# Precision DDGS Nutrition for Swine

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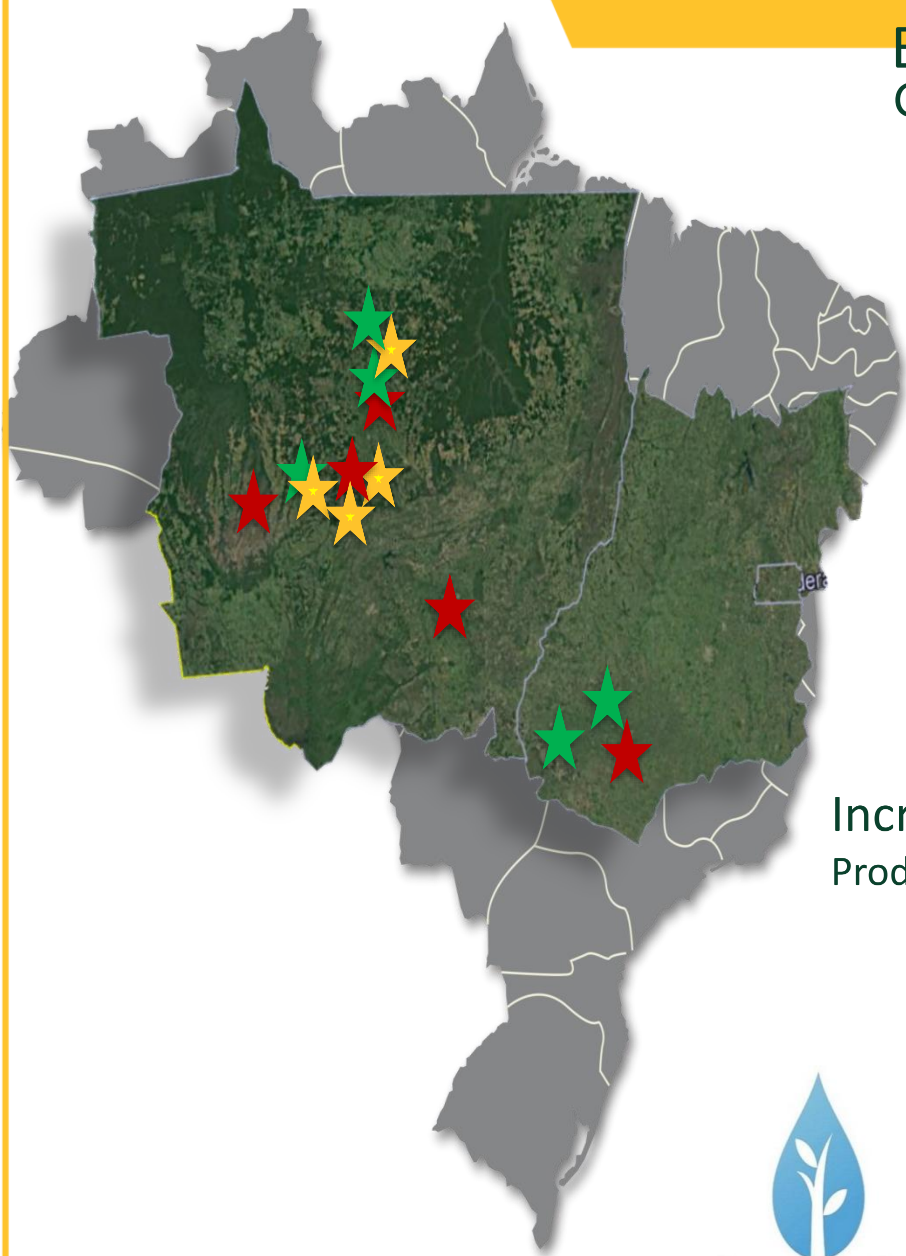
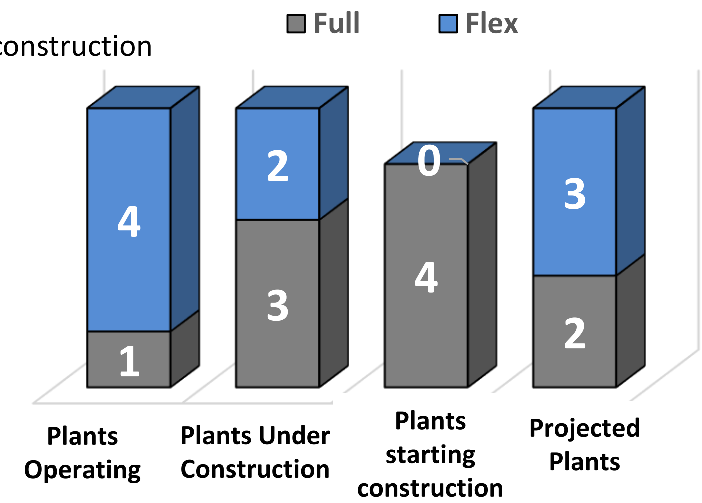
# Corn Ethanol Growth in Brazil

## Growth/Expansio

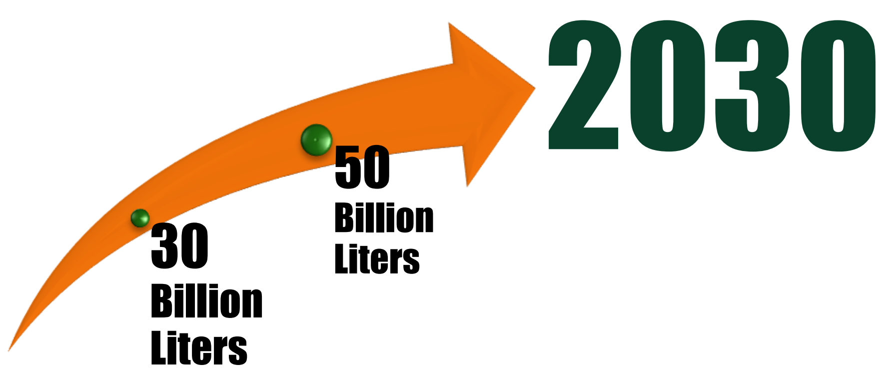



## Acual Scenario




## Increase in Ethanol Consumption

Produced from both sugar cane and corn ethanol




RenovaBio

Source: UNEM – Setembro/2018

# Evolution of U.S. distiller's co-products

"Backyard" Distilleries

Whiskey Distilleries


Wet Milling


Starch

Corn Gluten Feed

Corn Gluten Meal

Corn Germ Meal

Dry Grind

Wet Distiller's Grains

DDGS

## Emerging Co-Products

High-Protein DDG (40-50% CP)
- ICM
- FluidQuip

Corn Bran + Solubles

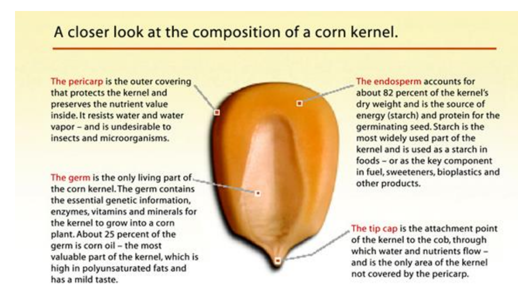
## Bio-Refineries

Back-End Oil Extraction

Distiller's Corn Oil

Reduced-Oil DDGS

Front-End Fractionation

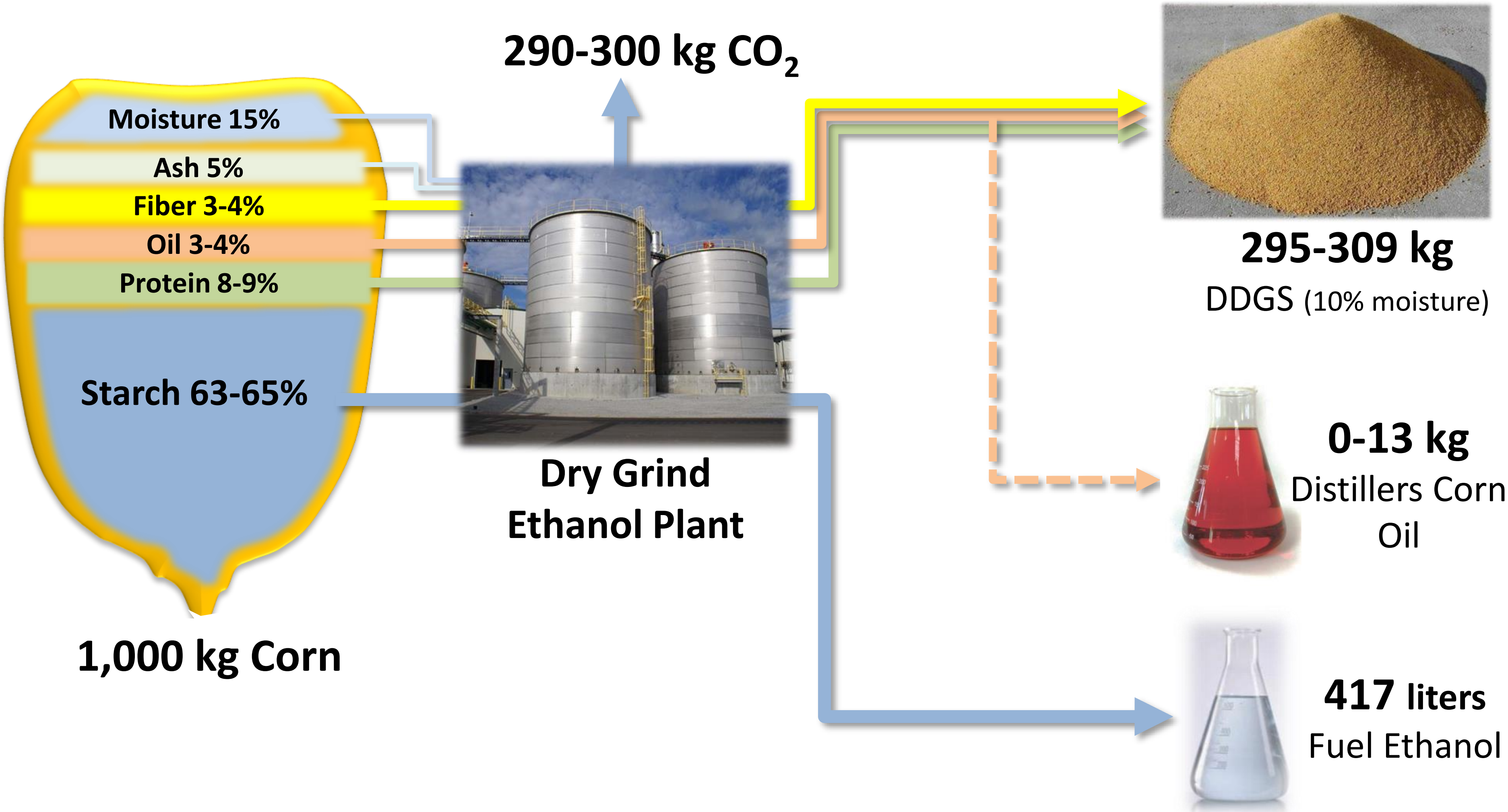



HP-DDG    Corn Bran    De-Oiled DDGS

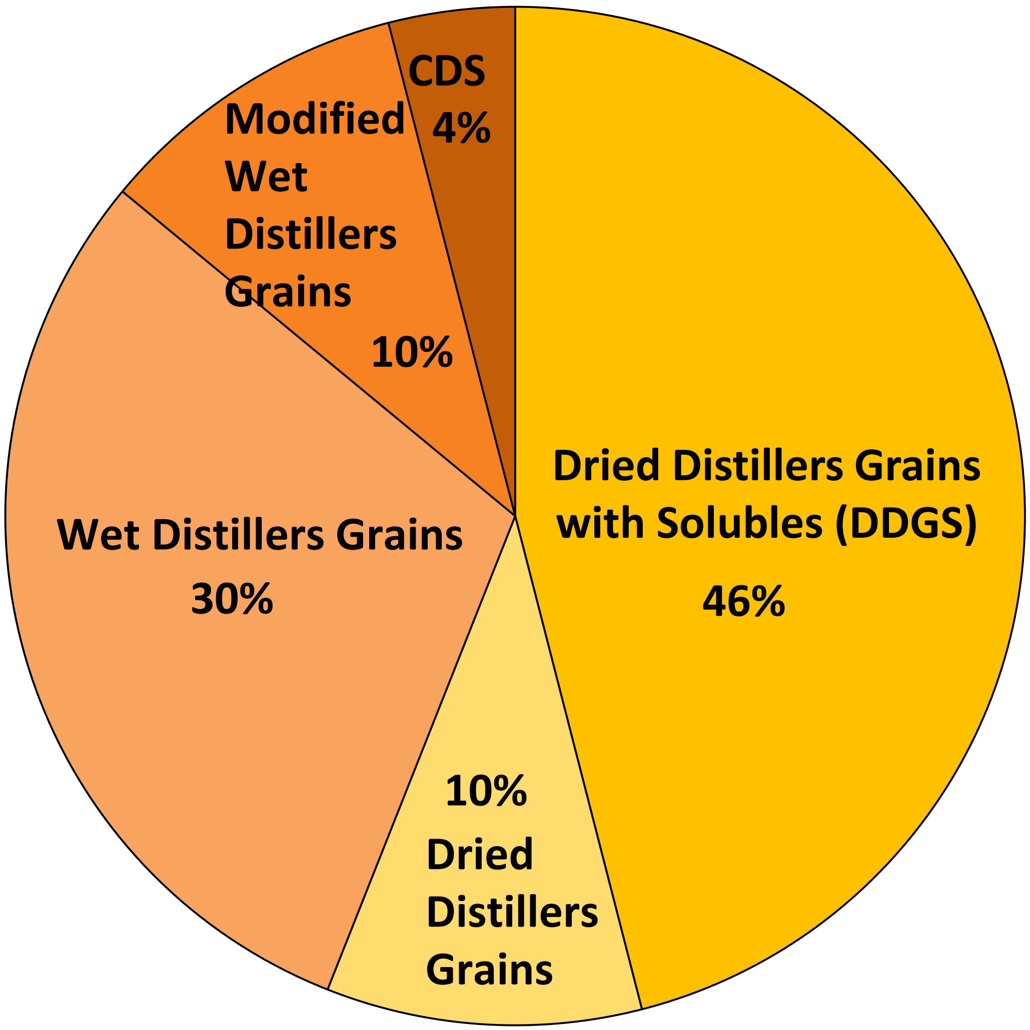
De-Hulled, De-Germed Corn

Dehydrated Corn Germ

# Major corn co-products from dry grind ethanol plants

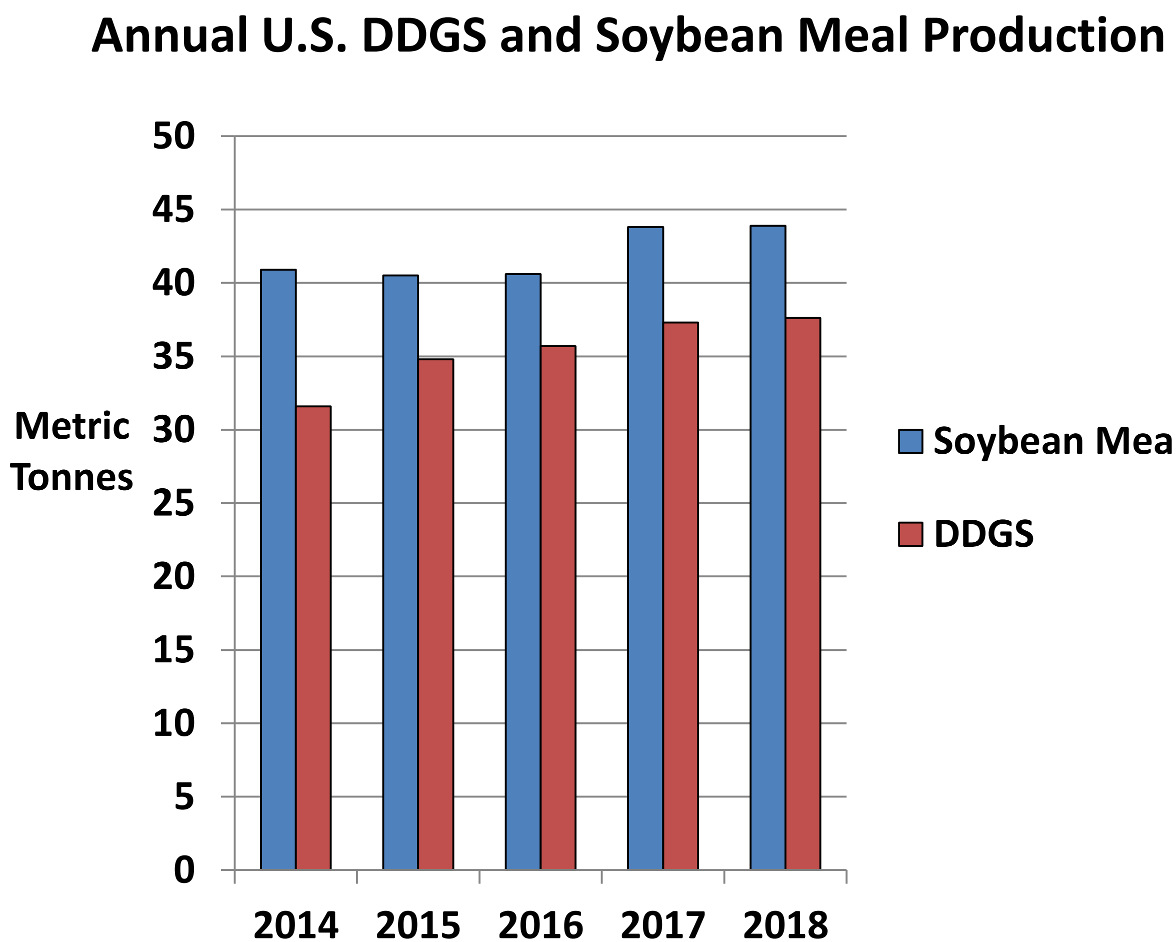


# Types of corn co-products produced

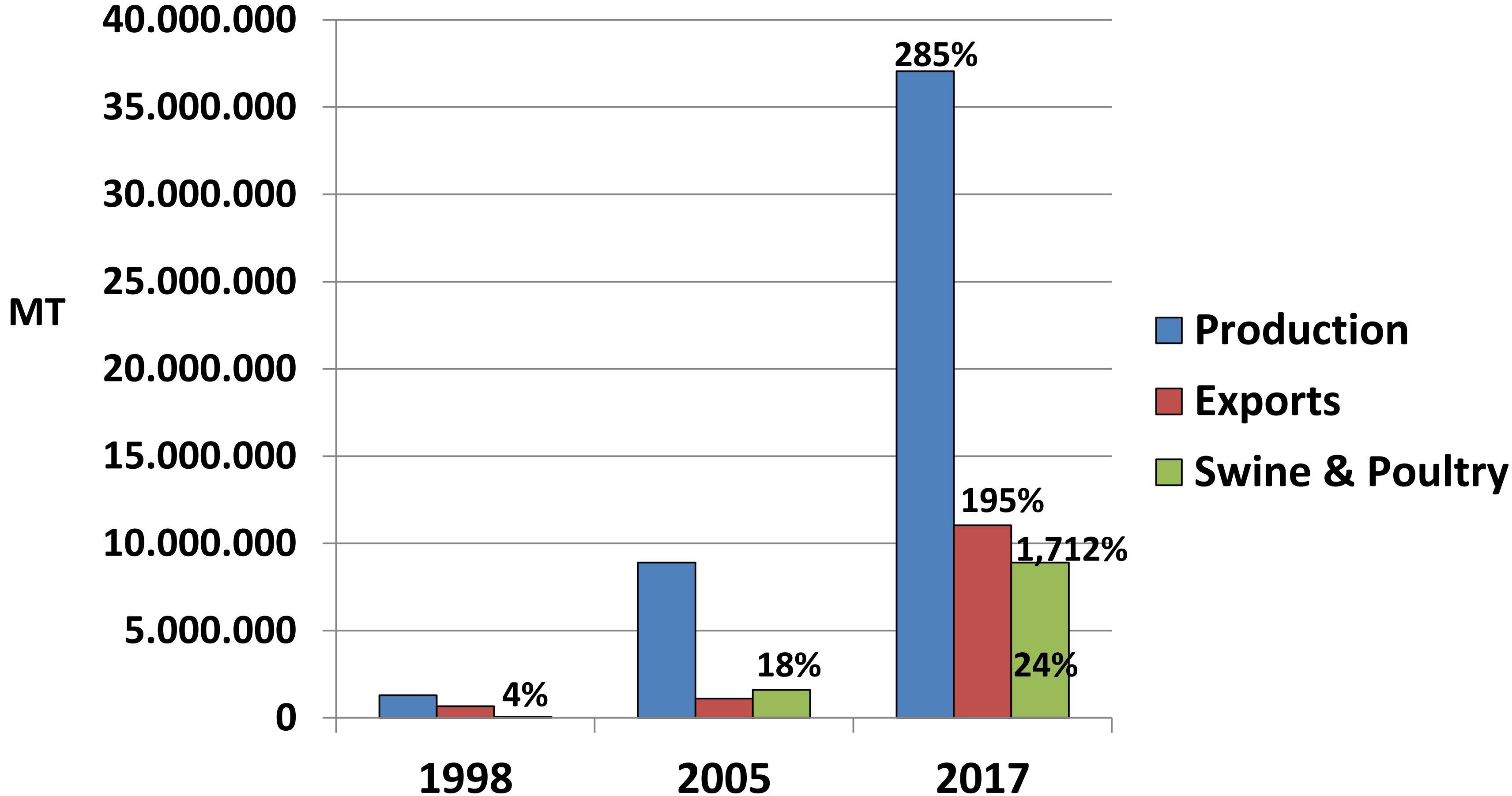



Source: Renewable Fuels Association

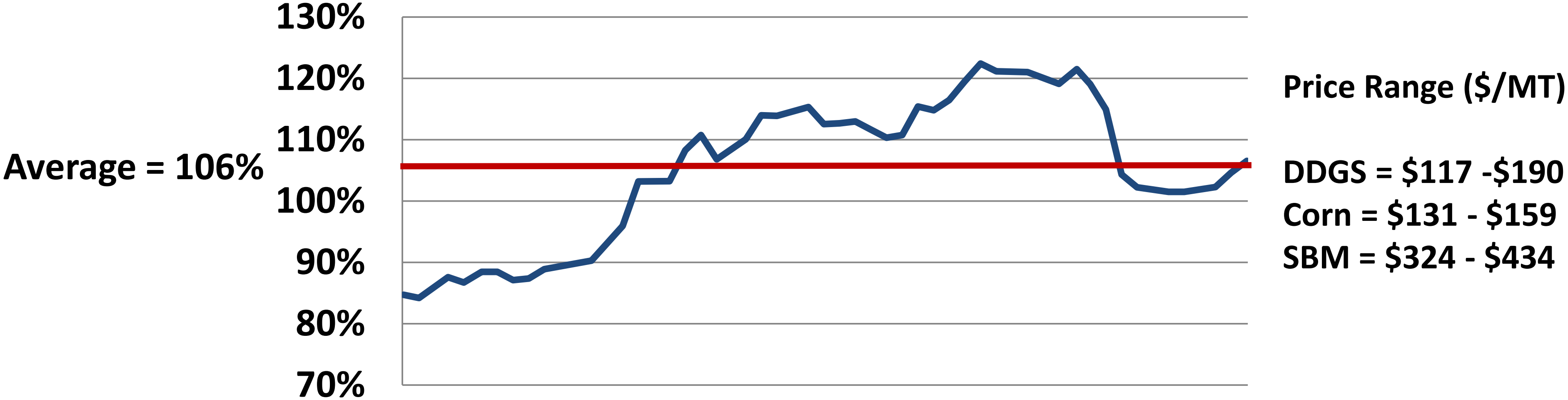
# Corn DDGS is major global feed ingredient



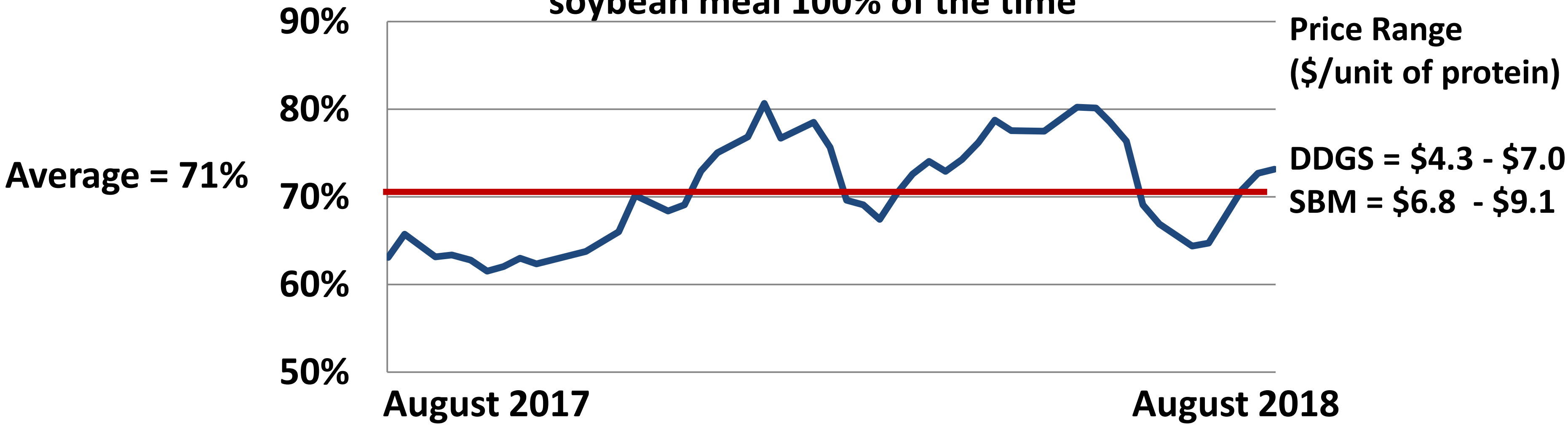
# Production, exports, and use in swine and poultry diets have increased dramatically since 1998



**Price of DDGS was less than corn 25% of the time**




**Price/unit of protein of DDGS was less than soybean meal 100% of the time**




Source: DTN DDGS Weekly Update

# DDGS value is greater than price

| | A | B | A - B |
|---|---|---|---|
| Crude protein, % | 26.6 | 25.7 | +0.4 |
| Crude fat, % | 5.8 | 8.7 | -2.9 |
| "Profat", % | 32.4 | 34.4 | -2.0 |
| Crude fiber, % | 6.7 | 7.1 | -0.4 |
| Nutritional value, $/MT | 279 | 219 | +60 |

Prices used in comparison:

DDGS spot price = $182/MT
Corn price = $138/MT
Soybean meal price = $343/MT

# Prediction equations accurately determine nutritional value of DDGS

| | A | B | A - B |
|---|---|---|---|
| ME, kcal/kg | 3,180 | 3,001 | +171 |
| NE, kcal/kg | 2,278 | 2,141 | +137 |
| SID Lys, % | 0.63 | 0.45 | +0.18 |
| SID Met, % | 0.58 | 0.42 | +0.16 |
| SID Thr, % | 0.86 | 0.62 | +0.24 |
| SID Trp, % | 0.17 | 0.14 | +0.03 |
| Avail. Phosphorus, % | 0.65 | 0.66 | -0.01 |

# Nutritional composition of DDGS varies among sources

- > 200 U.S. ethanol plants and DDGS sources
- Nutrient composition varies:
  - Corn composition
  - Processing factors
    - Enzymes
    - Temperatures
    - Amount of solubles added to grains
    - Dryers
    - Amount of oil extracted
- There are no grading standards

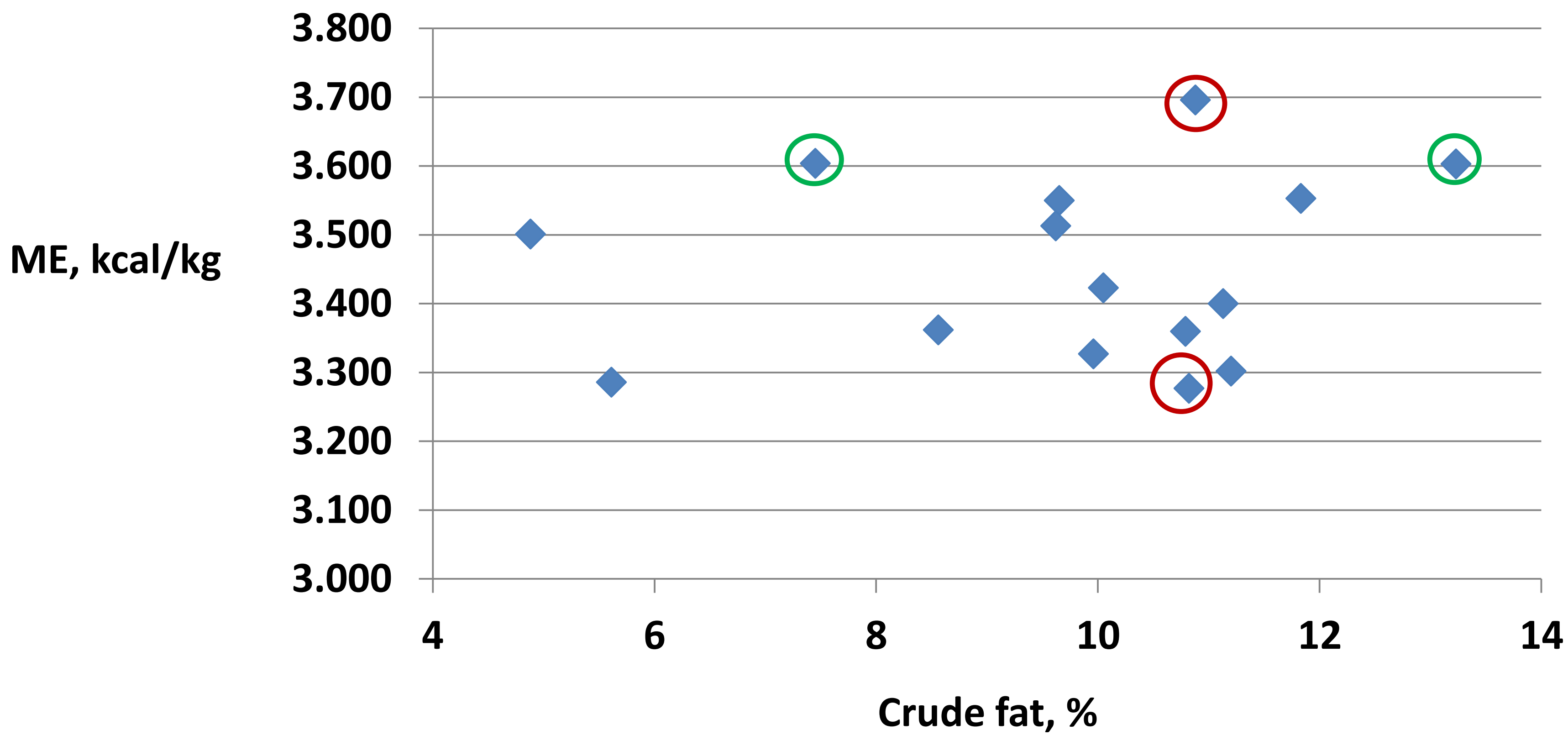
# DDGS composition varies among sources

| | Low value* | Difference | High value* |
|---|---|---|---|
| Swine ME, kcal/kg | 3,300 | 400 | 3,700 |
| Crude protein, % | 28 | 5 | 33 |
| Crude fat, % | 5 | 8 | 13 |
| Neutral detergent fiber, % | 29 | 15 | 44 |
| Starch, % | 1 | 3 | 4 |
| Ash, % | 4 | 2 | 6 |

*Values on a dry matter basis

Kerr et al. (2013)

# Crude fat does not predict metabolizable energy (ME) content for swine



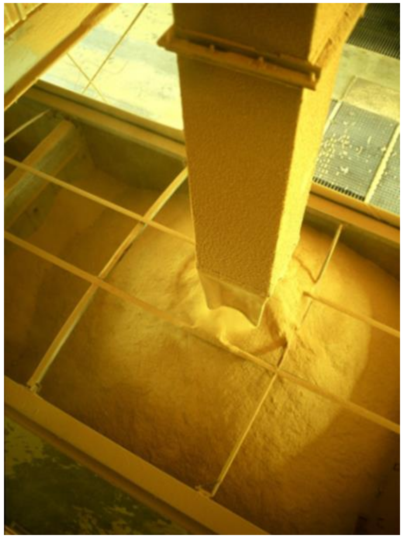

Kerr et al. (2013)

# Swine ME can be accurately estimated from chemical composition of DDGS

DE, kcal/kg = - 2,161 + (1.39 $\times$ GE, kcal/kg) – (20.7 $\times$ % NDF) – (49.3 $\times$ % Crude Fat)

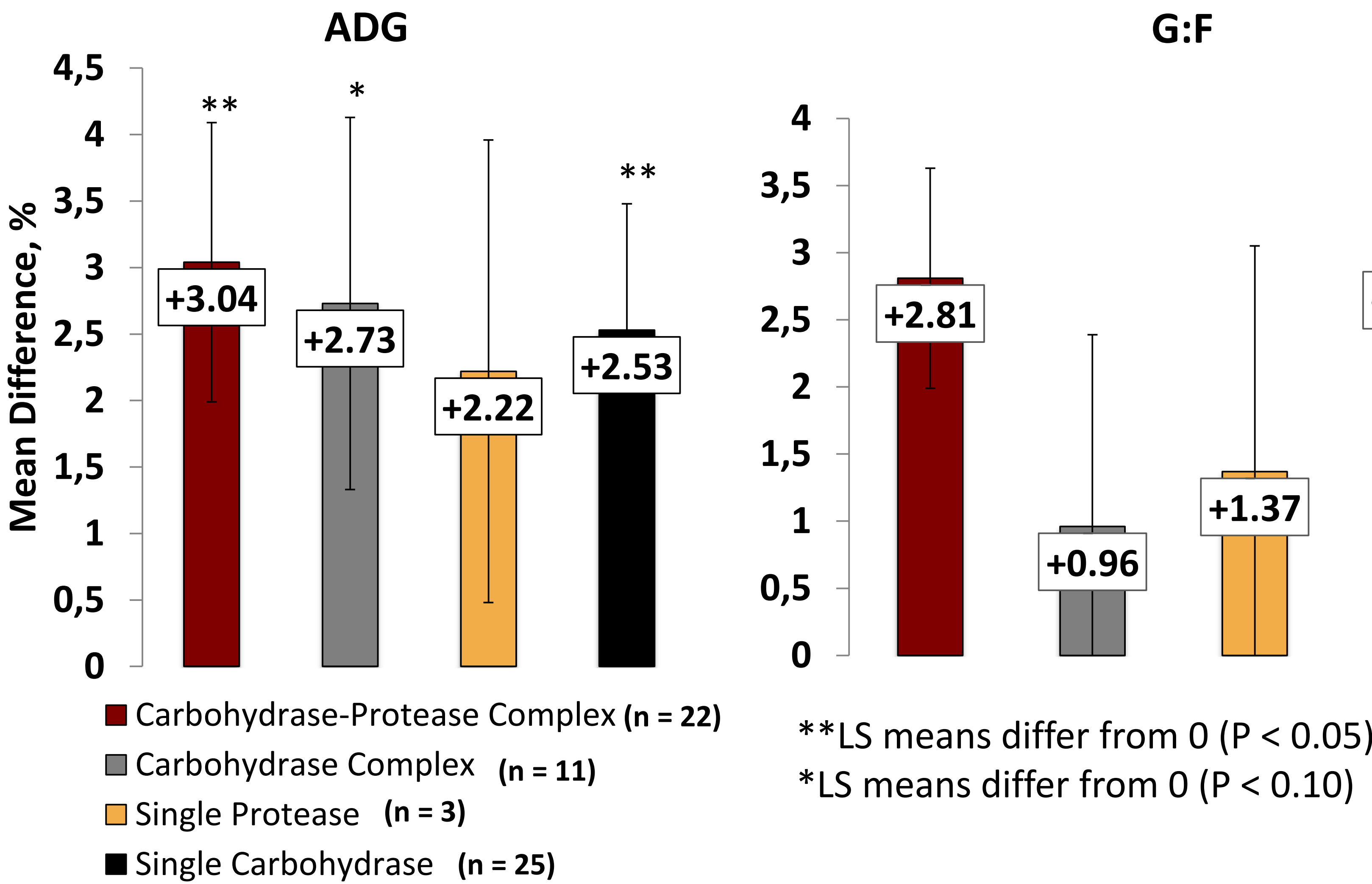
ME, kcal/kg = − 261 + (1.05 $\times$ DE, kcal/kg) − (7.89 $\times$ % CP) + (2.47 $\times$ NDF) − (4.99 $\times$ % Crude Fat)

Urriola et al. (2014)



| Corn | Corn DDGS |
| --- | --- |
|  |  |
| **GE** | **GE** |
| 4,454 kcal/kg DM | 5,429 kcal/kg DM |
| **NE:GE** | **NE:GE** |
| **0.68** | **0.49** |

# Effect of enzyme type in corn DDGS diets




Zeng et al. (2018)

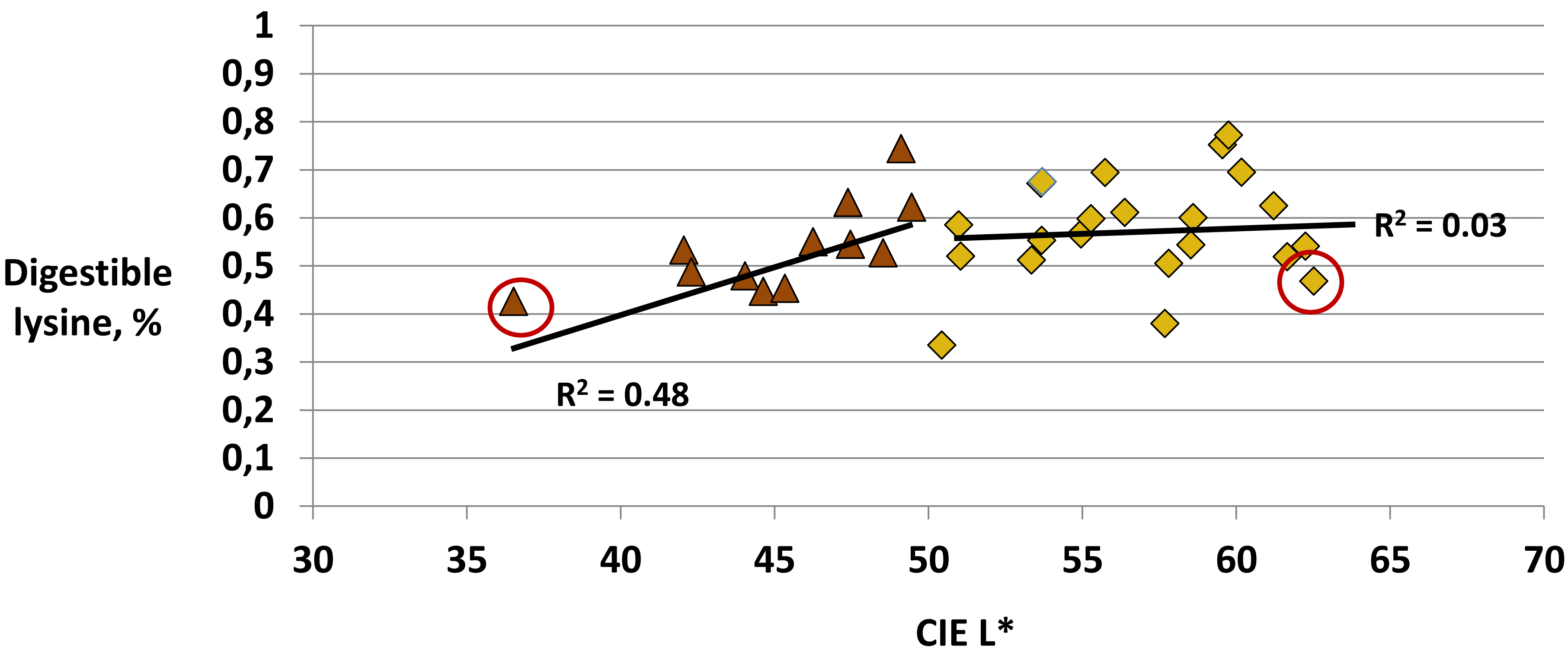
# SID amino acid content for swine varies among sources

| | Low value* | Difference | High value* |
|---|---|---|---|
| SID Lysine, % | 0.22 | 0.70 | 0.92 |
| SID Methionine + Cystine, % | 0.65 | 0.77 | 1.42 |
| SID Threonine, % | 0.54 | 1.09 | 1.63 |
| SID Tryptophan, % | 0.07 | 0.18 | 0.25 |

*Values on a dry matter basis

Zeng et al. (2017)

# Color is a poor indicator of amino acid digestibility in DDGS in swine




Urriola et al. (2013)

# DDGS digestible amino acid prediction equations for swine

SID Lys, % = -1.03 + (Lys, g/kg × 0.88) – (NDF, g/kg × 0.003) $R^2 = 0.98$

SID Met+Cys, % = 0.05 + (Met+Cys, g/kg × 0.92) - (NDF, g/kg × 0.005) $R^2 = 0.99$

SID Thr, % = 1.30 + (Thr, g/kg × 0.64) – (ADF, g/kg × 0.028) $R^2 = 0.99$

SID Trp, % = -0.17 + (Trp, g/kg × 0.89) $R^2 = 0.99$

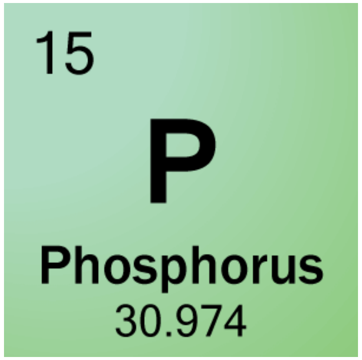
Zeng et al. (2017)

# Total and digestible phosphorus content varies among sources

| | Low value | Difference | High value |
|---|---|---|---|
| Total phosphorus, % | 0.71* | 0.20 | 0.91* |
| Apparent total tract digestibility, % | 52 | 14 | 66 |

*Values on a dry matter basis

Kerr et al. (2013)

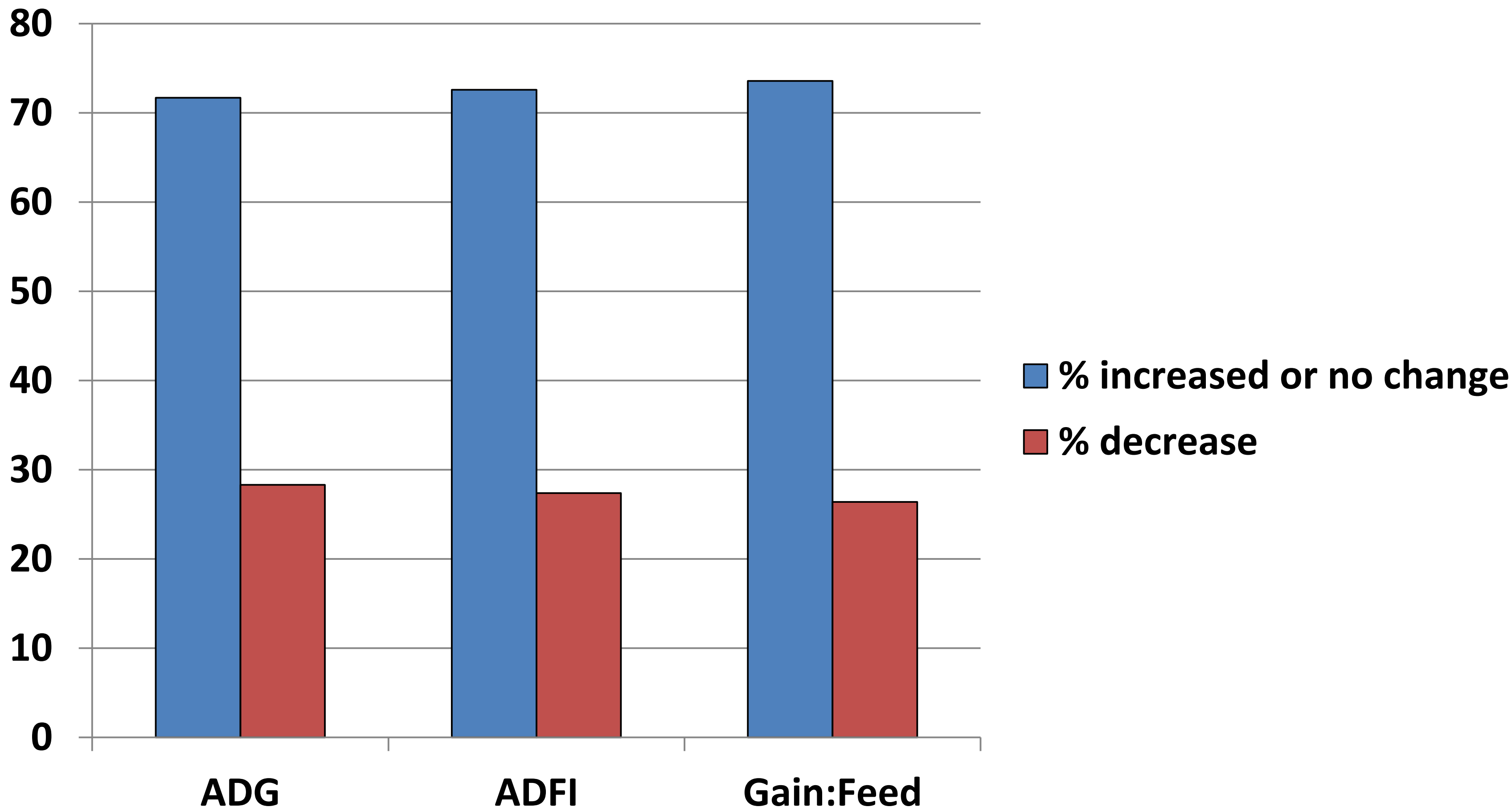



# Common dietary DDGS inclusion rates in commercial U.S. swine diets

| | Diet inclusion rate, % |
|---|---|
| Starter (> 7 kg BW) | 5 – 20 |
| Grower | 10 – 30 |
| Finisher | 10 – 30 |
| Gestation | 20 – 50 |
| Lactation | 10 – 30 |

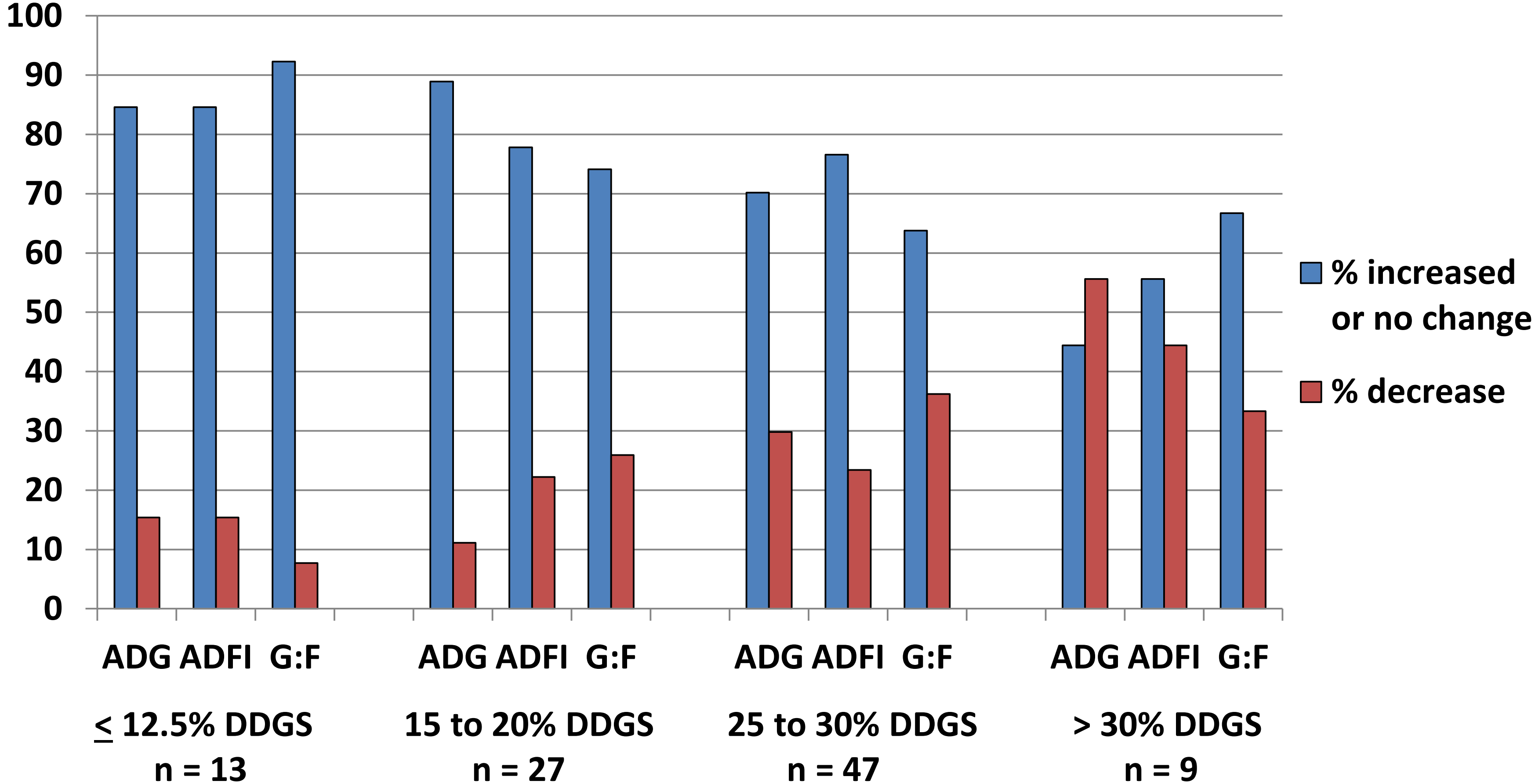


# Summary of growth performance responses in nursery and growing-finishing pigs fed DDGS diets



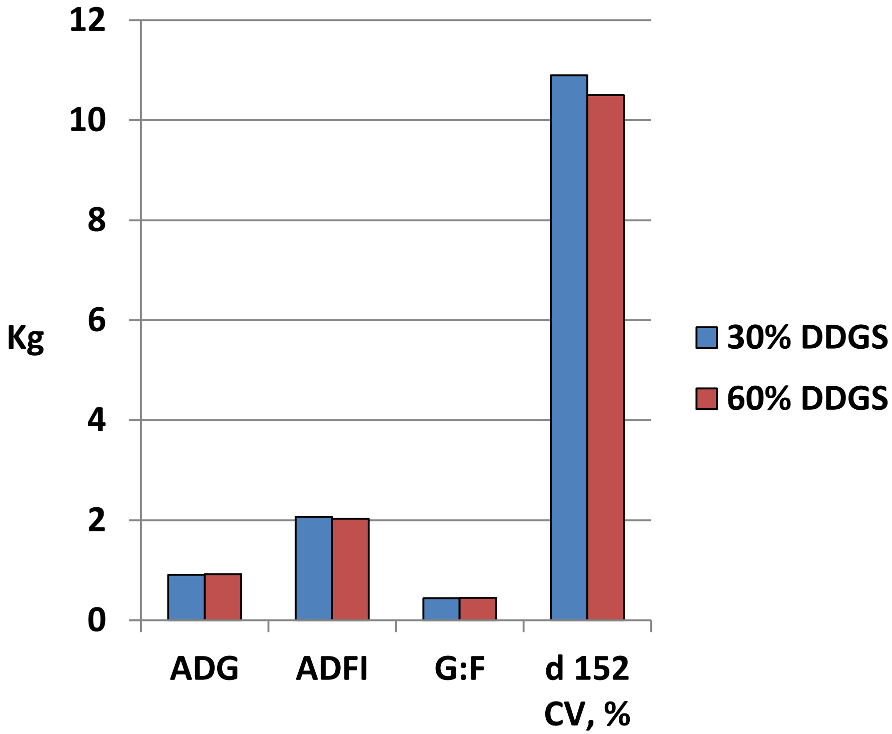

106 observations from 27 studies published since 2010

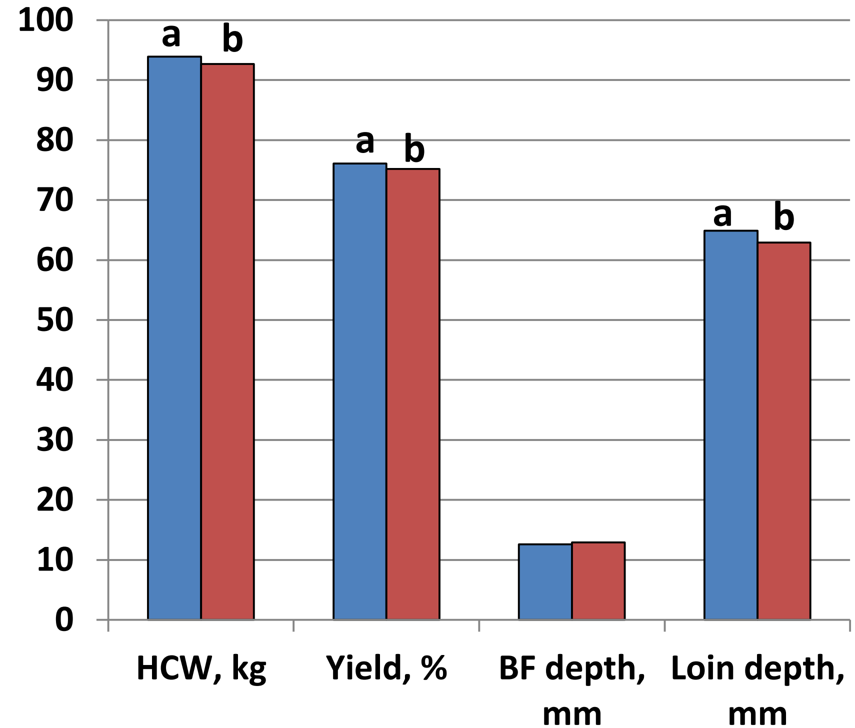
# Growth performance responses of increasing DDGS inclusion rates in nursery and growing-finishing pig diets




96 observations from 27 published studies since 2010

# The U.S. pork industry is beginning to use higher DDGS inclusion rates in growing-finishing pig diets



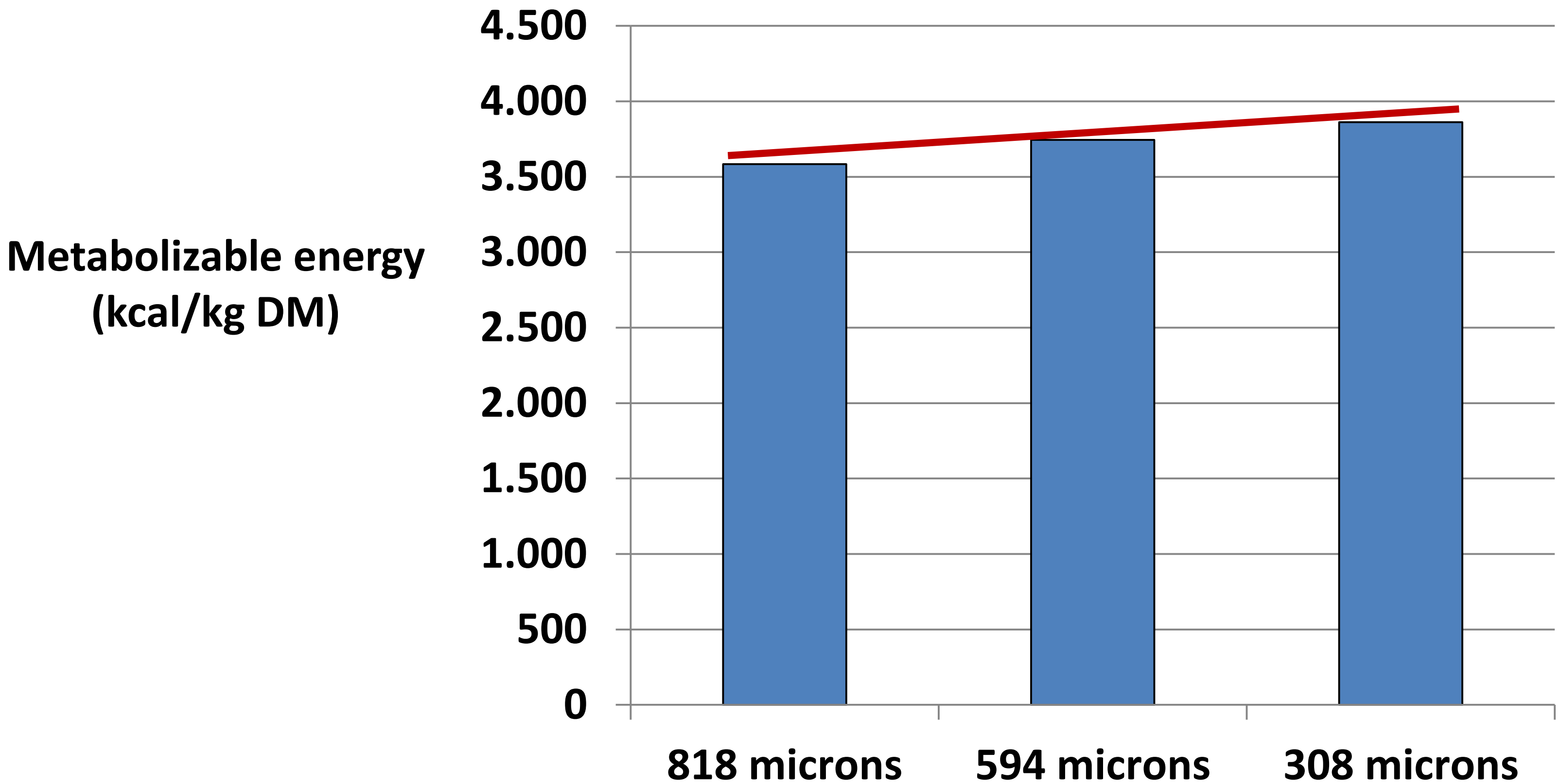

**Grower-finisher (d 56-155)**
**1,860 pigs in commercial facility**

[a,b]Means with different letters differ (P < 0.05)

**Weber at al. (2015)**


# Handling and processing DDGS diets

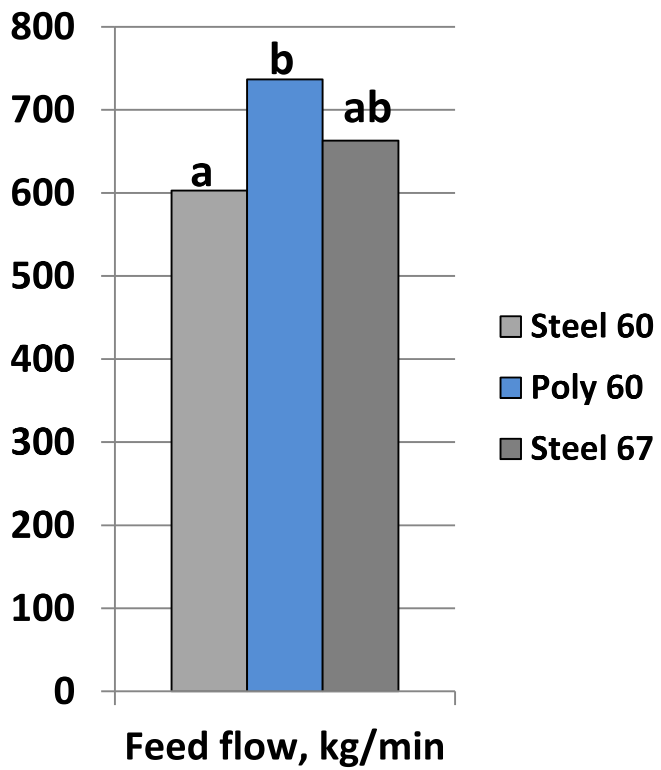
# Decreasing DDGS particle size increases ME content

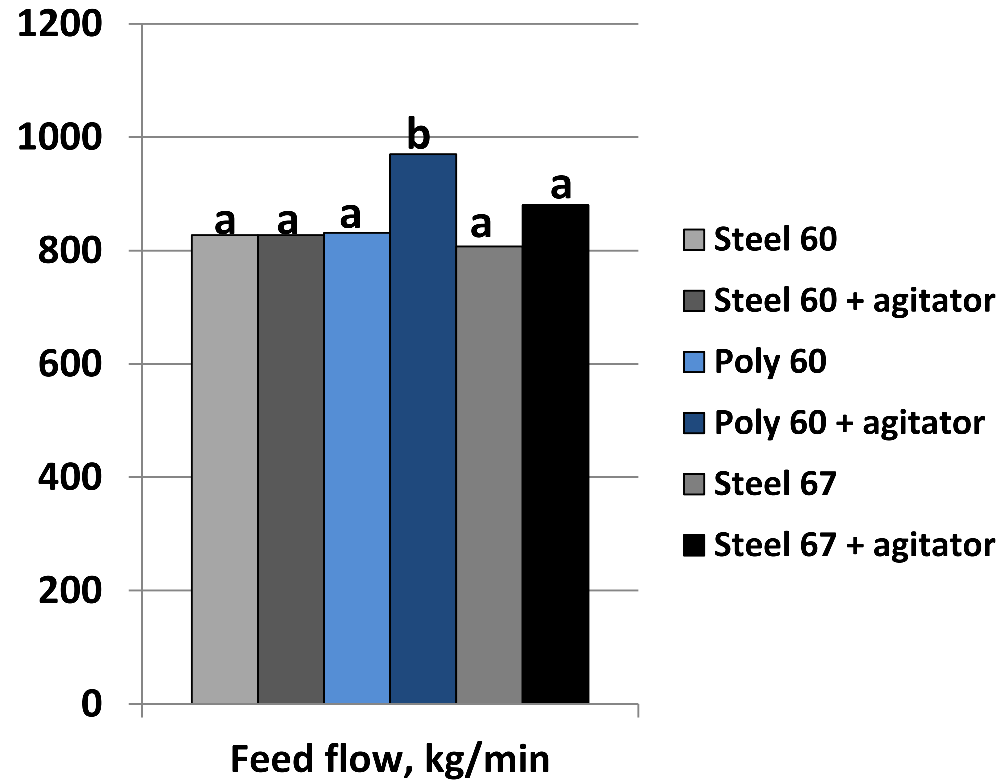



**Each 25 µm reduction in DDGS particles size increases ME by 13.46 kcal/kg DM**

**Liu et al. (2012)**

# Storage bin design and use of agitators affects flow rate of 40% DDGS diets

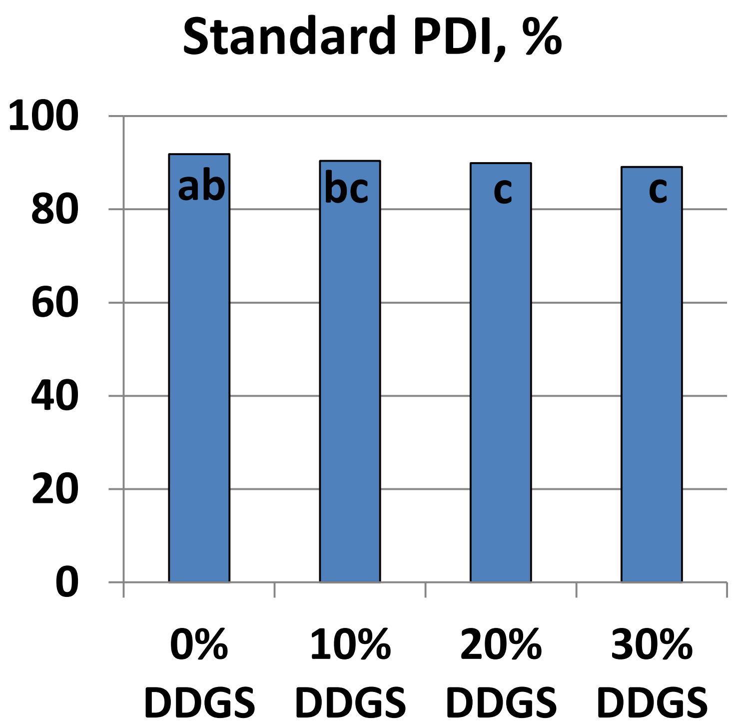


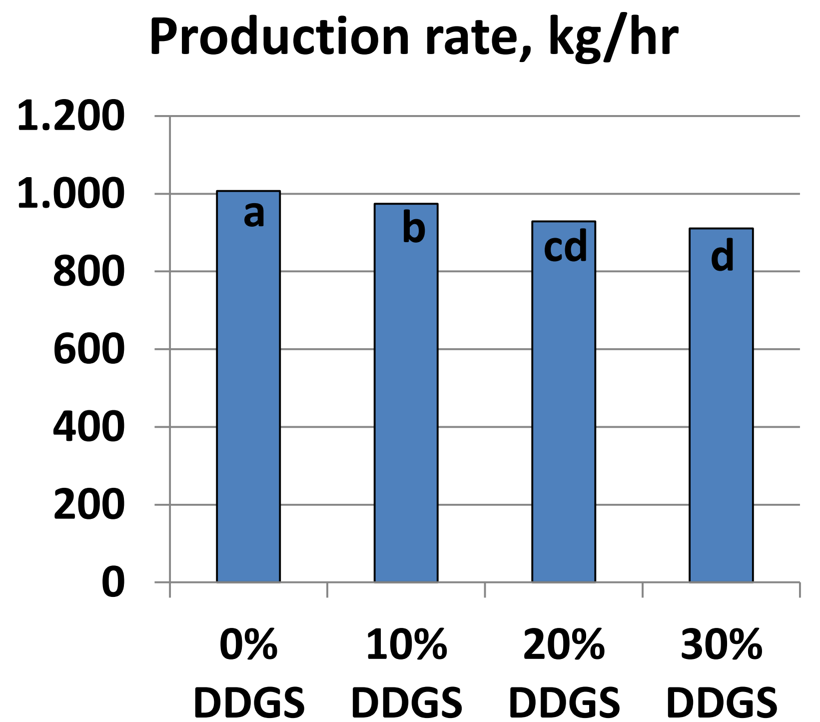




[a,b]Means with different letters differ ($P < 0.05$)

**Hilbrands et al. (2016)**

# Effect of increasing dietary DDGS content on PDI and pellet production rate



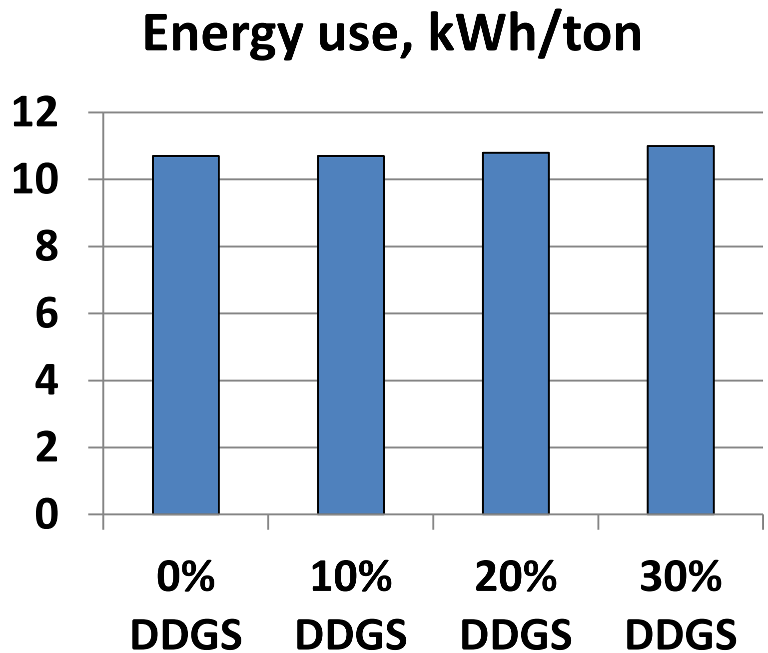

**Pelleting conditions:**

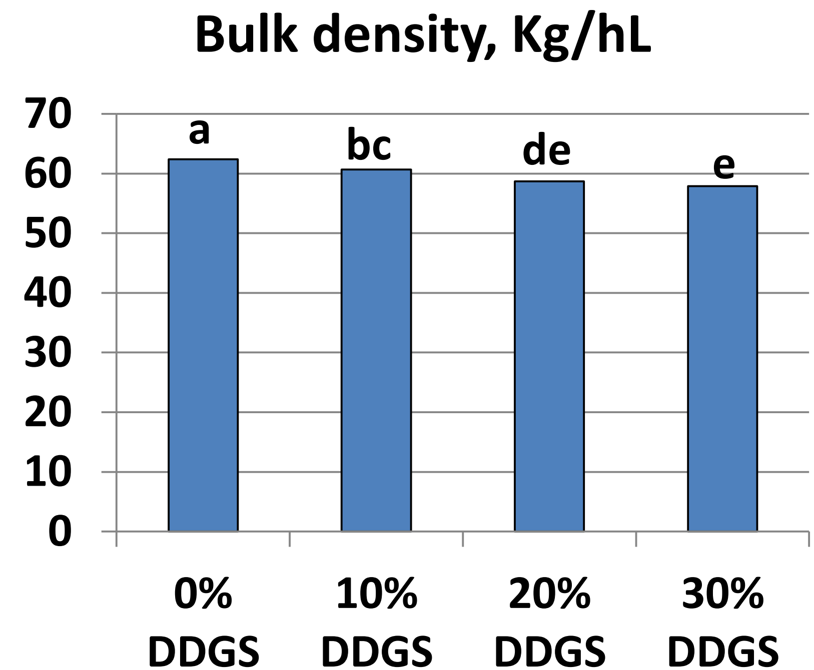
- 3.97 mm hole diameter × 31.75 mm die thickness
- Conditioner steam temperature = 85°C

[a,b,c,d]Means with different superscripts differ ($P < 0.05$).

Fahrenholz et al. (2013)

# Effect of increasing dietary DDGS content on energy use and pellet bulk density



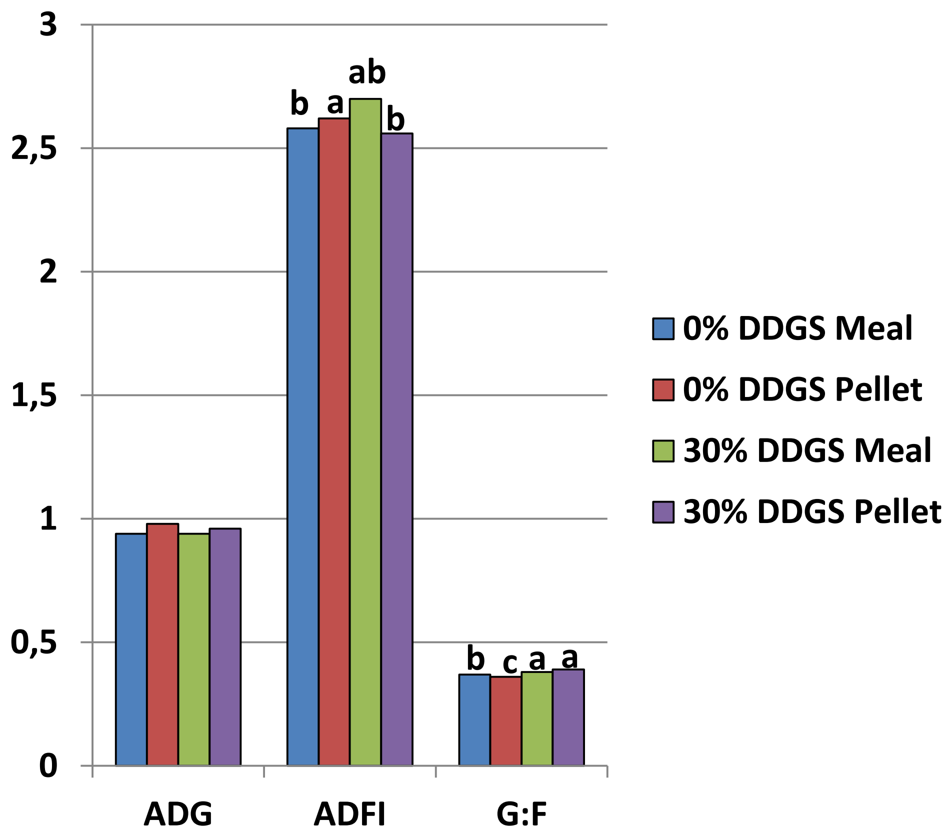

**Pelleting conditions:**

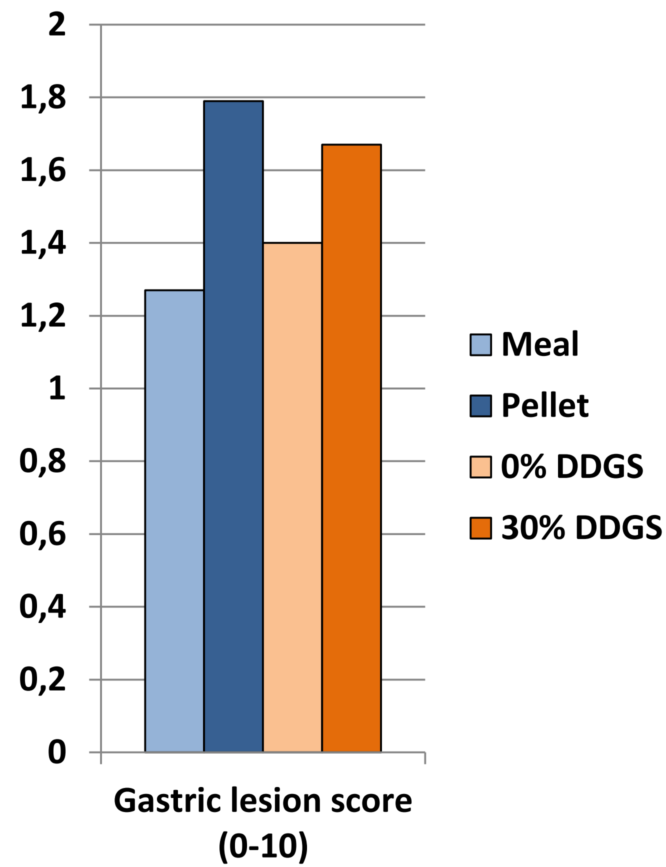
- 3.97 mm hole diameter × 31.75 mm die thickness
- Conditioner steam temperature = 85°C

[a,b,c,d,e] **Means with different superscripts differ ($P < 0.05$).**

**Fahrenholz et al. (2013)**

# Effect of meal and pelleted 30% DDGS diets on growth performance and gastric lesions

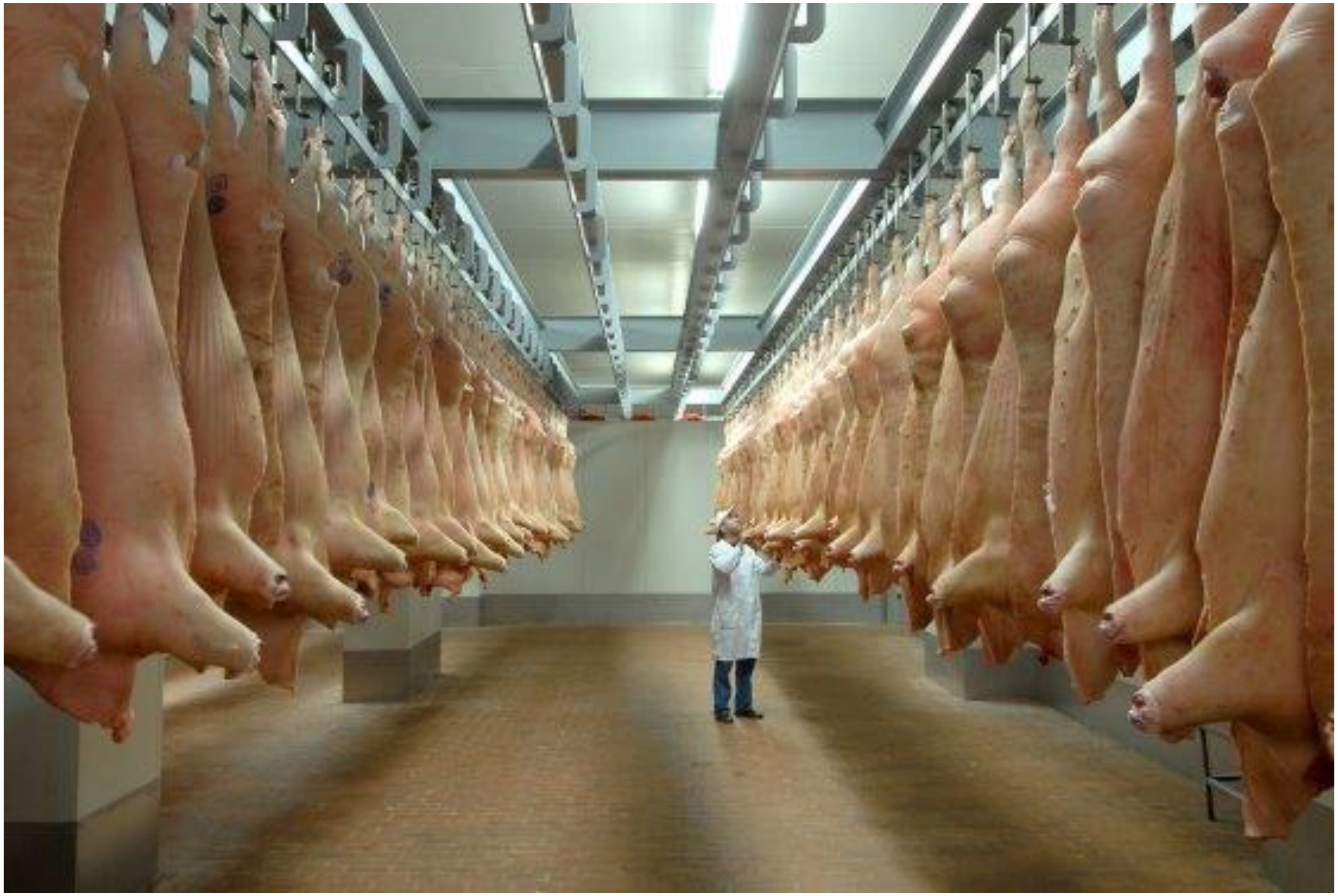


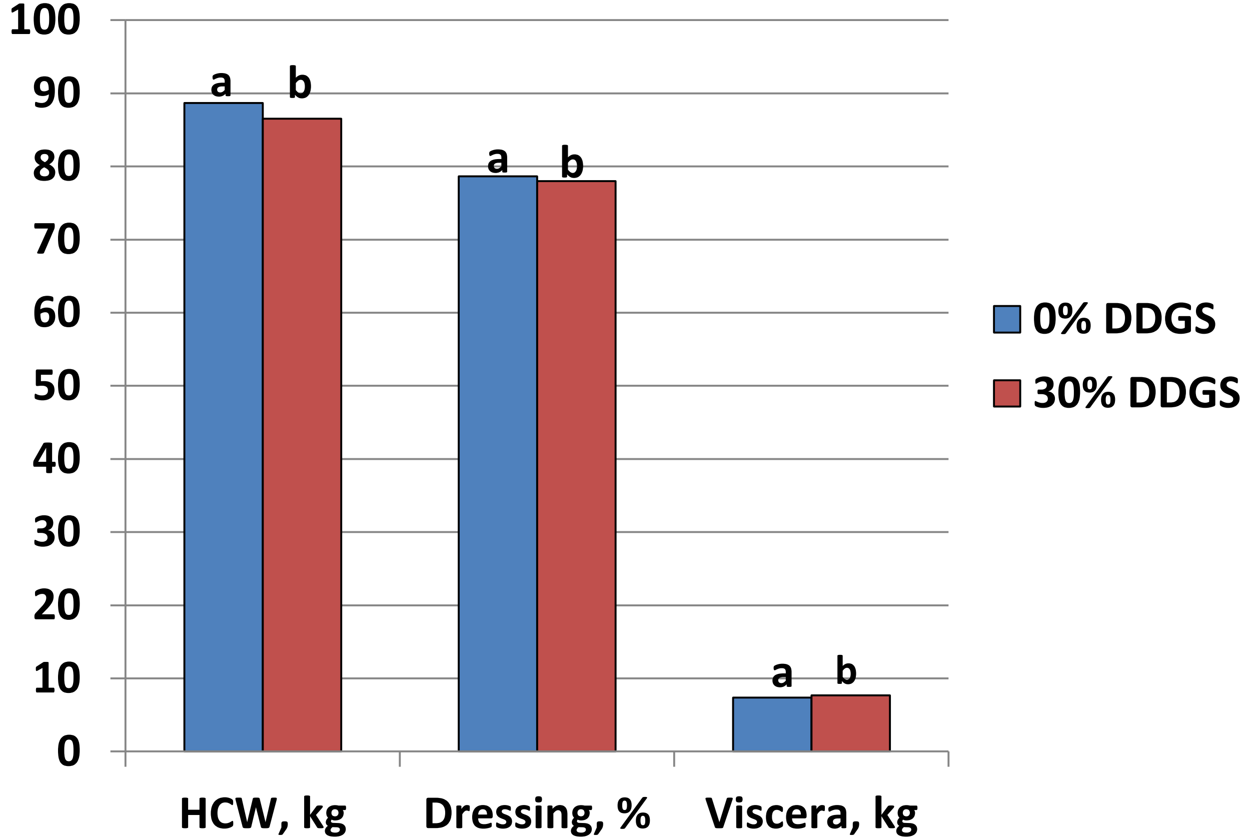

Pellet > meal (P < 0.01)
30% DDGS > 0% DDGS (P = 0.10)

Overholt et al. (2016)

# Carcass characteristics



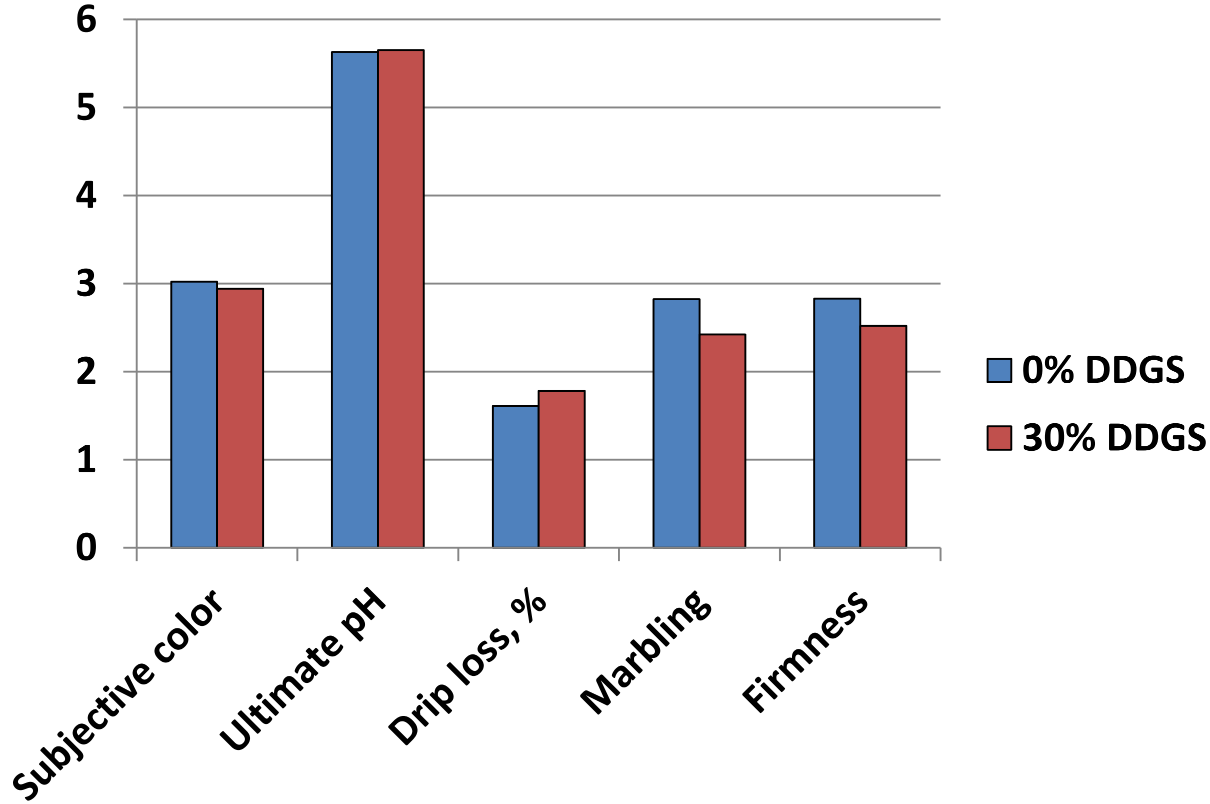
# DDGS reduces carcass yield




Overholt et al. (2016)

# Feeding DDGS does not affect meat quality

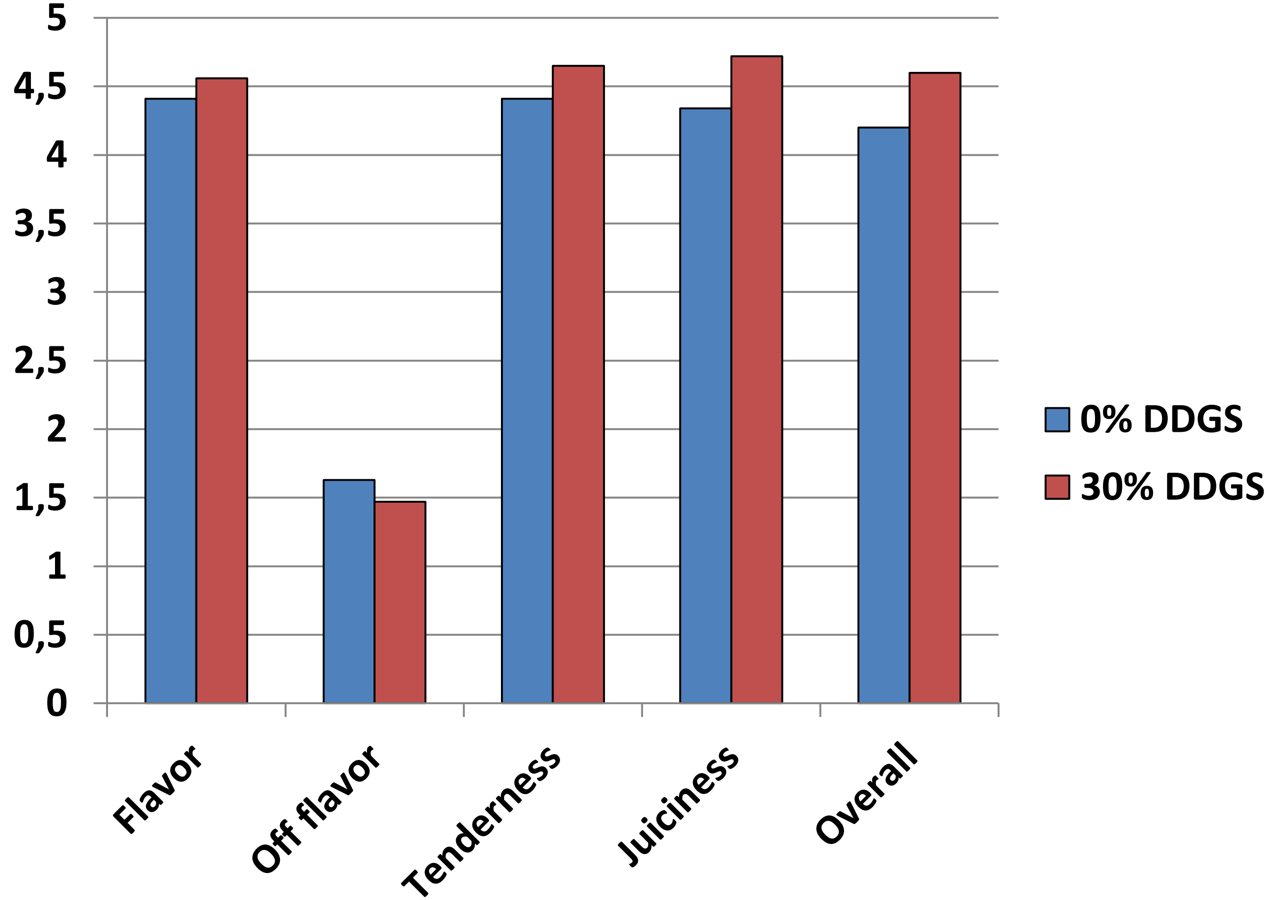
# Feeding 30% DDGS diets does not affect pork loin quality




Xu et al. (2009)

# Feeding 30% DDGS diets does not affect sensory characteristics of cooked pork loins

Trained taste panel scores (1 to 8)




Xu et al. (2009)

# DDGS reduces pork fat firmness

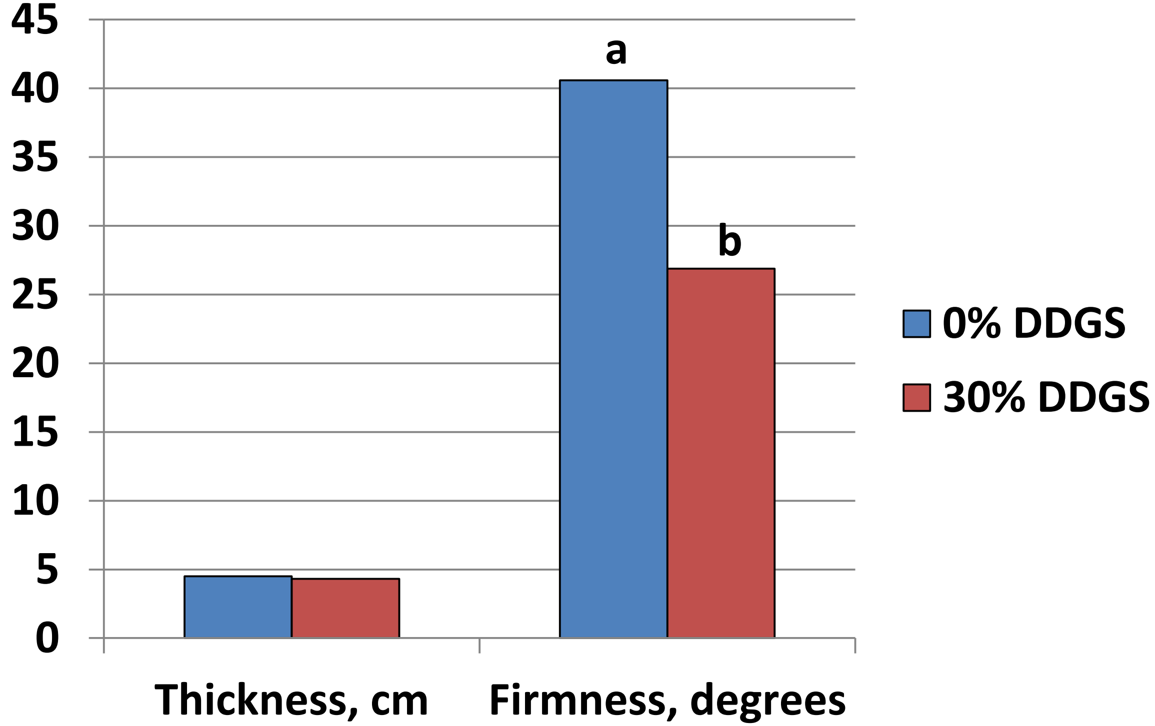
Fresh belly from feeding corn-soybean meal diets

Fresh belly from feeding 30% DDGS diets

**Managed by:**

- Feeding reduced-oil DDGS sources
- Withdrawal of DDGS from the diet before slaughter
- Formulating diets to control total PUFA intake
- Limit diet inclusion to 20%
- Using pork fat IV prediction equations
- Supplement diets with Lipinate™ or CLA

# Effect of feeding 30% DDGS diets on belly quality




[a,b]Means with different letters differ ($P < 0.05$)

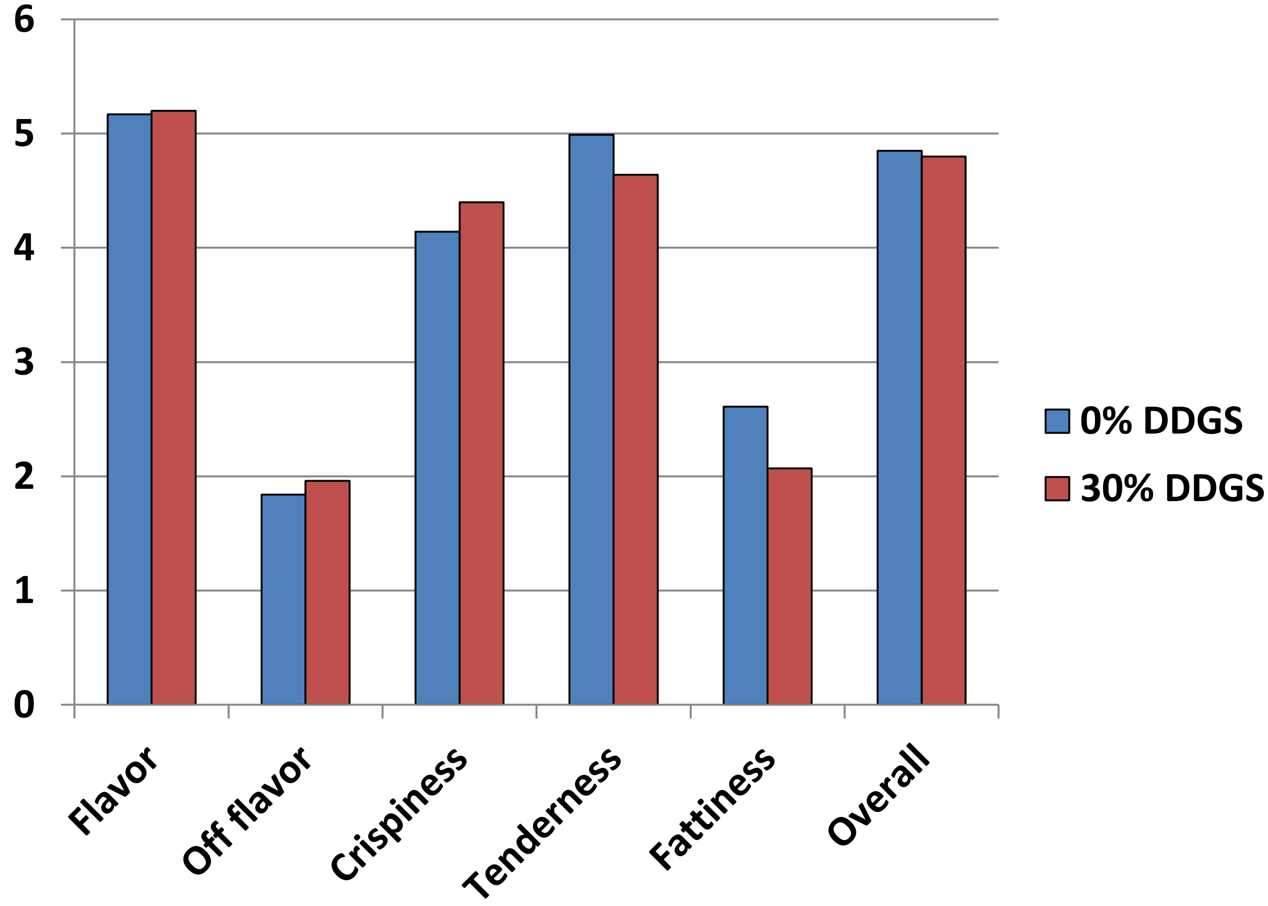
Xu et al. (2009)

# Feeding 30% DDGS diets has no effect on sensory characteristics of cooked bacon

**Trained taste panel scores**

**1 to 8 = flavor, crispiness, tenderness, overall**

**1 to 5 = off-flavor, fattiness**




**Xu et al. (2009)**

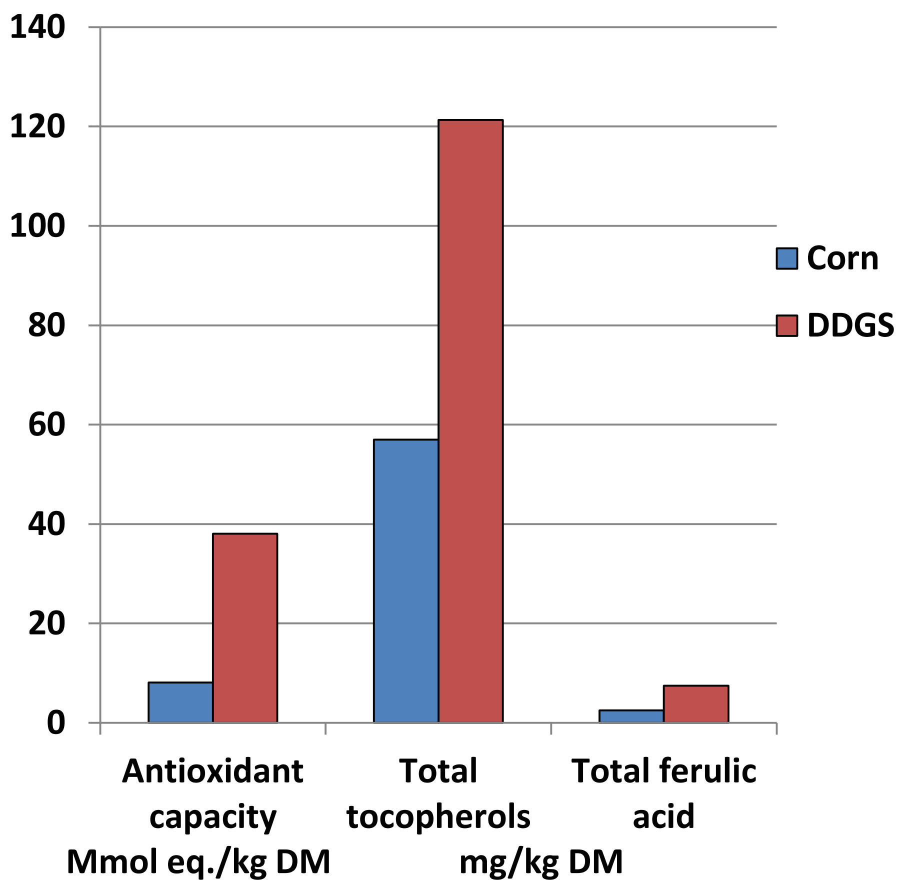
# Prediction equations for estimating effects of feeding DDGS diets on pork fat quality

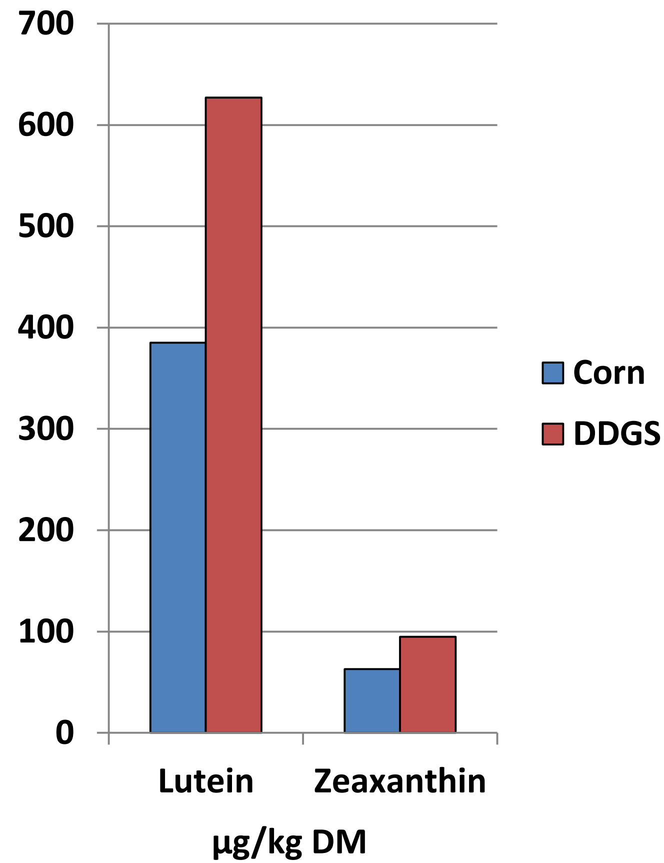
| Source | Equations | PE | Bias |
|---|---|---|---|
| Benz et al. (2011) | 51.946 + 0.2715 × Diet IVP | 6.46 | -5.07 |
| Bergstrom et al. (2010) | 57.89 + 0.18 × Diet IVP | 6.18 | -4.24 |
| Boyd et al. (1997) | 52.4 + 0.315 × Diet IVP | 4.60 | -2.18 |
| Restrepo et al. (2013) | 60.13 + 0.27 × Diet IVP | 5.03 | 3.03 |
| Madsen et al. (1992) | 47.1 + 0.14 × IVP/day | 6.44 | -4.98 |
| Cromwell et al. (2011) | 64.5 + 0.432 × % DDGS in diet | 8.26 | 7.10 |
| Restrepo et al. (2013) | 70.06 + 0.29 × % DDGS in diet | 9.19 | 8.00 |
| Benz et al. (2011) | 35.458 + 14.324 × Diet C18:2, % | 8.21 | -1.21 |
| **Paulk et al. (2015)** | **-** | **3.98** | **-0.91** |

**Wu et al. (2015)**

# Feeding DDGS diets may improve pig health

# DDGS has high antioxidant capacity

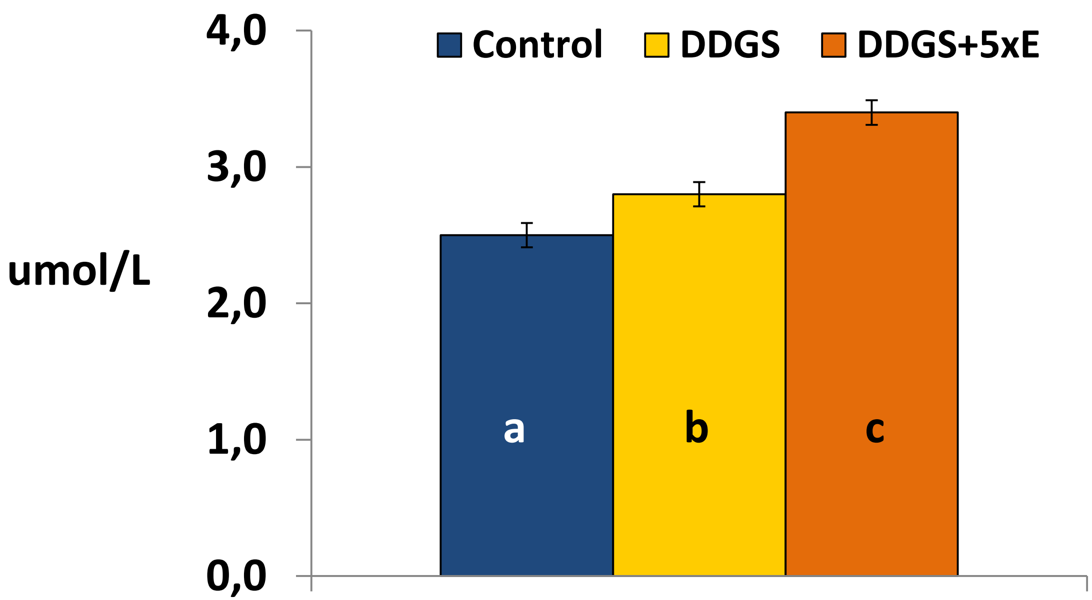



Shin et al. (2017)

# Feeding peroxidized DDGS increases serum α-tocopherol

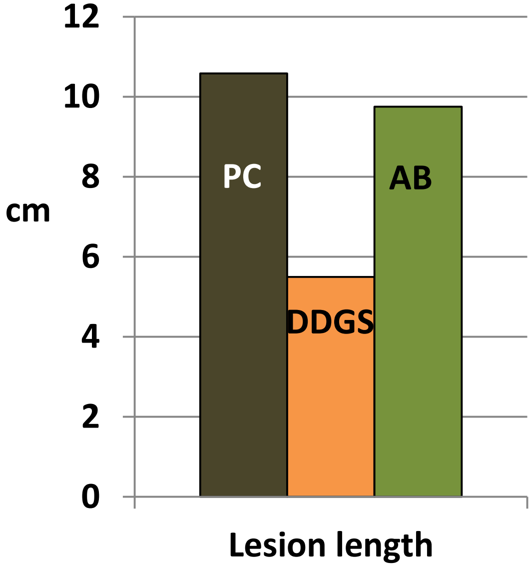
## <u>No pigs developed Mulberry Heart Disease</u>

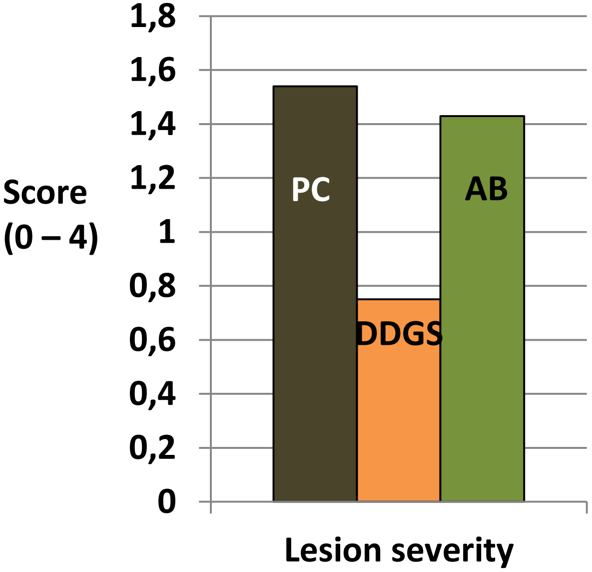


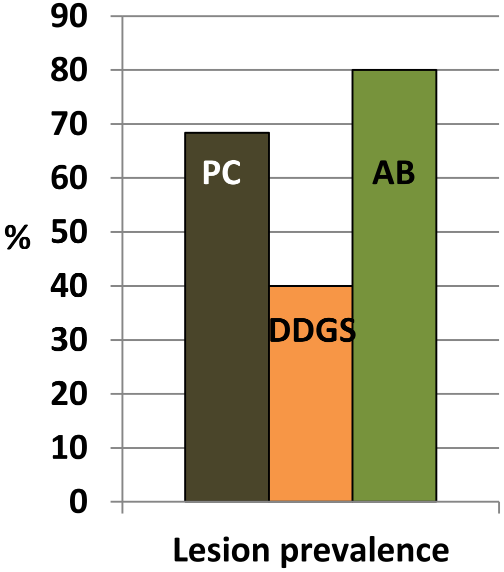

[a,b,c]Means with different letters differ ($P < 0.05$)

**Hanson et al. (2015)**

# DDGS reduces intestinal lesions in pigs infected with *Lawsonia intracellularis*




Whitney et al. (2006)

# Virus survival in feed ingredients from Trans-Pacific and Trans-Atlantic shipment models

| Virus | Soybean Meal | DDGS | Lysine | Choline | Vitamin D |
|---|---|---|---|---|---|
| Seneca Virus A (*surrogate for Foot and Mouth Disease Virus*) | | | | | |
| African Swine Fever Virus | | | | | |
| Porcine Sapelovirus (*surrogate for Swine Vesicular Disease Virus*) | | | | | |
| Porcine Epidemic Diarrhea Virus | | | | | |
| Feline Calicivirus V (*surrogate for Vesicular Exanthema of Swine Virus*) | | | | | |
| Porcine Circovirus Type 2 | | | | | |
| Porcine Reproductive and Respiratory Syndrome Virus | | | | | |
| Bovine Herpesvirus Type 1 (*surrogate for Pseudorabies Virus*) | | | | | |
| Influenza A Virus – Swine | | | | | |
| Bovine Viral Diarrhea Virus | | | | | |
| Canine Distemper Virus (*surrogate for Nipah Virus*) | | | | | |
| Vesicular Stomatitus Virus | | | | | |

Positive

Negative for virus isolation and positive by bioassay

Negative for both virus isolation and bioassay

Dee et al. (2018)

# Effects of feeding DDGS on manure characteristics

## Manure volume increases

| Fecal excretion increases<br>↓ in DM digestibility | Urine excretion not affected |
|---|---|

## N excretion increases

| Excess dietary crude protein (N) | Minimized by using synthetic amino acids |
|---|---|

## P excretion may vary

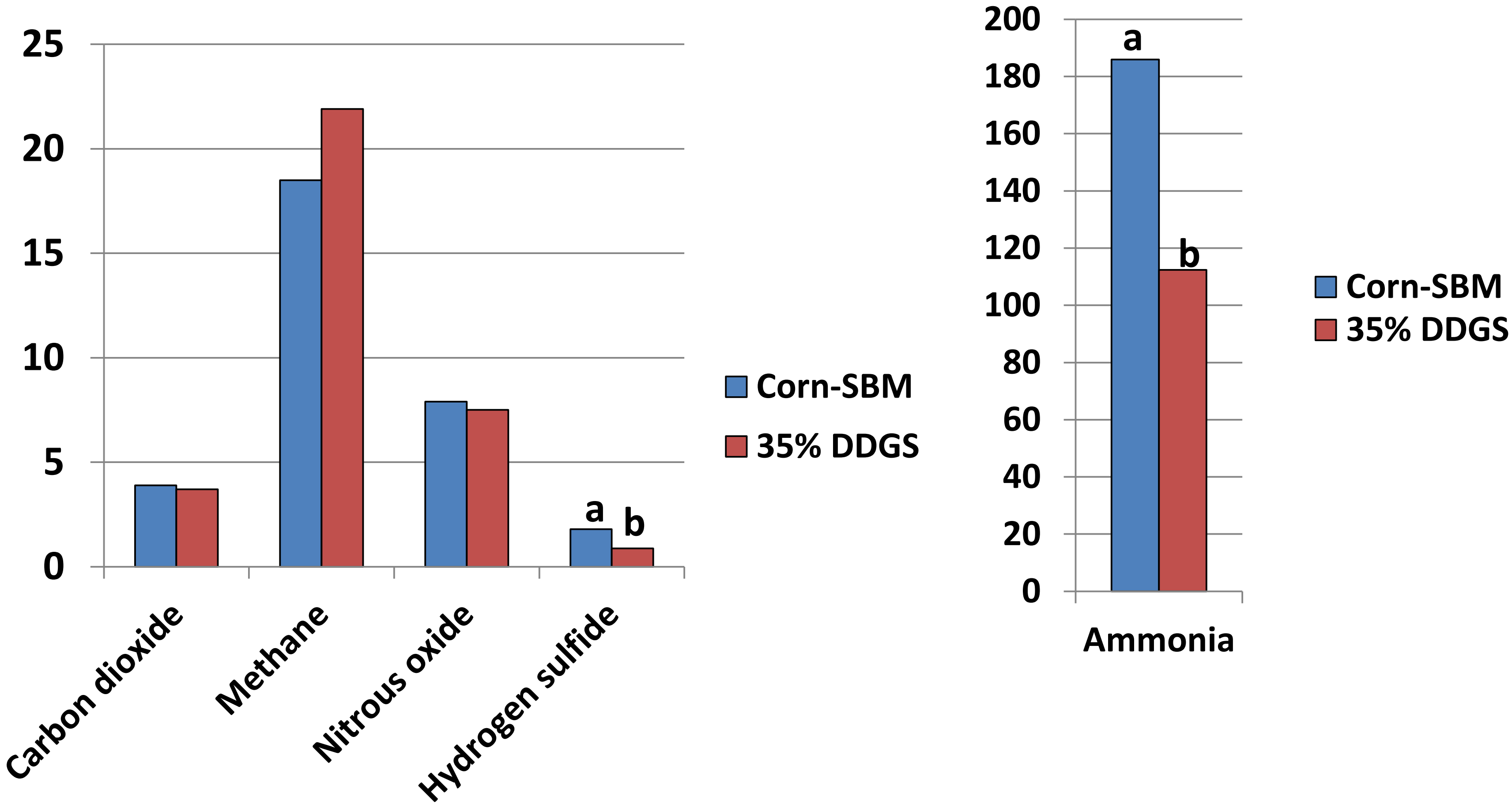
| ↓ < 20% DDGS + phytase | ↑ > 20% DDGS due to excess dietary P |
|---|---|

## Some gas emissions reduced

| Hydrogen sulfide | Ammonia |
|---|---|

## No effect on odor detection levels

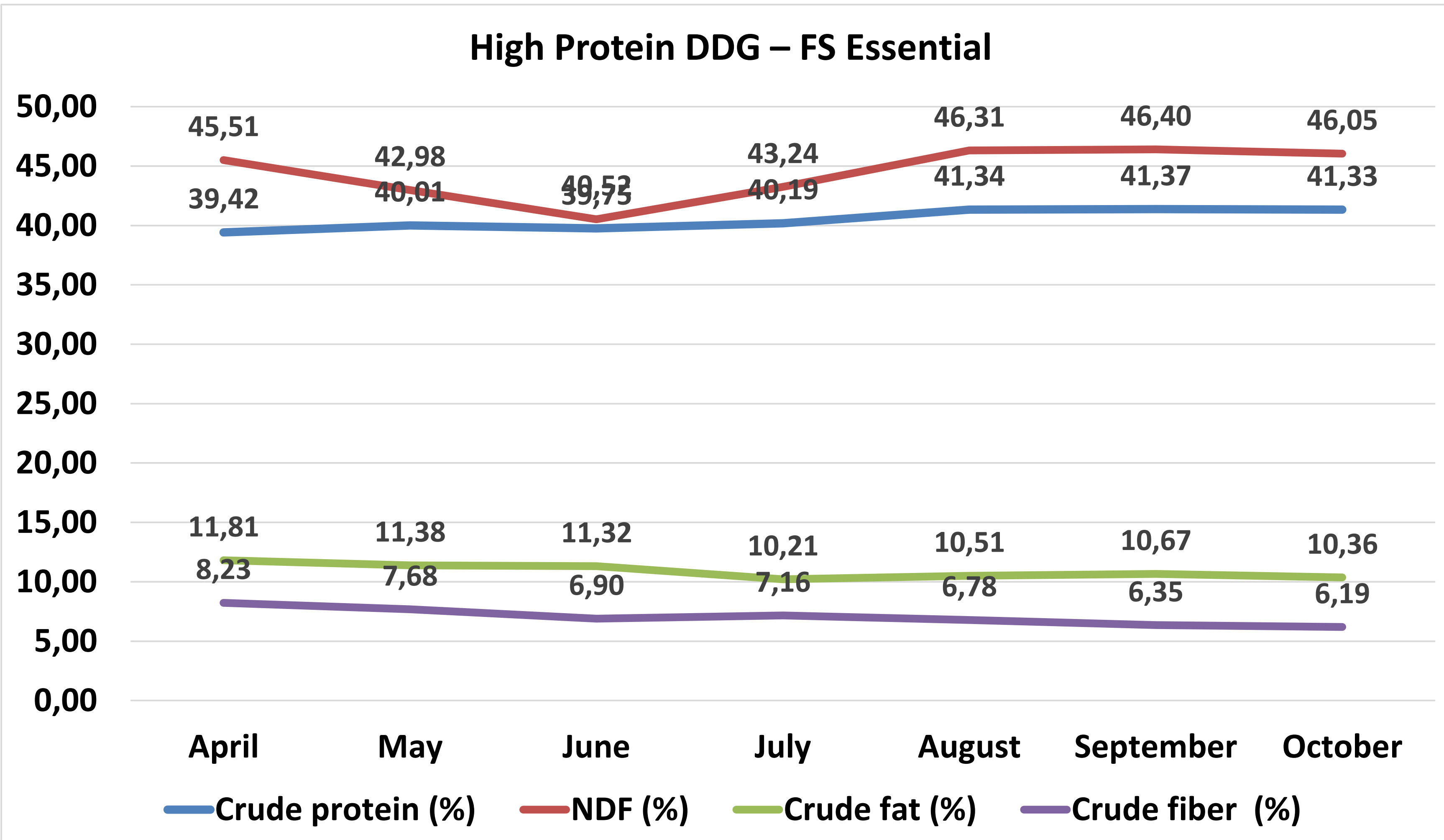
# Hydrogen sulfide and ammonia emissions are reduced from stored swine manure



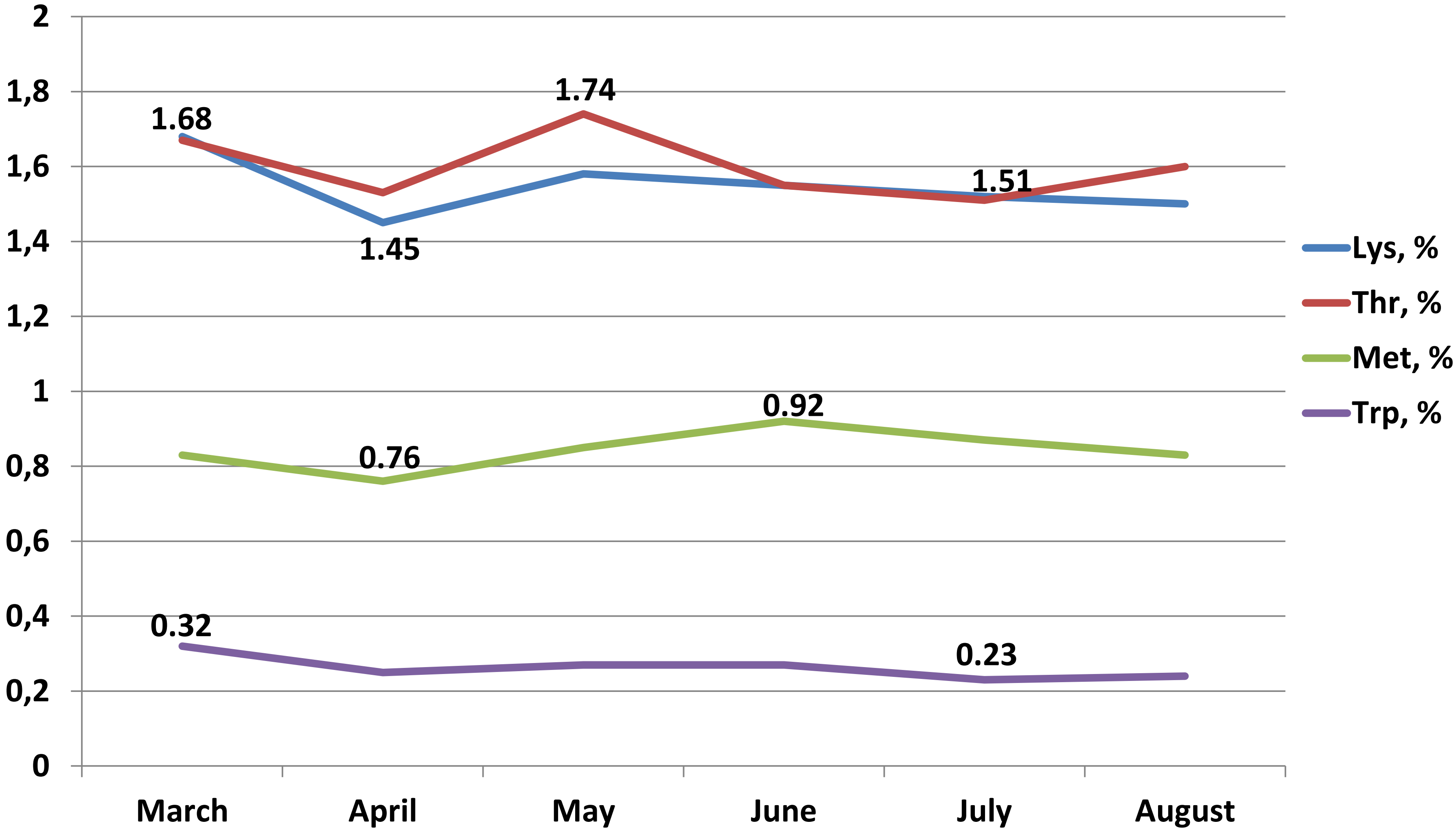

Trabue and Kerr (2014)

# High protein DDG

# Consistency of nutrient content of FS Essential (as-fed basis)



# Consistency of amino acid content of FS Essential (as-fed basis)

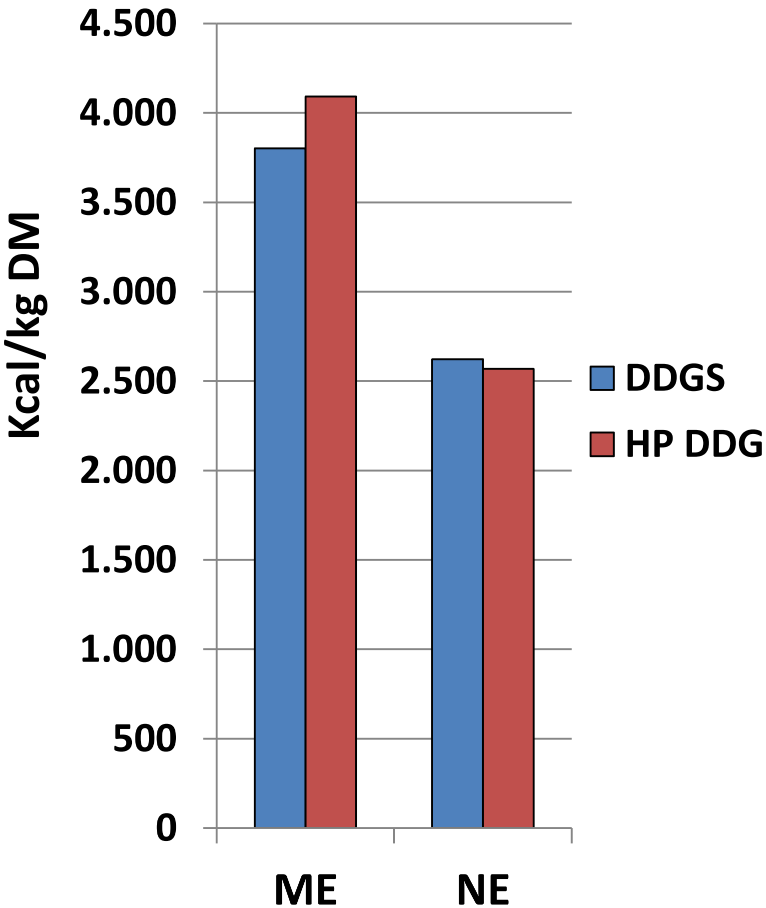


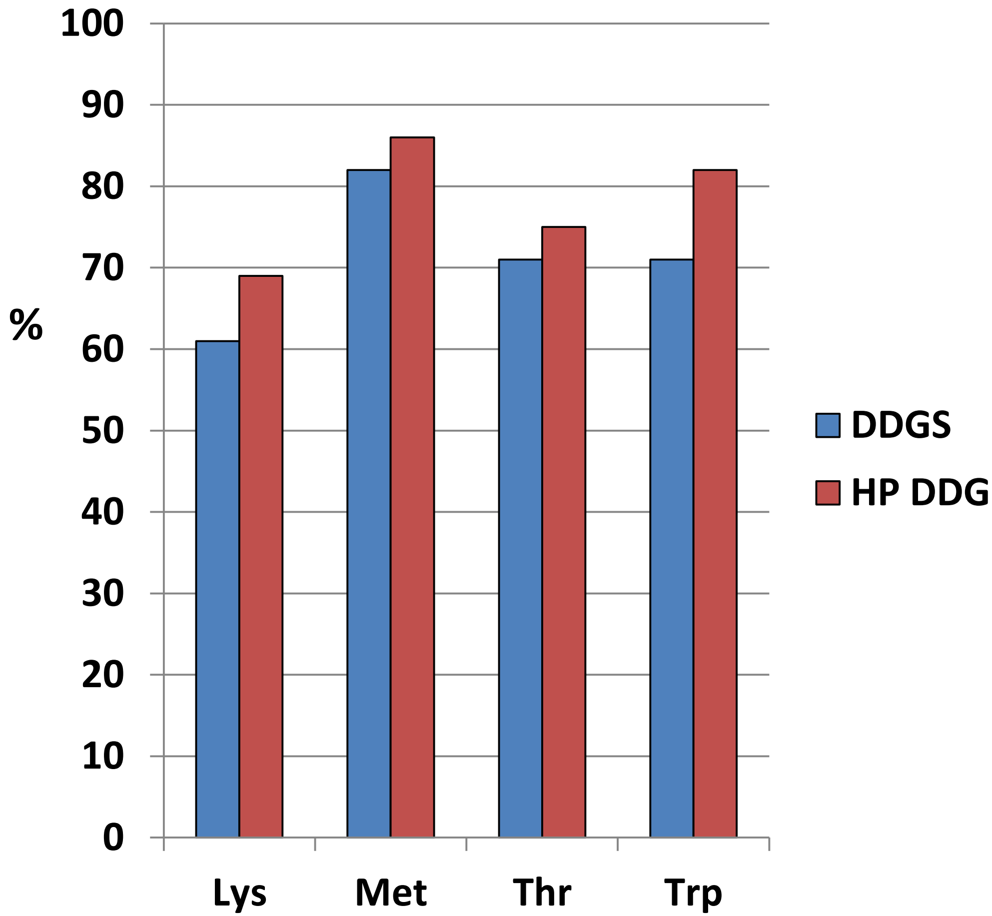
# FS Essential has very low risk of mycotoxins

| Mycotoxin | 3/18 | 3/18 | 4/18 | 4/18 | 5/18 | 5/18 | 6/18 | 6/18 | 7/18 | 7/18 | 8/18 | 8/18 | 9/18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Aflatoxins, ppb** | **ND** | **ND** | **ND** | **ND** | **ND** | **ND** | **ND** | **ND** | **ND** | **ND** | **ND** | **ND** | **ND** |
| **Vomitoxin, ppm** | **ND** | **ND** | **ND** | **ND** | **ND** | **ND** | **ND** | **ND** | **ND** | **ND** | **ND** | **ND** | **ND** |
| **Zearalenone, ppm** | **ND** | **ND** | **ND** | **ND** | **ND** | **ND** | **ND** | **ND** | **ND** | **ND** | **ND** | **ND** | **ND** |
| **Fumonisins, ppm** | **6.7** | **6.2** | **6.5** | **8.9** | **8.4** | **7.0** | **7.9** | **1.9** | **4.3** | **3.0** | **5.2** | **5.8** | **8.2** |

ND = below detection limit

# Comparison of ME, NE content and SID of amino acids of DDGS and HP DDG for swine




NRC (2012)

# Acknowledgements

FS Bioenergia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