

# **Overview of Nutritional Characteristics of DDGS in Aquaculture Feeds**

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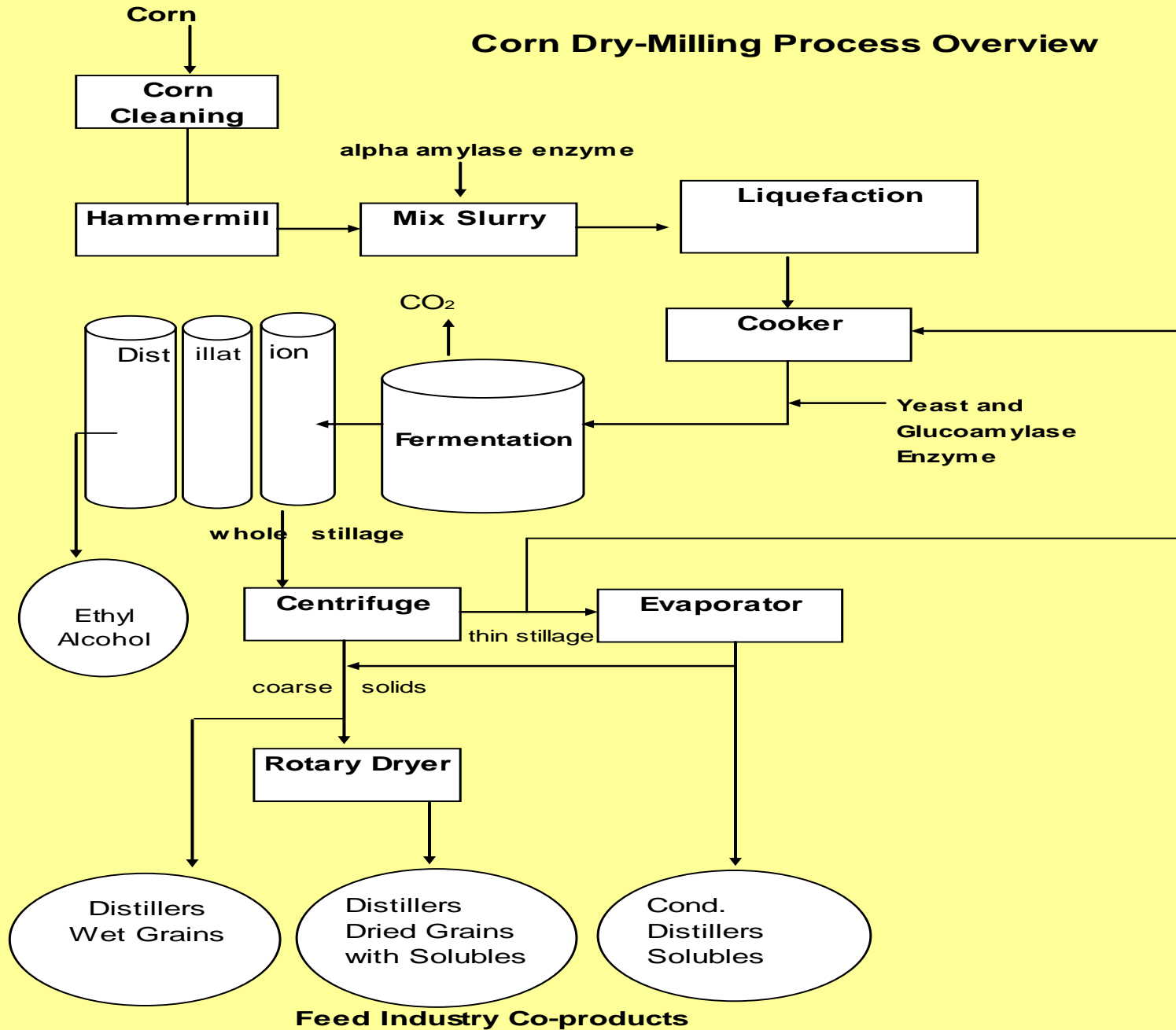
# What is DDGS?

- 27.6 \_\_\_\_\_ **Distillers Dried Grains with Solubles** is the product obtained after the removal of ethyl alcohol by distillation from the yeast fermentation of a grain or a grain mixture by condensing and drying at least  $\frac{3}{4}$  of the solids of the resultant whole stillage and drying it by methods employed in the grain distilling industry. The predominating grain shall be declared as the first word in the name.

AAFCO (2006)



# Corn Dry-Milling Process Overview

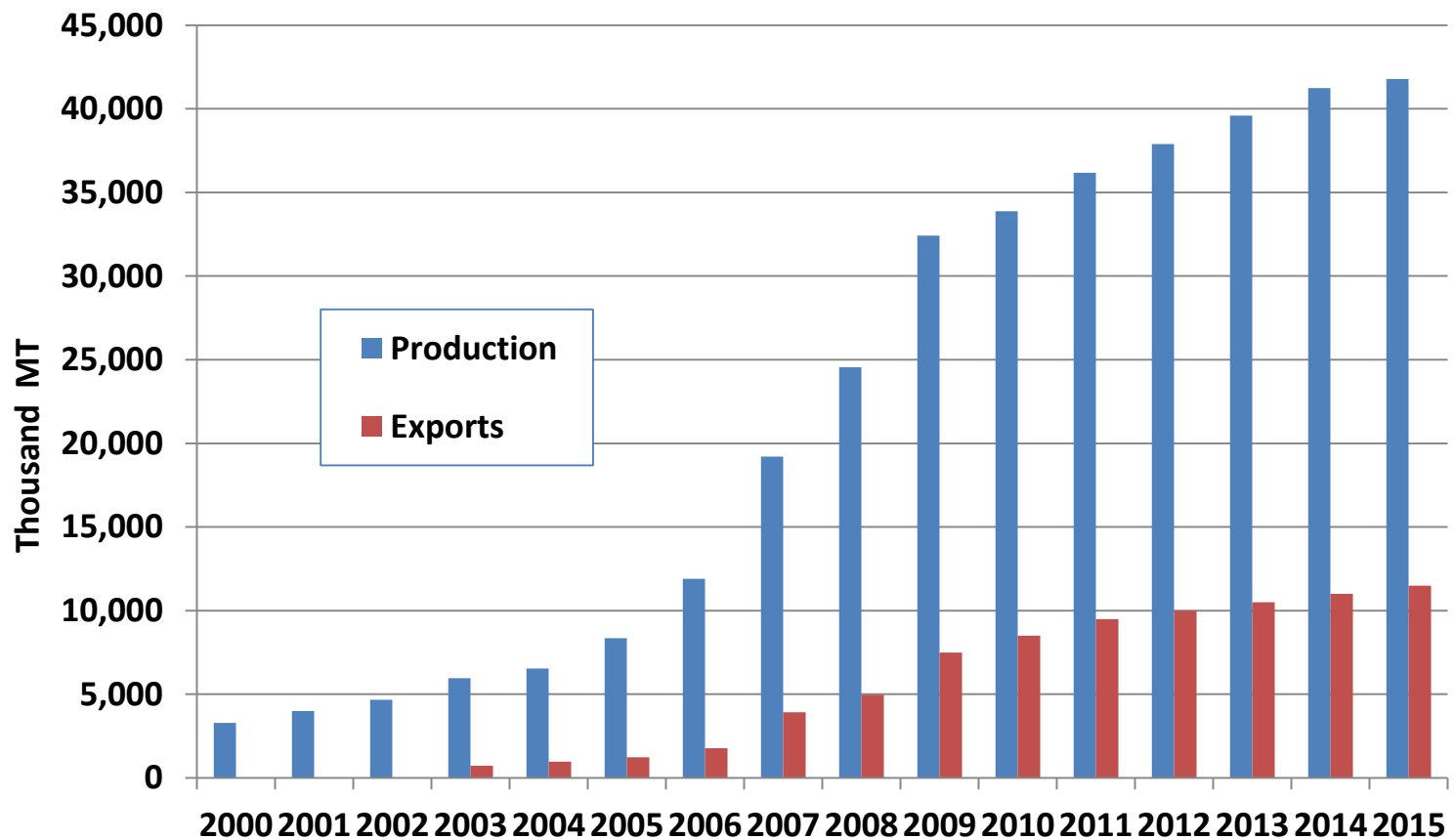


# U.S. DDGS production

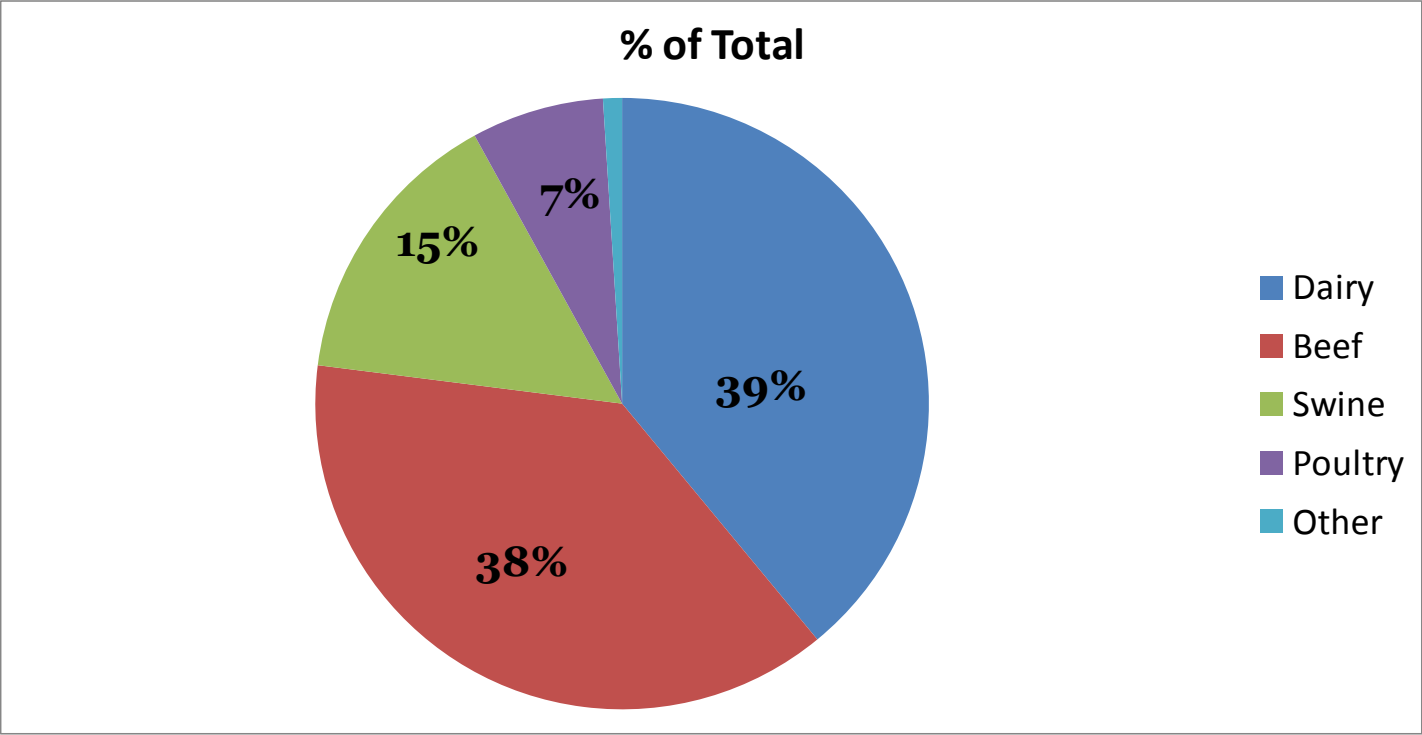
- Currently 207 ethanol plants in 29 states
  - Majority are dry-grind vs. wet mill
  - Most have capacity to produce 378 million L ethanol produced/yr
  - Plants operate 354 days/yr
  - 378 million L plants produce 5,625 MT tons of DDGS/week
  - Plant DDGS storage capacity is <1 wk
- 2011 – 36.5 million MT wet and dried distillers grains will be produced



# U.S. DDGS production and exports (Sep-Aug Marketing Year)



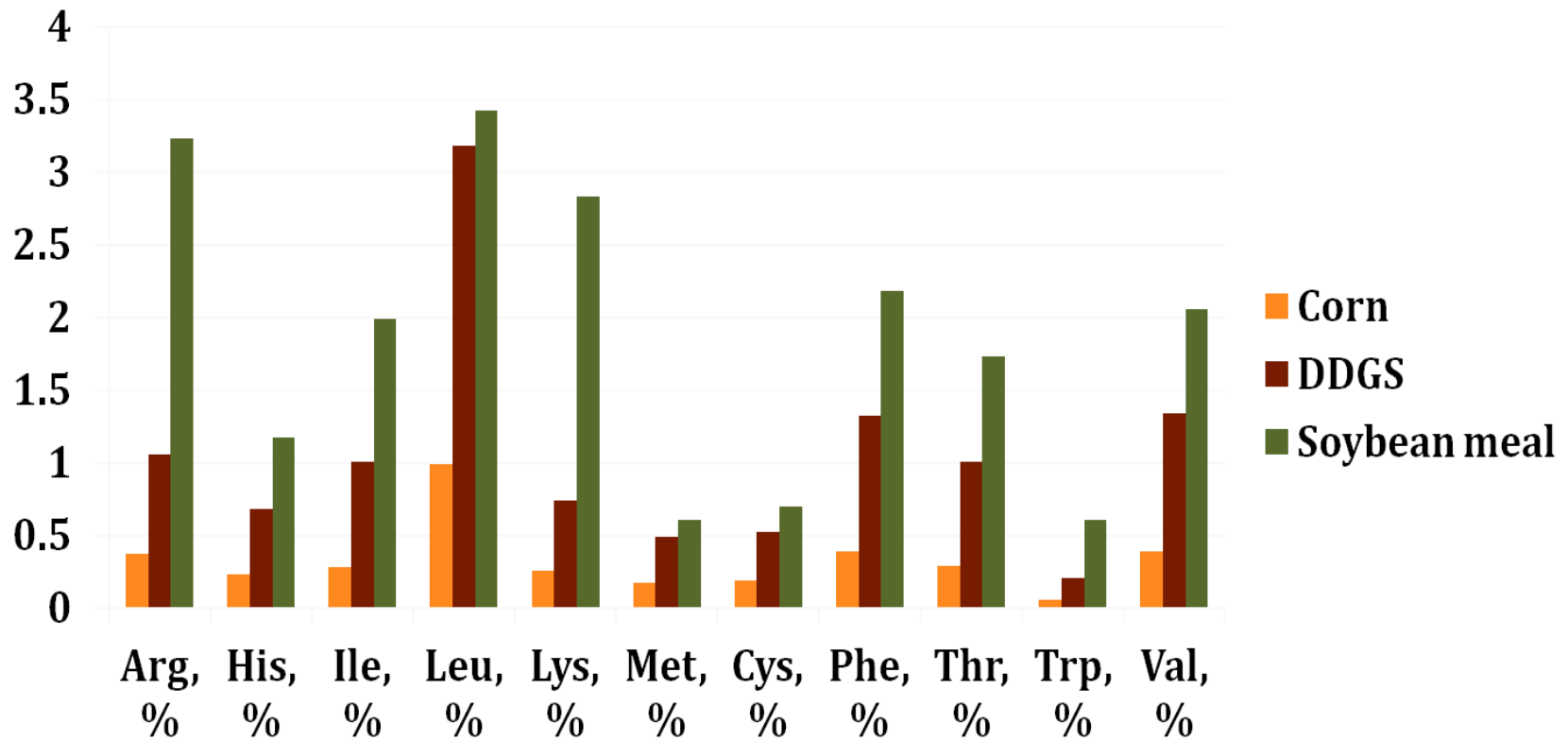
# Distribution of DDGS use in food animal production in the U.S.



# Corn DDGS is nutritionally different and often confused with other co-products

	<b>DDGS</b>	<b>Corn Gluten Feed</b>	<b>Corn Gluten Meal</b>	<b>Corn Germ Meal</b>	<b>Brewer's Dried Grains</b>
<b>Crude Protein, %</b>	<b>30.6</b>	<b>23.9</b>	<b>66.9</b>	<b>22.2</b>	<b>28.8</b>
<b>Crude Fat, %</b>	<b>10.7</b>	<b>3.3</b>	<b>3.2</b>	<b>1.1</b>	<b>7.9</b>
<b>NDF, %</b>	<b>43.6</b>	<b>37.0</b>	<b>9.7</b>	<b>41.8</b>	<b>52.9</b>
<b>Swine DE, kcal/kg</b>	<b>4011</b>	<b>3322</b>	<b>4694</b>	<b>3521</b>	<b>2283</b>
<b>Swine ME, kcal/kg</b>	<b>3827</b>	<b>2894</b>	<b>4256</b>	<b>3417</b>	<b>2130</b>
<b>Lys, %</b>	<b>0.83</b>	<b>0.70</b>	<b>1.13</b>	<b>1.00</b>	<b>1.17</b>
<b>Met, %</b>	<b>0.55</b>	<b>0.39</b>	<b>1.59</b>	<b>0.67</b>	<b>0.49</b>
<b>Thr, %</b>	<b>1.13</b>	<b>0.82</b>	<b>2.31</b>	<b>1.22</b>	<b>1.03</b>
<b>Trp, %</b>	<b>0.24</b>	<b>0.08</b>	<b>0.34</b>	<b>0.22</b>	<b>0.28</b>
<b>Ca, %</b>	<b>0.06</b>	<b>0.24</b>	<b>0.06</b>	<b>0.33</b>	<b>0.35</b>
<b>Available P, %</b>	<b>0.80</b>	<b>0.54</b>	<b>0.08</b>	<b>0.17</b>	<b>0.21</b>

# Amino acid content in corn, DDGS, and soybean meal





# DDGS - General Nutritional Characteristics

- High energy
  - High and variable crude fat
  - High insoluble fiber
  - Low starch
- Mid-protein
  - Poor protein quality (low lysine)
  - Digestibility varies due to drying processes
- High available P
  - Low phytate
- DDGS and soybean meal are complimentary
  - Possible to replace the majority of fish meal?
- No antinutritional factors found in other plant derived feed ingredients



# DDGS - General Nutritional Characteristics

- Crude protein (27%)
  - Low lysine (0.75%)
  - Low methionine (0.50%)
  - Low threonine (1.00%)
  - Low tryptophan (0.25%)
  - Digestibilities determined for rainbow trout
    - (> 90% except threonine)
- Phosphorus (0.75%)
  - Availability not yet determined in fish but should be high
  - Low phytate
- Only one study has been published (Cheng and Hardy, 2004) that evaluated nutrient digestibility of DDGS in fish diets.



# Variability in nutrient composition of DDGS among sources



# Composition of selected nutrients among 32 DDGS sources (DM basis)

Nutrient	Average (CV, %)	Range
Dry matter, %	89.3	87.3 – 92.4
Crude protein, %	30.9 (4.7)	28.7 – 32.9
Crude fat, %	10.7 (16.4)	8.8 – 12.4
Crude fiber, %	7.2 (18.0)	5.4 – 10.4
Ash, %	6.0 (26.6)	3.0 – 9.8
Lysine, %	0.90 (11.4)	0.61 – 1.06
Phosphorus, %	0.75 (19.4)	0.42 – 0.99

# Variation in digestible crude protein and amino acid content in 34 sources of corn DDGS for swine

<b>Nutrient</b>	<b>Maximum</b>	<b>Minimum</b>	<b>CV,%</b>
Crude protein, %	28.3	18.8	12.2
Lysine, %	0.77	0.33	18.4
Methionine, %	0.66	0.40	12.6
Threonine, %	0.96	0.68	10.2
Tryptophan, %	0.21	0.10	15.8

# DDGS color varies among sources

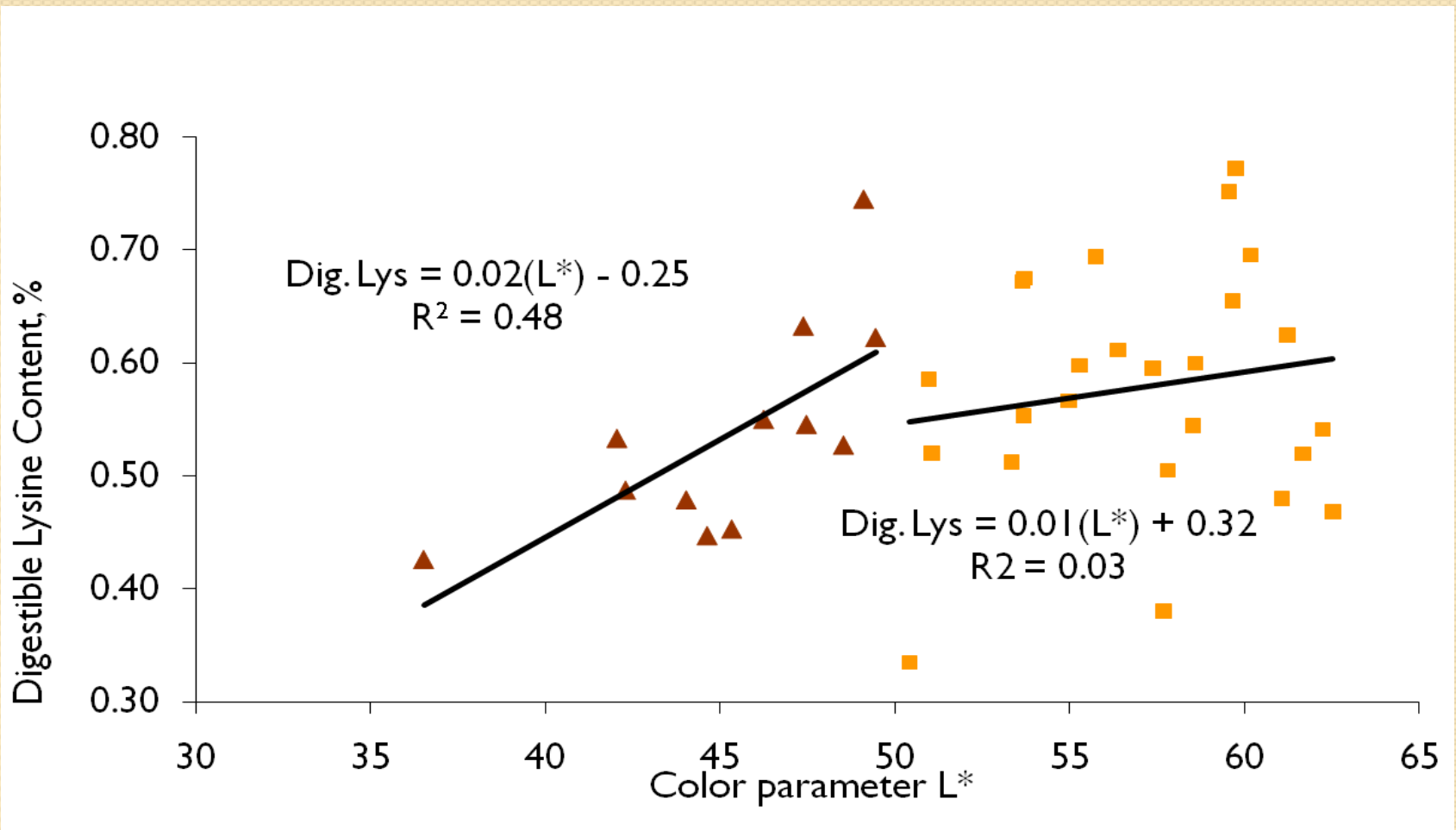


# Is color an indicator of DDGS quality?



- Negative effects of dark color
  - May indicate excessive heat used during drying
    - Maillard reaction – reduces amino acid digestibility
  - May indicate increased lipid oxidation
  - May indicate reduced xanthophyll content

# Relationship between color (L\*) and digestible lysine content in 36 sources of DDGS for swine





# Is color an indication of DDGS quality?



- Positive effects of dark color
  - May indicate more solubles added to grains to produce DDGS
    - Increased fat, energy, ash, phosphorus
    - Reduced crude protein and crude fiber
  - May indicate increased P availability

# DDGS - General Nutritional Characteristics

- Crude fat (5 to 12%)
  - 65% unsaturated fatty acids
    - 56% linoleic acid (C18:2)
    - 8% linolenic acid (C 18:3)
    - 0.14% DHA (C 22:6)
  - High  $\omega$  6 (58%):  $\omega$  3 (0.7%)
- Fiber
  - 7 % crude fiber
  - 11% ADF
  - 38 % NDF
  - 32 % TDF
  - Fiber digestibility has not been determined in fish
- Starch (2 – 9%)
  - Digestible or resistant starch?



# DDGS - General Nutritional Characteristics

- Yeast – 4 to 7%
  - Contributes 5.3% of protein content in DDGS
  - 7.6%  $\beta$ -glucans in DDGS
  - Immunological benefits
- Xanthophyll (3 to 30 mg/kg)
  - Can be a significant contributor to pigmentation



# Immunological benefits of DDGS in fish diets

- Resistance to *Edwardsiella ictaluri* in channel catfish fed up to 40% DDGS (Lim et al., 2009)



- Increased hemoglobin and hematocrit
- Increased total serum immunoglobulin
- Increased antibody titers 21 d post-challenge

- Resistance to *Streptococcus iniae* in Nile tilapia fed up to 40% DDGS (Lim et al., 2007)



- Hematological and immunological measures were not affected by diet

# Extrusion Studies with DDGS for Aquafeeds

- In general, high levels of fiber in DDGS are problematic, especially at high concentrations
  - Critical considerations for pelleting DDGS diets:
    - Die geometry
    - Temperature
    - Moisture content
    - Screw speed
- Various binding materials improve pellet durability and unit density
- Viable floating feeds containing 60% DDGS can be produced under specific conditions (Chevanan et al., 2007)
  - Unit density values from 0.24 g/cm<sup>3</sup> to 0.61 g/cm<sup>3</sup> – all pellets floated
  - Durability values ranged from 96 to 98%



# Published DDGS Research in Fish

- Tilapia



- Wu et al. (1994)
- Wu et al. (1996)
- Wu et al. (1997)
- Coyle et al. (2004)
- Shelby et al. (2008)
- Abo-State et al. (2009)
- Schaeffer (2009)

- Channel catfish



- Tidwell et al. (1990)
- Webster et al. (1991)
- Webster et al. (1992a, b)
- Webster et al. (1993)
- Robinson and Li (2008)
- Zhou et al. (2010)

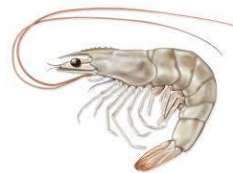


- Rainbow trout

- Phillips (1949)
- Sinnhuber (1964)
- Phillips et al. (1964a)
- Fowler and Banks (1976)
- Smith et al. (1980)
- Hughes (1987)
- Cheng et al. (2003)
- Cheng and Hardy (2004a,b)
- Stone et al. (2005)

- Freshwater prawns

- Tidwell (1993a, b)
- Coyle (1996)



- Pacific white shrimp

- Lim et al. (2009)

- Sunshine bass

- Thompson et al. (2008)

# Use of Corn DDGS in Aquaculture Diets



# Current Recommendations for Maximum Dietary Inclusion Rates of DDGS for Various Species of Fish

<b>Species</b>	<b>% DDGS</b>	<b>Comments</b>
Catfish	Up to 40%	Replacement for corn and soybean meal with lysine supplementation
Trout	Up to 15%	Without synthetic lys and met supplementation to replace 50% of fish meal
Trout	Up to 22.5%	With synthetic lys and met supplementation to replace 75% of fish meal
Freshwater Prawns	Up to 40%	Can replace some or all of the fish meal in the diet
Shrimp	Up to 10%	No studies are available but based upon research results with freshwater prawns, a minimum of 10% DDGS in shrimp should be acceptable.
Tilapia	Up to 35%	Without synthetic lys and supplementation in high protein diets (40% CP)
Tilapia	Up to 82%	With synthetic lys and trp supplementation in low protein diets (28% CP)



# Conclusions

- Use of DDGS in aquafeeds has been limited
- Opportunities exist to use significant quantities of DDGS in aqua feeds
  - We need more research
  - Inclusion rates are highest in species with greater ability to utilize fiber
    - Vary based on type of ingredients substituted
    - Levels of other protein sources (e.g. fish meal)
  - Supplemental lysine, methionine, and other amino acids are needed to meet requirements
    - High protein feeds may limit DDGS inclusion rates without adequate amino acid supplementation

# Conclusions

- DDGS is a valuable ingredient in aquafeeds
  - High in linoleic acid but low in other essential fatty acids
  - Excellent source of digestible P
  - No concerns about antinutritional factors
  - May provide immunological benefits
  - High quality pellets can be produced



# Conclusions

- DDGS is a valuable ingredient in aquafeeds
  - Diet inclusion rates of 20 to 40% DDGS have been successfully used in diets for:
    - Channel catfish
    - Tilapia
  - 15% DDGS can be used in rainbow trout diets



