



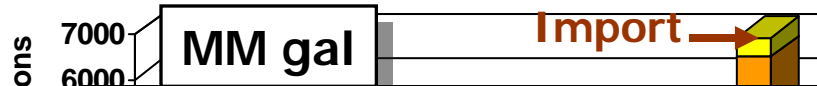
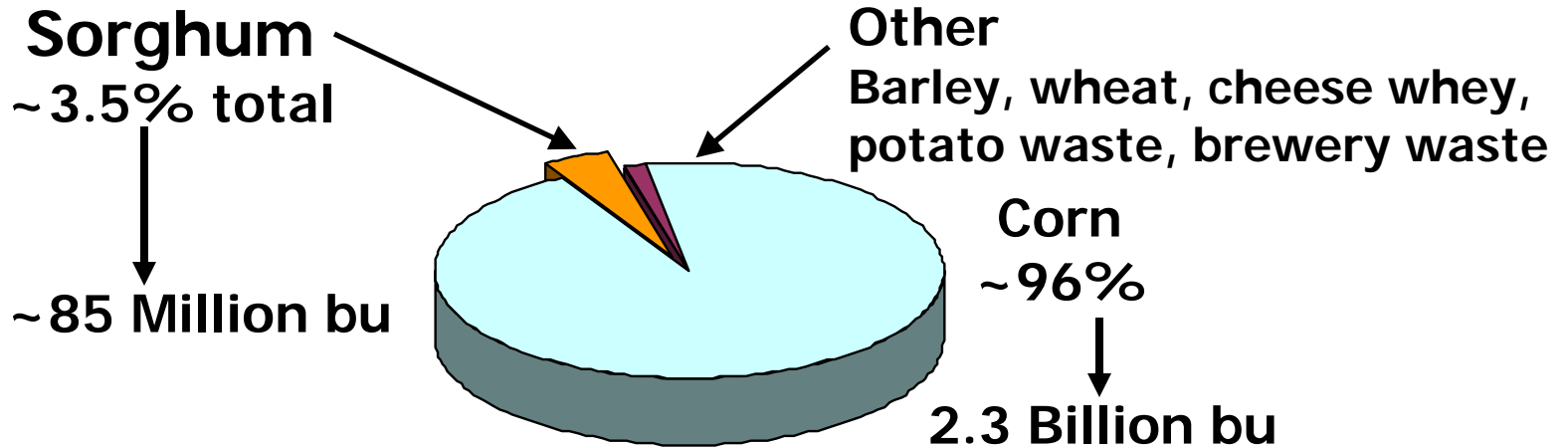
Sorghum Starch for Biofuels

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International Conference on Sorghum for Biofuel
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Raw materials for ethanol production

Current capacity is ~9 B gallons and will be ~14 B gal by 2009
Driven by corn grain production, with sorghum contributions



Compositions of corn & sorghum

The main focus is to understand the key factors (genetic, composition, chemical structure, and physical properties) affecting bioconversion efficiency of grain sorghum for biofuel production.

Production Import

Sorghum Samples:

Seventy sorghum samples with broad range of genetic backgrounds, chemical and physical features were selected from over 1200 sorghum lines and hybrids.

Ethanol Yields (% , V/V)

Variation = 22.1%

Low 12.2%



High 14.8%

Conversion Efficiencies (%)

Variation = 9.1%

Low 86.0%



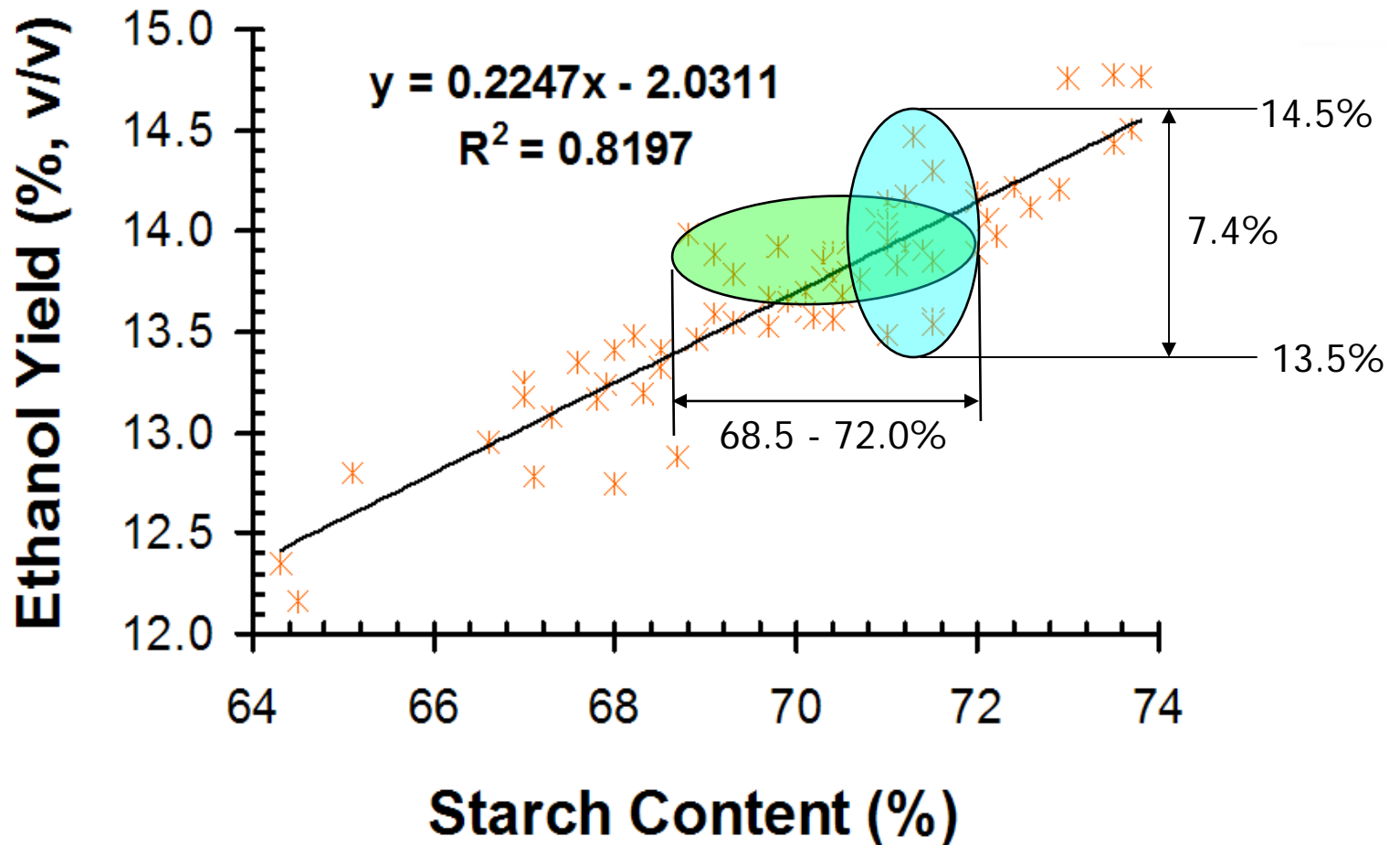
High 93.8%



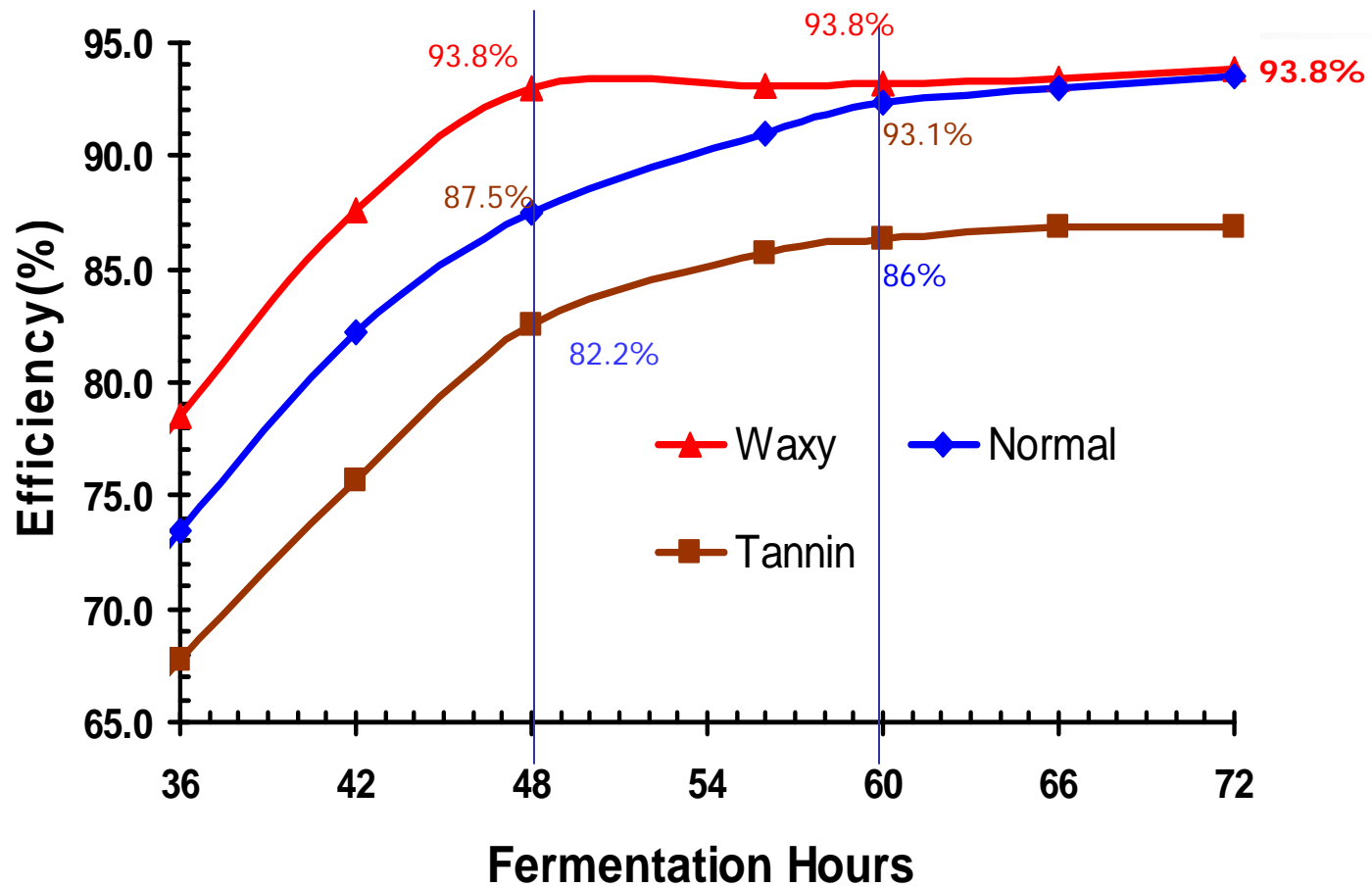
Major factors affecting sorghum bioconversion

- Starch content and type of starch
- Protein content and protein quality
- Protein starch interaction
- Mash viscosity
- Formation of amylose-lipid complex
- Phenol compounds
- Combined interactions

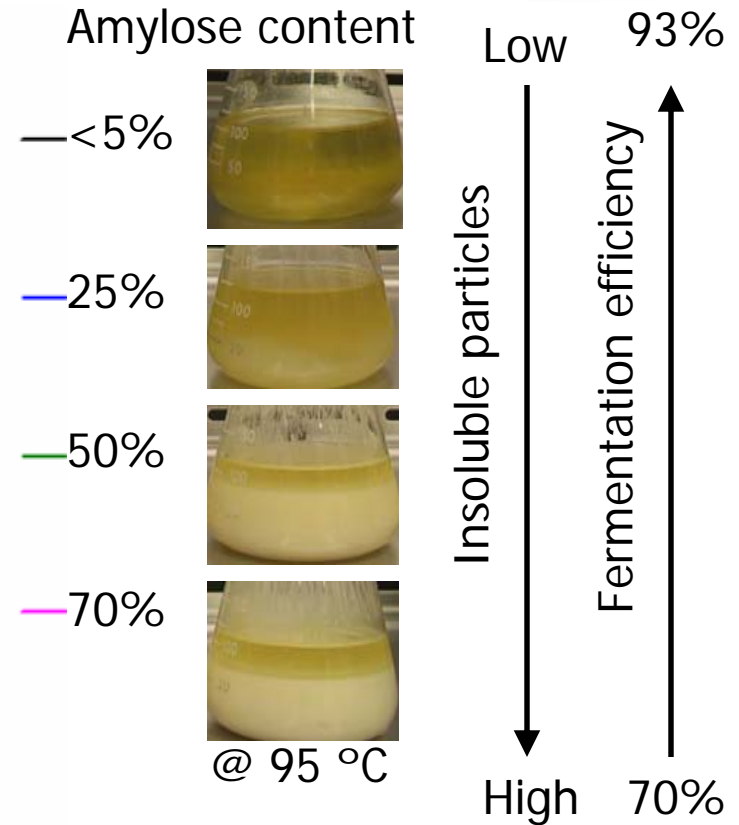
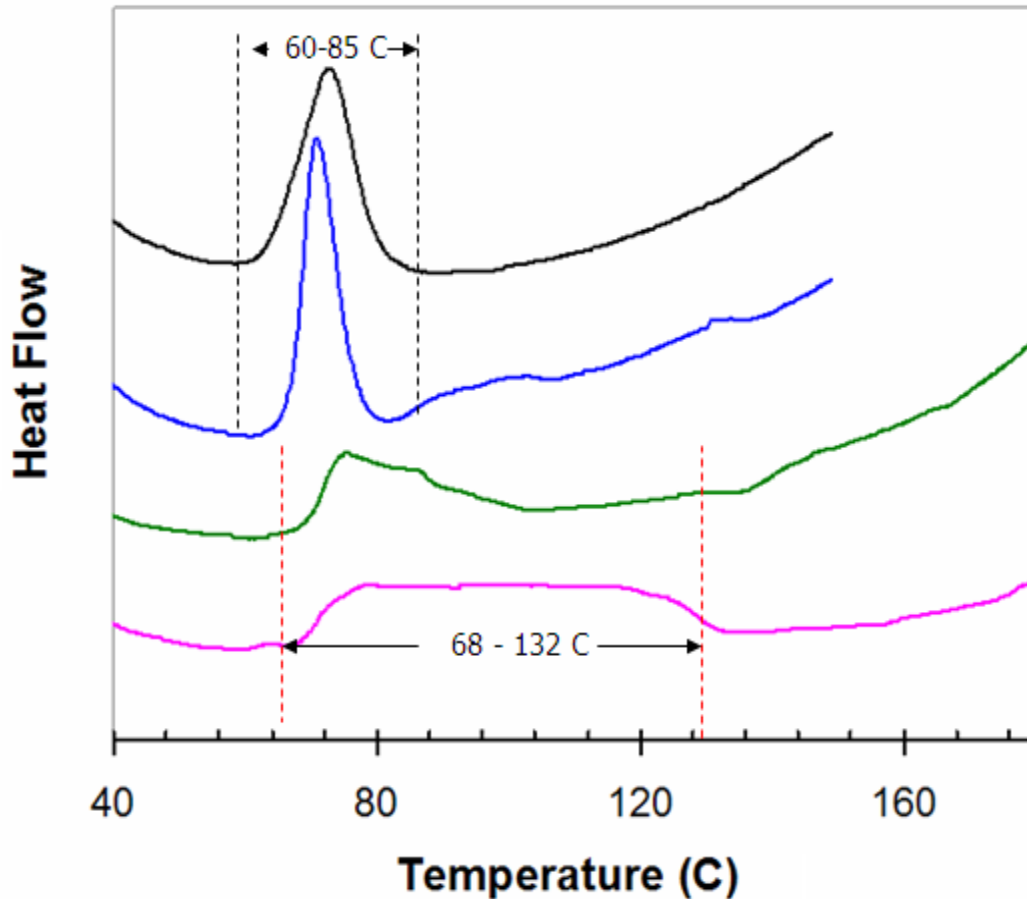
Starch content vs. Ethanol yield



Fermentation efficiency of grain sorghums



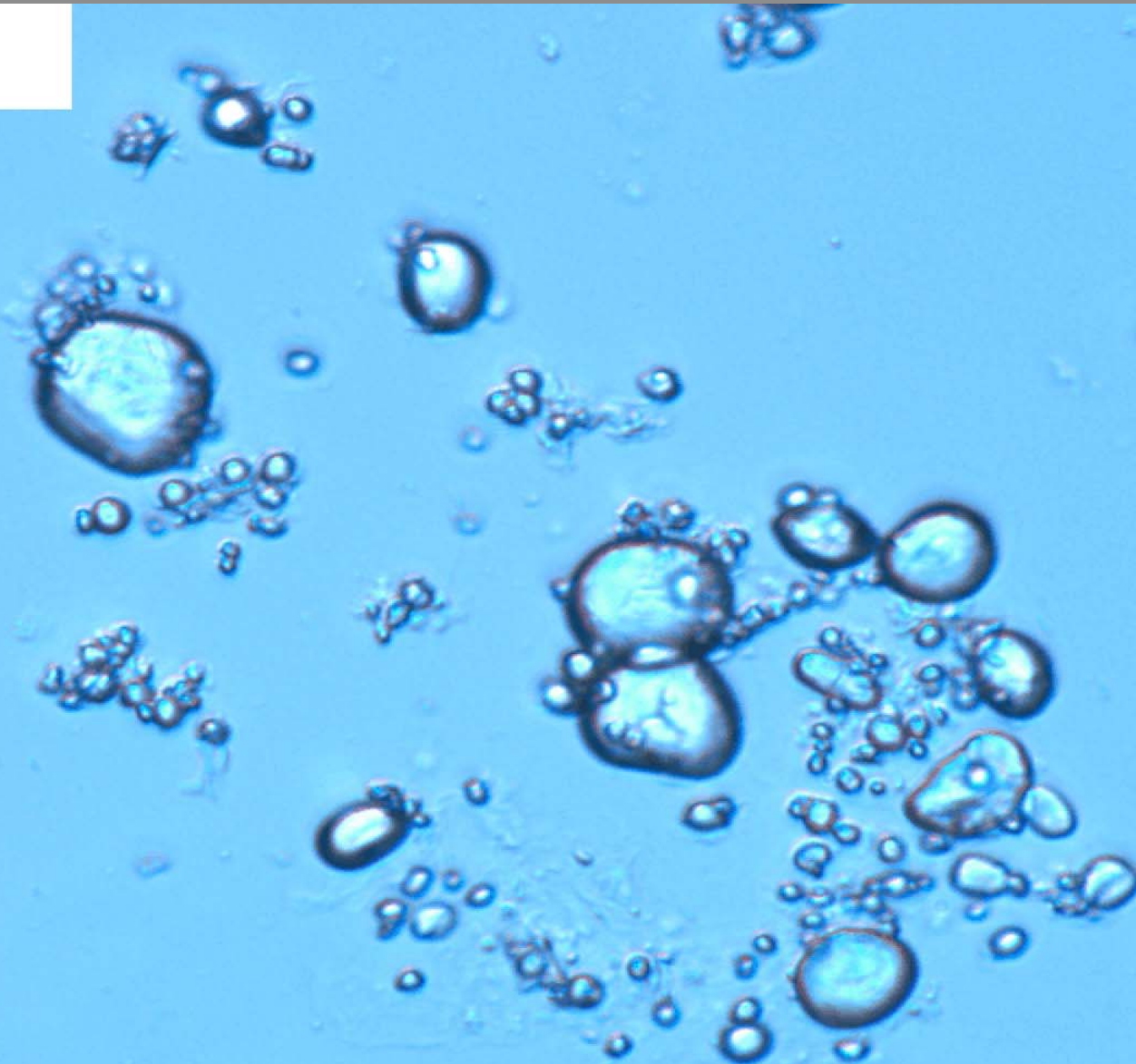
Effect of amylose content on starch gelatinization, insoluble, and efficiency



Starch gelatinization during cooking – Normal starch

Temperature = 31.0
15:35:01.539, 6-26-08
W16

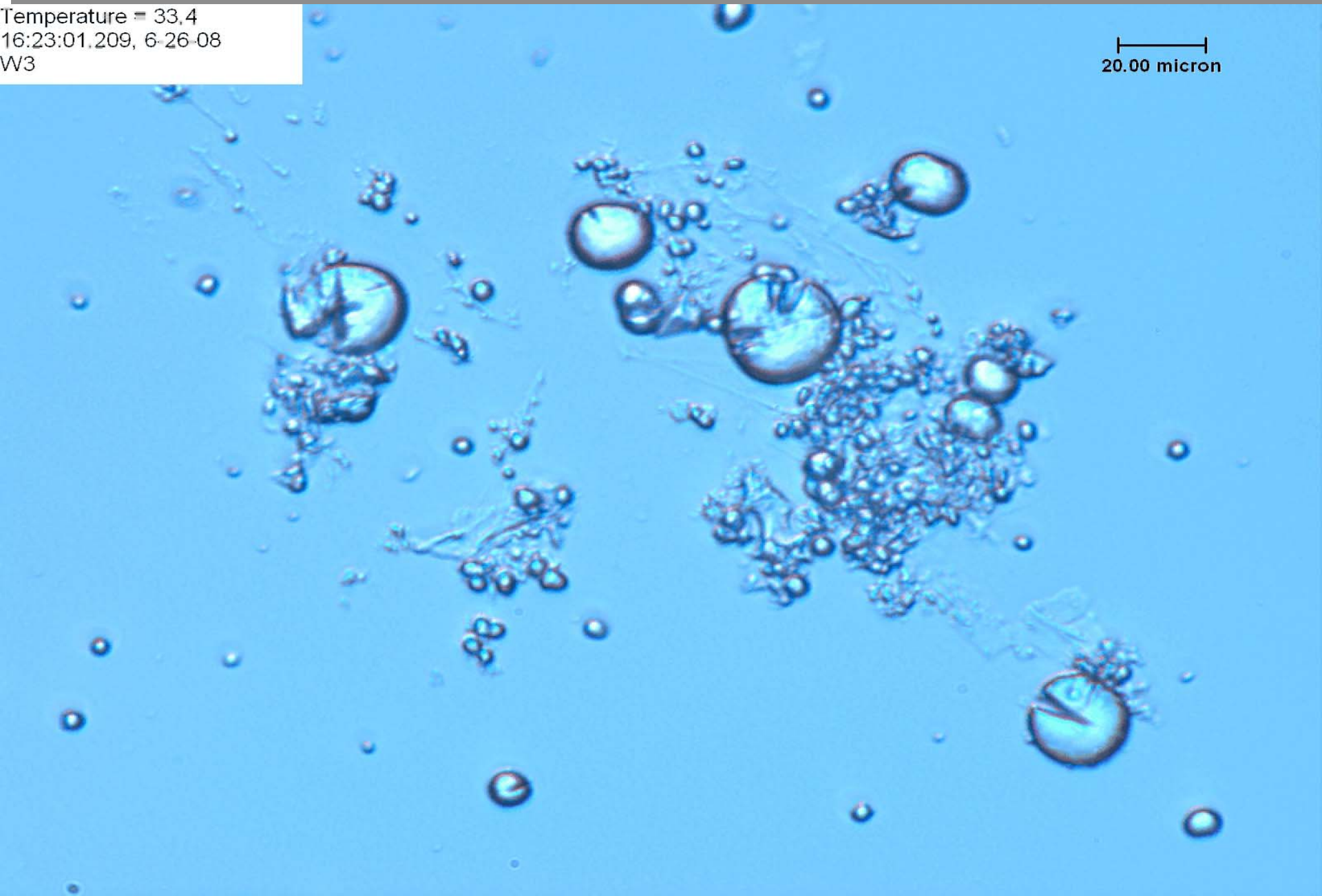
20.00 micron



Starch gelatinization during cooking – Waxy starch

Temperature = 33,4
16:23:01.209, 6-26-08
WV3

20.00 micron



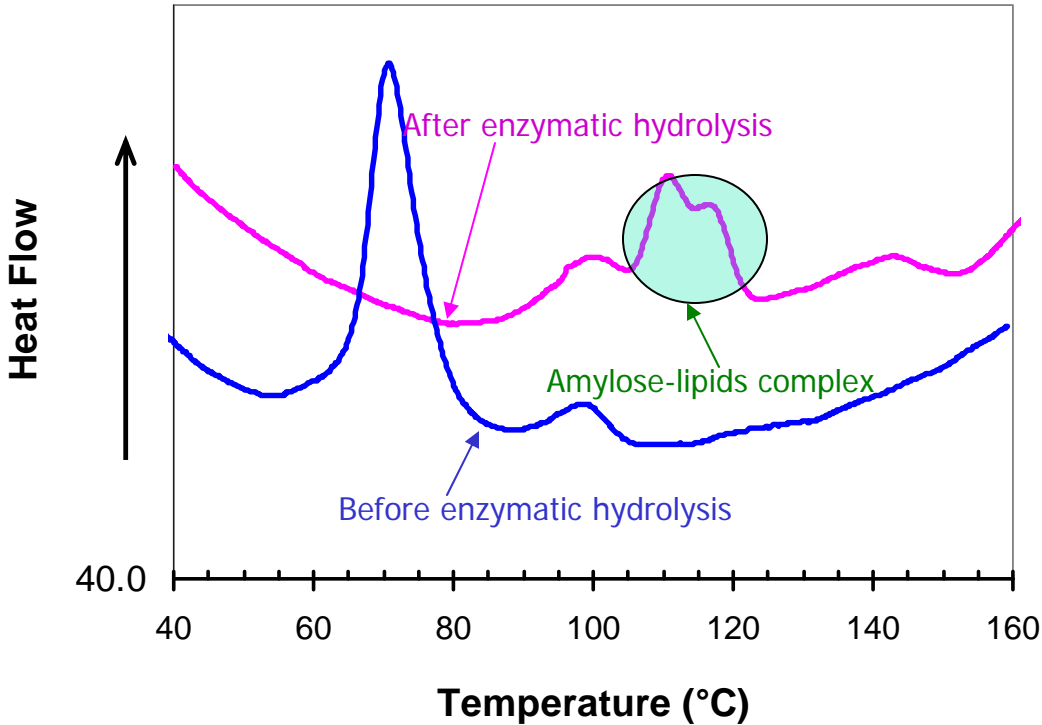
Formation of amylose-lipids complex



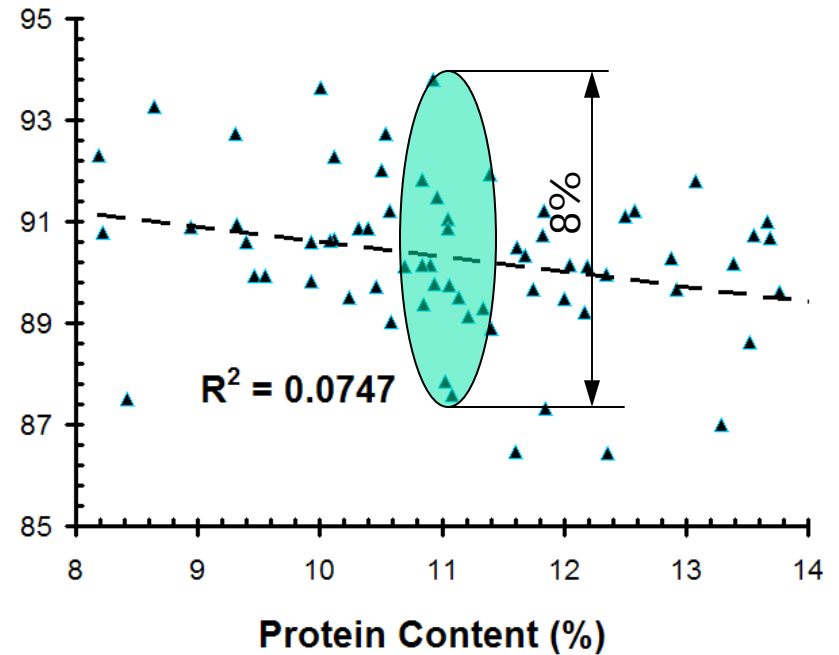
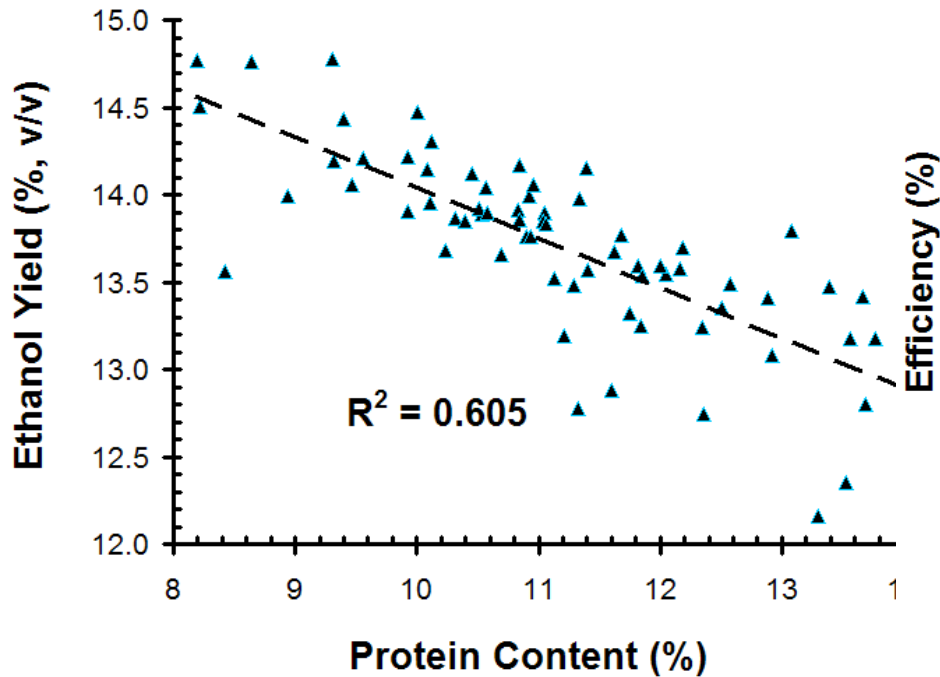
Solid residues after enzymatic hydrolysis



Before enzymatic hydrolysis

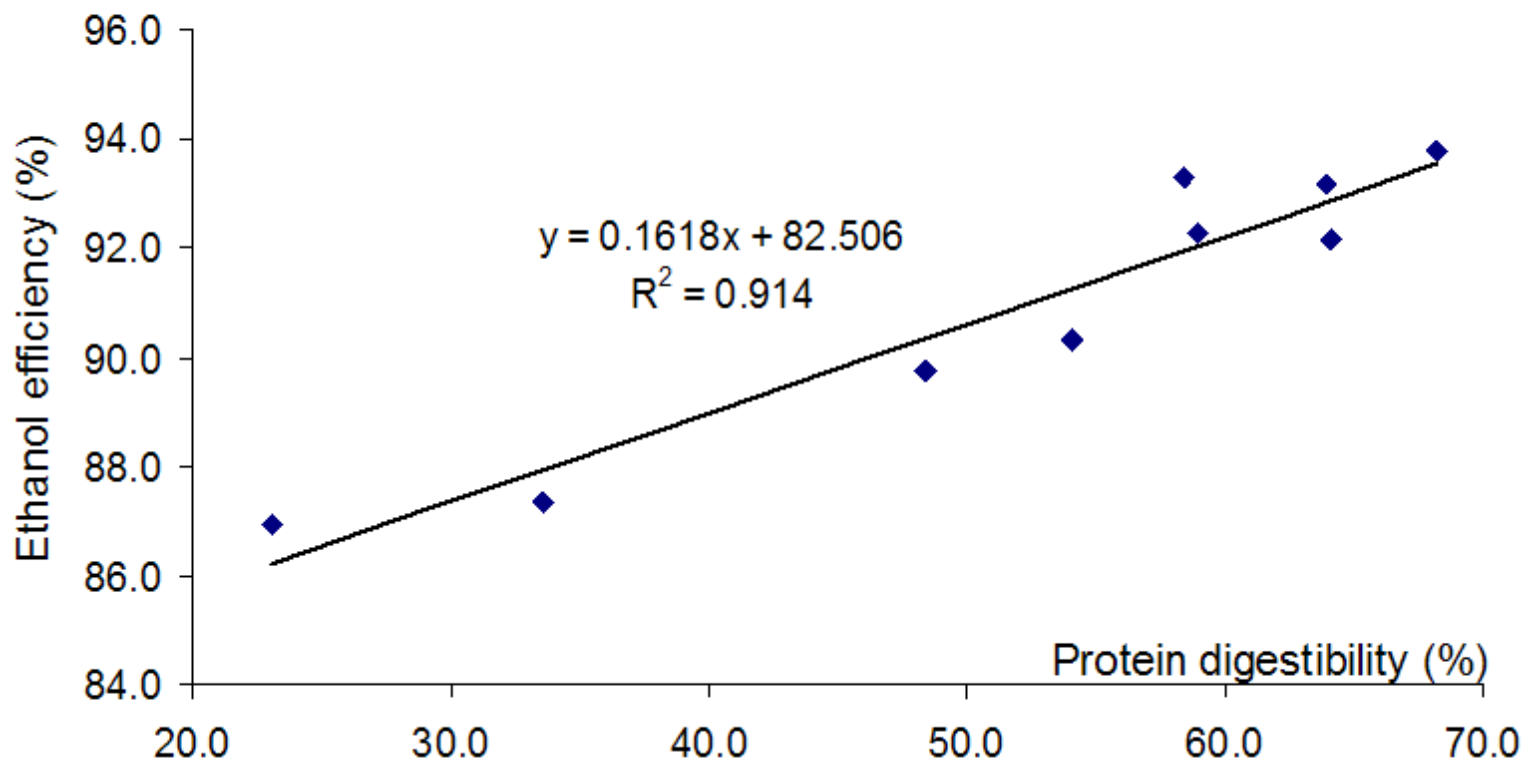


Effect of protein content on ethanol yield and fermentation efficiency

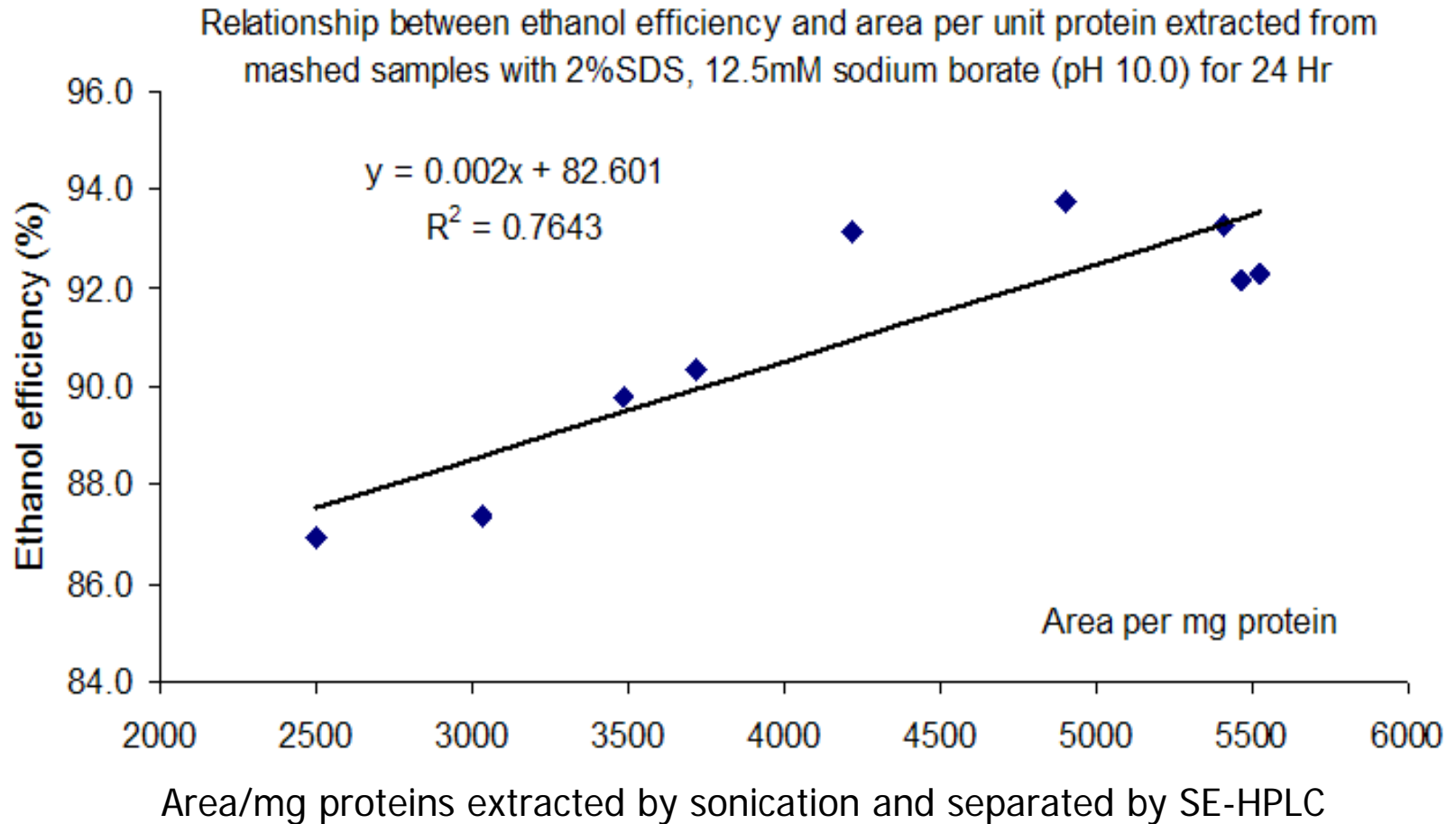


Ethanol fermentation efficiency vs. protein digestibility

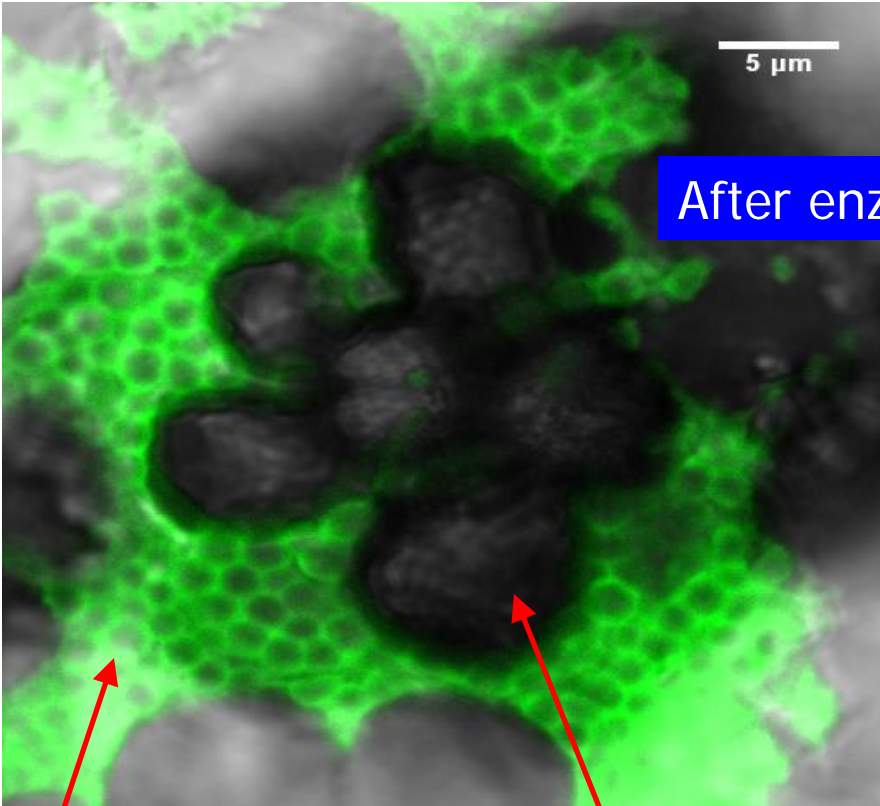
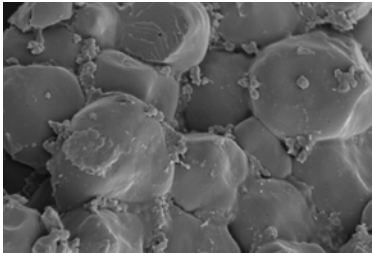
Relationship between ethanol efficiency and protein digestibility



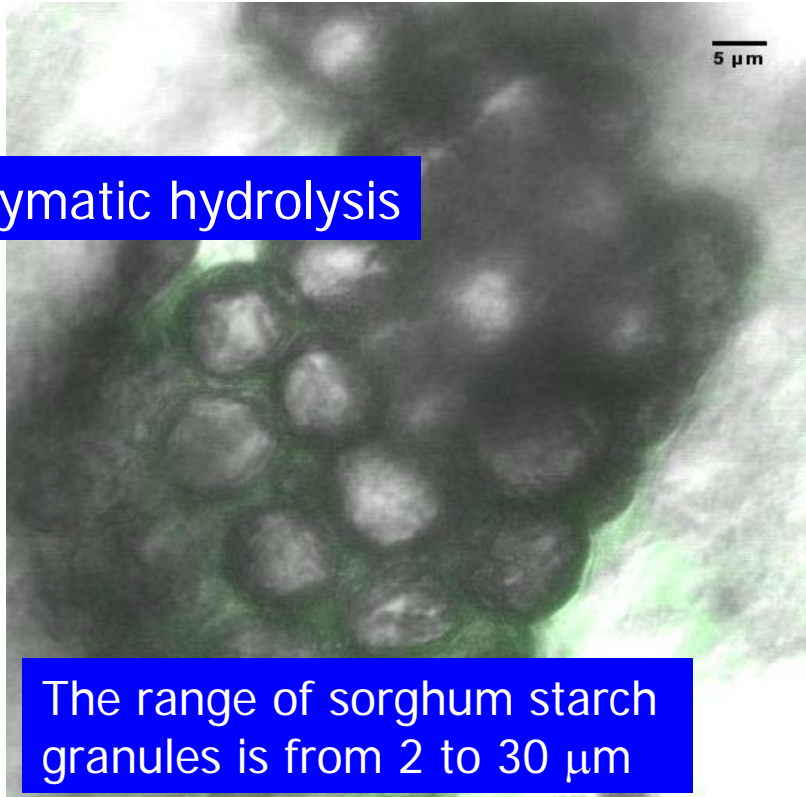
Ethanol fermentation efficiency vs. extractable proteins from mashed samples



Starch and protein interaction



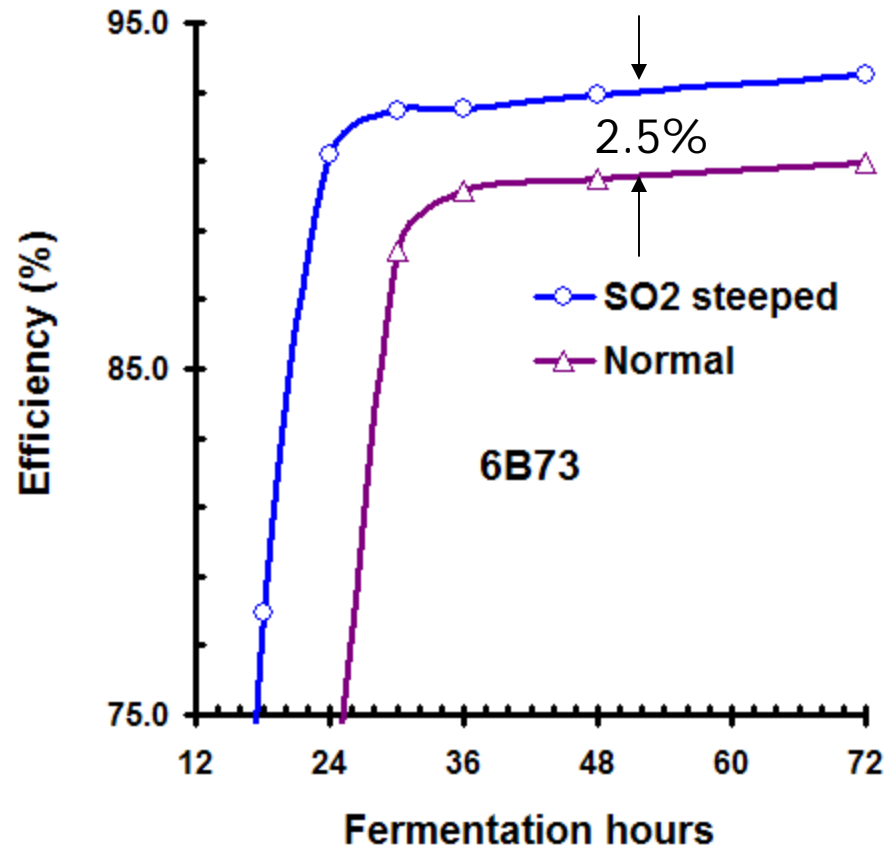
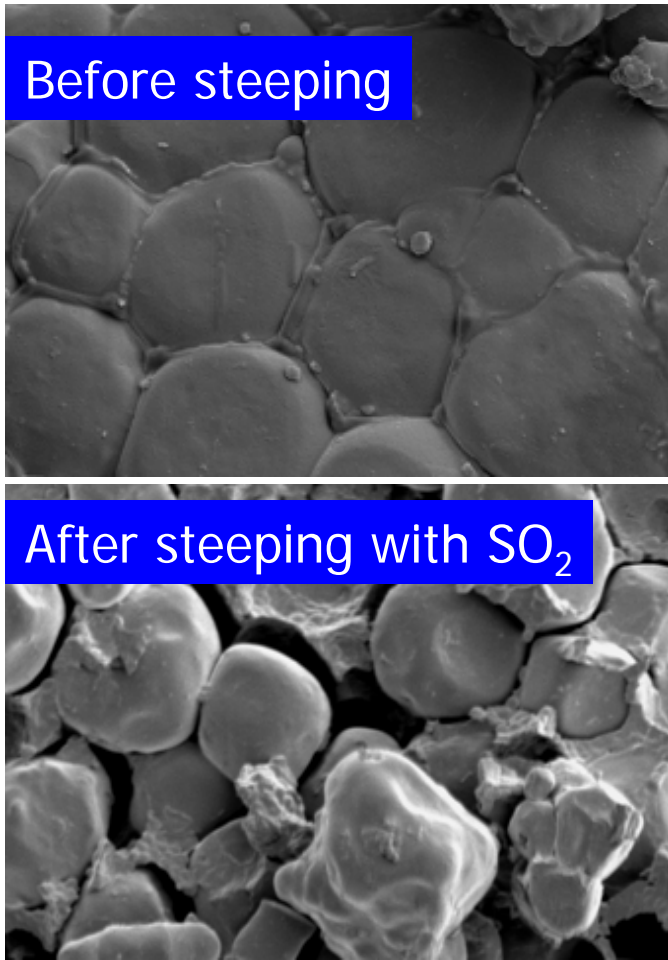
After enzymatic hydrolysis



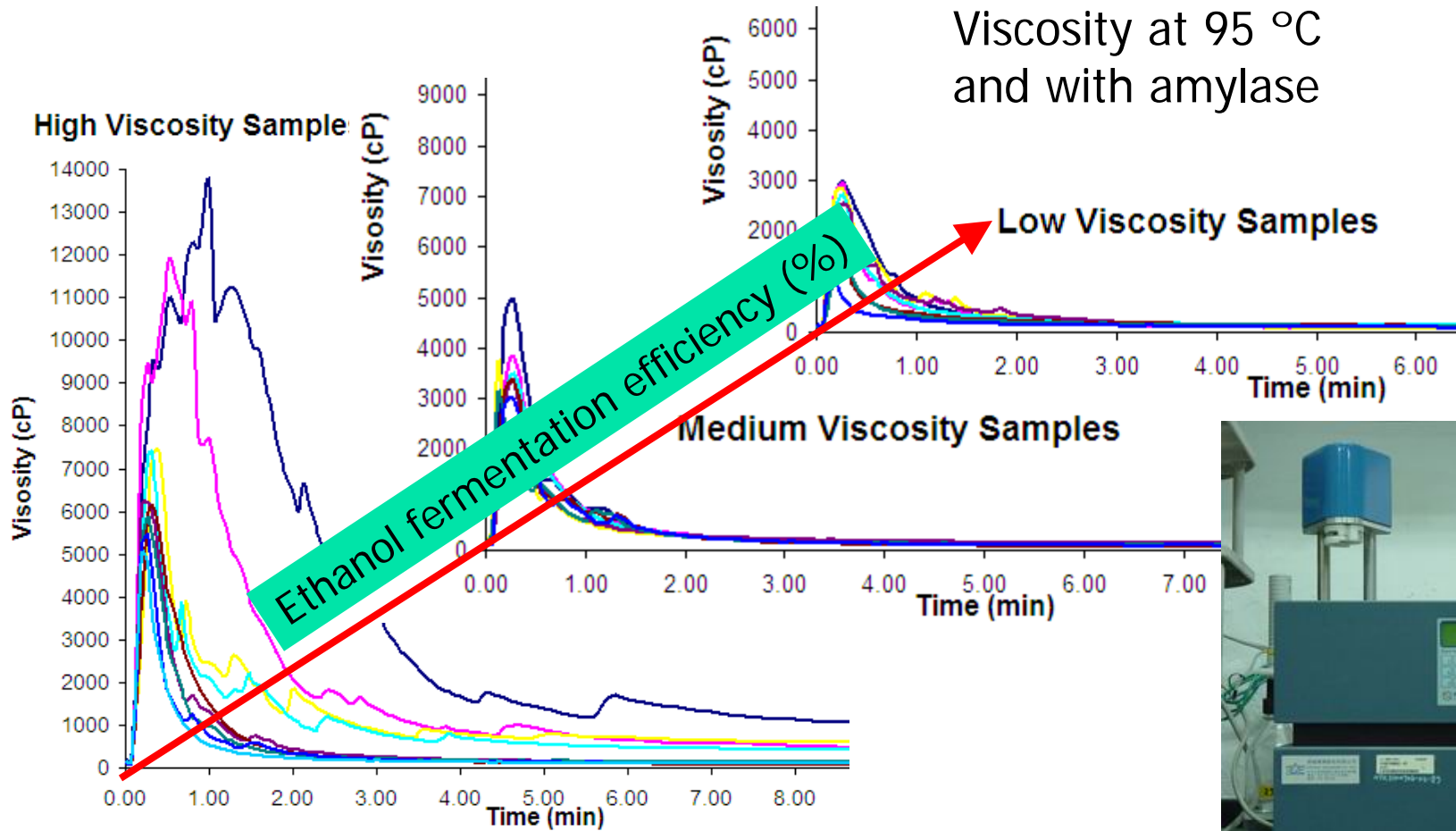
Protein body

Starch granules

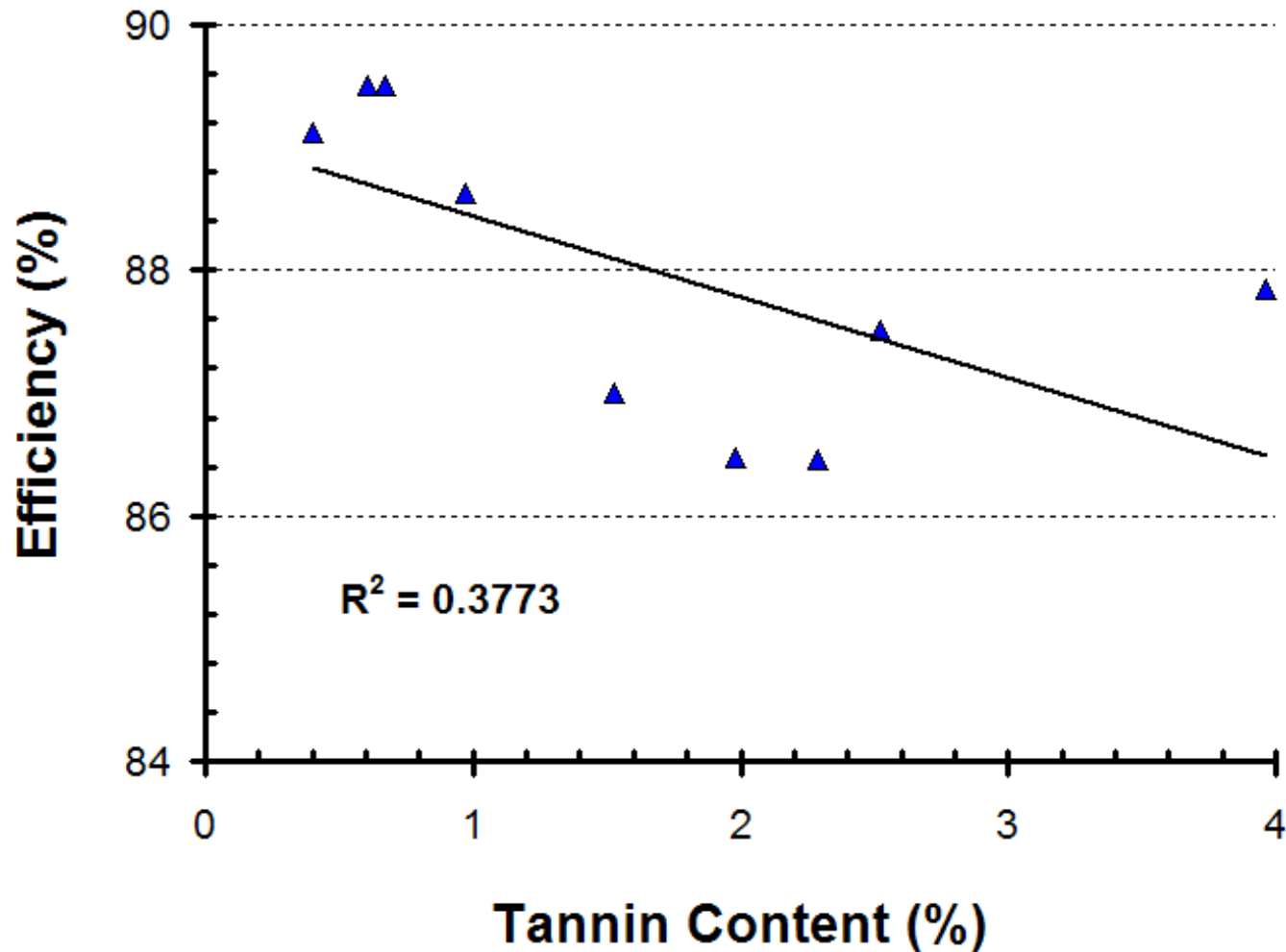
Starch and protein interactions



Viscosity is one of the key factors affecting sorghum bioconversion efficiency



Effect of phenolic compounds on mash viscosity and fermentation efficiency



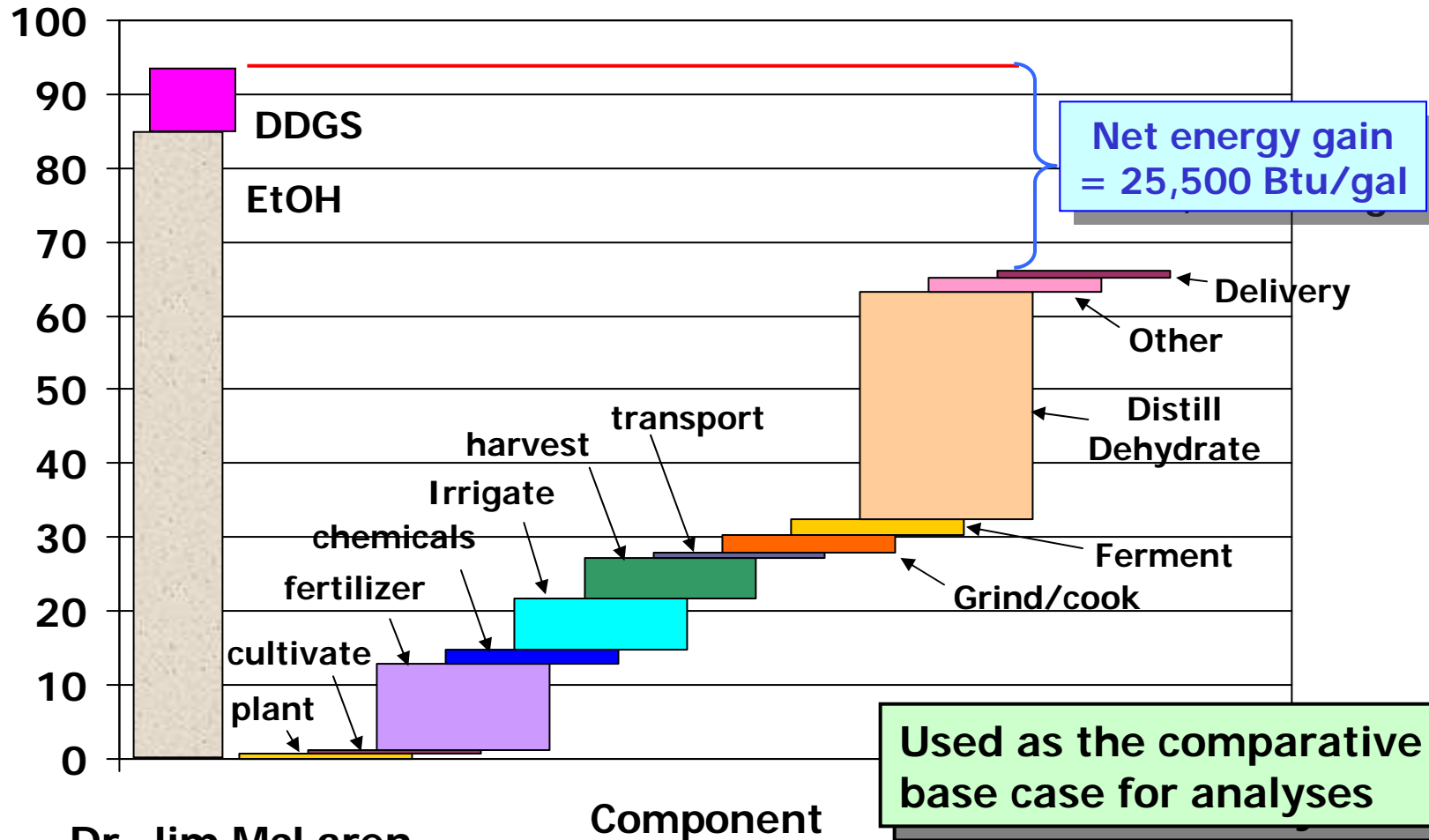
Comparison of high vs. low fermentation efficiency sorghums

Sorghum	Efficiency (%)	Chemical Composition (%)					Protein Digestibility (%)
		Starch	Protein	Fiber	Fat	Ash	
High (5)	93.3	72.1	9.33	1.63	2.69	1.59	65.7
Low (5)	86.8	68.8	12.10	2.10	3.50	1.90	50.8
Difference (%)	-7.0	-3.63	13.1	15.0	2.94	11.8	-22.8

ELCAM: Average "base case" ...

K Btu/gal EtOH

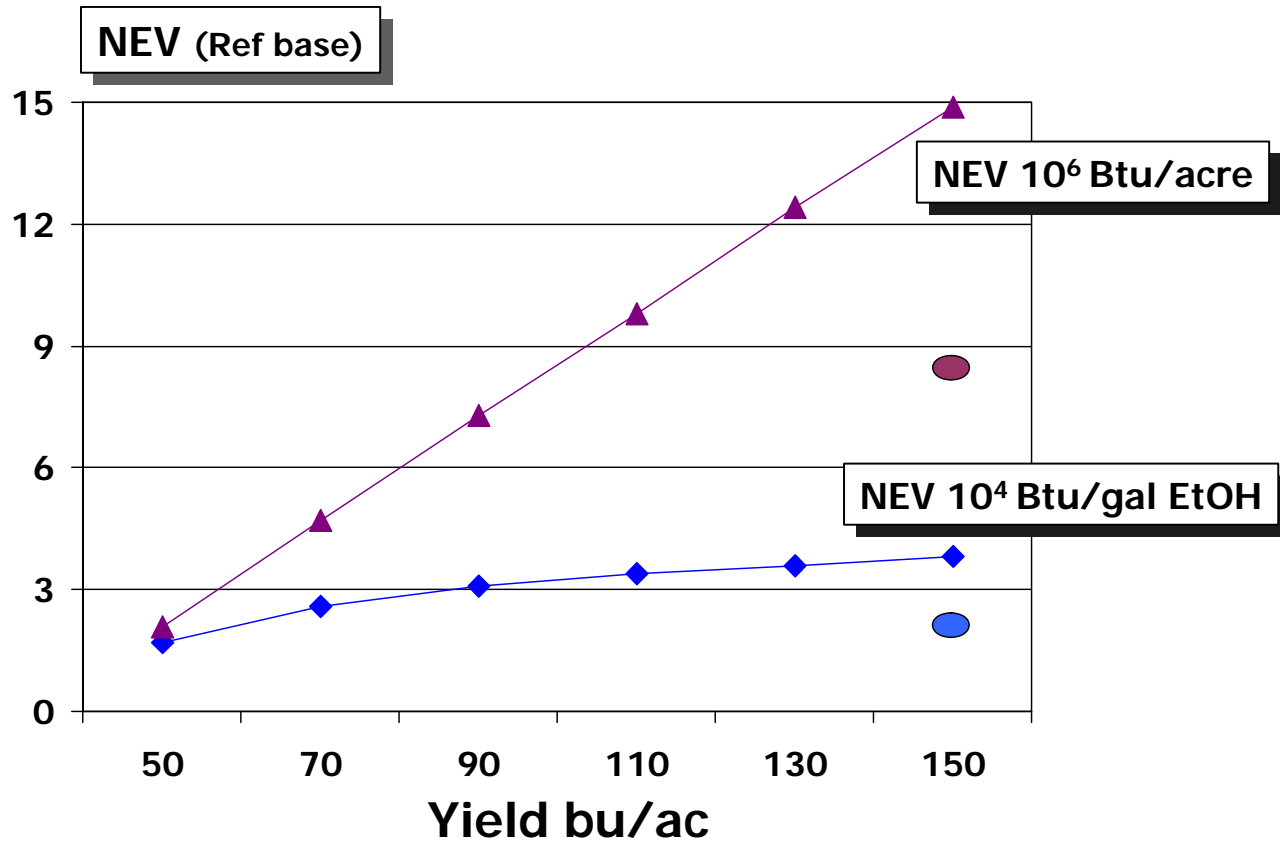
Sorghum, regional average, yield = 70 bu/ac



Dr. Jim McLaren

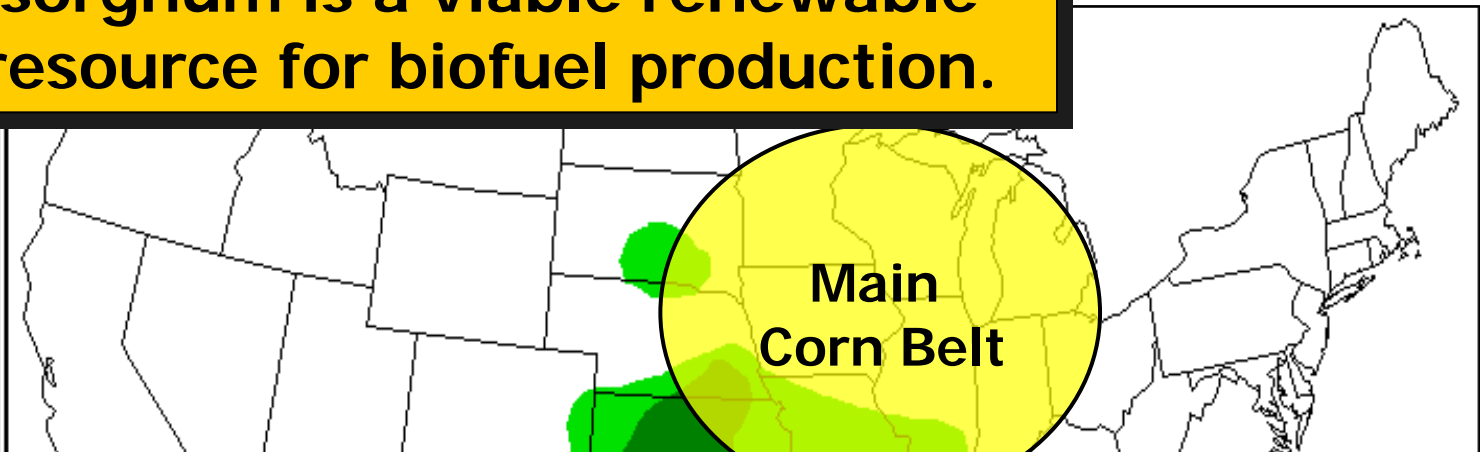
Component

Net energy value (NEV) for different levels of grain yield per acre



Sorghum can make a great contribution...

The research to-date shows that sorghum is a viable renewable resource for biofuel production.



Future research on sorghum bioconversion:

- Develop new or modified sorghum hybrids for biofuel production with high fermentation efficiency and low energy input.
- Increase starch content and grain yield per acre.
- Develop advanced bioprocessing technology to increase sorghum fermentation efficiency.



Acknowledgement

- Research Associates and Graduate students in Wang's research group,
- Drs. Bean, McLaren, Seib, Tuinstra, Shi, Hays, Madl, Mr. Lenz,
- Company: Monsanto Company, Novozymes, Inc.,



A wide-angle photograph of a large field of mature sorghum plants. The plants are densely packed and have turned a rich golden-brown color, indicating they are ready for harvest. The field stretches to the horizon under a clear, bright blue sky. The word "Thanks" is overlaid in the center of the image in a white, elegant cursive font.

Thanks