

## **Soft Wheat and Fiber**

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### **Biography of Edward Souza, PhD**

Dr. Edward Souza directs the regional laboratory for the United States Department of Agriculture, Agricultural Research Service charged with wheat quality research for the eastern US. He developed more than 20 new wheat varieties for the University of Idaho. While at the University of Idaho, he led a multi-disciplinary research project that integrated crop development with crop management, molecular genetics, and cereal chemistry. His research projects include multi-state efforts for breeding insect resistance and the development of cultivars for a new class of wheat for Asian export. Dr. Souza's consulting works with supply chain management to improve food quality and reduce costs in bakeries. His research and consulting experience includes work in North America, Mexico, Argentina, Brazil, and China.

# Soft Wheat and Fiber

Edward Souza and Mary Guttieri

USDA ARS Laboratories and Ohio State University, Wooster OH  
Research funded by Kraft Foods, Kellogg Co, and General Mills



## Soft Wheat and Fiber

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- ▶ **Overview of Fiber as an Ingredient**
  - ▶ Definitions
  - ▶ Method of Analysis
  - ▶ Variation in Fiber Content
  
- ▶ **Functional Analysis of the Primary Fiber in Wheat Flour**
  - ▶ Non-Starch Polysaccharides
  - ▶ Distribution in milling
  - ▶ Effects in white flour and whole grain flour

## Dietary Fiber Definitions

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- ▶ **Dietary Fiber** = nondigestible carbohydrates and lignin that are intrinsic and intact in plants.
  - ▶ **Soluble** (prebiotic, viscous) - readily fermented in colon.
  - ▶ **Insoluble** - metabolically inert, absorbing water throughout the digestive system.
- ▶ **Functional Fiber** = isolated, nondigestible carbohydrates that have beneficial physiological effects in humans.
- ▶ **Total Fiber** = Dietary Fiber + Functional Fiber.

USDA, NAL & NAS, Institute of Medicine, Food and Nutrition Board.

Dietary Reference Intakes for Energy, Carbohydrate, fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids (Macronutrients) (2005)

## Dietary Fiber Definitions

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- ▶ **Types of Fibers in Cereals**
  - ▶ Arabinoxylans and arabinogalactans
    - ▶ Primary fiber in wheat, rice, corn grain
  - ▶ (1→3),(1→4)-β-glucans
    - ▶ Dominant fiber in barley, oat grain
  - ▶ Pectins – a minor component in most cereal grains
  - ▶ Resistant Starch – High Amylose
    - ▶ Specialty starch genetics: corn, barley and more recently wheat
- ▶ **Health Claims**
  - ▶ Health claims are primarily related to total fiber or (1→3),(1→4)-β-glucans

*Critical Reviews in Food Science and Nutrition, 47:599–610 (2007)*

*Dietary Reference Intakes for Energy, Carbohydrate, fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids (Macronutrients) (2005)*

## Dietary Fiber Definitions

### ▶ Why Fiber in Biscuits and Crackers?

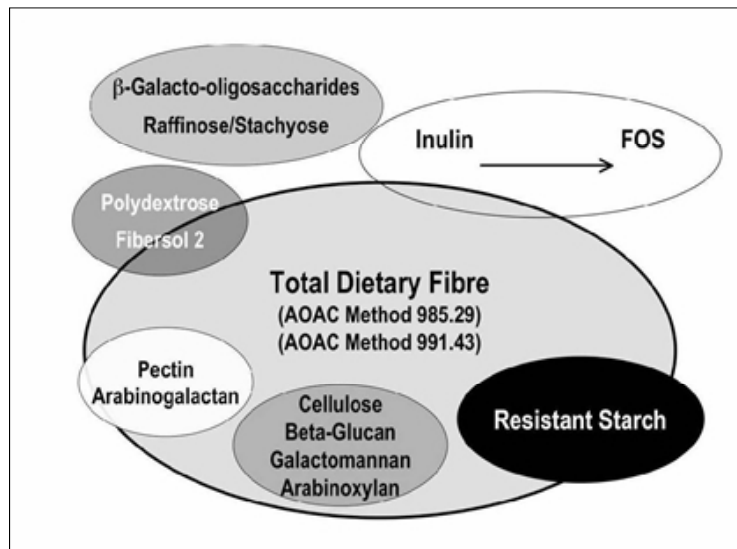
- ▶ Consistent, inverse association between dietary whole grains and incident cardiovascular disease in epidemiological studies.
- ▶ Intake of fiber from grains and whole-grain foods is inversely associated with incidence of small intestinal and colorectal cancer.

### ▶ Health Claims

- ▶ Health claims are primarily for total fiber (CVD, cancer) and (1→3),(1→4)- $\beta$ -glucans (lower cholesterol).
- ▶ No isolated major health claims approved for arabinoxylans or other components of dietary or total fiber, except  $\beta$ -glucans.

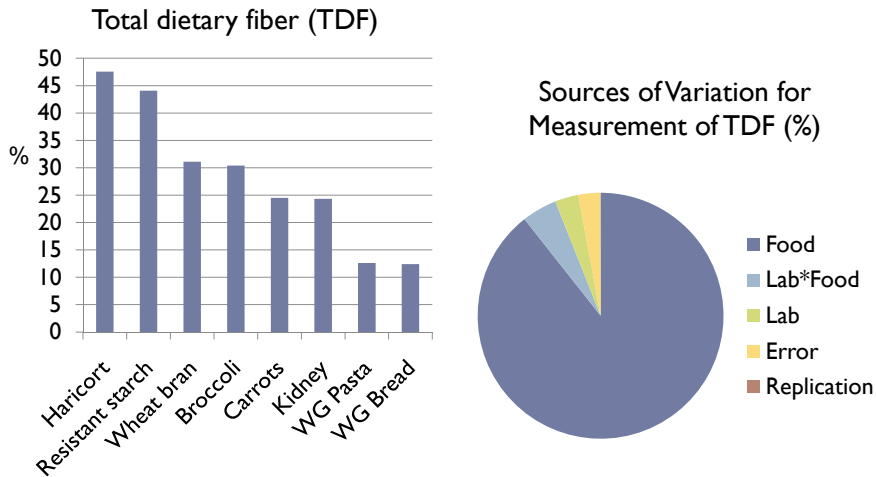
*Mellen et al. Nutrition, Metabolism & Cardiovascular Diseases 18, 283 -290 (2008)*  
*Schatzkin et al. Gastroenterology. 135:1163-7 (2008)*  
*Critical Reviews in Food Science and Nutrition, 47:599-610 (2007)*

Types of Fiber : AOAC 991.43 and AOAC 2009.1 (CODEX)



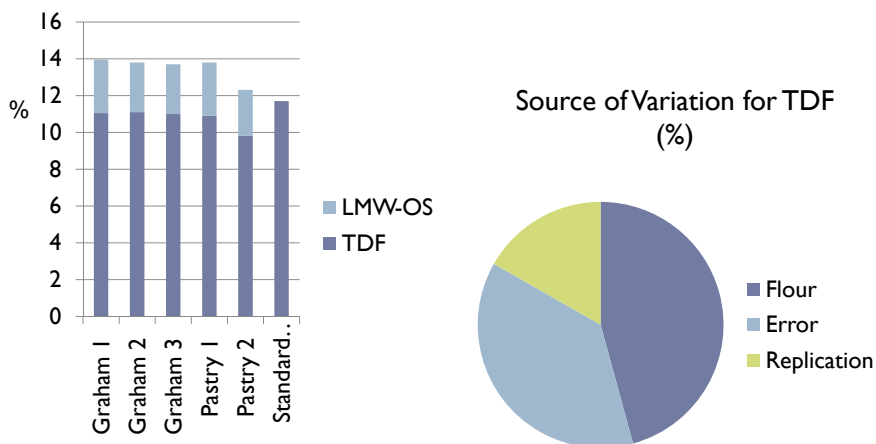
MCCLEARY ET AL.: JOURNAL OF AOAC INTERNATIONAL VOL. 93, NO. 1, 2010

Variation in Total Dietary Fiber (TDF):  
 AOAC 2009.1 CODEX Method AOAC Collaborative Study.  
 16 Labs/8 Foods/Two Replications



MCCLEARY ET AL.: JOURNAL OF AOAC INTERNATIONAL VOL. 93, NO. 1, 2010

Variation in Fiber Content of Whole-Grain Soft Wheat Flour  
 AOAC 2009.1 CODEX Method.  
 Commercial Flours and USDA Standard Reference Values



TDF: Total Dietary Fiber. LMW-OS : Low molecular weight – oligosaccharides.  
 Fiber analysis provided by Covance.

## Thoughts on Measuring Fiber Content

- ▶ The AOAC 2009.1 CODEX fiber test is accurate and reproducible for measuring ingredients.
  - ▶ Precision as measured in commercial laboratories meets or exceeds initial precision of published method.
  - ▶ Fiber content variation among flour samples is much smaller than variation among ingredients in initial AOAC collaborative.
  - ▶ Difficult to make specific claims of fiber advantages due to genetics or regional differences within wheat supply.
- ▶ Increased precision within any standard test.
  - ▶ Requires co-labs and review of protocols.
  - ▶ Professional society committee review.
  - ▶ Experience across diverse applications.

### Non-Starch Polysaccharides

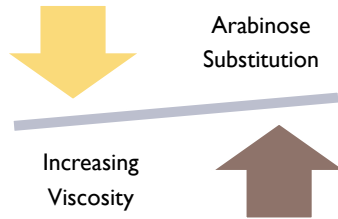
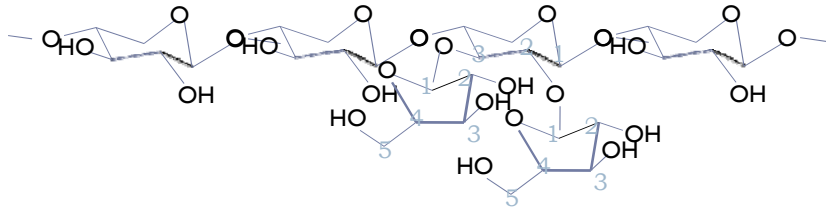
Arabinoxylans

AGP

Water-  
Extractable

Water-Unextractable

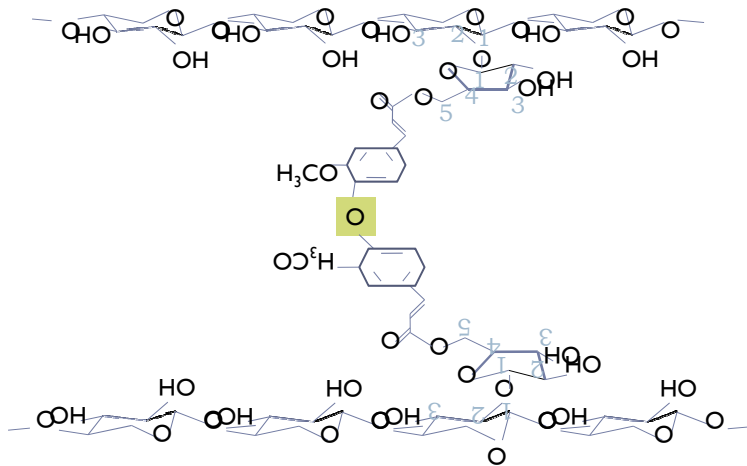
## Arabinoxylan Structure



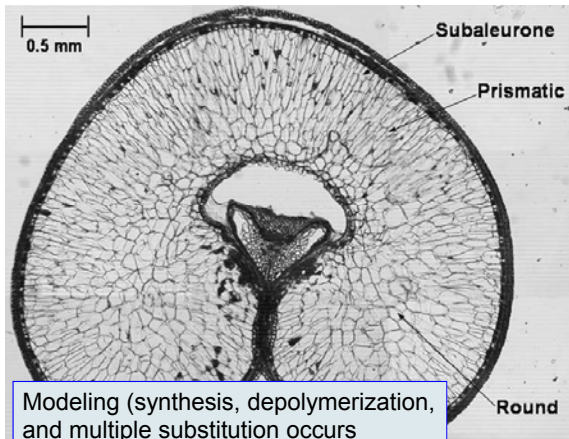
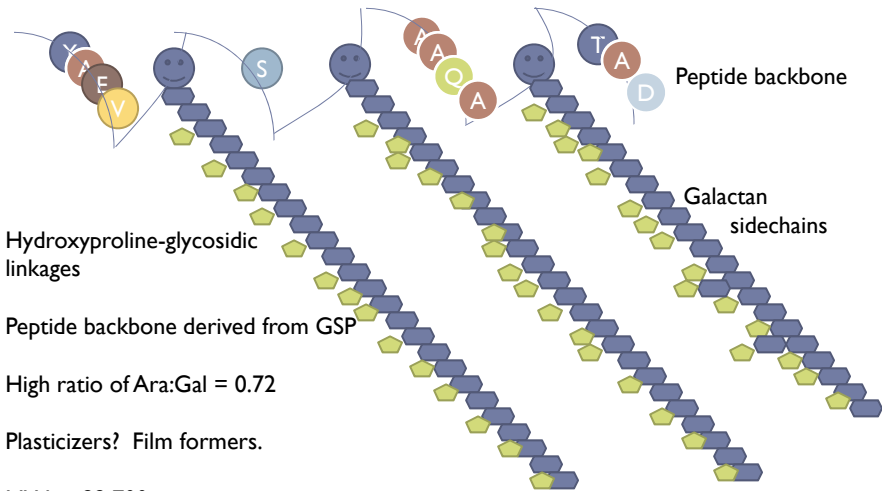
Branching is an ongoing part of a process of AX remodeling during grain filling.

Toole et al. *Planta* (2007) 225:1393-1403.

## Arabinoxylan Structure



## Arabinogalactan Peptides



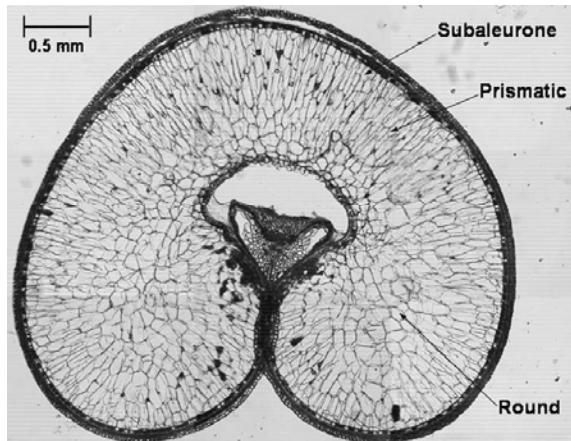
Toole et al, Planta 2009

Central endosperm cells are more feruloylated than prismatic and subaleurone cells.

Modeling (synthesis, depolymerization, and multiple substitution) occurs during development

Esterification with ferulic acid also increases with development

Both effects are sensitive to heat and stress.



Toole et al, Planta 2009

Central endosperm cells are more feruloylated than prismatic and subaleurone cells.

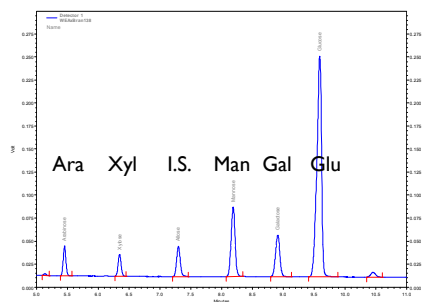
Flour milling tends to remove central round cells first with repeated milling steps milling closer to the aleurone

Enzyme extractable arabinoxylans have more arabinofuranosyl residues than water soluble arabinoxylans.

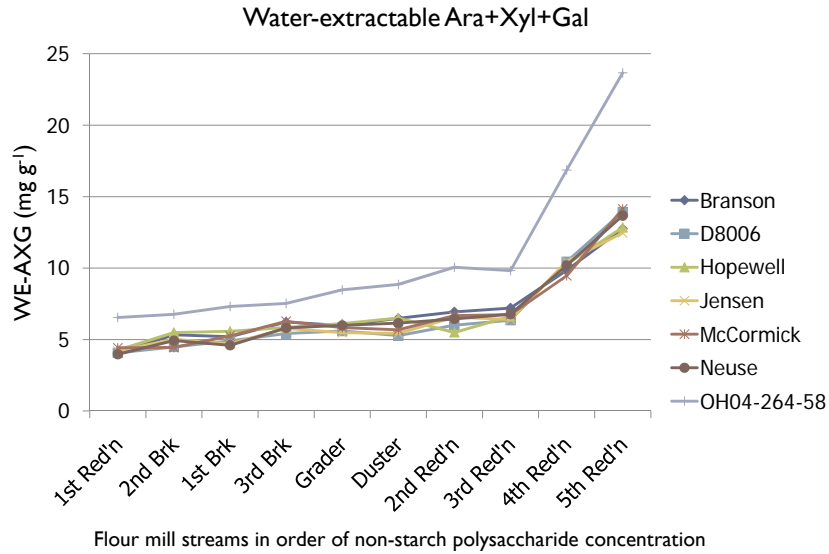
*Increasing* the degree of mono- and di-substituted xylopranosyl residues *decreases* flour water absorption.

## Analytical Method

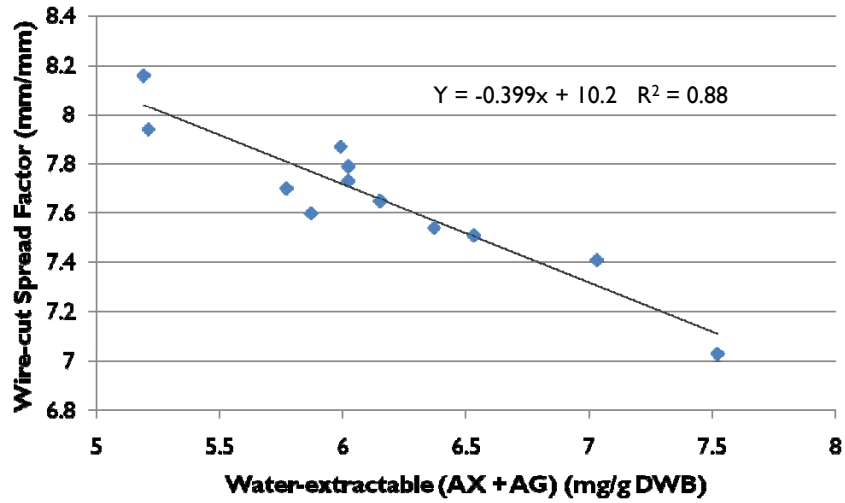
- ▶ **Monosaccharide Analysis**
  - ▶ Water SRC Supernatant
  - ▶ 1:1 with 4 N TFA; 105°C 1 hr
  - ▶ Reduce sugars to alditols with NaBH<sub>4</sub>
  - ▶ Derivatize to alditol acetates – acetic anhydride & N-methyl imidazole
  - ▶ Gas chromatography



Mill stream analysis of seven soft wheat samples milled on Miag Multo-mat flour mill, Soft Wheat Quality Laboratory, Wooster OH, 2010.



### Effect of Water-Extractable NSPs on White Flour Wire-Cut Cookies



Guttieri et al. 2008. J. Agric Food Chem. 10929-10932

## Flour Milling to Produce Whole Grain Soft Wheat Flour

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Miag Multomat



Quadrumat "Advanced"

## Bran Particle Size Reduction

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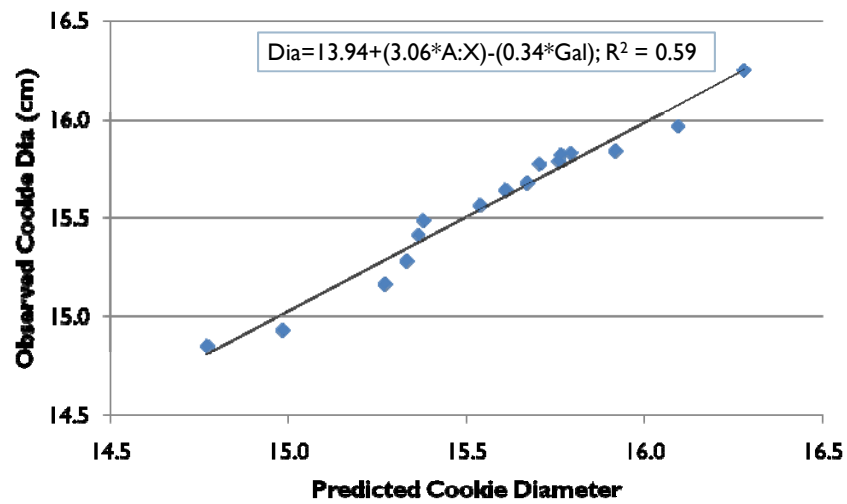


Quadro Comil  
*Minimum heat  
input*

## Bran Particle Size Reduction



## Whole Grain Cookie Dia = $f(\text{Ara:Xyl}, \text{Gal})$



## Galactans in milling and flour

- ▶ Galactans are typically present in the flour in the form of arabinogalactans (AG) and are often bound to short peptides cleaved from the Grain Softness Protein
  - ▶ AG have limited correlations to sucrose SRC values
  - ▶ AG disproportionately reduce soft wheat flour quality for high sugar baked products like cookies



Wire-cut cookies made with whole grain wheat flour

## Non-Starch Polysaccharide (NSP) Fiber in Flour

- ▶ Wide ranges in composition of NSP fiber
  - ▶ Arabinose to xylose ratio - an indication of branching
  - ▶ Arabinogalactan
  - ▶ Soluble and insoluble fractions present with soluble fractions generally more water active.
- ▶ Quality of Flour Can be Modified Substantially
  - ▶ Milling with short flow systems reduces damaged starch.
  - ▶ Genetic selection for high arabinose to xylose ratios and low arabinogalactan concentration would improve the suitability of whole wheat flours for biscuits and crackers.



*Thank you to...*

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