Does Synthetic Red40 Dye Absorb into White Chrysanthemum x Morifolium More Than Organic Beet Dye?

Abstract

In this experiment I aimed to explore the effects of red40 dye on *Chrysanthemum x morifolium*, in comparison to those of organic beet juice dye. I hypothesized that nourishing these white flowers with red40 dye-water mixture would produce an outcome of brighter, more vibrant coloration within the petals. To set up the experiment I created a dye from beets and water, and then mixed commercial red food coloring with water as well, in two separate jars. I then used a paper towel to absorb a small amount of each mixture to ensure the vibrancy transfer would be similar. After ensuring the two mixtures were diluted to the same amount to allow a fair chance to each mixture of coloring the plants. The results of my experiment concluded that the organic dye worked just as sufficiently as the artificial dye, and that other than coloration to the petals, no detrimental effects were observed more or less on either test group.

Keywords: organic, synthetic, Red40, sustainability, health, alternatives

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Introduction

This experiment came from an idea curated in order to better understand the impacts of organic vs. inorganic dyes and food additives. In artistic materials the source used to express different hues and values is incredibly important, “Digital printing and pigment-based dyeing processes are becoming popular amongst manufacturers as they dramatically reduce water and energy consumption while enabling faster turnaround with on-demand dyeing capabilities. It can be tagged as better alternatives to textiles made from screen printing.” (Gajanan, Verma, and Tripathi, 2024). However unlike in common foods, the use of synthetic dyes doesn’t harm human bodies or harshly impact the digestive system. When it comes to the products we consume for nutritional purposes, as marketing groups have discovered the human bias towards vibrant and craveable appearance, the “art” of “enhancement” has taken the food industry by storm. "This year the pigments market was valued around $30 billion and is expected to reach ~$35 billion by 2029, growing at a CAGR of ~3%."(Gajanan, Verma, and Tripathi, 2024) This information expresses the strong rate of popularity for the use of pigments and dyes. Seeing as this rate seems to constantly increase, the importance of understanding how natural dyes and synthetic dyes can affect the plants and foods we use for daily consumption is also extremely crucial to our health choices. Fresh cut flowers are often a symbol of care, gifted in times of love, condolence, appreciation, or simply as a kind gesture. When people take ownership of a bouquet of flowers, they spend around a week tending to and gazing at the life form placed on their kitchen table. Watching as different forms of red dye are absorbed, the effects on the flowers and the amount of color that is retained by mixing dyes into the water they use to fuel themselves, can represent

how the different dyes which we implement to many of our meals and snacks can affect our bodies. Keeping this in mind, I hope to use this experiment to explore ways that using naturally derived dyes and pigments for our foods can keep the bright and enthusiastic colorways while also maintaining balance with health and nutrition for our bodies.

Methods

When contemplating this experiment, I considered red40, a highly controversial dye, which has proven to have unhealthy consequences on the body and an alternative form of red dye, beet juice. I hypothesized that nourishing the white *Chrysanthemum x morifolium* with a red food coloring and water mixture would make the flowers absorb more red coloring in their petals. The independent variable in this experiment was the type of food coloring used: synthetic food coloring vs. beet juice. Dependent variables would be the amount of redness within the flower, as well as if there was any difference in the lifespan of each group. The controlled variables I kept were the 17.78cm length stems, 350mL of water/dye mixture in each vase, keeping all vases in the same room with the same lighting and temperature, and splitting the pre-packaged plant food evenly in half, providing about a tablespoon of feed to both the dye-infused vases.

Materials

The materials used in my experiment were three 12.7cm tall mason jars, three beets, a tablespoon of red food coloring, two white cushion pom bunches in each jar, scissors (to cut the stems), 350mL of water-dye mixture, a cellphone camera (to take pictures), a measuring tape and ruler (to measure the height of water relative to the stem as well as the length of the stems), a blender to smash the beets and liquify them by adding small amounts of water (¼ cup at a time).

Figure 1. Image of food coloring used.

Procedures

When curating this experiment I decided to keep as many things constant as possible. Throughout the experiment I kept precise records of changes and results that I was making or observing. To begin the experiment, I measured the amount of water that I see fit to consume the majority of the stems within the jar, without overflowing or depriving the plants. The decided measurement of liquid to fill each container was 350mL. The next step I took in this experiment was to take the freshly bought flowers and cut them each a length of 17.78cm (from the top of the where the center stem ends on a cushion pom flower stem's base), 5.08cm above the rim of the mason jars. I also removed all of the leaves from the stems. I then took three beets purchased from the store, and cut them into similarly shaped pieces, placing each cut up piece (one whole beet along with bits from the tips of their stems) at a time and a ¼ cup of water at a time until it reached the desired constancy of water-like texture while still maintaining the pigment. I then poured only 350mL of the total mixture into a mason jar and continued on to my next step. Following the previous strategy I poured the exact amount of water I needed into a jar and slowly added a teaspoon of food coloring into the water until it reached the desired pigment which matched that of the beet-dye. Once I separated the mixtures into their designated

containers, I took the prepackaged flower food and measure it to be roughly two tablespoons, then I transferred the measured powder to a tablespoon and dumped one into each jar–I must note, the transferring process along with the loose measuring must have added to the total percent yield in this experiment. The final step in my experiment was to place two bunches of pom flowers in each jar containing a dye-water mixture, and the one left over into the plain water jar(this jar did not contain any of the flower food as it was easier to split the pre portioned food in half than ⅓s) and then to observe the changes throughout the days. All of the vases were placed on the same table, adjacent to each other, the temperature of the house remained regulated as if the flowers were being cared for as a regular bouquet for non-scientific purposes.

Figure 2. These are images of the two jars containing dye-water mixture, pictured left is beet juice dye, pictured right is red40 food coloring. The paper towels were separately dipped in their designated jar, pictured left into the organic and pictured right into the synthetic. The paper towels were then held up next to each other (overlapping) to express the dilutedness of each mixture.

Figure 3. This is an image of the three jars with the flowers in each, the experiment remained set like this for the entirety of the observation period (40hours). Pictured left to right: beet dye(organic mixture) two flowers, plain water one flower, Red40 food coloring(synthetic mixture) two flowers.

Results

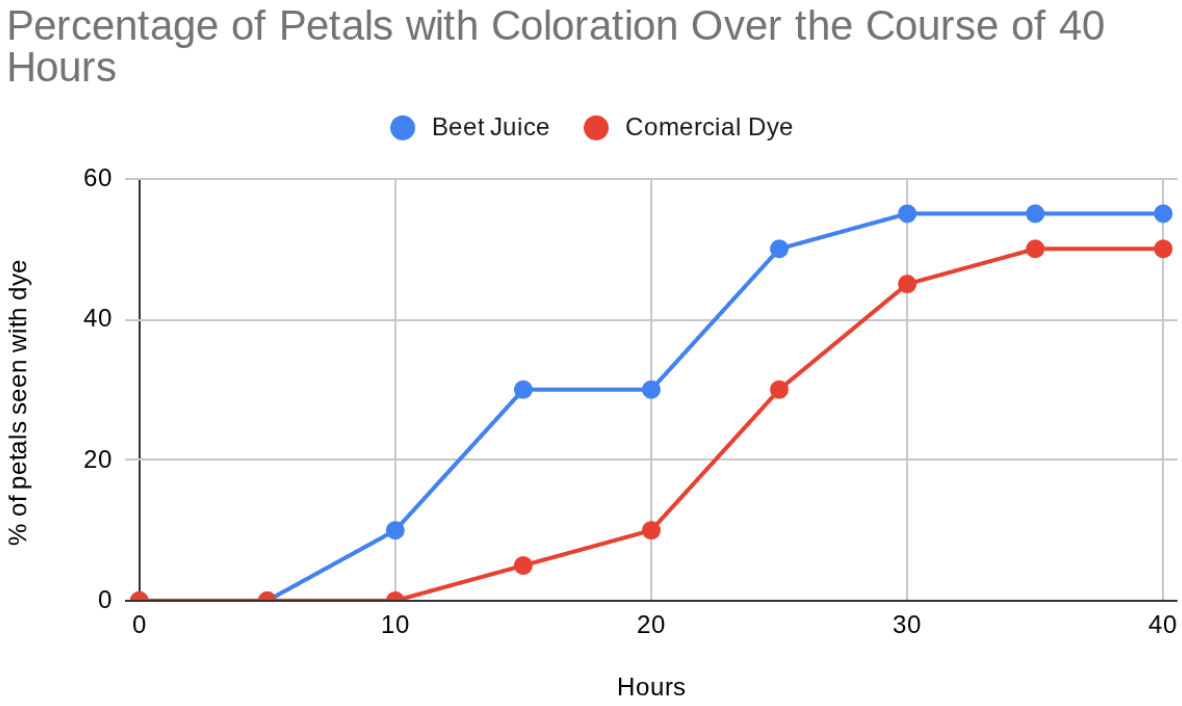

Figure 4. Graph representing the data collected over the 40 hour experiment. Y-axis represents the percentage of petals on the *Chrysanthemum x morifolium*. X-axis represents the hour intervals, data was recorded every 5 hours, the pattern labeled on the graph is grouped by 10's not 5's. Each circle represents the point at which data was collected and what percentage was recorded.

Figure 5. Images represent my interpretation of 10% of petals appearing dyed. These flowers are of the organic group, photos taken at 10 hours into the experiment duration.

Figure 6. Images represent my interpretation of 5% of petals appearing dyed. These flowers are of the synthetic group, photos taken at 15 hours into the experiment duration.

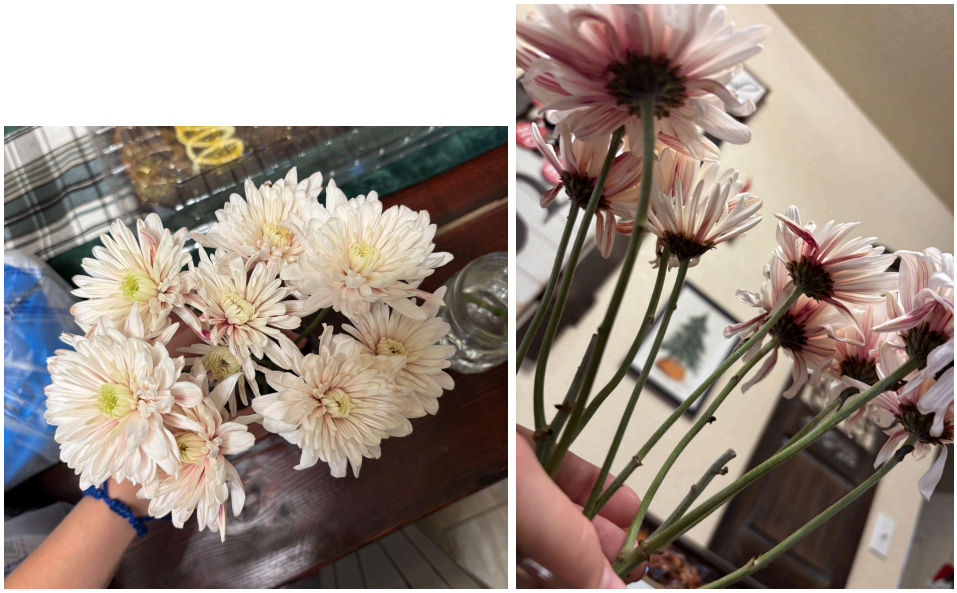

Figure 7. Images represent my interpretation of 55% of petals appearing dyed. These flowers are of the synthetic group, photographed at 30 hours into the experiment duration.

Figure 8. Images represent my interpretation of 50% of petals appearing dyed. These flowers are of the synthetic group, photographed at 35 hours into the experiment duration.

Conclusion

The goal of this experiment was to discover whether organically prepared dye would be absorbed into a flower with the same efficiency as artificial dye. The data concluded that the type of dye used, whether it be artificial or organic, did not take a large toll on the end result of the coloration within the cushion poms. Evidence provided to prove this conclusion was that after 40 hours of observation, the flowers absorbed a very similar amount of dye ranging from 50-55% of petals being colored, as shown in figure 4. This result directly rejects my hypothesis that infusing artificial red food coloring to the water being absorbed by the flowers would travel into the white petals, reddening them. During the first trial of this experiment I cut the stems 36cm long, and placed them in 425 mL of water/dye mixture, with both groups of water reaching 4 inches high on the stems. However by the time the flowers began to wilt, I saw barely any coloration in the petals. However the edges of the stems, where the leaves were removed, had retained the red color; this proved to me that it was possible for the flowers to absorb the color of the dye. Due to the process taking a much longer amount of time than I had planned, I decided to go through with restarting the experiment with shorter stems that were cut to 17.78cm, allowing for less travel length. Another variable to note was the method in retracting dye from the beets, in the first method I boiled beets in an unnecessarily large amount of water then decided it was far too diluted and then used some of the somewhat red water to blend with the previously boiled beets, I believe this may have just severely diluted the mixture resulting in absolutely no change within the flowers of this group. Consistent with this error, I diluted the artificial dye mixture to match that of the organic one in order to give each a fair chance, however in doing so I ultimately just removed the chances entirely. The contrast between the pigment of the paper towels used to absorb a small amount of dye from the first trial when compared to the second would be highly

less bright and therefore would explain the drastic variation in my experiment's results. Another change made during the second trial of my experiment was the type of flowers used. I originally studied the effects on white carnations, then I chose cushion poms to use for my updated experiment. I don't feel as though the change in flowers really contributed to the change in my results, however it is an important note to make regardless.

Through my pre-experimental research I discovered information about starch, a distinctive ingredient in red 40 dye, which was present in the artificial dye I chose to study in my experiment, "A recent study indicated that starch after chemical modification rather than physical modification could significantly change the rheological properties of ketchup"(Tan and Nie, 2021) this idea raises health concerns due to the following information: "emulsifiers and artificial sweeteners, including chronic systemic inflammation, increased intestinal permeability, bacteria translocation and metabolic disorders, despite their long-term safety record (Suez *et al*. 2014; Chassaing *et al*. 2015; Chassaing *et al*. 2017)."(Tan and Nie, 2021). With this knowledge, I am brought to question whether the artificial dyes we consume on a daily basis might be too dangerous to proceed a healthy symbiotic relationship with.

Discussion

What meaning does this evidence withhold? How can the knowledge retrieved through the observations made affect future precautions taken in the food industry? Through my experiment I hoped to prove that artificial dyes being absorbed by a flower will show how dangerous it is for it to be absorbed by our bodies when consuming it. This idea however was proven incorrect as when I put my hypothesis to the test I was shown that the flowers did not experience any faults or detrimental effects from the artificial dye. The results received didn't match what I expected, which proved to me that although observing these flowers absorb dye

isn't a great representation on how the dyes can affect the human mind and body, it expressed that organic dye can be used just as sufficiently as synthetic dyes. I discovered an article relating ADHD and SULT1A inhibitors which are present in red40 as well as some natural foods, such as beets. An important note made in one of these articles is, "Eight publications provided evidence of ADHD symptoms caused by the "inactive" materials containing SULT1A inhibitors." (Eagle, 2014) SULT1A is a compound used by the human body to "normally deactivate catecholamines, especially dopamine formed in the intestines; SULT1A inhibition can influence brain catecholamines through the intermediary of plasma tyrosine levels, which are influenced by dopamine inhibition of intestinal tyrosine hydroxylase."(Eagle, 2014). This information proves to us that even the healthy alternatives to commercial dyes can have the same unfavorable characteristics. It is important to understand that while it is very easy to find yourself constantly surrounded by information that overrides previous beliefs and ideologies, further research is always a helpful method in clarifying what choices to make to benefit your health in the best way possible. There have been various other tests conducted to prove that commercial dyes are baleful. A study I researched on was attempting to portray the eco-friendly alternatives of using natural dyes over synthetic, "The synthetic dye in the wastewater is not biodegradable and can be carcinogenic and toxic to ecosystems" (Becker, Howarth, & Ciesielska-Wróbel, 2024). The scientists in this experiment were able to exhibit results that proved similar to mine, offering an option of sustainable alternatives to commercial dye with the same success rate, "The eco-friendly dyeing methods, particularly those without synthetic chemicals like metallic mordants, showed promise in achieving sustainable coloration." (Becker, Howarth, & Ciesielska-Wróbel, 2024) Contradicting information can alter the ideas surrounding fake dyes and their ultimate impacts on human health along with the environment, but regardless of your

personal bias it is always important to research from every angle that you can in order to see what decisions can be made most compatible with your own lifestyle and preferences. Another article I found expressed the antibacterial characteristics of natural dyes such as those derived from beetroot like that of which I used in this experiment, "All preferred dye plants exhibited antibacterial activity against Pseudomonas spp., and nine of them were effective against Escherichia coli and Proteus spp." (Chervenkov, Ivanova, Bosseva, & Dimitrova, 2024). This study backs up the argument that organic dyes can be sustainable and healthy for humans while also being able to dye products just as sufficiently as commercial dyes.

In future science it is clear that we as a society need to get clear correlations between the artificial dyes and the bad health effects on humans. My experiment, while on a small scale, could be used to show people that if they are struggling to lean one way or another about organic alternatives being induced to their lifestyle, perhaps with more trials it could showcase a pattern of consistent results between artificial and natural dyes. Due to the lack of concise correlation between commercial dyes and unhealthy effects, it is hard to be completely sold on the idea of using an organic alternative. It is important to continue researching dyes like red40 in order to completely understand the strengths and weaknesses of constant consumption of products with these dyes.

References

Becker, P., Howarth, S., & Ciesielska-Wróbel, I. (2024). Eco-Friendly Dyeing Processes of Nylon 6.6 Woven Fabrics with Used Coffee Grounds (UCG). *Sustainability*, *16*(20). http://dx.doi.org.lapr1.idm.oclc.org/10.3390/su16208919

Chervenkov, M., Ivanova, T., Bosseva, Y., & Dimitrova, D. (2024). Cultural Perspectives on the Sustainable Use and Added Value of Plant-Based Food Dyes—A Case Study from Bulgaria. Sustainability, 16(20).http://dx.doi.org.lapr1.idm.oclc.org/10.3390/su16209049

Gajanan Saundarkar, T., Verma, S., Tripathi, D. (2024). Colorants: The Market and Footprints of Colorants Across Different Industries. Chemical Industry Digest, https://link-gale-com.lapr1.idm.oclc.org/apps/doc/A819441198/SCIC?u=azstatelibdev&sid=bookmark-SCIC&xid=cbade481

Eagle K. (2014). ADHD impacted by sulfotransferase (SULT1A) inhibition from artificial food colors and plant based foods. ScienceDirect, https://www.sciencedirect.com/science/article/abs/pii/S0031938414003424

Tan, H., & Nie, S. (2021). Functional hydrocolloids, gut microbiota and health: picking food additives for personalized nutrition. FEMS Microbiology Reviews, 45(4), 1C+. http://dx.doi.org.lapr1.idm.oclc.org/10.1093/femsre/fuaa065