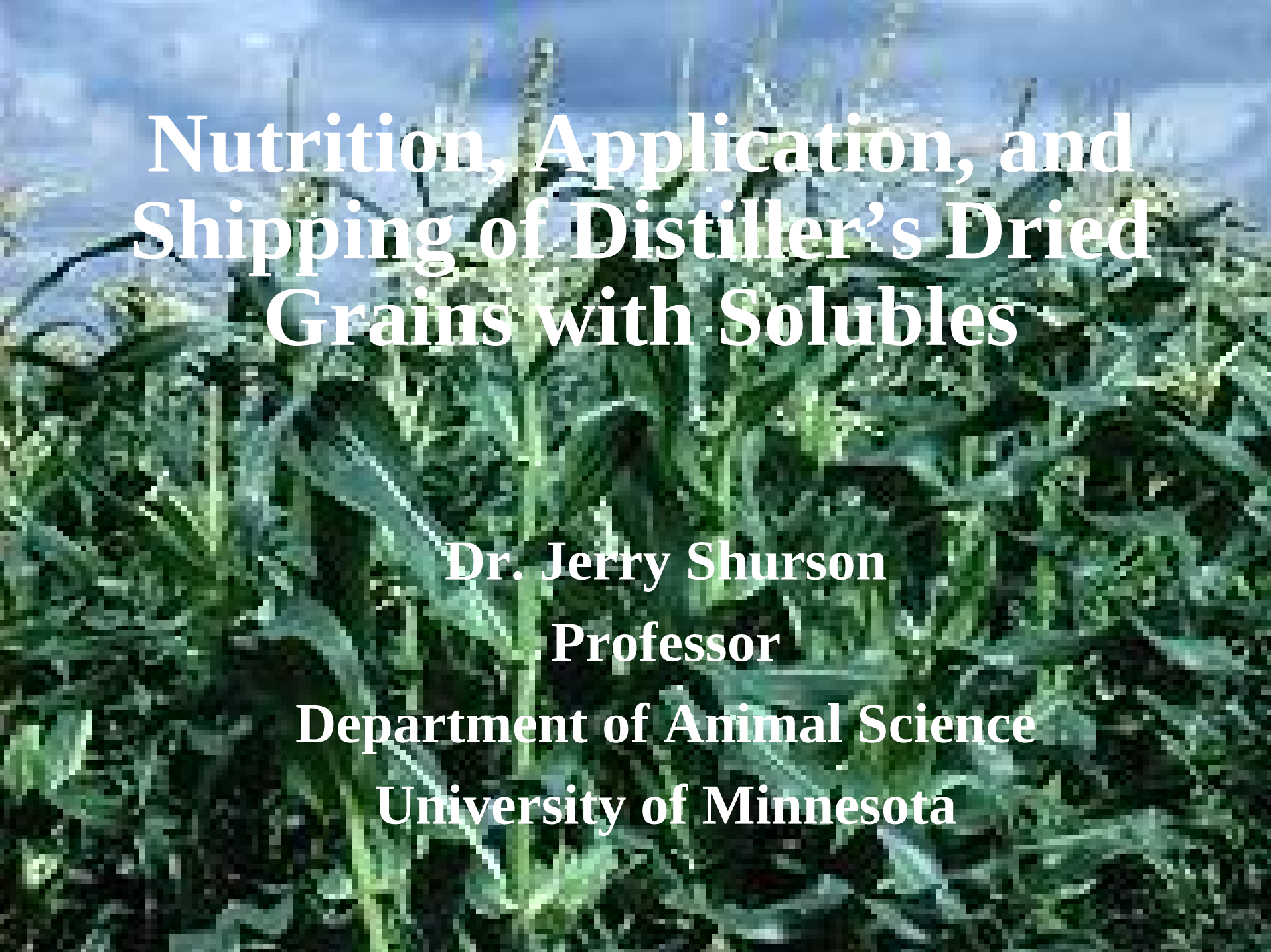

Nutrition, Application, and Shipping of Distiller's Dried Grains with Solubles

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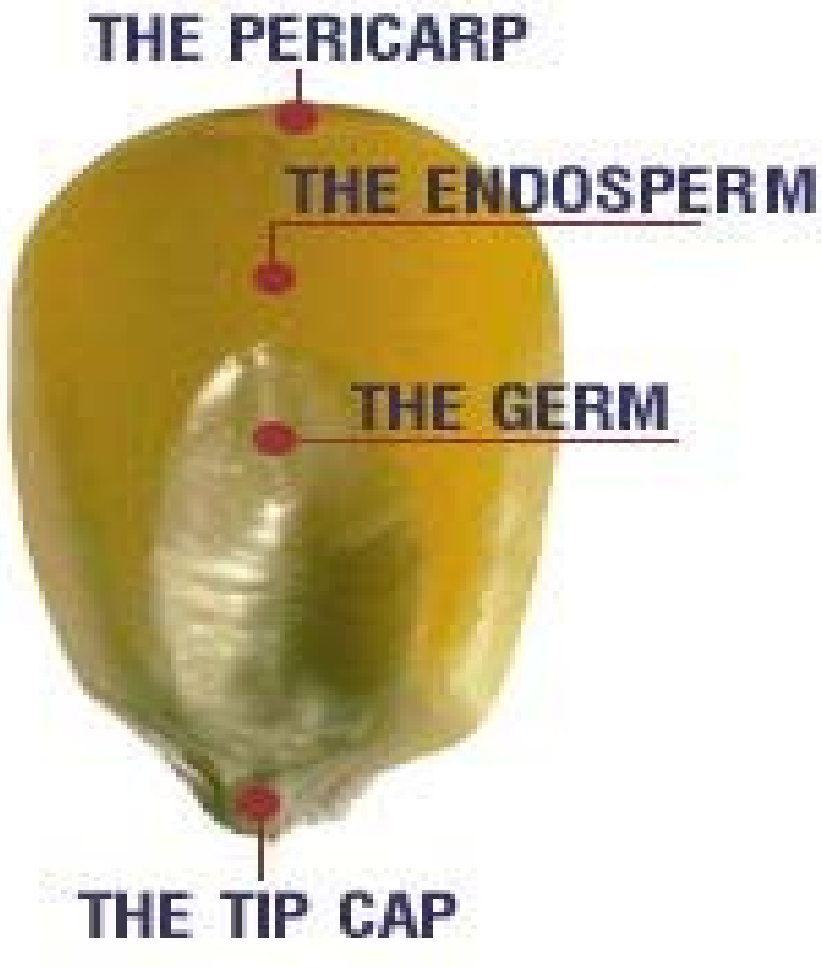
An Overview of DDGS Production

Production of DDGS

- Tightly linked to the production of fuel ethanol
- DDGS is a co-product of the dry milling ethanol production process
- About 40% of ethanol is produced using dry milling
- The other 60% of ethanol is produced by wet milling
  - co-products include: corn gluten feed, corn gluten meal, and corn germ meal

Components of Yellow Dent Corn

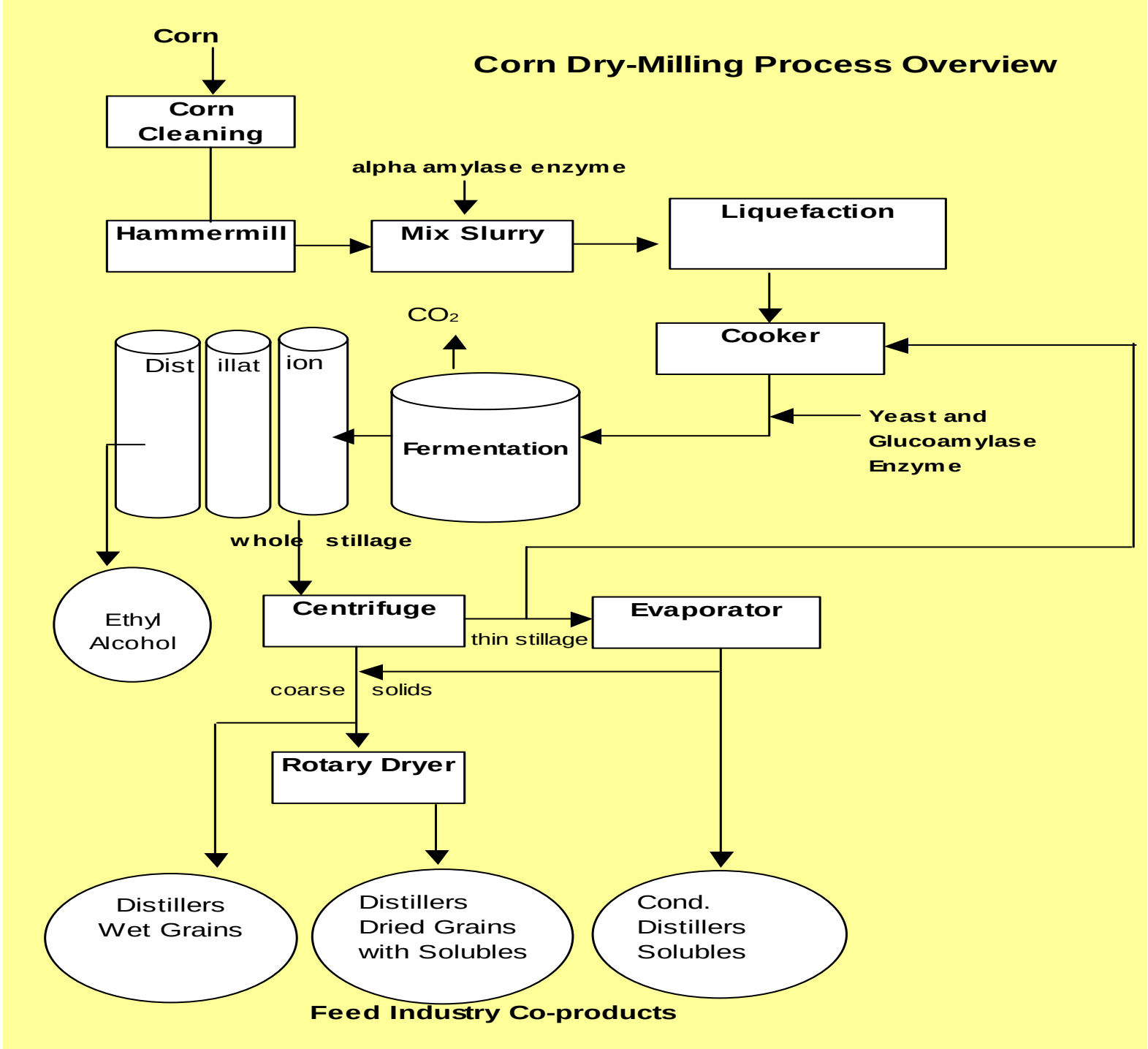
Starch	61.0 %
Corn Oil	3.8 %
Protein	8.0 %
Fiber	11.2 %
Moisture	16.0 %



Slide courtesy of Ms. Kelly Davis, CVEC

Production of DDGS

- Yeasts and enzymes are used to ferment the starch fraction of corn
- Ethanol and carbon dioxide are produced
- Distiller's grain and distiller's solubles are the residues remaining after fermentation
- These fractions and blended and dried to produce distiller's dried grains with solubles (DDGS)

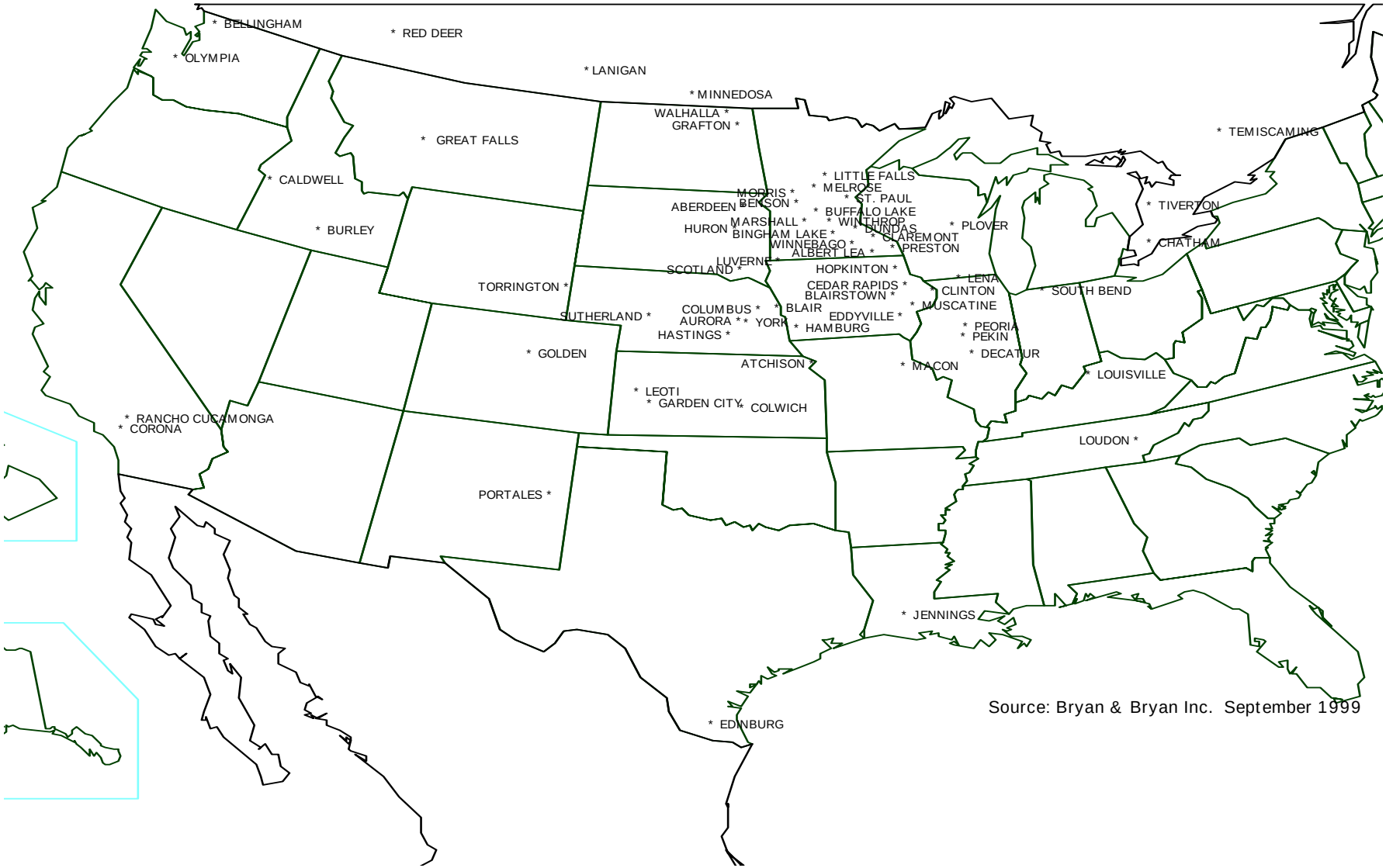

Corn
Corn Dry-Milling Process Overview
Corn Cleaning
alpha amylase enzyme
Hammermill
Mix Slurry
Liquefaction
CO2
Cooker
Dist
illat
ion
Fermentation
Yeast and Glucoamylase Enzyme
whole stillage
Ethyl Alcohol
Centrifuge
Evaporator
thin stillage
coarse solids
Rotary Dryer
Distillers Wet Grains
Distillers Dried Grains with Solubles
Cond. Distillers Solubles
Feed Industry Co-products

Dry-Milling Average Yield Per Bushel

- Ethanol 4.2 liters
- DDGS 8.2 kg
- CO_2 8.2 kg

Slide courtesy of Ms. Kelly Davis, CVEC

M a p o f U . S . E t h a n o l P l a n t s



DDGS Production

- 19 new ethanol plants are currently under construction
- additional capacity is being added to existing plants
- DDGS will increase from 3.3 million tonnes in 2000 to 5.5 million tonnes in 2005
  - 66% increase in supply of DDGS

DDGS Production and Use

- 3.2 to 3.5 million metric tonnes (MT) of DDGS are produced in North America/year
  - ~ 900,000 MT produced in MN-Dakota region
  - ~ 700,000 MT exported to the EU
  - ~ 2.65 million MT fed in U.S. and Canada
    - ~ 2.58 million MT (80%) fed to ruminants
    - ~ 45,000 MT fed in MN turkey industry
    - ~ 27,000 MT used in swine diets

Use of DDGS in Swine and Poultry Diets is Increasing

- DDGS produced by new Midwestern ethanol is higher in nutrient content and digestibility than DDGS from older plants
- Increased supply of DDGS has made it more economical to replace some of the corn, soybean meal, and dicalcium phosphate

Transportation Logistics

- Most of the DDGS is produced in the “Corn Belt” Midwest and must be transported by truck or rail cars to West Coast or Gulf of Mexico for export to Asia.
  - Costs approximately $20 to $40/tonne
- Daily DDGS production ranges from approximately 150 tonnes/day (smaller Midwestern plants) to 3,000 tonnes/day
  - Daily production from approximately 8 small ethanol plants is needed to fill a barge for shipment to the Gulf of Mexico (approximately 50 trucks)

Options for Shipping DDGS

- Bulk vessels
  - Least expensive
  - Hold approximately 40,000 tonnes
  - Quantity may be too large for some markets
- Containers
  - Can be economical at times
  - Hold 4,000 to 8,000 tonnes
  - Costs about $26/tonne to fill a container

Options for Shipping DDGS

- Totes
  - More expensive and labor intensive
  - Hold approximately 2,000 tonnes
  - Suited for markets that can’t handle large quantities
- Bags
  - Most expensive and labor intensive
  - Suited for markets that can’t handle large quantities and have inexpensive labor costs

Capacity of Grain Handling and Storage Facilities Affects Import Cost

- In order to reduce the import costs of DDGS, ingredient handling facilities must be large enough to take a large volume of DDGS in bulk.

The Use of DDGS in Swine Diets

DDGS Quality is Variable

- Nutritionists want PREDICTABILITY AND CONSISTENCY in feed ingredients.
- The keys for getting maximum value from DDGS are:

"Know what you have (or want)"

and

"Know how to use it"

DDGS Quality is Variable

- Color ranges from very light to very dark
- Odor ranges from sweet to smoky or burnt
- Range in concentration in selected nutrients:
  - Dry matter – 87 to 93%
  - Crude protein – 23 to 29%
  - Crude fat – 3 to 12%
  - Ash – 3 to 6%
  - Lysine – 0.59 to 0.89%

Source: Cromwell et al. (1993)

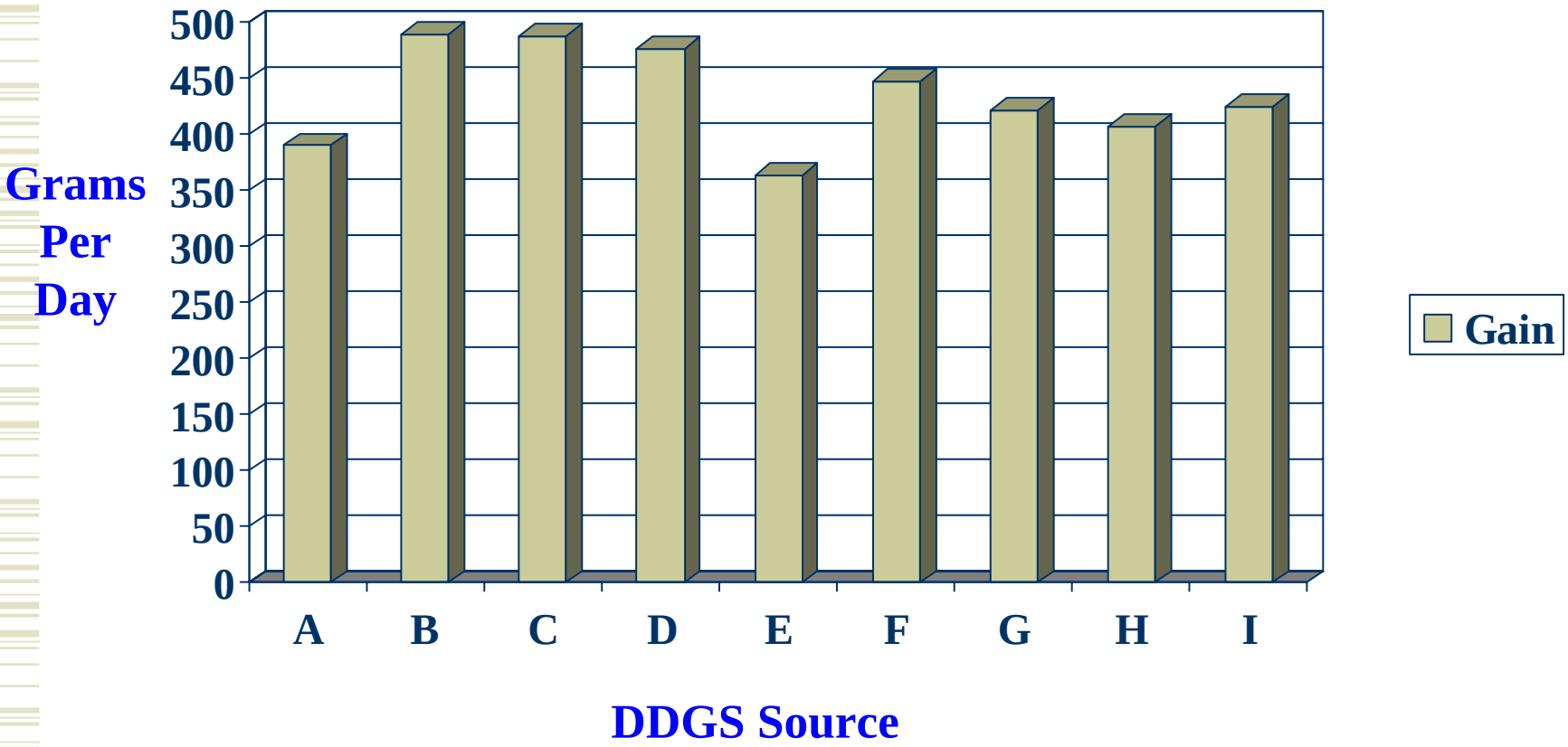
Low Quality,
Less Digestible
DDGS

High Quality,
Highly Digestible
DDGS

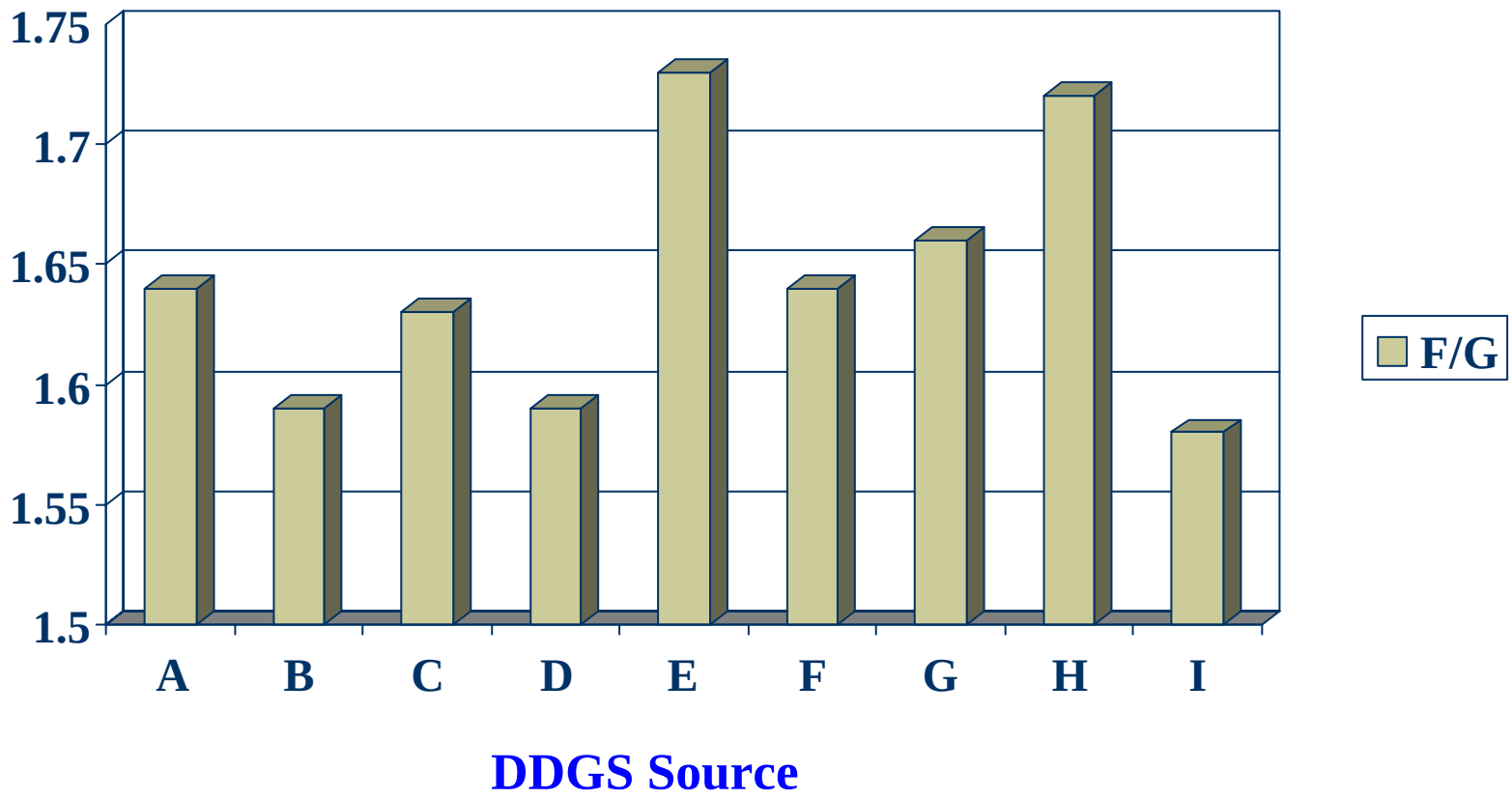
Nutrient Profile of Corn Distiller's Dried Grains with Solubles (DM Basis)

Nutrient	MW DDGS	Low Quality DDGS	NRC (1998)
Dry matter, %	88.9	88.3	93.0
Crude protein, %	30.2	28.1	29.8
Fat, %	10.9	8.2	9.0
Fiber, %	8.8	7.1	4.8
Calcium, %	0.06	0.44	0.22
Phosphorus, %	0.89	0.90	0.83
P availability, %	90.0	?	79.0
DE, kcal/kg	3965	3874	3449
ME, kcal/kg	3592	3521	3038
Lys, %	0.83	0.53	0.67
App. Dig. Lys, %	0.44	0.00	0.34
Met, %	0.55	0.50	0.54
App. Dig. Met, %	0.32	0.24	0.42
Thr, %	1.13	0.98	1.01
App. Dig. Met, %	0.62	0.36	0.60
Trp, %	0.24	0.19	0.27
App. Dig Trp, %	0.15	0.15	0.15

Growth of Chicks Fed Nine Sources of DDGS



Feed Conversion of Chicks Fed Nine Sources of DDGS



Nutritional Value of DDGS for Swine

- Must use high quality DDGS
  - Light color = high amino acid digestibility
- Excellent energy and available phosphorus source
- Nutritional value higher than previously thought
- May improve gut health (i.e. ileitis, gut edema)
  - Decreased mortality and improved growth performance
- Effective partial replacement for corn and soybean meal

Quality Considerations for Selecting DDGS Sources for Swine and Poultry

- Physical characteristics
  - Bulk density – .44 to .48 kg/cubic meter
  - Particle size:
    - maximum coarse particles - 10% on 2000 screen
    - maximum fine particles - 15% on 600 screen & in pan
  - Smell – fresh, fermented
  - Color – goldenrod

Quality Considerations for Selecting DDGS Sources for Swine and Poultry

- Nutrient Specifications
  - Moisture – maximum 12%
  - Protein – minimum 26.5%
  - Fat – minimum 10%
  - Fiber – maximum 7.5%
  - DE value is 100% of corn DE
  - ME value is 93% of corn ME

Maximum Recommended Inclusion Rates of DDGS in Swine Diets

- Nursery pigs (>15 lbs)
  - Up to 25 %
- Grow-finish pigs
  - Up to 20% (higher levels reduce pork fat quality)
- Gestating sows
  - Up to 40%
- Lactating sows
  - Up to 20%

Limitations of Using DDGS in Swine Diets

- Amino acid digestibility is reduced in dark colored DDGS
- High fiber limits its use in pre-starter diets (<6.8 kg BW)
- Excess nitrogen can be minimized by using synthetic amino acids
- High oil content limits maximum inclusion rates in grow-finish diets due to pork fat quality

Limitations of Using DDGS in Swine Diets

- Dietary inclusion rates should be gradually increased in gestation (up to 40%) and lactation (up to 20%) diets to allow sows to adapt.
- Because of the high fiber content, sows will take 2x longer to eat their daily feed allotment than sows on a corn-soybean meal diet.

Maximizing the Value of Corn DDGS in Swine Diets

- Formulate diets using digestible amino acid values
- High available P reduces the level of dietary P supplementation
- Adding 10% DDGS to grow-finish diets may reduce mortality due to ileitis and gut edema

Example Swine Grower Diet with Containing 20% DDGS

Ingredient	%	Nutrient Composition	
Corn	60.05	Crude protein, %	19.07
DDGS	20.00	App. Dig. Lysine, %	0.74
Soybean meal, 46%	17.70	App. Dig. M + C, %	0.51
Dicalcium phosphate	0.60	App. Dig. Thr., %	0.48
Limestone	1.05	App. Dig. Trp, %	0.15
Salt	0.30	ME, kcal/kg	3309
Vitamin-TM premix	0.15	Ca, %	0.60
L-lysine HCl	0.15	P, %	0.53
Total	100.00	Avail. P, %	0.30

Calculating the Value of DDGS in Swine Diets Using Soybean Meal 44%

Additions/1000 kg diet

+ 100 kg DDGS	x	cost/kg	= $
+ 1.5 kg limestone	x	cost/kg	= $
TOTAL ADDITIONS (A)			**= $**

Subtractions/1000 kg diet

- 88.5 kg corn	x	cost/kg	= $
- 10 kg SBM (44%)	x	cost/kg	= $
- 3 kg dicalcium phosphate	x	cost/kg	= $
TOTAL SUBTRACTIONS (S)			**= $**

S - A = Opportunity cost for DDGS/100 kg

Calculating the Value of DDGS in Swine Diets Using Soybean Meal 46%

Additions/1000 kg diet

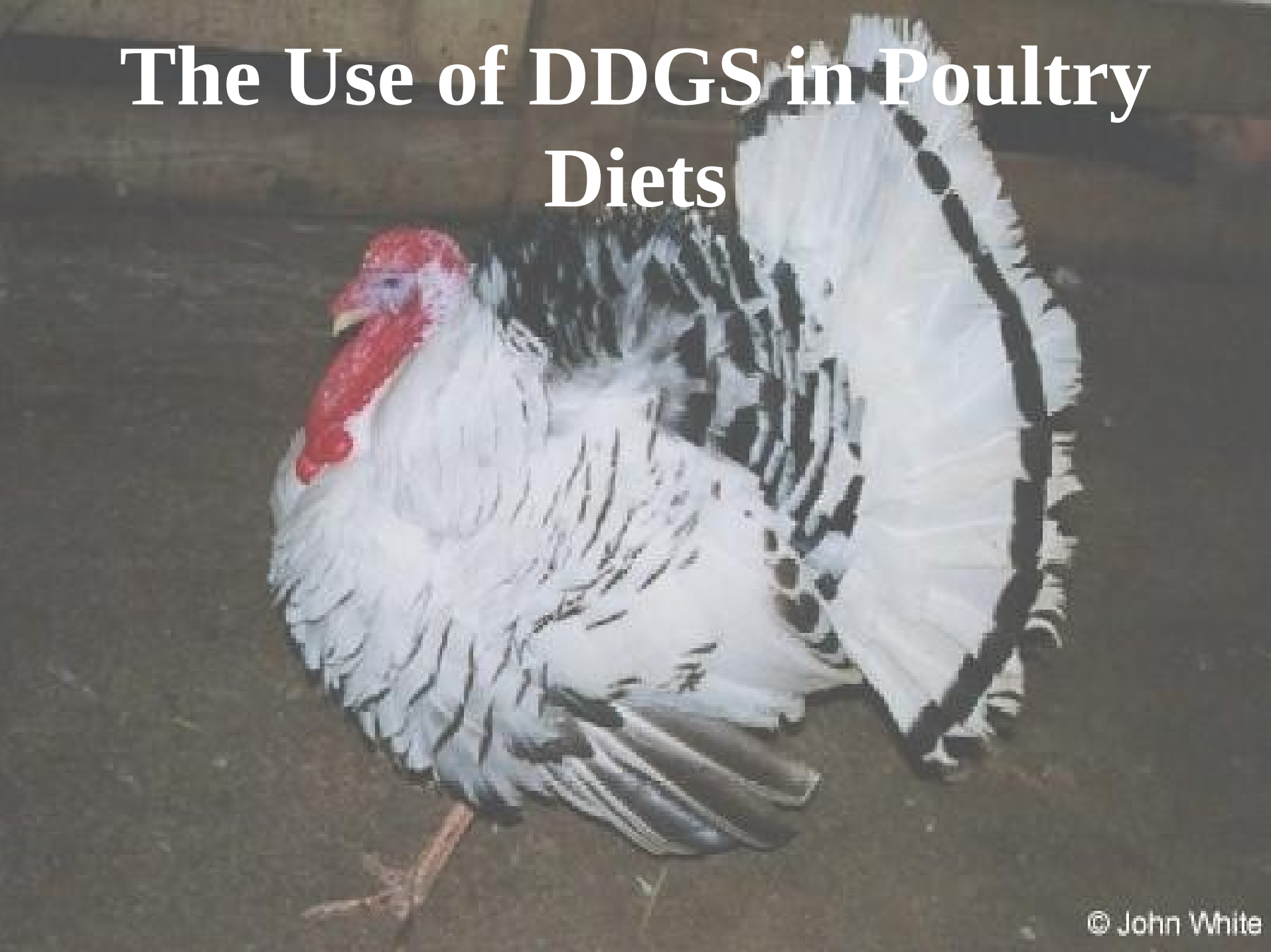
+ 100 kg DDGS	x	cost/kg	= $
+ 1.5 kg limestone	x	cost/kg	= $
TOTAL ADDITIONS (A)			**= $**

Subtractions/1000 kg diet

- 89 kg corn	x	cost/kg	= $
- 9.5 kg **SBM (46%)**	x	cost/kg	= $
- 3 kg dicalcium phosphate	x	cost/kg	= $
TOTAL SUBTRACTIONS (S)			**= $**

S - A = Opportunity cost for DDGS/100 kg

The Use of DDGS in Poultry Diets



Historical Use of DDGS in Poultry Diets in the U.S.

- Fed at low inclusion rates in U.S. poultry industry for many years
  - High B vitamin content (solubles)
  - Source of unidentified growth/reproduction factors?
  - Positive effect on palatability (Alenier and Combs, 1981)
  - Protein source when fed at higher dietary inclusion levels

Unidentified Growth or Hatchability Factor

- Growth response (Couch et al., 1957)
  - 5% DDGS in turkey diets
  - 17-32% improvement in gain
- Feed preference (Alenier & Combs, 1981)
  - 10% DDGS in chicken layer diets
- Reproduction improvement (Manley, 1978)
  - 3% DDGS in turkey breeder hen diets
  - improvement in egg numbers and hatch (late lay)

DDGS As Protein Supplement

- Limiting amino acids (Parsons et al., 1983)
  - Lysine
  - Tryptophan
  - Arginine (perhaps equally limiting with trp)
- Dietary lysine and energy adjustments are needed with inclusion of DDGS
  - growth
  - feed conversion

Performance of Broiler Chickens (0-42 days) to DDGS in Diets Adjusted and Not Adjusted for Energy *(Waldroup et al, 1981)*

DDGS Inclusion Level (%)	BW (g)		Gain/Feed	
	Fixed Energy	Variable Energy	Fixed Energy	Variable Energy
0	1288	1206	.513	.493
5	1237	1227	.518	.505
10	1237	1203	.508	.490
15	1220	1165	.513	.444*
20	1246	1164	.498	.467
25	1247	1096*	.500	.446*

*** Different from control**

Lysine Digestibility of DDGS for Poultry

- Lower than corn due to drying process
- Lysine bioavailability = 66%
  - Parsons et al. (1983)
- Lysine digestibility = 65%
  - NRC (1994)

Lysine Availability (%)

Source	Lysine Bioavail.	Lysine Digest.
Combs & Bossard (1969)	71-93	----
Parsons (1983)	66	82
Heartland (1998)	----	57

Ingredient Amino Acids (% of Protein)

AA	SBM	Corn	MBM	Canola	DDGS
M+C	3.0	4.6	2.4	4.3	4.2
Lys	6.2	3.0	5.4	5.5	2.8
Iso	4.3	3.2	3.0	3.6	3.6
Arg	7.2	5.0	6.7	6.0	4.4
Trp	1.5	0.9	0.7	1.5	0.8
Thr	4.0	3.5	3.2	4.2	3.8
Val	4.6	4.8	3.8	4.8	4.8

Amino Acid Digestibility (% of total)

AA	Corn	SBM	MBM	DDGS
	---------- % ----------			
Met	97.9	94.3	92.3	88.5
Cys	88.2	-----	84.7	78.4
Lys	86.2	91.8	90.3	78.6
Arg	96.1	93.5	94.0	92.5
Tryp	96.8	93.7	95.1	91.8
Thr	81.1	84.3	90.1	82.5
Iso	86.4	90.9	92.2	89.1
Val	93.3	89.4	90.2	88.1

Energy Utilization of DDGS by Poultry

- Crude protein = 27.4%
- Crude fat = 9%
- ME, kcal/kg = 2,480
- ME/GE, % = 49.1
- ME (% of corn) = 74.1

Maximum Inclusion Rates of DDGS in Poultry Diets

- Turkey, pullet, and broiler starter = 5%
- Turkey and broiler finisher = 15%
- Pullet developer = 10%
- Layer (peak) = 10%
- Layer (late lay) = 10%

Source: ME Jackson, 2002 Midwest Poultry Federation Convention, St. Paul, MN

Use of DDGS in Poultry Diets

- High inclusion rates have also provided good results
  - Favorable results with 25% DDGS in broiler diets
    - Waldroup et al., 1981
  - 15% DDGS in layer diets reduces fatty liver incidence
    - Jensen et al., 1974; Jensen, 1987; Akiba et al., 1983
  - 12% DDGS turkey diets gave similar performance to corn-soybean meal diets
    - Noll, 2002

Nutritional Value of DDGS for Poultry

- Must use high quality DDGS
  - Golden color = high amino acid digestibility
- Excellent energy and available phosphorus source
- Nutritional value higher than previously thought
- Unidentified growth factors?
  - 5% DDGS resulted in 17-32% improvement in gain
  - 3% DDGS in turkey breeder hen diets increased egg numbers and hatch
- Effective partial replacement for corn and soybean meal

Maximizing the Value of Corn DDGS in Poultry Diets

- Formulate diets using digestible amino acid values
- High available P reduces the level of dietary P supplementation
- Adding 5 % DDGS to may improve feed preference, egg number, and hatchability in breeder hens

Limitations of Using DDGS in Poultry Diets

- Must be golden color and highly digestible
- High fiber limits its maximum inclusion rate in poultry diets
- Excess nitrogen can be minimized by using synthetic amino acids

U of M DDGS Web Site

We have developed a DDGS web site featuring:

* research summaries (swine, poultry, dairy, & beef)
* presentations given
* links to other DDGS related web sites

Visit this web site at:

www.ddgs.umn.edu