Exploring Amaranth's Color Palette: Linking Phenotype, Plant Adaptation, and Human Health

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Why Study Amaranth?

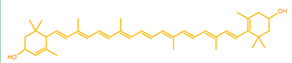
Amaranthus is a genus containing species that are highly desirable, yet underutilized crops and species that are highly despised pernicious agricultural weeds.[1]

- Cultivated species are primarily grown as nutritious pseudograins, colorful ornamentals, or leafy greens and are recognized for tolerance to heat, drought, and salinity.
- Weedy amaranths possess similar adaptive traits, in addition to evolved resistance to numerous herbicides, and pose severe challenges to global agriculture.
- Plant pigments (i.e., betalains, carotenoids) are central to understanding this impressive diversity of phenotypes and adaptive traits.

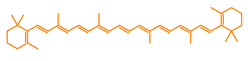
Objective

This project intersects with ongoing research in the Riggins Lab to explore genetic and phytochemical diversity in wild, weedy and cultivated amaranth species. My goal is to apply a simple spectroscopic assay to rapidly screen the diverse phenotypes for pigments. This assay builds upon previous research focused on betalain pigments and applicable uses as natural food colorants.[2] This screening would also reveal patterns of chlorophylls and carotenoids among weedy species (e.g., Palmer amaranth currently holds world record for photosynthetic efficiency in ambient air[3]).

Carotenoids are pigments that are essential to plant growth and function and are pertinent to human health. My study will provide baseline data on these important compounds in unexplored species and pigmented phenotypes suspected of producing high levels of carotenoids.

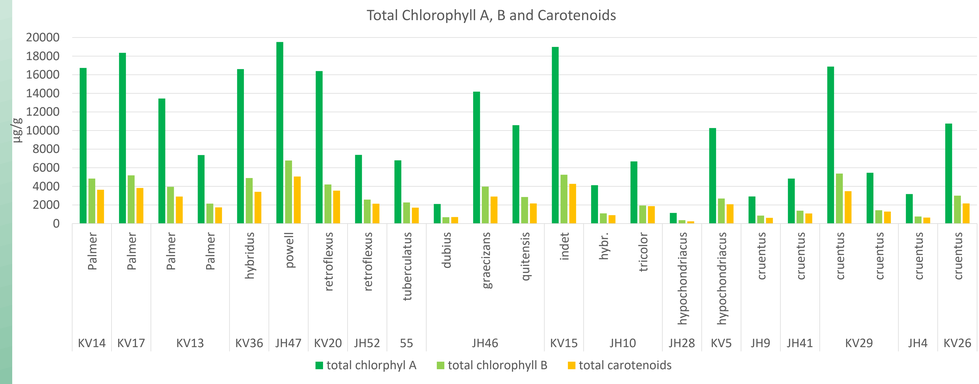


Lutein



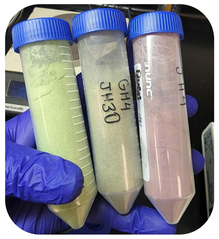
Beta-Carotene

Can Phenotype Predict Pigment Patterns?

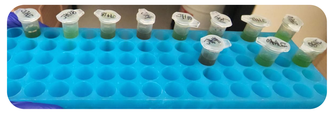


Species	A+B	Car
Palmer	21564	3636
Palmer	23533	3828
Palmer	17386	2903
Palmer	9501.6	1739
hybridus	21492	3415
powell	26285	5053
retroflexus	20589	3533
retroflexus	9959.5	2131
tuberculatus	9065.4	1708
dubius	2788.7	697.5
graecizans	18148	2906
quitensis	13425	2166
indet	24234	4270
hybr.	5217.2	899.6
tricolor	8620.8	1872
hypochondriacus	1504	237.5
hypochondriacus	12961	2076
cruentus	3763.3	611.1
cruentus	6220.9	1081
cruentus	22243	3477
cruentus	6890.4	1283
cruentus	3932.7	638.7
cruentus	13750	2159

Methods



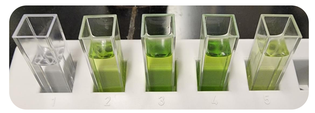
Start with lyophilized, powdered plant tissue



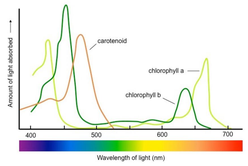
Extract 15 mg in 95% ethanol. Vortex and store at 5 ˚ C for 24 hrs

Vortex and centrifuge at 21100 RCF for 10 minutes

Pipet supernatant to new tubes



Pipet to a cuvette and dilute



Read absorbance at 470nm, 649nm, 664nm & 750nm by UV-Vis spectroscopy

Quantification of Chlorophylls and Total Carotenoids

Beer-Lambert Law relates absorbance to concentration.[4]

$$A = \alpha c l \qquad c = \frac{A}{\alpha \cdot l}$$

Where *A* = Absorbance, α = specific absorbance coefficient (L · g^{-1} · cm^{-1}), *c* = weight concentration (g · L^{-1}), and *l* = pathlength (cm)

Concentrations expressed in µg/g freeze-dried tissue

All measurements done in triplicate

$$Chlorophyll\ A\ (\mu g/g) = \frac{(13.36\ A_{664} - 5.19\ A_{649}) * DF * V}{M * L}$$

$$Chlorophyll\ B\ (\mu g/g) = \frac{(27.43\ A_{649} - 8.12\ A_{664}) * DF * V}{M * L}$$

$$Carotenoids\ (\mu g/g) = \frac{(3.657 A_{664} - 12.762 A_{649} + 4.785 A_{470}) * DF * V}{M * L}$$

Where *A* = Absorbance, *DF* = dilution factor, *V* = extract volume (mL), *M* = plant mass (g), and *l* = pathlength (cm)

Future Work

My research provides preliminary data on photosynthetic pigments across diverse *Amaranthus* species and will inform future steps to identify specific carotenoids using High-Performance Liquid Chromatography. Data from my research contributes new information on amaranth's nutritional traits and the potential roles of pigments as antioxidants that is currently being explored in the Riggins Lab. Additionally, my study provides novel insights on weedy amaranths that are resistant to carotenoid-inhibiting herbicides, which has implications for future studies of plant stress and noxious weed control.

References

1) Riggins and Mumm. 2021. *Curr. Biol.* 31:R821-837.

2) Howard, J. 2020. MS Thesis. Dept. Crop Sciences, UIUC.

3) Sage, R. 2016. *J. Experiment. Bot.* 67:4039-4056.

4) Lichtenthaler and Buschmann. 2001. *Curr. Protoc. Food Anal. Chem.* F4.3.1-F4.3.8.

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