Influence of Genotype and Harvest Year on Starch Properties of Malting Barley

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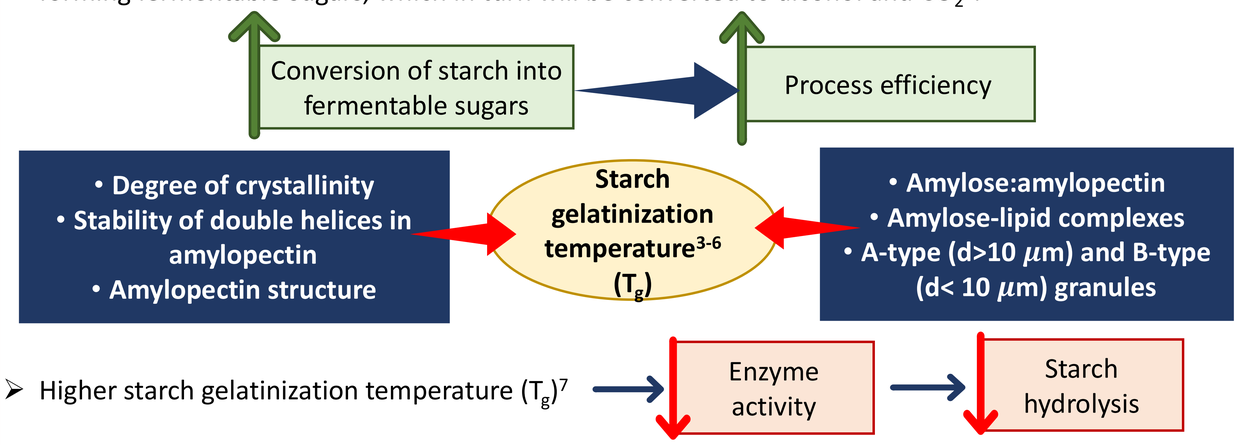
Introduction

- Canada is the fourth largest exporter of malting barley[1].
- In beer production, starch is gelatinized during mashing and hydrolyzed by amylolytic enzymes, forming fermentable sugars, which in turn will be converted to alcohol and CO_2[2].



- Higher starch gelatinization temperature (T_g)[7] → Enzyme activity → Starch hydrolysis
- Starch granule size distribution is likely affected by genotype[8,9] and growing conditions[10,11].
- To date, there are no studies that have evaluated the effect of environment and genotype on the starch properties of Canadian malting barley genotypes and their propensity to enhance brewing yield.

Objective

To investigate the impact of genotype and harvest year on the physicochemical properties of starch in Canadian malting barley genotypes.

Materials and Methods

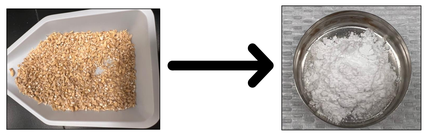
Materials

- Commercially important Canadian malting barley genotypes: AAC Connect, AAC Synergy, CDC Churchill, CDC Copeland, and CDC Fraser.
- Harvest years: 2023, 2024, and 2025

Year	June to August across AB, SK, and MB[12]		
	Temperature	Precipitation	Soil moisture
2023	Hotter in June	Below normal in most regions in June and July.	Very dry all three months
2024	Hotter in July	Well below normal in July	Normal to wet in most regions
2025	Normal temperatures	Mixed in June and July, above normal in August	Mixed, dry to normal in most regions

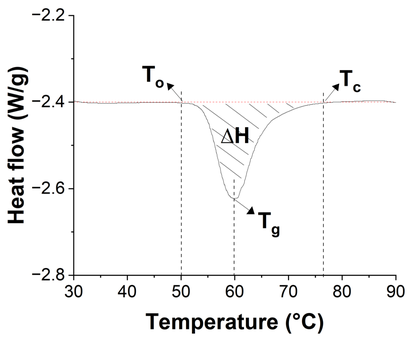
Methods

- **Starch isolation** was performed following You & Izydorczyk (2002)[13]



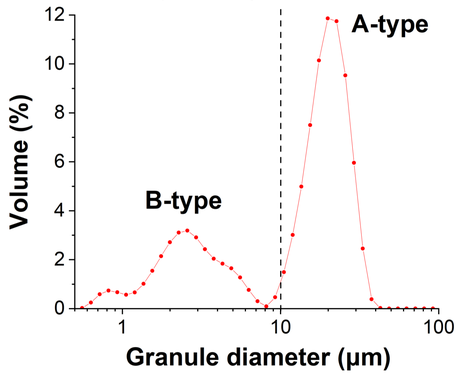
Coarsely ground barley (4 g) → Isolated starch (~2.5 g)

- **Thermal properties**
  - Differential Scanning Calorimetry (DSC, TA Instruments, DSC2500, New Castle, DE, USA)



T_o = Onset temperature; T_g = Gelatinization temperature; T_c = Conclusion temperature; ΔH = Enthalpy.

- **Granule size distribution**
  - Mastersizer 3000 (Malvern Panalytical, Malvern, UK), non-spherical mode.



- **Statistical analysis**
  - ANOVA, Tukey test were performed using OriginPro software (Version 2025. OriginLab Corporation, Northampton, MA, USA).

Results and Discussion

Thermal properties

Table 1. Percentage of total variance for each factor affecting DSC parameters.

Factors	Variance (%)			
	T_o (°C)	T_g (°C)	T_c (°C)	ΔH (J/g)
Year (Y)	33*	76*	1	5
Genotype (G)	16	5	18	42*
G × Y	22	3	38	24
Error	31	12	43	29

*factors significantly (p<0.05) affecting the respective DSC parameter. T_o = Onset temperature; T_g = Gelatinization temperature; T_c = Conclusion temperature; ΔH = Enthalpy.

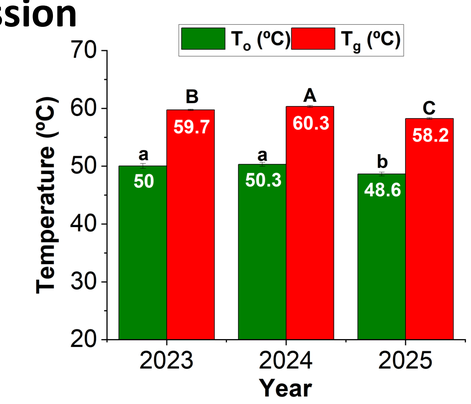


Figure 1. Mean DSC parameters (T_o and T_g) for 2023, 2024 and 2025. Error bars represent SE (n≥10). Means with different letters (lowercase for T_o and uppercase for T_g) are significantly (p<0.05) different.

- Year was the only factor that significantly (p<0.05) influenced T_o and T_g, whereas genotype significantly affected the enthalpy (ΔH), that is, the energy required for starch gelatinization (Table 1).
- Samples grown in 2024 exhibited a higher T_g and required slightly higher temperatures to start the gelatinization process (T_o), while samples grown in 2025 showed the lowest T_o and T_g (Figure 1).
- CDC Churchill exhibited the highest ΔH value, that is, the greatest energy per unit mass required for gelatinization, whereas AAC Connect showed the lowest ΔH, requiring the least energy (Figure 2).

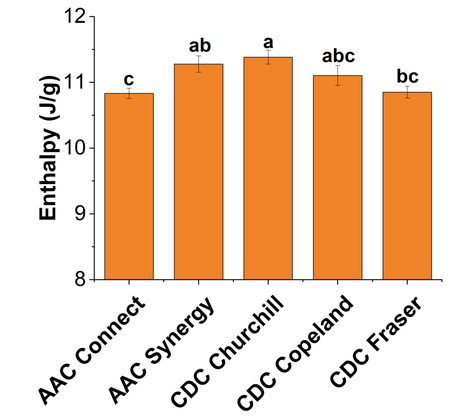


Figure 2. Mean Enthalpy (ΔH, J/g) for five Canadian malting barley genotypes. Error bars represent SE (n≥6). Means with different letters are significantly (p<0.05) different.

Granule size distribution

- Both year and genotype significantly (p<0.05) affected the volume of B- and A-type starch granules.
- Samples grown in 2024 showed significantly lower volume of B-type granules and higher volume of A-type granules (Figure 3).
- AAC Connect exhibited the highest volume of A-type granules and the lowest volume of B-type granules, whereas CDC Fraser and AAC Synergy showed the highest and lowest volumes of B- and A-type starch granules, respectively (Figure 3).

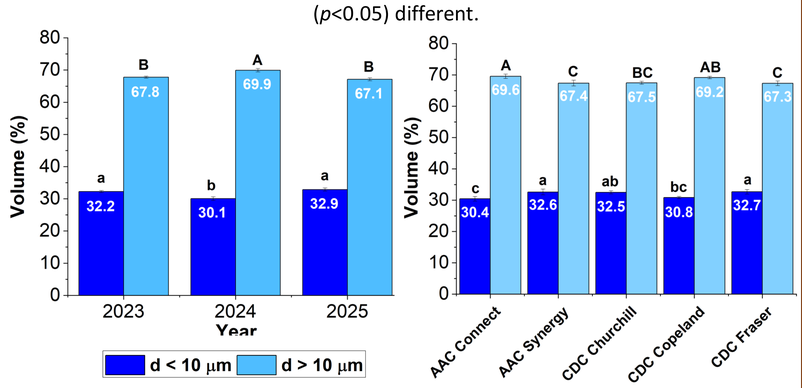


Figure 3. Volume (%) of B-type (d < 10 μm) and A-type (d > 10 μm) starch granules per year or genotype. Error bars represent SE (n≥10) for year and SE (n≥6). Means with different letters (lowercase for B-type and uppercase for A-type granules) are significantly (p<0.05) different.

Final message

- Starch thermal properties (T_o and T_g) were significantly influenced by harvest year, whereas genotype had a significant effect on the energy required for starch gelatinization (ΔH).
- Harvest year and genotype also significantly affected the volume (%) of A- and B-type starch granules, which could partially explain the changes in the starch thermal properties.
- Further studies are required to understand the impact of harvest year and genotype on other factors, e.g., the degree of crystallinity, the amylopectin molecular structure, and the amylose-to-amylopectin ratio, and how they influence starch thermal properties.

References

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