

Electrolysis-Based pH Modification of Aquaculture Wastewater for Hydroponics

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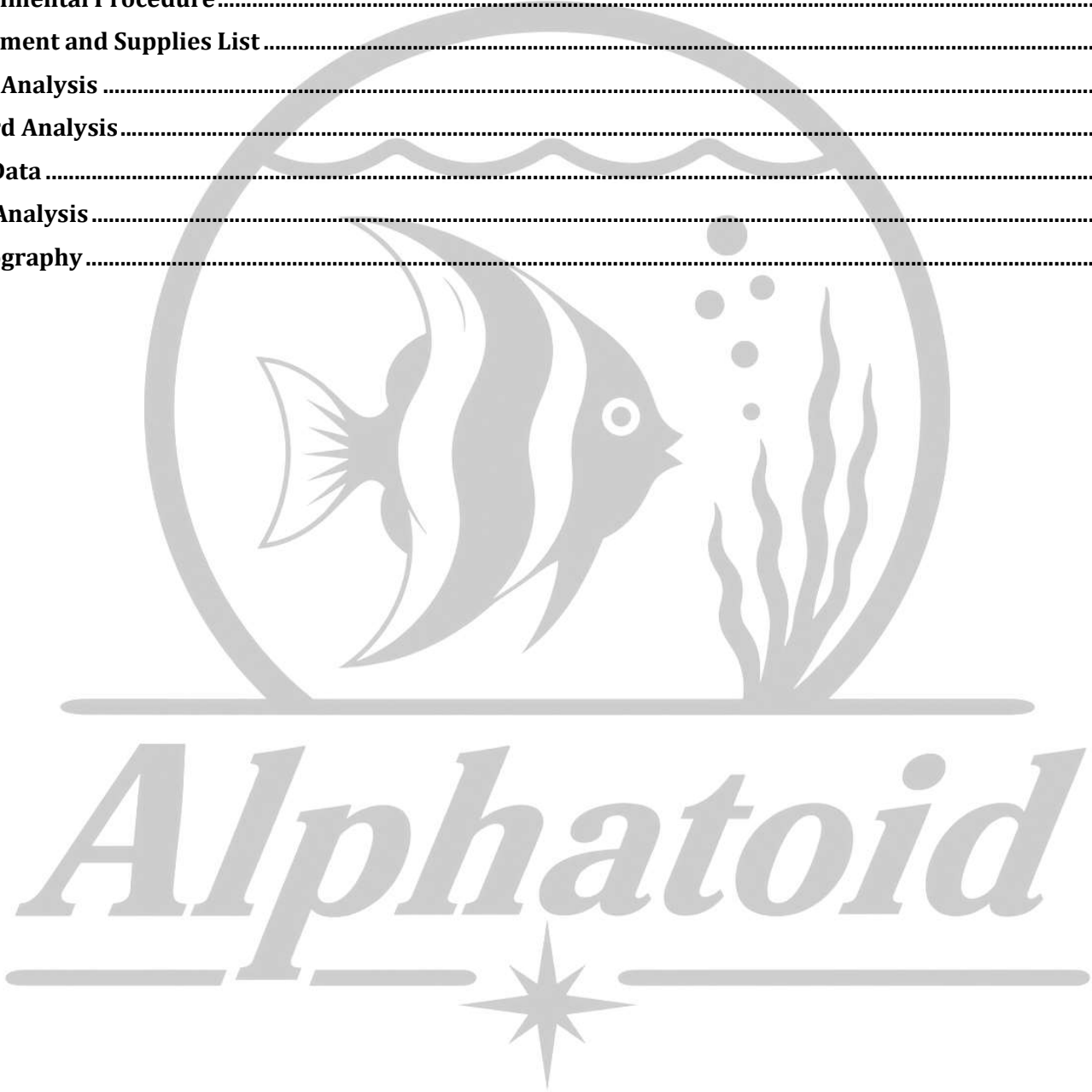
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Introduction

Problem: Aquaponics systems seem like an efficient synergy where the aquaculture subsystem's wastewater is nutrient-rich water for the hydroponic subsystem's plants, and by absorbing those nutrients the plants serve as biofilters for the aquaculture wastewater. Unfortunately plants and aquatic animals usually prefer their water to be in different pH ranges for optimum growth. Using chemical additives to optimize the pH as the water moves between the aquaculture and hydroponic subsystems comes with chemical related costs and risks, plus the problem of chemical buildup in recirculating aquaponic systems. Aquaponic systems must usually run at a compromise pH that both animals and plants can tolerate but is not optimum for either.

Goal: Develop and demonstrate a chemical-free method of optimizing aquaponics working fluid pH for each subsystem.

Hypothesis: Brassica juncea (Spicy Brown Oriental Mustard) microgreens grown hydroponically using aquarium wastewater treated in a proton-exchange-membrane electrolysis cell to reduce the pH to approximately 6.7 will grow more quickly than Brassica juncea microgreens grown under similar conditions using aquarium wastewater from the same batch that has not had its pH altered.

Result: The Brassica juncea microgreens grown in the pH optimized water achieved higher ($P < 0.05$) mean plant weight than Brassica juncea microgreens grown in untreated water from the same source. The mean weight of the treated microgreens was 55.2g, compared to a mean weight of 50.0g for the untreated microgreens. This statistically significant increase in mean plant weight of over 10% demonstrates that PEM electrolysis can be a practical, chemical-free method for pH optimization in aquaponic systems with the potential to reduce cost, reduce risk, and increase yield in a wide variety of crops.

Experimental Procedure

1. Place 70 mustard seeds in a 7x10 grid on .25" spacing onto two 6"x4" silicone reusable grow medium that have been cleaned according to the Kratky hydroponics kit components cleaning procedure.
2. Sprout the mustard seeds using the standard On-The-Grow microgreen sprouting procedure.
3. After the blackout sprouting phase (day 4), place each medium of sprouted seeds into a 3 cup Pyrex tray that has been cleaned according to the glassware cleaning procedure.
4. Fill one of the Pyrex trays with 511 grams of the control aquarium water. Label the tray "Control."
5. Fill the other Pyrex tray with 511 grams of the test aquarium water from the electrolysis treatment. Label the tray "Test".
6. Measure the pH of both trays with a calibrated pH meter. Record the pH readings, support ID, time, and date.
7. Place the Pyrex trays side by side symmetrically under the center of the SF300 LED light. Record the light timer settings.
8. Allow the microgreens to grow for 4 days according to the microgreen growing procedure.
9. Remove the growth medium supports, growth medium, and plants from the Pyrex trays. Record the time and date of removal.
10. Remove the each plant individually, weigh it, and record its weight and location according to the microgreen weight data collection procedure.
11. Conduct data analysis to determine the effect of the electrolysis pH reduction on the mustard plant growth.



Cleaning Kratky Hydroponics Kit Components

1. Wash components using non-scented dish soap.
2. Rinse and empty components using tap water repeatedly until rinse water no longer shows signs of being soapy or holding bubbles.
3. Verify that the components appear clean, else return to step 1.
4. Pour in sufficient white cleaning vinegar to cover the bottom of a container to a depth of 1/8".
5. Soak the flexible growth medium in the vinegar for at least 1 minute.
6. Invert the growth medium supports in the vinegar for at least 1 minute.
7. Wipe down trays with a paper towel soaked in vinegar.
8. Place the growth medium and growth medium supports in a deep growth tray. Fill glassware with tap water and completely empty it 6 times.
9. Verify that the components appear clean and do not smell of vinegar, else return to step 7.
10. Pour in sufficient distilled water to cover the bottom of the trays to a depth of 1/4" and swirl it around onto all wetted sides.
11. Pour distilled water over the growth medium and growth medium supports.
12. Allow all the components to air dry before use.

Glassware Cleaning Procedure

Glassware should be cleaned between changes in the fluid contained in them. Note: If glassware is being temporarily used to hold samples of the same fluid from the same larger fluid container, then it may simply be rinsed with distilled water and dried between uses.

1. Wash glassware using non-scented dish soap.
2. Rinse and empty glassware using tap water repeatedly until rinse water no longer shows signs of being soapy or holding bubbles.
3. Verify that the glassware appears clean, else return to step 1.
4. Pour in sufficient white cleaning vinegar to cover the bottom of the container to a depth of 1/8".
5. Swish vinegar around to contact all wetted sides of the glassware.
6. Fill glassware the rest of the way with tap water and then pour it out.
7. Fill glassware with tap water and completely empty it 5 more times.
8. Verify that the glassware appears clean and does not smell of vinegar, else return to step 7.
9. Pour in sufficient distilled water to cover the bottom of the glassware to a depth of 1/4" and swirl it around onto all wetted sides.
10. Heat the glassware in a toaster oven to 235 degrees for 15 minutes.
11. Allow to cool. Remember, **hot glass looks the same as cold glass!**
12. Rinse glassware with distilled water.

13. Allow to cool. Remember, **hot glass looks the same as cold glass!**

Microgreen Sprouting Procedure

1. Place clean 4"x6" silicone grow medium mat on 3d printed medium support.
2. Place a ¼" x ¼" seed guide centered over the grow medium.
3. Using the guide and tweezers to help, carefully place seeds on the grow medium in a ¼" x ¼" array.
4. Carefully lift the seed guide. Use tweezers to reposition any mislocated seeds.
5. Repeat steps 1 through 4 for a second set of seeds and grow medium.
6. Place the two sets of seeds, medium, and supports into a 10"x20" On The Grow deep sprouting tray symmetrically close to the center of the tray.
7. Gently, and from a distance of at least 6" (so as not to blow the seeds around), spray both sets of seeds thoroughly with distilled water until all the seeds are wet and the grow medium has a fine coating of water.



9. Photograph the mediums with seeds.
10. Place a 10"x20" On The Grow shallow sprouting tray on top of the seeds and weight it down with 6 rolls of pennies.
11. Place a post-it-note on the tray with the date and time of seeding.

12. Place trays in a safe area of approximately 74 degrees F for sprouting
13. Approximately every 12 hours for the next 3 days lift the shallow sprouting tray and spray the medium with distilled water until all the seeds are wet and the grow medium has a fine coating of water, then replace the shallow tray.



14. After spraying on the 4th day (the 7th spraying since placing the seeds) remove the rolls of pennies and flip the shallow sprouting tray so that the seedlings have no pressure on them.
15. Approximately 12 hours after flipping the sprouting tray lift the shallow sprouting tray and spray the medium with distilled water until all the seeds are wet and the grow medium has a fine coating of water, then replace the shallow tray.
16. After 4 complete days (8 total sprayings) inspect and photograph the seedlings.

Microgreen Growing Procedure

1. Measure and record the pH of the Test and Control water, along with the time and date.
2. Place one of the 3d printed medium support with grow medium and sprouts in a clean Pyrex Simpli-Store 3 Cup Glass Storage Container.
3. Place the second 3d printed medium support with grow medium and sprouts in a second clean Pyrex Simpli-Store 3 Cup Glass Storage Container.
4. Fill one of the Pyrex containers with control water until the medium support just begins to float.
5. Label the outside of the Pyrex container with the test water "Test" using a sharpie on painter's tape.
6. Fill the second of the Pyrex containers with the test water until the medium support just begins to float.
7. Place the two Pyrex containers with seedlings under the Spider Farmer LED grow light symmetrically near the center of the light. Record the height of the light.
8. Inspect the microgreens daily for 4 days.
9. After the 4th day, remove the microgreens and collect data.



Microgreen Weight Data Collection

1. Ensure scale is calibrated.
2. Remove the growing medium support from the sprouting tray.
3. Lay a paper towel down so you can dry the sprouts (you may also use another paper towel to store sprouts you want to reuse).
4. One by one, remove each sprout with tweezers, ensuring the plant stays intact and dry by dabbing it on the paper towel.
5. After drying, place the entire sprout on the scale and record the weight.
6. Separate the weights by row.

pH Meter Calibration Procedure

1. Follow Apera pH60 pH tester procedure.
2. Tally buffer solution use on painters tape taped to solution cap.
3. Replace pH4 and pH7 solution before 10th use. Replace pH10.01 solution before 5th use.

Aquarium Water Preparation Procedure

1. Fill 64 fl. oz. glass container approximately $\frac{3}{4}$ full of aquarium wastewater.
2. Microwave container of wastewater for 10 minutes, verifying that the water boils for at least 2 minutes.
3. Let the water and glass container cool. **Hot glass looks like cold glass!**
4. Filter the water into a clean glass container through a coffee filter.
5. Pour half of the water into the positive (anode) side container for the electrolysis cell. Save the other half for the control plants.

Equipment and Supplies List

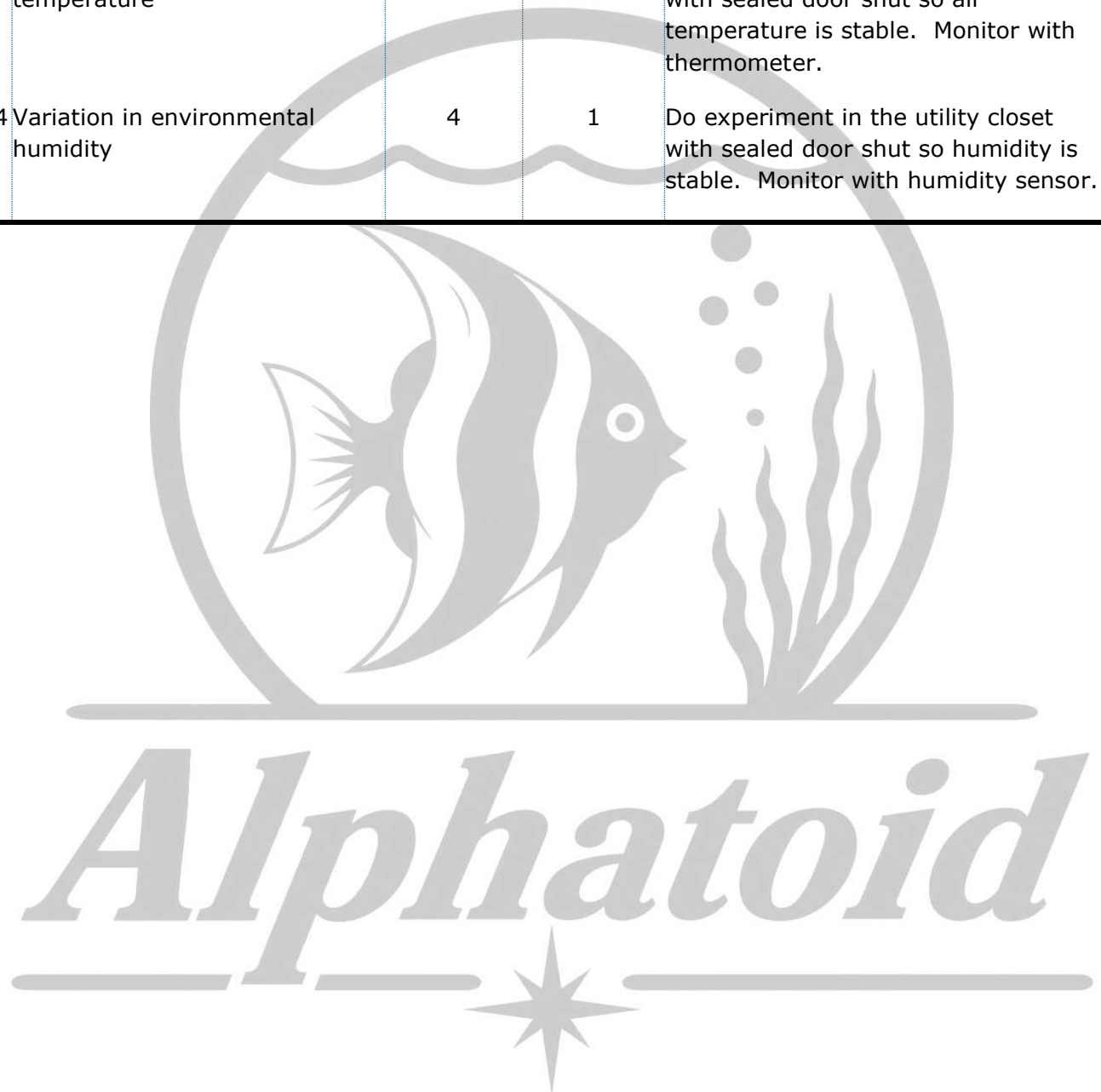
- Spicy Brown Oriental Mustard Seeds (Lot# 199449)
- Spider Farmer SF300 LED light
- 10"x20" On the Grow Kratky Hydroponics Kit
- Silicone Reusable Grow Medium
- Custom 3d printed Grow Medium Supports
- 8.5"x6.5"x2.25" Pyrex glass storage trays
- Aquarium water, heated and filtered (control)
- Aquarium water, heated, filtered, and reduced to approx. 6.7 pH via. Electrolysis (test)
- Apera pH60 pH tester
- Maxus D205 milligram scale



Error Analysis

ID	Hazard	Likelihood	Severity	Mitigation
1	Seeding density is different	3	3	Use a seed stencil to help place seeds in a regular pattern.
2	Variation in sunlight	5	4	Conduct the experiment in the utility closet where there are no windows.
3	Mold destroys plants	3	5	Keep the plant density low. Boil water before use. Clean equipment with vinegar.
4	Contamination in water	1	2	Filter with coffee filter before use.
5	Different LED light intensity	2	4	Place containers symmetrically about LED centerline. Use jig to make placement repeatable. Swap containers between test runs.
6	Pests destroy plants	1	4	Monitor plant growth. Use diatomaceous earth if necessary.
7	Variation in water level	2	3	Measure water volume for each tray and keep within 1ml of each other.
8	Variation in seed vitality	1	2	Visually inspect seeds and void using miscolored or misshapen seeds. Collect a large number of data points.
9	Variation in initial sprouting	2	3	Keep sprouting trays next to each other to keep conditions similar. Randomly select tray destination. Collect a large number of data points.
10	Water droplets clinging to roots affect weight measurement	3	3	Touch plants to dry paper towel before weighing to wick away droplets.
11	Scale out of calibration	1	2	Use relative weight differences so exact calibration is not necessary as long as scale is linear. Check scale response with calibration weights before use.

12	pH meter out of calibration	1	5	Use NIST traceable pH meter. Calibrate before each experimental run with manufacturer's pH buffer standards.
13	Variation in environmental temperature	4	1	Do experiment in the utility closet with sealed door shut so air temperature is stable. Monitor with thermometer.
14	Variation in environmental humidity	4	1	Do experiment in the utility closet with sealed door shut so humidity is stable. Monitor with humidity sensor.



Hazard Analysis

ID	Hazard	Likelihood	Severity	Mitigation
1	Electrical shock from LED lights	2	5	Use electrical equipment rated by a national lab.
2	Spilling water from the trays	5	1	Put a plastic storage container under the experiment
3	Breaking a glass tray	1	3	Use Pyrex™ glass trays
4	Mold growth	3	1	Boil water before using. Clean equipment with vinegar.



Raw Data

Electrolysis-Based pH Modification of Aquaponic Wastewater for Hydroponics,
Plant Masses

14 Jan 2026 Test Run: Test Water, modified to pH 6.7

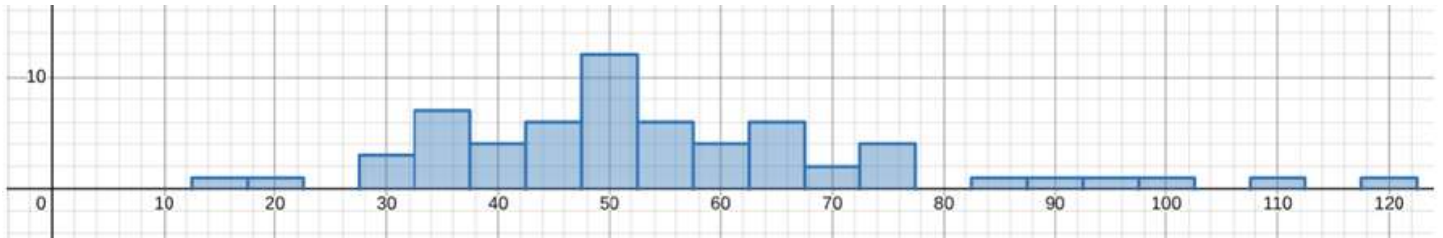
Row	Data(mg)								
A	17	47	41	40	64	49			
B	73	37	45	36	46	110			
C	85	34	33	37	50	58			
D	62	52	28	31	34	47	75		
E	67	61	47	54					
F	22	55	70	53	52	89	51	67	118
G	96	69	64	77	51	40			
H	59	77	56	52	56	41	52		
I	65	52	52	30	37	46			
J	48	48	56	100	63				

14 Jan 2026 Test Run: Control Water

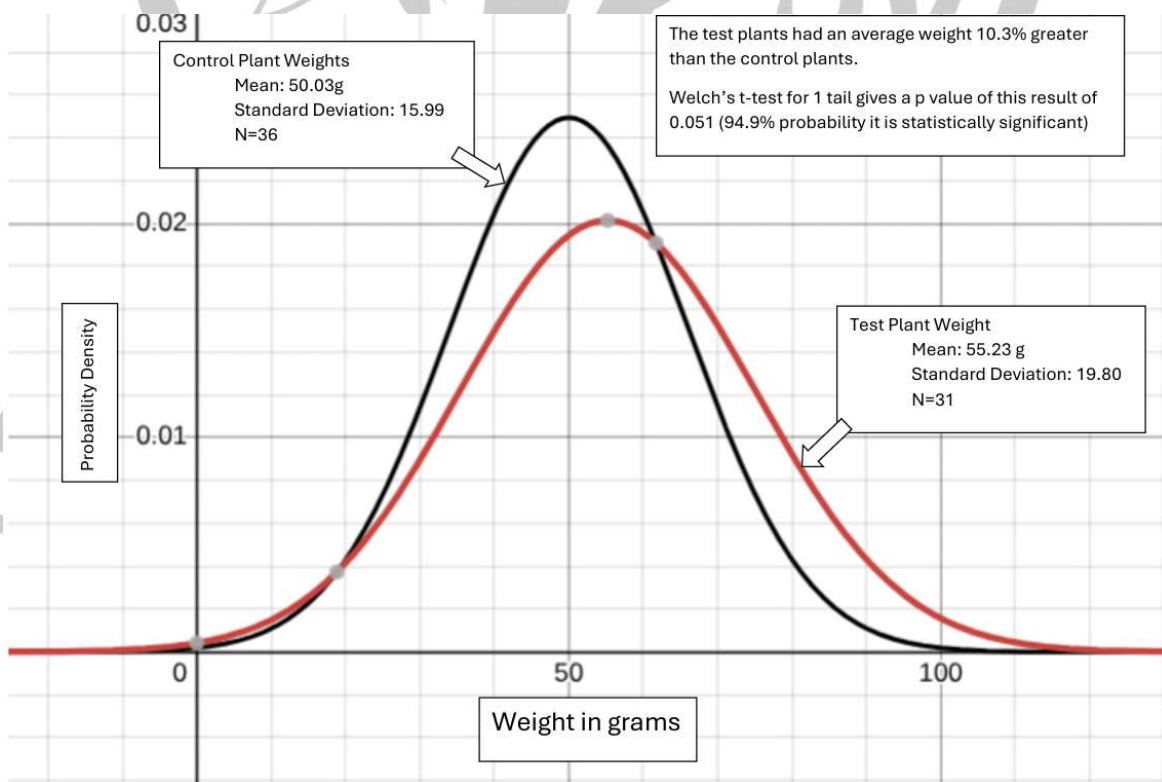
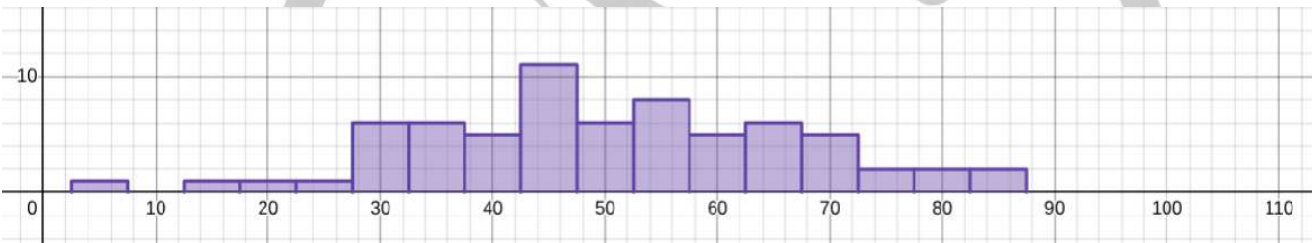
Row	Data(mg)								
A	63	50	63	55	36	43	57	27	36
B	63	46	32	53	32	61			
C	43	59	40	72	47	34	38	85	
D	55	54	50	73	26	34			
E	68	58	60	64	64	71			
F	17	39	72	40	53				
G	72	46	45	63	33	40	73		
H	52	47	29	44					
I	62	28	30	58	16	37	43		
J	80	45	21	35	30				
K	78	54	52	47	83	54	52	60	56

Data Analysis

Test Data Histogram: # of Plants vs. Plant Mass in mg



Control Data Histogram: # of Plants vs. Plant Mass in mg



Selected Bibliography

Spinu, V.C., Langhans, R.W. and Albright, L.D. (1998). ELECTROCHEMICAL PH CONTROL IN HYDROPONIC SYSTEMS. *Acta Hortic.* 456, 275-282

Shtepa, V. & Kireev, Sergey & Kozyr, A. & Shikunets, A.. (2024). Reagent-Free Technology for Intensifying the Process of Growing Microgreens in Aquaponic Systems. *Theoretical Foundations of Chemical Engineering.* 58. 211-216.

On The Grow. (27Jun2025). Grow 3 Popular Microgreens on Silicone Reusable Medium: 10x20 Tray Guide [video]. Youtube. <https://youtu.be/R3910i2dpRQ>

Thyssenkrupp Nucera. (31Jan2024). The Four Main Types of Water Electrolysis Technology. *New Era Insights.* <https://www.new-era-insights.com/article/the-four-main-types-of-water-electrolysis-technology/>

Apera. (2015). Premium Series pH60 pH Tester User Manual v8.3. Apera Instruments LLC.

