Degradation of phytate in soaked diets for pigs

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Introduction. Up to 80% of P in cereals and seeds widely used in pig feed is present as phytate (myo-inositol hexakisphosphate, IP_{6}) (Eeckhout & De Paepe, 1994). Phytate-P is poorly available for absorption by monogastric animals and to compensate for that feed phosphate is often supplied in order to meet the animals’ requirements. Consequently, more than half of the ingested P is often excreted in faeces resulting in serious environmental concern. Removal of phosphate groups from the inositol ring by plant (e.g., Pointillart et al., 1984; 1987) or microbial phytases (e.g., Pallauf et al., 1994a; 1994b) increases the digestibility of phytate-P. However, the effect of microbial phytase supplementation depends strongly on the composition of the diet and the plant phytase activity (Johansen and Poulsen, 2003). In experimental diets without feed phosphate addition, the maximal digestibility of P after microbial phytase supplementation rarely exceeds 60–65% in dry feed even at high levels of supplemented phytase. At present, the use of liquid feed is becoming more and more common in the pig production. A few studies have shown a substantial reduction in phytate content by soaking but only a limited effect on the digestibility of P (Näsi and Helander, 1994; Skoglund et al., 1997; Larsen et al., 1999). A series of experiments has been started in order to study the effect of diet composition, heat-treatment of the diets, phytase activity, time of soaking and temperature on (i) the degradation of phytate in soaked feed (part 1) and (ii) the quantitative amount of generated degradation products of inositol phosphates (IP_{6}-IP_{1}) in soaked feed (part 2). The hypothesis is that it is possible to improve the digestibility of P above 60–65% by a pre-digestion of phytate-P in liquid feeding compared with dry feeding as phytase requires a moist, weak acid and warm environment in order to optimise the split off of the phosphate groups on the inositol ring.

Materials and methods. The study was conducted as an in vitro study. The diets were based on barley and soybean meal or wheat and soybean meal that were either untreated or heat-treated and pelleted at minimum 81°C. Each of the four basic diets (barley or wheat based, non-heat-treated or heat-treated) was supplemented with no phytase or 500 FTU kg^{-1} (Natuphos, BASF). The diets were soaked with water (1:2.75) in 1-l fermentors (closed glass jar) and incubated at 10, 20 or 38°C. At 10 and 20°C, samples of 60 ml were taken at 4, 8, 12, 24, 48 and 72h. At 38°C, samples were taken at 2, 4, 6, 8, 10, 12 and 24h of soaking.

Part 1. pH and dry matter was measured. Phosphorus was analysed by the colorimetric vanadomolybdate procedure (Stuffins, 1967), phytate-P according to the method of Haug and Lantzsch (1983), and phytase activity by the method of Engelen et al. (1994).

Part 2. Further studies are conducted in order to distinguish between the different inositol phosphates present in the soaked feed by means of high-performance liquid chromatography measurements.

Results and discussion. Part 1. In general, phytate degradation was slower in heat-treated diets without phytase supplementation compared with non-heat-treated diets as the heat-processing reduced the plant phytase activity by 75–83%. Table 1 shows the results on barley
based diets as an example. When the heat-treated diets were supplemented with phytase the phytate degradation increased to the same levels as the non-heat-treated diets. On the other hand, addition of phytase to non-heat-treated diets did not improve phytate degradation as the non-heat-treated diets contained a considerably amount of plant phytase. At 10 or 20°C between 17 and 79% of the total amount of phytate in the diets were degraded within the first 8 hours of soaking with the greatest degradation rate at 20°C. However, at 38°C the comparable amount was degraded within 2 h of soaking.

Increasing the temperature resulted in a decrease in pH mainly due to an increase in lactic acid bacteria. Microbial phytase appeared to be considerably more active at lower pH-values than plant phytase, which showed no activity coincidently when pH reached values below 5. More details are published by Carlson and Poulsen (2003).

Table 1. Phytate degradation in the barley-based diets affected by temperature and time of soaking (g phytate-P kg⁻¹ dry matter).

<table>
<thead>
<tr>
<th></th>
<th>10°C</th>
<th>20°C</th>
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<tbody>
<tr>
<td></td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Non-heat-treated</td>
<td>3.3</td>
<td>2.0</td>
</tr>
<tr>
<td>Non-heat-treated + phytase</td>
<td>3.3</td>
<td>1.4</td>
</tr>
<tr>
<td>Heat-treated</td>
<td>3.3</td>
<td>2.9</td>
</tr>
<tr>
<td>Heat-treated + phytase</td>
<td>3.3</td>
<td>1.6</td>
</tr>
</tbody>
</table>

Part 2. Currently, the quantitative amount of inositol phosphates (IP₆-IP₁) in the diets is studied in order to compare the amount of different inositol phosphates as affected by diet composition, heat-treatment, phytase activity, time of soaking and temperature. The accumulation of the different degradation products will furthermore show at which stage the release of the phosphate groups on the inositol ring is lowered or stopped.

Conclusion. Phytate degradation is slower in heat-treated diets compared with non-head-treated diets as the heat processing inactivates to some extent the phytase activity. Addition of phytase to non-heat-treated diets has no effect on phytate degradation whereas phytase addition to heat-treated diets increases the phytate degradation to the same level as in non-heat-treated diets. The rate of phytate degradation increases markedly when the temperature is increased from 10 to 38°C. Microbial phytase is far more active at lower pH values compared with plant phytase which showed no activity at pH-values below 5.

References