Genetics of Arabinoxylans

Characterization of ways to measure arabinoxylans

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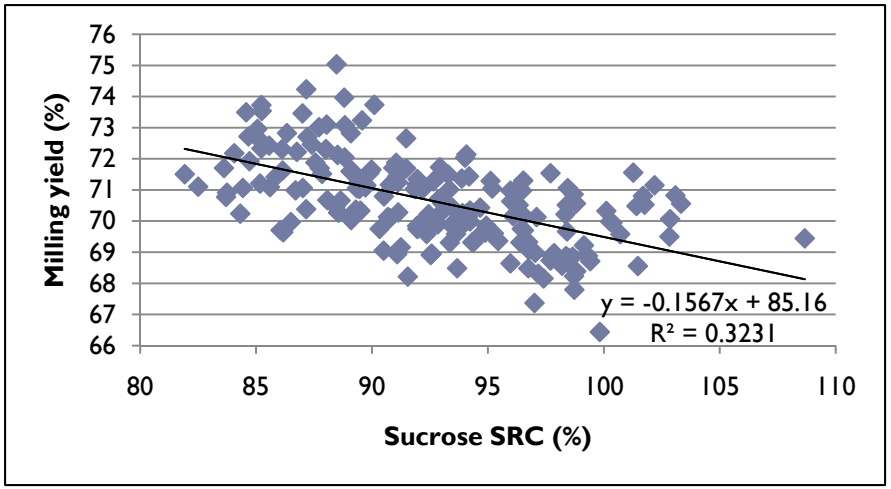
Agricultural Research Service

Background

- Water soluble arabinoxylans (WE-AX) and arabinogalactans (AG) are collectively non-starch polysaccharides that contribute to the sucrose SRC values and water absorption of flour
- AX, when complexed, form insoluble hemi-cellulose material that comprise a significant part of the cell walls of the endosperm and bran

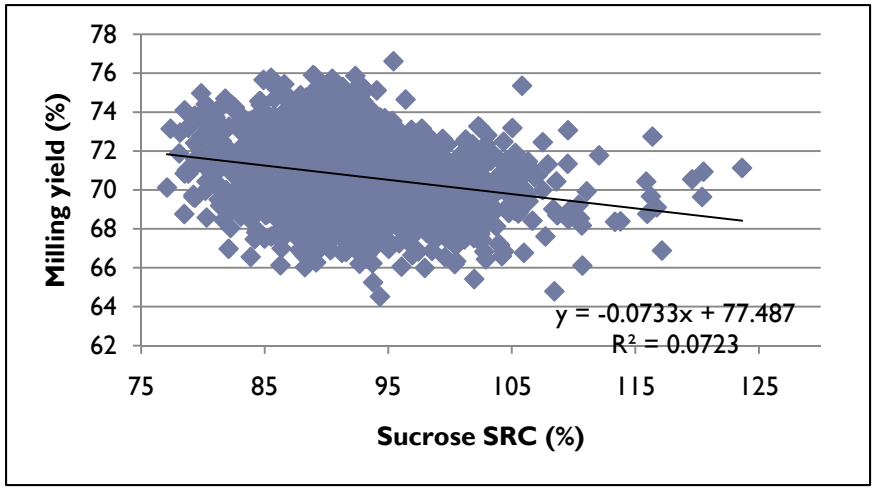
- The quantities of WE-AX and AG in flour are the result of genetics, environment, and flour mill

Sucrose SRC and Milling Yield are Intertwined in Soft Wheat



182 soft wheat cultivars
Association Mapping Study
Genetic means for each wheat grown across 7 environments

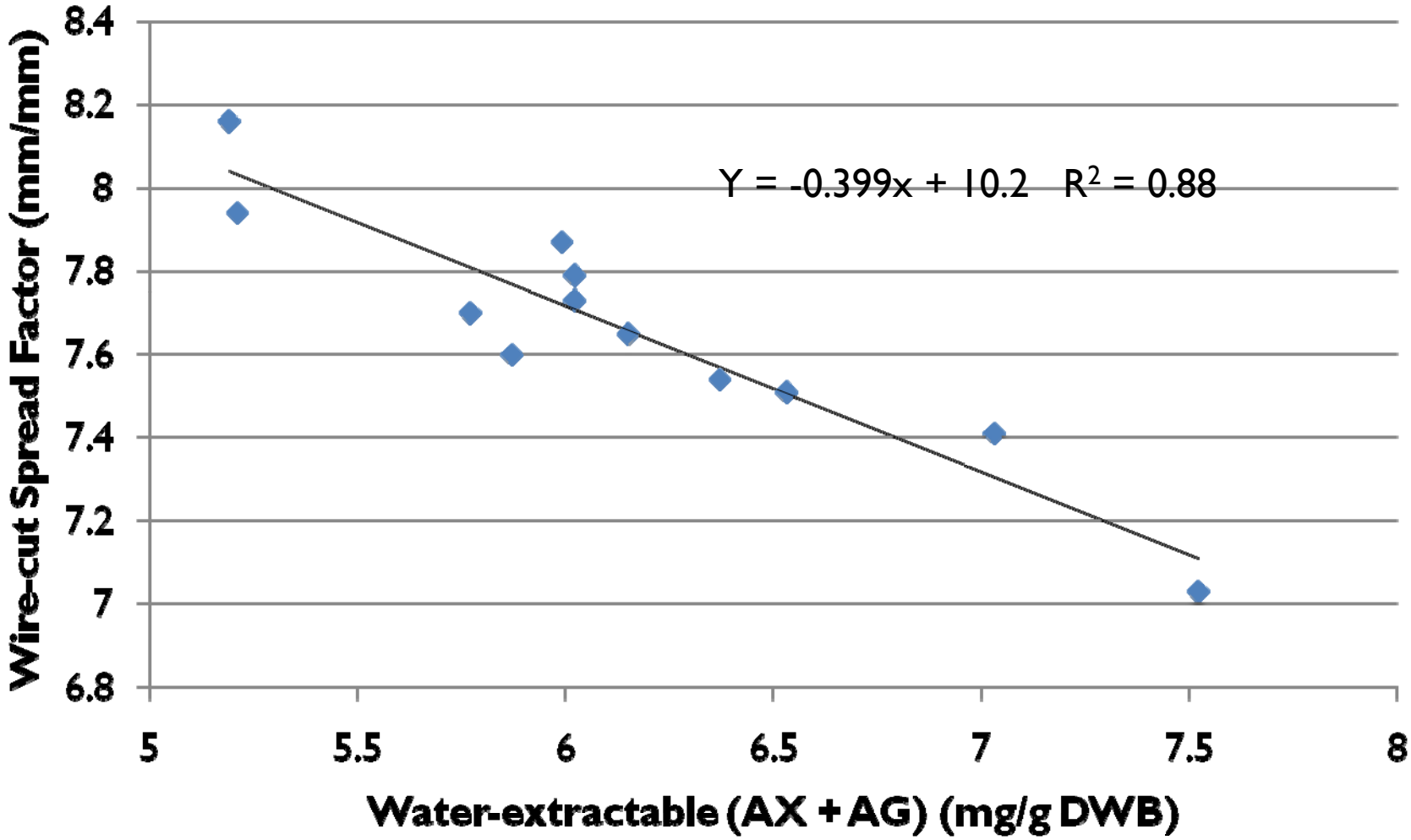
Genetic correlations are strong



182 soft wheat cultivars
Correlation of individual observation each cultivar within each of the 7 environments.

Environmental and phenotypic correlations are less strong

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



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

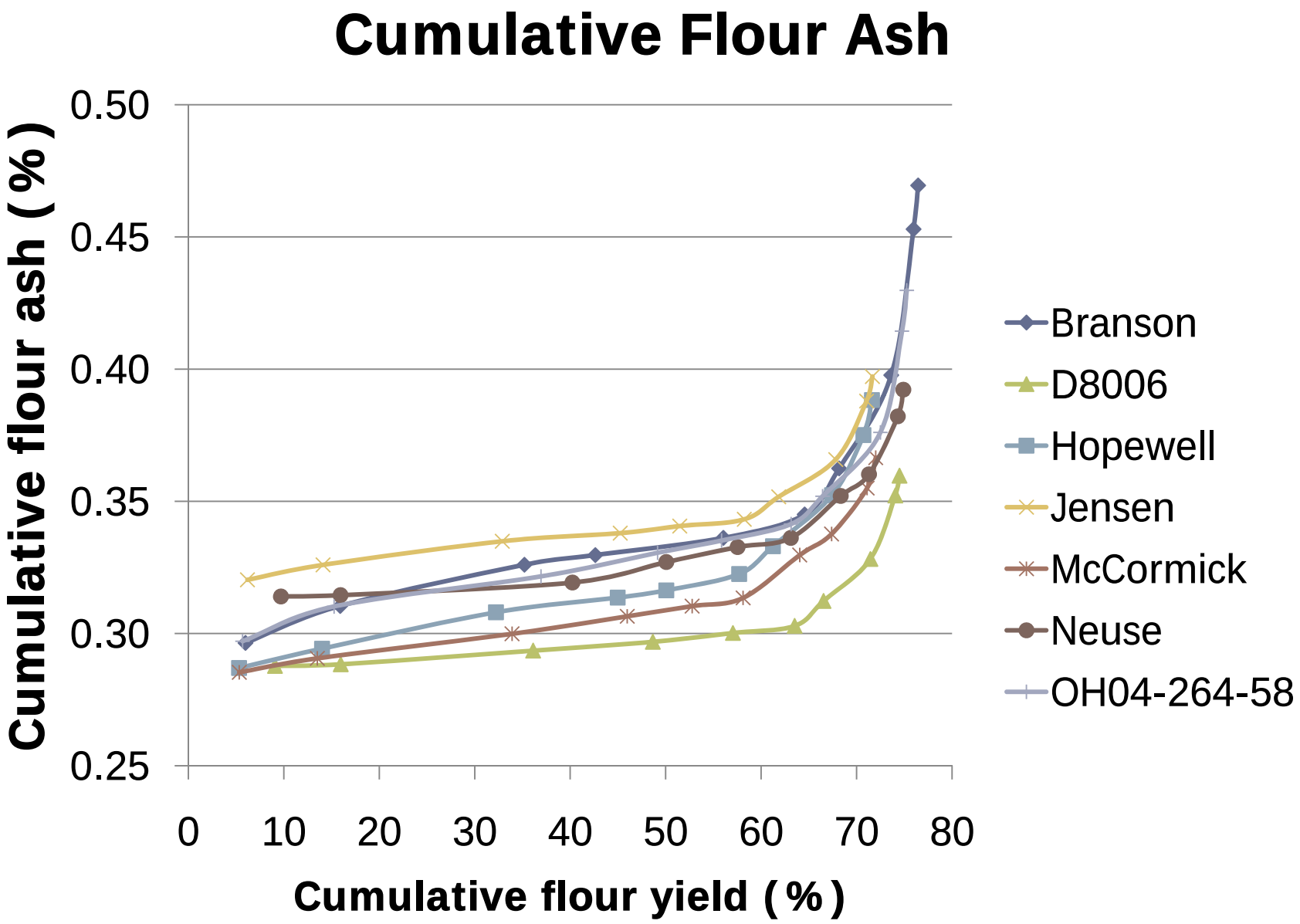
Background – Characterizing one level of the interaction

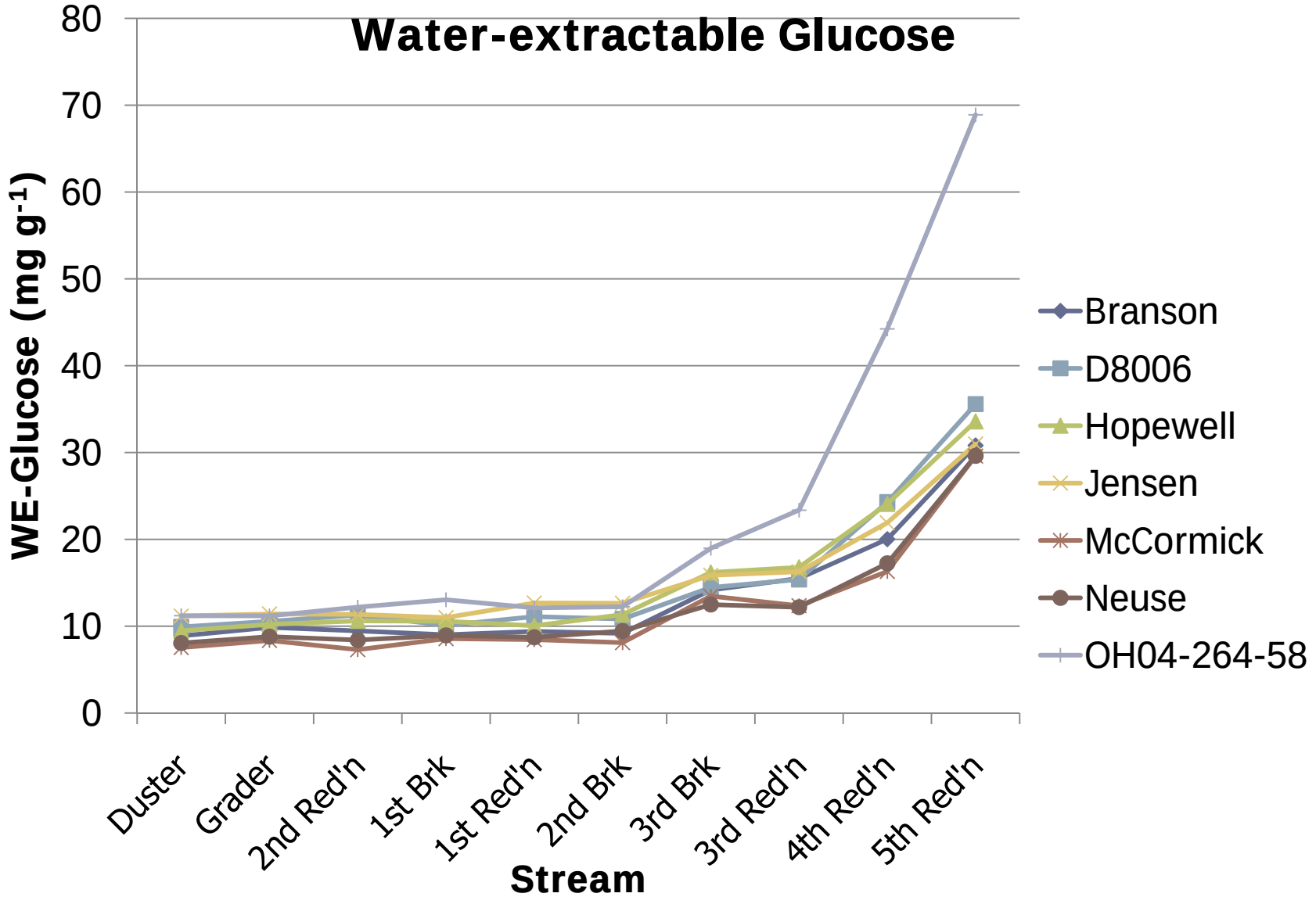
- The quantities WE-AX and AG in flour are the result of genetics, environment, and flour mill
  - Sucrose SRC is a catch-all for a wide variety of compounds
  - Concentration of WE-AX and AG is controlled by genes that synthesize, remodel, and cross-link.
  - As background to studying the gene (*next* 5 year project plan): characterization of milling system (*prior* 5 year project plan)

Reduction and bran streams from Miag mill

Methods (See poster for details)

- Seven soft wheat cultivars grown in Wooster, 2009
- Milled on Miag Multomat flour mill
  - 10 streams: 3 breaks, 5 mids, and two resifting streams
  - Mill streams captured separately as in an mill stream
  - Flour ash was analyzed by AACC 08-01
- Water extractable non-starch polysaccharide analysis
  - Aqueous phases from 1 g water SRC of millstreams
  - Hydrolyzed in 2 N trifluoroacetic acid for 1 h at 105 C
  - Derivatized to alditol acetates
  - Separated and quantified by gas chromotography (Guttieri et al. 2008).

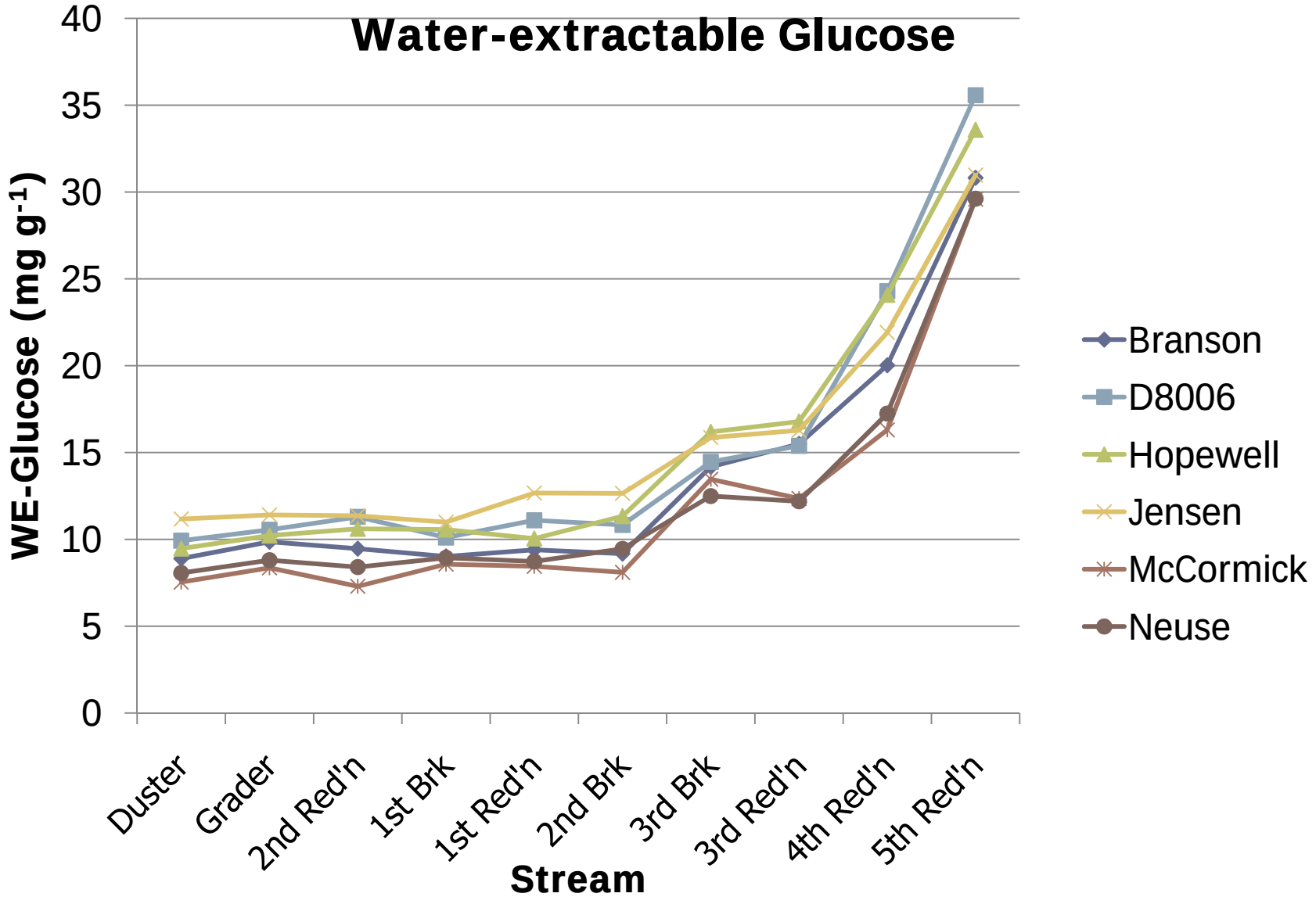

Cumulative Flour Ash
Cumulative flour ash (%)
0.50
0.45
0.40
0.35
0.30
0.25
0
10
20
30
40
50
60
70
80
Cumulative flour yield (%)
Branson
D8006
Hopewell
Jensen
McCormick
Neuse
OH04-264-58

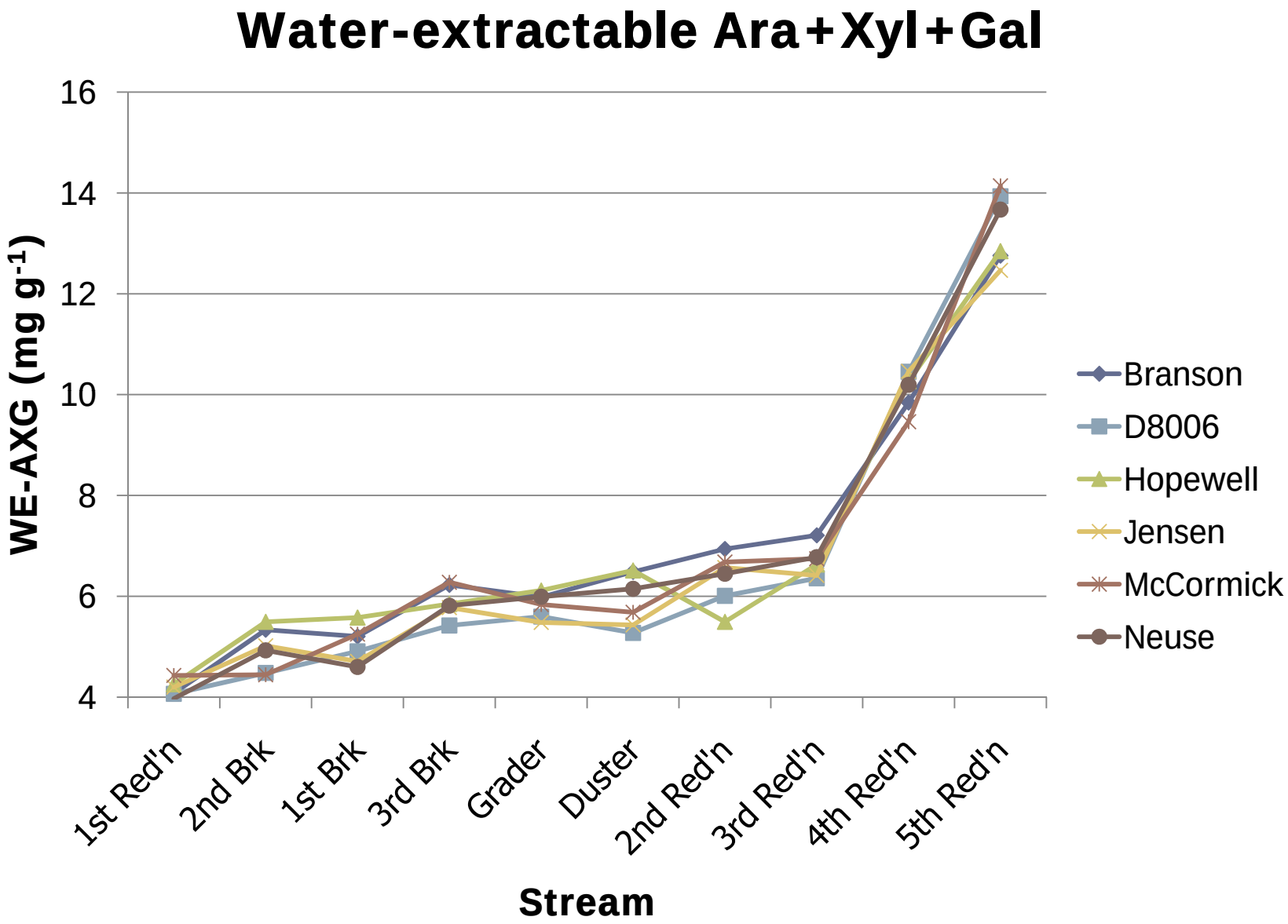


- Arranged by average value of stream for all genotypes

Damaged starch as measured by WE-glucose in GC analysis

- Cultivars have interactions with mill streams for the amount of damaged starch that is created in the milling process.
  - OH04-264-58 had the greatest interaction
  - For clarity it will be dropped from most of the subsequent slides
- Damaged starch in early roll streams may be independent of later streams.
  - Most damaged starch is derived from 3rd break and 3rd to 5th reduction
  - Greatest sample differences are observed in 3rd to 5th reduction streams


Water-extractable Glucose
WE-Glucose (mg g-1)
40
35
30
25
20
15
10
5
0
Duster
Grader
2nd Red'n
1st Brk
1st Red'n
2nd Brk
3rd Brk
3rd Red'n
4th Red'n
5th Red'n
Stream
Branson
D8006
Hopewell
Jensen
McCormick
Neuse

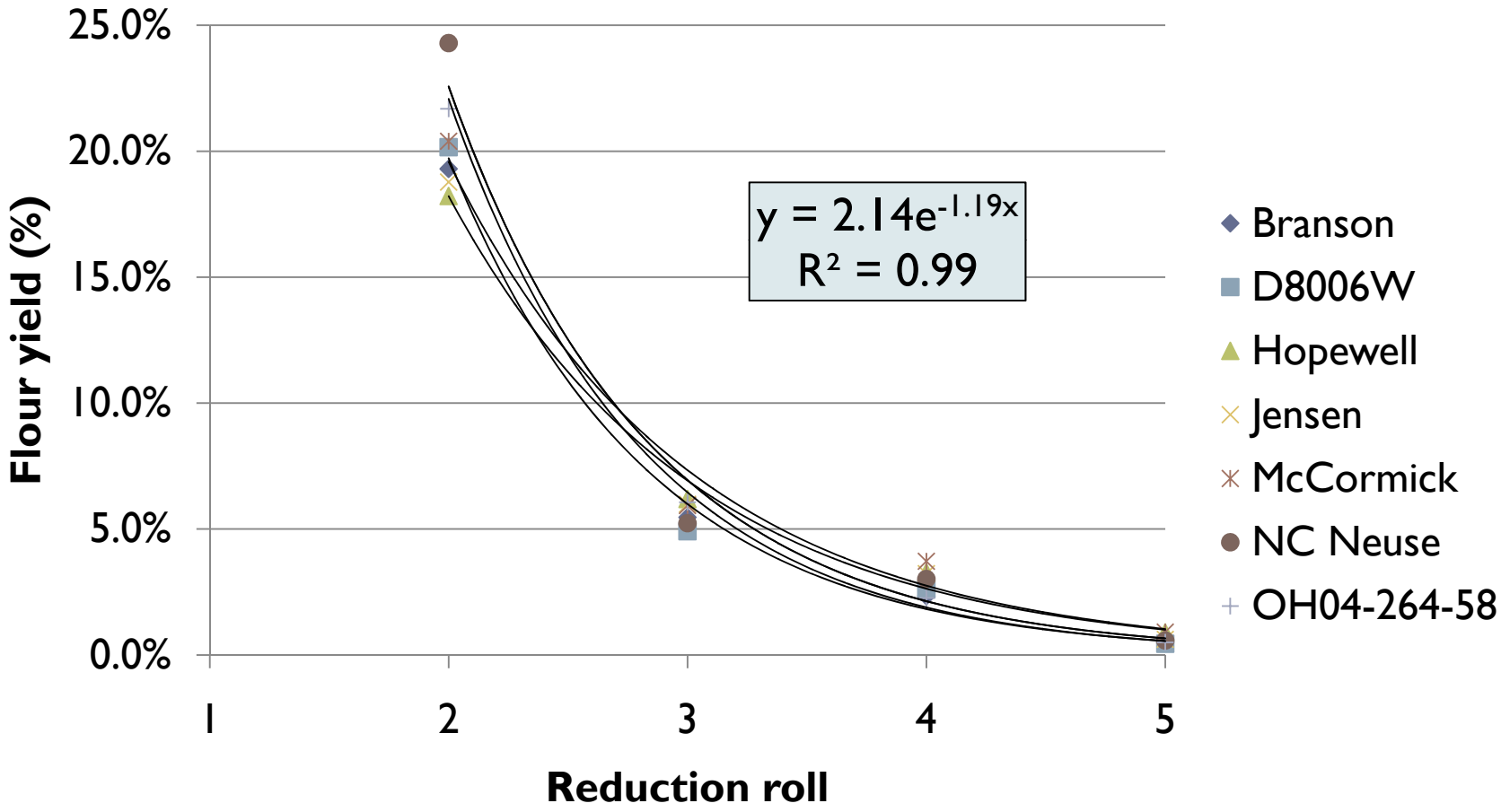


- Arranged by average value of stream for all genotypes

Where do the WE-AX and AG come from in the milling process?

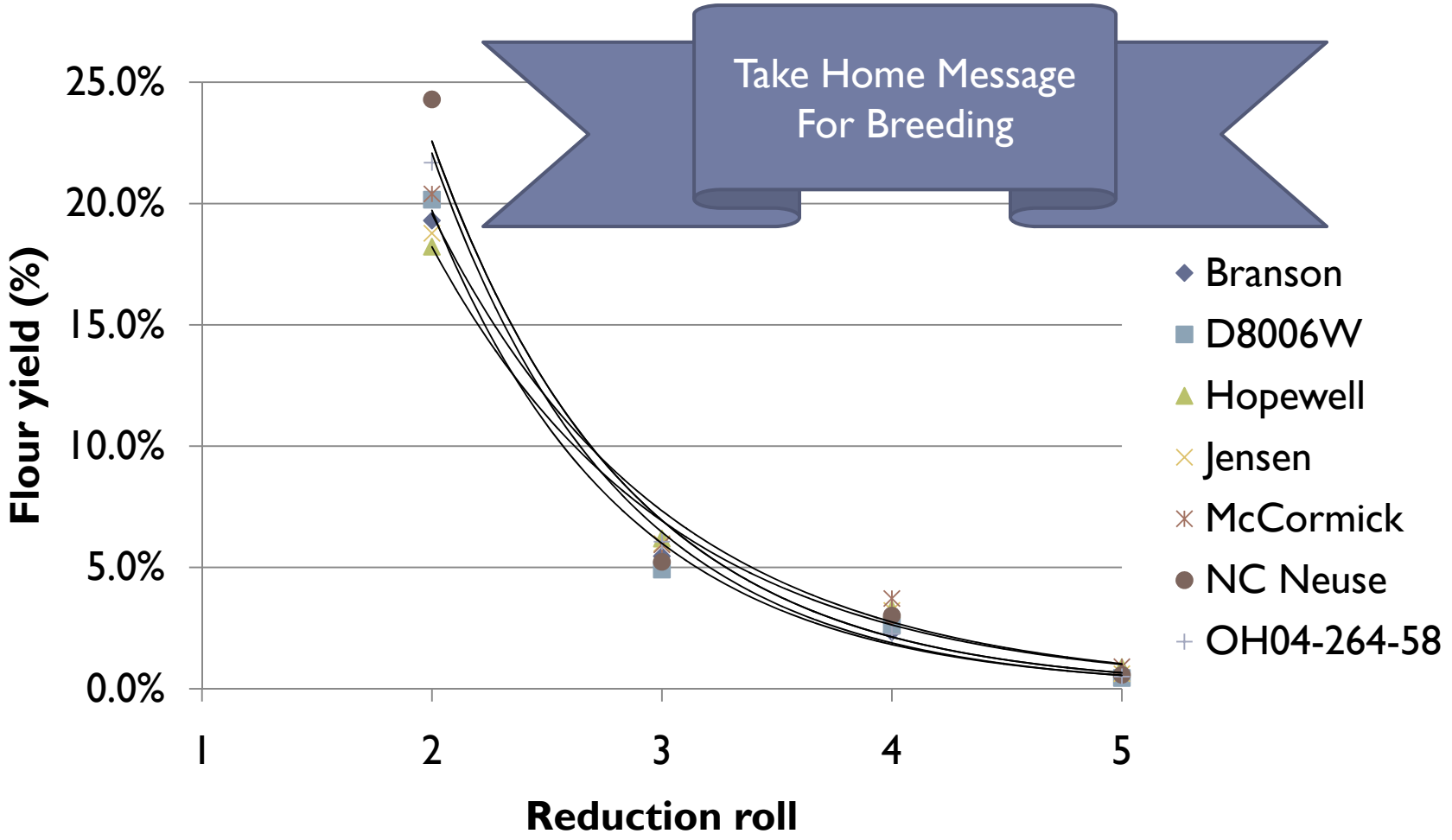
- Total concentration of combined ara, xyl, and galactose is similar among the six cultivars for each stream
- Concentration is greatest in 3rd to 5th reductions
- Relative differences in total arabinoxylans and arabinogalactans in flour are therefore due to primarily to quantity of flour recovered in different streams
- Structure and composition of the non-starch polysaccharide fraction affect greatly its water activity and impact of soft wheat quality

Flour Yield of Reduction Streams



- Exponential decay function Minimal differences in flour yield for 3rd to 5th Red'n

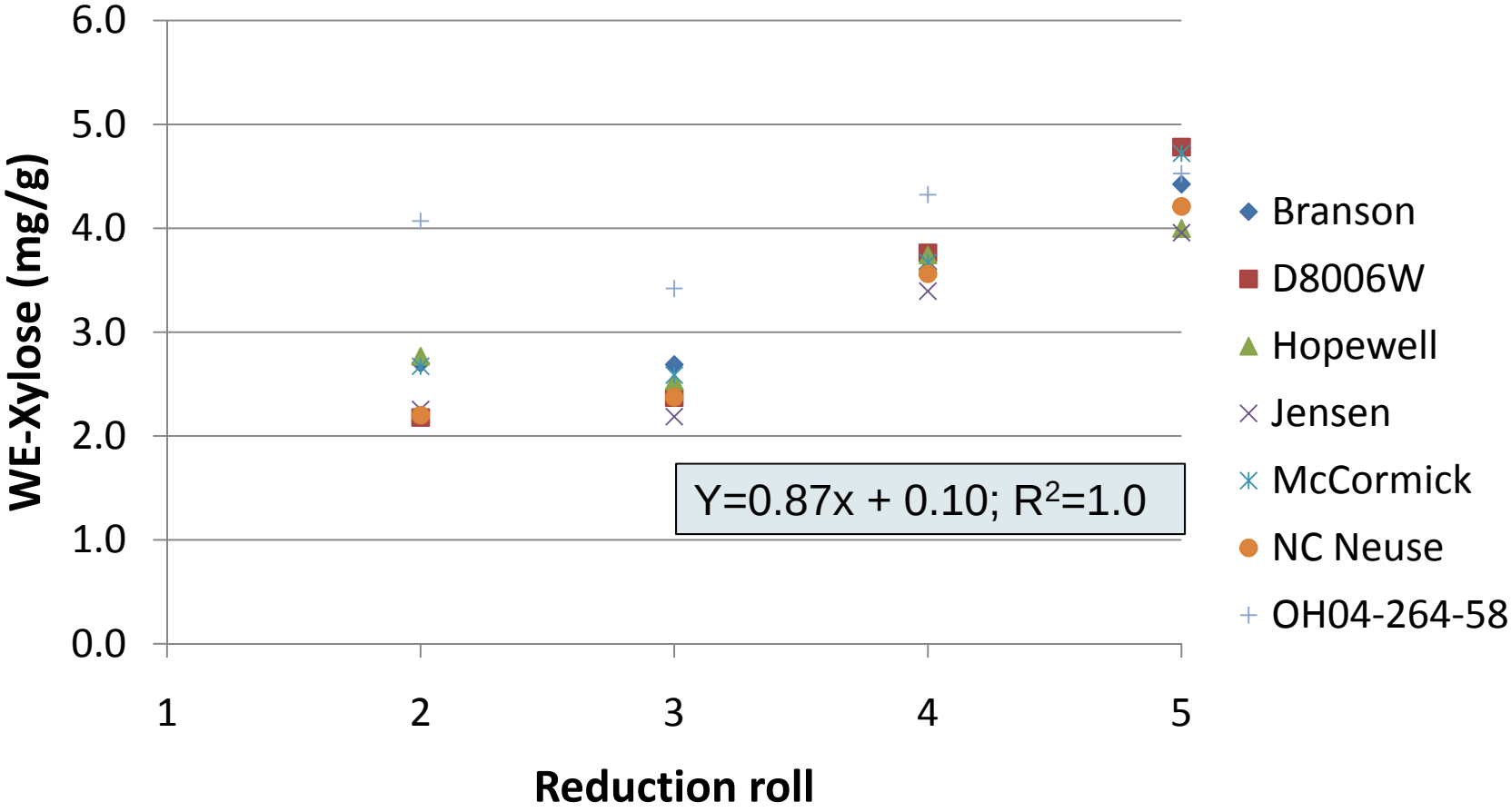
Flour Yield of Reduction Streams



- Exponential decay function Minimal differences in flour yield for 3rd to 5th Red'n

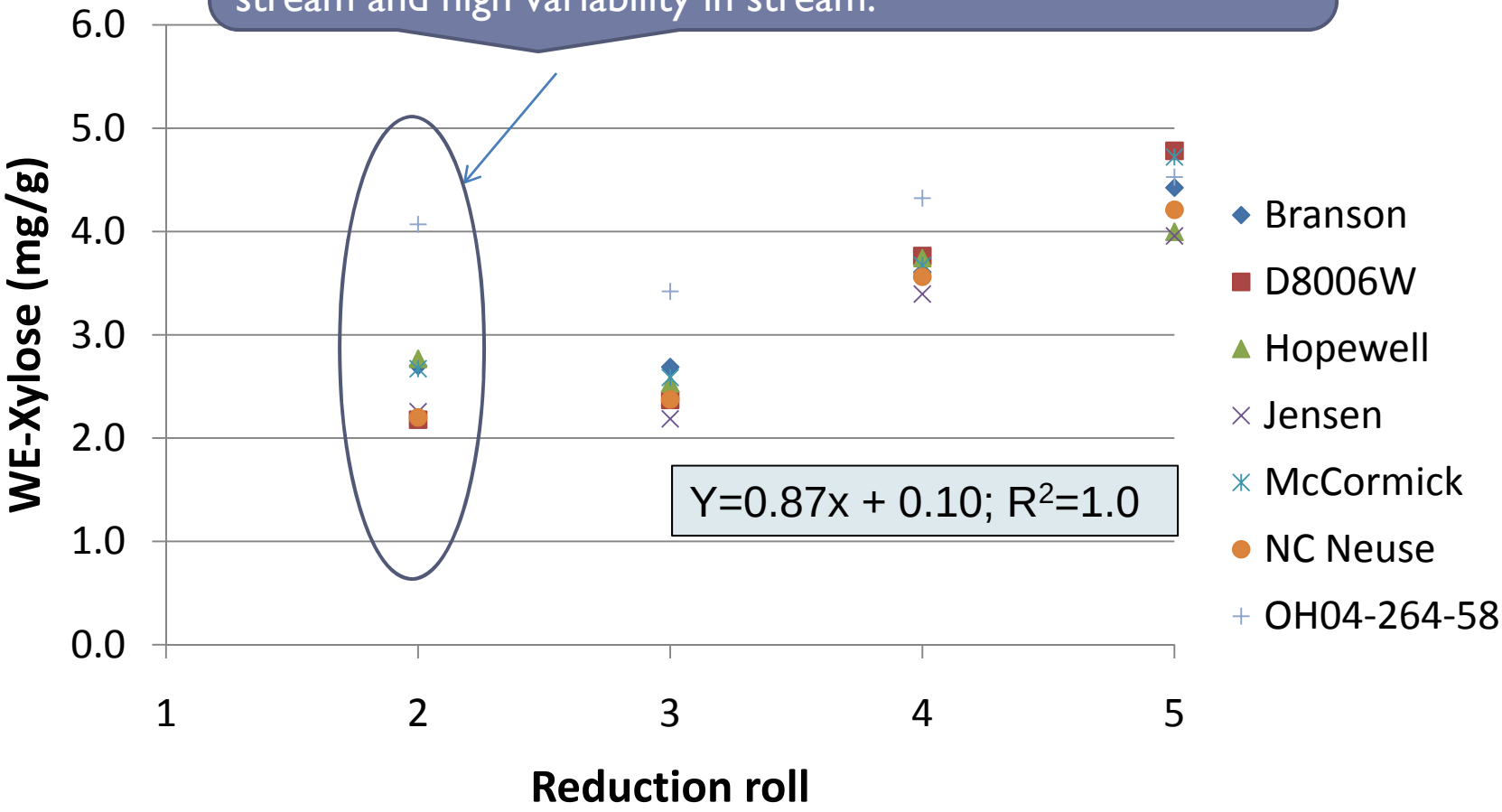
WE-Xylose in Reduction Streams

Xylose is recovered from reduction rolls in a linear function with minimal interactions between cultivars and streams



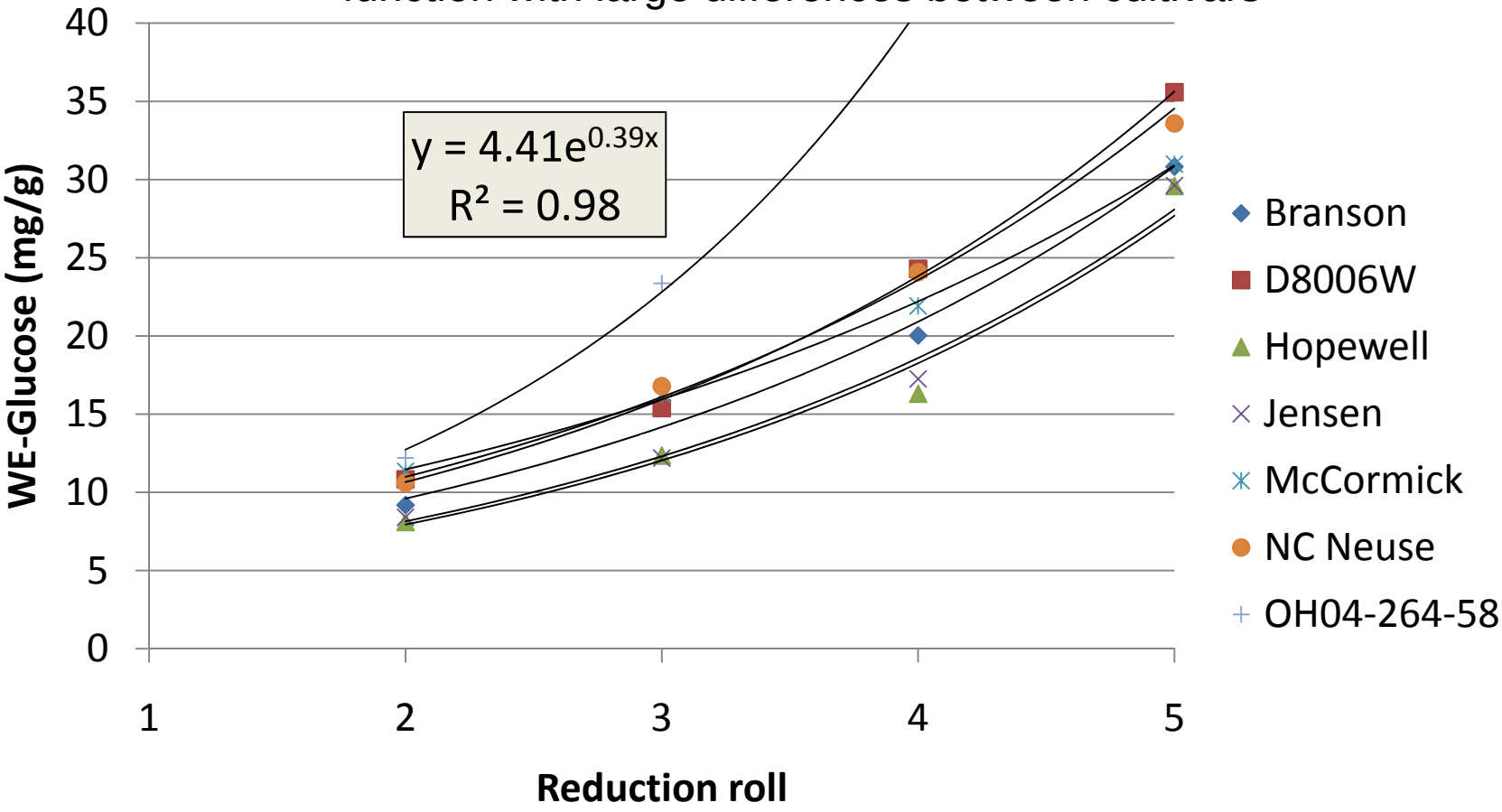
WE-Xylose in Reduction Streams

2nd Reduction Stream is the primary determinant of WE-AX differences in flour among genotypes due to high recovery of stream and high variability in stream.



Starch Damage in Reduction Streams

Starch damage across reduction rolls fits an exponential function with large differences between cultivars



The exponential function is used to model phenomena when a constant change in the independent variable gives the same proportional change (increase or decrease) in the dependent variable.

www.wikipedia.org

Starch Damage in Reduction Streams

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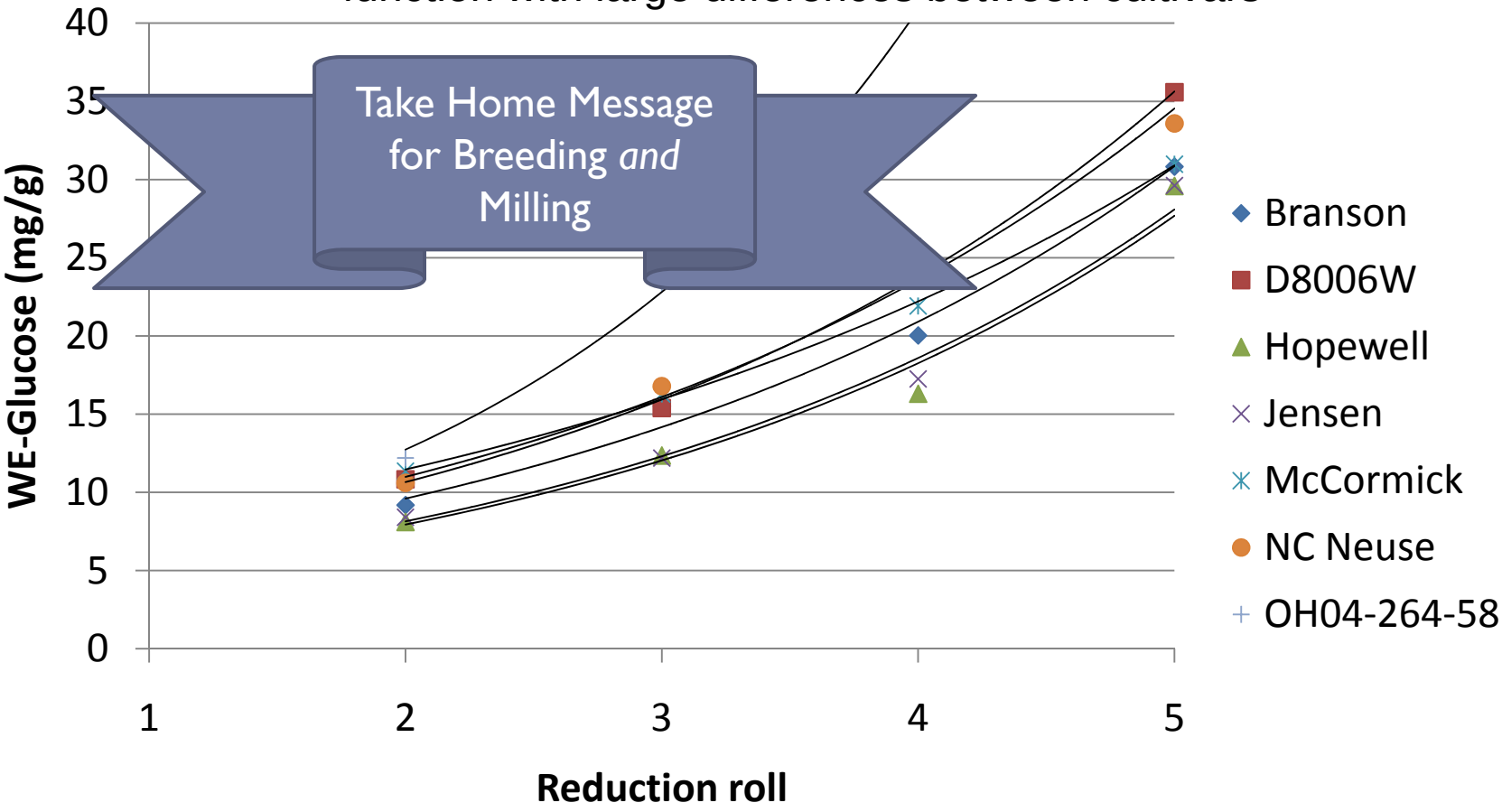
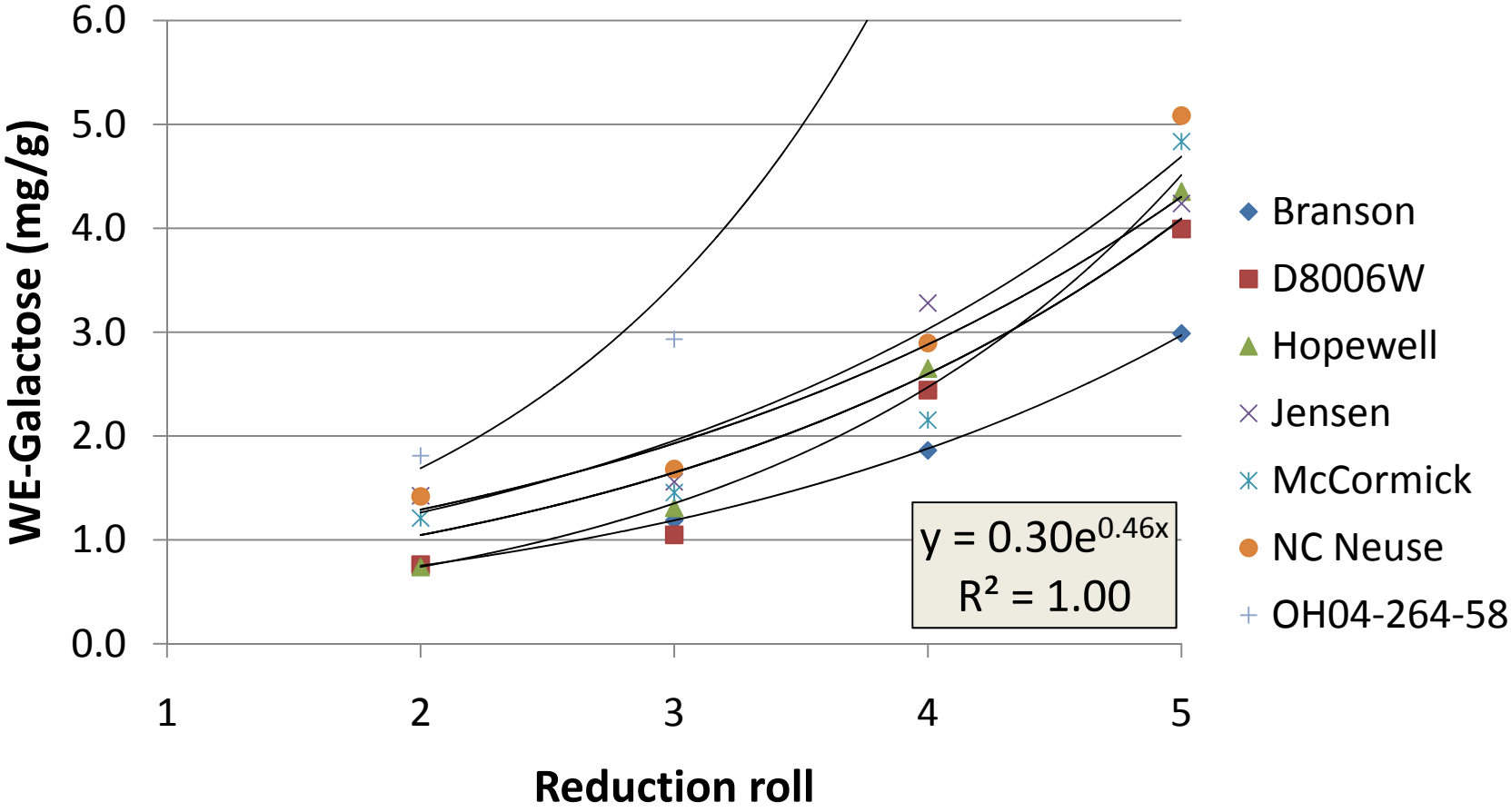


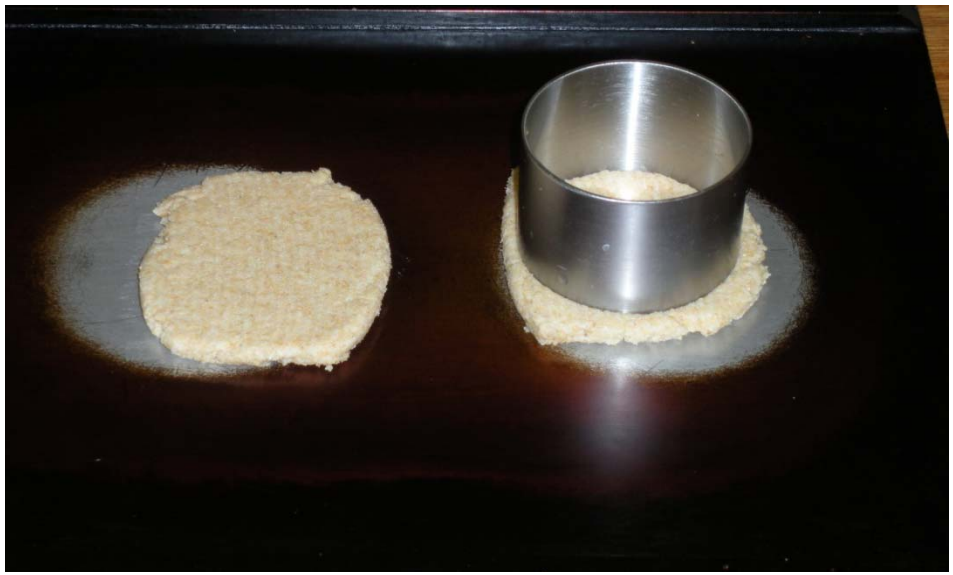
Galactans in Reduction Streams

Galactans have the greatest variation among cultivars, and the largest interactions between cultivar and rolls. Also an exponential function.



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 wheat flour

Galactans in milling and flour

- AG peptides in other tissues and other plants affect cell wall rigidity
  - Do they control milling behavior?
- Subsequent genetic studies
  - Genes affecting AG synthesis and location
  - Differences in AG content in reduction flour may be diagnostic

Arabinogalactan peptides visualized with Yariv stain in wheat endosperm

Conclusions for Milling

- The amount of flour recovered in later reduction rolls is largely a mechanical function rather than a grain function
  - Quad micro mills predict long-flow mills well because of this relationship
- Although flour quantity is determined by the mill in later reduction rolls, the damaged starch caused by the recovery and arabinogalactans added to flour varies greatly among cultivars
- Quality of flour recovered decays much faster than the amount of flour recovered in later reduction rolls due to compound action of rolls on particles resulting in exponential damage

Thank you to…

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