Effect of rate and extent of starch digestion on broiler and laying hen performance

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Background

- Starch is the most important energy source in poultry

- Factors affecting rate and extent of starch digestion include:
  - Size of the granule
  - Degree of crystallinity
  - Amylose:amylopectin ratio
  - Encapsulation

(Parada & Aguilera, 2011)
Starch classification

RDS: Rapidly digested starch
SDS: Slowly digested starch
RS: Resistant Starch

- Energy source for ileum
- Fermentation
- Nutrient sensing
- Post-absorptive effects

(Reddy & Hudson, 1996)

www.roysfarm.com
Energy source for ileum

Normal

L-glutamate + Food Particles → L-glutamate oxidation = Energy

SDS

Starch + Food Particles → L-glutamate oxidation + starch oxidation = Energy
Fermentation

Protein

Starch, fibre & sugar

Microbial Fermentation

Ammonia

Volatile Fatty Acids

Nocek & Russell, 1988; Scienecenews.org
Engelking, 2011

Brain
Kidney
Muscle
Adipose tissue

Glucose

Meal
Intestine
Glycemic index

In Vitro

Plasma glucose

In Vivo

Plasma insulin

(Seal et al., 2003)
Poultry – In vitro starch digestion (%)

(Weurding et al., 2003)
Feed:Gain (g/g)

<table>
<thead>
<tr>
<th>Digestible lysine content (g/kg)</th>
<th>Pea-Corn</th>
<th>Tapioca-Corn</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.50</td>
<td>1.59</td>
<td>1.63</td>
</tr>
<tr>
<td>9.13</td>
<td>1.57</td>
<td>1.60</td>
</tr>
<tr>
<td>9.75</td>
<td>1.54</td>
<td>1.57</td>
</tr>
<tr>
<td>10.38</td>
<td>1.57</td>
<td>1.57</td>
</tr>
<tr>
<td>11.00</td>
<td>1.52</td>
<td>1.54</td>
</tr>
</tbody>
</table>

(Weurding et al., 2003)
Objective

- To determine the effects of starch digestibility rate and extent on the performance of broiler chickens and laying hens using semi purified starch sources

Hypothesis

- Slowly or poorly digestive starch will result in more feed efficient broiler and egg production
Broiler Production Trial
## Materials – Starch sources

<table>
<thead>
<tr>
<th></th>
<th>Starch (%)</th>
<th>Moisture (%)</th>
<th>CP (%)</th>
<th>Fibre (%)</th>
<th>Fat (%)</th>
<th>Ash (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>92.50</td>
<td>7.00</td>
<td>0.30</td>
<td>0.10</td>
<td>0.06</td>
<td>0.00</td>
</tr>
<tr>
<td>Pea</td>
<td>80.00</td>
<td>5.78</td>
<td>6.31</td>
<td>1.71</td>
<td>0.89</td>
<td>0.95</td>
</tr>
</tbody>
</table>

Wheat Starch + Pea Protein = Pea Starch

<table>
<thead>
<tr>
<th>Starter diet</th>
<th>0 SDS</th>
<th>20 SDS</th>
<th>40 SDS</th>
<th>60 SDS</th>
<th>80 SDS</th>
<th>100 SDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat Starch</td>
<td>51.74</td>
<td>41.39</td>
<td>31.04</td>
<td>20.69</td>
<td>7.24</td>
<td>0.00</td>
</tr>
<tr>
<td>Pea Starch</td>
<td>0.00</td>
<td>11.87</td>
<td>23.74</td>
<td>35.61</td>
<td>51.04</td>
<td>59.35</td>
</tr>
<tr>
<td>Pea Protein</td>
<td>7.61</td>
<td>6.09</td>
<td>4.57</td>
<td>3.05</td>
<td>1.07</td>
<td>0.00</td>
</tr>
<tr>
<td>Total starch</td>
<td>59.35</td>
<td>59.35</td>
<td>59.35</td>
<td>59.35</td>
<td>59.35</td>
<td>59.35</td>
</tr>
</tbody>
</table>
# Methods

- 4500 Ross 308 broiler chickens
- 6 rooms of 12 floor pens/room (32 kg/m²)
- RCBD: 6 diets x 2 gender blocked by room
- Duration: 31 days

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>20</th>
<th>40</th>
<th>60</th>
<th>80</th>
<th>100</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Males</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>36</td>
</tr>
<tr>
<td>Females</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>36</td>
</tr>
<tr>
<td>Total</td>
<td>12</td>
<td>12</td>
<td>12</td>
<td>12</td>
<td>12</td>
<td>12</td>
<td>72</td>
</tr>
</tbody>
</table>
Methods

- Data collection
  - Dietary analysis
  - Body weight
  - Feed intake
  - Mortality
  - Meat yield

- SAS 9.3
  - Mixed model
  - Regression analysis
  - Significance level \( P < 0.05 \)
Results – *In vitro* digestibility (%)
Body weight gain (kg) 0-31 d

Linear regression $P = 0.0016$
(Quadratic response approached significance $P = 0.0904$)
Feed Intake (Kg) 0-31 d

Male Ross 308 = 2.74
Female Ross 308 = 2.47

M: Linear regression P = 0.0054  (Quad. P = 0.0555)
F: No regression
Feed efficiency (G:Fm) 0-31 d

Ross 308 = 0.68

Quadratic regression P = 0.0001
Meat Yield
Meat Yield – Live Weight

Linear regression $P = 0.0046$
Meat Yield – Carcass weight
(% of Live weight)

Quadratic regression approaches signific. P = 0.0814
Meat Yield – Breast meat
(% of Live weight)

Linear regression P = 0.0349
Meat Yield – Breast skin
(% of Live weight)

Linear regression P = 0.0096
Meat Yield – Thigh meat
(% of Live weight)

Quadratic regression P = 0.0234
Meat Yield – Whole drum
(% of Live weight)

Quadratic regression P = 0.0247
Meat Yield – Drum skin
(% of Live weight)

Linear regression P = 0.0022
Meat Yield – Abdominal fat (% of Live weight)

![Bar chart showing meat yield as a percentage of live weight across different abdominal fat levels. The chart shows a linear regression with P = 0.0081 and a quadratic response that approached significance with P = 0.0987.]

Linear regression $P = 0.0081$

(Quad. Resp. approached significance $P = 0.0987$)
Conclusion

- Low levels of SDS improved broiler performance
- Inclusion of SDS increased breast, thigh meat and whole drum yield
- Skin weight decreased as SDS inclusion increased
- Apparent shift in the allocation of resources from fat to muscle
Broilers vs. laying hens

- Age
- Development of digestive tract
- Microbial community
- Different feeding patterns
Laying Hen Production Trial
Materials & Methods

- 720 Lohmann LSL hens 26 weeks old

- Conventional cages (503 cm$^2$/bird)

- Dietary treatments:
  - 0, 20, 40, 60, 80 & 100 SDS

- Duration of the experiment: 20 weeks
Material & Methods

- Data collection
  - Dietary analysis
  - Feed intake
  - Daily egg production
  - Egg quality
  - Body weight

- SAS 9.3
  - Mixed model
  - Regression analysis
  - Significance level $P < 0.05$
Body Weight (Kg)

Quadratic regression $P = 0.0021$

Lohmann LSL = 1.73

Lohmann LSL = 1.60
Feed intake (g/hen per day)

Lohmann LSL = 103.5

Linear regression P < 0.0001
Total hen day production (%)

Lohmann LSL = 95.83

Linear regression $P = 0.0102$
(Quad. Reg. approached significance $P = 0.0524$)
Egg weight (g)

Lohmann LSL = 60.70

NO EFFECT
Specific gravity

Quadratic regression $P = 0.0004$
Egg cracks (%)
Egg mass (g/hen housed)

Linear regression $P = 0.0334$
Feed efficiency (Feed g/egg mass)

Quadratic regression $P = 0.0015$
Conclusions

- Intermediate levels of SDS improved egg production
- Quadratic response for FCR mostly related to increased feed intake at high SDS levels
- No effects of SDS on egg weight or quality
Take home message

Incorporation of low levels of starch sources in chicken diets with lower digestion rates and extent of digestion may result in better chicken performance.
Thank you

Questions?