Usefulness of Rendered Products in Poultry Feeds

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Auburn University
Animal Protein Products

- One-third to one-half of the weight of food production animals is not consumed by humans.

- Primary products: Meat and bone meal, meat meal, poultry meal, hydrolyzed feather meal, blood meal, fish meal, and animal fats.

- The primary products of rendering are feed ingredients for livestock, poultry, aquaculture, and pet-food industries.

- For poultry: Rendering serves two-fold – 1) Feed ingredient supplier and 2) Removal of inedible waste for human consumption.
Advantages of APM with Poultry

• Good source of digestible amino acids.

• Good source of phosphorous and is highly available.

• Source for metabolizable energy

• Can reduce cost in diet formulation.

• Can improve foot pad quality in meat birds.
Opportunities of APM with Poultry

- Variation in nutrient composition

- Variation in digestibility of amino acid content. This can be affected by the raw materials used.

- Potential for microbial contamination if recontaminated.

- Price can be problematic, particularly if the high quality products are diverted to pet-food.
• Amino Acids Composition and Digestibility of APM

• Phosphorus Availability of APM

• Oxidation of PBM

• Metabolizable Energy of Poultry Fat and Meat and Bone Meal
Amino Acids

• Chemical compound containing C, H, O, N, and sometimes S

• Large molecules with large molecular weights which vary widely in chemical composition

• Dietary requirement decreases with age

• Most costly nutrient
Ideal Protein = Barrel Stave Concept = Ideal Ratios

Lysine
Methionine
Threonine (TSAA)

Valine
Tryptophan

Arginine
Isoleucine

4th-7th?
4th-6th?
5th-7th?

2nd
3rd

1st

Feed Formulation Strategies Using Amino Acids

• Adoption of Ideal Amino Acid Profile (*Ideal AA Ratios = Ideal Protein = Balanced Protein*) to set minimum digestible Essential Amino Acid levels relative to digestible Lysine.
  – **Ideal protein concept**: defined as the amino acid profile which exactly meets the animals’ requirement for protein accretion and maintenance. *Fuller et al., 1989*
  – Assures amino acid balance.

• Transition from Crude Protein to Digestible Amino Acids.
Key Amino Acid Matrix Value Entries

- **Total Amino Acid Value (tAA)**
  - Determined preferably by Wet Chemistry.

- **Digestibility Coefficient (DC)**
  - Apparent
  - True
  - Ileal

- **Digestible Amino Acid Value (dAA)**
  - This should be calculated from the two above
    \((dAA = tAA \times DC/100)\), using global equation within formulation software.
  - NOTE: Assumes DC is entered as whole number.
## TRUE AMINO ACID DIGESTIBILITY VALUES FOR POULTRY
### INGREDIENT INFORMATION: MEAT & BONE MEAL (HIGH QUALITY)

#### Choose Ingredient:
MEAT & BONE MEAL (High Quality)

### AVERAGE VALUES

<table>
<thead>
<tr>
<th></th>
<th>Lysine</th>
<th>Methionine</th>
<th>Cysteine</th>
<th>TSAA</th>
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<td>50.96</td>
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<tr>
<td>CP %</td>
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<table>
<thead>
<tr>
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<th>Leucine</th>
<th>Histidine</th>
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<td>87.55</td>
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<td>81.33</td>
<td>0.17</td>
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### STANDARD DEVIATIONS

<table>
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### ADJUSTED VALUES

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<tr>
<td>Dig %</td>
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<td>77.04</td>
<td>0.25</td>
<td>0.35</td>
<td>74.88</td>
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</tbody>
</table>

% of the SD to include in Adjusted Values:

Total % | DC %
--------|-------
0       | -50   

NOTE: Enter a Negative Value to Adjust the Average Values Downwards.

### RATIOS PRINT MAIN MENU
Meat and Bone Meal–Lys

% Apparent Ileal Digestibility

% Total Lys content

Ravindran et al., 2002
True AA Digestibility

32 Commercial Meat and Bone Meal Samples

Wang and Parsons, 1998
Effects of Temperature on AA Digestibility

Lysine
Methionine
Threonine

Wang and Parsons, 1998
Effects of Processing System on AA Digestibility

Total residence or processing time ranged from 15 to 240 min

Wang and Parsons, 1998
Dealing with AA Variability of APM

- Diet formulation on a digestible amino acid (AA) basis
- Relatively low inclusion levels (~5%)
- Safety margins for AA

- Animal protein blends
  - Contain various animal by-products
  - Supplemental AA
In Vitro Evaluation of AA Quality

• Pepsin digestibility assay

• Immobilized digestive enzyme assay (IDEA) (Novus International, Inc.)
  – Provides prediction of AA digestibility

• Poultry Complete IDEA for APM
  – Fish meal: Highly correlated with in vivo values: $R^2$ values 0.73 for Lys to 0.99 for Arg (Boucher et al., 2009)

• Useful tools for nutritionists
Objective

- To evaluate a novel digestive enzyme assay (PC IDEA) (Poultry Complete IDEA, Novus Int., Inc.) and pepsin digestibility as indicators of SIAAD of 20 APM in broilers
Dietary Treatments

• Total of 21 dietary treatments:
  – Treatments 1 to 20: SP diets containing 1 APM as the sole source of dietary AA (20 % CP)
  – Treatment 21: N-free semi-purified diet for determination of endogenous AA flow

• Experimental diets were mixed for each cage (126 diets) to allow independent values of SIAAD, PC IDEA, and pepsin digestibility.
# Methionine

<table>
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<tr>
<th></th>
<th>SIAAD</th>
<th>PC IDEA</th>
<th>Pepsin</th>
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<tr>
<td>Mean</td>
<td>75.2</td>
<td>71.5</td>
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<tr>
<td>SEM</td>
<td>1.3</td>
<td>0.8</td>
<td>0.3</td>
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<tr>
<td>P-value</td>
<td>&lt;0.001</td>
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**Pepsin**

- P-value: <0.001
- $r = 0.591$
- PC IDEA: 0.638

![Graph showing Methionine levels over APM](image-url)
Lysine

<table>
<thead>
<tr>
<th>Mean</th>
<th>SIAAD</th>
<th>PC IDEA</th>
<th>Pepsin</th>
</tr>
</thead>
<tbody>
<tr>
<td>74.8</td>
<td>61.9</td>
<td>89.0</td>
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<table>
<thead>
<tr>
<th>SEM</th>
<th>1.4</th>
<th>1.2</th>
<th>0.3</th>
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</table>

<table>
<thead>
<tr>
<th>P-value</th>
<th>0.582</th>
<th>0.630</th>
</tr>
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</table>

$P$-value < 0.001

$r = 0.582$

$P$-value < 0.001

%
Phosphorus

- Essential for animal growth and development
- Bone formation
- DNA structure
- Buffering
- Membrane component
- Signal transduction
- Energy “currency”
Feeding Phosphorus to Animals

- All plant and animal feed ingredients have phosphorus
  - Non-phytate phosphorus (nPP)
  - Phytate phosphorus

Not sufficient to sustain rapidly growing production animals.
# Animal Protein Meals

<table>
<thead>
<tr>
<th></th>
<th>CP</th>
<th>CF</th>
<th>Ash</th>
<th>Ca</th>
<th>P</th>
<th>Na</th>
<th>K</th>
<th>Cl</th>
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<tr>
<td><strong>All APM</strong></td>
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<td></td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>Max</td>
<td>61.8</td>
<td>13.1</td>
<td>45.0</td>
<td>19.9</td>
<td>9.4</td>
<td>1.30</td>
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<td>1.55</td>
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<td>Avg</td>
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<td>26.7</td>
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<td>4.8</td>
<td>0.71</td>
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<tr>
<td>Min</td>
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<td>4.1</td>
<td>16.8</td>
<td>5.9</td>
<td>2.3</td>
<td>0.34</td>
<td>0.13</td>
<td>0.10</td>
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<td><strong>Meat and bone meals</strong></td>
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<td></td>
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<tr>
<td>Max</td>
<td>55.6</td>
<td>10.9</td>
<td>45.0</td>
<td>19.9</td>
<td>9.4</td>
<td>1.3</td>
<td>0.48</td>
<td>1.37</td>
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<tr>
<td>Avg</td>
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<td>9.4</td>
<td>30.9</td>
<td>11.6</td>
<td>5.9</td>
<td>0.76</td>
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<td>0.55</td>
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<tr>
<td>Min</td>
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<td>19.2</td>
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<td>4.3</td>
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<tr>
<td>Max</td>
<td>61.8</td>
<td>13.1</td>
<td>28.4</td>
<td>10.0</td>
<td>5.1</td>
<td>1.30</td>
<td>0.63</td>
<td>1.55</td>
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<tr>
<td>Avg</td>
<td>57.5</td>
<td>9.2</td>
<td>22.6</td>
<td>7.7</td>
<td>3.7</td>
<td>0.66</td>
<td>0.40</td>
<td>0.65</td>
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<tr>
<td>Min</td>
<td>50.1</td>
<td>5.0</td>
<td>16.8</td>
<td>5.9</td>
<td>2.3</td>
<td>0.34</td>
<td>0.21</td>
<td>0.23</td>
</tr>
</tbody>
</table>
Six samples of poultry byproduct meal

Three samples of bovine meat and bone meal

Four samples of porcine meat and bone meal

Four samples of mixed bovine and porcine meat and bone meal
Poultry Byproduct Meal

Waldroup and Adams, 1994
Meat and Bone Meal

Waldroup and Adams, 1994
Dozier et al. (unpublished data)

- 34 dietary treatments were fed from 8 to 21 d of age in four trials. In each trial, 680 birds were allocated to 68 battery cages.

- Negative control (0.15% NPP) and 10 APM sources were added to the negative control diet to achieve nonphytate phosphorus levels of 0.25, 0.35, and 0.45%.

- At 22 d of age, 3 birds per pen were euthanized by carbon dioxide asphyxiation. Right tibia was removed from each bird for ultimate shear strength and ash measurements.
Results

• Broilers fed diets containing 10 APM sources did not differ ($P = 0.23$) for shear strength, ash, and relative P bioavailability.

• Relative bioavailability ranged from 98 to 128% and 92 to 137%, respectively, for shear strength and ash.
Challenges With Poultry By-Product Meal

- Nutrient variability
- Fat quality: Oxidation
Examined fat stability and its variability in feed-grade and pet-food grade sources of poultry by-product meal.

Initial peroxide, 4 and 20-h active oxygen method, and ethoxyquin were measured.
Materials and Methods

• Forty-six samples were obtained from commercial feed mills from Delaware, Georgia, North Carolina, South Carolina, and Virginia during winter and summer months.

• Twenty-one samples were Pet-Food Grade and 25 samples were Feed-Grade.
Initial Peroxide Value, Summer

<table>
<thead>
<tr>
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<th>Pet-Food Grade</th>
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<tbody>
<tr>
<td>Maximum</td>
<td>116.2 mEq/kg</td>
<td>326.0 mEq/kg</td>
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<tr>
<td>Minimum</td>
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<tr>
<td>Average</td>
<td>42.6 mEq/kg</td>
<td>123.9 mEq/kg</td>
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SD = 118.1
SD = 20.4
Ethoxyquin, Summer

- Feed-Grade
- Pet-Food Grade

Maxium: 440 ppm (SD = 164), 156 ppm

Minimum: 20 ppm (SD = 64), 20 ppm

Average: 135 ppm, 62 ppm
Increased Feed Ingredient Costs


- Broiler or egg/feed price ratio per 1 lb broiler live weight
- Broiler or egg/feed price ratio per 1 doz market eggs

Objectives

• Compare ME of feed-grade and pet-food grade sources of poultry by-product meal

• Determine $\text{AME}_n$ of poultry fat in broiler chicks from 2 to 6 weeks of age

• Determine $\text{AME}_n$ and fat digestibility of fat and oil samples in broiler chicks from 26 to 28 d of age

• Ascertain $\text{AME}_n$ of meat and bone from 14 to 21 d of age
TME, Pet-Food Grade

Avg = 3,351
SD = 36
TME, Feed-Grade

Sample 1: 3326 kcal/kg, Avg = 3,249 kcal/kg, SD = 333 kcal/kg
Sample 2: 2775 kcal/kg
Sample 3: 3555 kcal/kg
Sample 4: 3339 kcal/kg
AME, Poultry Fat

Kim and Dozier, 2010
AME\textsubscript{n} Determination

\begin{equation*}
P < 0.001 \\
SEM = 246
\end{equation*}

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<thead>
<tr>
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<td>2</td>
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<td>6</td>
<td>Poultry</td>
</tr>
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<td>7</td>
<td>A-V Blend</td>
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<td>8</td>
<td>Soybean Oil</td>
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Pre-Planned Orthogonal Contrasts

\begin{tabular}{llllll}
1 vs. 2 & Linear & Lack of Fit & 1 vs. (3, 4, 5) & 6 vs. (3, 4, 5) & 7 vs. (3, 4, 5) & 8 vs. (3, 4, 5) \\
<0.001   & 0.69   & 0.79        & 0.41           & 0.22           & 0.98           & 0.71           \\
\end{tabular}
Fat Digestibility

$P < 0.001$
SEM = 1.1

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Pre-Planned Orthogonal Contrasts

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91.6$^a$, 89.8$^{ab}$, 88.4$^{ab}$, 89.0$^{ab}$, 86.8$^{bc}$, 86.7$^{bc}$, 91.4$^a$
Metabolizable Energy of Porcine Meat and Bone Meal

Bolarinwa et al., 2012
Summary

• Variability of amino acid content can be problematic and *in vitro* tools and NIR equations can assist in managing variability.

• Reduced antioxidant content can influence oxidation in animal protein meals particularly during the summer.

• Animal protein meals can be a good source of energy and phosphorus.