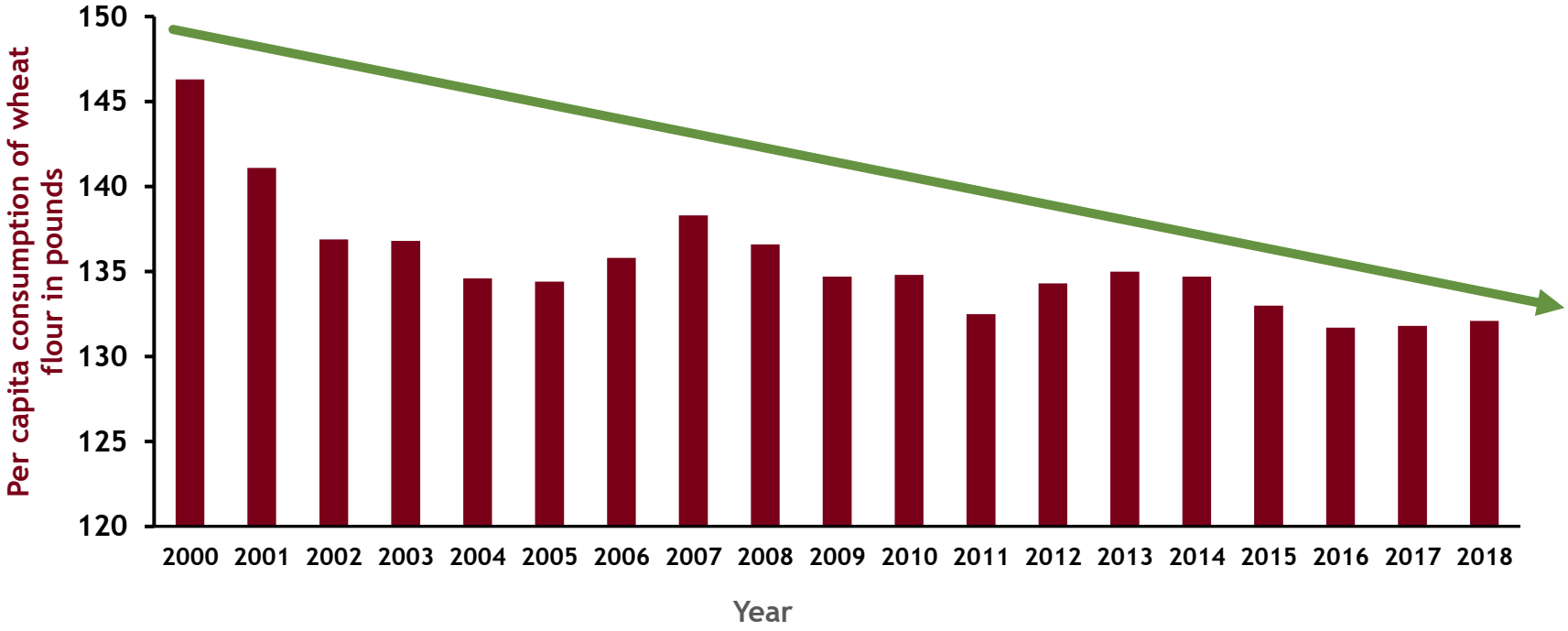
Growing and Processing Wheat that's Easier to Eat: Genetics, Sourdough Process, and the FODMAP and ATI Digestibility Connection

UMN - George Annor, James Anderson, and Prabin Bajgain

AURI – Harold Stanislawski

Per Capita Wheat Consumption in the U.S.



Source: US Department of Agriculture; Economic Research Service: Conducted by the Economic Research Service; US Department of Agriculture Survey period: 2000 to 2018

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Why the Decline?

Fad diets

- Promotion of Fad diets, resulting in an increasing percentage of the population to remove starches from their diet
- Avoidance of Gluten and/or Wheat

https://www.uab.edu/news/youcanuse/item/9287-fad-diets-or-lifestyle-changes-where-do-three-popular-weight-reduction-plans-fit-in

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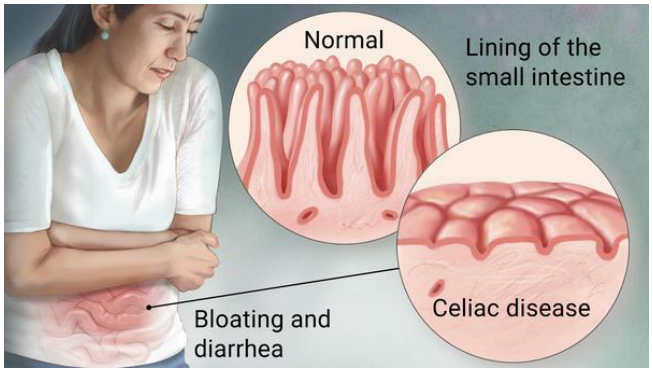
Why the Decline?

Avoidance of Gluten and/or Wheat

- Gluten is a protein found in the grain of wheat, rye, and barley

- **Celiac disease**
  - Celiac disease is an immune disease in which people can't eat gluten because it will damage their small intestine
  - ~1% of Americans have celiac.
- **Wheat Allergy**
- **Non-allergy-non-celiac wheat sensitivity (NCWS)**

https://www.drperlmutter.com/yes-gluten-sensitivity-is-very-real/



https://support.google.com/websearch/answer/2364942?p=medical_conditions&hl=en

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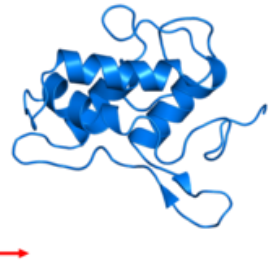
Why the Decline?

So, if it's not gluten per se, what are other possible causes of Non-allergy-non-celiac wheat sensitivity (NCWS)?

- FODMAPS -Fermentable Oligo-, Di- and Monosaccharides and Polyols
  - Fructose, lactose, fructo- and galactooligosaccharides (fructans, and galactans)
  - Polyols (such as sorbitol, mannitol, xylitol and maltitol)
- ATI - Amylase Trypsin inhibitors



https://enjoylifefoods.com/blogs/content/about-fodmap-friendly-living-enjoy-life-products

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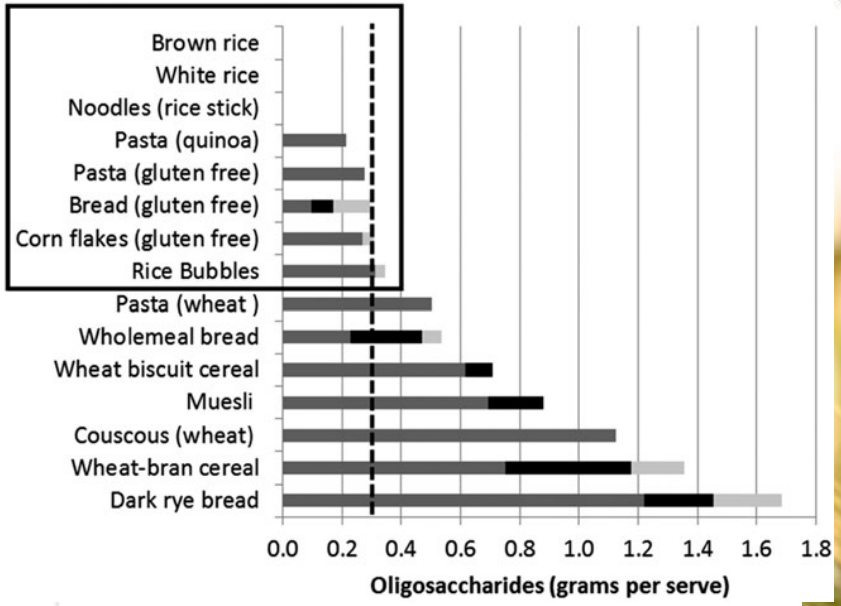
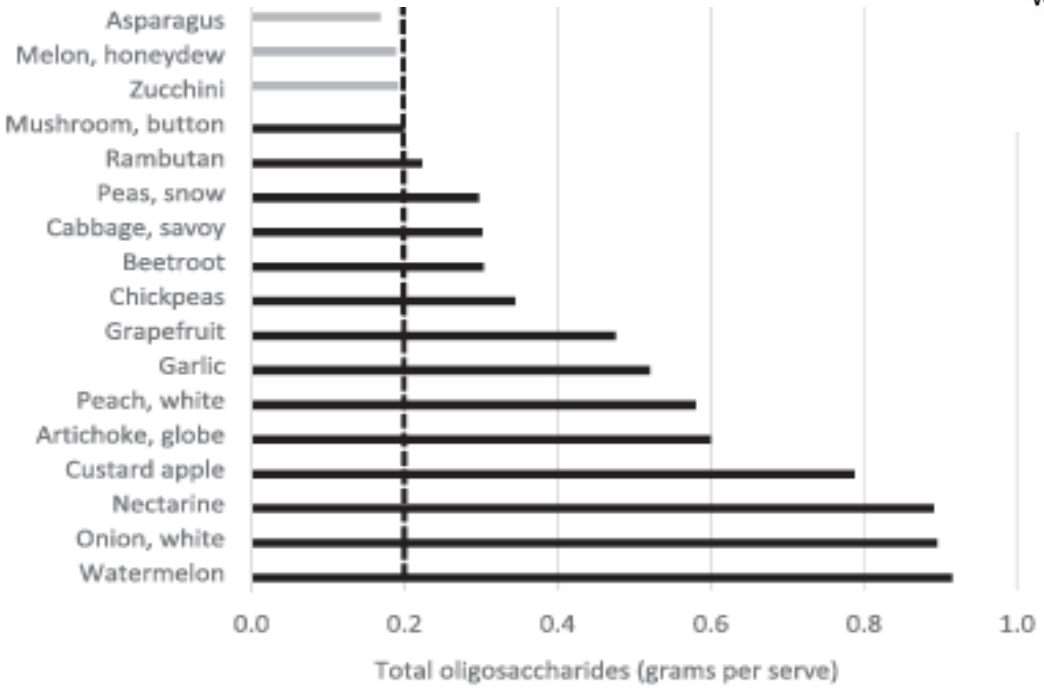
FODMAP Levels in some common foods

- Best tolerated if < 0.3 g/serving





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Project Partners Agreed to Tackle Issue

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MINNESOTA WHEAT
RESEARCH & PROMOTION COUNCIL

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- Reduce the discomforts resulting from the consumption of wheat-based products
- Improve the health of consumers
- Increase the profitability of wheat farmers

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Specific Objectives

1. Characterize variation and identify genetic markers for FODMAPs and ATI activity in ancient, heritage and modern wheat varieties from different growing environments in Minnesota

2. Explore the use of fermentation as a technique to reduce FODMAPs and ATI activity in wheat food products

3. Establish a pathway for industry to implement research outcomes.

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Materials and Methods
Objective 1

- A panel of 220 ancient, heritage and modern wheat varieties were grown at U of MN field sites at Crookston and St. Paul, MN in 2019

- Genetic markers were determined by extracting DNA from the panel of 200 wheat varieties and genotyped using Genotyping-By-Sequencing.

- Whole grains analyzed for % FODMAPs (via HPAEC) and ATI (HPLC)

- Association mapping was used to identify DNA markers associated with FODMAPs and ATI activity

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Wheat Materials for FODMAP Evaluation

Material	No. lines
Heritage wheats:	46
Modern wheats (>1970):	142
Durum:	5
Einkorn (A genome):	10
Emmer: (AB)	11
Synthetic hexaploids (ABD):	16
Total:	**230**

Lots of variation observed for heading date, height, yield

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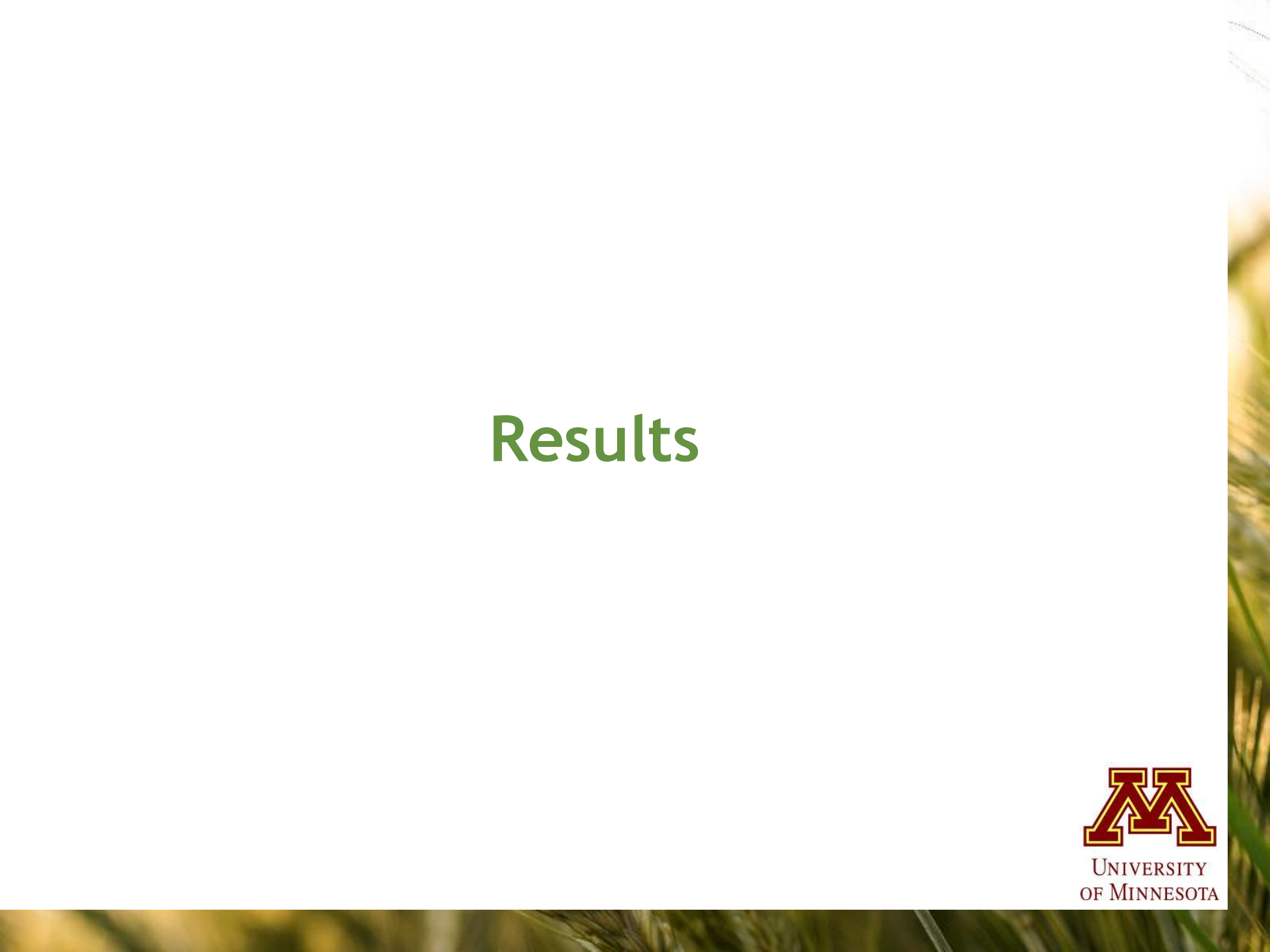
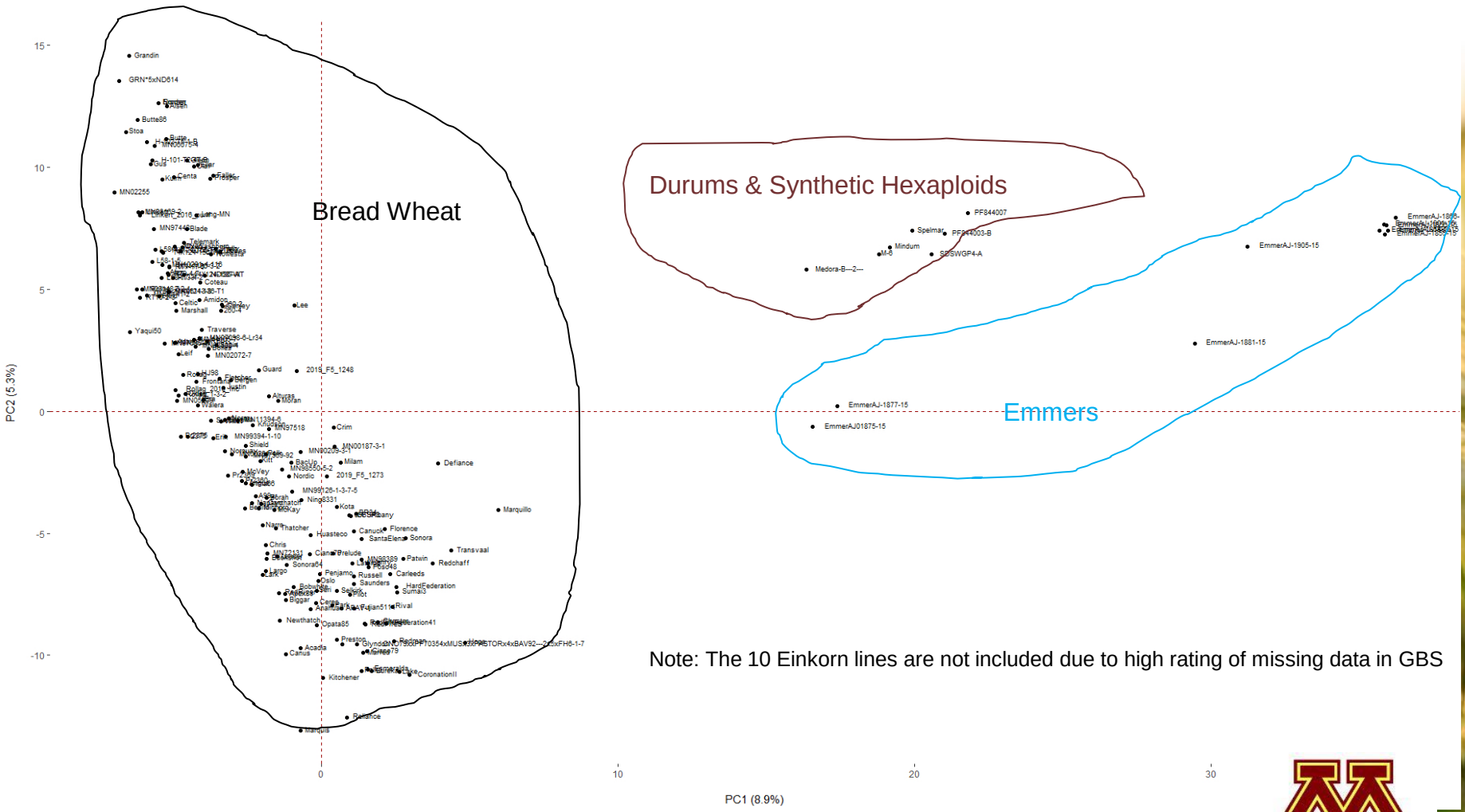
Results



Genetic Diversity of 220 FODMAP panel lines



Note: The 10 Einkorn lines are not included due to high rating of missing data in GBS

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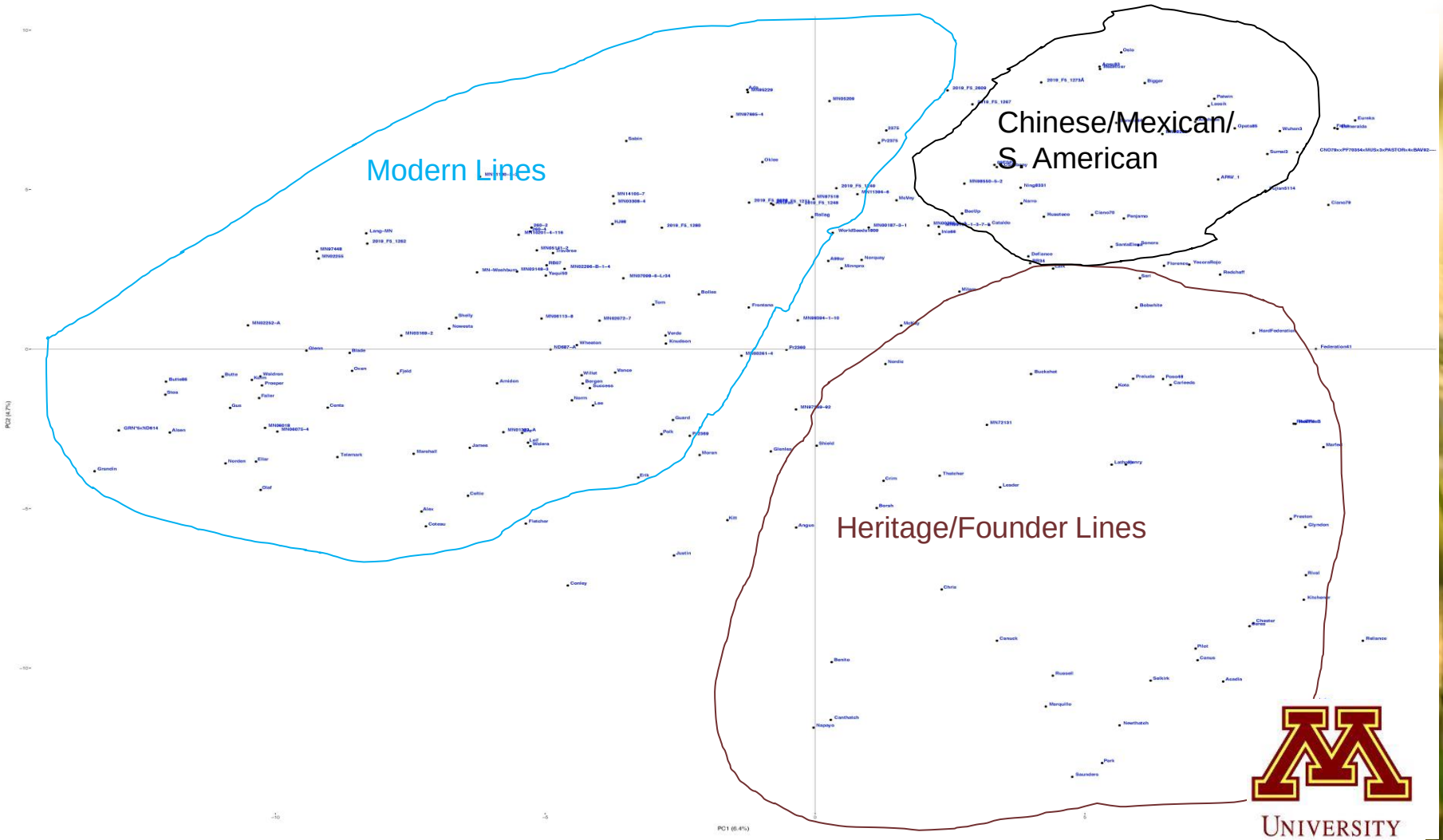
Genetic Diversity of 190 FODMAP bread wheat panel lines

- Excludes durums, emmers, and synthetic hexaploids



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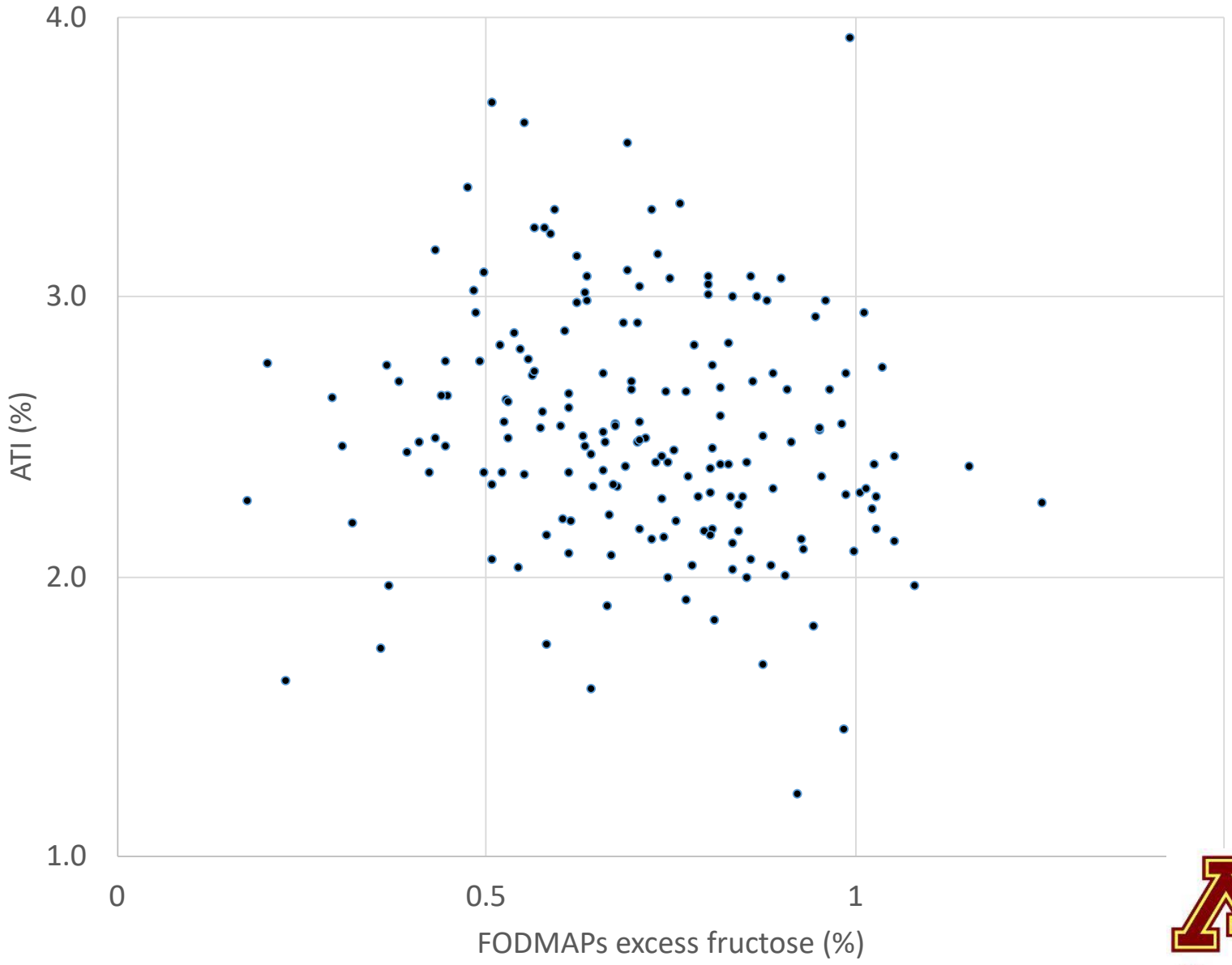
ATI and FODMAP % of 167 Common Wheat Varieties



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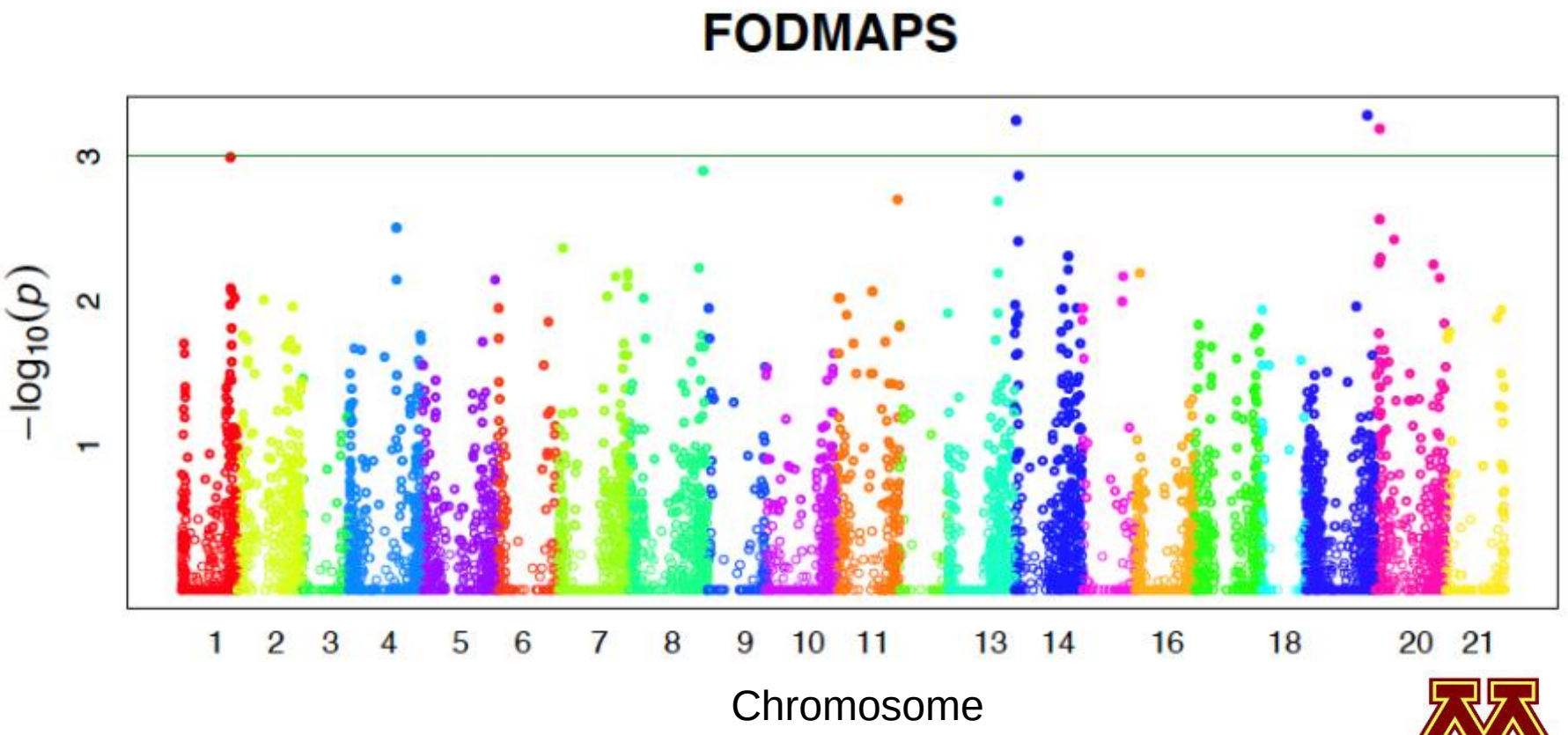
Association of Genetic markers along the 21 wheat chromosomes with FODMAP content



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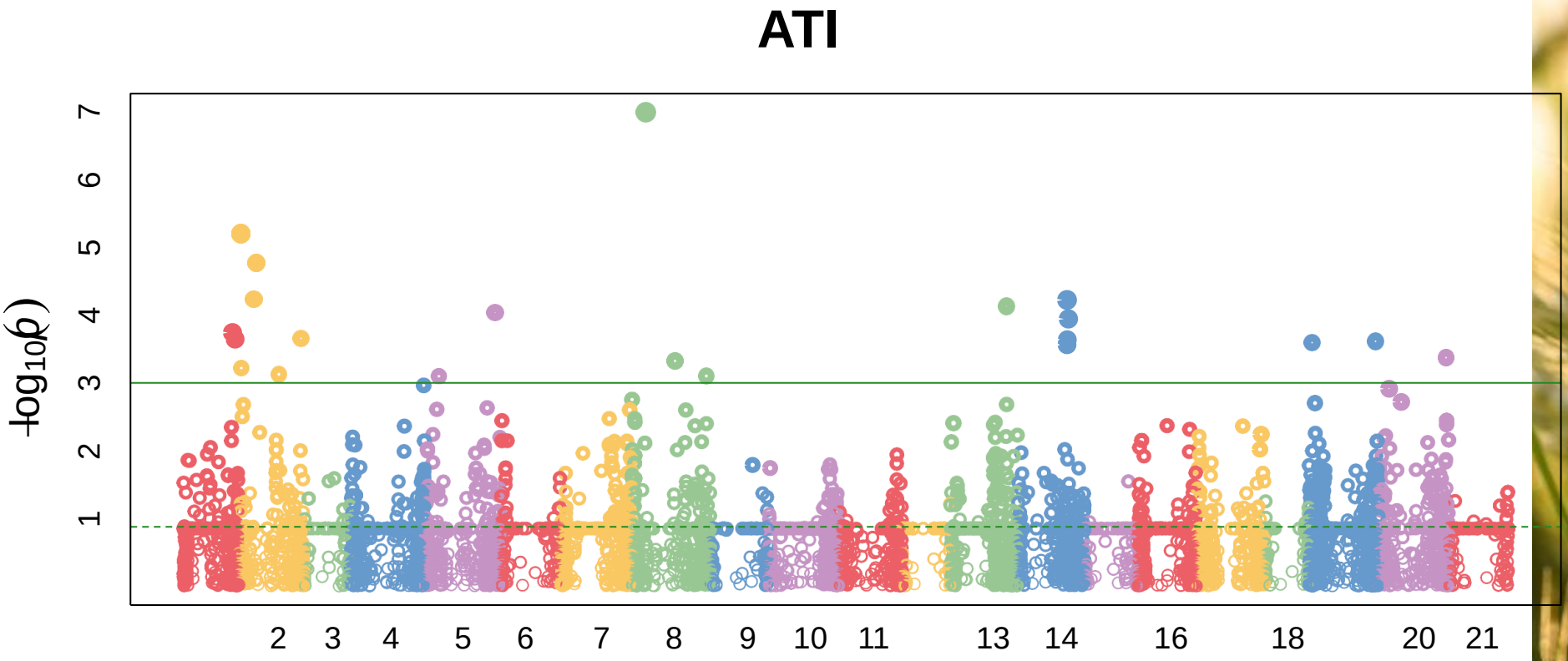
Association of Genetic markers along the 21 wheat chromosomes with ATI content



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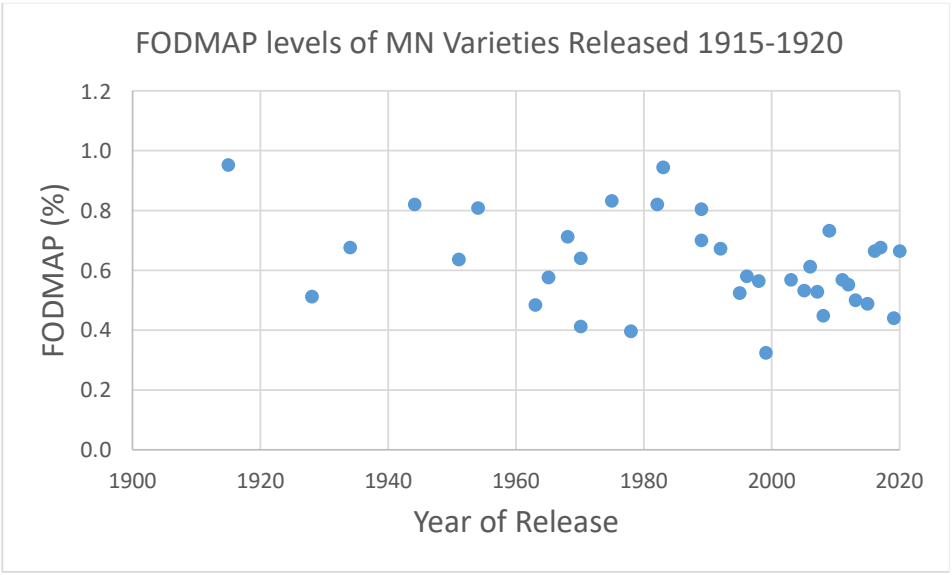
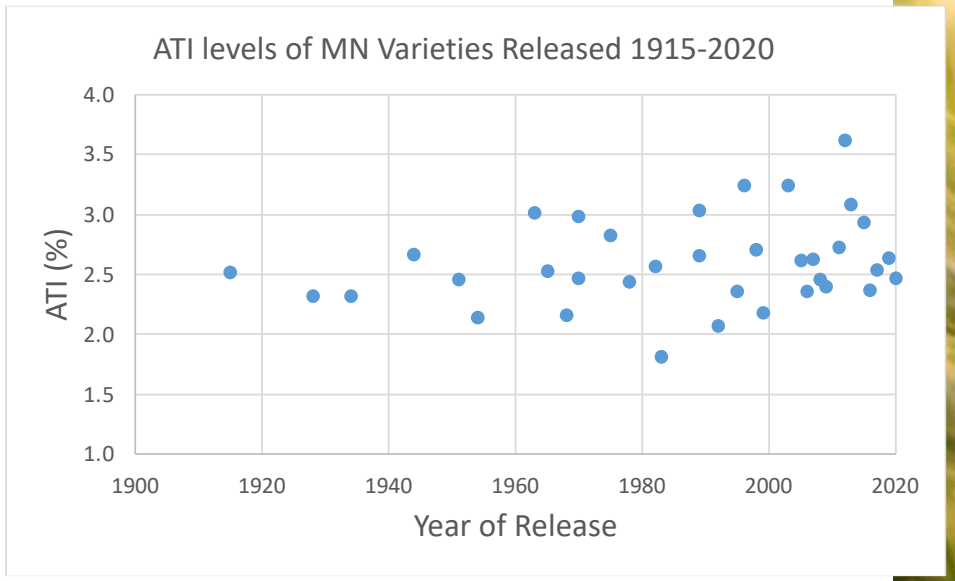
FODMAPs and ATIs have not increased over time





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FODMAP & ATI Summary

- Genetically diverse set of wheat lines being analyzed
- Wide differences in FODMAPs and ATI Content
  - Among common wheat varieties:
    - FODMAPs 0.4-1.2%
    - ATIs 1.8-3.9%
  - Einkorn's low in ATI (1.3) and FODMAP (0.3); Emmer's low in FODMAP (0.4)
- No genomic region is responsible for a large portion of the genetic variation for these traits, but should be amenable to selection
- No identifiable patterns regarding FODMAP and ATI concentrations vs. year of release among common whe varieties

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Fermentation Study

Materials and Methods
Objective 2

Explore the use of fermentation as a technique to reduce FODMAPs and ATI activity in wheat food products

- Sourdough was prepared from wheat varieties to determine effects of different fermentation times on the levels of FODMAPs and ATI activity.

- Sample selection was based on the classification of the wheat varieties into low, medium and high FODMAPs and ATIs with 10 varieties from each group.

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Sourdough Fermentation

Photo Credit: Rolf Hagberg

Sourdough Fermentation Overview

- Looked at the potential for sourdough to degrade or eliminate FODMAPs and/or ATI's.
- 10 varieties of each ranked by low, medium, and high FODMAPs and 10 varieties of each ranked low, medium, and high ATI from two locations—St. Paul and Crookston, MN.
- Type 1 sourdough fermentation model was applied to each of the wheat samples on a 4-hour and 12-hour fermentation cycle.
- A portion of the Type 1 sourdough was sequestered as a control.

- Photo credit: Suzanne Irwin

Sourdough Fermentation Overview – Type 1 Process

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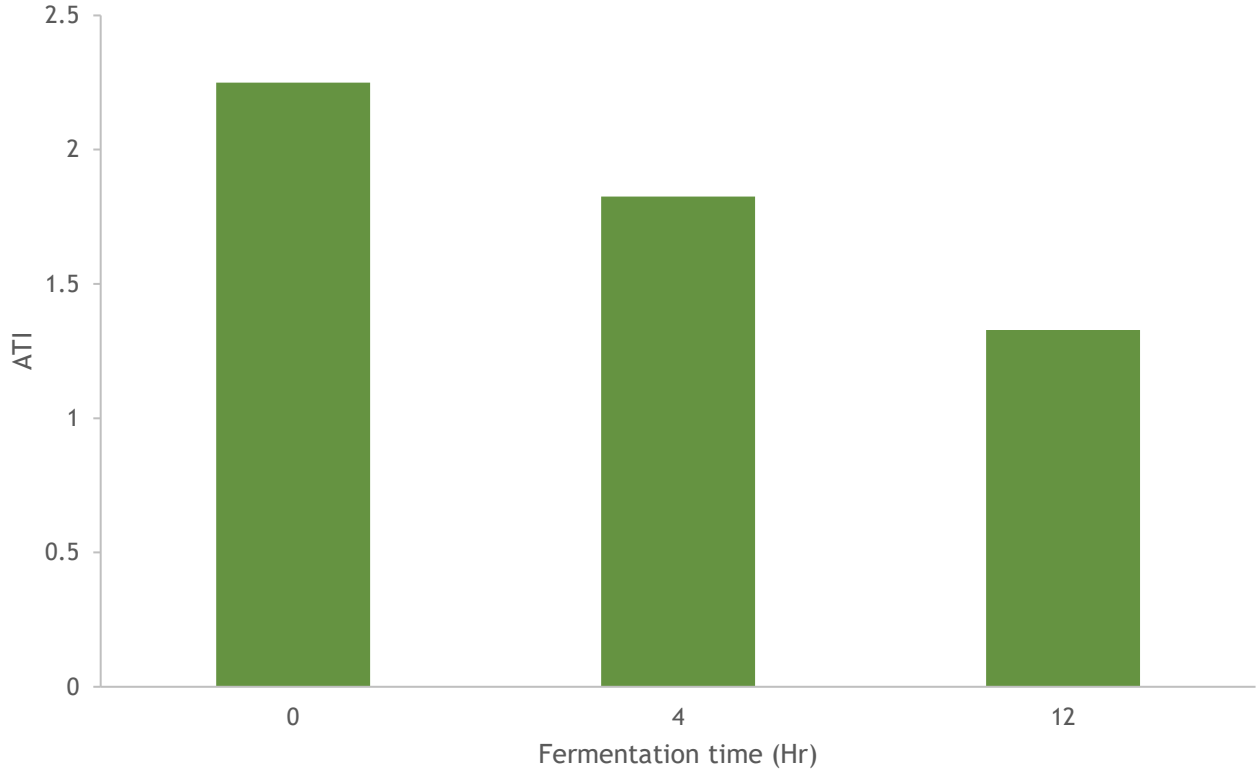
Photo credit: Suzanne Irwin

Sourdough Fermentation Outcome

- 600 individual test samples were completed and subsequently frozen and sent to Dr. Annor for analysis of the effect of fermentation on reduction to FODMAP and ATI's. This included 6 alternates from each location.

Photo Credit: Suzanne Irwin

Sourdough Fermentation effects on ATI



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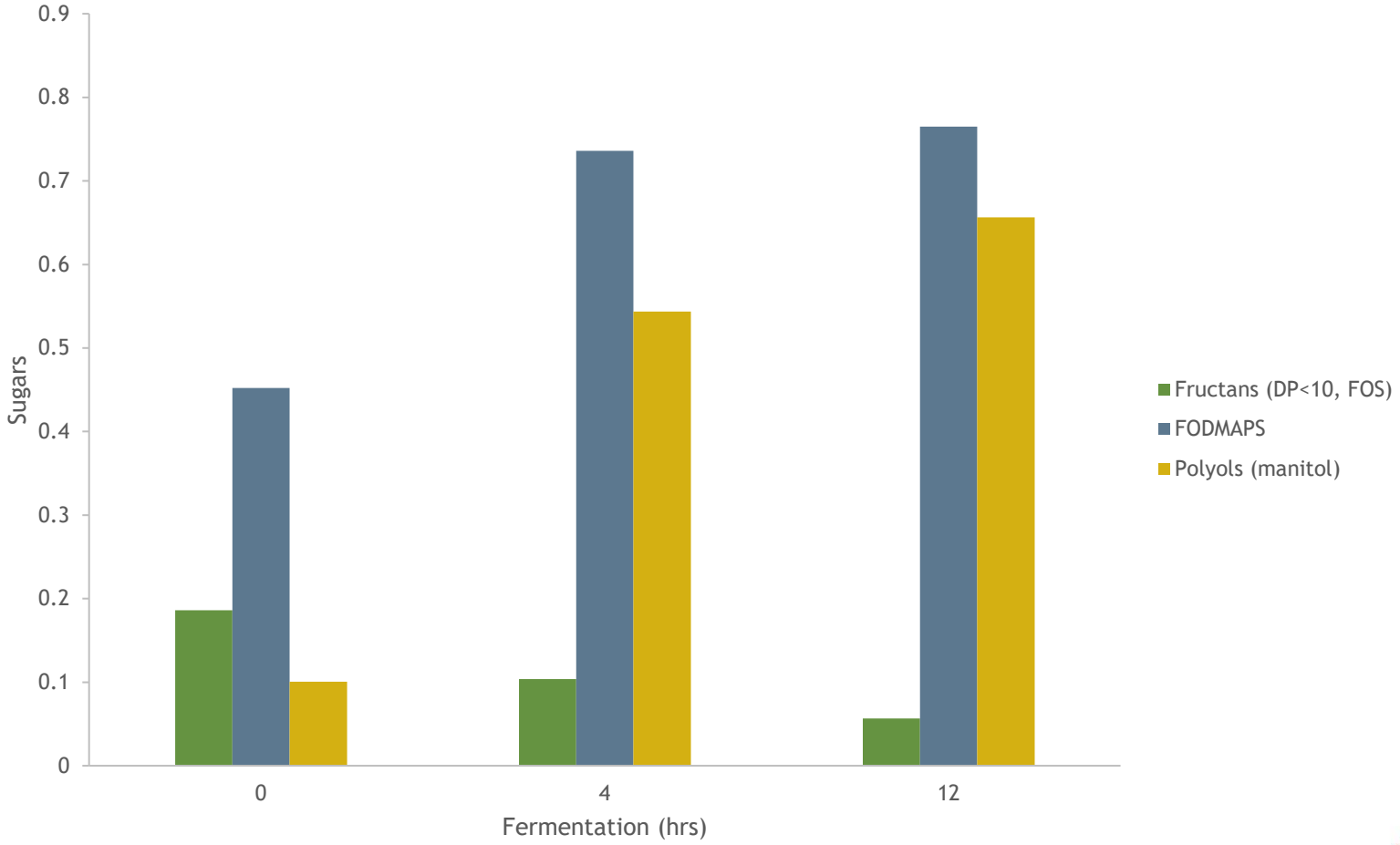
Sourdough Fermentation effects on FODMAPs



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Objective 3: Establish a pathway for industry to implement research outcomes

- Outreach efforts were lead by AURI in partnership with the UMN – Regional Development Partnership, UMN Researchers, the MWRPC, and Back When Foods, Inc.
  - Approximately 60 outreach activities.
- Project promotion / education began in 2019 focused on farmers via the annual Prairie Grains Conference and MAWG/UMN Small Grains Update Meetings, and Farmfest; and the industry value chain **including indigenous and underserved ag producers.**
- Research overall was broadly targeted to reach farmers, industry, researchers and consumers/general public through multiple avenues—webinars, social media, and news publications. emerging, indigenous, and underserved ag producers
- Project-related articles were published throughout the project timeline in the Prairie Grains Magazine – Reached 22,703 members (MN, ND, SD, MT, Canada and others).
- Several webinars were held to promote throughout the industry value chain – Wheat Foods Council, American Bakers Association, MN Institute of Food Technologists, Northern Crops Institute, and two AURI Connects/Fields of Innovations webinars.
- MAWG/AURI Video created on Wheat Digestibility and Sourdough fermentation. 203 views since launched in October 7, 2021.
- Industry and research-focused brochures developed highlighting the project and research findings.
- Review of USDA Process Verified Program for future industry adoption and quality verification. Potential pilot being discussed.

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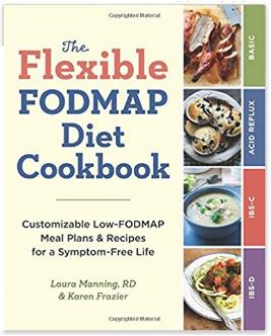
LowFODMAP central

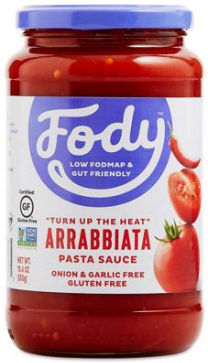
Low FODMAP Diet

world's first certified low FODMAP wheat flour and bakery range, developed by Australian family-owned international agribusiness Manildra Group.

Casabi Casabe Artisan Flatbread (Cassava Bread)

Nestlé HealthScience





US Low FODMAP Food Distribution, the USA's first dedicated low FODMAP food distributor.

Low FODMAP Products

FODMAP life

~ A Visual Guide ~ United States

Based on the low-FODMAP ingredients, these products appear to be safe for the low-FODMAP diet. Most are available in supermarkets, natural foods stores or online. Currently, they're not certified low-FODMAP. For a list of certified low-FODMAP products please visit http://fodmaplife.com/low-fodmap-brands/

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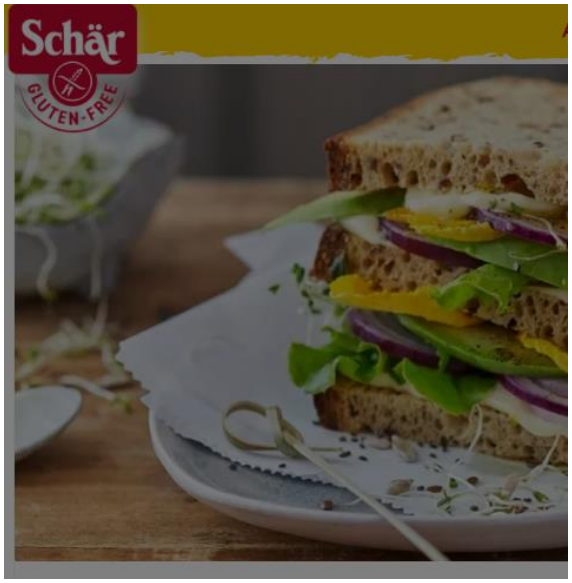

MONASH UNIVERSITY LOW FODMAP CERTIFIED™

Although many Schar products have been tested and certified low FODMAP by Monash University, **not every Schar product is low FODMAP.** Here is a list including *some* of Schar's certified options available in the United States.

- Deli-Style Seeded Bread
- Deli-Style Sourdough Bread
- Hamburger Buns
- Ciabatta Rolls
- Multigrain Ciabatta Rolls
- Hot Dog Rolls
- Baguette

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Example: Commercial Opportunity

- Manildra Group – operates Australia's largest flour mill
  - Launched low FODMAP flour in 2018
  - LoFo Pantry – has a U.S. operation (Manildra Group USA) marketing low FODMAP flour

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The Future is Bright

- Research results will benefit the value chain – wheat industry and consumers.
  - FODMAP Certification for food
  - Commercial Opportunities

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Next Steps

Phase II research proposal *Breeding Wheat with Improved Digestibility and High Fiber for Better Health*

(in review with MN Dept. Ag)

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Next Steps

- Objectives

1) Evaluate the effects of different amylose levels on agronomic performance and dough functionality
2) Develop and evaluate wheat germplasm with high amylose and low ATIs/FODMAPs
3) Analyze wild wheat germplasm from WGRC-IURC for FODMAPs and ATIs for new breeding material
4) Establish a pathway for industry/emerging farmers to implement findings, and processes and protocols for Process Verified

e.g., USDA Process Verified Program, Low FODMAP Certification in Australia

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Amylose/Resistant Starch and why it is important

- Resistant starch is that fraction of dietary starch that escapes digestion and absorption in the upper gut
- Resistant starches stimulate the proliferation and metabolic activity of microbial populations
- Resistant starch intake overall is low because most are highly refined and extensively processed
- Dietary targets for resistant starch have been suggested (e.g., ~20 g/d for adults
- Increasing the resistant starch content of wheat will increase the die fiber consumption of consumers

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Amylose/Resistant Starch and why it is important

- A novel wheat that has a markedly elevated amylose content has been recently developed
- Laboratory studies have established that this new wheat variety is greatly enriched in resistant starch (>10-fold increase)
- Consequently, it is markedly higher in total dietary fiber, and has as other favorable compositional changes in the grain.
- There is limited availability of high fiber wheat in the current marketplace, so high fiber wheat with low FODMAP and low ATI would be unique.

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Acknowledgements:

UMN:
Emily Conley (Researcher)
Susan Reynolds (Researcher)
Nate Stuart (Researcher)
Prince Boakye (PhD Student)
Ibilola Kougbglenou (Researcher)

UMN-Extension RSDP:
Sarah Swan Ray

AURI:
Shannon Schlecht
Harold Stanislawski
Becky Philipp (Project Manager)
Lolly Occhino

MN Wheat:
Charlie Vogel
Melissa Carlson

Back When Foods, Inc.
Brian LaPlante

Funding:

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To learn more about this research and follow its progress, visit:

www.auri.org/agri

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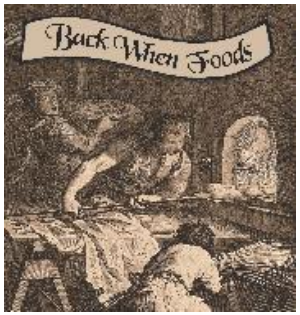

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