



Canadian Grain
Commission

Commission canadienne
des grains



Improving the Fermentability of Canadian Malt

Aaron MacLeod, Canadian Grain Commission

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Canada 

Project Background

- **It started with a conversation over a beer**
- **The goal of Strategic Project Grants is to increase research and training in targeted areas that could strongly enhance Canada's economy, society and/or environment within the next 10 years.**

Strategic Project Objectives

1. Validate a new rapid, small scale fermentability assay.
2. Examine the effects of common seed-borne barley disease organisms on fermentability.
3. Develop tools for screening and development of more fermentable Canadian barley germplasm/varieties
4. Understand of the influences of barley variety and enzyme activity on fermentability.

Fermentability

- **What is fermentability?**
 - The effective conversion of fermentable sugars to alcohol by yeast
 - impacted by malt quality, yeast vitality, and brewhouse conditions
- **In addition to source of fermentable sugars, malt must supply essential micro-nutrients for yeast and may contain pro-and anti-fermentation factors**

Fermentability Assays

- **Attenuation limit**
 - Rapid (24 hours)
 - Congress Wort
 - Excess yeast
- **Broth Method**
 - Rapid (24 hours)
 - Wort & maltose syrup
 - Low pitching rate

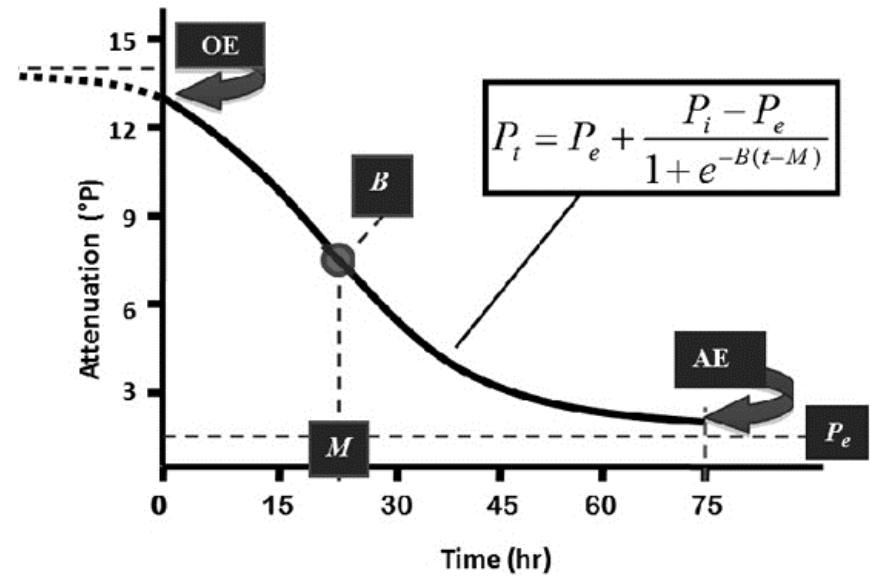
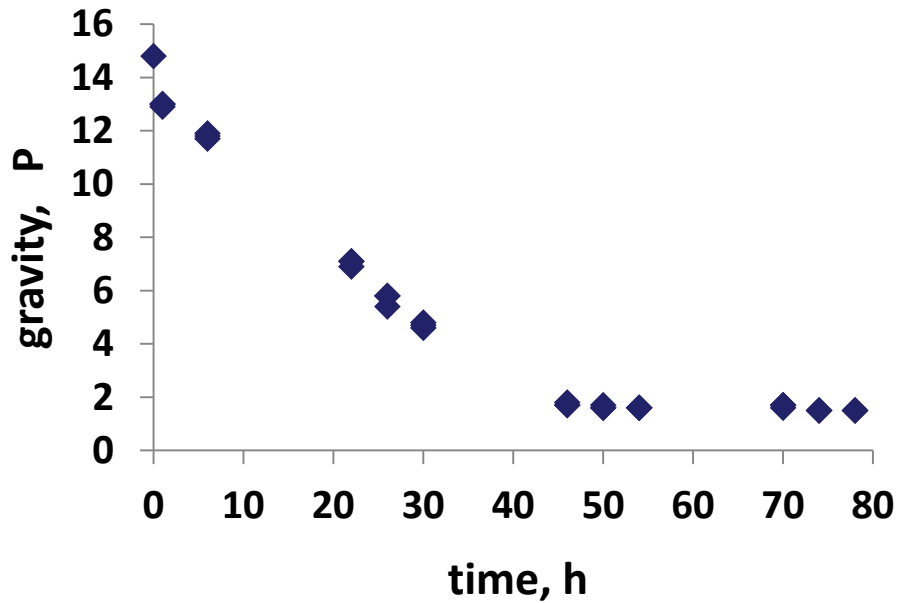


Miniature Fermentation Test

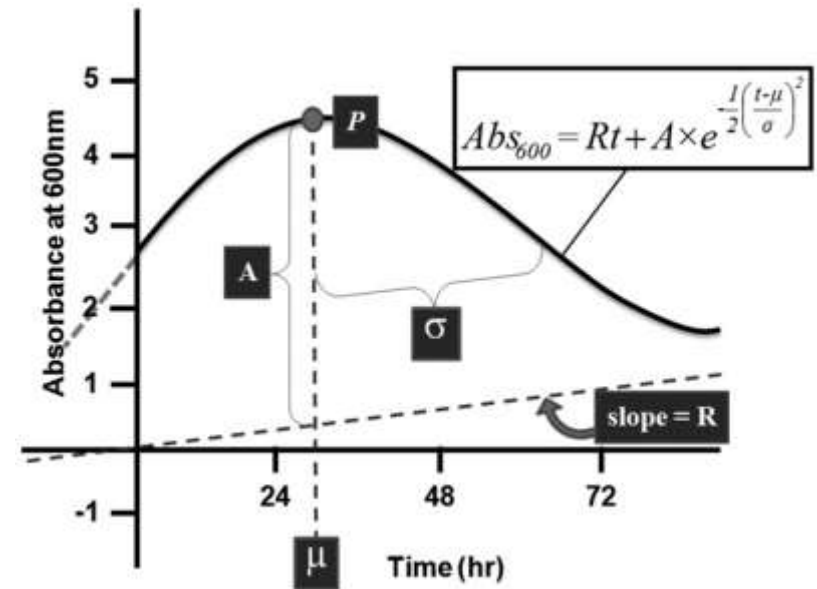
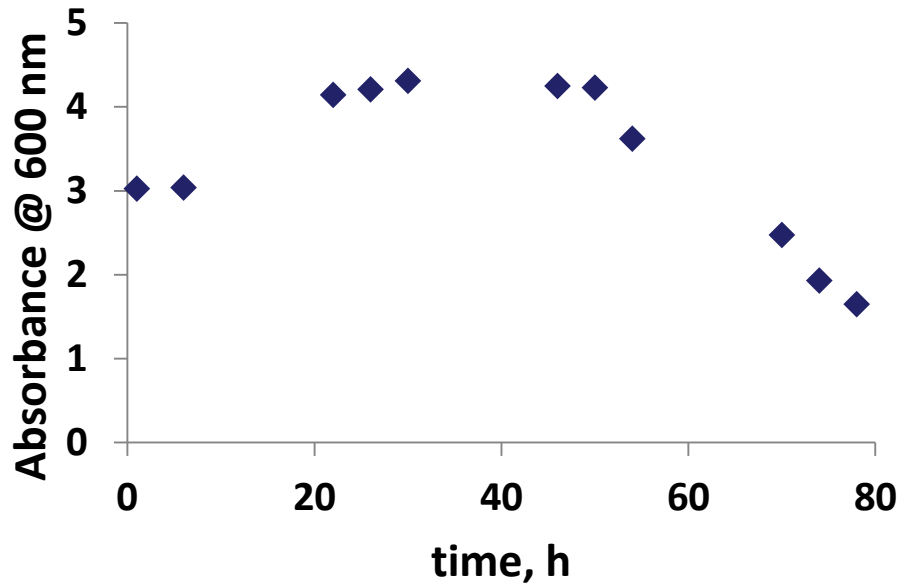
- 15 mL of wort in 30 tubes
- Density & turbidity measurements taken at 10 time points over 75 hours @21 C
- Model the decrease in gravity and yeast in suspension,
- Adopted as ASBC Official Method (Yeast-14)



Modeling decrease in density



Modeling yeast in suspension



Premature Yeast Flocculation

- **What is PYF?**
 - Early sedimentation of the yeast which results in incomplete conversion of sugars to alcohol
 - Suspected to be related to microbial contamination on barley
- **There are no indicators for PYF positive malt found in any conventional malt analysis**

Effect of Fungal Infection on Fermentation

- **Fungally infected barley subjected to pilot malting**

Variety	Innoculum
AC Metcalfe	Control
CDC Bold	Control
AC Metcalfe LDN	net blotch (<i>P. teres</i>)
CDC Bold LDN	net blotch (<i>P. teres</i>)
AC Metcalfe NSF LDN	spot blotch (<i>C. sativus</i>)
CDC Bold NSF LDN	spot blotch (<i>C. sativus</i>)
AC Metcalfe FHB	<i>F. graminearum</i>
CDC Bold FHB	<i>F. graminearum</i>

Effect of Fungal Infection on Fermentation

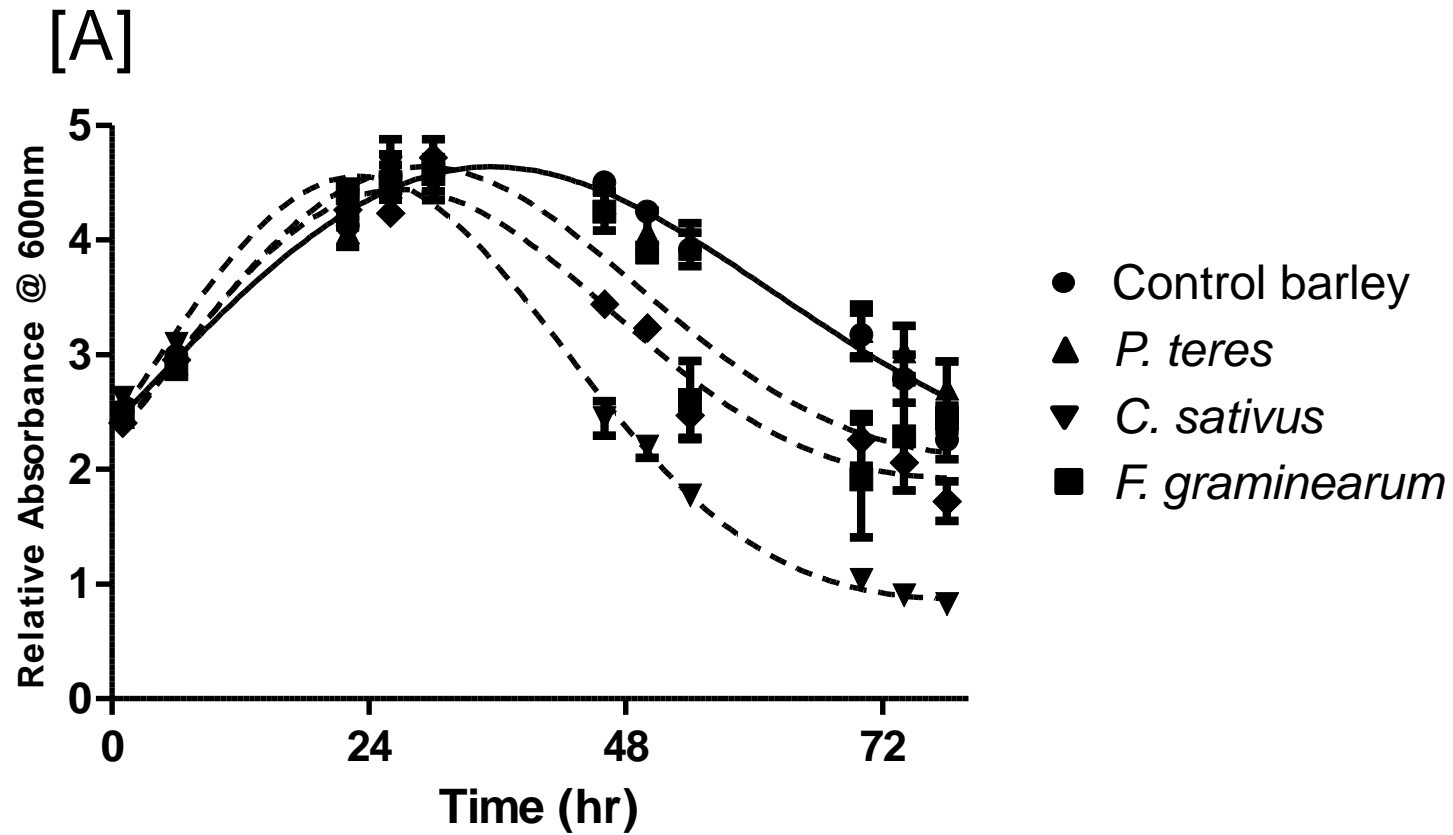


Control barley
(CDC Bold)



Net blotch Nursery
(CDC Bold)

Effect of Fungal Infection on Fermentation



Association Mapping

- **91 genotypes selected from the Western Canadian 2R Coop**
- **SNP genotyping**
 - BOPA1 Illumina GoldenGate® Assay
 - 1,536 SNPs
 - University of Minnesota
- **malting and malt analysis**
 - malting at CDC, analysis at GRL & Dalhousie
 - Extract, Friability, Soluble Protein, FAN, Amino Acids, Fermentability

Correlations with malt quality

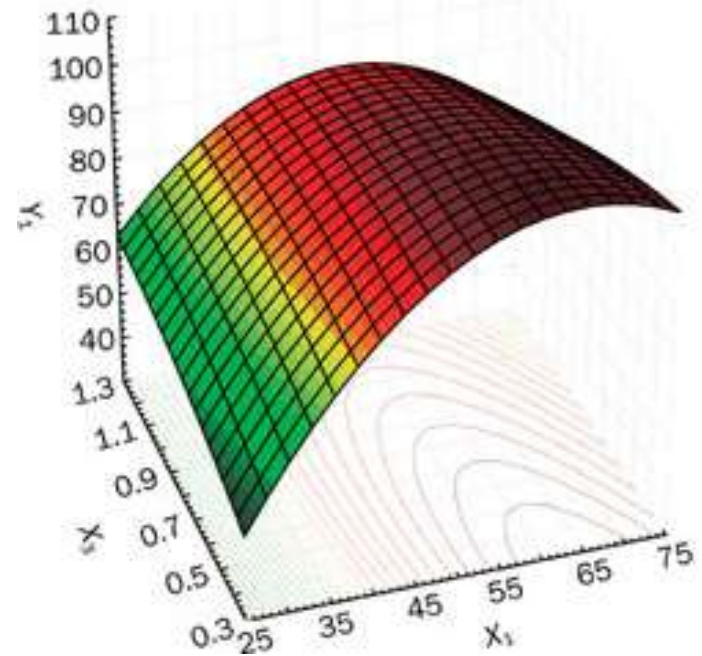
	EBC	Broth	Mini
Extract, %	0.697	0.536	0.557
Soluble Protein, %	0.762	0.935	0.731
B-glucan, mg/L	-0.780	-0.801	-0.763
Diastatic Power, L	0.796	0.761	0.748
Alpha Amylase, D.U.	0.704	0.793	0.696
FAN, mg/L	0.751	0.946	0.743
Friability, %	0.657	0.570	0.600

Fermentability Loci

Trait	Unigene (35)	Chromosome	cM	P-Value	Other Traits
EBC	45406	1H	107	0.0002	BG
Speers	16004	2H	10	0.0002	
EBC	15511/17047	2H	52	0.0002	
EBC/Broth	16494	2H	71	0.00001	AA, BG, DP, FAN, Extr, SP, Gln, Leu, Lys, Ser, Phe
Speers	2001	2H	127	0.0002	BG, Ext, FAN, Leu, Ser, Phe
Broth	19747	3H	102	0.0002	
Broth	5138	4H	20	0.00001	Extr, FAN, SP, Gln, Leu, Ser, Phe
Broth	14662	5H	51	0.0002	DP, Extr, Phe
EBC	3958	5H	70	0.0001	
Speers	15001	5H	179	0.0001	
Broth/EBC/Speers	15894	5H	191	0.00001	AA, BG, DP, FAN, Extr, SP, Gln, Leu, Lys, Ser, Phe
EBC/Speers	16792	6H	112	0.00001	

The Future: Optimizing Enzyme Levels

- Need to better understand the interplay between α -amylase, β -amylase, limit dextrinase
- Model enzyme systems used to study interactions



The Future: Designer Fermentations

- **Traditional definition:**
 - Fermentability is potential for *maximum* alcohol production
 - DP is the standard metric
- **Reframed objective:**
 - Brewers want *control* of attenuation
 - Requirements for different beer styles vary
 - Blending malts based on knowledge of individual enzyme activities

Collaborators

- Dr. Alex Speers, Dalhousie University
- Dr. Michael Edney, CGC
- Dr. Brian Rossnagel, Dr. Aaron Beattie, CDC

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