Phytochemical profile of a bread wheat family segregating for purple, red, and white kernel color

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Background

- Antioxidants function by "scavenging" free radicals and slowing cellular damage, reducing risk of human chronic disease *(3).*
- Anthocyanins cause the blue to red color in fruits such as blueberries and raspberries and function as antioxidants *(4).*
- Hard Red Winter (HRW) and Hard White (HW), the main market classes of wheat in the southern and central U.S. Plains, do not produce a significant amount of anthocyanins in the grain.
- Purple wheat has been shown to contain phytochemicals that reduce the risk of cardiovascular disease *(3).*

Objectives

- Confirm differences in anthocyanin concentration among Oklahoma-adapted breeding lines segregating for kernel color.
- Test for correlated effects on total phenolics and antioxidant capacity, if phenotypic variability in anthocyanin concentration is observed.

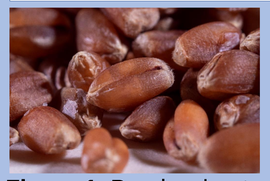

Figure 1. Purple wheat kernels from a progeny of F-Gen14/Smith's Gold sib//Big Country.
Courtesy: Todd Johnson, OSU

Figure 2. Three phenotypic classes of wheat. From left to right: purple, white, and red.

Materials and Methods

Genetic Material

- Up to 29 full-sib experimental progeny from the cross, F-Gen14/Smith's Gold sib//Big Country, and the three parents.
- Grain harvested in Yuma, AZ (2020), and Stillwater and Lahoma, OK (2021).
- Three kernel color phenotypes: P, purple (from F-Gen14); R, red (from Smith's Gold sib); and W, white (from Big Country). (Figures 1-3).

Phytochemical Analysis

- Flour extracted with acidified methanol (85:15 v/v, methanol: 1 *N* HCl).
- Samples centrifuged and stored at -20°C until analyzed.
- Total anthocyanin concentrations determined by a colorimetric assay with cyadinin 3-glucoside as the standard *(1, 2).*
- Total phenolic content determined by the Folin-Ciolcateau assay, expressed as gallic acid equivalents *(3, 6).*
- Antioxidant capacity determined with ABTS and DPPH assays by measuring the inhibition of a solution with free radicals, expressed by % inhibition of the free radicals *(5).*
- Subsample values were averaged for each sib line before means comparisons among groups of sibs, using a simple one-sided t-test ($\alpha < 0.05$ considered statistically significant).

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Results

- Purple wheat produced the greatest anthocyanin concentrations across locations and years.
- Purple wheat has higher antioxidant activity than white wheat.
- The purple class has significantly higher total phenolic content than either of the other classes.
- Weathering appeared to play a role in anthocyanin and total phenolics concentration when comparing results of Stillwater (delayed harvest) vs. Lahoma (timely harvest).
- Purple wheat shows highest anthocyanin in the bran; other phenolic compounds may influence the high concentration in the shorts mill fraction of red wheat, albeit at a low proportion of the total kernel weight (<5%).

Figure 4. Concentrations of total anthocyanins (A) and total antioxidant activity (B) among 25 sibs grown at Yuma, AZ in 2020.

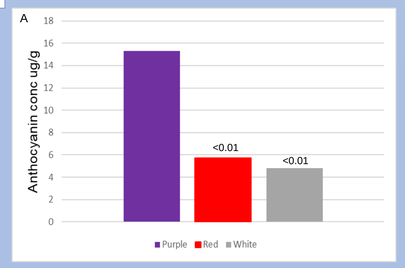

Figure 5. Concentrations of total anthocyanins (A) and soluble phenolics (B) among 29 sibs grown at Lahoma, OK in 2021.

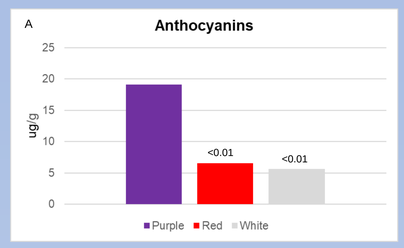

Figure 6 . Concentrations of total anthocyanins and soluble phenolics among 20 purple progenies at two locations, Stillwater and Lahoma OK, in 2021.

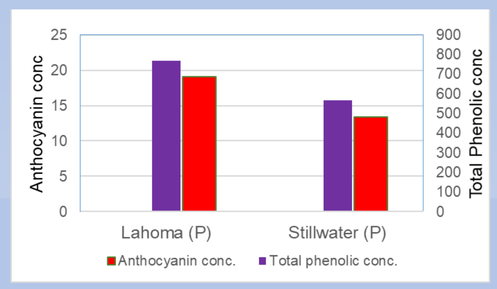

Figure 7. Concentrations of total anthocyanins in the bran, white flour, and shorts mill fractions from Lahoma, OK in 2021.

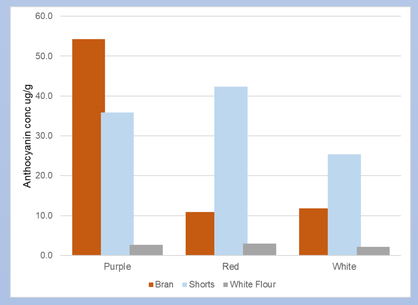

Table 8. DPPH activity among a subset of sibs from Lahoma, OK in 2021.

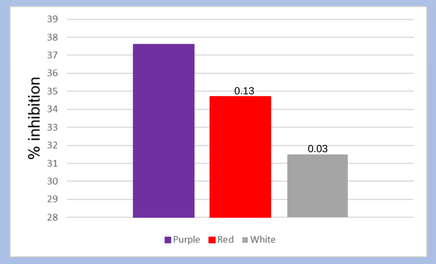

Figure 3. Purple wheat spike near full maturity.

Discussion

- Comparison of the 2021 locations indicates that timely harvest may be key to preserve pigmentation and nutritional activity in the kernel.
- Estimates of antioxidant capacity differed between 2020 and 2021 due in part to procedural changes.
- Further investigation is needed to quantify individual phenolics and other molecules that can differentiate wheat flour and influence antioxidant activity.

Conclusions

- Purple wheat might provide health benefits and could lend today's wheat a natural fit to the "health foods" marketplace.
- Future testing will focus on the end-use properties of purple wheat and to ensure the purple brancoat trait, originally introduced from a wild wheat relative, can be packaged into a commercial cultivar adapted to the Great Plains.
- Anti-inflammatory properties will be explored through LPS-stimulated macrophages.

References

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