Intermediate Wheatgrass: Food Science Work to Develop Applications

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What is Food Science and Why are We Working on IWG?

Food science is the study of the physical, biological, and chemical makeup of food; and the concepts underlying food processing. **Food technology** is the application of food science to the selection, preservation, processing, packaging, distribution, and use of safe food.

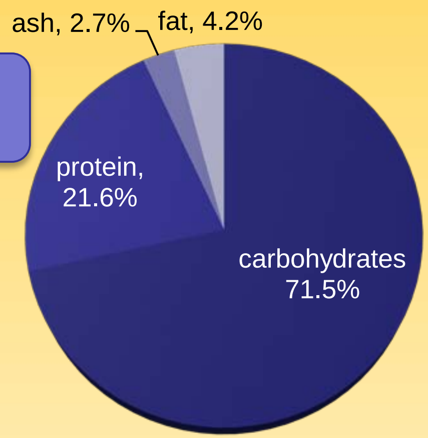
To Use Any Food Ingredient on an Industry Scale, we need to understand:

- **Functionality**
  - **how do the protein and starch behave when we cook or bake with IWG?**
  - **Can we modify this through processing? Breeding for certain traits?**
- **Storage stability**
  - **What impacts shelf-life? Lipids? Enzymes?**
  - **Can we control this through processing?**
- **Flavor**
  - **How does it compare to other grains and products we know?**
  - **What is unique about it?**
- **Nutrients**
  - **What is its composition?**
  - **Are the unique components? Are there any anti-nutritional factors?**

Benefits and Challenges of IWG - Composition of IWG Compared to Wheat

Composition IWG
(average of 13 breeding populations)

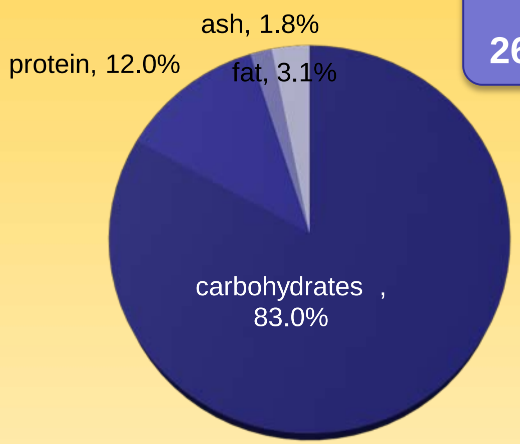
IWG (2004)
3.9 g/1000 seeds



More protein

Composition Whole Wheat
(Hard red spring)

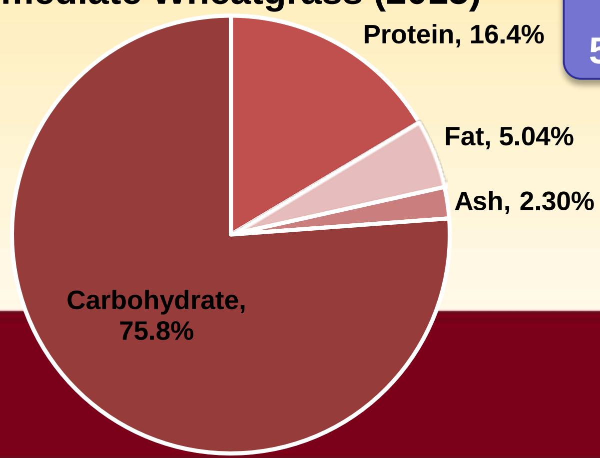
HRW
26 g/1000 seeds



More carbohydrates

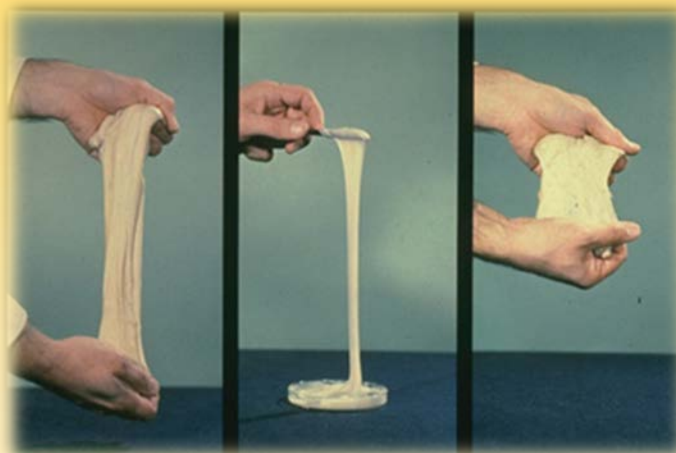
Intermediate Wheatgrass (2015)

IWG (2015)
5.1 g/1000 seeds



Importance of Protein & Starch for Product Functionality

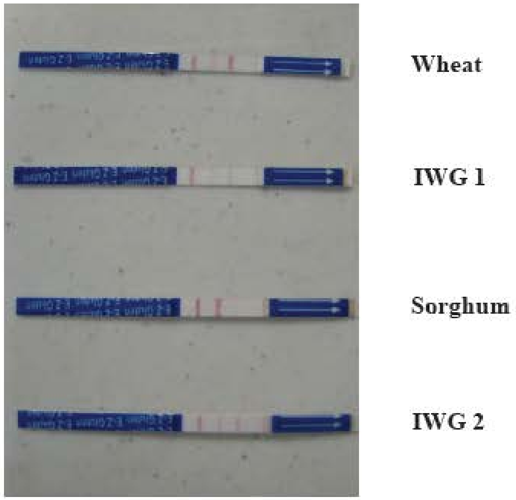
- Proteins can be used to hold gas in baked goods (bread & popovers). Some products you want “strong” gluten, some you don’t (think bread flour vs. all-purpose flour)



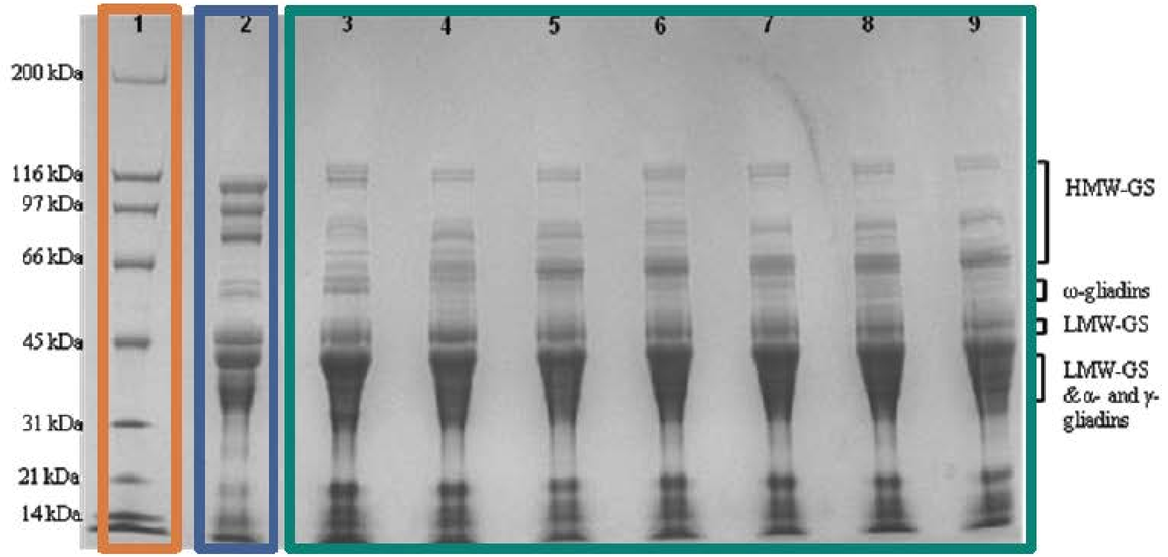
gluten **gliadin** **glutenin**

- Starch is important for adding viscosity and to set products like cake
- Also source of fermentable sugars

Gluten



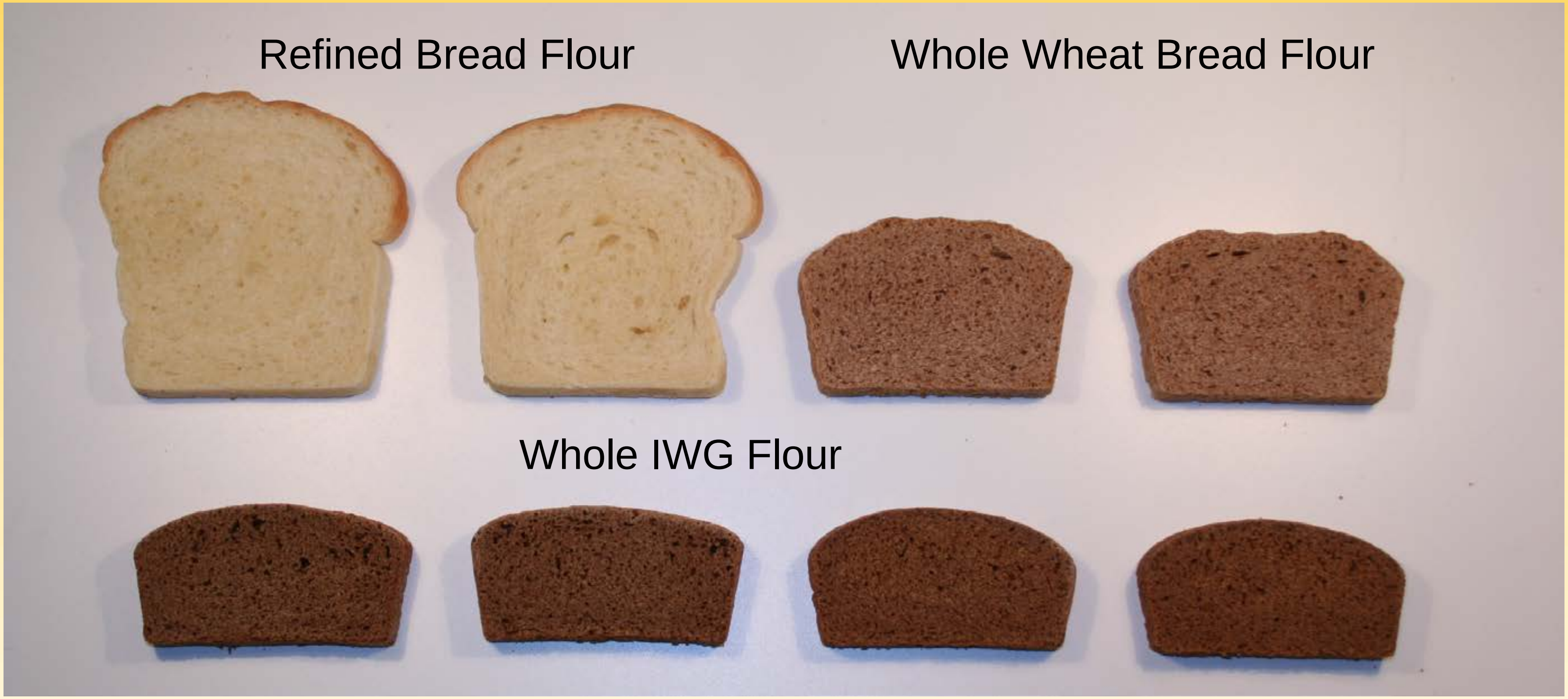
Gluten ELISA test strip confirming presence of gluten proteins in IWG



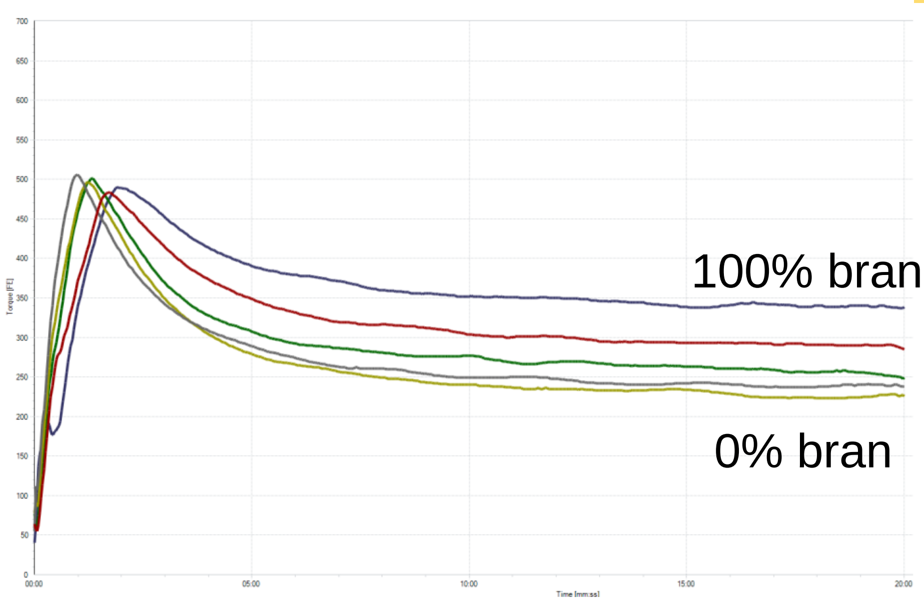
Protein patterns of wheat/IWG glutens by SDS-PAGE. Lane 1: protein marker; 2: whole wheat flour gluten; 3: Bulk IWG (Kernza); 4: IWG LI-1; 5: IWG LI-2; 6: IWG LI-3; 7: IWG LI-4; 8: IWG LI-5A; 9: IWG LI-5B

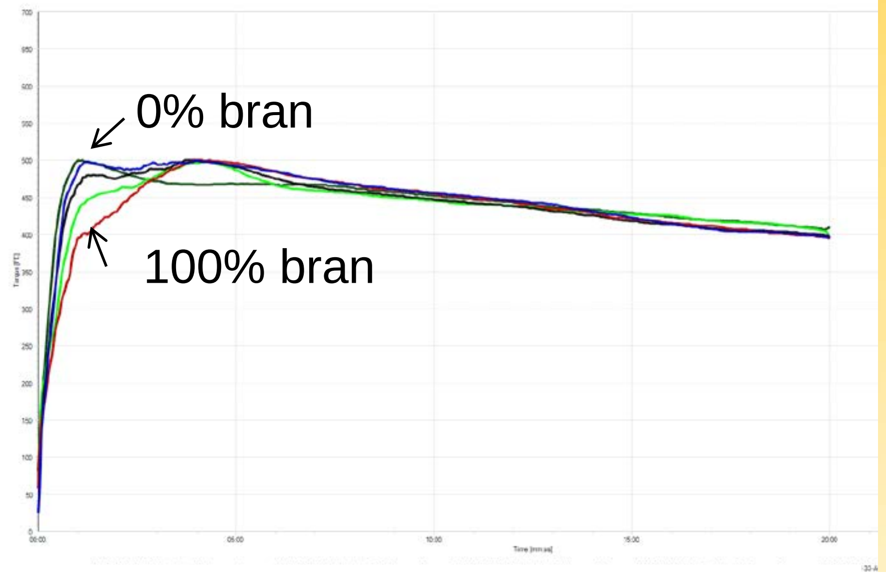
Just because IWG does not “form gluten”, and has some different proteins, does not mean it is not a wheat allergen. It is.

Challenge for Whole IWG flour in products that rely on protein to hold gas



Farinogram of Rouseau, MN grown IWG vs. Hard Red Wheat with various amounts of bran

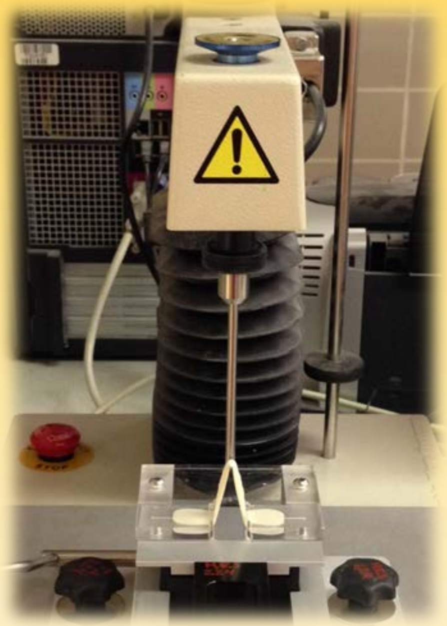




Removing bran does not improve the gluten forming abilities

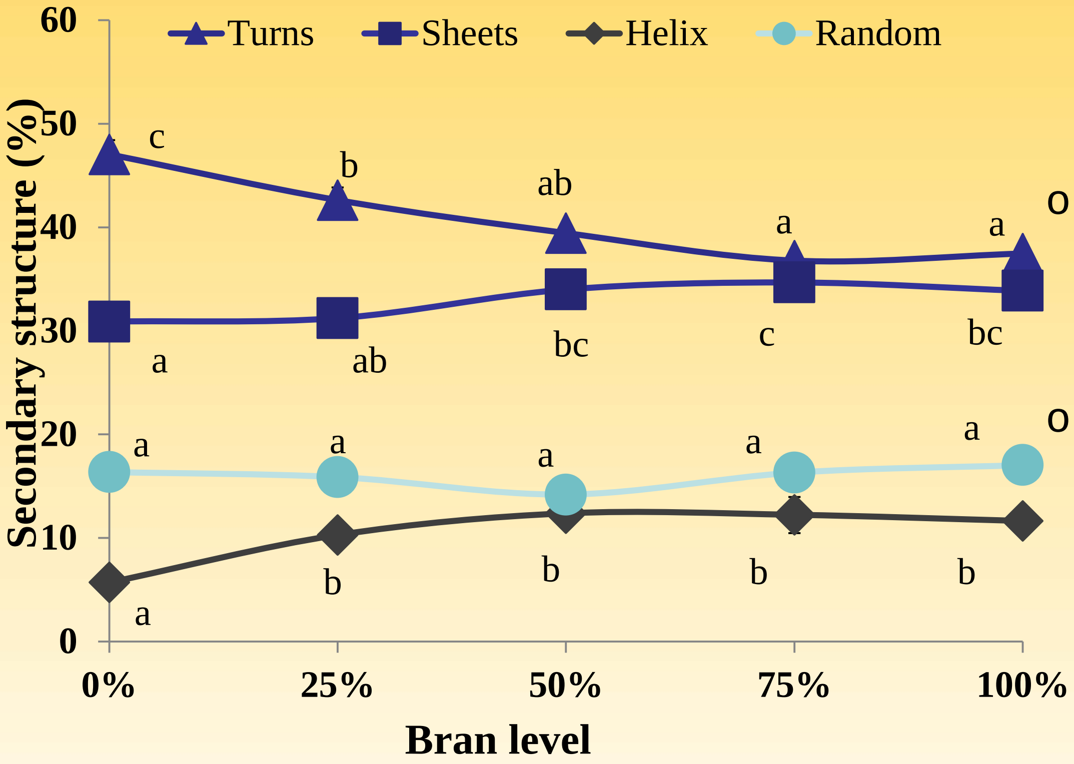
Extensibility of IWG vs. Hard Red Wheat with various amounts of bran

Bran (%)	Resistance to Extension (g)			Total Extensibility (mm)		
	Rosemount	Rousseau	HRW	Rosemount	Rousseau	HRW
0	22.33	32.86	37.38	0.34	0.3	2.69
25	19.2	27.25	38.3	0.47	0.37	2.07
50	17.43	24.96	40.98	0.6	0.59	1.93
75	15.25	22.95	40.73	1.25	0.6	1.49
100	14.3	19.56	41.39	1.98	0.66	1.5



IWG Flour Refining

Changes in protein secondary structure determined by ATR-FTIR



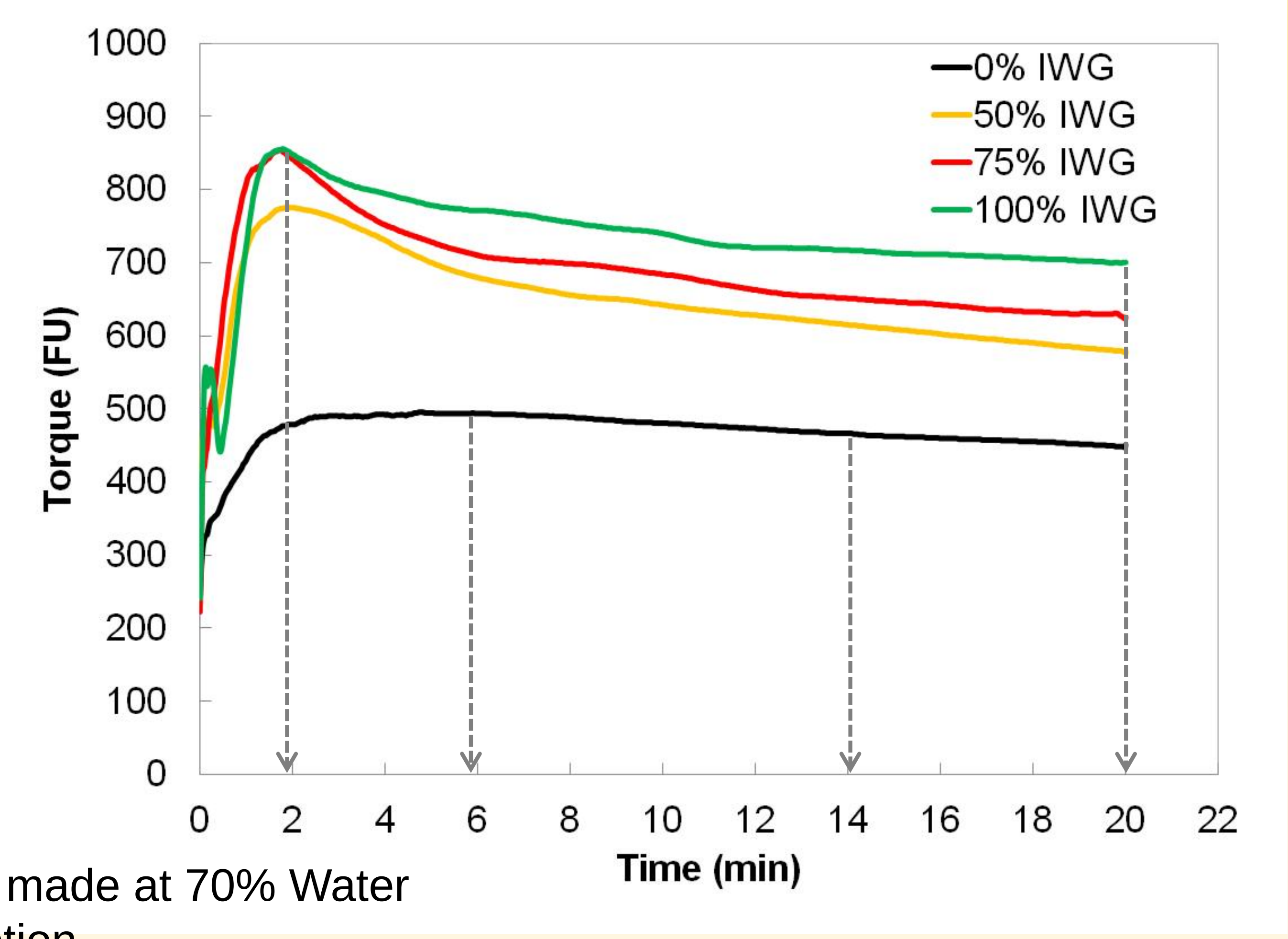
- Complete refinement does not lead to the optimum ratio of β-turns to β-sheets
- 75%_Bran_IWG has the best sheets/turns ratio suggesting a good compromise between dough extensibility and elasticity

Ongoing work on strategies to improve funtionality

- Continue looking at refinement (have done cookies & crackers, bread in progress)
- Dough conditioners
  - oxidizers (citric acid)
  - enzymes (xylanases, alpha amylase, transglutaminase)

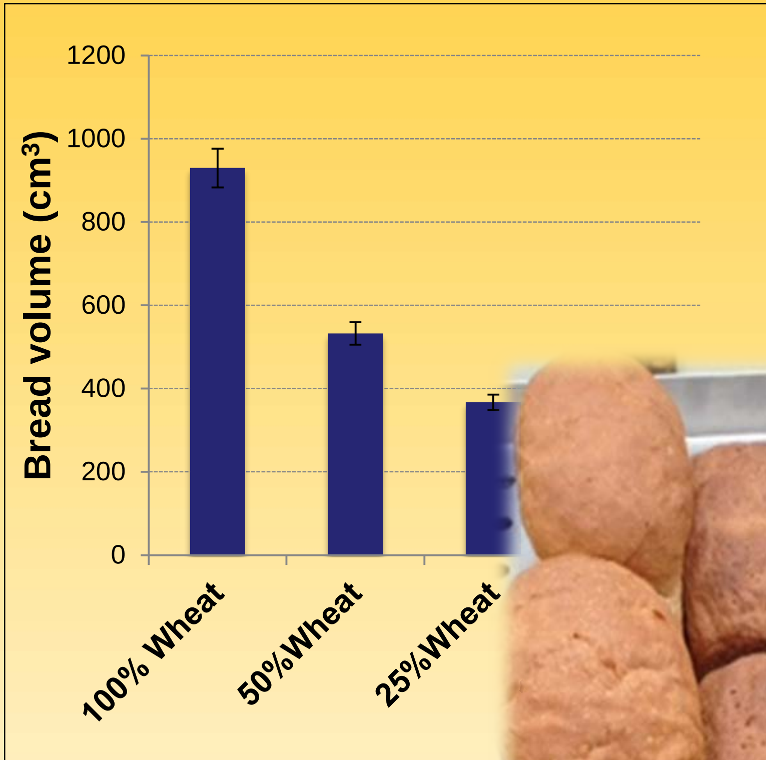
Maybe Blending Isn't So Bad?

Work by A. Marti, Jayne E. Bock, Maria Ambrogina Pagani, Koushik Seetharaman



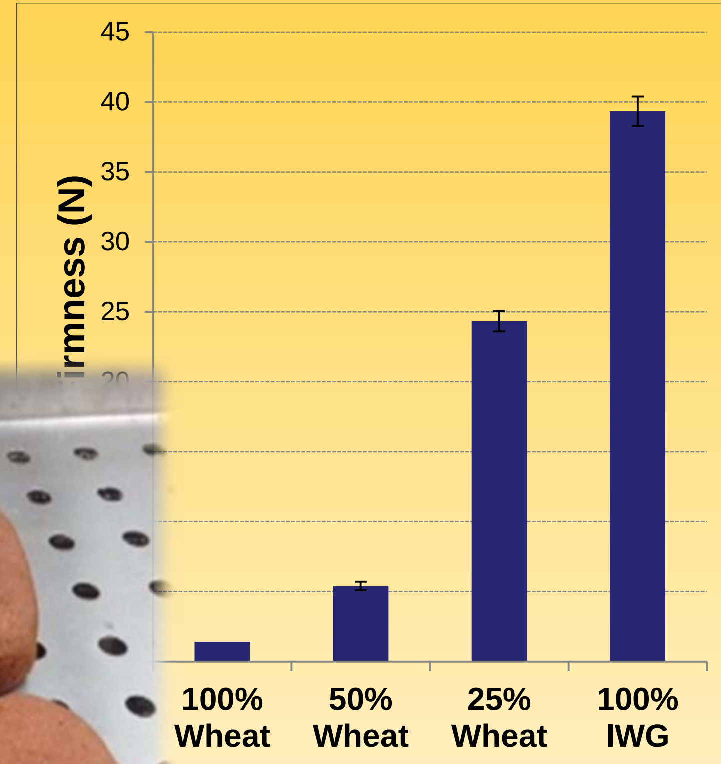
Dough made at 70% Water Absorption

Blending whole grain IWG with refined HRW



Standard AACC method: AACC 1

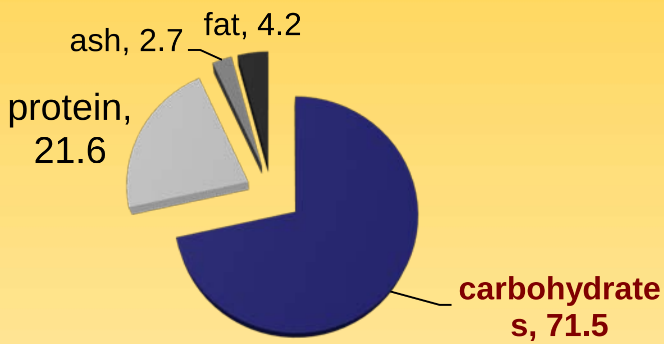
100%W 50%W 25%W 100%IWG



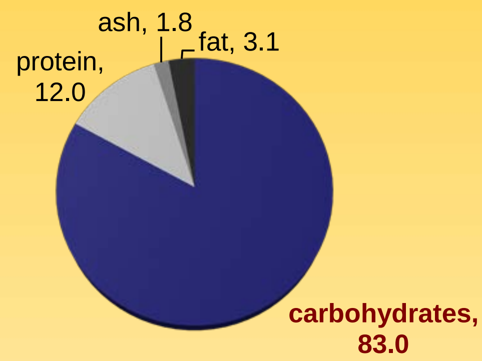
rd AACC method: AACC 74-09.01

IWG's Carbohydrates

Composition IWG
(average of 13 breeding populations)



Composition Whole Wheat
(Hard red spring)

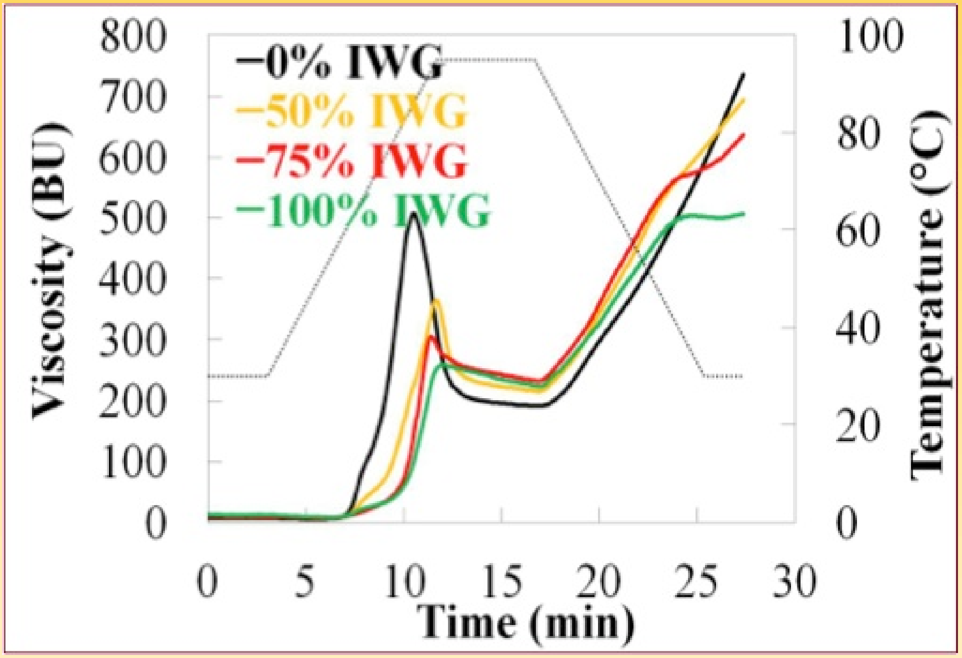


more bran!

21.8	**% Fiber**	15
47.7	**% Starch**	67.4

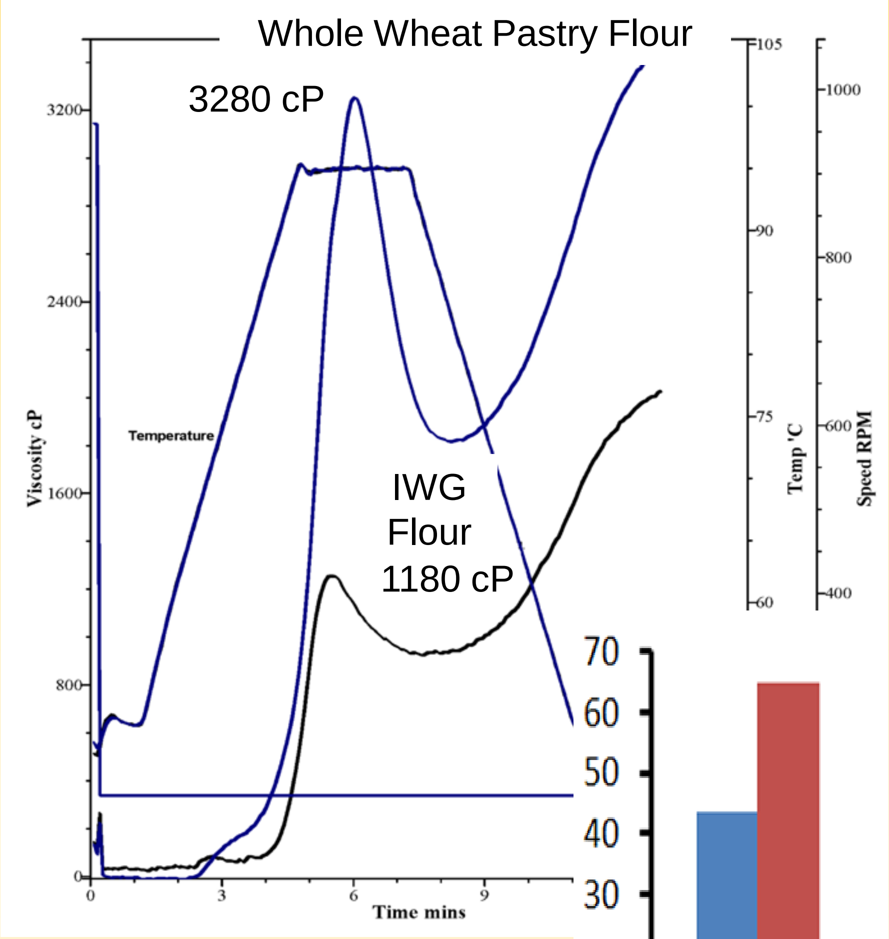
	Milling yield	
59	% bran	40
41	% refined flour	60

Starch Pasting Profile



MVAG of blends with hard wheat

Less starch, lower peak viscosity



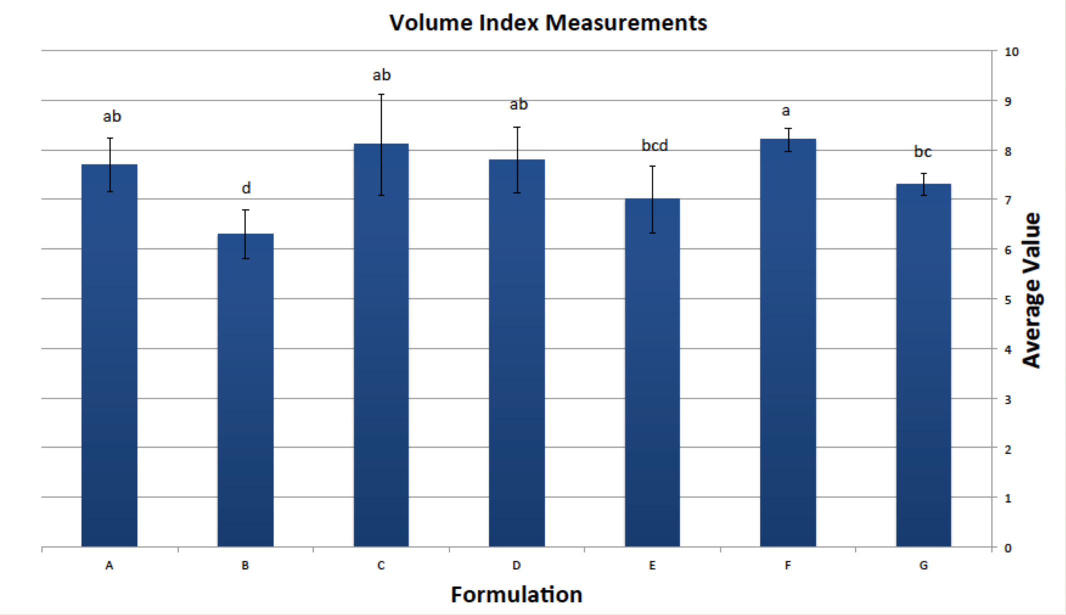
RVA

How can we improve IWG performance in cakes? Used gluten-free strategies

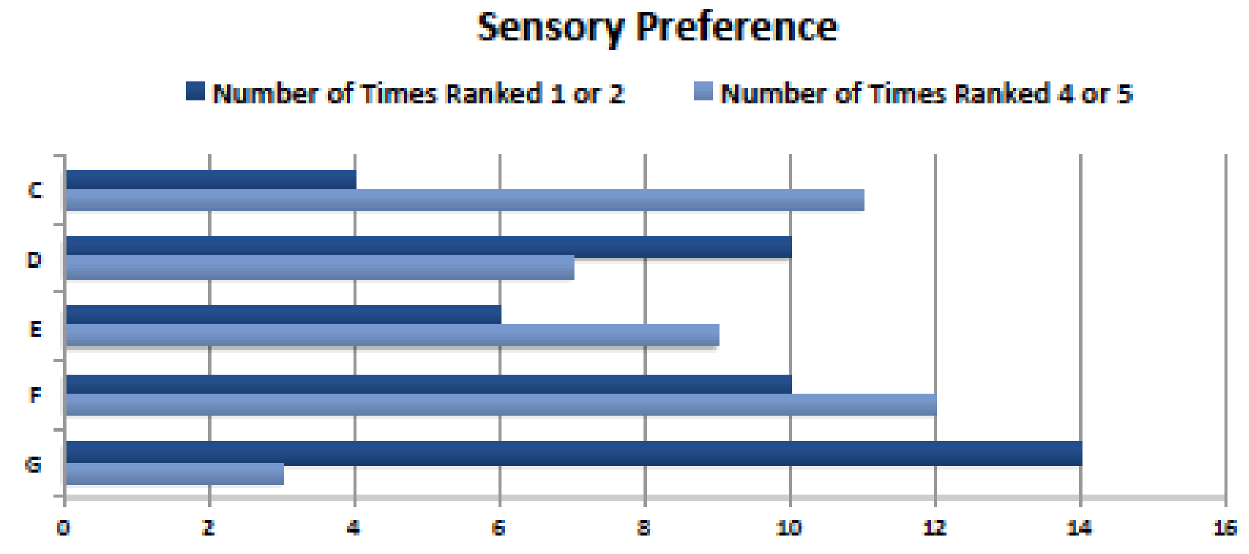
A	B	C	D	E	F	G
White Wheat flour	IWG	IWG	IWG	IWG	IWG	IWG
Water	+ Water	+ Water	+ Water	+ Water	+ Water	++ Water
Albumin		+ albumin	+ albumin	+ albumin	+ albumin	+ albumin
Baking Powder		+xanthan	+ xanthan	+ xanthan	+ xanthan	+ xanthan
Sugar			+ sorghum flour	+ rice flour	+ rice flour	+ rice flour
Nonfat Dried Milk			+ arrowroot starch	+potato starch		
Salt			+ potato starch			
Shortening						

Things that improved Volume and Texture

- more water
- more egg white
- Xanthan gum helped with volume
- Different starches had different effects

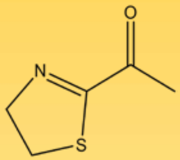


Most preferred formula:
1.75X the water of control
(moister, less gritty)
2x the albumin
+ rice flour
+ xanthan gum

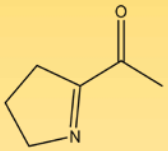


Flavor

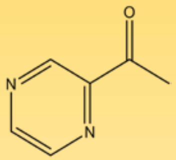
Toasted



2-acetyl-2-thiazoline



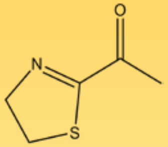
2-acetyl-1-pyrroline



2-acetylpyrazine

Roasted

methional



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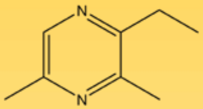
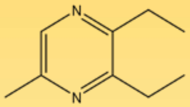
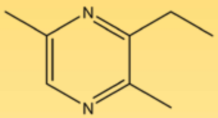


2-ethyl-3,5-dimethylpyrazine



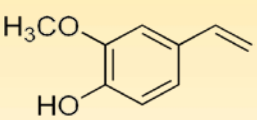
2,3-diethyl-5-methylpyrazine



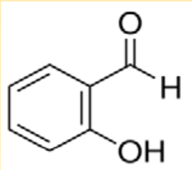
2-ethyl-3,6-dimethylpyrazine

Rated higher in Whole Wheat

Raisin

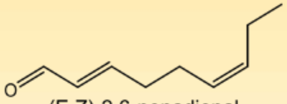


2-methoxy-4-vinylphenol

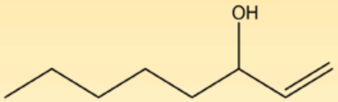


saliclyaldehyde

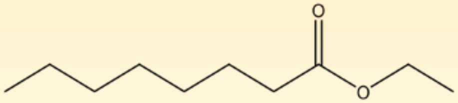
Green



(E,Z)-2,6-nonadienal

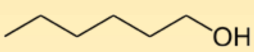


1-octen-3-ol

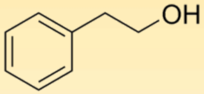


ethyl octanoate

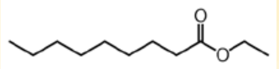
Bran



1-hexanol



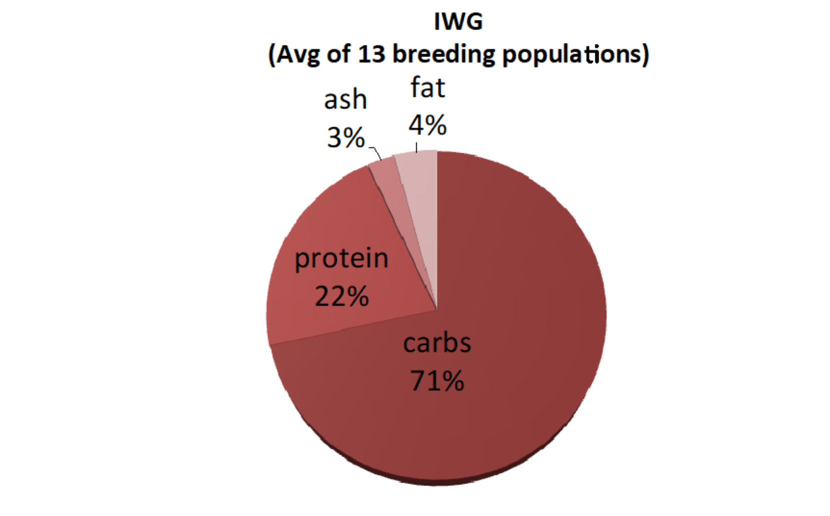
2-phenylethanol

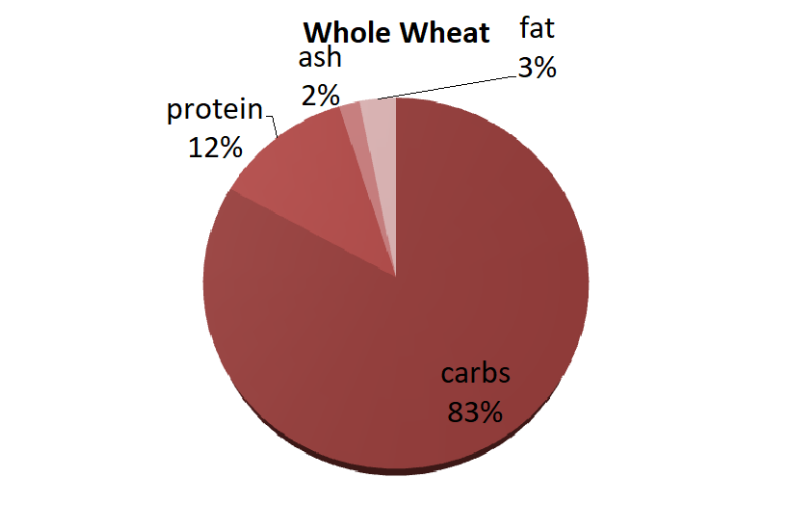


ethyl nonanoate

Rated higher in IWG

Great Nutritional Story!

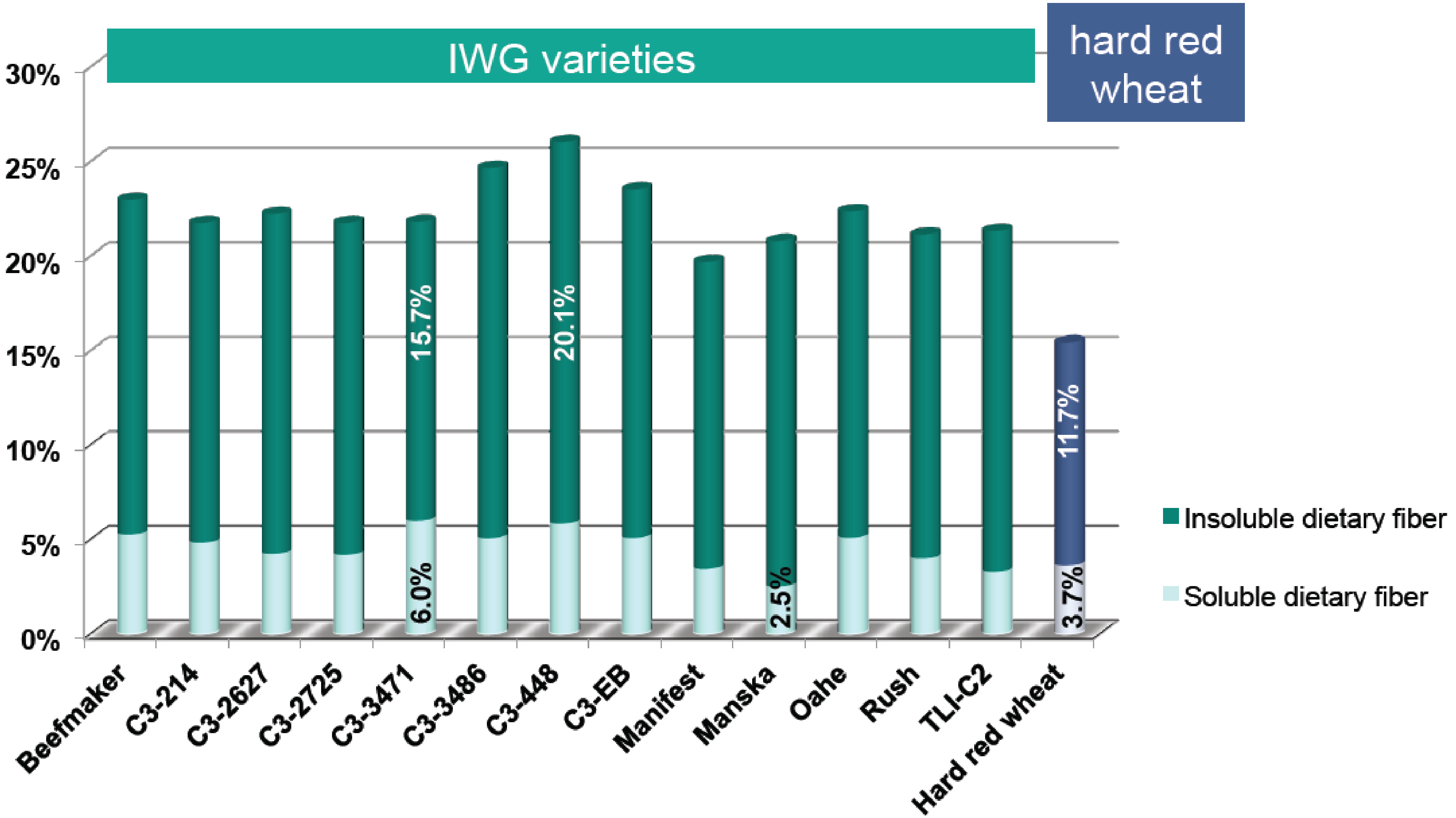




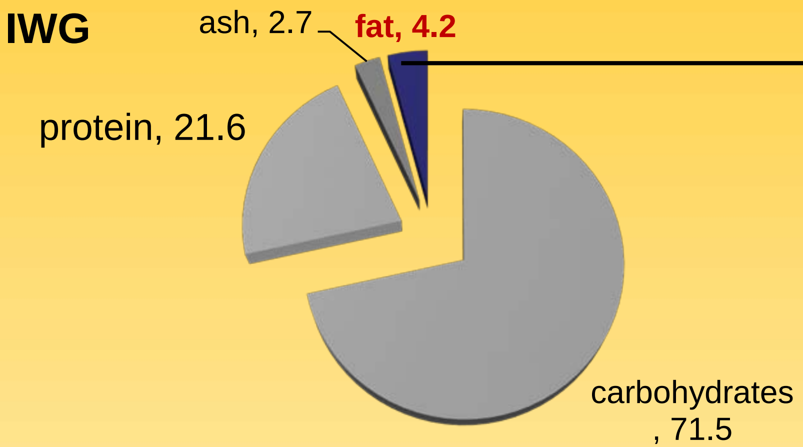
more bran!

21.8	**% Fiber**	15
47.7	**% Starch**	67.4

Dietary fiber (Whole grain flours, dry basis)



Storage Stability

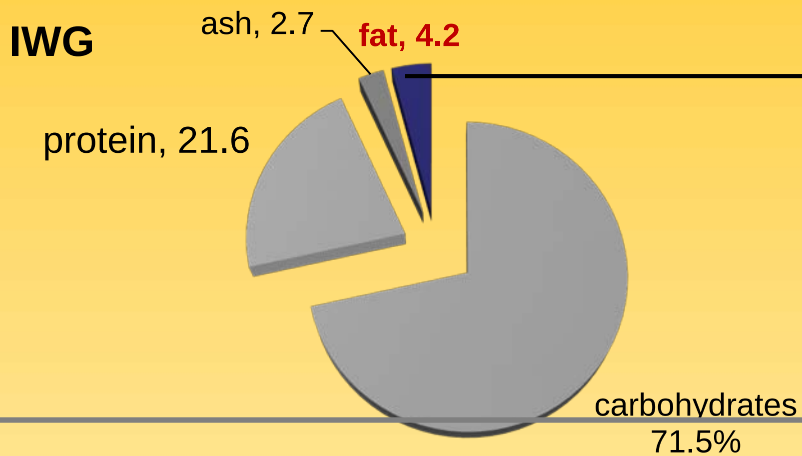


- ✓ Main fatty acids: linoleic, oleic and palmitic acid (similar to wheat)
- ✓ Higher in carotenoids than wheat

	HRW	IWG
Lipoxygenase Activity (U/g)	5.36*	5.00
Lipase Activity (U/g)	1.84	2.79*

Heat treatment of groats/flour during processing may be used to inactivate problematic enzymes

Storage Stability



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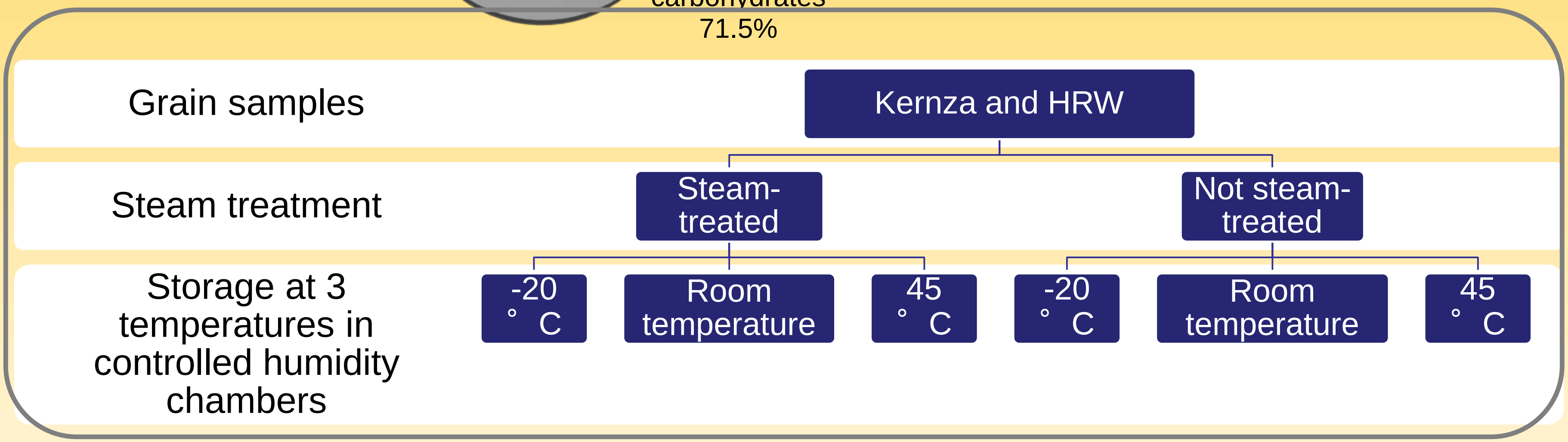
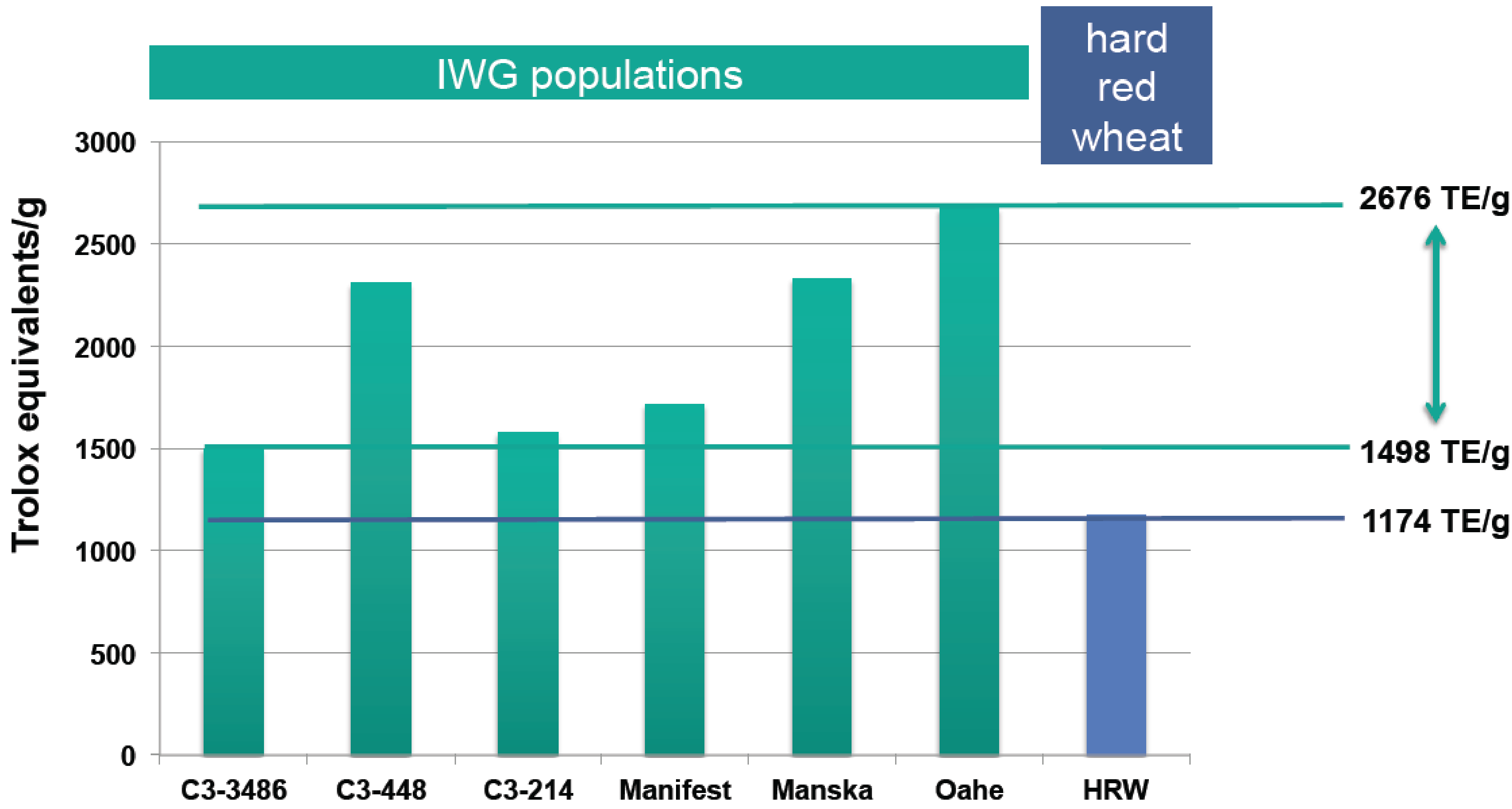


Results so far: Oxidative rancidity in IWG did not increase over accelerated storage compared to HRW, while hydrolytic rancidity increased slightly

Factors Influencing Storage Stability: Antioxidant Content & Activity

Sample	Hydroxycinnamic Acids (µg/g flour)			Carotenoids (mg/100g flour)		Antioxidant Activity (TE[b]/g)	
	Ferulic Acid	*p*-Coumaric Acid	Sinapic Acid	Lutein	Zeaxanthin	DPPH[a]	LMB[e]
IWG	813*	20.4*	76.4*	3.36*	0.392*	74.1	0.765*
HRW	506	7.00	50.0	0.292	0.009	65.3	0.589

Antioxidant activity (DPPH)



Suggested Future Food Science Studies

- Processing
  - milling
    - tempering (time, temp)
    - type of mill
  - other processes
    - extrusion
    - flaking
    - puffing
- Chemistry
  - starch damage
  - effect of aging
  - fermentation
- Sensory characterization of flour and products at different refinement levels
  - Trained panels and consumer panels

Funding and Collaborators

- Initiative for Renewable Energy and the Environment (IREE)
- Forever Green Initiative (led by Dr. Donald Wyse)
- Minnesota Department of Agriculture
- The Land Institute

Collaborators:

- Dr. James Anderson and his research group at the University of Minnesota Agronomy/Plant Genetics Department
- Dr. Lee DeHaan (The Land Institute)
- North Dakota State University Wheat Quality and Carbohydrate Laboratory under Dr. Senay Simsek
- Dr. Alexandra Marti, University of Milan, Food Science, Agricultural Plant Science, Agronomy and Adjunct faculty member at UMN
- USDA-ARS Cereal Crops Research Unit under Dr. Jae-Bom Ohm