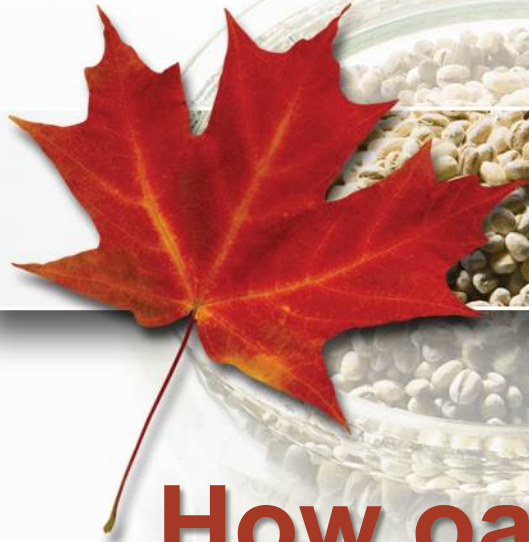




Agriculture and  
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Canada



# How oat processing affects the ability of oat $\beta$ -glucan to reduce cholesterol and blood glucose

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*Agriculture and Agri-Food Canada*

*July 14, 2014*

# Health Benefits of Oat Foods

Shown to:

- Significantly reduce serum total and LDL-cholesterol levels
- Significantly reduce post-prandial blood glucose
- Extend satiety



# Soluble Fibre

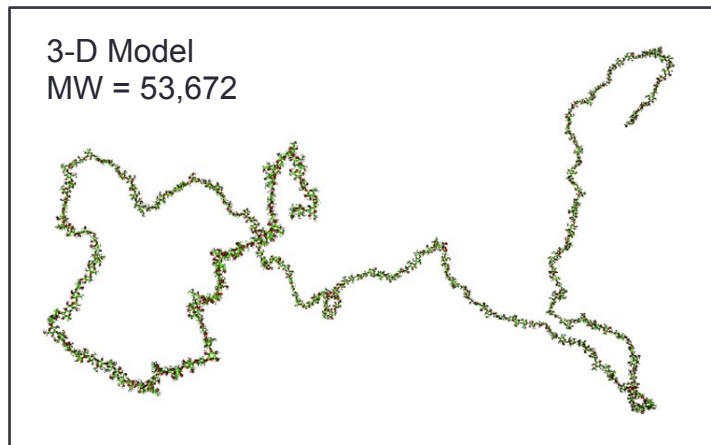
## *Mixed linkage $\beta$ -glucan*

Grain	$\beta$ -glucan content (%)
Oat groats	3.9 – 6.8
Barley	3.0 – 10.6
Rye	1.0 – 2.1
Wheat	0.5 – 1.0
Corn	0.1
Rice	0.1

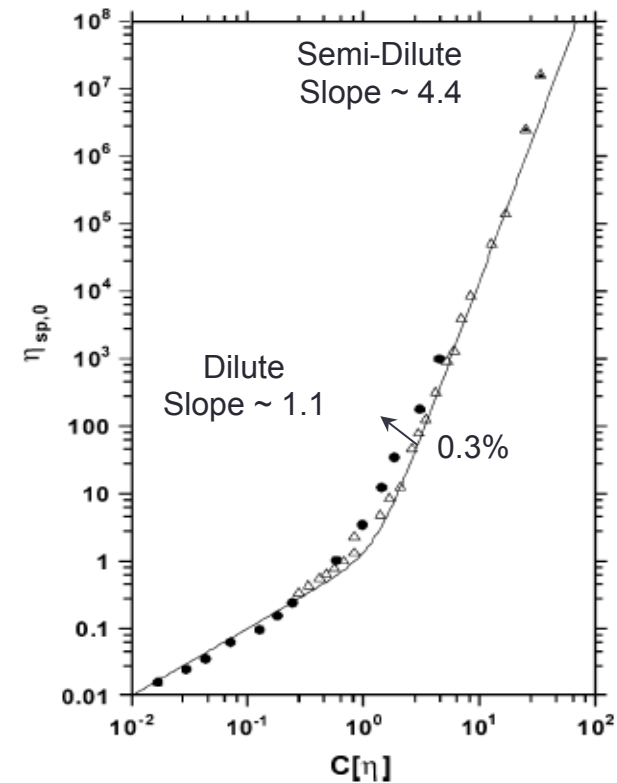
- $\beta$ -Glucan is a major component of cell wall in oat groats
- Oats and barley have the highest  $\beta$ -glucan contents of the cereal grains

# A Viscous Polysaccharide

- Linear polymer of glucose
- High molecular weight
  - >1,000,000 g/mol in native state
  - More than 12,000 glucose monomers



(Li et al., 2012)



(Ren et al., 2003)

# Mechanisms of Action

- Slow mixing in stomach
- Delay gastric emptying
- Slow mixing of digestive enzymes with food
- Hinder emulsification of fat
- Intact cell walls limit access
- Delay absorption of nutrients
- Increase bile acid and cholesterol excretion



# Legislation

## *Cholesterol Reduction*

- Four jurisdictions
  - USA
  - Canada
  - European Union
  - Malaysia



- Recommend 3g oat  $\beta$ -glucan should be consumed per day in order to obtain the claimed effect

# Conditions of Use

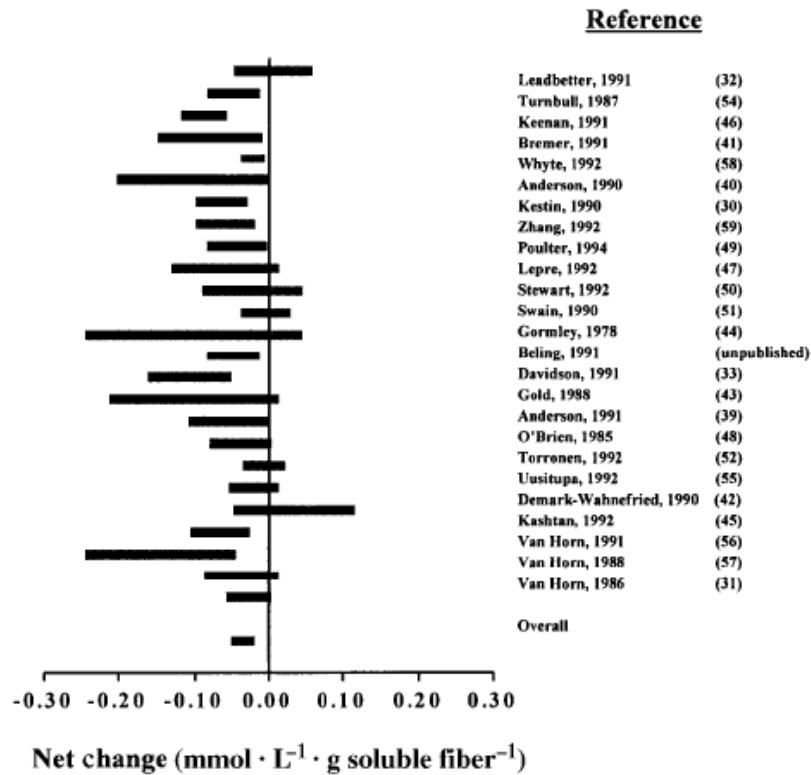
	Requirements
USA	0.75 g $\beta$ -glucan/serving
Canada	0.75 g $\beta$ -glucan/serving
European Union	1 g $\beta$ -glucan/serving
Malaysia	2 g $\beta$ -glucan/100g (solids)

- Although, all acknowledge that viscosity plays a role in the effect, none stipulates that the  $\beta$ -glucan demonstrates viscous behaviour.

# Evidence of Efficacy

Total Cholesterol

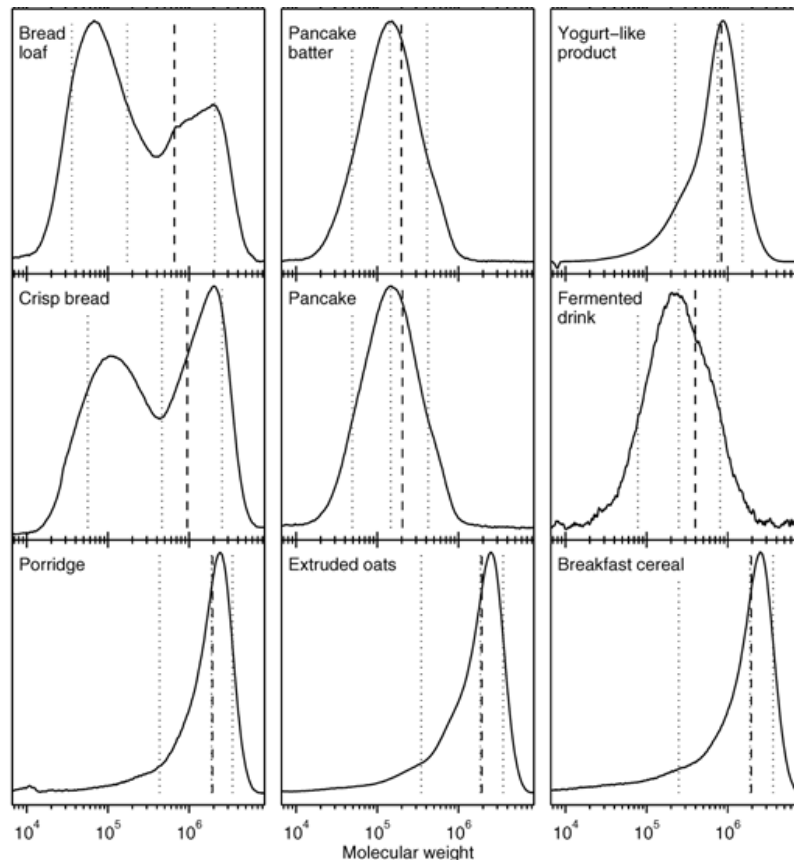
Oat products  
*n* = 25  
 No. of subjects = 1600  
 Average dose: 5.0 g



(Brown et al., 1999)



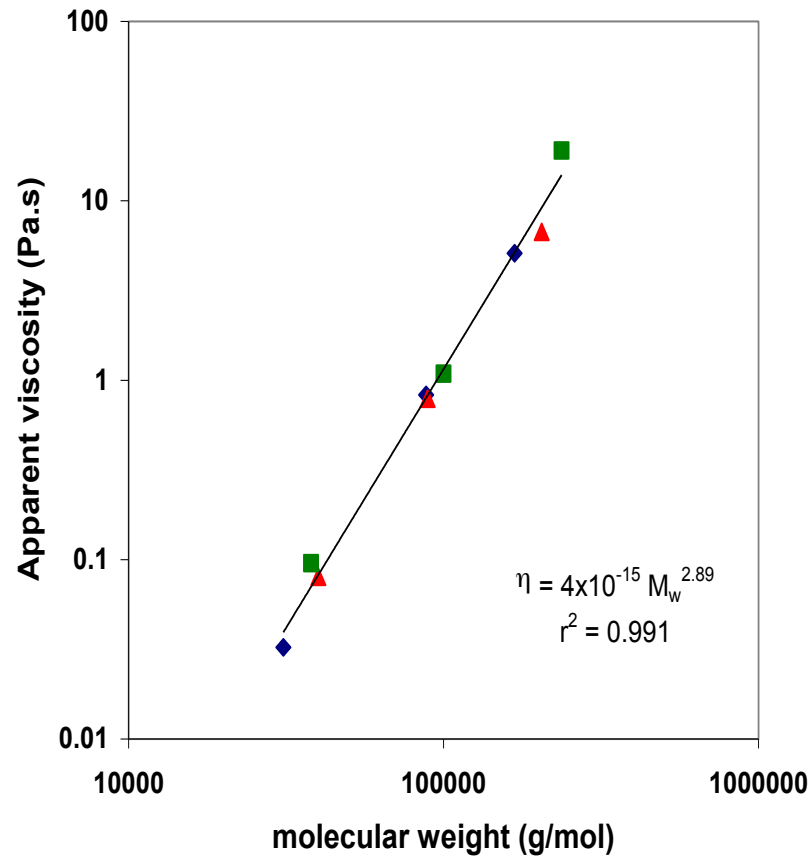
# Effects of Processing



(Åman et al, 2004)

- $\beta$ -Glucanase enzymes occur naturally in flours
- Oat products are heat treated to reduce lipase activity
- Wheat, barley, rice and rye flours can cause depolymerization
- Oxidizing agents like ascorbic acid can also cause depolymerization

# Molecular Weight Effect

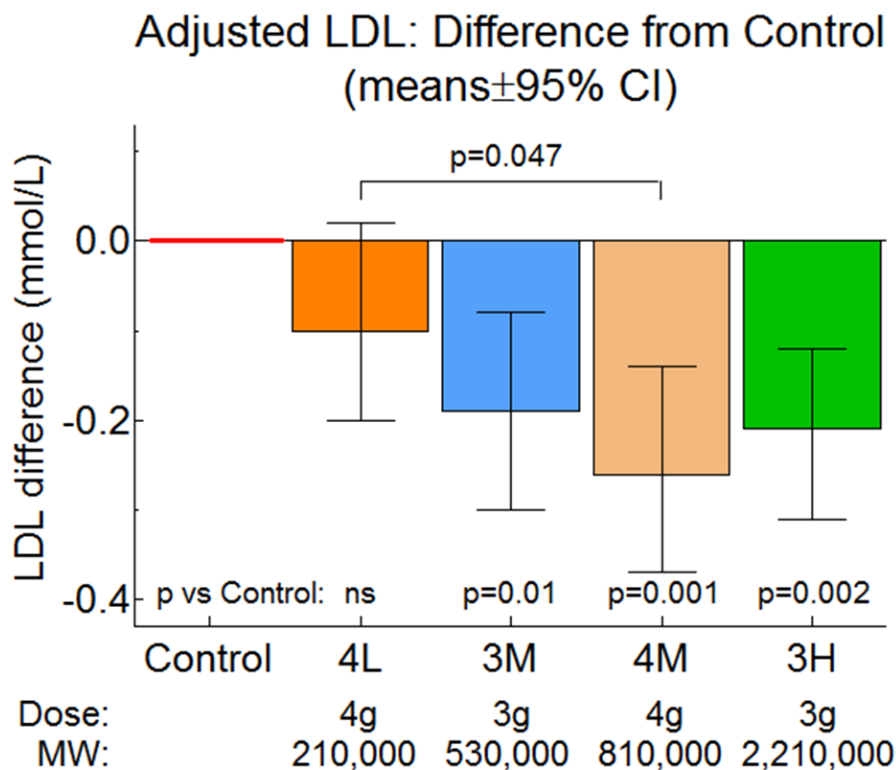


- Viscosity decreases exponentially as  $\beta$ -glucan is depolymerized



(Tosh et al., 2004)

# Effect of $\beta$ -Glucan Molecular Weight



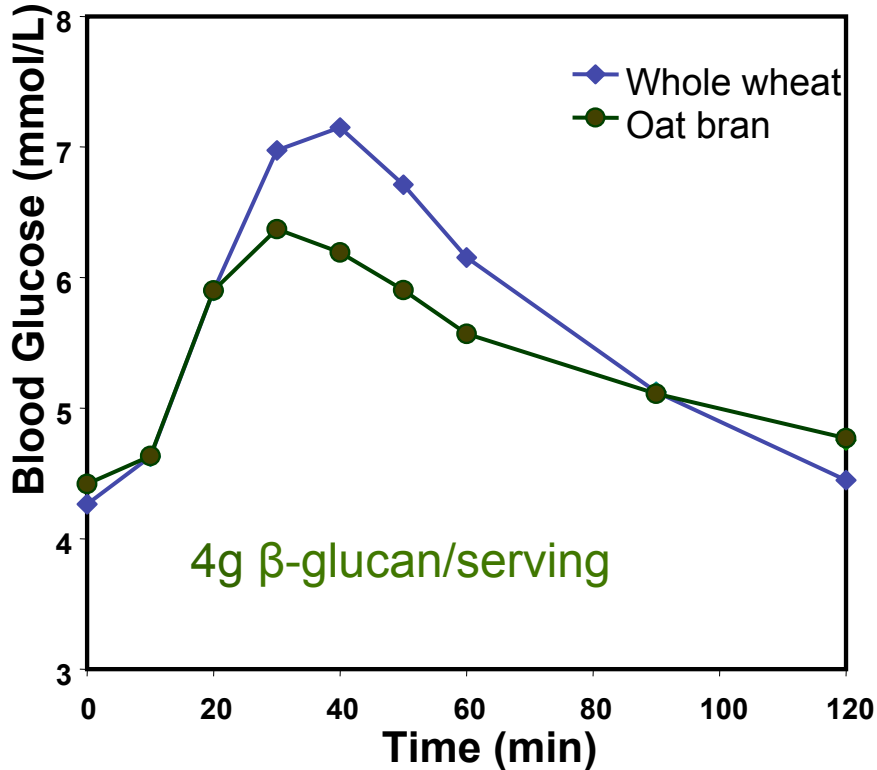
(Wolever et al., 2010)

- Four oat bran cereals extruded under different conditions to produce a range of molecular weights



# Glycemic Response

- Relative blood glucose concentration after a meal



(Tosh et al., 2008)

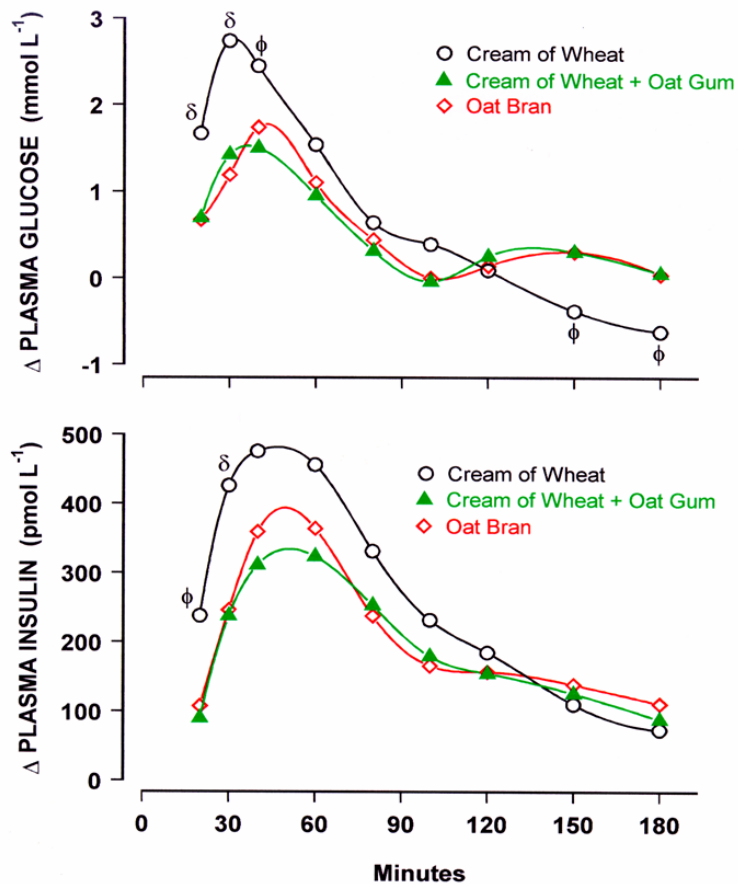
- Oat Bran Muffins
- Lower glycemic response than whole wheat muffins
- Prevent blood sugar spikes



# Legislation for Glycemic Response

- European Union allows:
  - “Consumption of  $\beta$ -glucans from oats or barley contributes to the reduction of the glucose rise after a meal”
  - 4g  $\beta$ -glucan per 30g available carbohydrate
- Glycemic Index labelling allowed in Australia and New Zealand
- Canada has draft legislation for glycemic response health claims
- USA has no specific legislation

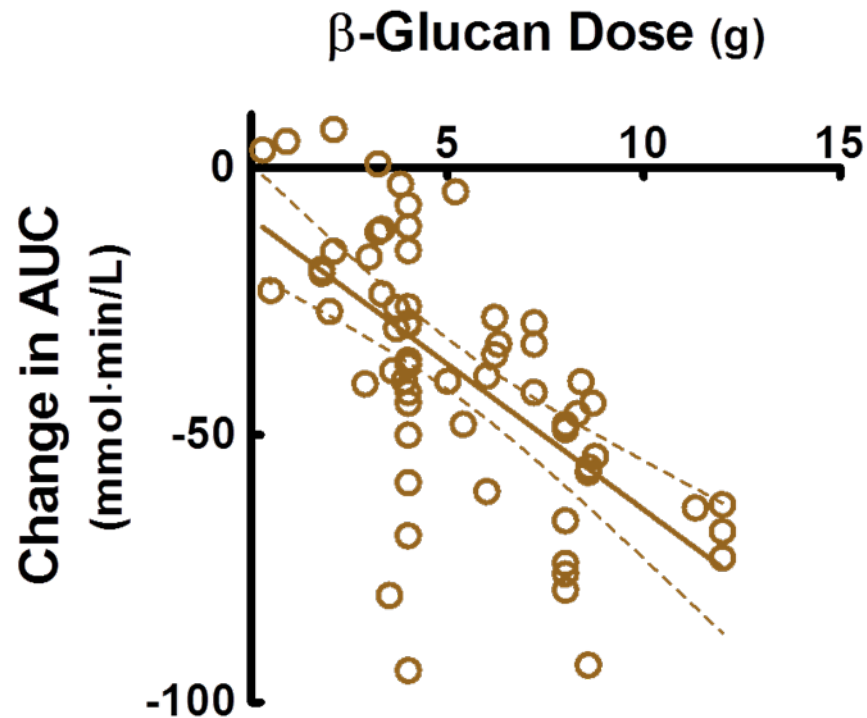
# Bioactive Component is $\beta$ -Glucan



- Glycemic response to oat bran porridge was lower than to cream of wheat porridge
- Purified  $\beta$ -glucan added to cream of wheat porridge lowered glycemic response equivalently
- Insulin response showed the same trends

(Braaten et al., 1994)

# Evidence of Efficacy



(Tosh, 2013)

- Review of 22 research articles
- 66 foods tested
- Reduction in AUC of  $5.5 \pm 0.8$  mmol·min/L for each gram oat  $\beta$ -glucan consumed
- 69% of foods significantly reduced glycemic response

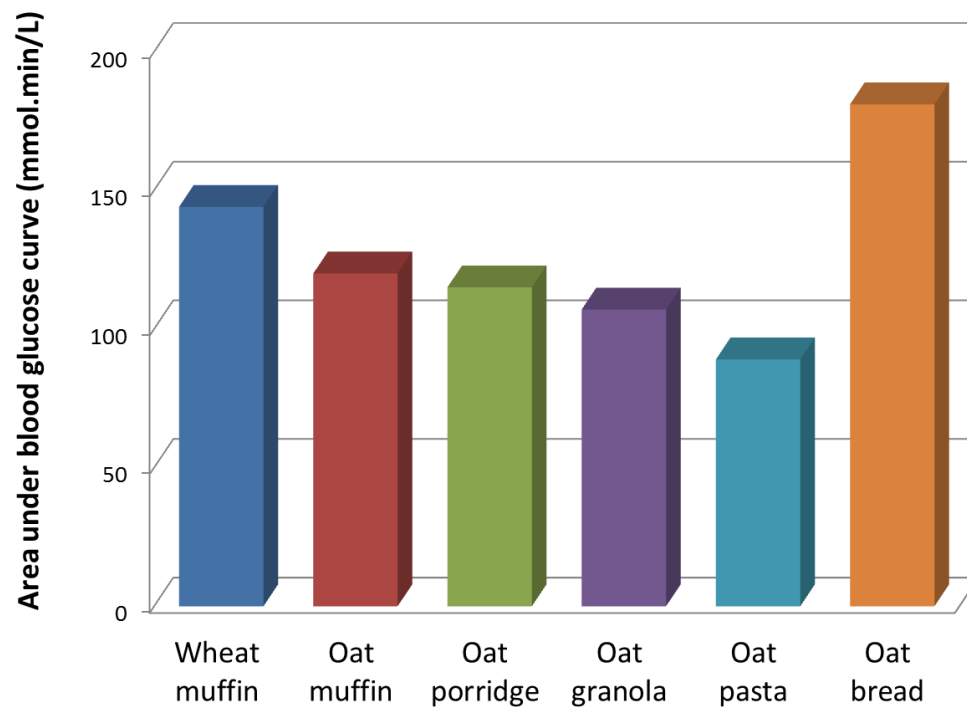
# Role of Processing in Modulating Glycemic Response

- Changes in food microstructure during processing
  - Cell wall integrity
  - Starch gelatinization and depolymerization
  - Solubilization of  $\beta$ -glucan
  - Depolymerization of  $\beta$ -glucan



# Processing and Glycemic Response

Glycemic response to different oat foods



(Regand et al., 2008)

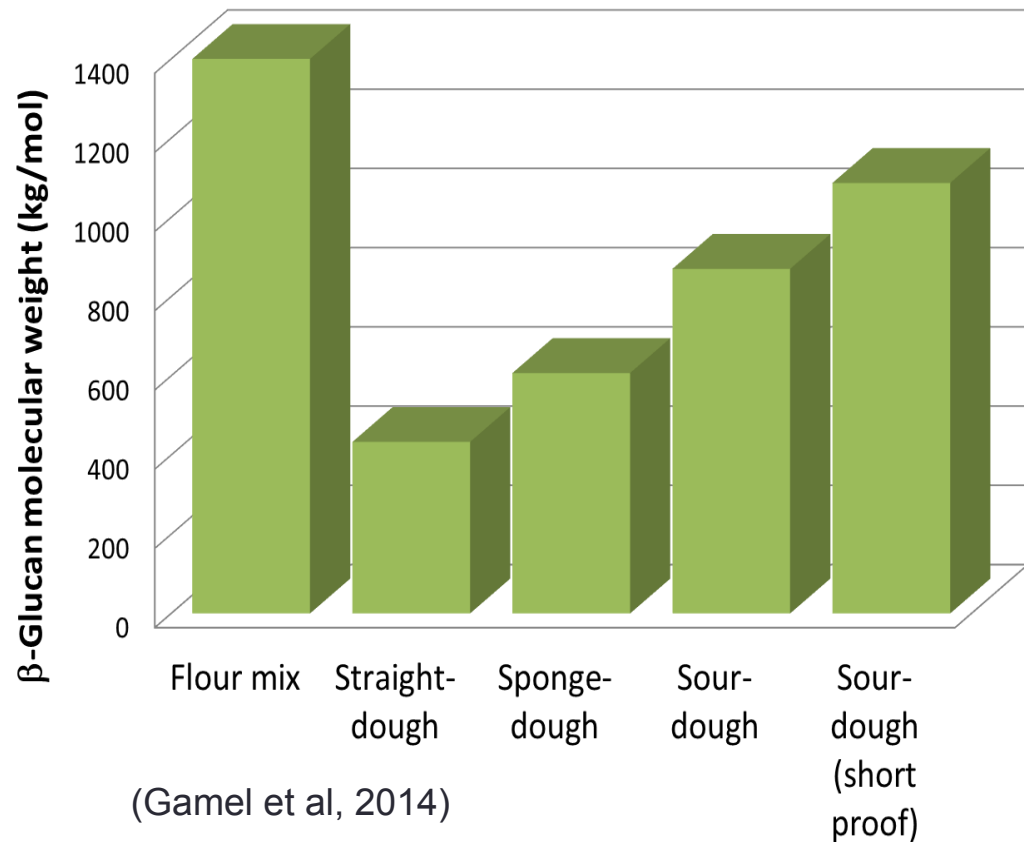
- Products with similar nutrient profiles
- Processes differ in
  - Heat
  - Moisture
  - Pressure
  - Enzymes



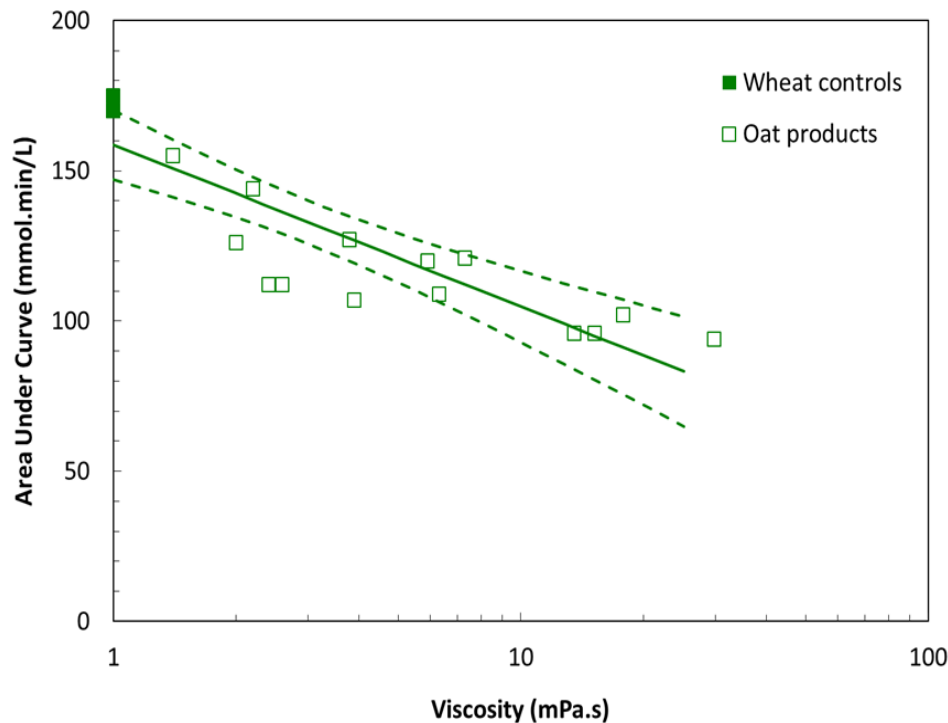
# Bread Processing

- Process can be optimized to protect  $\beta$ -glucan against depolymerization
- Reduce contact time between wheat and oat ingredients
- Organic acids in sour inhibit enzyme activity

Depolymerization in Oat/Wheat Bread



# Viscosity and Glycemic Response



(Tosh, 2013)

- Viscosity development estimated by in vitro digestion protocol
- Foods developed to generate a range of viscosities
  - Dose, solubility, molecular weight
- Glycemic response decreased as viscosity increased

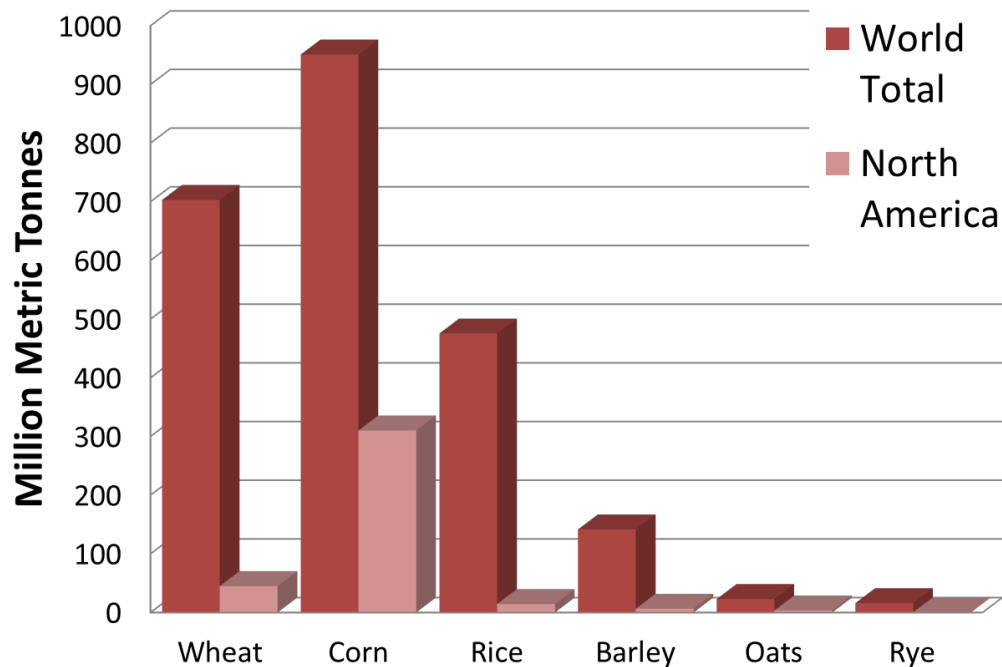
## Next Steps



- Increase oat consumption
- Provide new products with health benefits
- Functional foods is the fastest grow sector of the food industry
- Challenge of changing consumer behaviour

# Current Situation

## Grain Consumption - 2013/2014



- Current oat consumption in North America
  - 8% that of wheat
  - 1% that of corn
- Most people are not eating enough oat fibre to meet recommendation

USDA, Foreign Agricultural Service,  
Production, Supply and Distribution Online

# Challenge

- Think outside the cereal bowl!
- Innovative products
  - Convenient
  - Tasty
  - Nutritious
- Snacks, side dishes, and more



# Summary

- The bioactivity of oat  $\beta$ -glucan has been attributed to its ability to form viscous solutions during digestion
- Foods can be designed to change the microstructure, molecular weight and solubility of  $\beta$ -glucan
- Ultimately these characteristics determine the ability of foods to impact lipid and carbohydrate metabolism
- Food processing can be used to optimize health benefits of oat food products.
- Increase in oat consumption is necessary to meet recommended 3g/day to realize potential health benefits



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**Thank you!**