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Breeding Healthy Cereals for Today's Consumer Driven Markets

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Canada

Presentation Outline

- Defining today's consumer driven market.
- Rationale for development of more nutritious cereal cultivars
  - Ethical reasons for improving health of Canadians
  - Improving consumer consumption of grain based products
  - Health Claims (consumer education and marketing)
- Potential beneficial physiological effects
- Strategies for improving nutritional value of cereals
  - Breeding
  - Processing

Today's Consumer

- Concerned with health benefits, safety, taste and texture.
- Becoming "label savvy" and are knowledgeable about disease risks and food that may have preventative bioactives.

Ethical Reasons for Improving Health of Canadians

- Target populations include aging consumers facing diseases associated with “metabolic syndrome” and a nutritionally educated generation
- Main disease targets of cereal grains and their protective components:
  - Cardiovascular disease
  - Diabetes
  - Cancer
  - Obesity
- reduce impact of diet related diseases on health care system
- Canadians should benefit from significant clinical findings regardless of health claims and marketing agendas

Encouraging Consumption of Cereal Grains

- Improve consumer perception (e.g. wheat)
  - not all cereals are recognized as functional foods- in fact many cereal products continue to be avoided due to perceptions as high calorie, low nutrient products.

- Improve awareness (e.g. barley)
- Improve end-product usage (e.g. oat)
- Improved nutrition (cultivars).

Health Claims

- New potential health claims: disease reduction through oat and barley beta-glucan, whole grains

- Consumer demands and trends are closely monitored by industry.
  - Functional foods
  - Probiotics and prebiotics
  - Natural Preservatives (e.g. grain-based antioxidants)

Whole Grain Health Claim

- Health Canada will be implementing a whole grain claim in 2008
- Based on AACC whole grain definition
- Whole grain cereal products must contain whole grain in proportions similar to the original grain (endosperm, germ and bran) to be called 100% whole grain flour.
- Opportunity for breeders to develop cultivars whole grain products with improved functional and sensory characteristics.

Research on Hard White Wheat

- colour analyses of seed, flour and end-products;
- identification of colour components and their relationship to flavour;
- consumer preference studies of whole wheat products;
- nutritional advantages of consuming whole wheat products.

AC Barrie **Snowbird**

Justification for a Canadian Barley Health Claim?

- Improve health of Canadians.
- Educate consumers.
- Encourage barley processing by industry.
- Expand markets for Canadian food barley.
- Encourage further research

Example: Reports suggest the emerging Japanese market is due in part to recent FDA approval of the barley soluble fibre health claim.

Current Status of Canadian Barley Beta-glucan Health Claim

✓ Step 1 – Search Totality of Relevant Literature

✓ Step 2 – Assess Inclusion Criteria

✓ Step 3 – Summary Table of Studies

✓ Step 4 – Evaluation of Study Quality

✓ Step 5 – Creation of “Acceptable Study” Summary Table

→ Step 6 – Assessment of Acceptable Studies by Reviewers

• Step 7 - If enough evidence, then industry coalition to submit the claim. If not enough evidence, then further research needs to be conducted to fill in gaps.

Physiological Effects of Grain Consumption

- Oats and barley are well known to be concentrated sources of dietary fibre.
  - Soluble fibre as beta glucan basis of health claims in US and Europe for lowering cholesterol and risk of CVD. Dose response established (3 grams/d).
  - Mediation of insulin and glucose response well documented in clinical trials.
  - Mechanisms not definitely established. Relationship between MW/viscosity and efficacy needs to be confirmed
- Rich in antioxidants which are linked to disease prevention and can be secondary preservatives.
- Oat proteins with bioactivity as anti-hypertensive peptidase inhibitors and against age-related cognitive decline .

Update of Clinical Information: Glycemic Response

- Addition of β -glucan reduced GI of foods by 4 units per gram without reducing palatability, making it a useful functional food component (Jenkins et al. 2002, European J Clinical Nutrition).
- Consumption of barley β -glucan but not resistant starch in muffins was effective in reducing glucose and insulin response in mildly insulin resistant men (Behall et al, 2006 Nutrition Research).
- High amylose barley (Himalaya 292) reduced glycemic and insulinemic response but not satiety in healthy women subjects (Keogh et al, 2006, EJCN)
- The β -glucan found in oats and barley can help to overcome harmful effects caused by saturated fats such as insulin resistance,elevated blood glucose, and elevated cholesterol. (Yokoyama and Shao, 2006)

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Wheat Bran

- Wheat bran consumption improves glucose tolerance (Anderson and Chen,1979).
- Wheat bran more strongly inversely associated with CHD than most other whole grains (Liu *et al* 1999).
- Improvement may increase utilization of wheat bran as a functional ingredient/nutraceutical as well as result in more acceptable whole grain products.

- Wheat bran is one of the most concentrated sources of dietary fibre, containing as much as 50%; common additive used to increase the fibre content of food.
- Oligosaccharide content of wheat (fructans) affects bifidobacteria in the gut while decreasing E. Coli
- Wheat bran was shown to provide protection against colorectal cancer in human intervention studies.
- Preliminary research shows anti-tumor activity correlated to lignan content which differed among four wheat cultivars.

Wheat Bran Animal Trials

Recent studies between AAFC and the University of Manitoba (2007) show a reduction in epididymal fat with specific fractions and cultivar. Cell culture studies underway.

Effect of Whole Grains on C-Reactive Protein

- Significant decrease in C-reactive protein and abdominal body fat in participants consuming whole grains than those consuming refined grains.
- Magnitude of reduction in C-reactive protein concentration with whole grain diet was similar to that of statins.

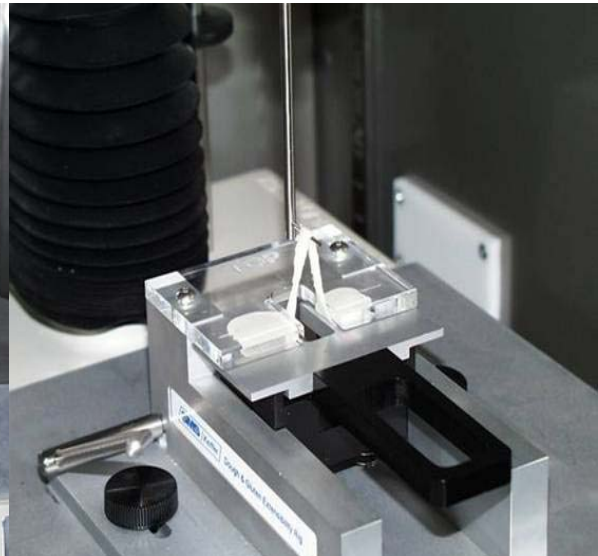
Katcher et al. 2008. Am J Clin Nutr.

Strategies for Improving Nutritional Value of Cereals

Traditional Wheat End Product Quality

- Modern wheat cultivars have been bred to meet the demands of the milling industry: e.g. high flour yields, large and uniform loaves of white bread.
- Over 20 quality traits are tested – none focus on nutrition
- To satisfy consumer needs and benefit the health of Canadians, nutritionally beneficial compounds present in wheat, particularly in the bran and germ fractions should be optimized.



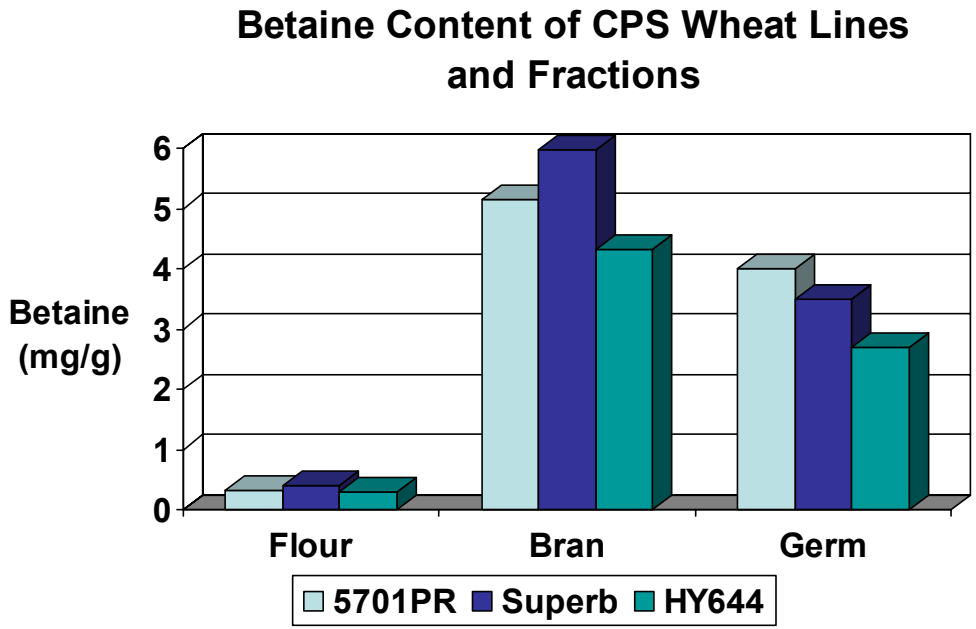


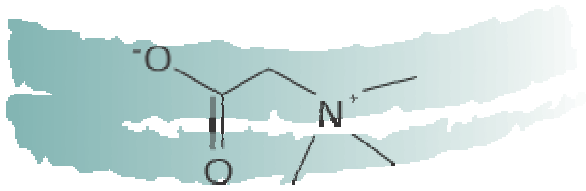
What is needed to successfully develop cereal products with enhanced nutrition and consumer appeal?

- Uncover genetic variation for human health promoting phytochemicals in bran.
- Utilization of mammalian cell cultures, in vitro reactor system, animal bioassay,human feeding and sensory as breeding criteria.
- Optimizing processing to balance functional and physiological attributes.

Characterize Canadian wheat germplasm for known health promoting phytochemicals

- High lutein lines are being developed to provide consumers with increased nutrition (eye health)
- Wheat is one of the highest sources of betaine (as a methyl donor, betaine participates in the methionine cycle in human liver and kidneys)





Betaine

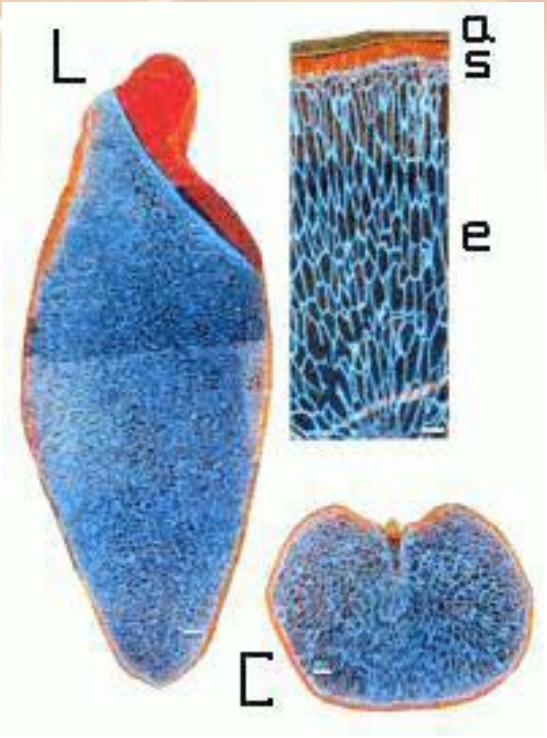
Experimental Plan

- Feed bran (or extracts) from genetically characterized material to SD rats as well as cell culture.

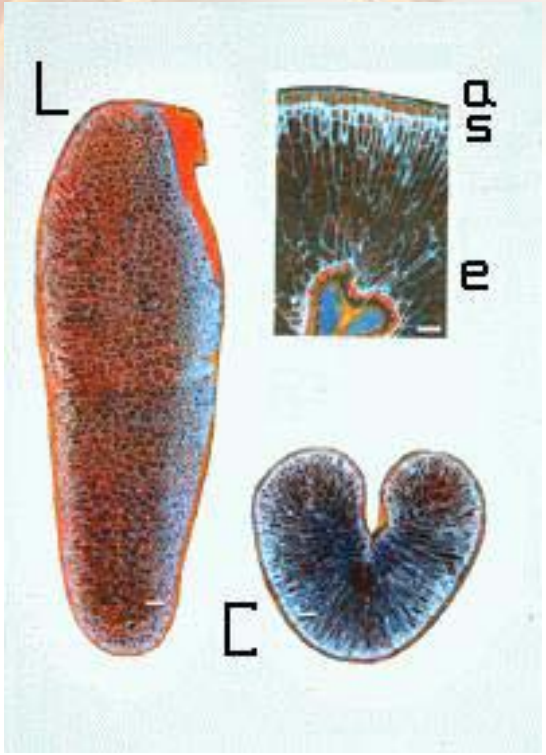
- Isolate tissues of interest, extract RNA and use microarrays to study altered gene expression in the animals. Examine cell cultures for phenotypic changes.

- Identify regions of the wheat genome responsible for changes in mammalian gene expression

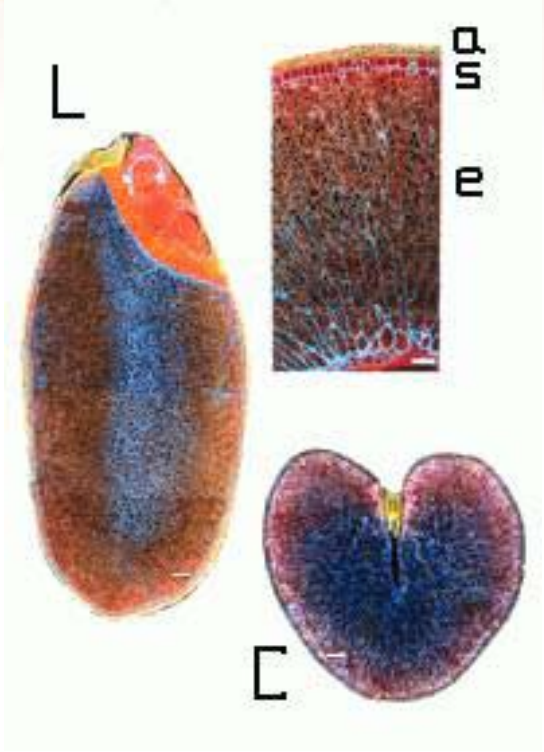
Potential for Altering the Distribution of Nutrients within the Kernel



Barley



Oats



Wheat

From Dr. Karin Autio, Foods Under the Microscope
Food Structure http://www.magma.ca/~scimat/

Cultivar Differences in Wheat Bran (10% pearled)

Superb

TDF: 47.3%

BG: 2.0%

SC8021-V2

TDF: 48.4%

BG: 1.31%

Karma

TDF: 38.6%

BG: 2.2%

Majestic

TDF: 46.3%

BG: 1.7%

Wheat Bran Composition Differences with Degree of Pearling

Wheat Class	Pearling %	Total Starch %	Total Phenolics Gallic Acid Equivalents, ug/g	Antioxidant Activity Trolox Equivalents (umoles)/100g
Hard Red Spring	10	19.25	1015	5005
	15	23.89	952	4694
	20	28.27	895	4248
Durum	10	11.58	953	5279
	15	17.30	895	4955
	20	23.32	830	4525
Soft White Spring	10	22.39	739	4137
	15	29.06	714	3751
	20	33.13	684	3431

Oat Breeding: Enough Beta-Glucan to Lower Cholesterol?

4% beta-glucan (Minimum)

78 g or 3 bowls of oatmeal

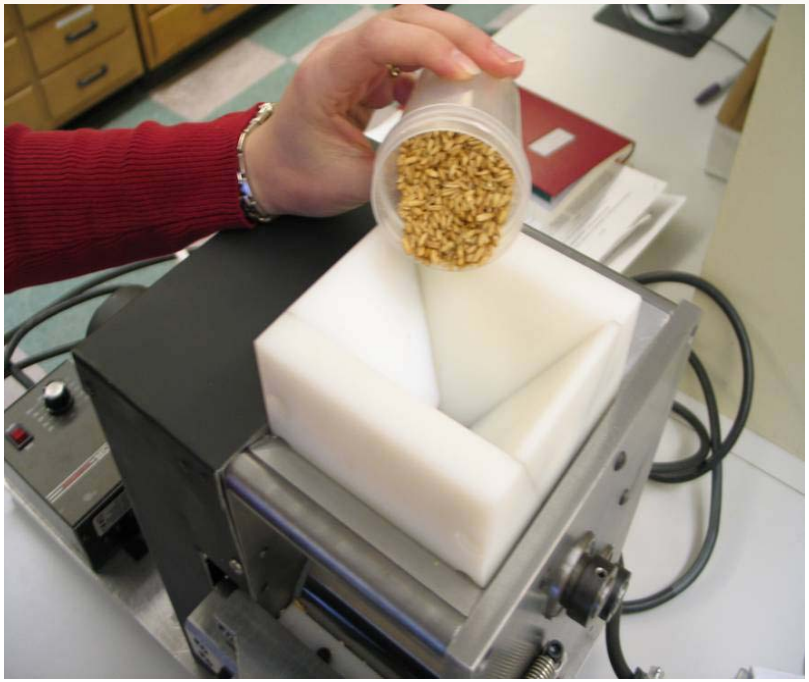
6% beta-glucan

52 g or 2 bowls of oatmeal

8% beta-glucan

39g or 1.5 bowls of oatmeal

Early Generation Oat Testing



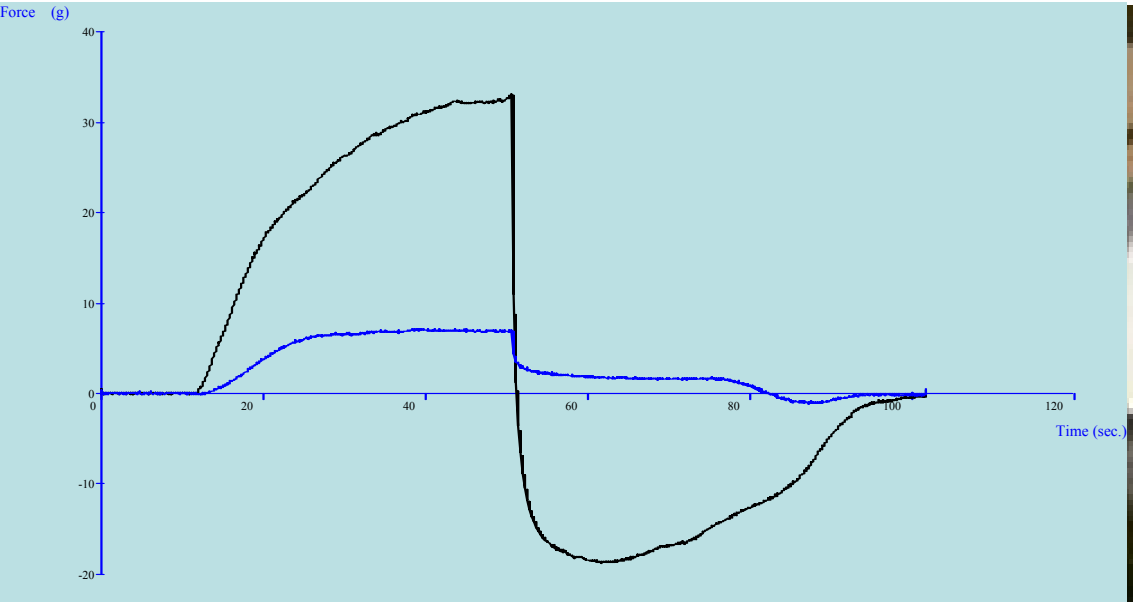
Ames and Rhymer, 2003. Cereal Chem 80(6):699-702

Oat Nutrition and End Product Texture: Genotypic and Environmental Effects

Summary of ANOVA for Oat Beta-glucan, Total Dietary Fiber and Antioxidant Activity

		ANOVA *F*-Value[a]			
Characteristic	Mean	Genotype	Environment	GxE	Dup(Envir)
β-glucan	5.88	229.66**	6.25^{ns}	5.73**	7.93**
Total Dietary Fiber	14.40	29.97**	1.04^{ns}	1.74^{ns}	6.53*
Antioxidant Activity	1478	12.30**	7.18^{ns}	4.32**	3.78*

[a] P < 0.001 and P < 0.05 indicated by ** and * respectively, ns = not significant



Fibre Content of Oat Pasta

Pasta Type	Beta-glucan % (d.b.)	Total Dietary Fibre % (d.b.)
100% Oat	4.34	12.79
100% Whole Wheat	< 1.00	5.00
100% Durum	0.00	3.00

Barley Breeding: Utilizing Genetic Diversity

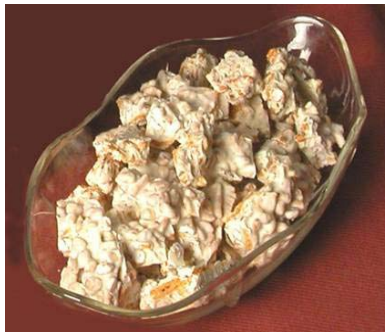
Move beyond the “one bag of flour” concept

Identifying Genetic Diversity Creates Opportunities for Improved Healthy Grain Products

Diverse Barley Genotypes






Novel Barley End-Products for Taste, Convenience and Nutrition

Properties of Western Canadian Barley Cultivars

	Beta-Glucan (%)	AEV (cps)
CDC McGwire	4.92	12
CDC Candle	6.48	75
CDC Rattan	7.28	131
CDC Alamo	7.42	82
CDC Fibar	10.12	237



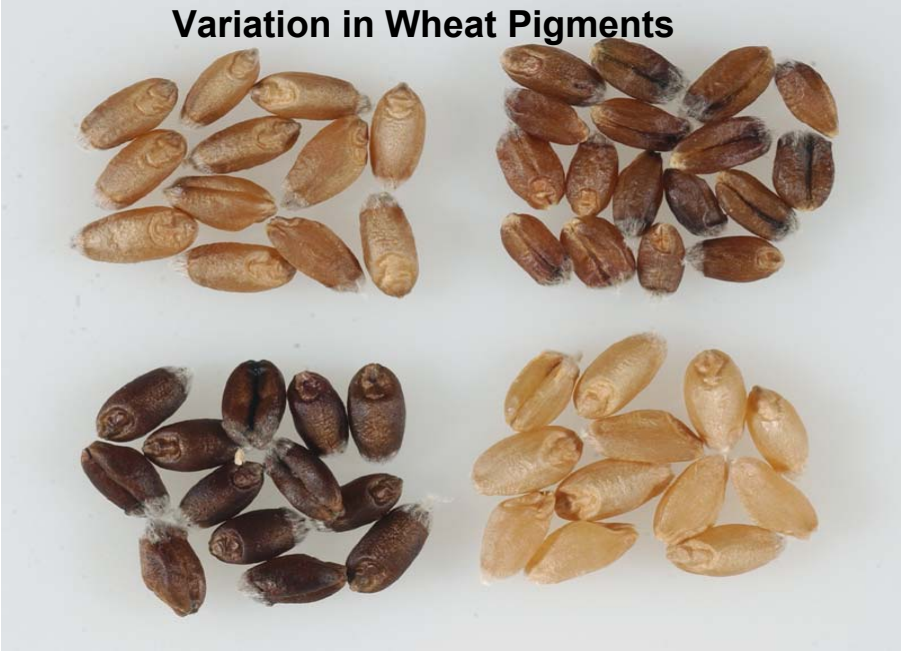
Effect of Infrared Heat Treatments on Fibre and Beta-Glucan Extract Viscosity of Barley Milling Fractions

Milling Fraction	Micronization Tempering Level %	Beta-Glucan (%, db)	TDF (%, db)	AEV (Pa.s x 100)
Straight Grade Flour	not micronized	4.19	9.32	1.32
	16	4.65	10.96	3.58
	20	4.98	11.44	7.05
	24	5.56	12.95	13.35
Flour from Dusted Bran	not micronized	8.47	19.08	15.12
	16	8.74	22.81	19.57
	20	8.71	22.15	27.25
	24	8.54	21.55	42.85
Flour from Dusted Shorts	not micronized	8.76	21.05	16.55
	16	8.55	20.54	27.61
	20	8.23	19.72	32.21
	24	8.02	19.57	50.45

Grain as a Source of Antioxidants

- Potential use in…
  - human health
  - natural food preservation
  - flavour modification

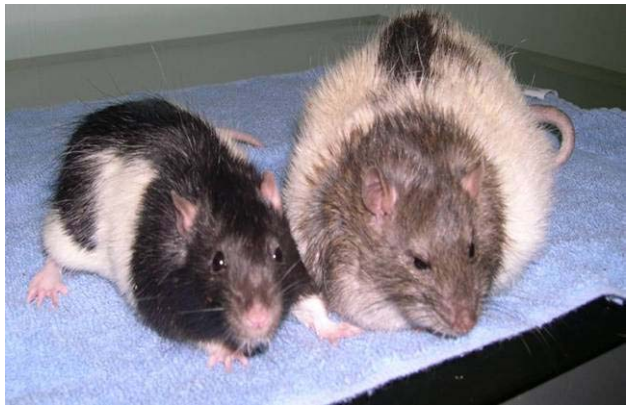
- Compounds present in grain need to be identified and their various roles confirmed through clinical trials

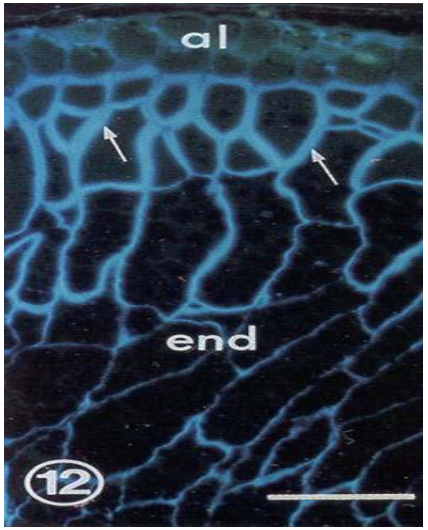


Rye Composition

Rye Sample	Beta-glucan (%, d.b.)	TDF (%, d.b.)	Protein (%, d.b.)	Total Phenolics (GA equiv, ug/g d.b.)	Antioxidant Activity (T.E.umoles/100g sample d.b.)
Normal Gluten	4.6	16.6	13.0	1046	1172
Strong Gluten	4.5	17.7	14.5	1003	1178
White Rye	1.6	17.6	15.6	1303	1352

Breeding Priorities for Improving Cereal Nutrition





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