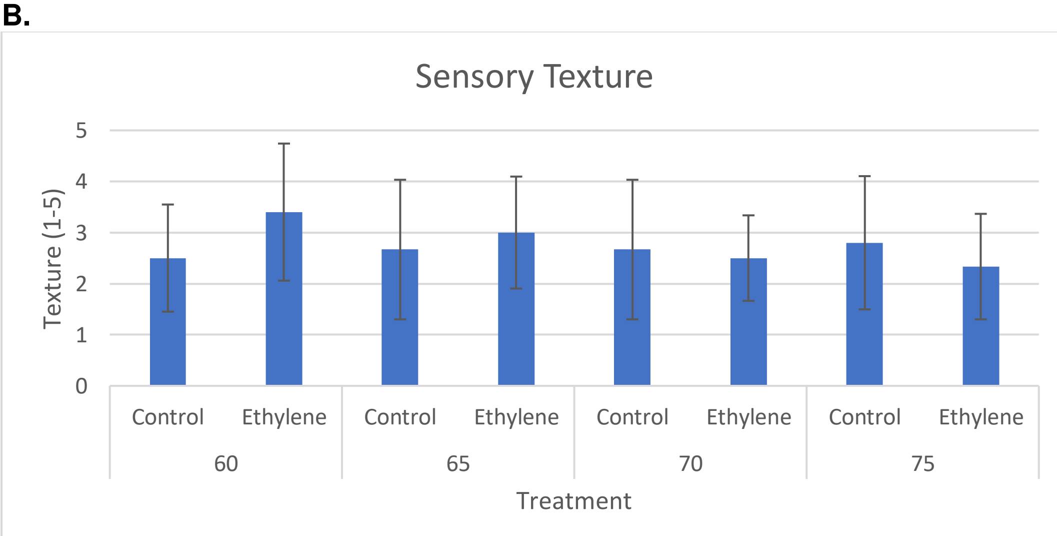

Sensory Overall Quality
Overall ratings (1-5)
5
4
3
2
1
0
Control
Ethylene
Control
Ethylene
Control
Ethylene
Control
Ethylene
60
65
70
75
Treatment

Figure 36. Sensory quality (**A.** Aroma, **B.** Texture, **C.** Juiciness, **D.** Sweetness, **E.** Acidity, **F.** Appearance, and **G.** Overall Quality) of the second sample of Keitt fruit on Day 9 when the sensory evaluations were performed.

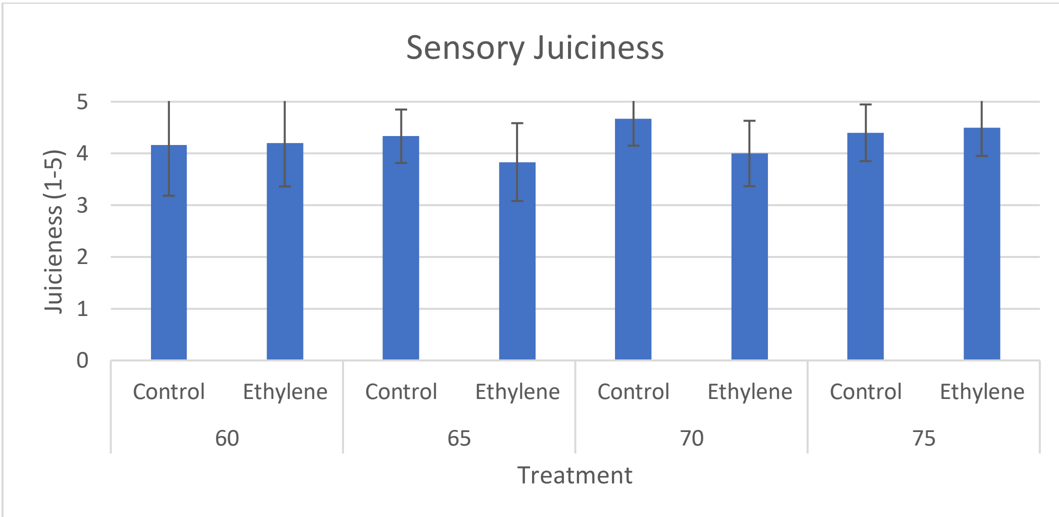
A.



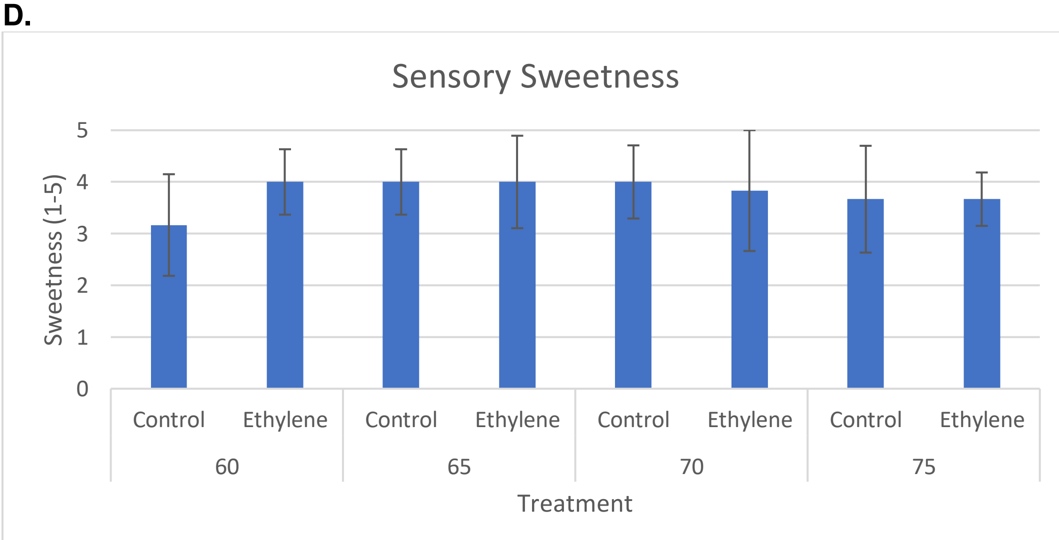
B.



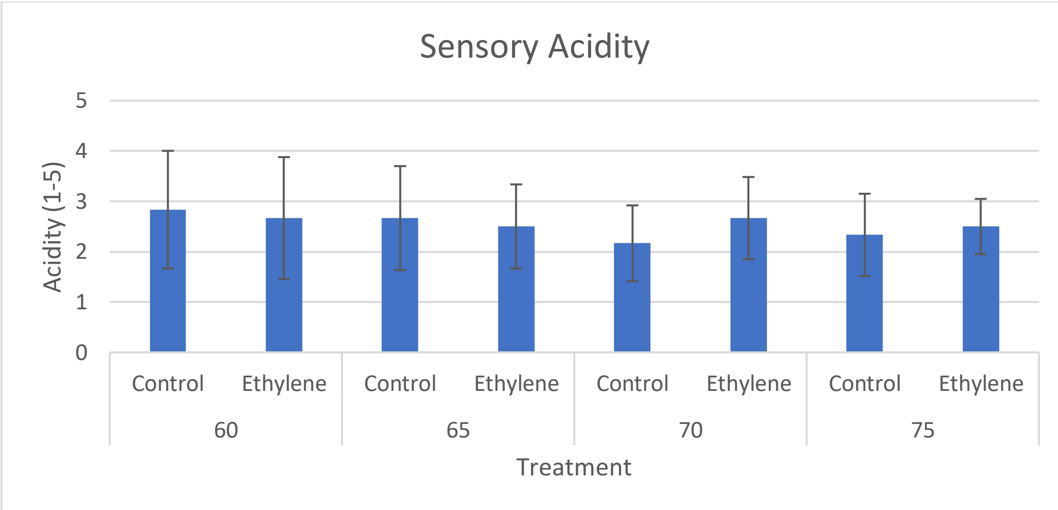
C.


Sensory Juiciness
Juicieness (1-5)
0
1
2
3
4
5
Control
Ethylene
Control
Ethylene
Control
Ethylene
Control
Ethylene
60
65
70
75
Treatment

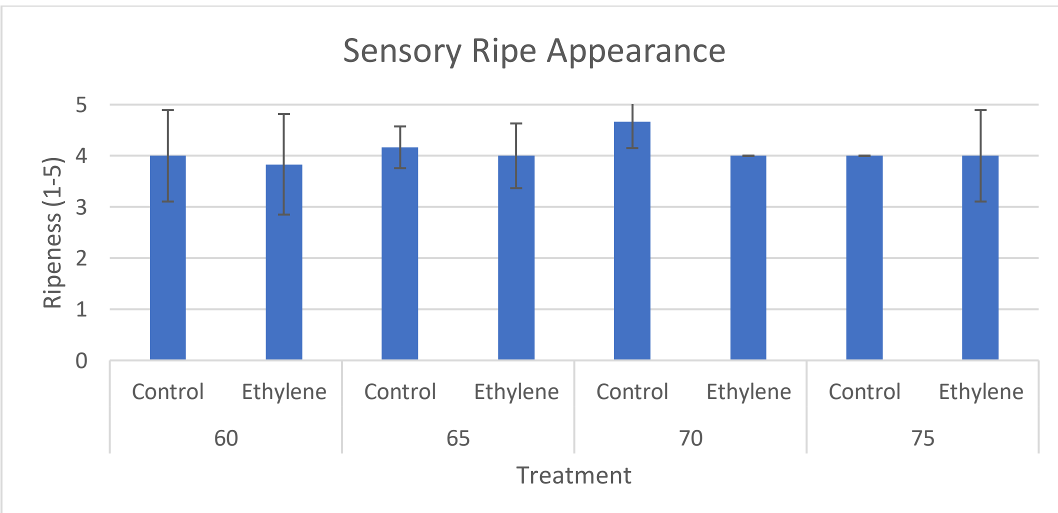
D.


Sensory Sweetness
Sweetness (1-5)
0
1
2
3
4
5
Control
Ethylene
Control
Ethylene
Control
Ethylene
Control
Ethylene
60
65
70
75
Treatment

E.


Sensory Acidity
Acidity (1-5)
0
1
2
3
4
5
Control
Ethylene
Control
Ethylene
Control
Ethylene
Control
Ethylene
60
65
70
75
Treatment

F.


Sensory Ripe Appearance
Ripeness (1-5)
0
1
2
3
4
5
Control
Ethylene
Control
Ethylene
Control
Ethylene
Control
Ethylene
60
65
70
75
Treatment

G.

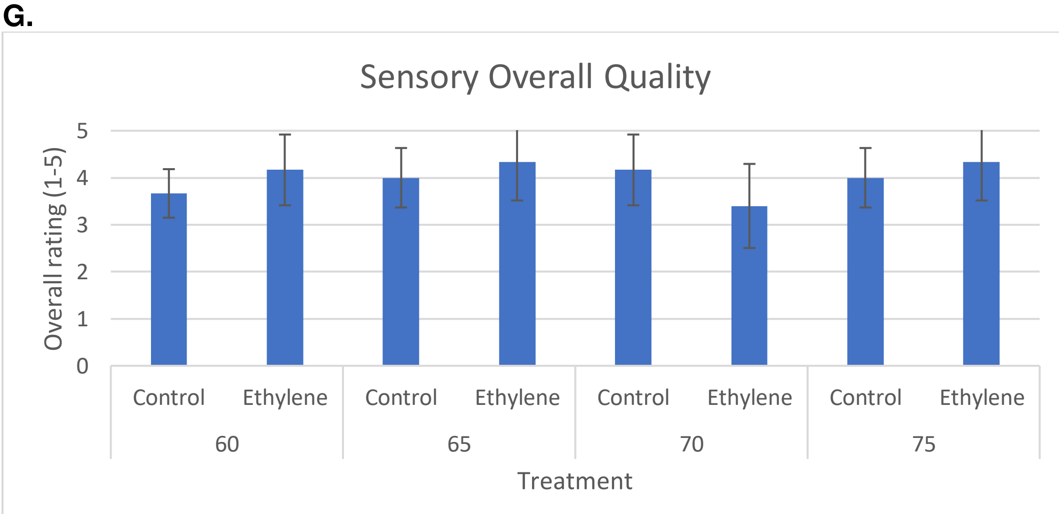
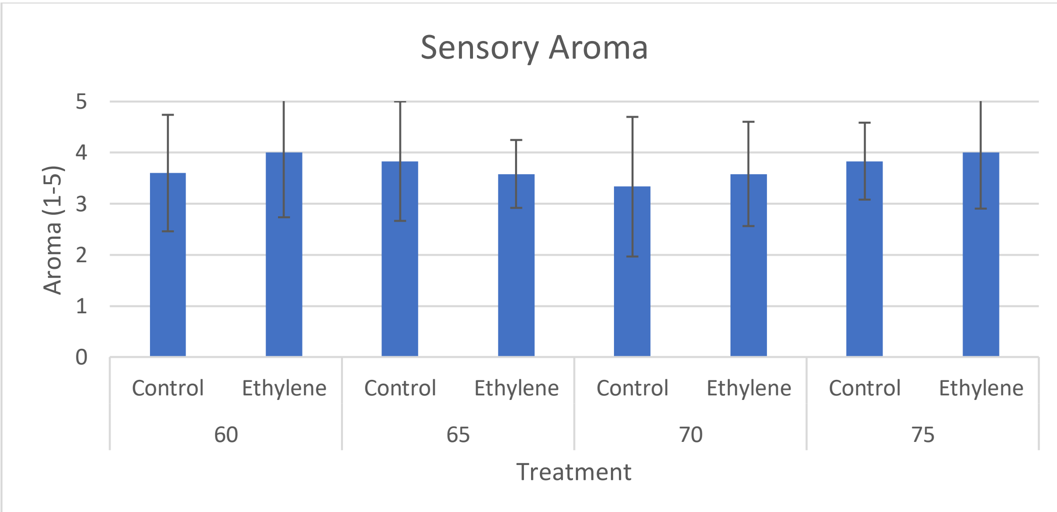
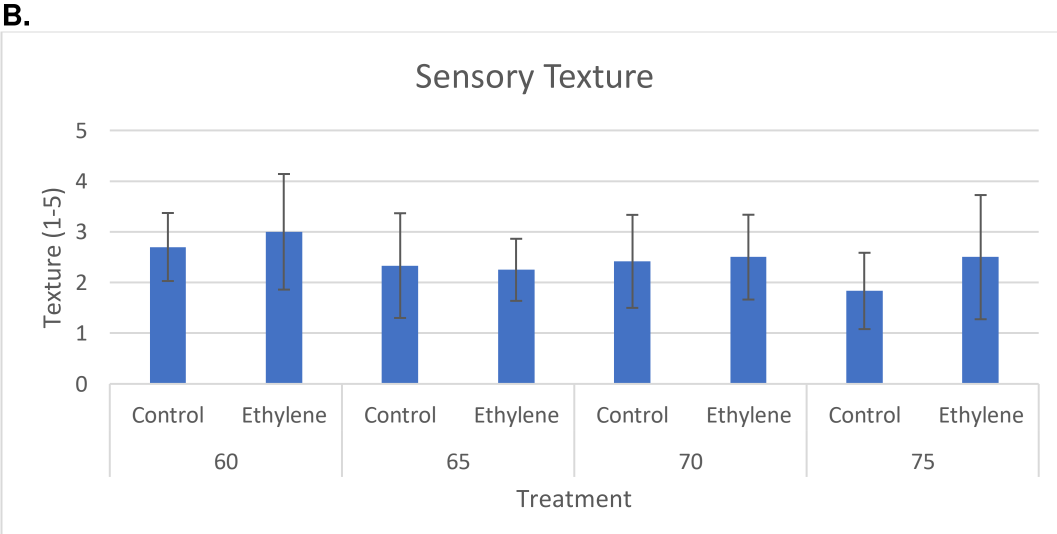

Sensory Overall Quality
Overall rating (1-5)
0
1
2
3
4
5
Control
Ethylene
Control
Ethylene
Control
Ethylene
Control
Ethylene
60
65
70
75
Treatment

Figure 37. Sensory quality (**A.** Aroma, **B.** Texture, **C.** Juiciness, **D.** Sweetness, **E.** Acidity, **F.** Appearance, and **G.** Overall Quality) of the first sample of Honey fruit on Day 12 when the sensory evaluations were performed.

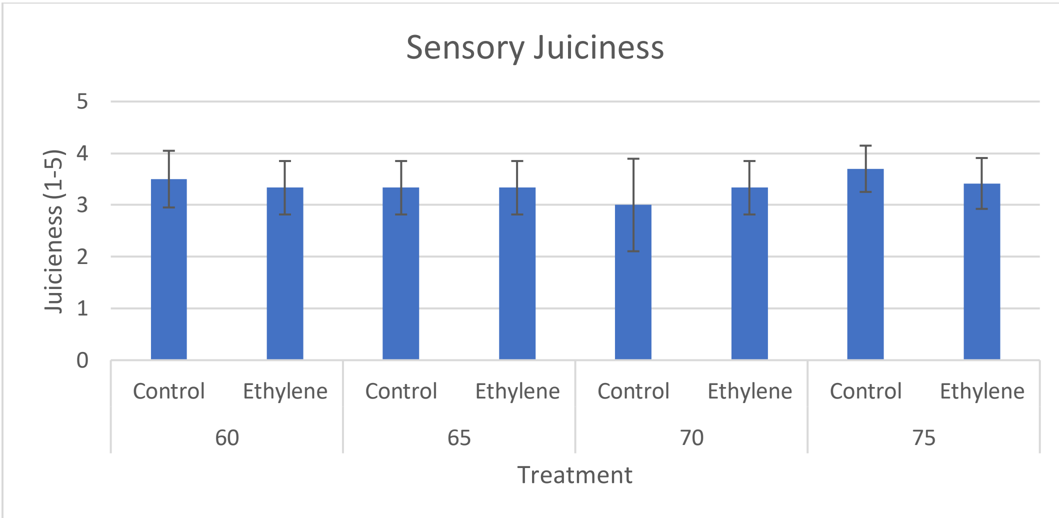
A.



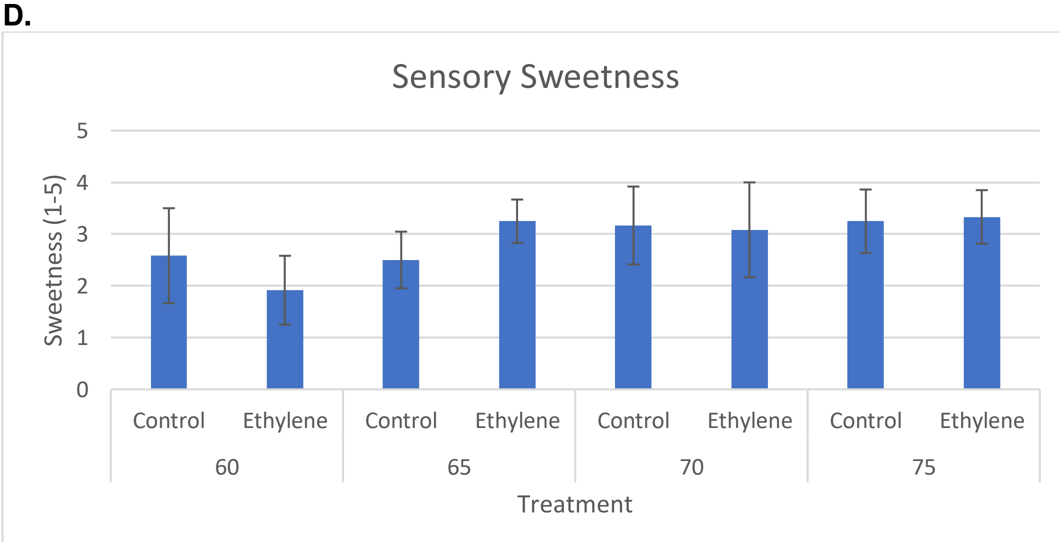
B.



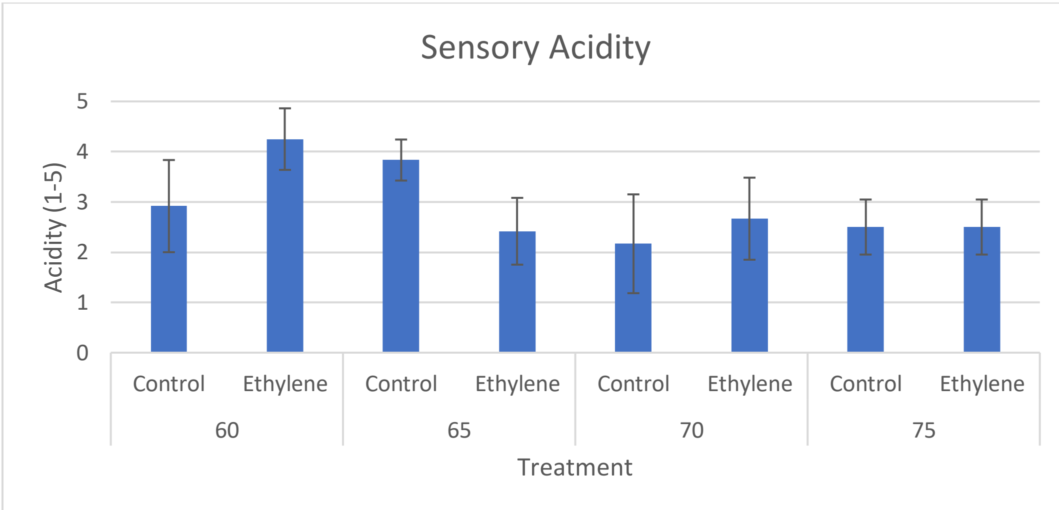
C.


Sensory Juiciness
Juicieness (1-5)
0
1
2
3
4
5
Control
Ethylene
Control
Ethylene
Control
Ethylene
Control
Ethylene
60
65
70
75
Treatment

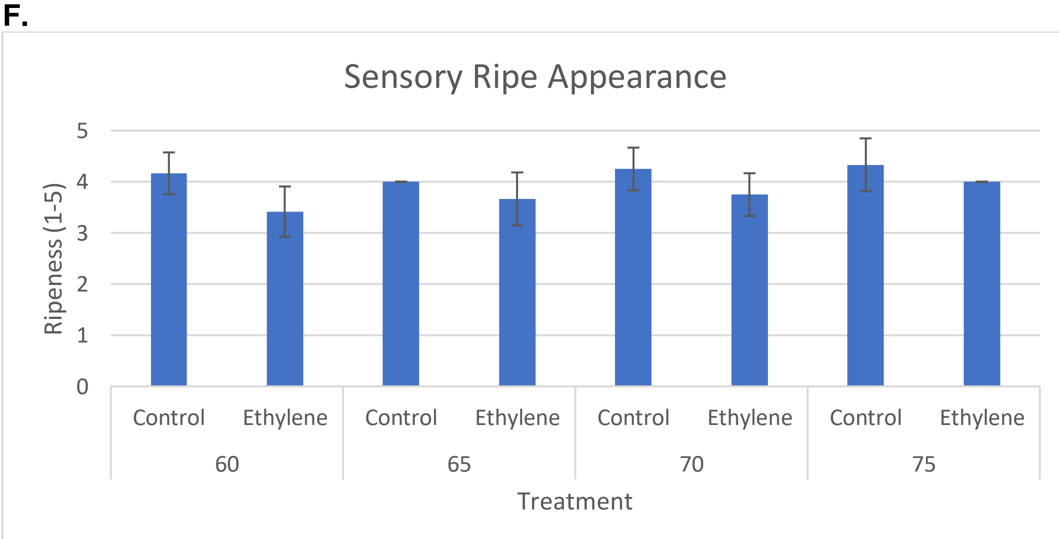
D.


Sensory Sweetness
Sweetness (1-5)
0
1
2
3
4
5
Control
Ethylene
Control
Ethylene
Control
Ethylene
Control
Ethylene
60
65
70
75
Treatment

E.


Sensory Acidity
Acidity (1-5)
5
4
3
2
1
0
Control
Ethylene
Control
Ethylene
Control
Ethylene
Control
Ethylene
60
65
70
75
Treatment

F.


Sensory Ripe Appearance
Ripeness (1-5)
5
4
3
2
1
0
Control
Ethylene
Control
Ethylene
Control
Ethylene
Control
Ethylene
60
65
70
75
Treatment

G.

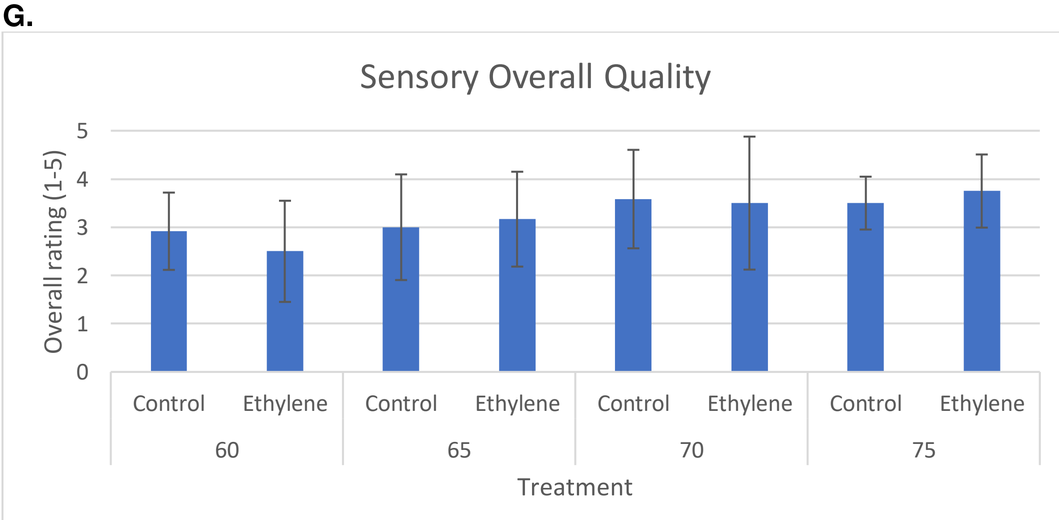
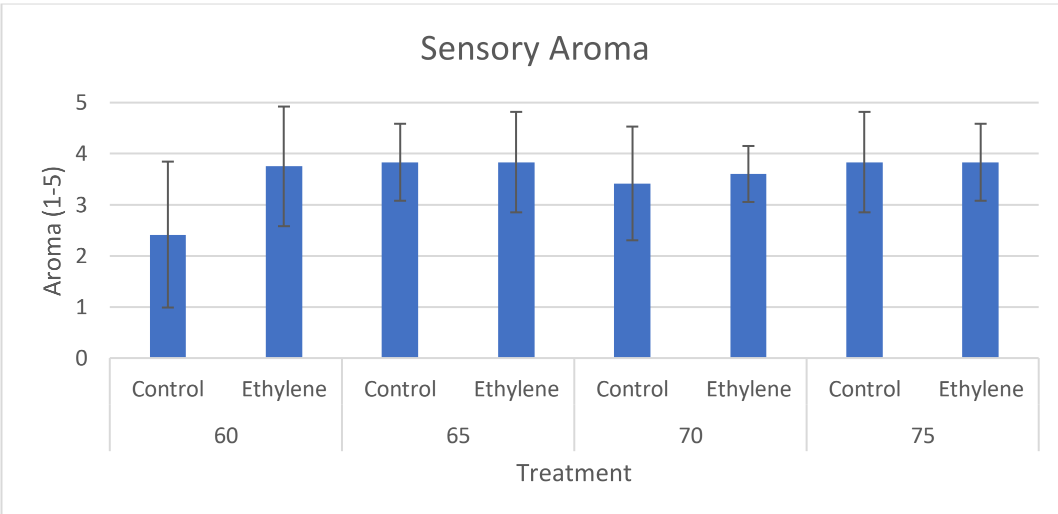
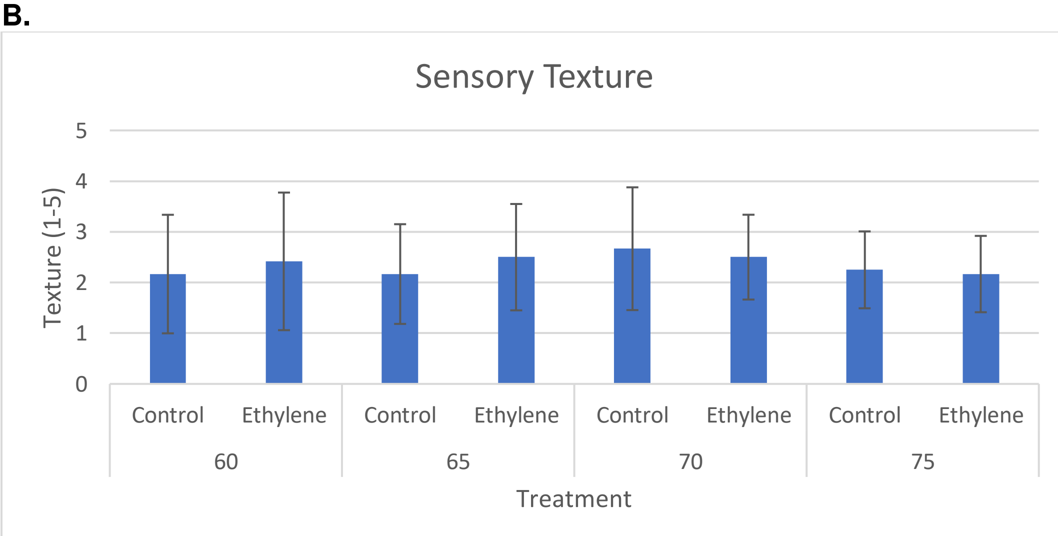

Sensory Overall Quality
Overall rating (1-5)
5
4
3
2
1
0
Control
Ethylene
Control
Ethylene
Control
Ethylene
Control
Ethylene
60
65
70
75
Treatment

Figure 38. Sensory quality (**A.** Aroma, **B.** Texture, **C.** Juiciness, **D.** Sweetness, **E.** Acidity, **F.** Appearance, and **G.** Overall Quality) of the second sample of Honey fruit on Day 17 when the sensory evaluations were performed.

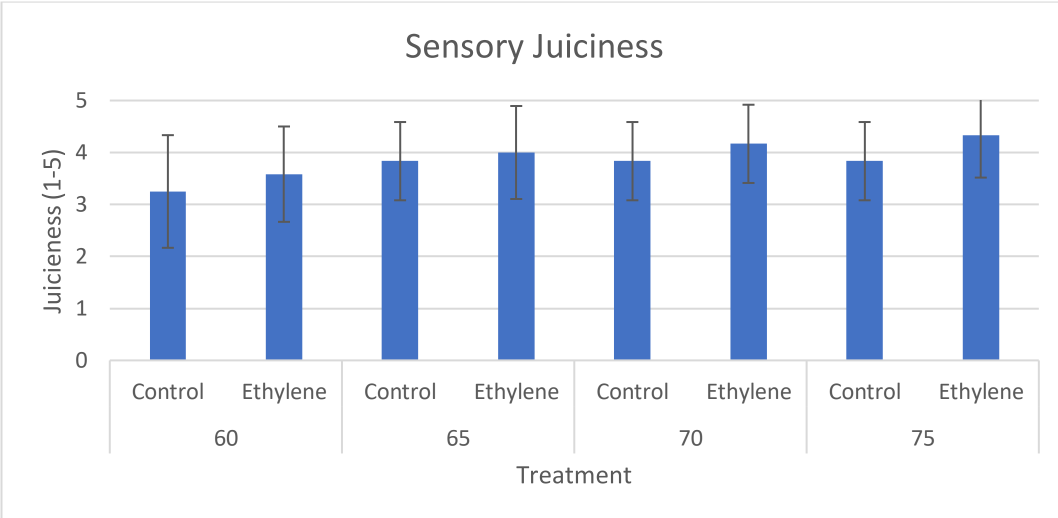
A.



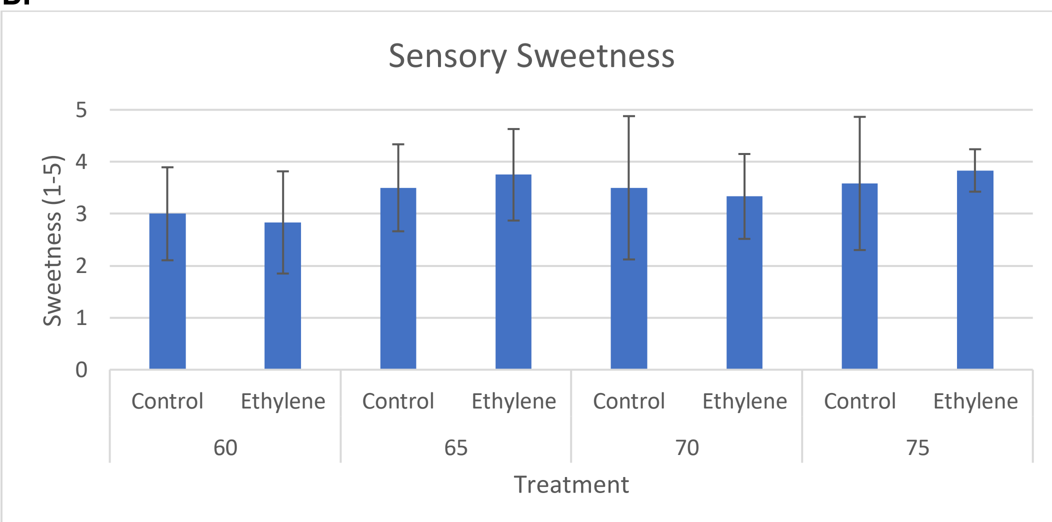
B.



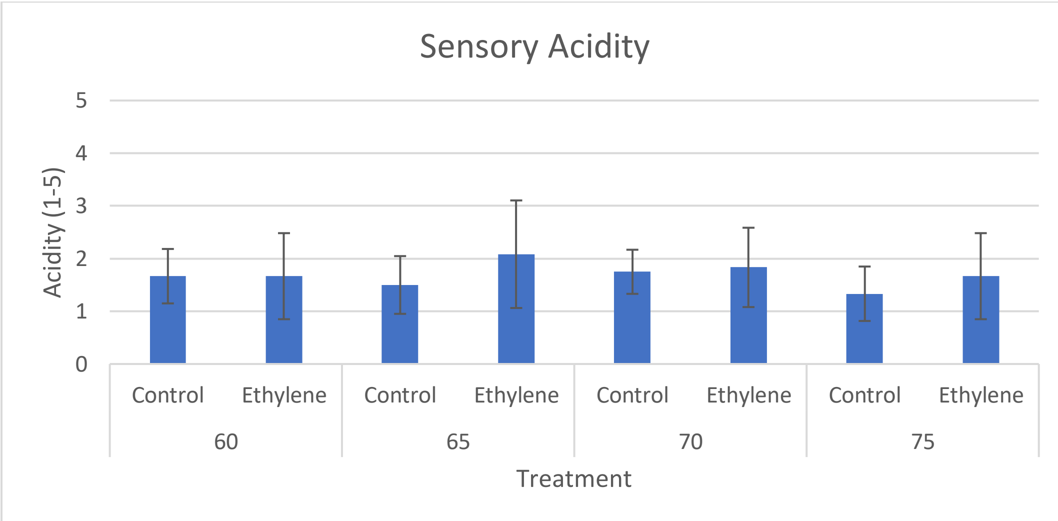
C.


Sensory Juiciness
Juicieness (1-5)
0
1
2
3
4
5
Control
Ethylene
Control
Ethylene
Control
Ethylene
Control
Ethylene
60
65
70
75
Treatment

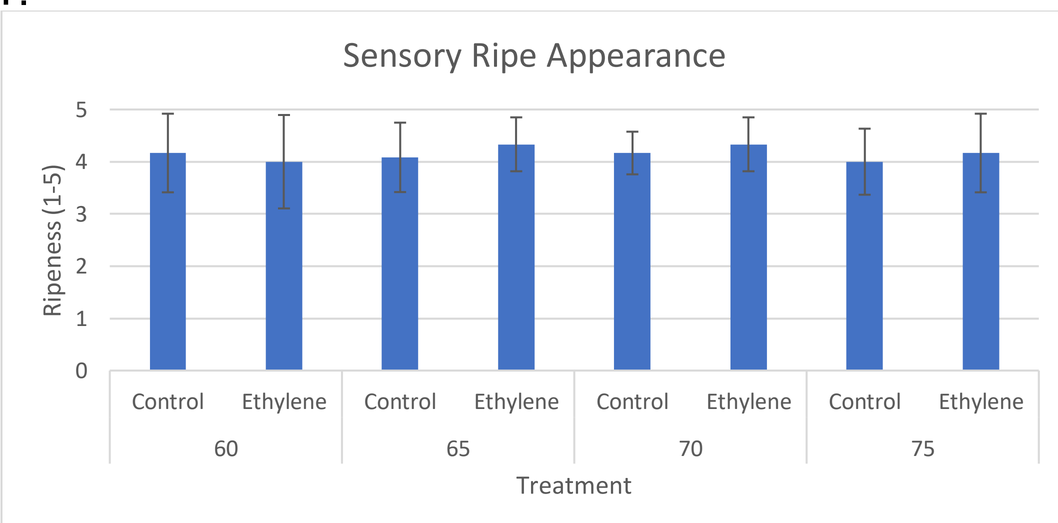
D.


Sensory Sweetness
Sweetness (1-5)
0
1
2
3
4
5
Control
Ethylene
Control
Ethylene
Control
Ethylene
Control
Ethylene
60
65
70
75
Treatment

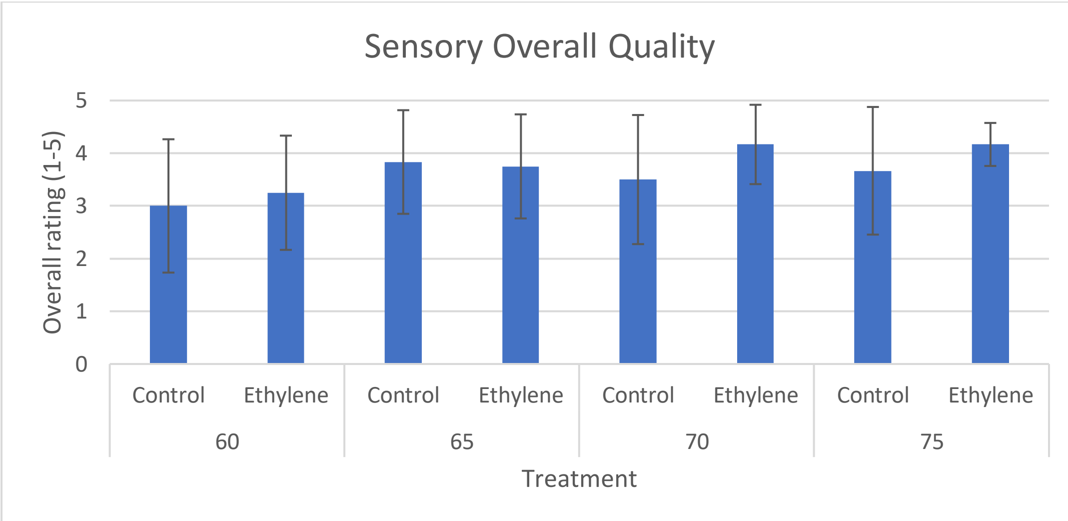
E.


Sensory Acidity
Acidity (1-5)
0
1
2
3
4
5
Control
Ethylene
Control
Ethylene
Control
Ethylene
Control
Ethylene
60
65
70
75
Treatment

F.


Sensory Ripe Appearance
Ripeness (1-5)
0
1
2
3
4
5
Control
Ethylene
Control
Ethylene
Control
Ethylene
Control
Ethylene
60
65
70
75
Treatment

G.



Discussion:

Exogenously applied ethylene is used on climacteric fruits like bananas, avocadoes, pears, and mangos to improve the speed and uniformity of ripening so that the fruit can be offered to consumers at retail in the most desirable condition. Ethylene doesn't change anything about how the fruit ripen, because it's no different than the ethylene the fruit itself makes naturally. Applying exogenous ethylene just speeds up the process. Nothing in this research conflicts with the importance of starting with fully mature fruit at harvest that have high dry matter content. That is what determines the potential quality of the ripe fruit.

It may be important to state that the purpose of ethylene treatment isn't to improve individual fruit quality. It is used to speed up the ripening of the population of fruit as a whole and, perhaps more importantly, to make the ripening within the population of fruit more uniform. That is because the effect of the ethylene treatment is greater on the less advanced fruit in a population and less on the more advanced fruit. The net effect of a ripening program is that conditioning/ripening ensures that the mangos will all be ripe at retail when they are offered to the consumers.

Conclusions:

- This project showed that the main effect of ripening room temperature is on the rate of ripening, while the presence of ethylene had little effect
    - > Little ethylene effect makes sense because mangos are picked after their ripening and internal ethylene production have already been initiated
- In these tests, ripening mangos at the lower temperatures of 60 or 65°F for the first 4 days did not have any major detrimental effects on the final quality of the fruit when they reached full ripeness after completing the ripening process at 70°F

- Although ripening room temperatures and treatment with ethylene had some intermediate effects on mango ripening (mainly improving fruit-to-fruit uniformity), when ripening was complete there was little difference in the quality of the fruit

- **The main benefit of using ripening rooms for mangos is that the fruit will ripen faster and therefore be more desirable to consumers at the point of purchase.** Improved ripening uniformity can also be realized for lots of fruit with more fruit-to-fruit variability

- There is much room for further study on mango ripening procedures with so many possible combinations of factors that need to be taken into account: Time-temperature schedules, ethylene concentrations and exposure times, humidity, air movement and air exchange (CO_2 levels)

- Going into this project, we did not know if the low ripening room temperatures (60 and 65°F) being used by some retailers are having a negative effect on the ripe mango flavor. The results of this research project show that is not the case, which is a welcome result.

Acknowledgement: Thanks to Michael Warren of CAPCO Farms for the very useful discussions regarding mango ripening procedures and customer needs and requirements, as well as for his excellent cooperation with us in procuring the mangos used for this research.