CRACKING THE RYE PROBLEM

TAKE CARE OF HIGH VISCOSITY AND LOWER YIELD FROM RYE IN YOUR MASH

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SALES OF RYE ARE SIGNIFICANTLY INCREASING

Rye consumption declined from the repeal of Prohibition until about 2000.

With growth of “Cocktail Culture,” sales of rye have increased since that time.

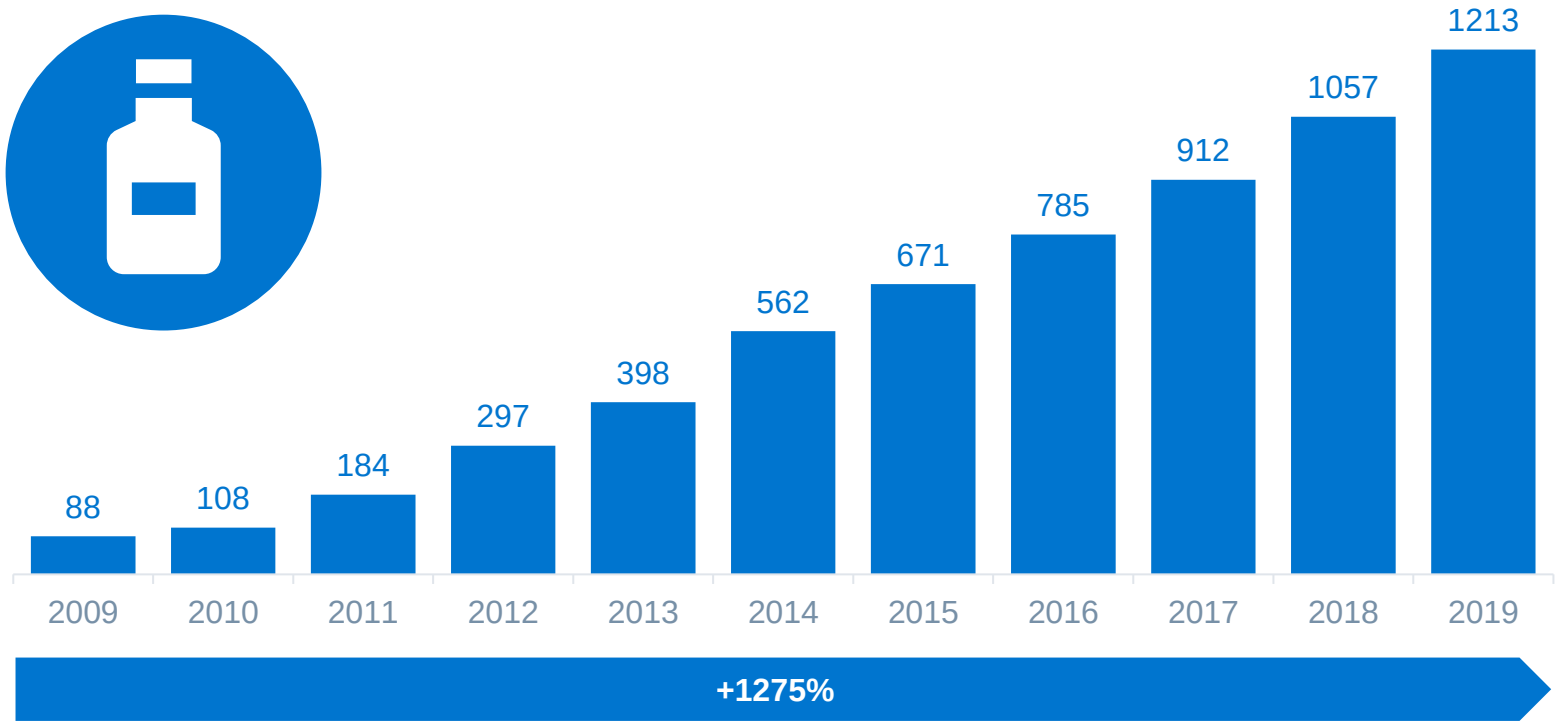
Some reasons:

- Rye was an ingredient in classic cocktails before Prohibition.
- Today cocktail drinkers want authenticity in their drinks and value the flavor and characteristics from rye.

Result:

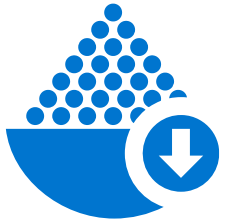
- Consumption increased **1275%** from 2002-2019, as indicated by the chart.

U.S. RYE WHISKEY, 2009-2019, 9-LITER CASES (000)



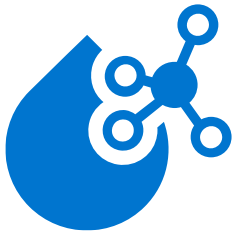
Source : The Distilled Spirits Council of the U.S.

RYE PRESENTS ITS UNIQUE CHALLENGES



Low starch content limits the amount of fermentable sugar

As starch content is lower, it is also less accessible

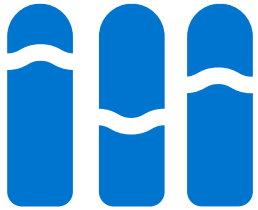


High water binding capacity and can form a gel

Mash difficulties include high viscosity, sticky product / gumming, difficult to pump, plugged heat exchangers, difficulty cleaning, etc

Foam production in fermentor

Spill over and loss or a lower fill volume



Uneven product flow in column

More column rinsing/cleaning

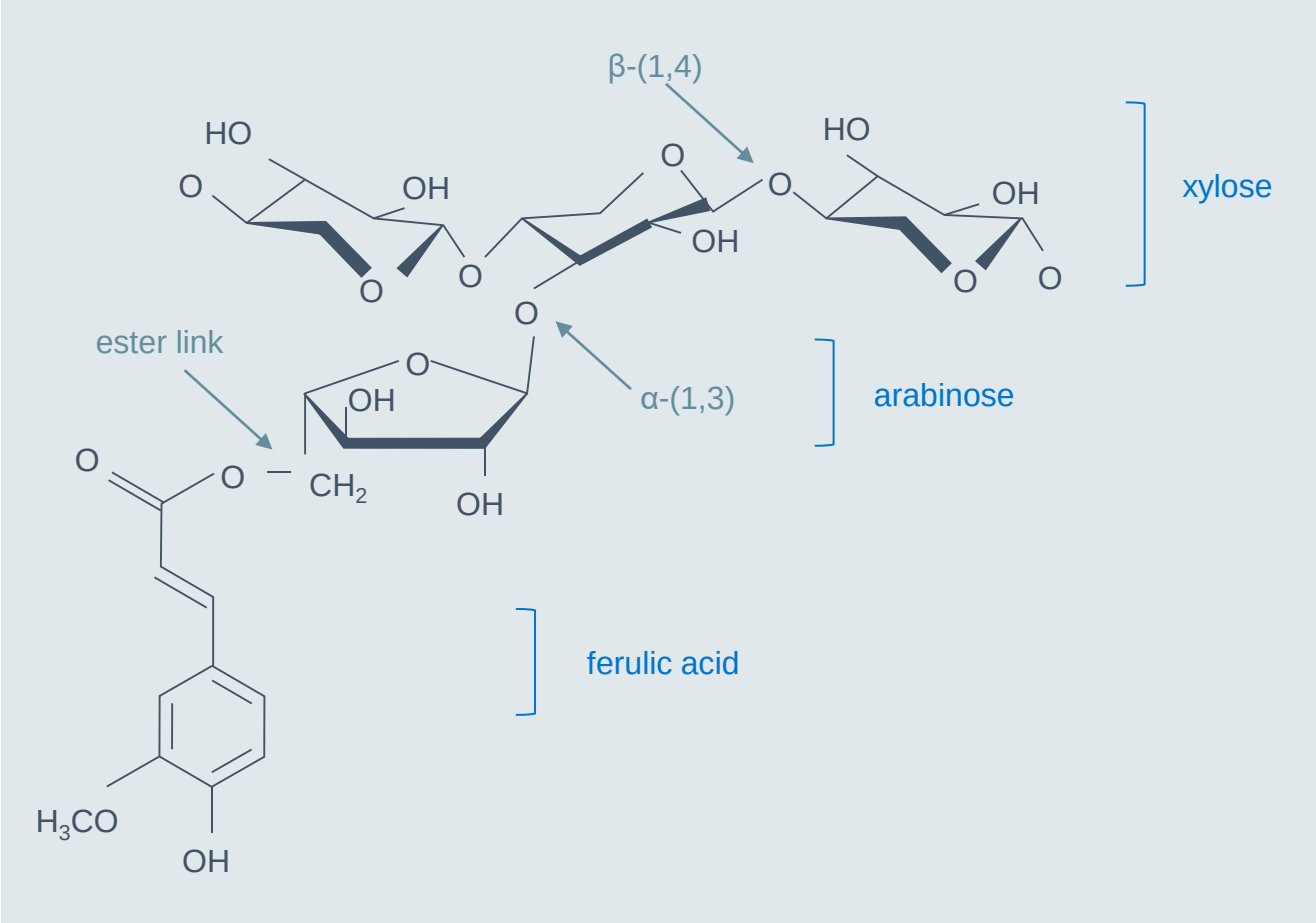
Reduced dryer capacity and increased dryer fire risk

Reduced/slowed production cycle

WHAT CAUSES THIS PROBLEM? ARABINOXYLAN (AX)

Arabinoxylan:

- It is a **non-starch polysaccharide** found in plant cell walls, along with beta-glucan.
- The primary parts of arabinoxylan consists of a xylose backbone, with arabinose and ferulic acid.
- Similar to beta-glucan, it has a high water binding capacity, leading to gels and high viscosity in a cook.
- It requires a specific enzyme to break the break the bonds between the xylose: Xylanase.
- Also known as AX. You may also hear “hemicellulose” and “pentosan”.



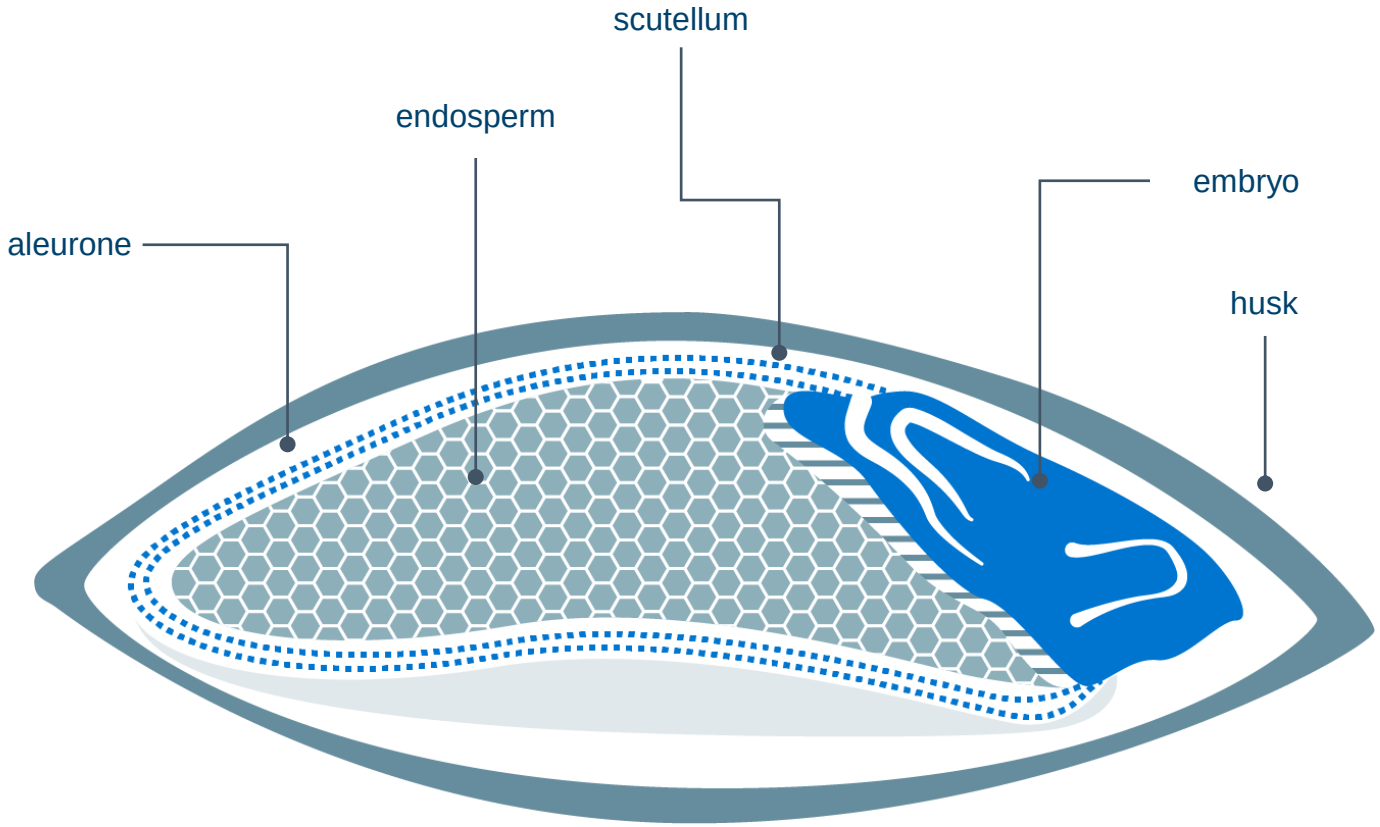
WHERE IS IT FOUND?
IN THE CEREAL GRAIN STRUCTURE

Arabinoxylans are found in the aleurone layer of the kernel and in the cell wall surrounding starch granules in the endosperm.

These polysaccharides provide a structural function for the kernel and must be broken down by enzymes to provide access to the starch. This takes place in both germination and in mashing.

In a distiller's cook, enzyme from the grains will be limited, if at all.

Enzymes need to be added for hydrolysis.



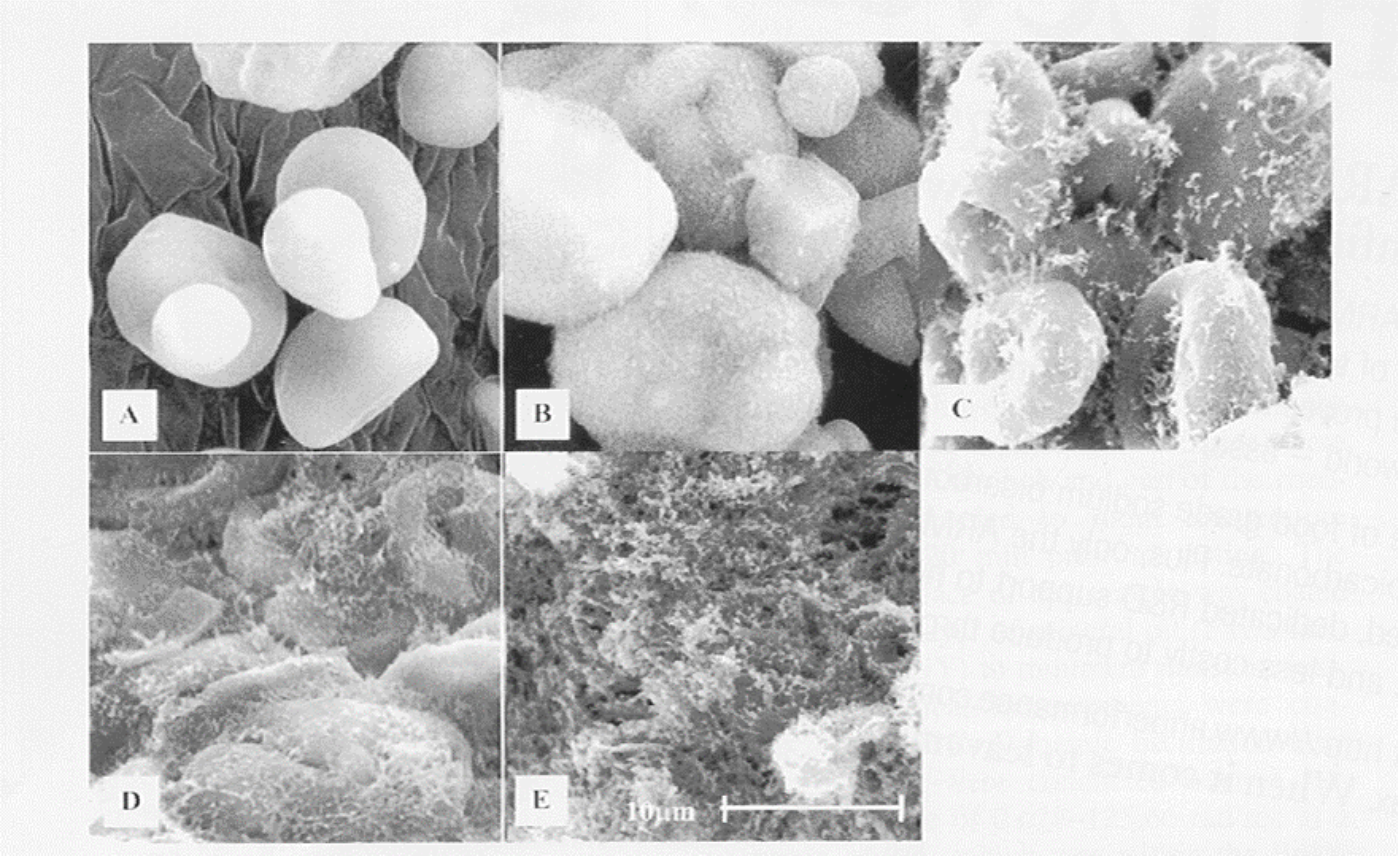
STARCH GRANULES AND THE CELL WALL MATRIX

This series of photos shows the progression of starch gelatinization and liquefaction.

Note also how the cell wall matrix is also broken down.

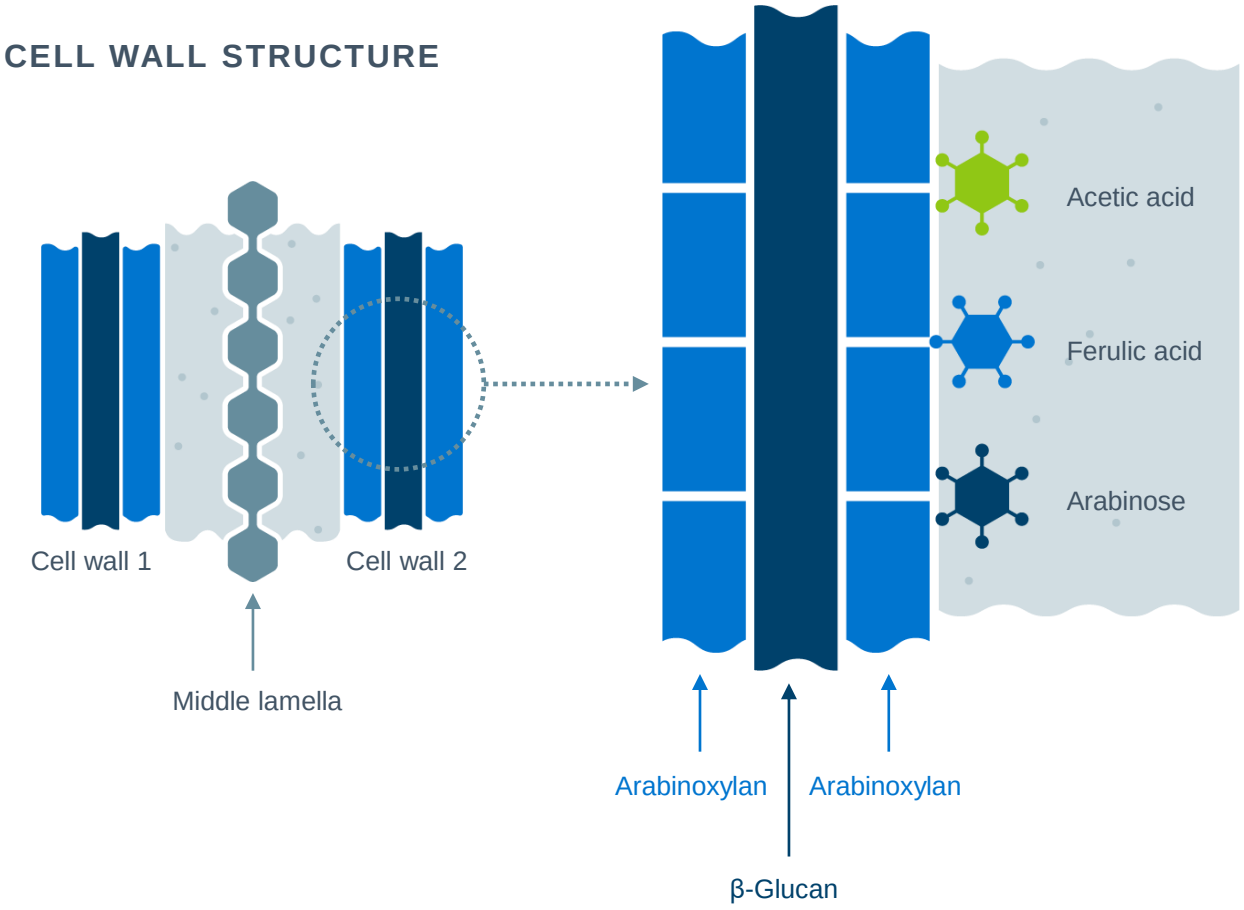
The more complete the hydrolysis of the cell wall, the greater the access to starch.

In rye, xylanase will be needed to hydrolyze the cell wall matrix and produce low viscosity.



Source:??

ARABINOXYLAN, BETA GLUCAN, AND PROTEINS PRESENT HUGE CHALLENGES IN BREWING



Endosperm cell wall is surrounded by **arabinoxylans, beta-glucans, and proteins** to provide structural integrity for the kernel.

These are broken down in germination.

In production, they produce problems including:

- Increased viscosity
- Limited access to starch
- Excess foam

Note: Distiller's malt will not sufficiently breakdown these components, if at all.

1) The enzymes from barley are sensitive to kilning.
2) The amount of malt in the grist is very low.
3) Cook cycle is very short and very hot, limiting any potential enzyme activity.

HOW DOES IT CAUSE TROUBLE? ARABINOXYLANS LINKED TOGETHER

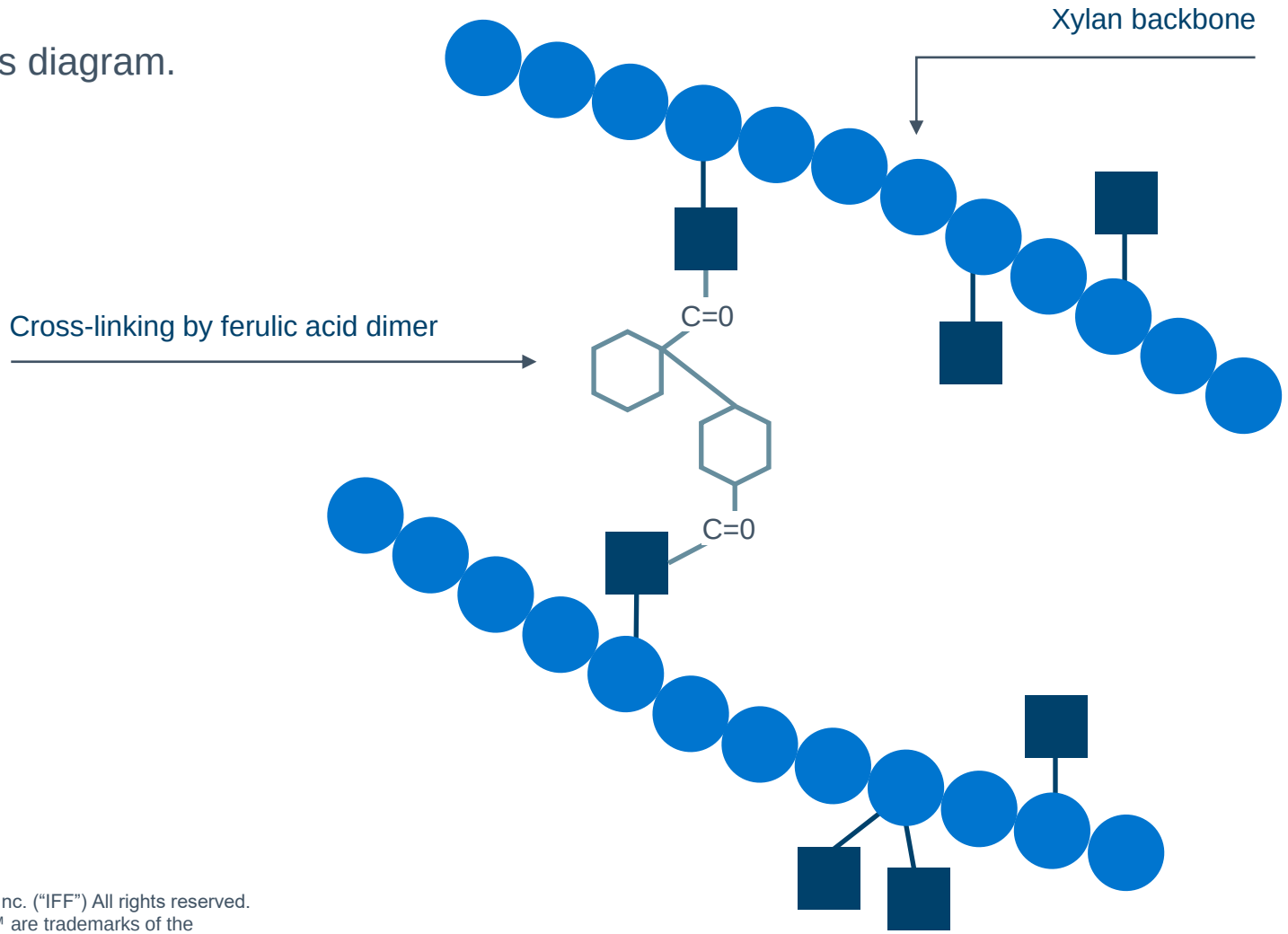
Cross linking is shown here in this diagram.

Arabinose

Xylose

Ferulic acid

COOH



From: Andersen and Simsek, 2018

COMPARISON OF CEREAL GRAIN COMPOSITION

% CONTENT OF DRY MATTER

	Barley	Wheat	Rye	Sorghum	Millet	Corn	Rice	Cassava (starch)	Oats
Protein	10-12	12-14	10-15	11-12	15.4	9-12	6.8	2	12
Fat	2.5-3	3	2-3	3.6	3.9	4.5	0.6	0.7	8
Starch, as is	65-68	67-72	55-65	67-75	70.8	75-80	77-81	62-70	55-65
Ash	1.5	2	2	1.7	1.2	9.6		4	
Total cell wall material	9.6	11.4	14.6	n/a	n/a	9.6		n/a	
Water extractable non-starch polysaccharides (NSP):									
Arabinoxylans	0.3	0.6	1.4+	0.08	-	0.03	0.06	-	0.1
Beta-glucans	2.4 (3-5)	0.14 (0.2-0.7)	0.8 (0.8-3)	-	0.01-0.1	0.05	-	-	3-5

From Advancebio/"The Alcohol School" and some adaptation and NSP articles

OTHER CAUSES OF HIGH VISCOSITY

1. Starch

- Hydrolyzed to fermentable sugars.
- Ungelatinized starch can cause high viscosity.
- Needs alpha amylase.

2. Beta-glucan

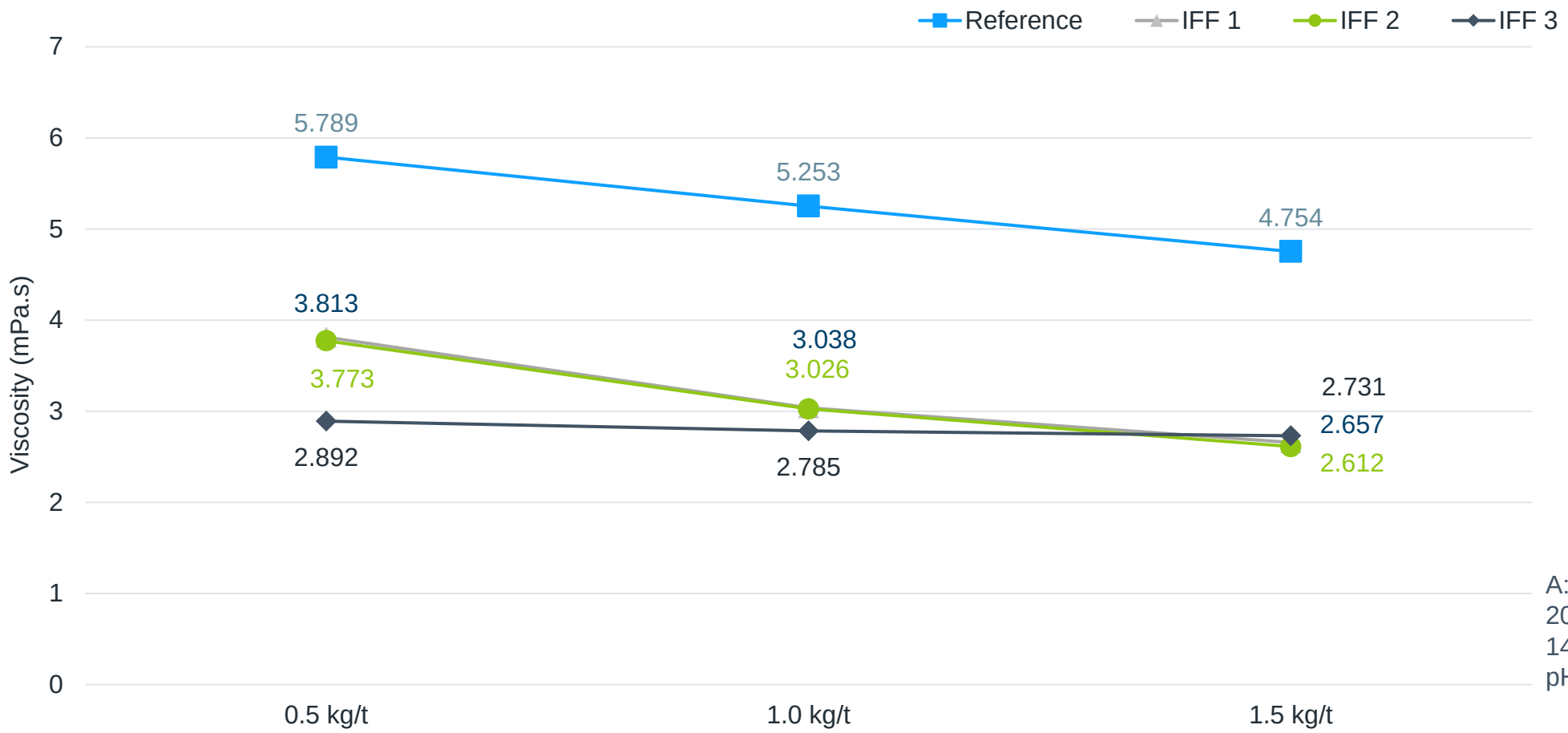
- Part of the cell wall matrix.
- Provides structural integrity to the kernel.
- Similar to AX, when mashed, it is solibulized, binds water, and causes high viscosity.
- Beta-glucans generally low in rye.
- However, in barley and wheat, the amount of beta-glucan is higher.
- Needs beta-glucanase.

PROBLEM: HIGH VISCOSITY

SOLUTION	Reduce rate	Lower fermentor fills	Reduce solids	
	Don’t gelatinise	Mill coarser	Reduce rye inclusion	Try enzymes

IFF ENZYMES HELP MANAGE VISCOSITY

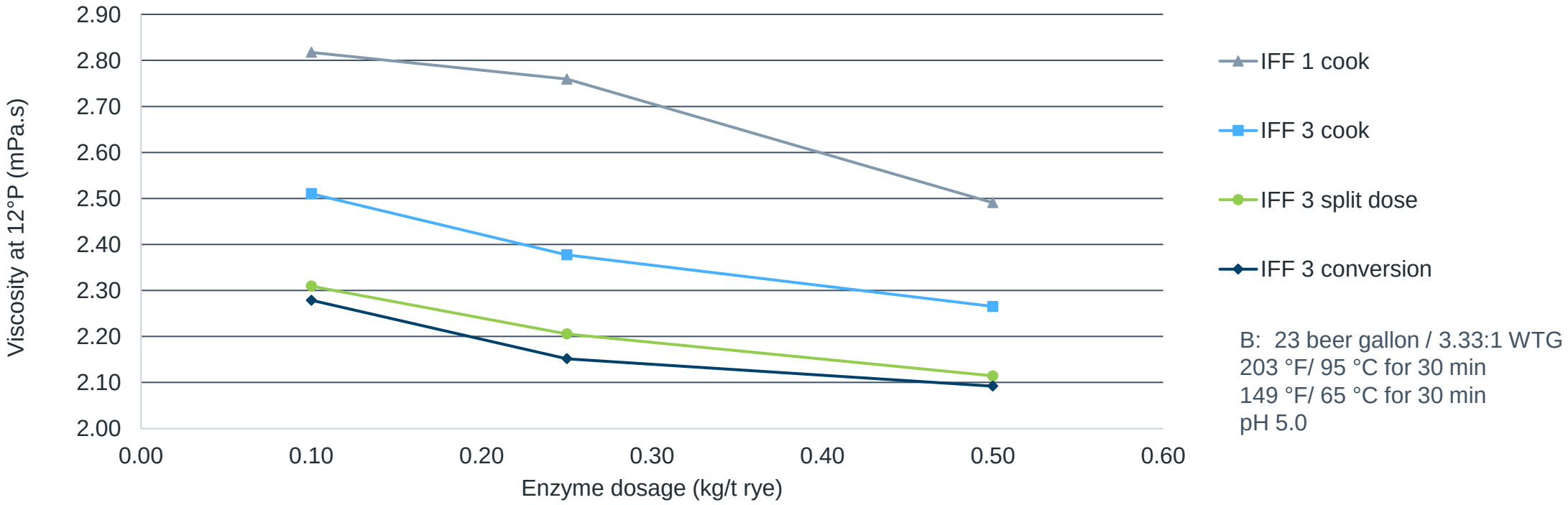
Dose rate response with increasing dose of enzyme



A: 20 beer gallons / 3:1 WTG
203 °F/ 95 °C for 30 min
149 °F/ 65 °C for 30 min
pH 5.5

VISCOSITY REDUCTION IN FURTHER STUDIES

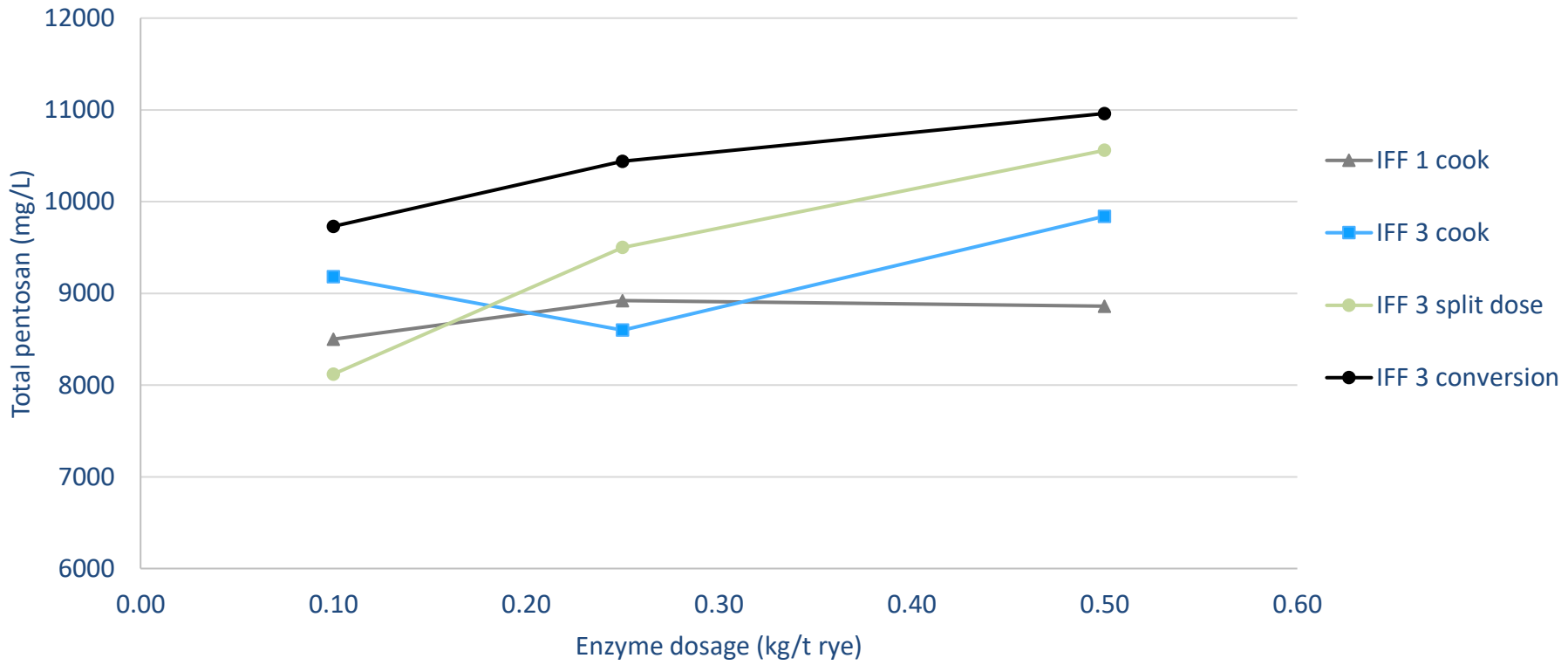
Reduced viscosity with increasing dose rate, comparing dose at cook and dose at conversion.



B: 23 beer gallon / 3.33:1 WTG
203 °F/ 95 °C for 30 min
149 °F/ 65 °C for 30 min
pH 5.0

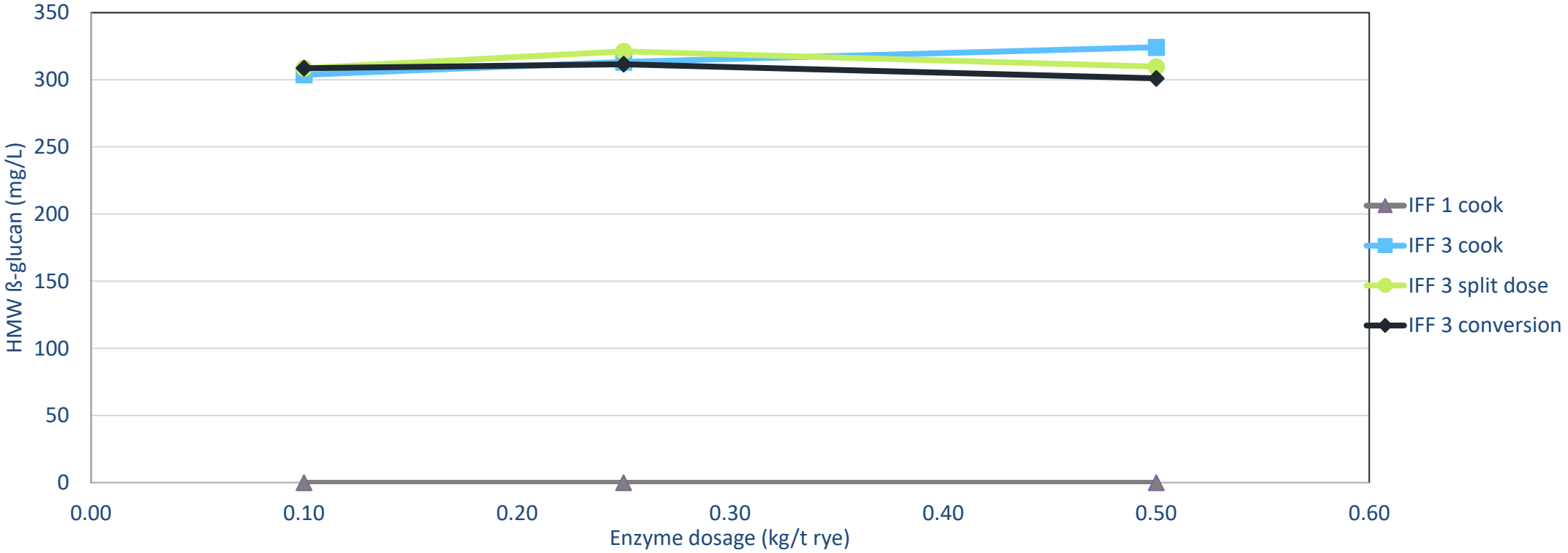
PENTOSAN IN THE COOK

Solubilizing more arabinoxylans with higher dose corresponds to lower viscosity



PENTOSANS ARE THE PROBLEM FOR RYE

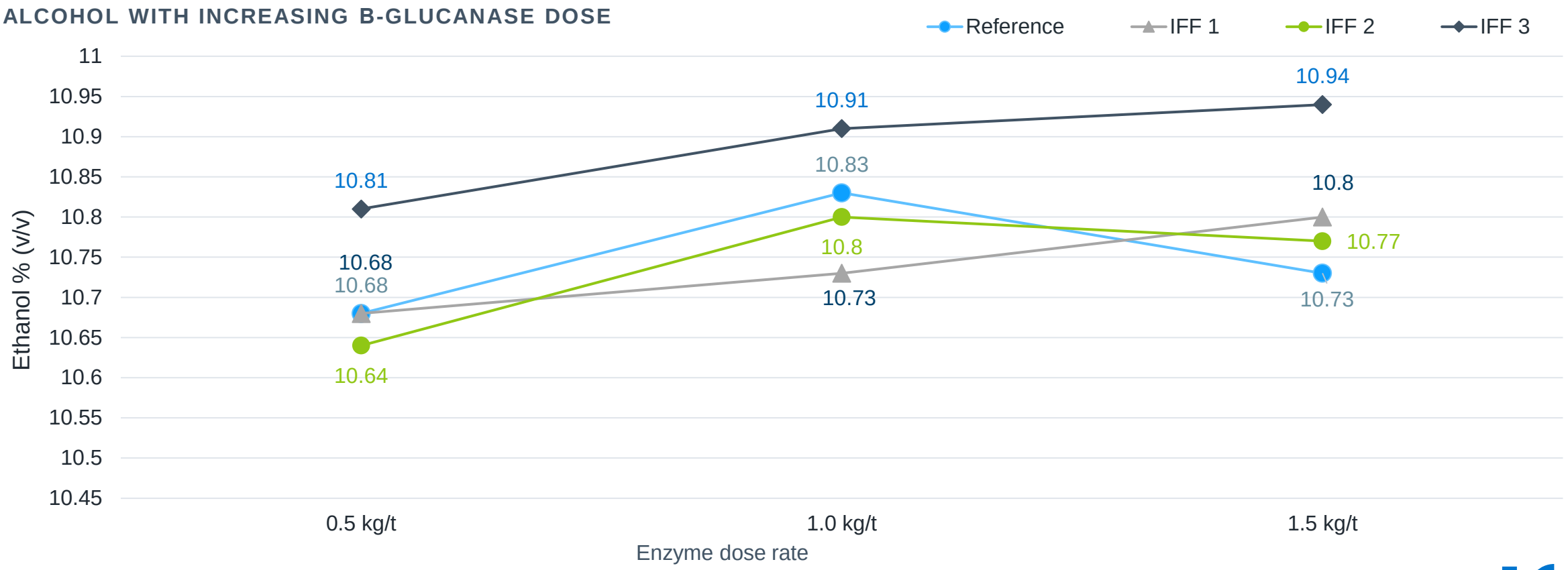
Beta-glucan reduction has limited effect on viscosity reduction



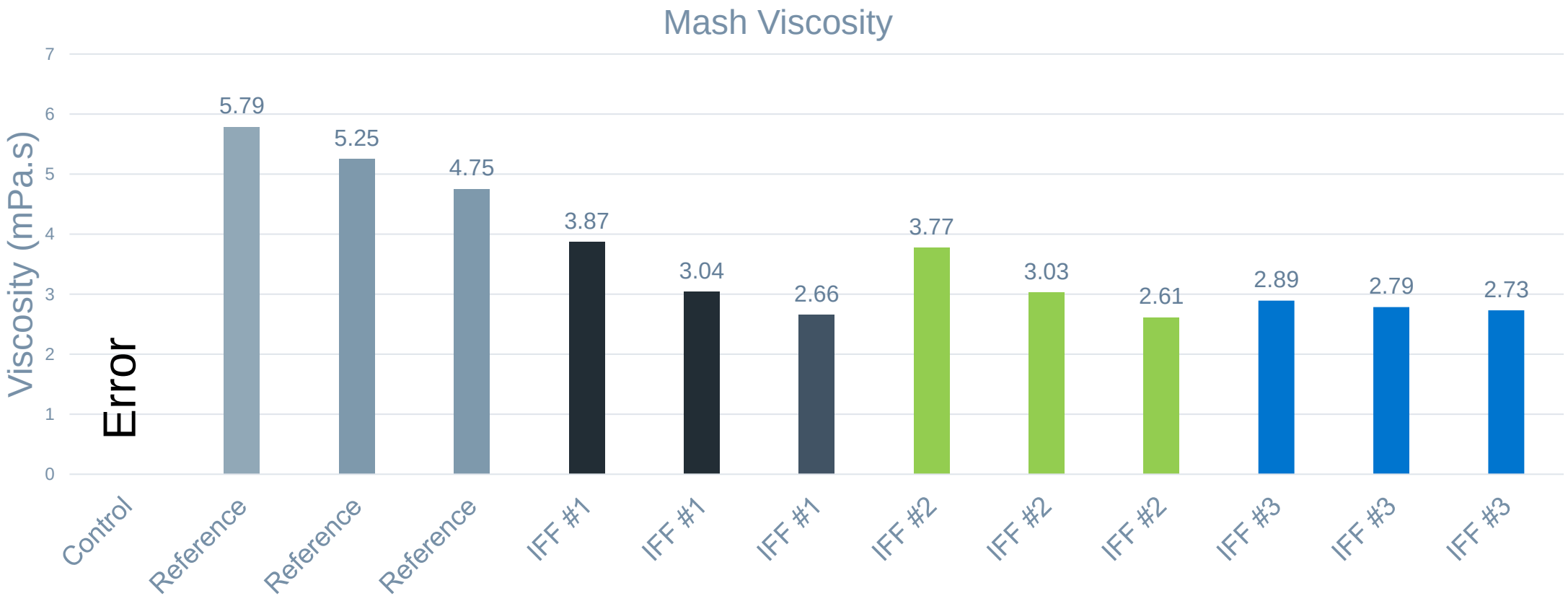
Eliminating beta glucan still leaves arabinoxylan in the cook

GREATER CELL WALL DEGRADATION LEADS TO GREATER ETHANOL PRODUCTION

Increasing the dose rate of xylanase increased the amount of ethanol



DISADVANTAGE OF NO ENZYME USE



The viscosity on the control cooks was so high that it was too thick to measure viscosity.
Problem: High viscosity and low ethanol yield.

CONCLUSION

Rye has unique problems when used in distilling:

High viscosity

Malt enzymes not sufficient to fully break down endosperm cell wall. The result is high viscosity.	→ It needs a xylanase
Beta glucan can cause high viscosity.	→ It needs a beta glucanase
Starch can also cause high viscosity.	→ It needs alpha amylase

IFF continues to work on solving the problem of high viscosity in rye.
We are happy to work with you to run free trials to help you optimize your process.

CONCLUSION

Arabinoxylans in rye cause unique problems when used in distilling:

Rye: Low starch / low yield

Rye: High viscosity

LAMINEX® C2K

IFF continues to work on solving the problem of high viscosity in rye.
We are happy to work with you to run free trials to help you optimize your process.

THANK YOU!

QUESTIONS?

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