Managing phosphorus cycling in agriculture

Reduction of Dutch agricultural phosphorous load through bio-refinery

Introduction

The Dutch agricultural sector has a phosphorous surplus which causes problems with eutrophication of waterways. The phosphorous surplus is caused by the import of phosphorous-rich animal feeds, and only very little export of the resulting manure. The import of phosphorous can be reduced, through a reduction of the animal feed phosphorous content.

For the nutrition of pigs and poultry, it is important to discriminate between easily digestible and organically bound phosphate (usually in the form of fytate). Many fodder crops contain high amounts of fytate that are barely available for the animal. This phosphorous will mainly end up in the manure. Through the removal of fytate from feed, the intake of phosphorous can be reduced without risks for the health of the animals.

Bio-refinery

Bio-refinery involves the fractionation of a raw material through a series of separation steps. As a result, several more or less pure product streams are produced. Because of the high purity of the products, the sum of the value of the fraction is higher than the value of the raw material. Through this strategy, the value of animal feeds can also be increased.

Through extraction, specific fractions can be obtained from the raw material. At low pH, phosphates will dissolve, and at high pH, proteins will dissolve. Through washing, salts (K) can be removed. From the extracts, the phosphates and proteins can be precipitated. In the end, a phosphate precipitate, a protein precipitate, a low NPK wet feed and a digestible water stream will be obtained (Figure 1).

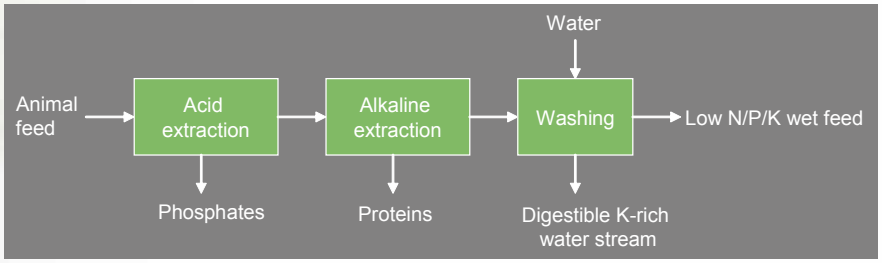

Figure 1, Schematic representation of animal feed bio-refinery

Results 2009/2010

Through acid extraction, phosphates were extracted from animal feeds. The phosphates were precipitated through addition of lime. The precipitate can be upgraded to produce feed supplements or fertilizers. Easily digestible phosphates for the production of feed supplements can be produced from through enzymatic hydrolysis of fytate after acid extraction. The import of feed supplement phosphate can be reduced because of this new easily digestible phosphate product. Another possibility is the precipitation or with potassium to form Struvite which is a valuable fertilizer.

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Through alkaline extraction, a protein rich fraction was produced. After precipitation, this fraction will have a high value on the feed market.
The low NPK wet feed remaining at the end of the process will (in case of a low P policy) have a considerable value on the feed market.
Through counter current extraction, a high recovery can be reached with a low extraction liquid flow (Figure 2). This will also increase the concentration of the extracted component and thus reduce the recovery costs.

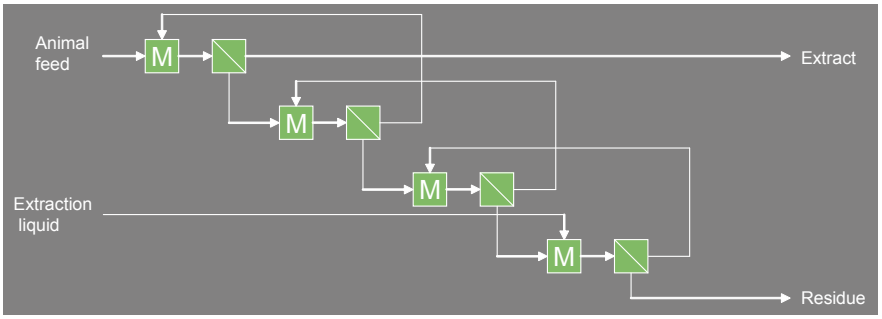

Figure 2. Four stage counter current extraction

A rough economical evaluation has shown that the added value of the process is high enough to justify the required investments. Because the margin is relatively small, the influence of uncertainties and unexpected future changes is high: small changes can radically change the profitability of the process. In the future, the profitability is likely to increase because a world wide shortage of phosphorous is expected. A strong policy on phosphorous load reduction will increase the profitability of the process.

Conclusions, follow-up and recommendations

Conclusions:

- Phosphorous can be removed from fytate-rich animal feeds through bio-refinery.
- Thus, the phosphorous intake of pigs can be reduced without risk of animal health problems as a consequence of phosphorous shortage.
- Thus, the manure phosphorous content will reduced and the Dutch phosphate load is reduced as a consequence.
- The removed phosphorous can be recovered for production of fertilizers of feed supplements.
- The low NPK wet feed can be sold in the feed sector at a reasonable price.
- If a low phosphorous policy is enforced, bio-refinery can help to produce a good quality feed at limited extra costs for the Dutch breeding industry.
- Bio-refinery can prevent the exclusion of fytate rich local side streams (such as wheat middlings) from pig feed.
- Thus, long distance transport of these raw materials is prevented.
- The first rough process design has shown that counter current extraction and drastic water recycling are essential for the feasibility of the process; this substantially adds to the model's complexity.
- Bio-refinery seems economical feasible, but a fair uncertainty remains.
- The technical and financial feasibility of the concept should be studied in more detail.

Follow up and recommendations:

- The process design should be elaborated in more detail.
- A pilot should give more insight into the technical and financial feasibility of the process.

Factsheets Wageningen innovation studies on manure processing:

No. 23 Tentative results from innovation studies in a nutshell
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