Ideal Grain Ingredients:
Breeding Wheat for Health

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Canadian Wheat – High Yield, High Quality

- Wheat is the major cereal grain crop grown and exported in Canada
- Production and grain handling systems help deliver high quality wheat to the world
- Strict variety registration system
  - Ensures continuity in Canadian wheat quality
  - Addresses industry needs (agronomic, disease resistance and processing)
- Canadian wheat breeders have continued to improve yield and disease resistance while maintaining world renowned quality

Can wheat breeders also develop cultivars that provide added health benefits?
Wheat helps feed the world

- Wheat-based foods are among the most widely consumed products in the world
- World population is increasing by 82 million a year and is expected to double in the next 58 years
- Continued rise in diet related health issues

Wheat is a natural vehicle for providing nutrients to a growing population
Can Wheat be a Functional Food Ingredient?

- Major source of minerals and vitamins – potential for prevention of malnutrition in susceptible populations
- Whole wheat products and wheat bran are major sources of dietary fibre in the North American diet
- Contains several bioactive components that impart nutritional benefits and play a role in disease prevention

Staple vs. Health Food - Wheat can be both
However….
there is a lack of consumer awareness and misinformation about the health benefits of wheat

- Refined wheat products are mainstream and there is still a lack of healthful wholegrain products on the market.
- Consumers are not being educated on the health benefits of wheat based on current science.
- Gluten-free foods are being sought after by the general population.
- Popular press is telling consumers that…
  - “foods made with wheat make you fat”
  - “grains are destroying your brain”
  - modern wheats are blamed for increase in obesity, celiac disease & gluten allergy.
A recent paper by Dr. Kasarda, USDA, concluded that he has:

“..not found clear evidence of an increase in the gluten content of wheat in the United States during the 20\textsuperscript{th} century, and if there has indeed been an increase in celiac disease during the latter half of the century, wheat breeding for higher gluten content does not seem to be the basis.”  

What Science Is Telling Us About the Health Benefits of Wheat
Whole grain consumptions is associated with lower chronic disease risk.
Wheat: Rich source of fibre and bioactive compounds

- Wholegrain wheat: 10–14% bran, 2.5 - 3.0% germ and 80 - 85% endosperm.
- 9 to 17 g total fibre per 100 g edible portion - more than in most vegetables (generally 6 g/100 g edible portion).
- soluble:insoluble fibre ratio is about 1:5 wheat, 1:10 for wheat bran and 1:3 for wheat germ

Majority of the phytochemicals beneficial to health are present in the bran & germ fractions
Insoluble wheat fibre

- Increased gut transit time, faecal bulking and improved stool regularity. This may reduce colon cancer risk and improve overall gut health.

- The effects in cancer are likely mediated through delivering bound antioxidant and reducing exposure to / or binding carcinogens. (reviewed by Fardet in NRR, 2010)

- In 153 low fibre consumers, consumption of 3.5 g/d of wheat bran fibre for 14 days improved perception of bowel function, digestive feelings (bloating, constipation & discomfort) and general wellbeing. (Lawton et al. Nutrients, 2013)
Insoluble wheat fibre

Satiety effect - potentially helpful in weight maintenance or reduction

- In a randomized, single blind, crossover study of 14 healthy women, wheat fibre enriched bread decreased ghrelin and increased PYY after consumption compared to oat fibre or white bread. (Weickert et al. *BJN*, 2006)

- Ghrelin and PYY are satiety hormones (Ghrelin promotes food intake; PYY is released after eating and may reduce appetite.)
Soluble wheat fibre

• Potential benefits related to Type 2 Diabetes and CVD

• Improved glucose control through delayed gastric emptying, improved insulin response

• Potential to lower cholesterol via SCFA synthesis and bile acid binding

• Arabinoyxylan is a soluble fibre of interest from wheat with demonstrated health benefits
Arabinoxylan Content of Sequentially Pearled Wheat

<table>
<thead>
<tr>
<th>Sequential Pearling Layer, %</th>
<th>Arabinoxylan %</th>
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<tbody>
<tr>
<td>Wholemeal</td>
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<td>5.0-7.5</td>
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<td>7.5-10</td>
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<td>10-12.5</td>
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<td>15-17.5</td>
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<td>17.5-20</td>
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</table>

Arabinoxylan Distribution Within the Bran

Ames lab data
“Scientific Opinion on the substantiation of health claims related to arabinoxylan produced from wheat endosperm and reduction of post-prandial glycaemic responses”

- Cause and effect relationship was established
- To obtain the effect, 8g of arabinoxylan rich wheat fibre per 100g of available carbohydrates should be consumed.

EFSA Journal 2011;9(6):2205
Phytosterols in wheat

Phytosterols are cholesterol-like compounds that have been shown to lower cholesterol absorption

- Naturally occurring phytosterols in wheat germ have an impact on cholesterol absorption

- Cholesterol absorption from wheat germ test meals was substantially lower than after consumption of phytosterol-free wheat germ test meals in 10 healthy participants (Ostlund et al. AJCN, 2003)
Breeding Wheat with Improved Nutritional Value and Health Benefits
Current Canadian Wheat Breeding Program

• **Modern wheat cultivars are bred for the following priorities:**
  - Yield & agronomic performance
  - Plant disease resistance
  - End-product quality (to meet the demands of the milling and baking industry)

• **Testing is performed on straight grade flour not whole grain**
  - High straight grade flour yields
  - White flour colour
  - Large and uniform white bread loaves

**Over 50 quality traits are tested – none focus on nutrition**
Potential Opportunities to Breed for Nutritionally Superior Wheat

• Wheat for improved wholegrain product quality
  - Increase dough strength to accommodate increased bran and germ fractions (e.g. 7BX overexpressed or specific gliadins)
  - Remove astringent flavour compounds present in bran

• Increase minerals to alleviate malnutrition
  - Genes affecting mineral remobilization
  - Mineral uptake based on location

• Wheat-based functional foods
  - Wheat for products that target specific health benefits
  - Contain superior levels of proven bioactives e.g. high lutein pasta (Itochu, Japan)
  - High amylose (resistant starch) breeding lines
  - High arabinoxylan or beta-glucan varieties
What is needed to breed for healthier wheat?

- Clear indication of what are the health benefits and value in the marketplace
- Industry needs to have a vision of the opportunities
  - Seeking added-value: specific varieties with desired traits for premium quality products (e.g. Warburtons Bakery, UK; Itochu)
- Signals for economic pull
  - Breeders need to know there is a demand from industry
- Researchers and breeders need to work closely with industry to provide the required science and tools
- Implement nutrition-based screening into the breeding program
  - Whole grain vs. refined flour; bioactive components
  - Rapid predictive screening tools (e.g. NIR equations for fibre components; measure cysteine in early generations to predict dough strength)
  - Utilize nutrigenomics technologies (e.g. cell culture, RNA profiling, QTL analysis)
AAFC Research in Support of Breeding for Healthier Wheat

• New analytical tools suitable for plant breeding (NIR equations for fibre components; Electronic Nose)

• Discovery of bioactives and variability in wheat germplasm (arabinoxylan, lutein, betaine, fibre)

• Validation of physiological effects in animal and human models

• Investigating claims regarding functional and nutritional differences in modern vs. heritage wheats.
Variation in Wheat Arabinoxylan Content

• Range in wholegrain (EU): 5.53 – 7.42 %
  (n=129 winter wheat varieties from the EU HEALTHGRAIN diversity screen; Andersson et al 2013)

• 5.94 – 7.69% range among 20 Canadian heritage and modern wheat genotypes grown at 3 environments

• Range in bran: 14.99 – 27.69 %
  (n=12 HRSW and HWSW grown in the US)
Animal Trial results: Rats fed a wheat bran fraction diet had a 27% reduction in epididymal adipose mass compared to the control group.
Current Research: Red Fife and Descendants

How has Canadian wheat changed over the years?

• Investigating 20 key varieties spanning over a century of Canadian wheat production

• Compare the quality of landraces verses modern cultivars:
  • Agronomics – Ron DePauw
  • Milling & Baking – Nancy Edwards
  • Nutrition – Nancy Ames

• Will provide scientific evidence for consistencies and/or changes in quality
Preliminary Results: Milling & Baking Quality

- ~1% increase in protein over Red Fife
- Improvement in strength
- Water absorption
- Loaf volume
Preliminary Results – Nutritional Quality

- Some reductions in total starch content
- Analysis in progress:
  - Dietary Fibre
  - Trehalose, Betaine, Cysteine
  - Minerals

### Starch

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<th>Variety</th>
<th>Ladoga</th>
<th>Hard Red Calcutta</th>
<th>Red Fife</th>
<th>Marquis</th>
<th>Thatcher</th>
<th>Neepawa</th>
<th>Katepwa</th>
<th>Columbus</th>
<th>Laura</th>
<th>CDC Teal</th>
<th>AC Barrie</th>
<th>AC Elsa</th>
<th>Mckenzie</th>
<th>Superb</th>
<th>Lillian</th>
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### Arabinoxylan – Soluble Fibre

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### Ferulic Acid

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**IN SUMMARY**

**Healthy Wheat: See the Opportunities**

- Wheat is an ideal vehicle for providing health-promoting nutrients to a growing population
- Contains a number of bioactive components, concentrated in the bran and germ fractions
- Clinical trial evidence for wheat’s role in...
  - Improving gastrointestinal health
  - Increasing satiety
  - Lowering glucose and insulin response
  - Lowering cholesterol
- **Working towards breeding for healthier wheat**
  - Identifying superior genotypes for nutrition
  - Developing rapid screening tools
  - Examining quality of heritage and modern varieties
- **Need to have economic pull and a vision of the opportunities**
- **Acknowledgements**
  - Dr. Ron DePauw, Senior Principal Wheat Breeder, AAFC, Swift Current
  - Dr. Nancy Edwards, Cereal Scientist, CGC
  - Dylan MacKay, Ph.D. Candidate, University of Manitoba
NEW SCIENCE: Proposed clinical trial to refute Wheat Belly

A weight loss trial that compares carbohydrate sources (balanced for fibre and macronutrients)

- Modern wheat variety
- Ancient wheat variety
- Corn/Rice blend

Objective: weight loss and satiety

Secondary objectives: CVD risk factors, glucose tolerance, insulin sensitivity and inflammation
THANK YOU