Energy Value of Corn Milling Co-Products in Swine

B. J. Kerr, USDA-ARS / P. V. Anderson, Iowa State University / G. C. Shurson, University of Minnesota

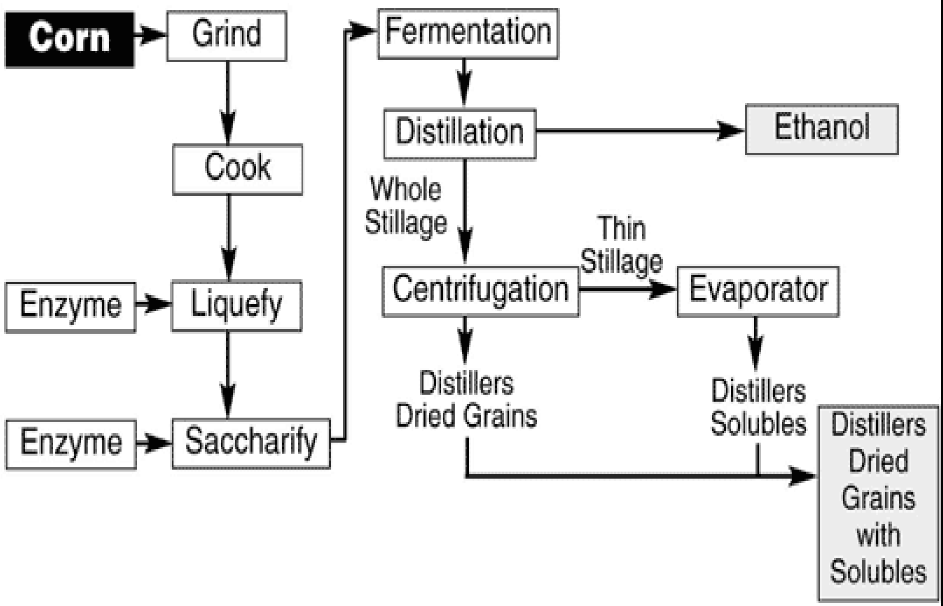
USDA

United States
Department of Agriculture

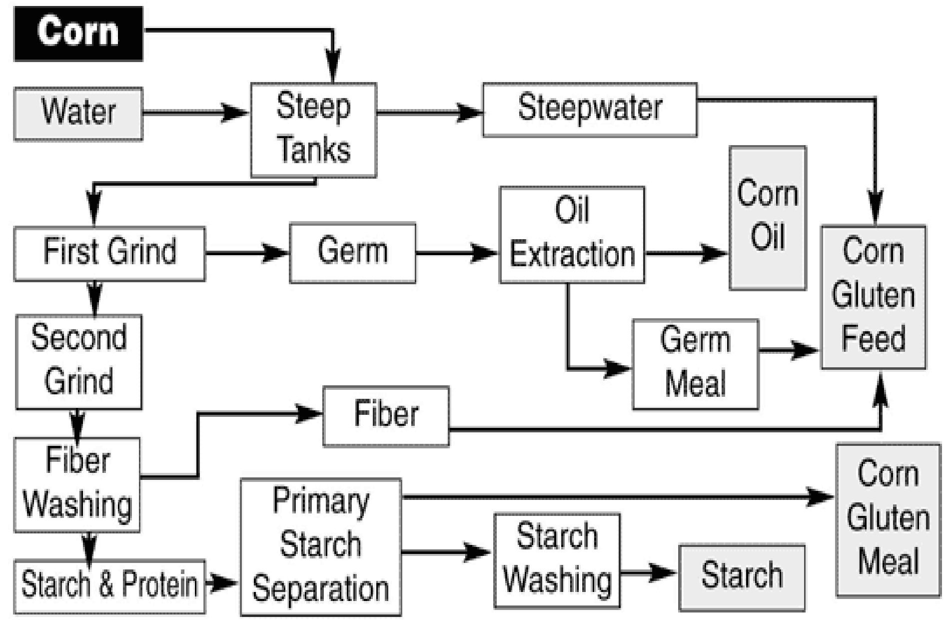
National
Soil Tilth
Laboratory

Creating
Agricultural
Success

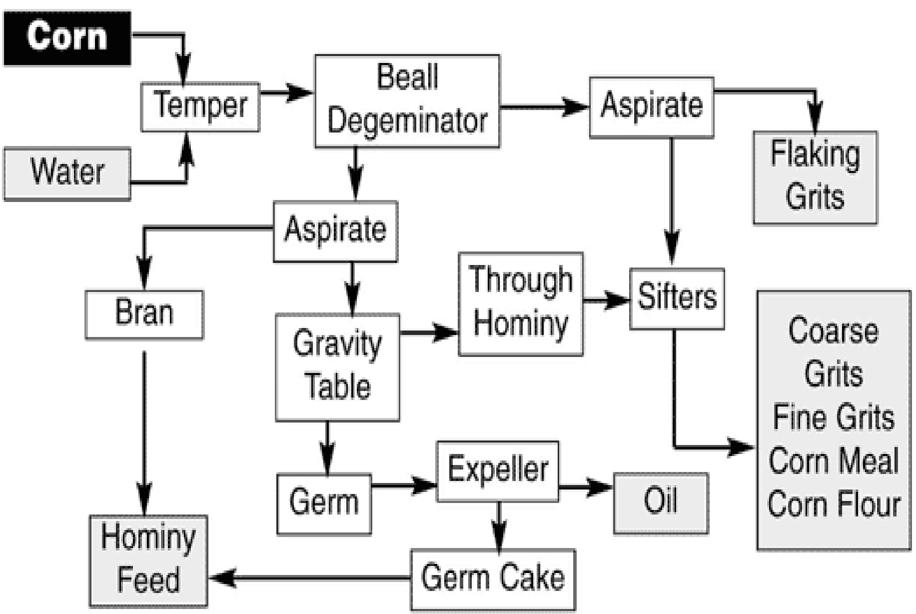
Dry Grind Ethanol



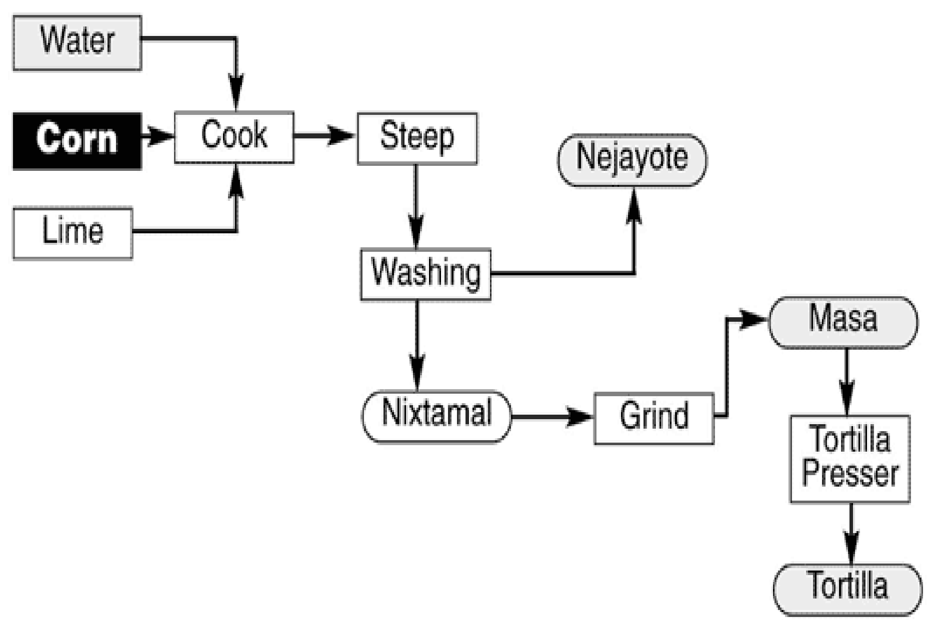
Corn Wet Milling Process

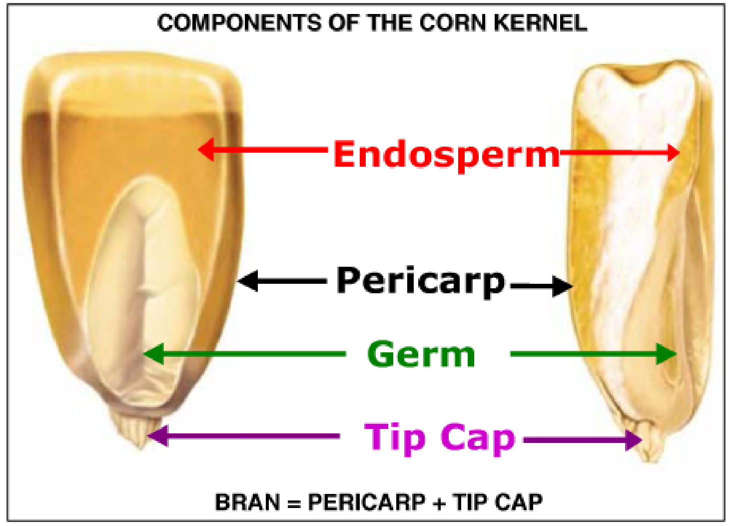


Corn Dry Milling



Masa Process





Corn	Nutrient	DDGS
57.1	Starch	7.2
7.2	Crude Protein	28.3
0.26	Lysine (total)	0.82
3.9	Crude Fat	10.6
6.7	Neutral Detergent Fiber	35.1
0.20	Phosphorus	0.75

Comparison of Dietary Fiber Methodology

Campbell et al., 1997

Method	Beet pulp	Corn bran	Oat fiber	Soy polysaccharide
NDF (van Soest)	43.8	59.2	78.4	23.2
TDF (Prosky)	60.0	53.5	91.0	74.1
NSP (Englyst)	46.5	32.8	76.4	66.5

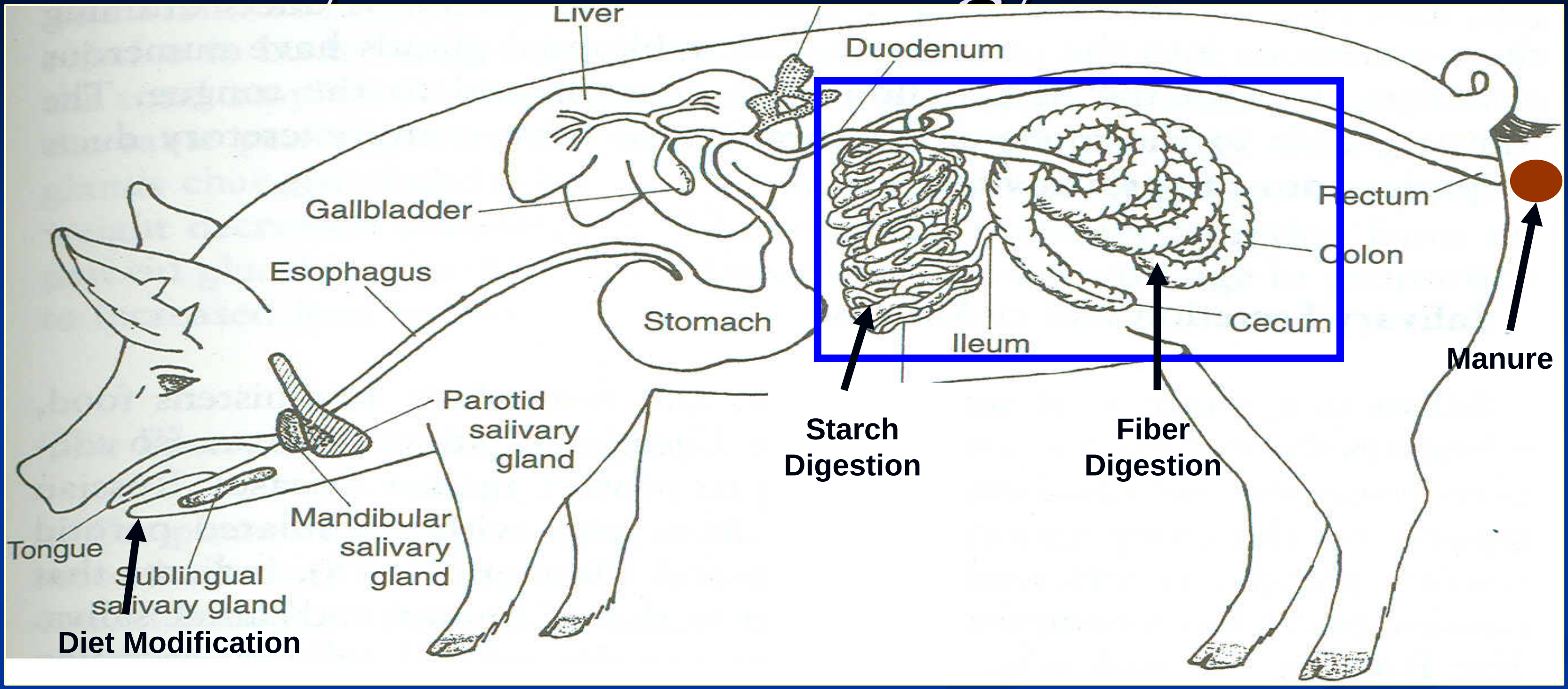
Beyond Fiber?

- Arabinose
- Rhamnose
- Galactose
- Glucose
- Xylose
- Mannose
- Fucose

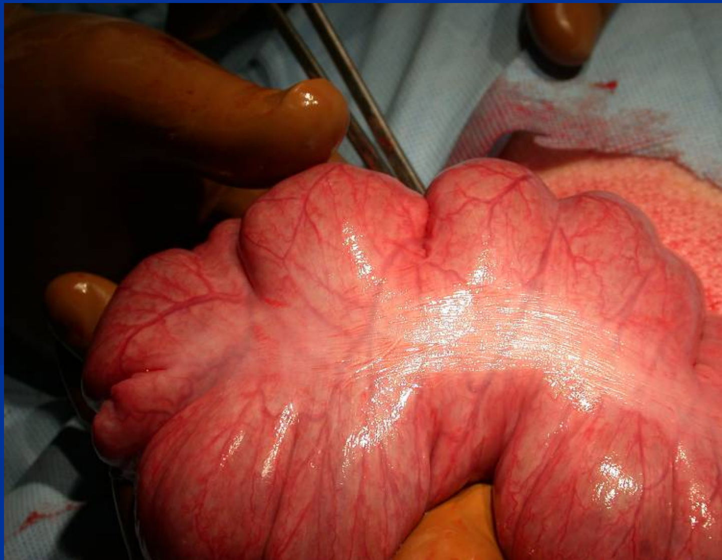
Campbell et al., 1997/Sem. Food Anal. 2:43
Kim et al., 2008/Bioresource Technol. 99:5165

What is the degree of functional redundancy in microbes producing SCFA?

Dietary Fiber and Energy Utilization



- E from SCFA to NE_m ranges from 15 to 24% for gf pigs (Dierick et al., 1989; Yen et al., 1991; McBurney & Sauer, 1993)
- E from microbial fermentation accounts for 2.4 to 29.6% of total DE (Jensen, 2001)
- Available E as SCFA provides between 7.1 and 17.6% of the total available E (Anguita et al., 2006)



Renessen Is Developing A New Corn Processing System Increasing Refinery Yields And Co-Product Benefits

2006 UPDATE

- THE RENESSEN CORN PROCESSING SYSTEM CAN BOLT ON TO A CONVENTIONAL DRY MILL PROCESS

STEP 1:

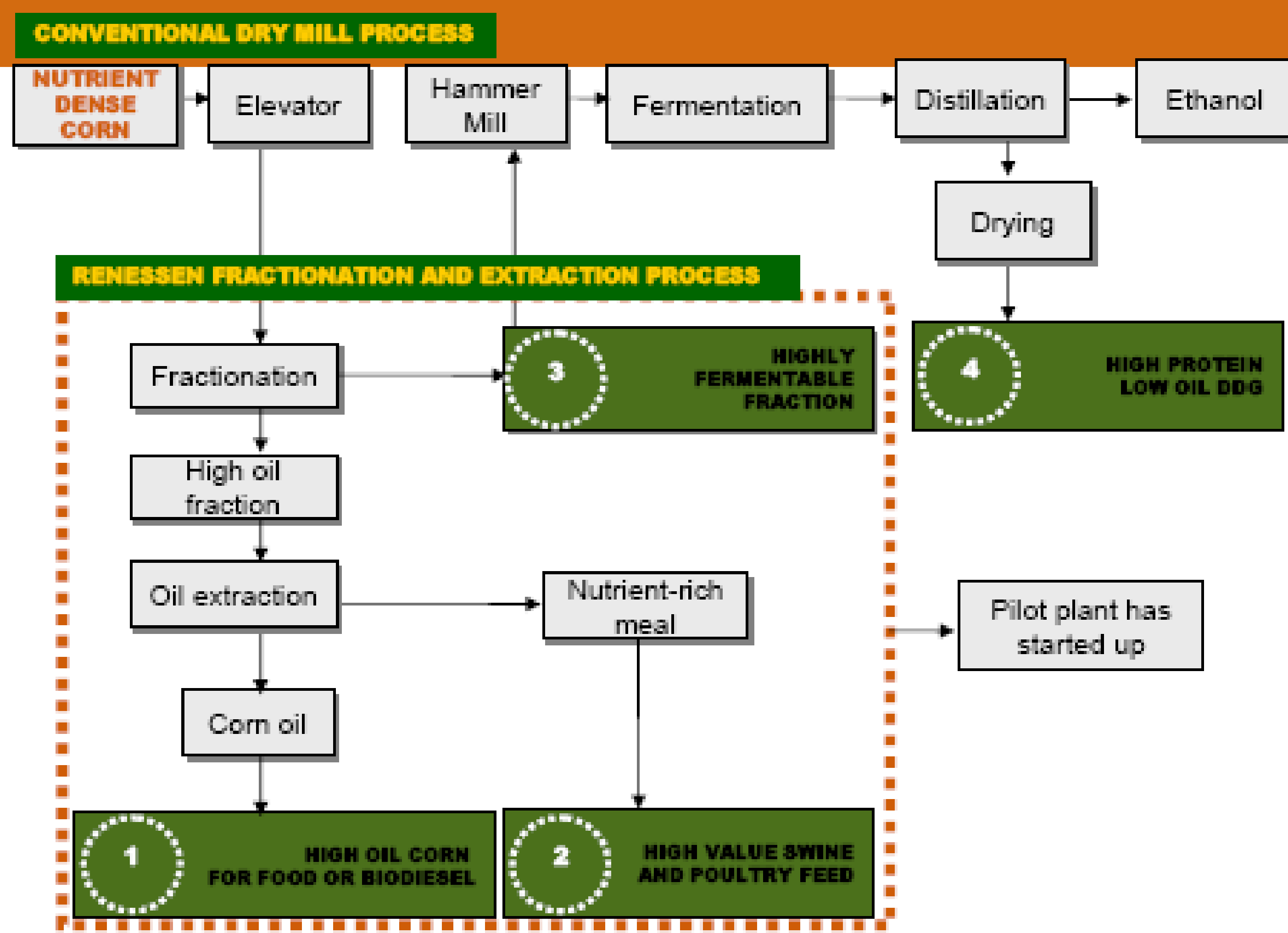
- START WITH A NUTRITIONALLY DENSE CORN DEVELOPED THROUGH BIOTECH OR A CONVENTIONAL HYBRID

STEP 2:

- PROCESS THE CORN THROUGH A NOVEL PROCESS TECHNOLOGY DEVELOPED BY CARGILL AND RENESSEN

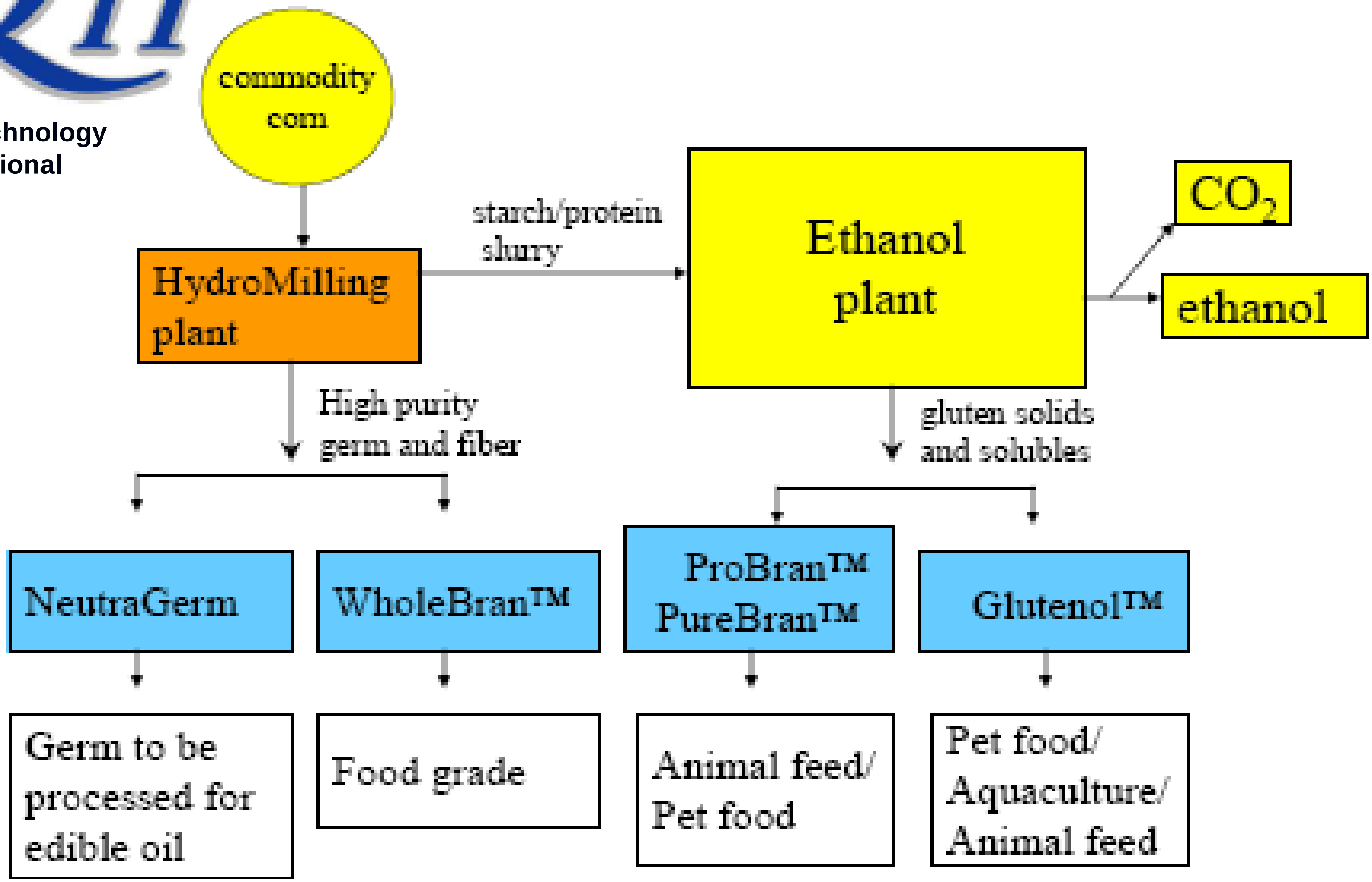
STEP 3:

- DELIVER FOUR HIGH VALUE REVENUE STREAMS
  - 1: FOOD GRADE CORN OIL OR BIODIESEL
  - 2: HIGH VALUE SWINE FEED
  - 3: HIGHLY FERMENTABLE STARCH FOR ETHANOL PRODUCTION
  - 4: HIGH PROTEIN, LOW OIL DDG



HydroMilling overview

Quality Technology International



Glutenol, WholeBran, ProBran, PureBran are trademarks of QTI, Inc. Elgin, IL

Feed Ingredients

In the feed industry, there are currently three primary Solaris brand names. Customized products can be created as the demand arises. Consistency in production and nutritional values are the keystones of the Solaris brand.

Energia™ – With a higher protein level than DDGS, Energia is a low fat, high protein ingredient that is very palatable and extremely digestible. It can be used in higher concentrations by both ruminants and monogastrics. Energia is also low in phosphorus and low in potassium, and is a highly digestible source of critical nutrients.

ProBran™ – A highly digestible source of NDF, ProBran is a very palatable, high fiber option. A great energy ingredient for ruminants. Low dust, ProBran is very flowable. This low fat product is great for creating additional value in your rations.

Glutenol™ – This concentrated source of protein is high in energy, sulfur amino acids and available phosphorus. Unlike corn gluten meal, SO_2 is not added during the process, making Glutenol very palatable. Very low in moisture, it is also low dust and flowable, allowing it to mix easily. High cartenoids content creates a desirable gold color for eggs and poultry.

Glutenol XP™ – With no solubles, XP is a more concentrated source of protein and amino acids.

NeutraFiber™ – A pure fiber that is neutral in color, odorless, and bland in flavor. A consistent product, NeutraFiber is very concentrated in total dietary fiber (TDF).

Food Ingredients

Solaris custom corn products are a natural addition to the food industry. With a concern for trans fats and allergens, corn ingredients are the perfect source for stable vegetable oil, protein and fiber. With the exclusive SO_2-free HydroMilling process allowing for separation of the corn germ and bran, the possibilities for food applications are tremendous. Contact a QTI representative to learn more about food applications and Solaris products.

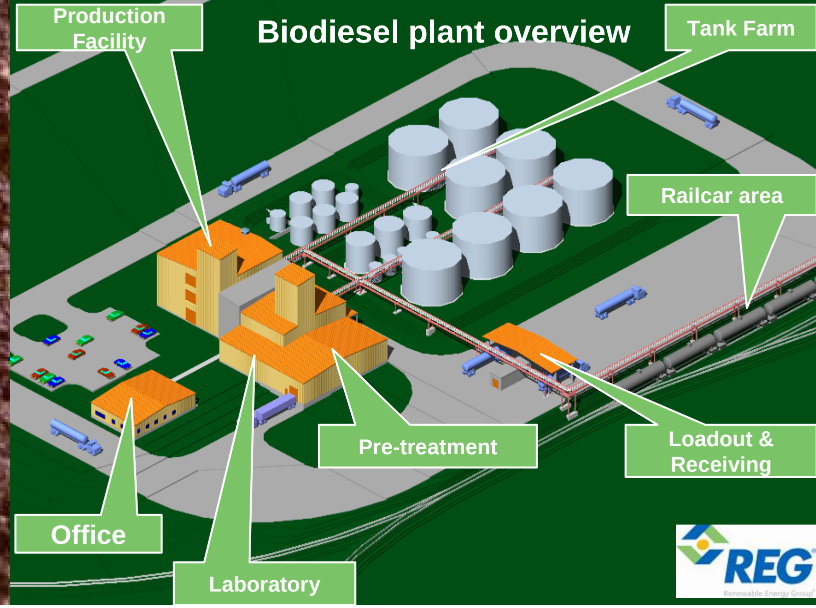
Solaris

The opportunity to create better food and feed products exists today from the burgeoning ethanol industry which utilizes corn to help lessen dependence on depleting oil sources. Quality Technology International is partnering with ethanol, food, feed and farming to market innovative technologies to advance these industries.

Solaris brands are on the forefront of creating higher-value, natural products that add to the appeal of ethanol production. A commitment to quality control assures products that are consistent time after time. To learn more about the Solaris brand of products, call your QTI representative or visit our website at **www.solarisquality.com.**

QUALITY TECHNOLOGY INTERNATIONAL, INC. • [illegible] POINT BOULEVARD • SUITE [illegible]
ELGIN, IL [illegible] • [illegible] • [illegible] • WWW.QTITECH.COM


Kellogg's
Calories 80 4%
Total Fat 1g 2%
Sodium 80mg 3%
Sugars 6g
Fiber 10g 40%
Calcium 100mg 10%
Nutrition at a Glance
ALL-BRAN
Get happy inside!
Original
Natural Wheat Bran High Fiber Cereal
TRY THE 10 DAY CHALLENGE
40% DAILY VALUE OF FIBER
NET WT. 18.3OZ. (1 LB. 2.3 OZ.) (519g)
General Mills
with Whole Grain Guaranteed
Nutrition Highlights
original
FIBER ONE
BRAN CEREAL
57% Daily Value of FIBER
14 Grams of Fiber
bestlife
NET WT 1 LB 0.2 OZ (16.2 OZ) (459g)



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The Biodiesel Reaction

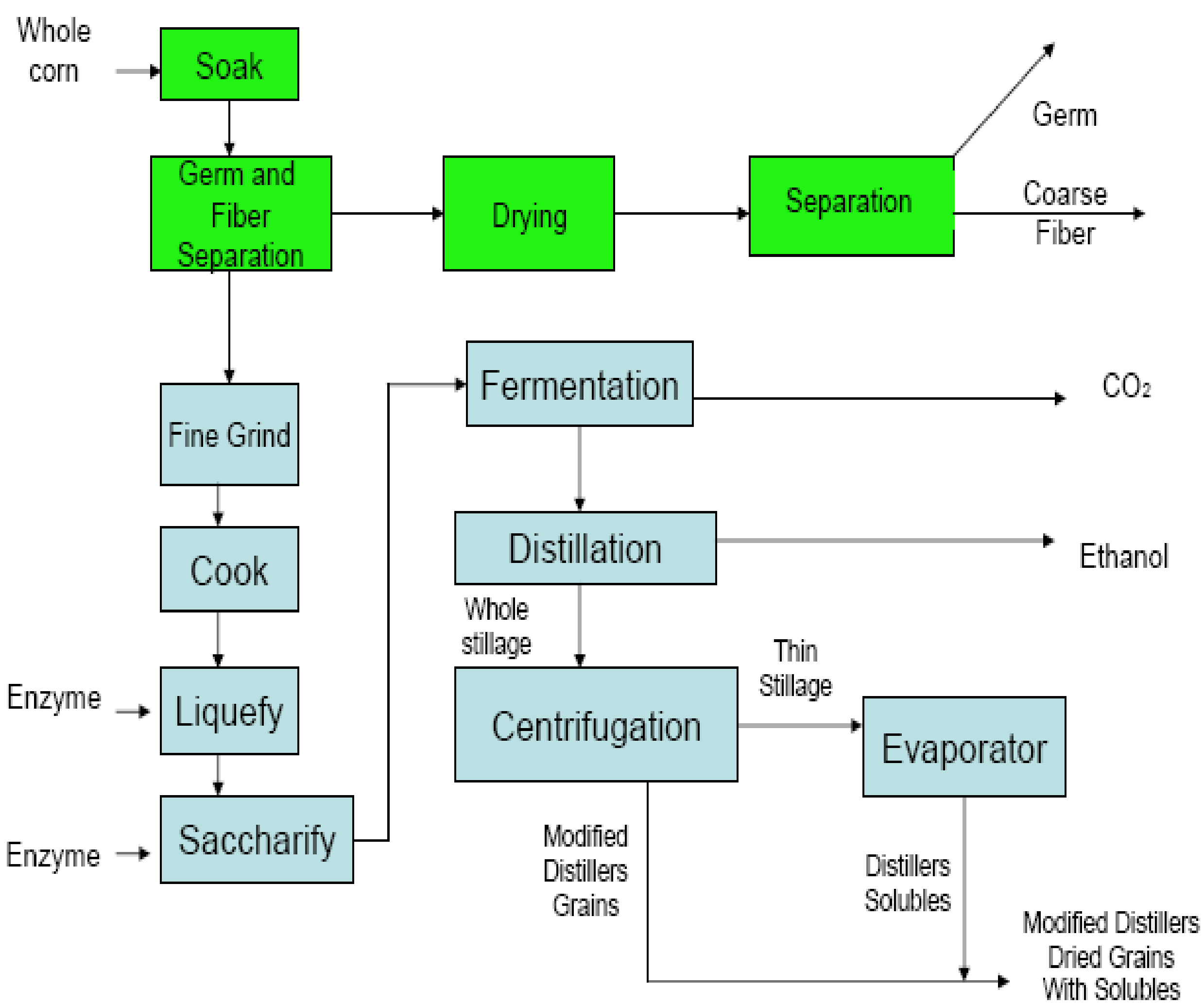
Ethanol delivers 25% more energy than input E while biodiesel delivers 93% more energy than input E. (PNAS 103:11206-11210)

CH_2OCOR'''				CH_2OH		$R'''COOR$
|			Catalyst	|		
CH_2OCOR''	+	3 ROH	------>	CH_2OH	+	$R''COOR$
|				|		
CH_2OCOR'		Methanol	NaOH KOH (Na methylate)	CH_2OH		$R'COOR$
100 pounds Oil or Fat		10 pounds Alcohol (3)		10 pounds Glycerin		100 pounds Biodiesel (3)

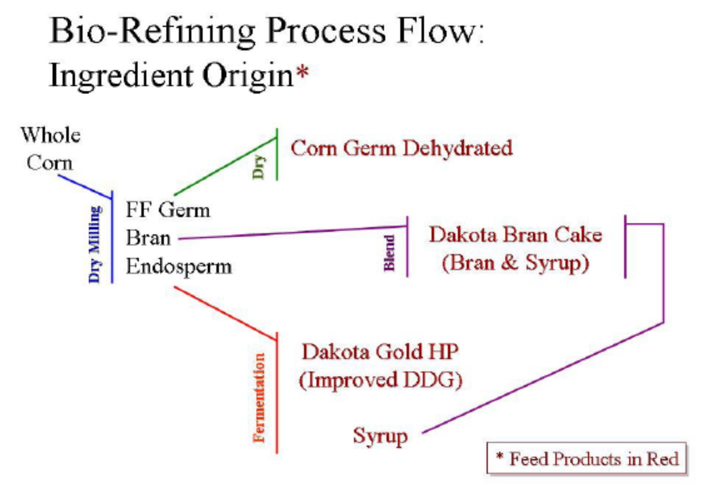
160°F for 1-8 hours

Corn Fractionation/Processing

A schematic of the modified ethanol process with germ and fiber recovery



- DDGS
- Reduced oil DDGS
- Corn germ
  with or without oil
- DDG
- Solubles/stillage/liquor
- Corn bran
  with or without S
- HP-DDG
- Corn germ meal
- Corn gluten meal
- Corn gluten feed
- Corn oil
- Corn starch
- Dehulled degermed corn



Corn	Nutrient	dCGM	DDGS	HP-DDG	Bran
9.3	Crude Protein	16.3	29.8	43.2	14.6
0.29	Lysine (total)	0.86	1.01	1.22	-
4.4	Crude Fat	17.3	11.5	3.9	9.8
10.8	Neutral Detergent Fiber	23.2	26.5	24.2	21.3
0.31	Phosphorus	1.49	0.92	0.48	0.65

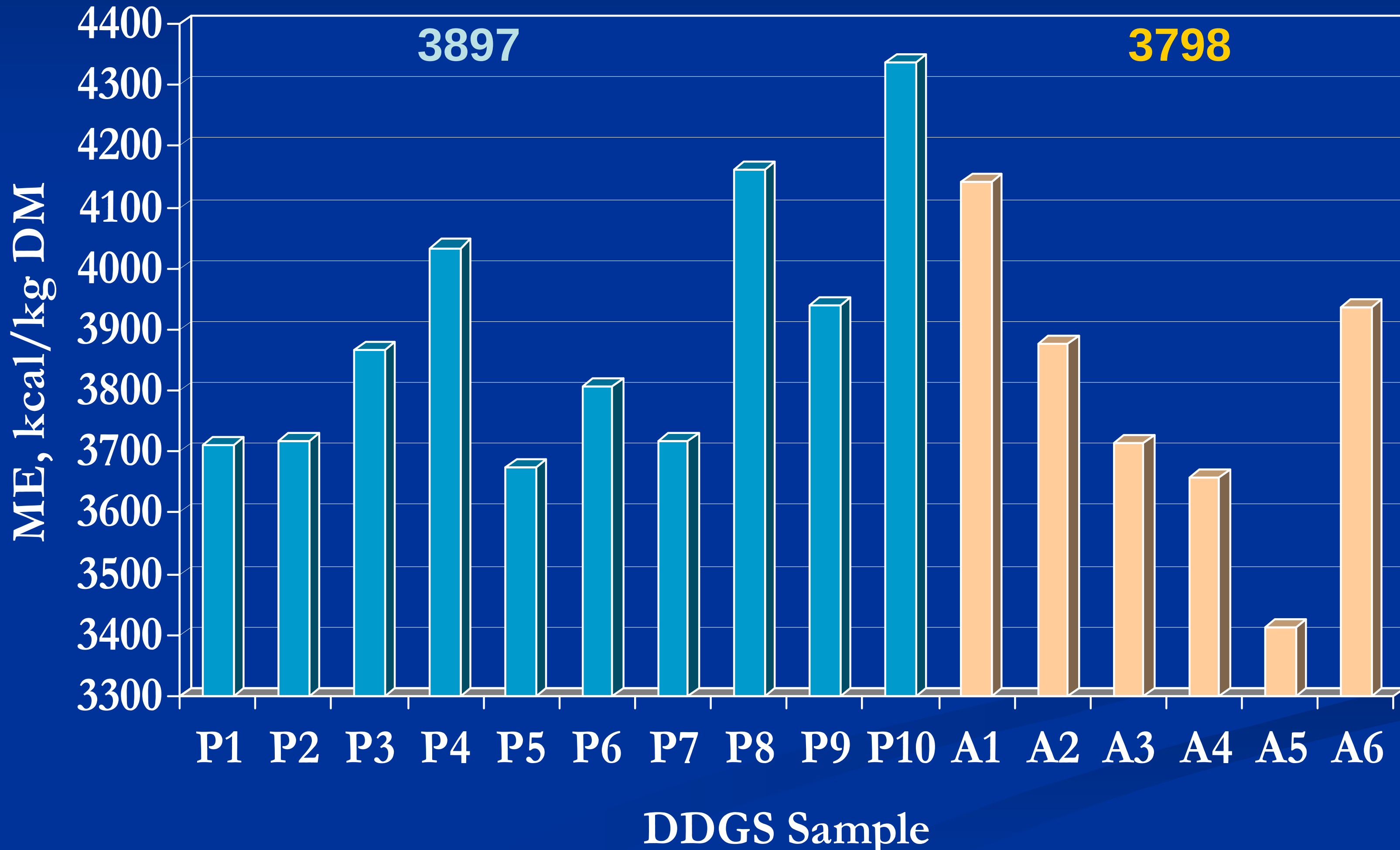
Evaluation of corn co-products in finishing pigs (preliminary data)[1]							
		ADFI, kg		Fecal	DM	Energy, kcal/kg	
Ingredient	BW, kg	Basal	Test	output, g/d	digest, %[2]	DE[2]	ME[2]
Gluten feed	111.3	1712	800	620	51.52	2517	2334
Bran (ICM)	111.4	1689	720	521	55.99	3004	2957
Bran (Poet)	111.4	1671	759	466	63.66	3282	3031
DDGS (ACE)	118.6	1647	749	371	80.50	4332	4141
DDGS (MNdrum)	119.3	1525	660	355	69.72	4116	3876
DDGS (MNmicro)	116.2	1532	652	346	70.47	4016	3713
DDGS (Hawk)	112.9	1763	776	458	69.19	3841	3659
DDGS (Poet)	109.5	1673	746	449	66.16	3705	3414
DDGS (VS)	113.0	1762	744	403	75.04	4164	3937
RO-DDGS (VS)	111.9	1728	736	406	73.87	3868	3650
Gluten meal	118.0	1574	702	276	90.71	5047	4598
HP-DDG (ICM)	113.3	1634	717	369	75.00	3994	3676
HP-DDG (MOR)	117.2	1570	702	305	86.59	4955	4606
HP-DDG (Poet)	106.8	1521	716	315	81.00	4210	3823
DCG (Poet)	106.0	1630	739	380	74.22	3889	3692
Germ meal	112.0	1574	684	387	74.57	3521	3417
Solubles (20%)	111.9	1729	383	269	75.49	4762	4525
DH-DG corn	110.7	1692	720	207	100.32	4401	4316
Starch	113.4	1603	717	156	101.39	4082	4080
Oil (10%)	117.3	2097	266	232	97.22	8988	8755

Comparative ME values, kcal/kg DM

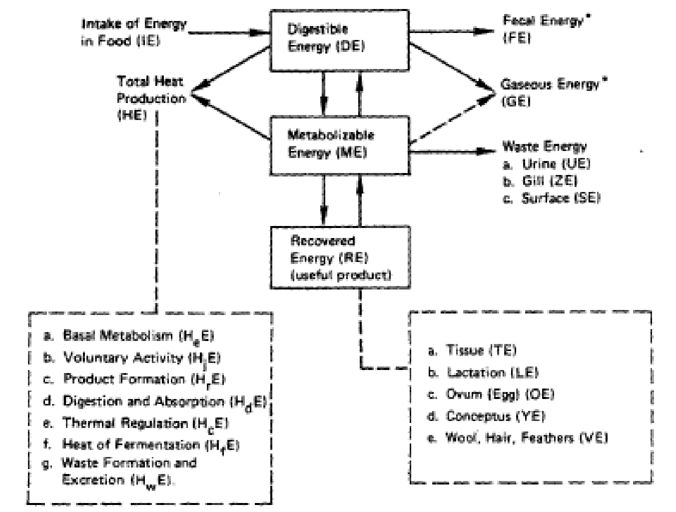
	Corn	Starch	Oil
Anderson	3771	4080	8755
NRC	3843	4025	8405
Moeser 2002	3788		
Pedersen 2007	3989		
Widmer 2007	3972		

Variation in ME content of DDGS

Corn = P3989 A3771 (3830 Spiehs)



Prediction of DE, ME, or NE from Feed Components



*Under some circumstances the energy contained could be considered to be a useful product for fuel.

FIGURE 1 The idealized flow of energy through an animal.

- Drennan & Maguire, 1970 (DE)
- Harris et al., 1972 (ME)
- Morgan et al., 1975 (DE, ME)
- King & Taverner, 1975 (ME)
- Henry, 1976 (DE)
- Kirchgessner & Schneider, 1978 (NE_{fat})
- Batterham et al., 1980 (DE)
- Jorgensen, 1980 (ME)
- Perez et al., 1980 (DE)
- Wiseman & Cole, 1979 (DE, ME)
- Eeckhout & Moermans, 1981 (DE, ME, NE_{growth})
- Kirchgessner & Roth, 1981 (ME)
- Wenk, 1982 (DE)
- Just et al., 1984 (DE, ME, NE)
- Noblet & Perez, 1993 (DE, ME)
- Noblet et al., 1994 (DE, ME, NE)
- Adedokun & Adeola, 2005 (ME for M&B)
- Pederson et al., 2007 (DE, ME)

Nutrients to analyze, but note there is variation in determination of components within a feedstuff!

- DM
- GE
- CP
- Starch
- EE
- Ash
- CF
- NDF
- ADF
- ADL

Factors Affecting Energy Utilization

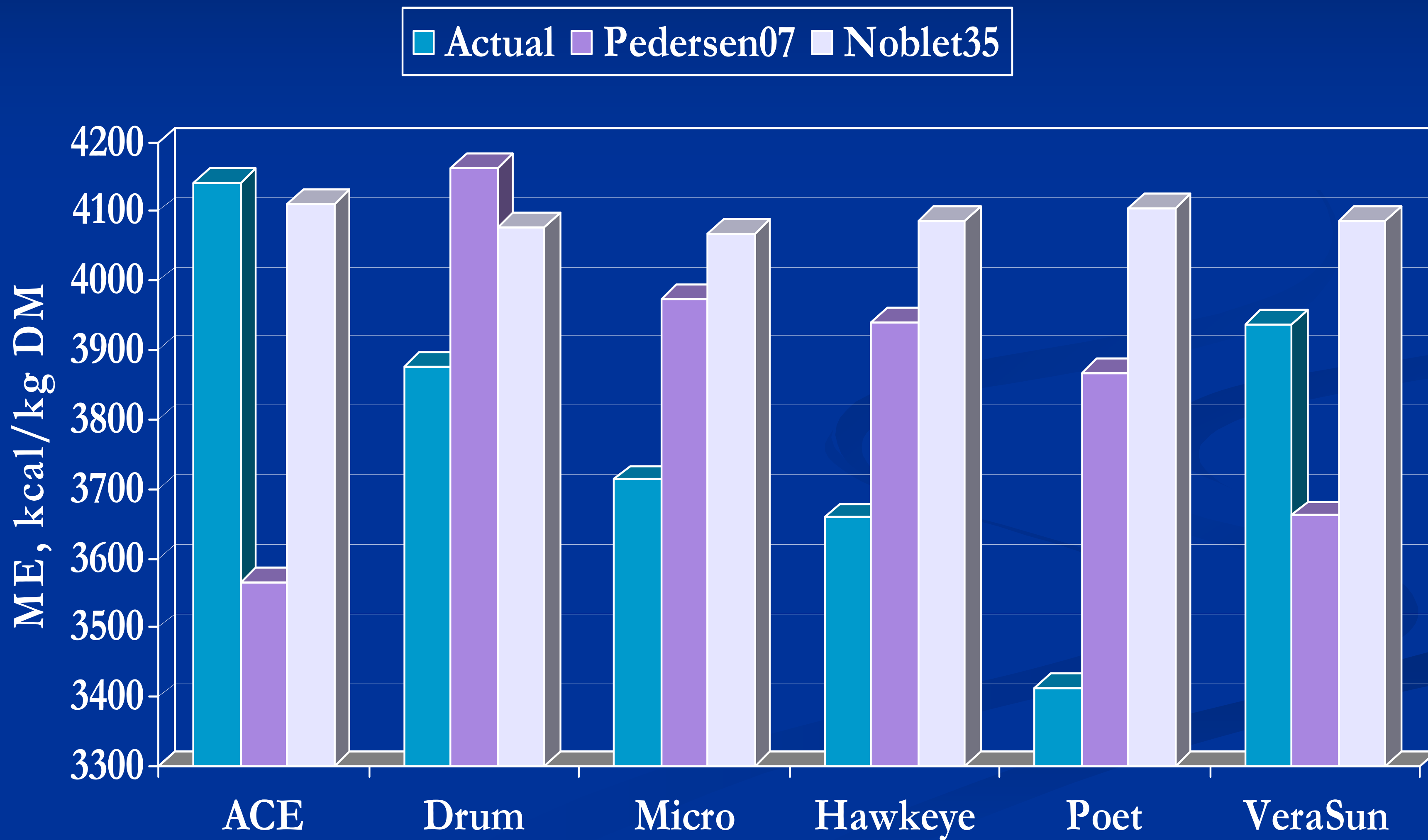
- $DE_{28} = 1{,}161 + (0.749 \times GE) - (4.3 \times Ash) - (4.1 \times NDF)$
- $ME_{45} = (0.997 \times DE) - (0.68 \times CP) + (0.23 \times EE)$
  - $ME/DE \times 100 = 99.7 - (0.18 \times \%CP)$ Morgan et al., 1975
- $NE_{8} = (0.726 \times ME) + (1.33 \times EE) + (0.39 \times ST) - (0.62 \times CP) - (0.83 \times ADF)$

Noblet & Perez, 1993/JAS 71:3389
Noblet et al., 1994/JAS 72:344

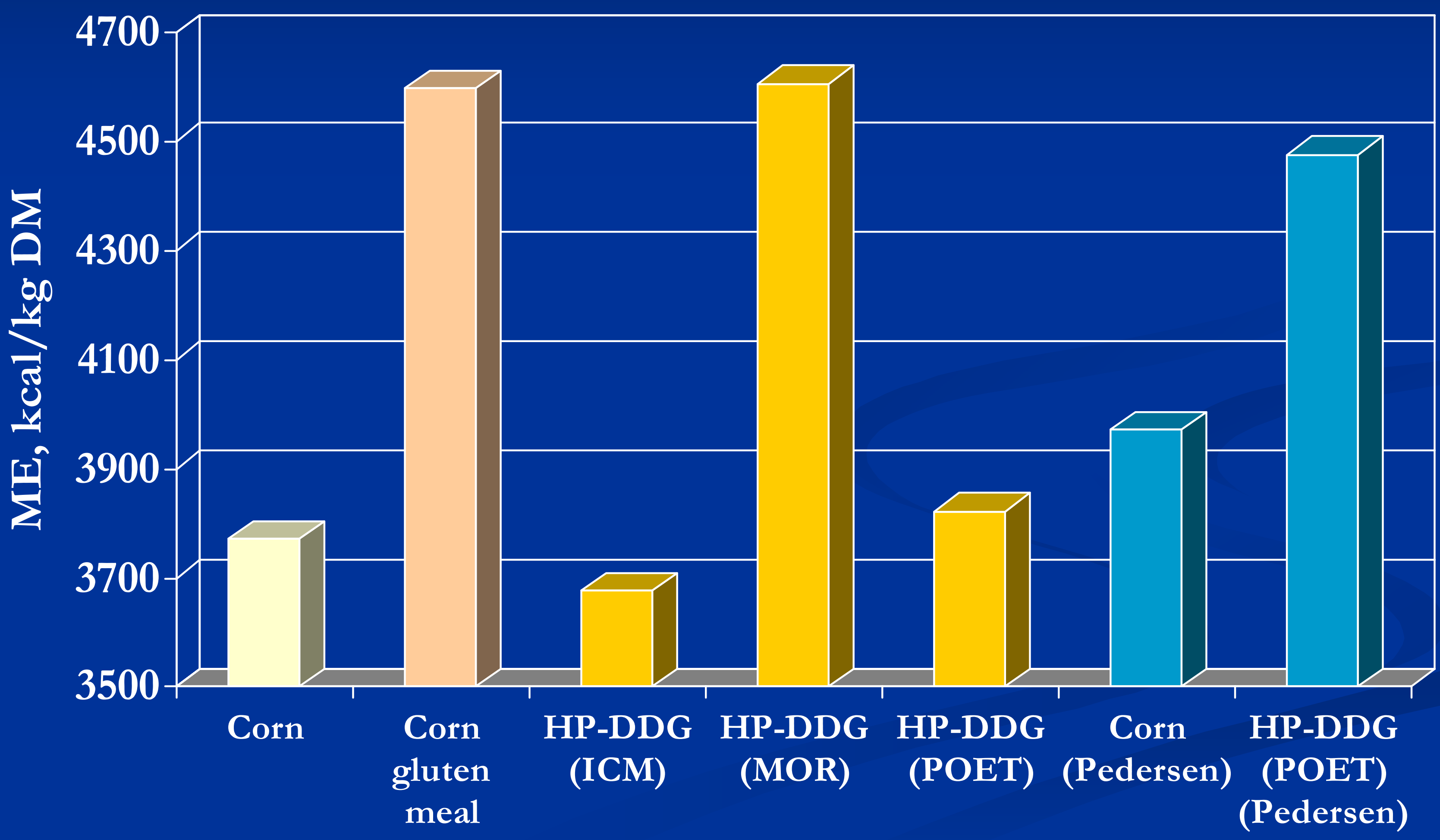
Prediction of ME (Anderson data)

ME = -11,128 – (124.99×ash)+ (35.76×CP) – (63.40×EE) – (150.92×ADF) + (14.85×NDF) + (3.023×GE)
[Pedersen et al., 2007/JAS 85:1168]

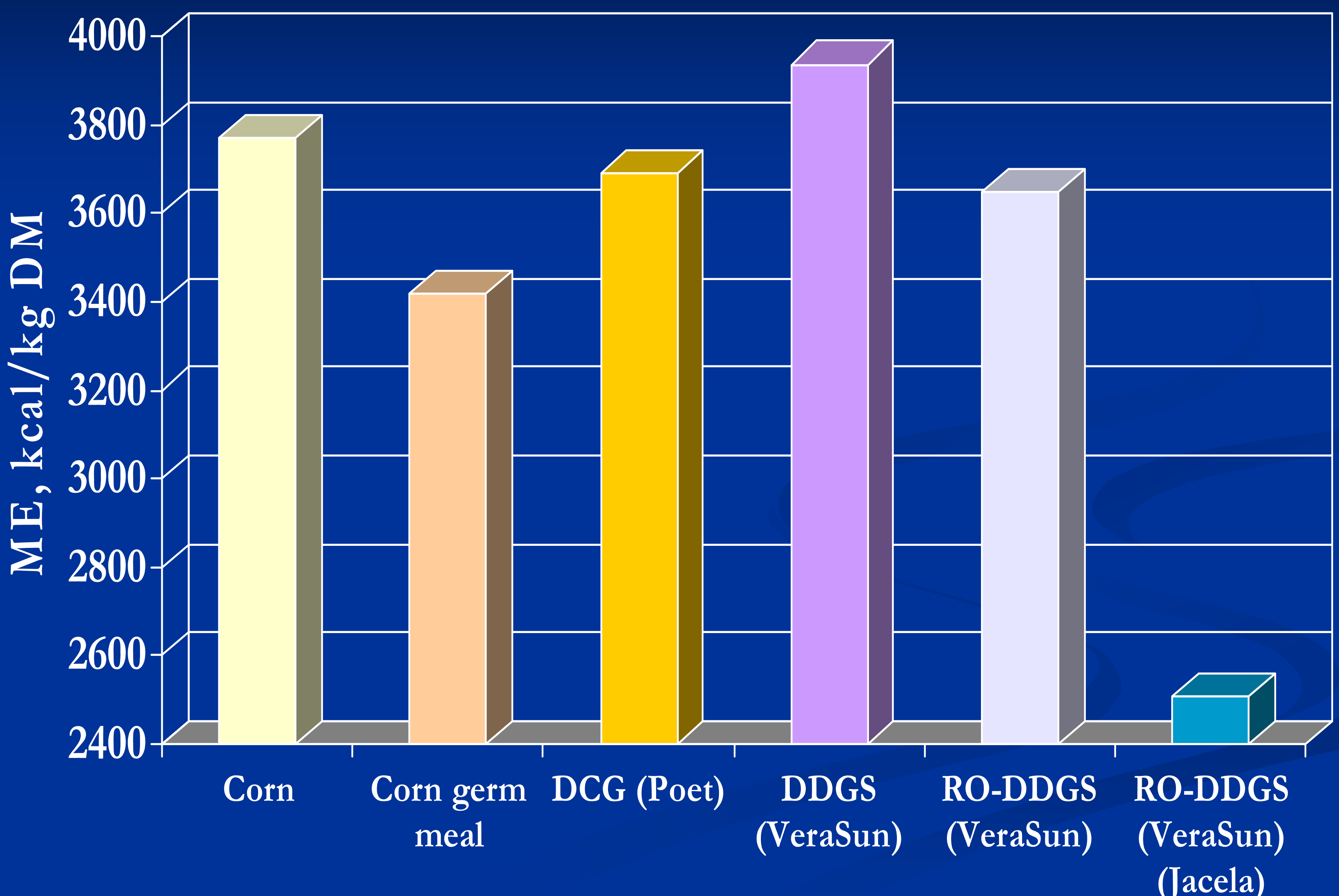
ME = 4,194 – (9.2× ash) + (1.0×CP) + (4.1×EE) – (3.5×NDF) [Noblet & Perez, 1993/JAS 71:3389]



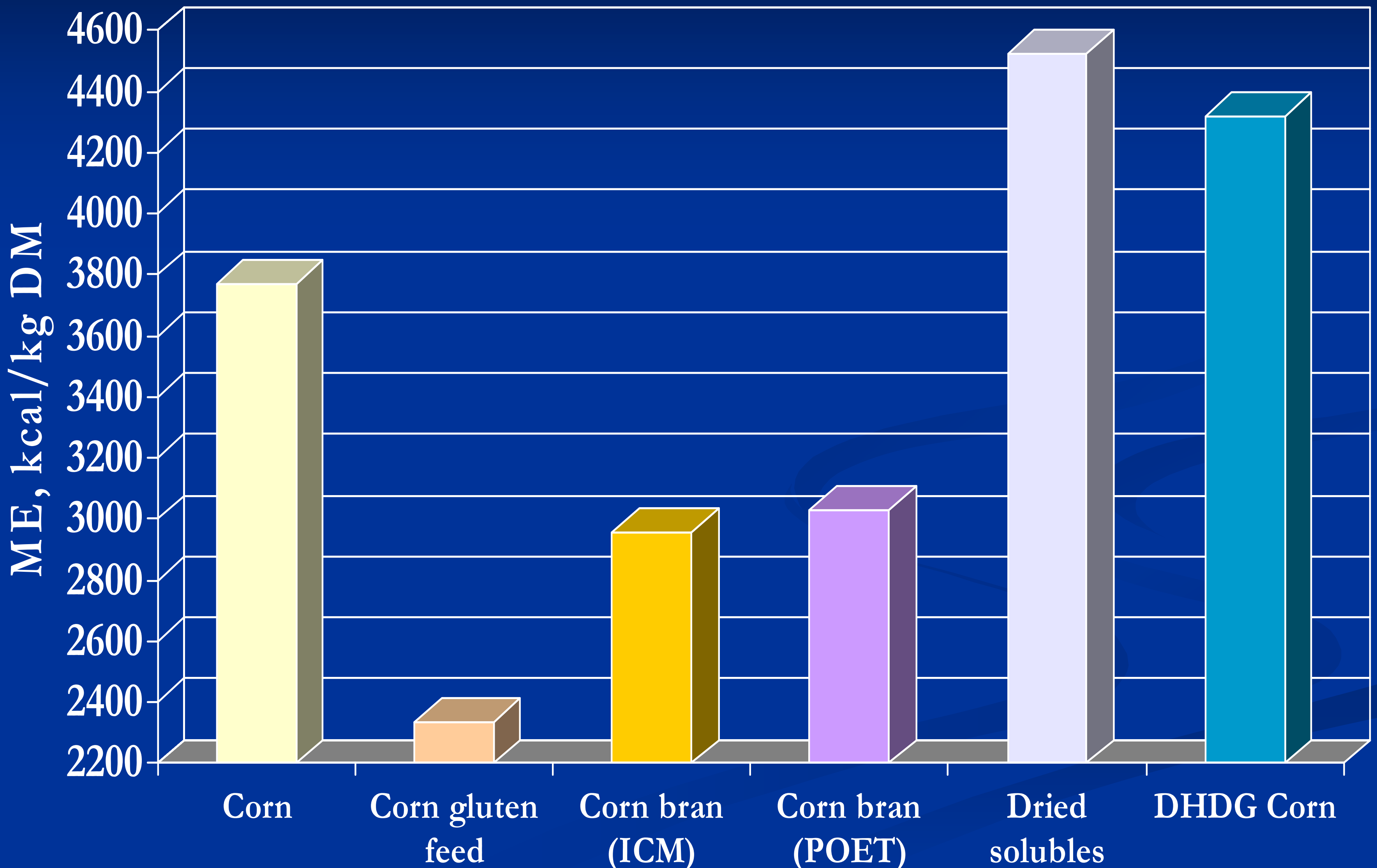
ME of high protein corn co-products



ME of reduced oil corn co-products



ME of high and low fiber corn co-products



Fiber in Swine Diets

- Increase endogenous protein loss
  - Increased mucin production (affects threonine nutrition)
- Decrease absorption of proteins and lipids
  - Decrease urinary urea excretion (increased fecal N excretion)
  - Lipid metabolism and meat quality…
- Increase in intestinal mass (in some cases)
  - Maintenance requirements increase
  - Initial increase, may not be noted long term trial
- Increased heat increment (increased energy loss)
- Feed intake
  - Variable effects (+ or -)
- Dealing with fiber in swine diets
  - Feed low levels
  - Enzymes
  - Processing
  - Genetics…

Concerns with Co-Products

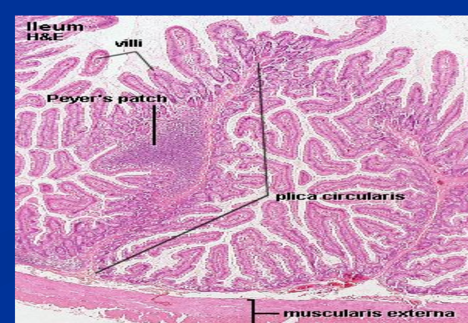
- Alternative feedstuffs.
  - EtOH co-product variation
  - Left with corn fiber and protein
    - Energy removed for ethanol AND?
  - Fat fraction remains for now!
    - Removal of oil for biodiesel production is currently underway!

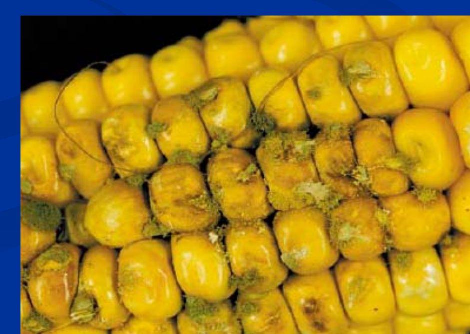
- Carcass quality concerns.
  - Fat quality / Lipid composition.
  - Pork nutritional value?
  - Carcass yield.
  - Oil content may soon be going down due to removal of oil for biodiesel!

- Positive impacts on whole animal and/or intestinal health?
  - Inflammation.
  - Ileitis severity.

- Mycotoxin concentration?

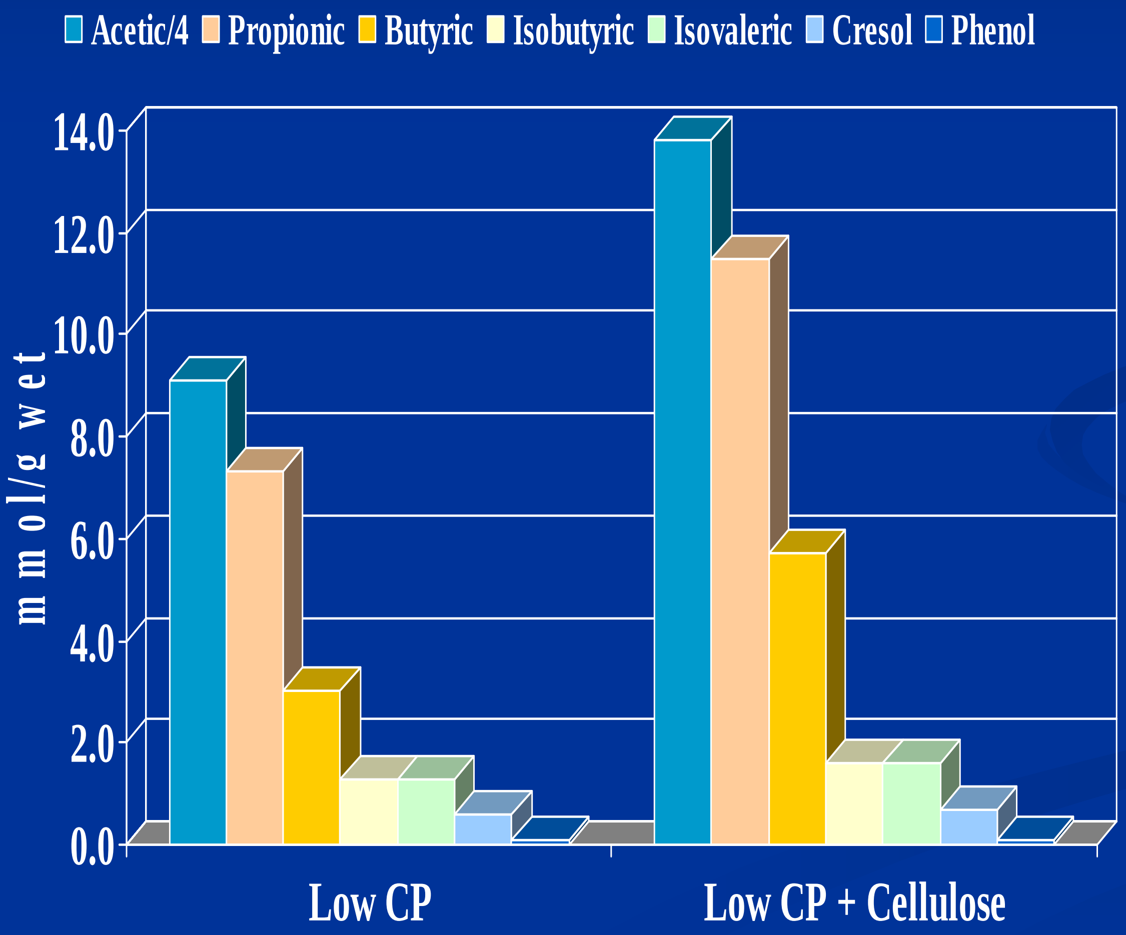
- Handling characteristics.





- Feeding fermentable fibers will increase VFA concentrations in feces and manure and thereby reduce manure pH and ammonia emissions.

Chan et al., 1998/JAS 76: 1123 & 1187



Manure DM output increase!

CSBM = 302 g/d

DDGS 30% = 430 g/d (+42%)

Corn bran 30% = 521 g/d (+73%)

The research goal is to develop practical technologies resulting in improved gastrointestinal and whole-animal nutrient utilization and a modified microbial ecology (including pathogens) leading to a reduction of the impact of livestock production on the soil, water, and air environment.