Carotenoid Content and Composition in Relation to Dough Sheet Yellowness of Hard Red Spring Wheat

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Introduction

Yellow pigment content is of significance for hexaploid wheat (*Triticum aestivum* L.). While bright flour color is important, the preference for yellowness is end-product dependent. To better understand the wheat pigments in relation to flour/dough sheet color, this research was conducted to investigate the inter-relationships between flour total yellow pigment (TYP) content, carotenoid content and composition with the yellowness (b*) of dough sheet. Forty-three bread wheat and eight durum cultivars were selected for this study based on their diverse TYP contents. Bread wheat and durum samples were milled into flour and semolina, respectively. Flour water dough sheets were prepared with a small pasta sheeter, and their colour characteristics were measured with a Minolta Chroma Meter CR-410. Carotenoid composition was identified using RP-UPLC.

Materials and methods

Wheat samples

Thirty-six hard red spring wheat cultivars, seven hard red winter cultivars, and eight durum cultivars were selected from 2020 Canadian wheat variety registration trials. Each varietal composite was prepared from wheat grown at multiple locations in western Canada.

Milling

For bread wheat cultivars, flours were generated on an experimental Buhler MLU 202 test mill following AACC International Approved Method 26-21.02. Semolina was prepared with a four stand Allis-Chalmers laboratory mill (West Allis, WI, USA) in conjunction with a laboratory purifier following the mill flow previously describe by Dexter et al. (1990).

Water dough sheet color measurement

Water dough sheet was prepared with a small pasta sheeter (Imperia RMN220 Electric Pasta Machine, San Francisco, USA). In a typical experiment, 45 g of flour is mixed with water (35% absorption) using a SpeedMixer (Hauschild GmbH & Co. KG, Germany) at 3000 rpm for 30 seconds. The resulting dough crumb is molded by hand into a rectangle shape and then subjected to 10 sheeting passes. After the final pass, the dough sheet is folded and stored in a plastic bag or airtight container to prevent moisture loss. Colour measurements are taken on the folded dough sheet 2 hours after the completion of sheeting using a Minolta colorimeter with D65 illuminant.

Determination of total yellow pigment content (TYP)

A micro scale rapid extraction procedure as described by Fu et al. (2013) was used for determination of total yellow pigment (TYP) content of semolina and flour.

Determination of pigment composition by RP-UPLC

Flour and semolina were first extracted with water saturated n-butanol on a Tissue Lyser for 5 min at 30Hz/s, followed by constant shaking on microfuge mixer for 1h. Extracts were then centrifuged for 10 min at 15000 g and filtered through 0.2 µm PVDF syringe filter. Carotenoids were separated using Acquity I-Class UPLC equipped with a BEH 300 C18 column (2.1 x 10 mm i.d. 1.7 µm), preceded by a C18 guard column (2.1 x 5 mm, i.d., 1.7 µm). Extracts were eluted with a 27 min gradient using solvents A (5 mM ammonium acetate/methanol/ACN/ethyl acetate, 50/22.5/22.5/5) and B (ACN/ethyl acetate, 50/50). Data were collected at 1 nm increments with photodiode array detector set in the range of 210 to 500 nm.

Results

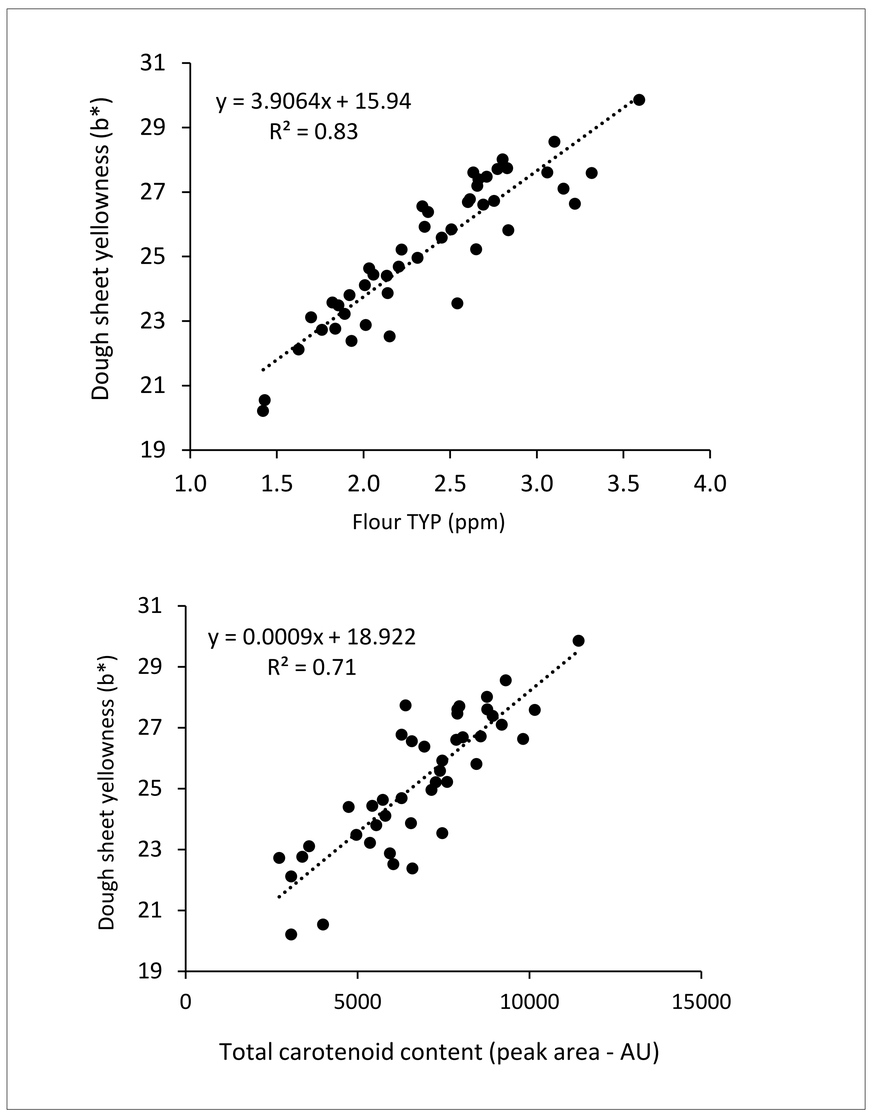

Figure 1 Relationships of flour TYP and total carotenoid content with dough sheet yellowness

- Wide variation in dough sheet yellowness was seen for bread wheat cultivars with b* varied from 20.2 to 30.0
- Difference in b* was mainly attributed to difference in flour TYP content (1.4 to 3.6 ppm)

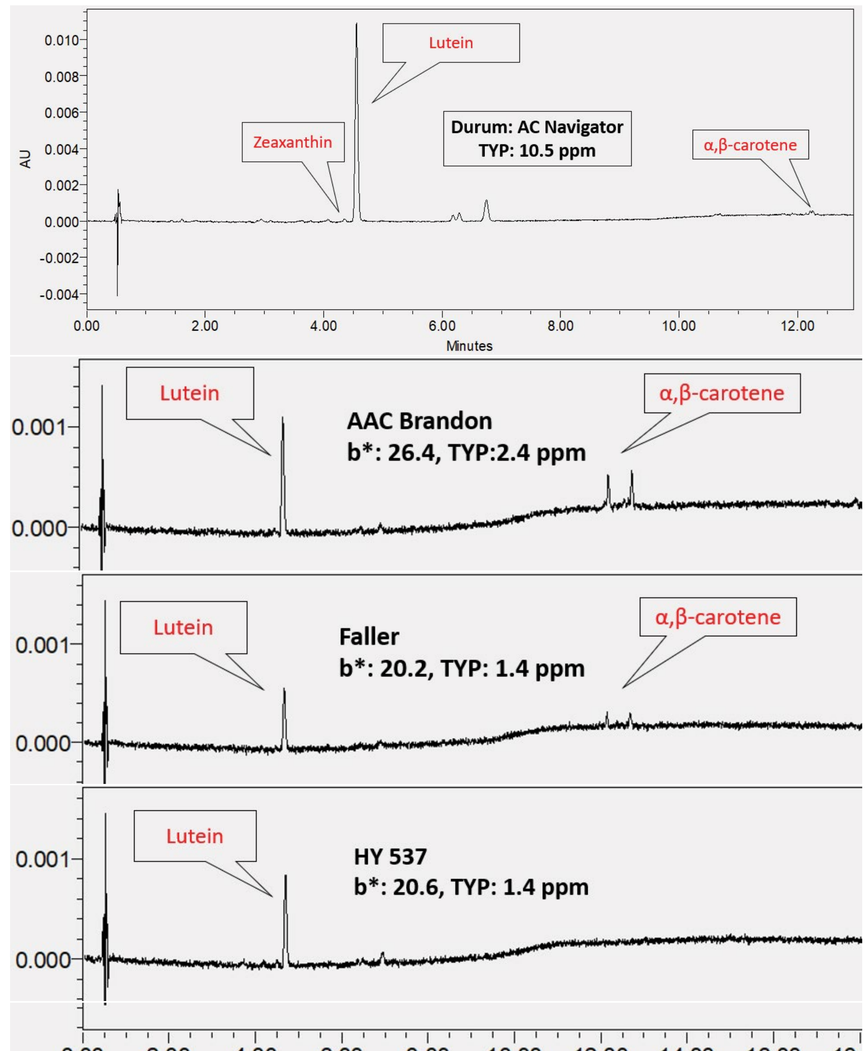

Figure 3 Selected sample chromatograms of durum variety AC Navigator and hard red spring wheat cultivars with wide range of dough sheet yellowness (AAC Brandon, Faller, and HY537)

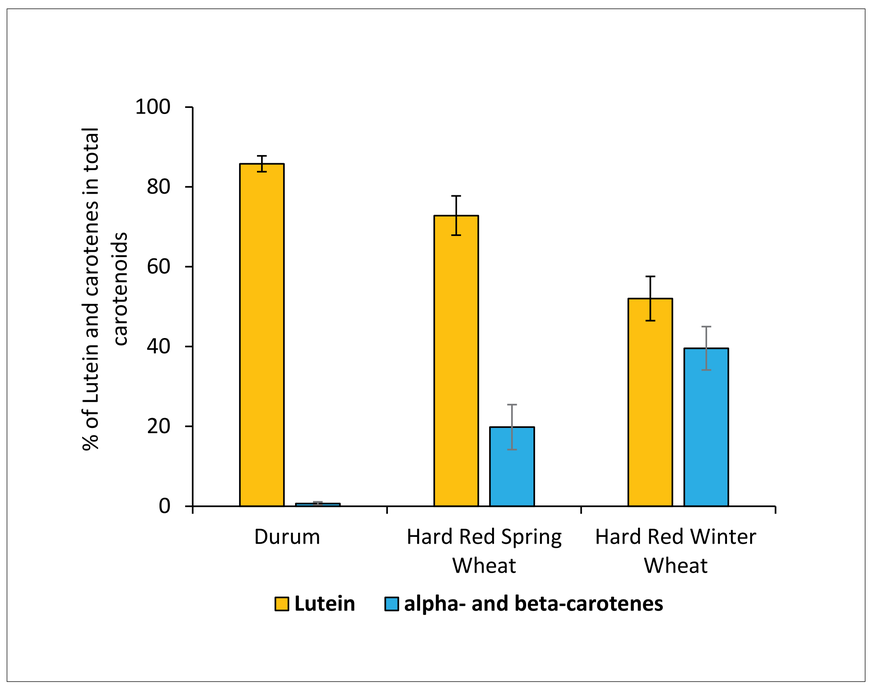

Figure 2 Compositional difference of carotenoid in relation to selected wheat classes

- Carotenoid composition significantly different among selected wheat classes
- *Trans*-lutein represents about 65-75% and 45-55% of total carotenoids in flour samples for hard red spring wheat and hard red winter wheat, respectively.
- In contrast, *trans*-lutein consists of 85-90% of carotenoids in durum semolina

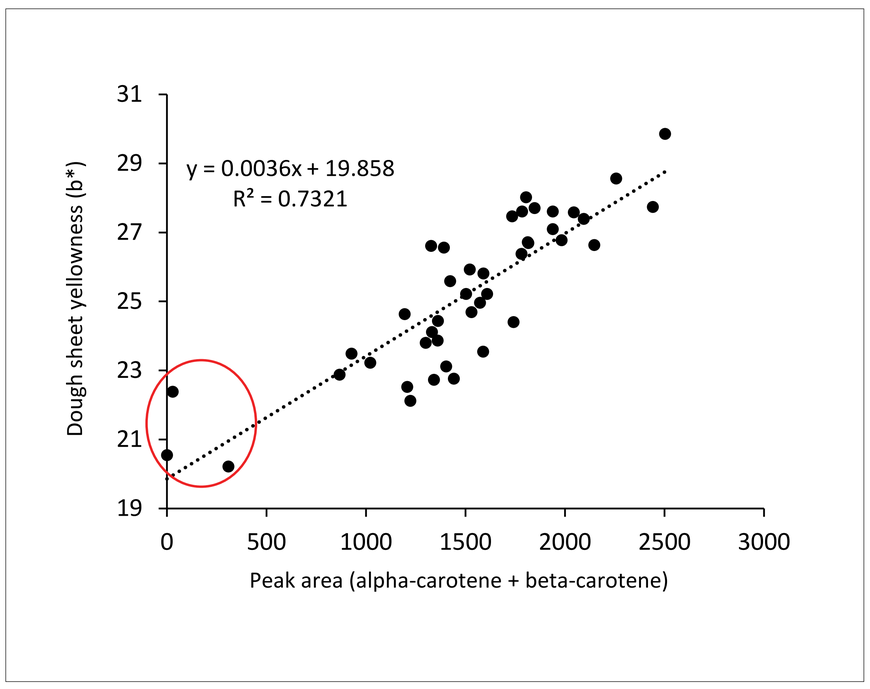

Figure 4 Relationship between dough sheet yellowness and α- and β-carotenes content

- α- and β-carotenes were not detected (or detected in low levels) for cultivars with very low dough sheet yellowness (b* < 22).
- Their absence might be associated with bread wheat genotypes with low TYP and dough sheet yellowness
- As α-carotene is a metabolic precursor to lutein, limiting its formation can result in low TYP content and low dough sheet yellowness

Conclusions

- Total carotenoid content was responsible for most of the variation in dough sheet yellowness
- Greater accumulation of α- and β-carotene in hexaploid wheat (15-45%) than durum (0.2-1.3%) suggests carotenes might play different roles in the carotenoid biosynthetic pathways between those two types of wheats.
- The potential association between carotenoid composition (i.e., presence of α- and β-carotenes) and TYP in some wheat genotypes and classes warrants further study.

References

Dexter, J. E.; Matsuo, R. R.; Kruger, J. R. (1990). The spaghetti making quality of commercial durum wheat samples of variable amylase activity. Cereal Chem, 67, 405-412.

Fu, B.; Schlichting, L.; Pozniak, C.J.; Singh, A.K (2013). Pigment loss from semolina to dough: Rapid measurement and relationship with pasta color. J. Cereal Sci, 57, 560–566.

Acknowledgements

The authors are grateful to Ray Bacala in conducting dough sheet color measurement. The technical support of Yuming Chen and Jerry Suchy in UPLC analysis were also greatly acknowledged.