


Composition of Corn Dry-Grind Ethanol By-Products: DDGS, Wet Cake, and Thin Stillage

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Midwest Consortium for Biobased Products & Bioenergy


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For gifts of enzymes

Genencor (Enzymes)

Distillers Grains and Stillage

Big River Resources

Interactions and Inputs

Brent Shanks, Iowa State University

Bryan Bals, Michigan State University

Big River, LLC

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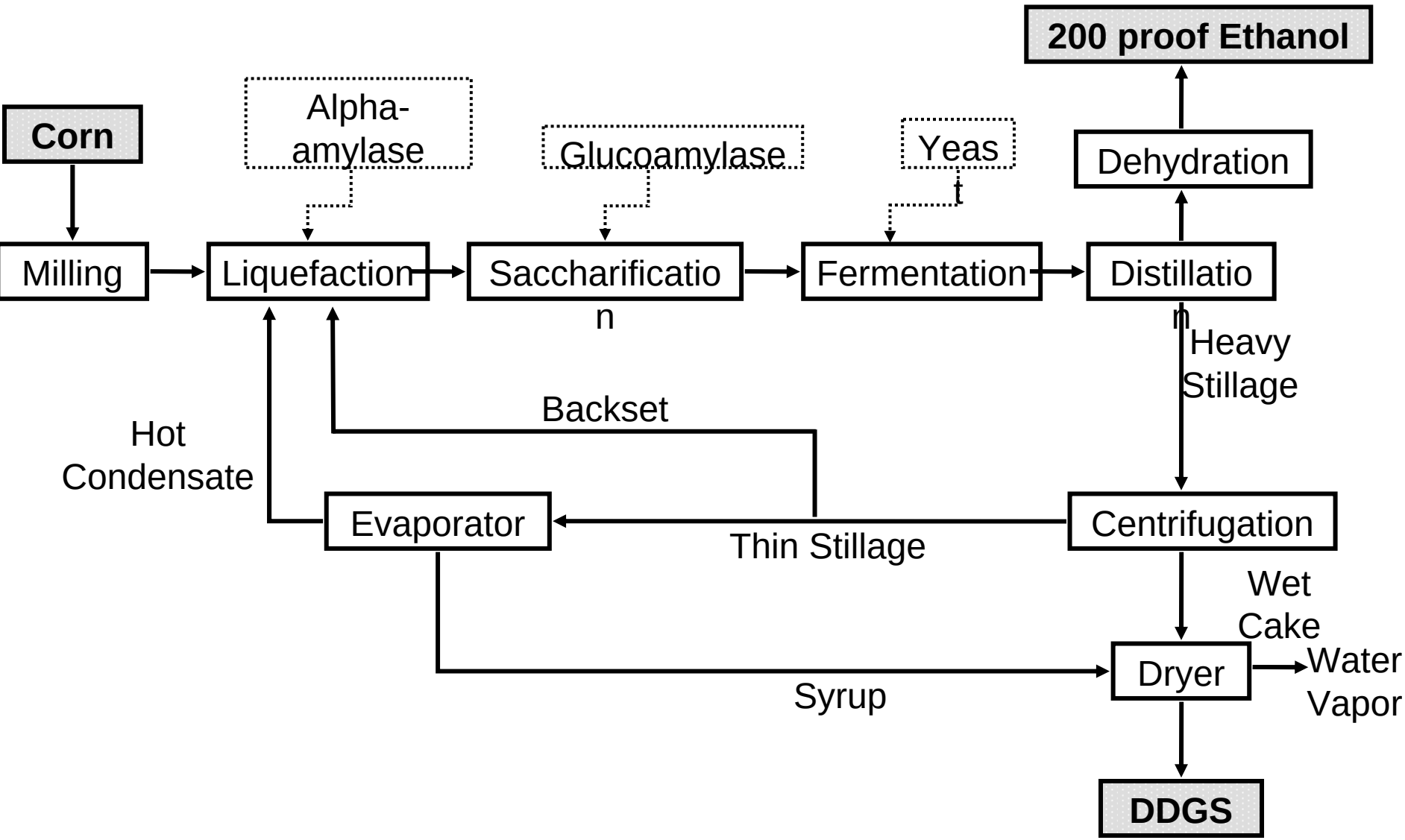
DDGS Composition

	Spiehs et al., mean value, coefficients of variation)	Belyea et al., mean
Moisture Content (% total)	11.1%	na
Dry Matter Content (% total)	88.9% (1.7%)	na
Total mass closure	100.0%	
Crude Protein	30.2% (6.4%)	31.3%
Crude Fat	10.9% (7.8%)	11.9%
Crude Fiber	8.8% (8.7%)	10.2%
Starch	na	5.1%
ADF	16.2% (28.4%)	17.2%
Ash	5.8% (14.7%)	4.6%

Spiehs, M.J., Whitney, M.H., Shurson, G.C., 2002. Nutrient database for distillers' dried grains with solubles produced from new ethanol plants in Minnesota and South Dakota. J. Anim. Sci. 80, 2639-2645.

Belyea, R.L., Rausch, K.D., Tumbleson M.E., 2004. Composition of corn and distillers' dried grains with solubles from dry grind ethanol processing. Bioresource Technol. 94, 293-298.


200 proof Ethanol
Corn
Alpha-amylase
Glucoamylase
Yeast
Dehydration
Milling
Liquefaction
Saccharification
Fermentation
Distillation
Heavy Stillage
Backset
Hot Condensate
Evaporator
Thin Stillage
Centrifugation
Wet Cake
Dryer
Water Vapor
Syrup
DDGS

Comparison of Analytical Systems

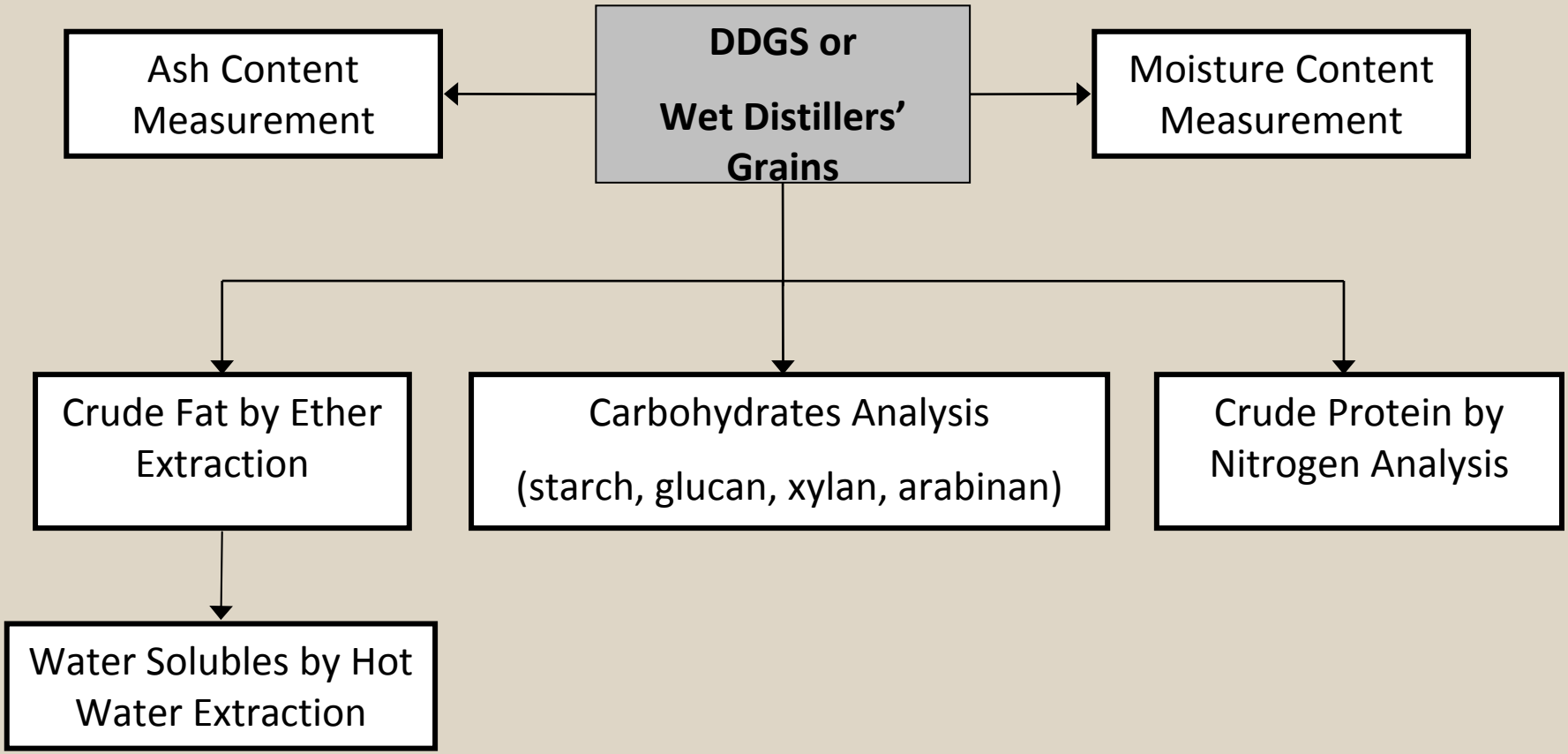
Forage/Feed Analysis

- Animal nutrition focus
- Protein (crude and amino acid)
- Fat
- Digestible energy
  - Neutral Detergent Fiber
  - Acid Detergent Fiber

Biomass Analysis

- Focus on potential fermentable sugars
- Defines polysaccharides by constituent monosccharides
- Gravimetric measurement of monosaccharides
- Lignin
- Protein and fat secondary

Biomass Compositional Analysis



Feed/Forage Analysis Methods

DDGS

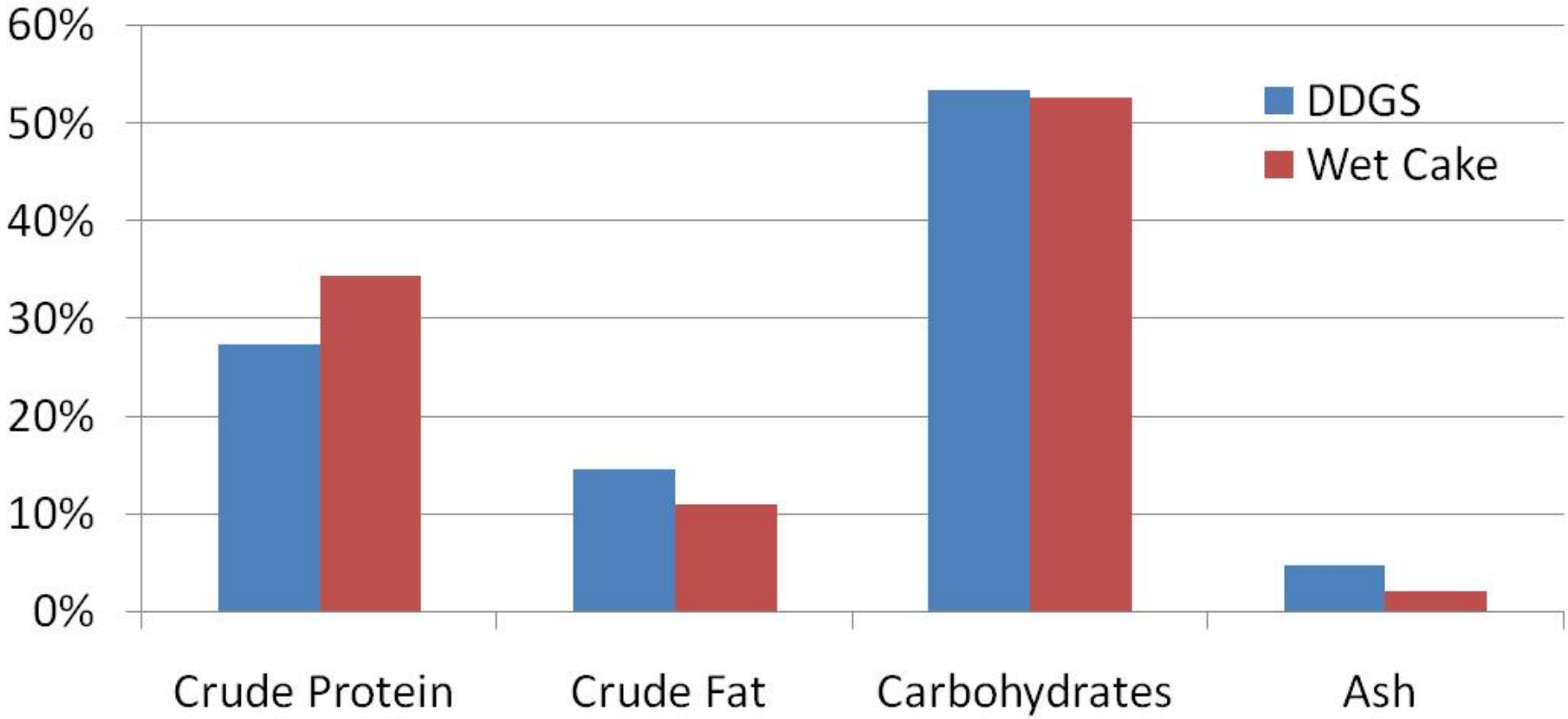
Dry Matter	88.9%
Crude Protein	27.3%
Crude Fat	14.5%
Carbohydrates	53.5%
Ash	4.7%
Total	100%

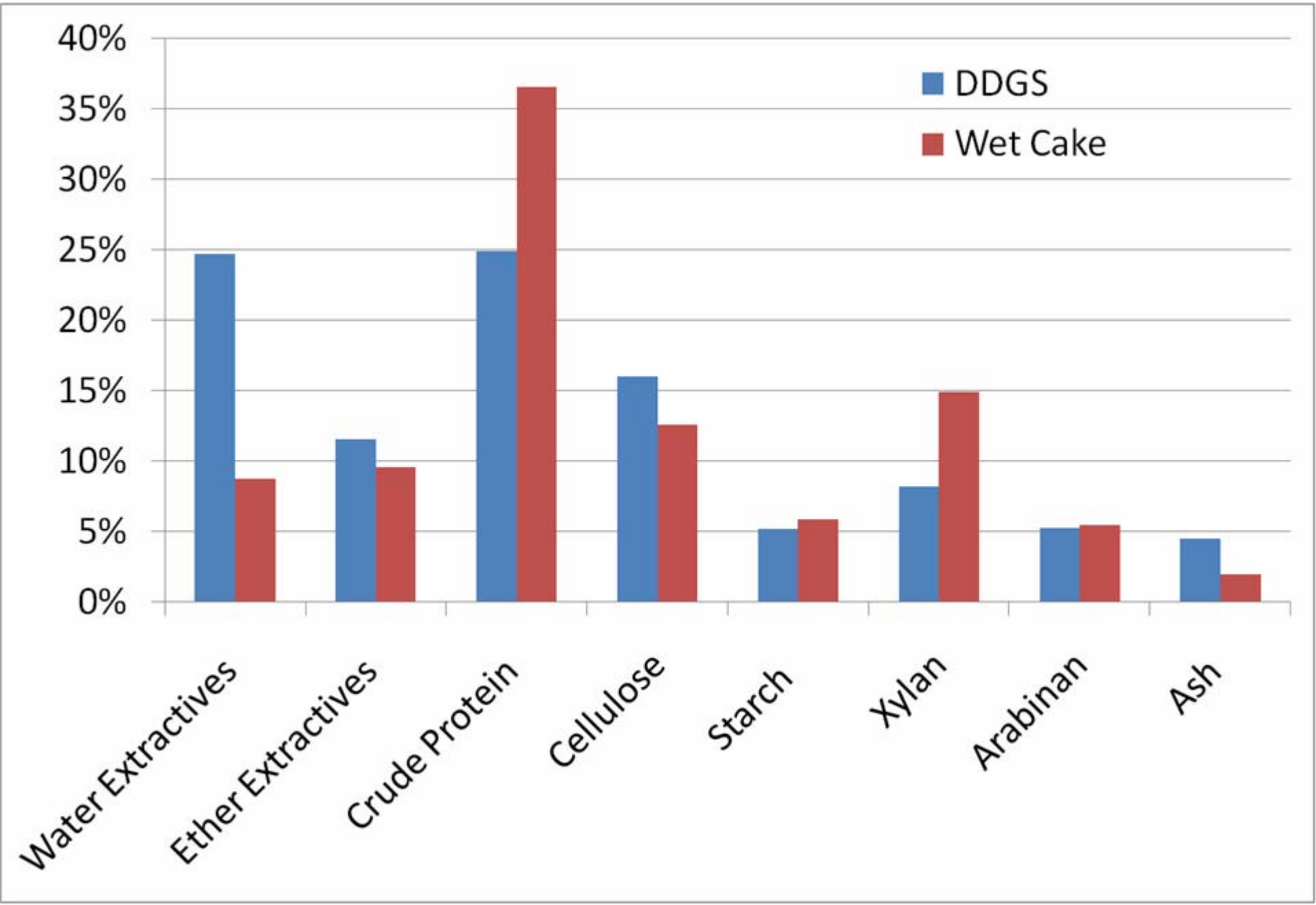
Analyses Carried out by University of Missouri, Columbia Agricultural Extension Chemical Laboratories

Cellulosic Biomass Methods

DDGS

	Average
Dry Matter	88.8%
Water Extractives	24.7%
Ether Extractives	11.6%
Crude Protein	24.9%
Glucan (total)	21.2%
Cellulose	*(16%)*
Starch	*(5.2%)*
Xylan and Arabinan	13.5%
Xylan	*(8.2%)*
Arabinan	*(5.3%)*
Ash	4.5%
Total Dry Matter Mass Closure	100.4%


60%
50%
40%
30%
20%
10%
0%
DDGS
Wet Cake
Crude Protein
Crude Fat
Carbohydrates
Ash


40%
35%
30%
25%
20%
15%
10%
5%
0%
DDGS
Wet Cake
Water Extractives
Ether Extractives
Crude Protein
Cellulose
Starch
Xylan
Arabinan
Ash

Feed/Forage Analysis Methods

Wet Cake

Dry Matter	44.1%
Crude Protein	34.4%
Crude Fat	10.9%
Carbohydrates	52.7%
Ash	2.0%
Total	100%

Analyses Carried out by University of Missouri, Columbia Agricultural Extension Chemical Laboratories

Cellulosic Biomass Methods

Wet Cake

	Average
Dry Matter	35.3%
Water Extractives	8.8%
Ether Extractives	9.6%
Crude Protein	36.6%
Glucan (total)	18.5%
Cellulose	*(12.6%)*
Starch	*(5.9%)*
Xylan and Arabinan	20.9%
Xylan	*(14.9%)*
Arabinan	*(5.5%)*
Ash	2.0%
Total Dry Matter Mass Closure	96.4%

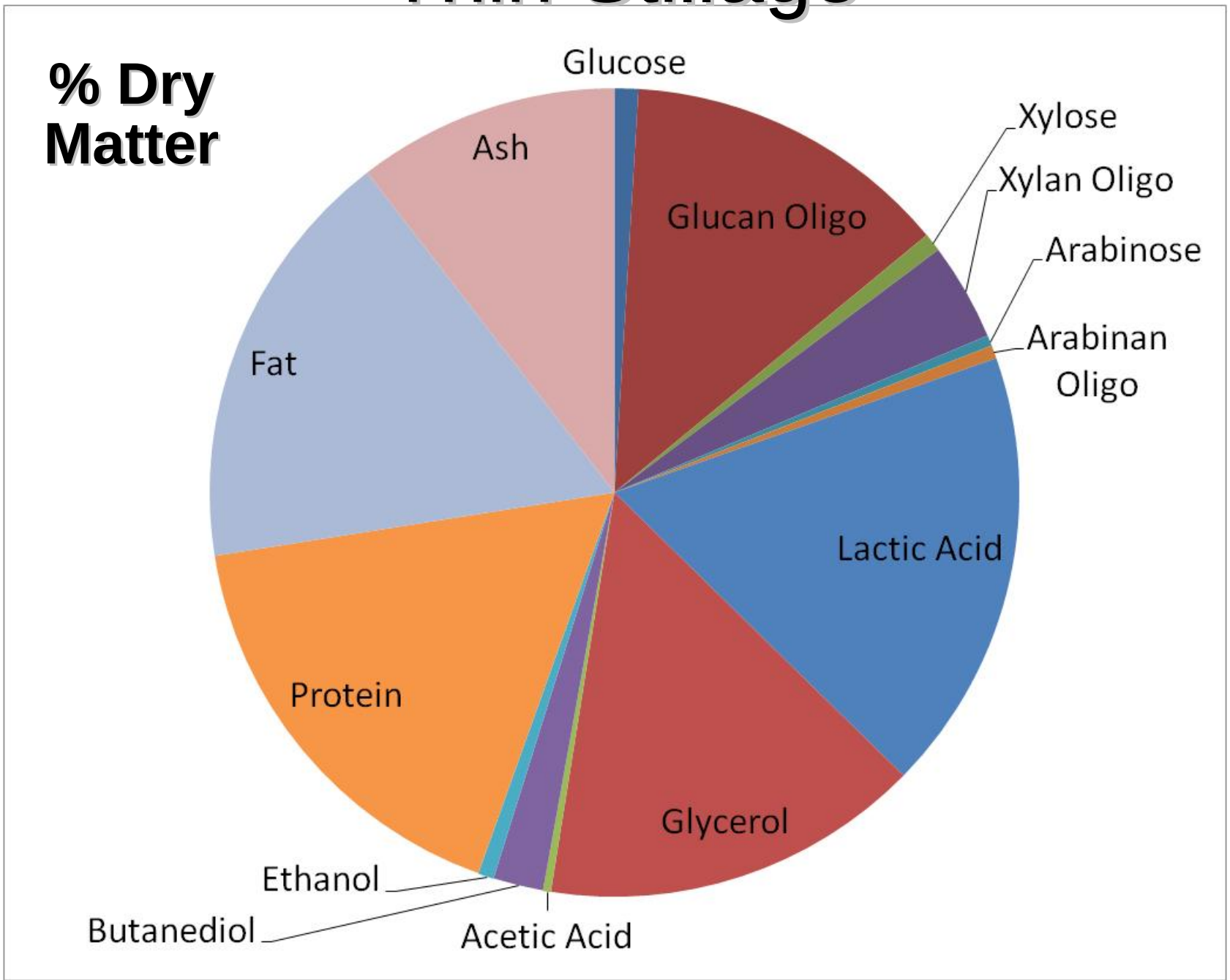
Feed/Forage Analysis Methods

Thin Stillage

Dry Matter	6.2%
Crude Protein	1.3%
Crude Fat	1.3%
Carbohydrates	2.8%
Ash	0.8%
Total	100%

Analyses Carried out by University of Missouri, Columbia Agricultural Extension Chemical Laboratories

Thin Stillage



Amino Acid Profiles
% of Crude Protein

	DDGS	Wet Cake	Thin Stillage
Isoleucine	4.4%	4.1%	4.5%
Lysine	3.9%	3.2%	5.4%
Methionine	2.2%	2.3%	1.8%
Cystine	2.1%	2.4%	2.7%
Threonine	4.3%	3.8%	4.5%
Tryptophan	0.8%	0.9%	0.9%
Valine	5.8%	5.2%	6.3%

Limiting amino acids, swine rations

Summary

- DDGS and wet distillers' grains rich in polysaccharides (29.4% and 33.4%)
- DDGS is rich in protein (25%)
- DDGS also contains significant oil (11.6%)
- Opportunities exist to extract added value of the carbohydrates, protein, and oil from DDGS