Fiber and nutrient retention responses of supplemental xylanase in broiler chickens fed wheat based diets are independent of the acclimatization period to test diets

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²Institute of Veterinary, Animal and Biomedical Sciences, Massey University, Palmerston North, New Zealand
Variability in wheat nutritive value

AME (MJ/kg) of 12 UK wheat Samples

<table>
<thead>
<tr>
<th></th>
<th>AME (MJ/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>8.43</td>
</tr>
<tr>
<td>B</td>
<td>8.43</td>
</tr>
<tr>
<td>C</td>
<td>9.29</td>
</tr>
<tr>
<td>D</td>
<td>9.43</td>
</tr>
<tr>
<td>E</td>
<td>9.89</td>
</tr>
<tr>
<td>F</td>
<td>10.95</td>
</tr>
<tr>
<td>G</td>
<td>11.22</td>
</tr>
<tr>
<td>H</td>
<td>11.41</td>
</tr>
<tr>
<td>I</td>
<td>12.00</td>
</tr>
<tr>
<td>J</td>
<td>12.63</td>
</tr>
<tr>
<td>K</td>
<td>13.67</td>
</tr>
<tr>
<td>L</td>
<td>13.74</td>
</tr>
</tbody>
</table>

CV = 16%

Performance (7-28 d), CV % (94 samples)

- Feed: 6.7
- Gain: 10.0
- FCR: 4.5


Austin et al. 1999. J. Cereal Sci. 29:77-88
Measurable factors that impact the nutritive value of wheat

Correlation between measured AME in broilers and chemical/physical characteristics of 94 wheat samples

- Soluble NSP: -33.4
- Non-starch polysaccharides: -44.5
- In vitro viscosity: -21.6
- Hardness: -6.8
- Thousands grain weight: 5.7
- Specific weight: 11.4

The value of Supplemental xylanase in improving the nutritive value of wheat for broilers is well proven.

- High response in low AME wheat
- Reduce variability between wheat samples

Many factors (singly or interactively) have been suggested to influence the nutrients utilization & AME responses seen with supplemental xylanases in broilers

<table>
<thead>
<tr>
<th>Enzymes</th>
<th>Dietary</th>
<th>Animal</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Substrate specificity</td>
<td>• Substrate level &amp; matrix</td>
<td>• Age</td>
</tr>
<tr>
<td>• Microbial source</td>
<td>• Substrate source</td>
<td>• Sex</td>
</tr>
<tr>
<td>• Optimal Temp, pH</td>
<td>• Nutrients density</td>
<td>• Breed</td>
</tr>
<tr>
<td>• Dosing</td>
<td>• Nutrients balance</td>
<td>• Microbial load</td>
</tr>
<tr>
<td>• Side activities</td>
<td>• Fat, salt, antibiotics, other activities</td>
<td>• Feed intake</td>
</tr>
<tr>
<td>• Stability in feed</td>
<td>• Diet form</td>
<td>• Husbandry</td>
</tr>
<tr>
<td>• Stability in the gut</td>
<td>• Particle size</td>
<td>• Transit time</td>
</tr>
</tbody>
</table>

Protocols for measuring the efficacy of fiber degrading enzymes such as xylanase on the retention of fiber and nutrients rarely examine the impact of the duration of exposure to test diets.

1. Constant feeding: test diets introduced at d 10 and fed throughout
2. 5 days: commercial chick replaced by test diets 5 days before sampling

Feed enzyme dietary energy uplift has been associated with certain clusters of gut microbial community…. implying that the presence of specific beneficial and/or absence of specific detrimental bacterial species is part of the improved performance seen with supplemental enzymes.

A) $m=7$ ((72.5% of trace (G)))

B) $m=2$ ((89.1% of trace (G))

- Control, barley diet
- Control, plus feed enzyme

Furthermore gut is a Living Ecosystem

...Influenced by age and diet composition

Composition of ileal bacterial community of 3 genetic lines of broilers as determined by terminal restriction fragment length polymorphism analysis.

Lumpkins B S et al. Poultry Science 2010;89:1614-1621

Objective

we evaluated the effects of exposing broilers to xylanase-supplemented diets for 7 or 21 d on fiber and nutrient retention at 21 d of age
## MATERIALS AND METHODS

### Treatments

<table>
<thead>
<tr>
<th>Exposure period</th>
<th>Xylanase*</th>
<th>U/kg of feed</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-21</td>
<td>Control</td>
<td>0</td>
</tr>
<tr>
<td>0-21</td>
<td>Xyl1</td>
<td>2,500</td>
</tr>
<tr>
<td>0-21</td>
<td>Xyl2</td>
<td>5,000</td>
</tr>
<tr>
<td>14-21</td>
<td>Control</td>
<td>0</td>
</tr>
<tr>
<td>14-21</td>
<td>Xyl1</td>
<td>2,500</td>
</tr>
<tr>
<td>14-21</td>
<td>Xyl2</td>
<td>5,000</td>
</tr>
</tbody>
</table>

*Danisco Xylanase: DuPont-Danisco Animal Nutrition, UK

The experimental procedures were approved by the Massey University Animal Ethics Committee and, complied with the New Zealand Code of Practice for the Care and Use of Animals for Scientific Purposes
### MATERIALS AND METHODS

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hard Wheat</td>
<td>49.78</td>
</tr>
<tr>
<td>Wheat Bran</td>
<td>5.00</td>
</tr>
<tr>
<td>Wheat middlings</td>
<td>5.00</td>
</tr>
<tr>
<td>Soybean Meal 44%CP</td>
<td>31.27</td>
</tr>
<tr>
<td>Animal Fat/AV blend</td>
<td>4.35</td>
</tr>
<tr>
<td>L-Lys/Met/Thr</td>
<td>0.35/0.29/0.26</td>
</tr>
<tr>
<td>Sodium Bica/salt</td>
<td>0.10/0.30</td>
</tr>
<tr>
<td>Limestone/MCP</td>
<td>1.51/0.49</td>
</tr>
<tr>
<td>Poultry Vits/TE's</td>
<td>1.00</td>
</tr>
<tr>
<td>Phytase*</td>
<td>0.01</td>
</tr>
<tr>
<td>Titanium dioxide</td>
<td>0.30</td>
</tr>
<tr>
<td>Calculated provisions</td>
<td></td>
</tr>
<tr>
<td>ME, MJ/kg</td>
<td>11.65</td>
</tr>
<tr>
<td>CP, %</td>
<td>21.5</td>
</tr>
<tr>
<td>Dig Lys, %</td>
<td>1.19</td>
</tr>
<tr>
<td>Ca, %</td>
<td>0.88</td>
</tr>
</tbody>
</table>

*Axtra® PHY is a *Buttiauxella* spp. phytase expressed in *T. reesei*

### Analyzed Composition, as fed

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry Matter, %</td>
<td>88.80</td>
</tr>
<tr>
<td>GE, MJ/kg</td>
<td>17.38</td>
</tr>
<tr>
<td>Crude protein, %</td>
<td>22.44</td>
</tr>
<tr>
<td>Fat, %</td>
<td>5.845</td>
</tr>
<tr>
<td>Ca, %</td>
<td>0.636</td>
</tr>
<tr>
<td>P, %</td>
<td>0.593</td>
</tr>
<tr>
<td>Carbohydrates, %</td>
<td></td>
</tr>
<tr>
<td>Starch, %</td>
<td>36.45</td>
</tr>
<tr>
<td>NDF, %</td>
<td>11.82</td>
</tr>
<tr>
<td>ADF, %</td>
<td>3.69</td>
</tr>
<tr>
<td>Hemicellulose, %</td>
<td>8.13</td>
</tr>
<tr>
<td>Non-starch polysaccharides (NSP), %</td>
<td></td>
</tr>
<tr>
<td>Soluble NSP</td>
<td></td>
</tr>
<tr>
<td>Arabinose</td>
<td>0.66</td>
</tr>
<tr>
<td>Xylose</td>
<td>0.88</td>
</tr>
<tr>
<td>Total soluble NSP</td>
<td>2.78</td>
</tr>
<tr>
<td>Insoluble NSP</td>
<td></td>
</tr>
<tr>
<td>Arabinose</td>
<td>1.93</td>
</tr>
<tr>
<td>Xylose</td>
<td>2.67</td>
</tr>
<tr>
<td>Total insoluble NSP</td>
<td>10.12</td>
</tr>
<tr>
<td>Total NSP</td>
<td>12.90</td>
</tr>
</tbody>
</table>

DuPont-Danisco Animal Nutrition, UK
A total of 384 male broiler (Ross 308) DOC

8 chicks per cage

Group 1 (d0-21), allocated diets based on d0 BW

Group 2 (d14-21), allocated diets based on d14 BW

The room temperature started at 31°C gradually reduced to 24 °C by d21.

20-hours of fluorescent illumination and free access to the diets and water

Digestibility and retention determined using index method (TiO$_2$)
RESULTS: Performance parameters; d 14-21 (on Test feed)

<table>
<thead>
<tr>
<th>Exposure period</th>
<th>Day 14 to 21 performance, per bird</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>d 14 BW, g</td>
</tr>
<tr>
<td>Long Exposure 0-21 days</td>
<td>428b</td>
</tr>
<tr>
<td>Short Exposure 14-21 days</td>
<td>456a</td>
</tr>
<tr>
<td>SEM</td>
<td>3.73</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Xylanase Level, U/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control 0</td>
</tr>
<tr>
<td>Xylanase dose 1 2,500</td>
</tr>
<tr>
<td>Xylanase dose 2 5,000</td>
</tr>
<tr>
<td>SEM</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Exp. Period</th>
<th>Xylanase Level, U/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long Exposure Control</td>
<td>419</td>
</tr>
<tr>
<td>Long Exposure Xylanase dose 1 2,500</td>
<td>434</td>
</tr>
<tr>
<td>Long Exposure Xylanase dose 2 5,000</td>
<td>432</td>
</tr>
<tr>
<td>Short Exposure Control</td>
<td>452</td>
</tr>
<tr>
<td>Short Exposure Xylanase dose 1 2,500</td>
<td>460</td>
</tr>
<tr>
<td>Short Exposure Xylanase dose 2 5,000</td>
<td>456</td>
</tr>
<tr>
<td>SEM</td>
<td>6.462</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Exposure period</th>
<th>Xylanase</th>
<th>Exp. * Xylanase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long Exposure</td>
<td>0.1908</td>
<td>0.7097</td>
</tr>
<tr>
<td>Short Exposure</td>
<td>0.9198</td>
<td>0.4581</td>
</tr>
</tbody>
</table>

Exp. * Xylanase (P < 0.0001)
There was no interaction \((P>0.05)\) between exposure period and xylanase

### Ileal Digesta

<table>
<thead>
<tr>
<th></th>
<th>Dry Matter</th>
<th>Nitrogen</th>
<th>Fat</th>
<th>Starch</th>
<th>Digestible energy</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Exposure Period</strong></td>
<td>0.0001</td>
<td>&lt;0.0001</td>
<td>&lt;0.0001</td>
<td>0.8939</td>
<td>0.0004</td>
</tr>
<tr>
<td><strong>Xylanase</strong></td>
<td>0.0008</td>
<td>&lt;0.0001</td>
<td>0.0001</td>
<td>&lt;0.0001</td>
<td>0.0008</td>
</tr>
<tr>
<td>*<em>Exp. Pd.<em>Xylanase</em></em></td>
<td>0.890</td>
<td>0.055</td>
<td>0.612</td>
<td>0.936</td>
<td>0.897</td>
</tr>
</tbody>
</table>

### Excreta/Retention

<table>
<thead>
<tr>
<th></th>
<th>Dry matter</th>
<th>Fat</th>
<th>NDF</th>
<th>AMEn</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Exposure Period</strong></td>
<td>&lt;0.0001</td>
<td>0.0238</td>
<td>0.0001</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td><strong>Xylanase</strong></td>
<td>&lt;0.0001</td>
<td>0.0007</td>
<td>&lt;0.0001</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>*<em>Exp. Pd.<em>Xylanase</em></em></td>
<td>0.647</td>
<td>0.540</td>
<td>0.547</td>
<td>0.606</td>
</tr>
</tbody>
</table>

*Values represent p-values*
Xylanase linearly improved ileal nutrients and energy digestibility in broilers fed wheat based diets.

**RESULTS: Effects of Xylanase on Ileal Digestibility**

**Ileal DE, MJ/kg DMI**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>U/kg of feed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>0</td>
</tr>
<tr>
<td>Xyl1</td>
<td>2500</td>
</tr>
<tr>
<td>Xyl2</td>
<td>5000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>DM</th>
<th>Nitrogen</th>
<th>Fat</th>
<th>Starch</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>62.9b</td>
<td>79.1b</td>
<td>86.1b</td>
<td>93.4b</td>
</tr>
<tr>
<td>Xyl1</td>
<td>66.0a</td>
<td>82.5a</td>
<td>88.2a</td>
<td>97.7a</td>
</tr>
<tr>
<td>Xyl2</td>
<td>67.2a</td>
<td>83.0a</td>
<td>89.0a</td>
<td>98.1a</td>
</tr>
<tr>
<td>SEM</td>
<td>0.760</td>
<td>0.439</td>
<td>0.451</td>
<td>0.556</td>
</tr>
</tbody>
</table>

**Contrasts**

<table>
<thead>
<tr>
<th></th>
<th>Linear</th>
<th>Quadratic</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt;0.0001</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td></td>
<td>0.0052</td>
<td>0.0041</td>
</tr>
</tbody>
</table>

**SEM = 0.14**
Xylanase linearly improved nutrient retention and AMEn in broilers fed wheat based diets

**RESULTS: Effects of Xylanase on Retention**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>U/kg of feed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>0</td>
</tr>
<tr>
<td>Xyl1</td>
<td>2500</td>
</tr>
<tr>
<td>Xyl2</td>
<td>5000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>DM</th>
<th>Fat</th>
<th>NDF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>574.6b</td>
<td>55.1b</td>
<td>19.6c</td>
</tr>
<tr>
<td>Xyl1</td>
<td>605.6a</td>
<td>57.1a</td>
<td>31.5b</td>
</tr>
<tr>
<td>Xyl2</td>
<td>616.9a</td>
<td>57.3a</td>
<td>36.2a</td>
</tr>
<tr>
<td>SEM</td>
<td>4.500</td>
<td>0.411</td>
<td>1.582</td>
</tr>
</tbody>
</table>

Contrasts:
- Linear: <.0001
- Quadratic: 0.1614

SEM = 0.08
Shorter exposure to experimental diets resulted in higher apparent ileal nutrients digestibility

<table>
<thead>
<tr>
<th></th>
<th>Dry matter, %</th>
<th>Nitrogen, %</th>
<th>Fat, %</th>
<th>Starch, %</th>
<th>Digestible energy, MJ/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day 14-21</td>
<td>67.2a</td>
<td>83.0a</td>
<td>89.9a</td>
<td>96.4</td>
<td>13.8a</td>
</tr>
<tr>
<td>Day 0-21</td>
<td>63.5b</td>
<td>80.0b</td>
<td>85.7b</td>
<td>96.4</td>
<td>13.2b</td>
</tr>
<tr>
<td>SEM</td>
<td>0.620</td>
<td>0.359</td>
<td>0.368</td>
<td>0.454</td>
<td>0.113</td>
</tr>
</tbody>
</table>
RESULTS: Effects of Exposure Period, at the excreta level

Longer exposure to experimental diets resulted in higher apparent components retention

<table>
<thead>
<tr>
<th></th>
<th>Dry matter, g/kg</th>
<th>Fat, g/kg</th>
<th>NDF, g/kg</th>
<th>AMEn, MJ/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day 14-21</td>
<td>585.1b</td>
<td>56.0b</td>
<td>25.2b</td>
<td>12.9b</td>
</tr>
<tr>
<td>Day 0-21</td>
<td>612.9a</td>
<td>57.1a</td>
<td>33.0a</td>
<td>13.4a</td>
</tr>
<tr>
<td>SEM</td>
<td>3.674</td>
<td>0.335</td>
<td>1.291</td>
<td>0.062</td>
</tr>
</tbody>
</table>

Longer exposure to the test diets may have resulted in stabilization of fiber utilizing microorganisms

Figure 1 Effect of age on total volatile fatty acid levels in the caecum of broiler chickens (Fischer, 2003).

Fisher, 2003, MSc. Thesis
University of Saskatchewan
Summary and conclusions

Independent of test diet exposure period:

- Xylanase linearly improved nutrients and energy utilization in broilers fed wheat based diets
- Xylanase responses on d 21 retention of fiber, nutrients and energy were independent of the test diets (7 or 21 d) exposure

The data also showed that longer exposure resulted in more retained fiber suggesting possible microbial adaptation