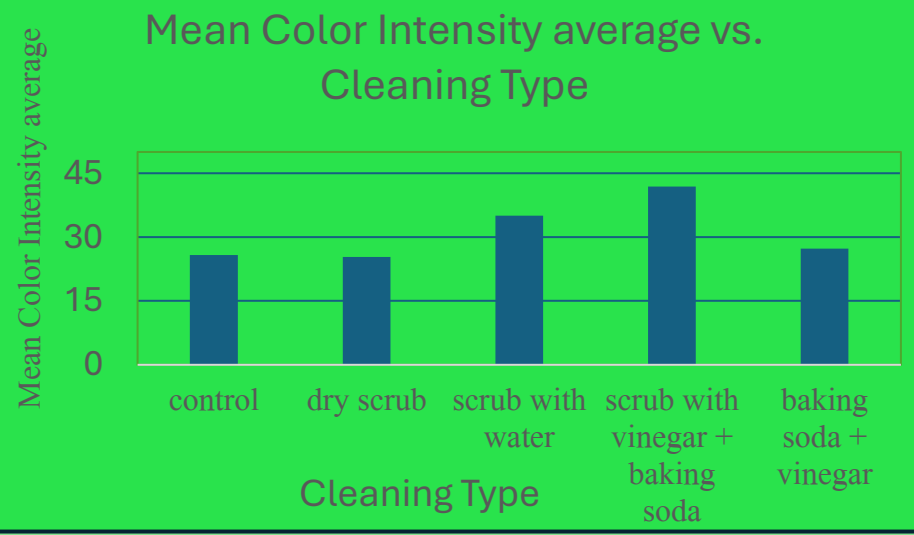
Effects of Postharvest Decontamination Methods on Citrus Reticulata Simulated Pesticide Residue Amounts

Research Question

How do different postharvest decontamination methods of produce affect the amount of simulated pesticide residue on Citrus Reticulata?
Independent Variable: Cleaning Type
Dependent Variable: Color Intensity

Data Analysis



Procedure

1. Sharpie(pesticide) was put onto Citrus Reticulata samples
2. Cleaning methods were tested on each Citrus Reticulata and data was recorded
3. This data was analyzed using ImageJ's histogram tool

Conclusion

In conclusion, some post-harvest decontamination methods affect simulated pesticide residue, as proved in the graph above. This graph showed that some cleaning types were more effective. For example, the control only had a color intensity of 25.8, where scrub with water had 35.

Introduction to Pesticides

Pesticide Use

Pesticides are chemicals used to manage and kill “pests”, which are organic factors that harm and target plant species (Shekhar, Chander).

Negative Effects of Pesticides

In the long-term, pesticide exposure was known to cause cancer, learning disabilities, and cognitive defects (Kalyabina 2021). This means that pesticide exposure should be prevented in order to help stop these effects.

Photo: https://brewerint.com/news-insights/101-guides/pesticide-drift-from-spray-applications/

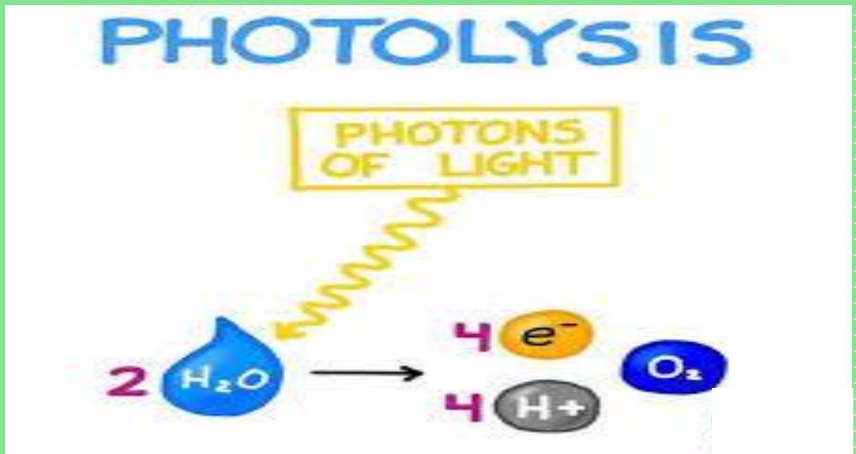
Produce Cleaning Types

Photolysis

Photolysis is a cleaning process that includes using ultraviolet light to decompose pesticide residue on produce(Xiao 2022). This process is too expensive to use at home.

Negatives of Photolysis

While Photolysis is an effective postharvest decontamination method, its high energy input does not make it a valid cleaning type for produce(Xiao, 2022). This means that chemicals(such as vinegar and baking soda) are used for decontamination.



https://www.pinterest.com/pin/photolysis-the-lightsplitting-process-in-photosynthesis--113504853102935933/

Research Question and Hypothesis

Research Question	How do different cleaning methods of produce affect the amount of simulated pesticide residue on produce?
Hypothesis	Different cleaning methods for produce affect the amount of simulated pesticide residue on produce to different extents.
Variables	Independent: Cleaning type(dry scrub, scrub with water, scrub with vinegar and baking soda, baking soda and vinegar) Dependent: Color intensity data(mean, minimum, maximum, standard deviation)

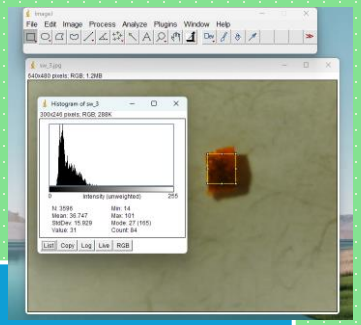
Procedure

1. The experiment was conducted in 4 trials that did each cleaning process once. Each orange had one 1cm^2 square of sharpie on it.

2. Dry scrub was a microfiber cloth scrub. Scrub with water only added water submersion. Control did not have anything done to it.

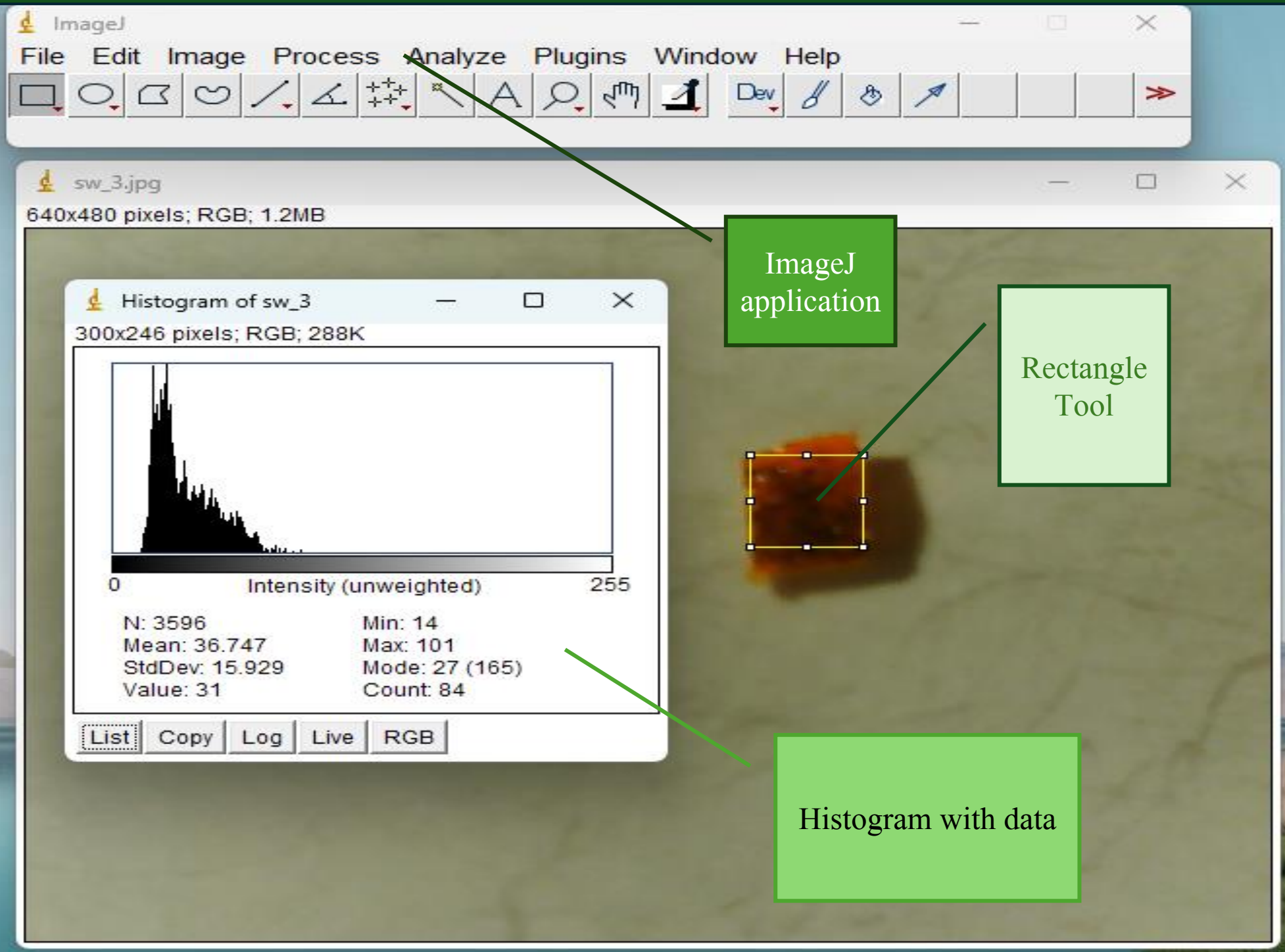
3. Baking soda and vinegar had the citrus sit in a pool of the mixture for 5 minutes and scrub with vinegar and baking soda added a scrub

4. All 1cm^2 squares were photographed and labeled online. These images were then analyzed on ImageJ using the histogram feature.

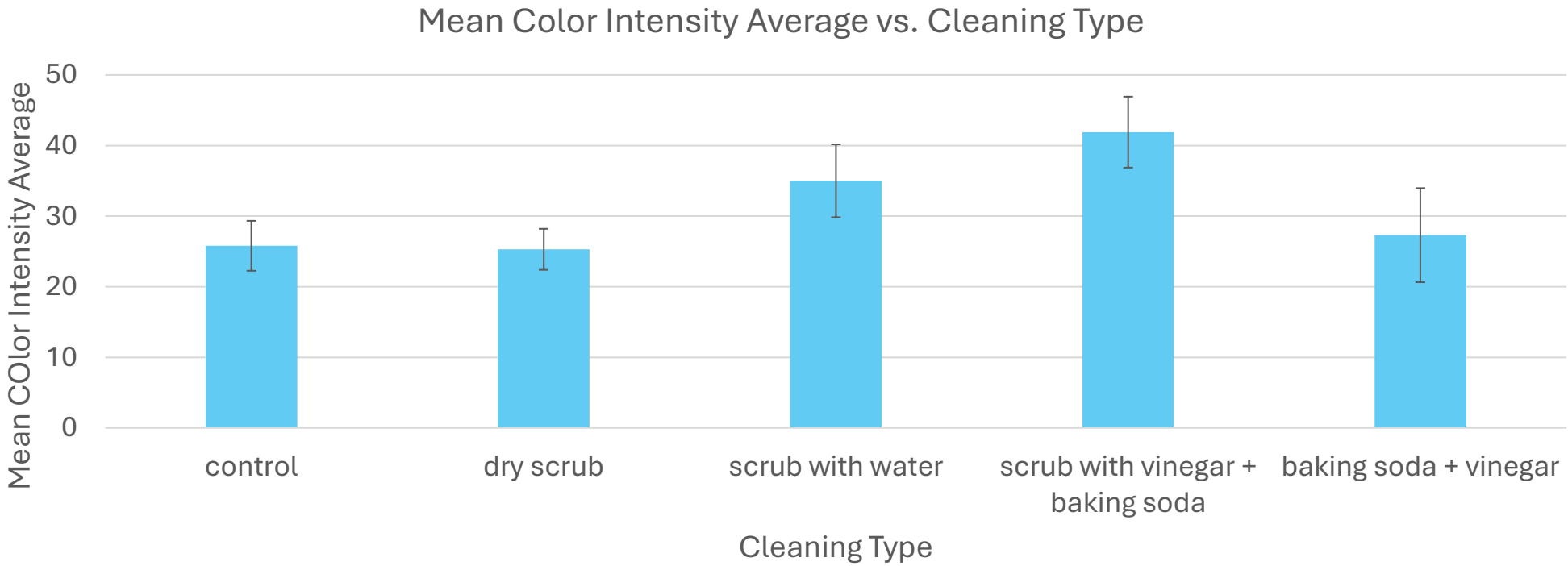


5. The Histogram feature automatically collected the data from the image and determined color intensity.

Example of ImageJ Software

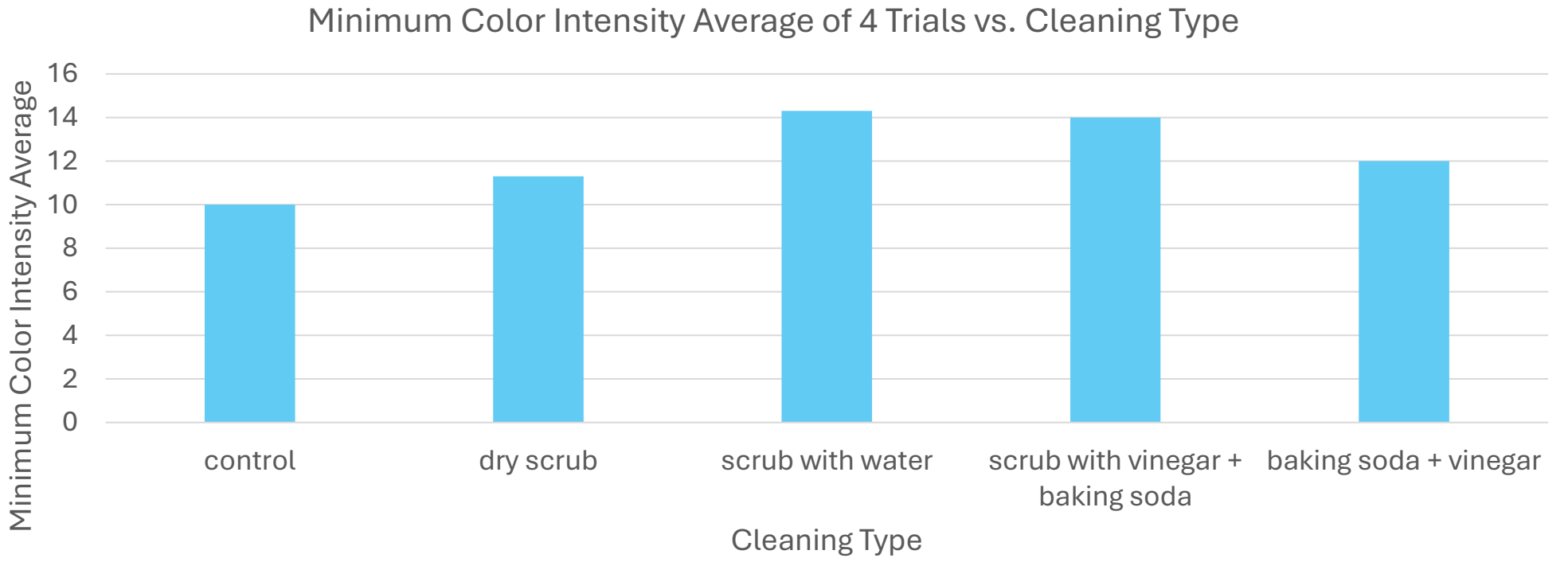


Mean Color Intensity Average of 4 Trials vs. Cleaning Type



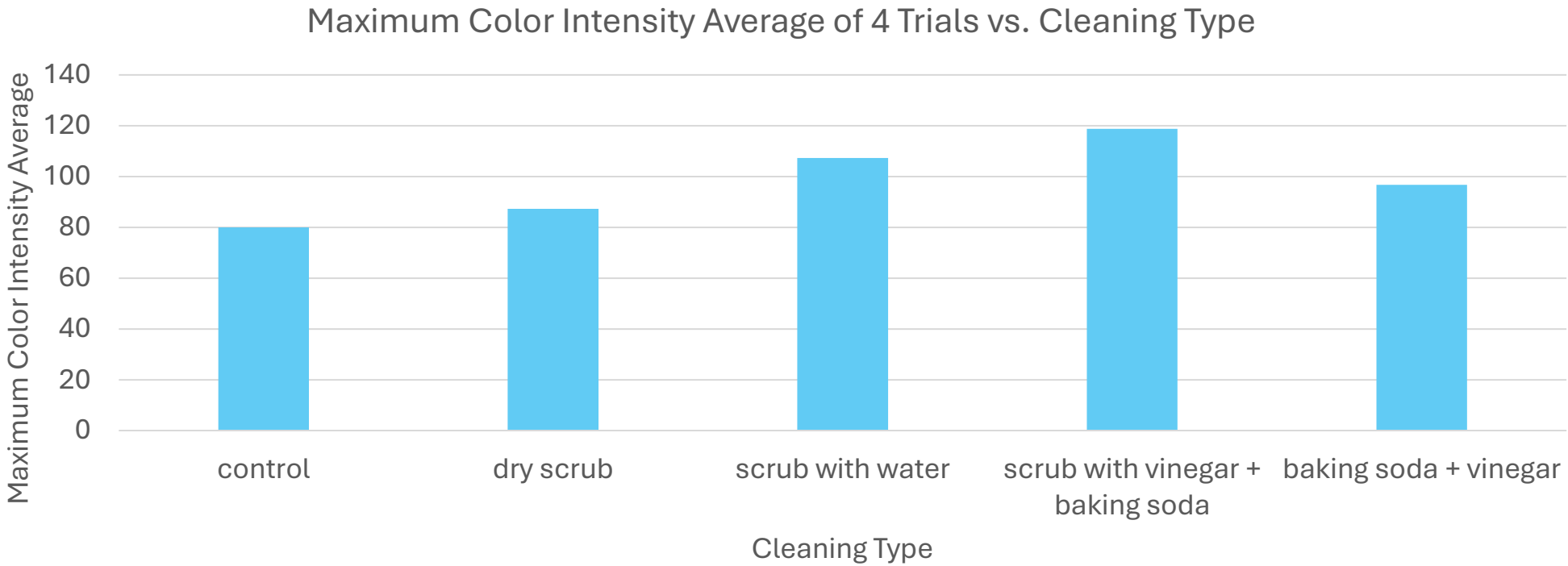
The graph Mean Color Intensity average vs. Cleaning Type showed that the cleaning type changed the mean intensity of test subjects. The “baking soda + vinegar”, “dry scrub”, and “control” all had similar intensity numbers. This meant that there was little to no effect of the “dry scrub” and ‘baking soda + vinegar” cleaning types on removing Sharpie. The 2 cleaning types that had increased mean intensity compared to the control were “scrub with water” and “scrub with vinegar + baking soda”. This meant that these cleaning types removed more black (sharpie) from their test samples. Mean intensity measured color intensity between 0 (black) and 255 (white). This means that the higher the number, the less black (sharpie pesticide) was present on the orange. Mean intensity was measured by taking all data points, adding them, and then dividing that number by the number of data points.

Minimum Color Intensity Average of 4 Trials vs. Cleaning Type



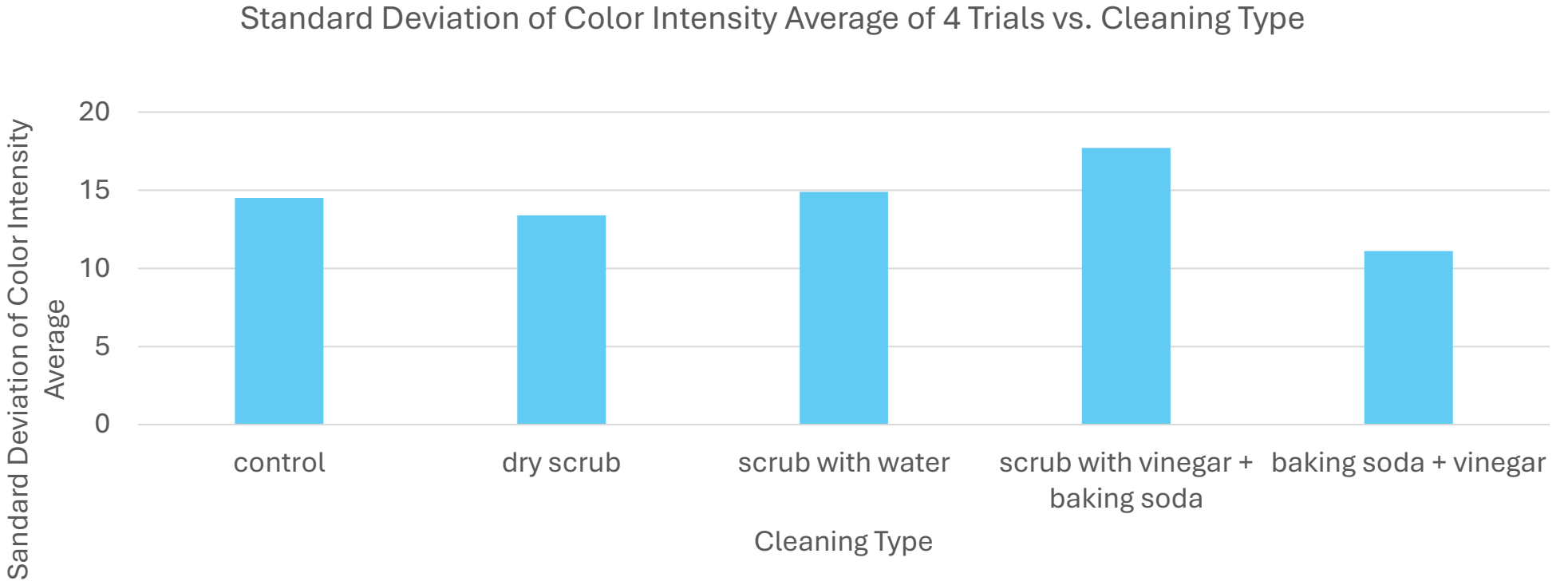
The graph Minimum Color Intensity Averages vs. Cleaning Type showed that the minimum color intensity, measured between 0 (black) and 255 (white), was lowest for the control of the data set and highest for "Scrub with water." This meant that the control had the darkest minimum intensity between tests and was therefore least effective at cleaning. This data also shows that "scrub with water" had a higher minimum intensity compared to "scrub with vinegar + baking soda". This means that while "scrub with vinegar + baking soda" was greater in mean intensity, "scrub with water" was more effective at removing the pesticide to a higher minimum. The average for each cleaning type's minimum was found by averaging the smallest data point in the sets.

Maximum Color Intensity Average of 4 Trials vs. Cleaning Type



The graph Maximum Color Intensity Averages vs. Cleaning Type showed that the maximum intensity, which was measured by color intensity between 0 (black) and 255 (white), showed that “control” had the lowest maximum intensity, while “scrub with vinegar + baking soda” had the highest maximum intensity. This meant that the control was the least effective, and scrub with the vinegar solution was the most effective. This graph showed a trend that is almost exact compared to the mean intensity, apart from “control” and “dry scrub”. This is important because the correlation between these 2 data sets could have been used to infer data for one or the other. This also meant that, in regard to mean intensity, the maximum intensity of the data set correlated better with mean intensity than with minimum intensity. The average for each cleaning type’s maximum was found by averaging the largest data point in the sets.

Standard Deviation of Color Intensity Average of 4 Trials vs. Clean Type



The graph Standard Deviation of Color Intensity Average vs. Cleaning Type showed that “baking soda + vinegar” had the smallest deviation, and “scrub with vinegar + baking soda” had the largest deviation. This meant that cleaning during “baking soda + vinegar” was the most consistent and led to the least amount of deviation. The largest deviation was “scrub with vinegar + baking soda”, which meant that it was the least consistent cleaning method and had the largest deviations from the mean. There seemed to be no correlation between this data set and the data sets of the other data points recorded in this experiment. Standard deviation used a calculation that averages the deviation from the means of the different cleaning types individual deviations from each data set.

Results

Claim

- The scrub with vinegar and baking soda was the most effective cleaning method for postharvest decontamination.
- Dry scrub and the baking soda and vinegar soak had no effect on pesticide residue amounts on the citrus.
- Scrub with water to clean to the best minimum color intensity.

Evidence

- The highest mean color intensity was the scrub with vinegar and baking soda with 41.9 on the color intensity scale.
- Dry scrub and baking soda and vinegar had deviations of less than 1.5 on the scale of mean color intensity.
- Scrub with water had the highest minimum color intensity with 14.3.

Reasoning

- The highest mean color intensity means that the most black(pesticide residue) was removed from the citrus, making it the most effective.
- The lack of variation between the mean color intensity of the control, dry scrub, and baking soda and vinegar means that they did little more than nothing.
- The highest minimum color intensity was “scrub with water”, which means that it removed the black to the highest minimum.(Color intensity is measured between 0[black] and 255[white])

Discussion

Possible Errors

The camera that was used to record the images of the oranges had glare from some angles, which could have led to areas of light on the skin of the citrus. Another error could have been the coloring of the 1cm^2 area of Sharpie. Close to the end of the experiment, the last 2 oranges had difficulty getting a full coat of Sharpie on them. The starting color of the oranges (although they came from the same package) could have impacted the color intensity of the samples.

Fixes To Possible Errors

The glare of the oranges could be fixed with better lighting. The Sharpie error could be remedied with more Sharpie replacements. The orange color difference did not affect the experiment in any major way. Also, more sets of the experiment could be conducted to gather more precise data.

Example of Glare

Potential Reasoning for Results

"Scrub With Water" Effectiveness

Due to Sharpie ink being a highly formulated chemical, it mixes well with water, which causes it to rub off from the citrus. This effect also leads to pesticide pollution of waterways(Shekhar, 2024).

"Dry Scrub" Effectiveness

While water and the combination of baking soda and vinegar mix well with Sharpie ink, the dry scrub did not have a mixing agent. The absence of a mixing agent led to no decrease of pesticides from the samples.

Future Investigation and Application

Future Investigation

The data from this experiment only tested 4 cleaning methods on Citrus Reticulata. In the future, different postharvest decontamination methods could be used to further the research of cleaning methods. Also, different fruits could be used to test the variation of effectiveness of cleaning methods among fruit species

Application

The results of this experiment can be applied to at-home or industrial cleaning methods for fruit. The use of a baking soda and vinegar scrub on fruit before serving could help reduce pesticide residue exposure in humans. This reduction in exposure would help stop the negative effects of pesticide residue exposure on humans.

Photo: https://www.aljazeera.com/economy/2017/3/8/un-200000-die-each-year-from-pesticide-poisoning

References

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4. Shekhar, Chander, et al. “A Systematic Review of Pesticide Exposure, Associated Risks, and Long-Term Human Health Impacts.” *Toxicology Reports*, vol. 13, Dec. 2024, p. 101840. *ScienceDirect*, https://doi.org/10.1016/j.toxrep.2024.101840.

5. Xiao, Qian, et al. “Photolysis for the Removal and Transformation of Pesticide Residues During Food Processing: A State-of-the-Art Minireview.” *Frontiers in Nutrition*, vol. 9, May 2022. *Frontiers*, https://doi.org/10.3389/fnut.2022.888047.