Introduction: Microgreens are a growing product that is becoming popular in consumption and production. The crops contain health-promoting phytochemicals and are nutrient-dense. Many restaurants and farmers are looking for the most efficient way to grow crops that are both aesthetically appealing to the eye and nutritious. Since LED lighting was introduced in plant cultivation, studies about the applicability of LED for indoor cultivation have grown dramatically **(Zhang, et al, 2020).** This study showed that different lights are important for the quality of certain plant characteristics. Red LED light is important for the development of photo-morphogenesis, while blue LED light could affect chlorophyll concentrations, photo-morphogenesis, stomatal opening, and antioxidant accumulation (**Zhang et al, 2020**).

While obtaining the data used in the article as a base research analysis, a video from Youtube, *Onthegrow.Net*, corroborated the findings and provided insight into the experimental growth of microgreen popcorn. The corn prized for its sweet aftertaste, and potentially we can use custom light mixtures to increase the sweetness of popcorn sprouts. The study's purpose was to decide the sweetness of sugars in corn grown with no light and with regular sunlight. In the video, microgreen popcorn is grown under those 2 different light settings and then concludes by comparing them by height and color and determining if it still contains sugar content. In our experiment, Dr. Smith and I took all the information from the youtube video plus the studies on Chinese Kale, grown under different lights, and deduced the question; How much sugar can the microgreens of corn contain under different light variations? Limited research has shown that increasing blue light can increase concentrations of antioxidants, essential oils, and phenolics. Therefore narrow-spectrum LED lighting has the potential to increase the growth, flavor, and aroma of culinary herbs (Currey et al).

The experiment is conducted with a base light comparison of blue and red, to the following lights: green, UV, far-red, blue, Low PPFD (Photosynthetic Photon Flux Density), and an instance of no light. By synthesizing information, we have conducted a study that analyzes the differences in light treatments and their effects that cause higher or lower amounts of sugar. The chlorophyll and carotenoid extractions were made to test if the color of the microgreens also changed and to see the quantitative differences between each test. In the end, the microgreen with the sweetest and best variation can change the culinary meals' appearances and flavor. The chlorophyll and carotenoids were extracted upon reading the light's effects on the gustatory system and human health compounds; carotenoids. The chlorophyll extraction was specifically to measure and observe the amounts of chlorophyll created in the different light variations. In this experiment, Microgreen corn was cultured under different red: blue, and other LED variations, to investigate the sugar accumulation, Chlorophyll production, Carotenoid creation, and color and length differentials.

Methods and Results: This experiment was conducted in the Milton Hershey School Horticultural center. 32 groups of microgreen popcorn with 15-16 grams of kernels in each, soaked in water overnight and covered with a lid to block off the light. With Dr. Smith's help, the microgreens were cultivated in Pro-Mix BX potting media (from Griffin Greenhouses) and split into a 32 cell insert tray with overall dimensions of 10x20 inches. After planting kernels in each container, the microgreens were left to grow in a greenhouse. After the microgreen leaves started to show, they were illuminated under different light treatments.

Light Recipes	PERCENTAGES					
	Red	Green	Blue	UV	Far Red	TOTAL %
Base recipe Samples 11+12	85.0%	0.0%	15.0%	0	0	100.0%
Blue-enriched Sample 7+8	75.0%	0.0%	25.0%	0	0	100.0%
Green-enriched Samples 3+4	68.0%	20.0%	12.0%	0	0	100.0%
UV-enriched Samples 1+2	78.2%	0	13.8%	8.0%	0	100.0%
Far Red-enriched Samples 9+10	68.0%	0	12.0%	0	20%	100.0%
Low ppfd Samples 13+14	85%	0	15%	0	0	100%
Zero ppfd Samples 5+6	0	0	0	0	0	0

Table 1: *The percentages of the different light photon fluxes. Each variation amounted to 100% and was based on the base recipe of red and blue.*

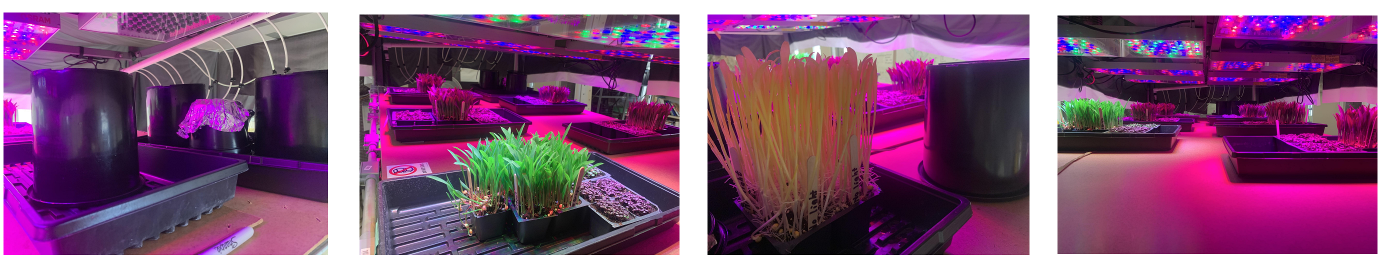

Figure 1: *Pictures of the microgreen popcorn at various stages of growing under the light array.*

In this experiment, Dr. Smith and I are conducting a test to examine which variances of light waves affect the product's taste and image. Our experiment includes three tests: Sugar quantification, Chlorophyll assay, and carotenoids extraction. Plants on earth evolved with the solar radiation broad-spectrum, and so when grown under electric light that doesn't have all the wavelengths that are like sunlight, they biochemically respond. This gives the plants a unique appearance and size. The LED lights were provided from the Milton Hershey School Horticulture center. The plants were illuminated for 12 hours per day for 5-6 days under 7 light treatments. The total ppfd in all treatments was 140 umol/m^2/s, except for the low ppfd (70) and the zero ppfd treatments.

Sugars were extracted from the samples of Microgreen popcorn grown under each light treatment. The microgreens were cut off by their stems and weighed to an amount of about 10 grams in each group. They were ground up in a mortar and given a dilution of distilled water at room temperature. Each sample has two different dilutions; 10ml and 50ml, in order to confirm tests of sugar content in each category. The sample was poured into an Erlenmeyer flask and stirred within a magnetic stir for 20 minutes. After they were filtered through filter paper, then the filtrate was pushed through a 0.45 mm filter disk, using a 5 mL syringe, into an autosampler vial to be run through HPLC (High-performance liquid chromatography) at the Hershey Technical Center.

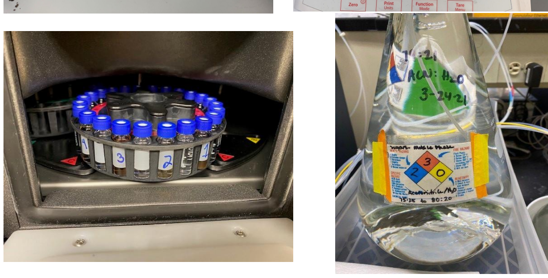

Figure 2: *Various photos of the extraction process and HPLC*

Sample Number	Sample Description	Fructose Concentration %	Glucose Concentration %	Sucrose Concentration %	Maltose Concentration %	Lactose Concentration %
1	+UV	0.13	1.0	<0.02	0.06	<0.02
3	+G	0.07	0.70	<0.02	0.04	<0.02
5	No Light	0.18	0.92	<0.02	0.04	<0.02
7	+B	0.15	0.96	<0.02	0.07	<0.02
9	+FR	0.03	0.10	<0.02	0.04	<0.02
11	Base	0.08	0.57	<0.02	0.05	<0.02
13	Low PPFD	0.08	0.60	<0.02	0.05	<0.02

Table 2: *HPLC results from the 1:1 samples, Results of samples extracted at the 1:5 dilution ratio gave concentration values that are less than the Limit of Detection (LOD) for this method. LOD for all five sugars is 0.02%.*

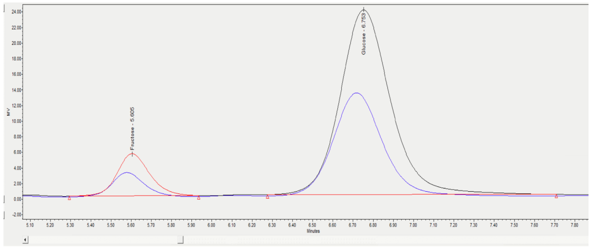

Figure 3: *This is an overlay of the Chromatograms for sample #1 +UV and sample #11 Base to show the difference in peak height from a higher concentration sample to that of a lower.*

The HPLC machine (High-performance liquid chromatography) separates, identifies, and quantifies each sugar component. Upon quantification, the amounts of fructose in blue light sample 7 are surprisingly similar in concentration from the no light sample (Table 2). Though in the glucose concentration, the blue light has more glucose and is interestingly close in comparison with the no light. Far red-enriched had lower fructose and glucose.

To extract the chlorophyll and carotenoids, the leftover extraction liquid from the 1:5 dilutions was placed in a cuvette. Using a Vernier SpectroVis Plus Spectrophotometer calibrated with a blank cuvette of deionized water, samples were placed in the spectrophotometer and a full spectrum of absorption was run on 400-750 nm and graphed. Each value calculated the amount of chlorophyll a, b, lycopene, and beta carotene using the method of **Nagata and Yamashita(1992).**

$$\textit{Chlorophyll a (mg/100 mL)} = 0.999A_{663} - 0.0989A_{645}$$

$$\textit{Chlorophyll b (mg/100 mL)} = -0.328A_{663} + 1.77A_{645}$$

$$\textit{Lycopene (mg/100 mL)} = -0.0485A_{663} + 0.204A_{645} + 0.372A_{505} - 0.0806A_{453}$$

$$\beta\textit{-carotene (mg/100 mL)} = 0.216A_{663} - 1.22A_{645} - 0.3044A_{505} + 0.452A_{453}$$

$$\textit{where } A = \textit{absorbance}$$

Sample	Absorbance at 663 nm	Absorbance at 645 nm	Absorbance at 505 nm	Absorbance at 453 nm	Chlorophyll A (mg/100 mL)	Chlorophyll B (mg/100 mL)	Lycopene (mg/100 mL)	Beta-Carotene (mg/100 mL)
2 - UV-enriched	.130	.133	.351	.532	0.117	0.193	0.109	0.000
4 - Green-enriched	.193	.189	.395	.597	0.174	0.271	0.129	-0.039
6 - Zero ppfd	.087	.089	.168	.285	0.078	0.129	0.054	-0.012
8 - Blue-enriched	.186	.187	.446	.697	0.167	0.270	0.139	-0.009
10 - Far Red-enriched	.139	.142	.299	.437	0.125	0.206	0.099	-0.037
12 - Base	.103	.109	.302	.494	0.092	0.159	0.090	0.021

14 - Low ppfd	.100	.107	.333	.535	0.089	0.157	0.098	0.032

Table 3: *The absorbance levels at each light treatment and calculated amounts of Chlorophyll A/B, Lycopene, and Beta-Carotene in each light treatment.*

An interesting analysis is that sample #8 of Blue enriched light has an amazing amount of Chlorophyll A/B. Compared to the base light level of sample #12, the light percentages close in comparison, though the blue-enriched provides more. While the nutrient levels differ as well, in table 2 the levels of sugar are completely different and have a gap between the 2 samples.

Conclusion/Discussion: We have demonstrated that samples containing more UV light treatment had a stupendous increase in all sugars apart from, Sucrose and Lactose. Sucrose may be an important sugar for humans, but as shown in the data sucrose or lactose are abundant in neither of the samples of light treatment. As for Glucose, it has been analyzed to become more abundant under the +UV and +B treatment. A combination of blue, red, and UV can enhance both crop quality and the production of Chlorophyll A/B, Lycopene, Beta-Carotene, and different sugar extractions. In this study, the increase in blue, UV, and absence of light treatments presented higher contents of fructose and glucose than the others. We believe we would produce better results if the experiment replicated again because due to time constraints we only had one measurement per light treatment whereas, glucose is increasingly rich in the UV samples and this makes an efficient reliable source that chefs can use. This production process allows for the sweetest and best nutritional-based growth for producers to sell, giving a sweeter and better health-benefiting product that will surely attract more sales. The high amounts of fructose, glucose, chlorophylls A/B, and lycopene produced in +B and +UV treatments allow the growth of the microgreens to be more nutritious without compromising the sweetness, and increasing production.

References:

- Zhang, Yiting et al. “Growth, Nutritional Quality and Health-Promoting Compounds in Chinese Kale Grown Under Different Ratios of Red:Blue LED Lights.” Agronomy 10.9 (2020): 1248. Crossref. Web.
- Snowden, M. C.. “Effects of blue and green light on plant growth and development at low and high photosynthetic photon flux.” (2015).
- Kopsell, Dean A., Carl E. Sams, and Robert C. Morrow. "Blue Wavelengths from LED Lighting Increase Nutritionally Important Metabolites in Specialty Crops". HortScience horts 50.9 (2015): 1285-1288. < https://doi.org/10.21273/HORTSCI.50.9.1285>. Web. 6 Apr. 2021.
- “Corn Microgreens - Light vs No Light - On The Grow.” YouTube, YouTube, 15 Apr. 2020, www.youtube.com/watch?v=IADpv-GNAgI.
- Lopez, Roberto, and Erik S. Runkle. Light Management in Controlled Environments. Meister Media Worldwide, 2017.
- Nagata, M., Yamashita, I. 1992, Simple method for simultaneous determination of chlorophyll and carotenoids in tomato fruit. *Nippon Shokuhin Kogyo Gakkaish*, 39(1), 925-928.

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