LIQUID CO-PRODUCTS: A PRACTICAL OVERVIEW

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ABSTRACT
With a growing world population and unprecedented competition for grains and protein sources, pork producers are looking for alternatives to traditional feed ingredients. Current liquid ingredients from the food and fuel industries already assist in reducing dependence on grain and protein crops while new liquid ingredients are constantly being evaluated. By making small changes to the way they handle, store, analyze and deliver liquid co-products, producers can take full nutritional and economic advantage of them.

INTRODUCTION
Liquid co-products can come from a variety of industries. Food and fuel industries are the key drivers of current and potential co-products. The Ontario marketplace for liquid co-products is fragmented and usually made up of agreements between producers and the manufacturers of the food/fuel product that the co-product is derived from. This is the opposite of the mature co-product marketplace that exists in Northern Europe for both dry and wet co-products. Liquid co-products have potential to provide savings and performance on farm provided some simple and practical guidelines are adhered to. Everything from analysis, storage, and handling to dosing of the product can have an impact the value of a feed ingredient on farm.

CURRENT CO-PRODUCTS

Corn distillers solubles (CDS)
Corn distiller’s solubles are the liquid fraction of dried distiller’s grains with solubles (DDGS) that get added back on to DDGS after ethanol production. This product is currently one of the most commonly used liquid co-products in Ontario. CDS typically has a dry matter (DM) of 27-30% and contains approximately 20-22% crude protein (CP) on a DM basis. It also contains energy in the form of fat, 15-19% on DM basis (de Lange et al., 2006). This makes CDS a valuable feed ingredient provided we remember that it has an amino acid profile that is reflective of corn. The poorer amino acid profile can simply be balanced using other on farm ingredients or via your premix.

Corn steep water (CWS)
Corn steep water is a co-product from the corn wet milling industry which produces corn sweeteners and other corn products. CSW typically has a DM of 35- 40% and a CP of 40% on a DM basis (de Lange et al., 2006). CSW also contains approximately 20% lactic acid on a DM basis (Niven et al., 2006), which not only acts as an energy source for the pig but also helps preserve the product and keep harmful bacteria out. As with CDS, CSW is just a condensed corn AA profile that needs to be balanced properly using various protein sources or synthetic AA’s.
Brewer’s yeast

Brewer’s yeast is the slurry of yeast-containing liquid from beer production. Brewer’s yeast has a cyclical availability tied in to typical beer consumption patterns. The volume tends to reduce during colder months and increase during the warmer months during which people consume more beer. Brewer’s yeast is starting to be dried down and sold to pet food manufacturers and even for human consumption. Brewer’s yeast typically has a dry matter content of 10-15% and a protein content of 45-50% (on a DM basis) (Crawshaw, 2001).

Whey

Liquid whey and whey permeate are actually two separate ingredients. Whey is a co-product of the cheese industry and used to be abundant in Ontario. With increased pressure from human food markets and biogas production whey has become more and more difficult to find and feed. Whole whey is the co-product available from cheese producers that has not undergone any further processing such as condensing or removal of proteins. Whole whey typically has a dry matter content of 4-7% and a protein content of 10-12% (on a DM basis) (Braun and de Lange, 2004, Crawshaw, 2001). Whey permeate is whey that has been taken and passed through filters to remove the proteins which are used in the human food industry for health food products.

Table 1. Nutrient composition and recommended feeding rates of current Ontario co-products.

<table>
<thead>
<tr>
<th></th>
<th>DM(%)</th>
<th>CP(%)</th>
<th>ME (MJ/kg)</th>
<th>Max Inclusion(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CDS</td>
<td>27-30</td>
<td>20-22</td>
<td>13.5-16.5</td>
<td>15</td>
</tr>
<tr>
<td>CSW</td>
<td>35-40</td>
<td>45-50</td>
<td>12.5-14</td>
<td>7</td>
</tr>
<tr>
<td>Brewer’s Yeast</td>
<td>12-15</td>
<td>45-50</td>
<td>15.25-18.75</td>
<td>5</td>
</tr>
<tr>
<td>Whey</td>
<td>4-7</td>
<td>10-13</td>
<td>13.5-14.5</td>
<td>20</td>
</tr>
<tr>
<td>Whey Permeate</td>
<td>20-30</td>
<td>2-8</td>
<td>14-14.5</td>
<td>20</td>
</tr>
</tbody>
</table>

1 Based on DE values from survey of Ontario samples (Braun and de Lange, 2004).

POTENTIAL CO-PRODUCTS

Potato products

Potato co-products such as liquid potato starch and steamed potato peels have been in use in countries such as the Netherlands and parts of Canada for many years. With their food processing industries the supply is abundant and it is a common product. Potato products are primarily an energy source in pig rations but can provide a reasonable amount of protein to the diet in certain forms. When added to a liquid ration, potato products will help hold particles that have poorer water holding capacities in solution and allow for a more homogeneous mix to be sent to the pens. Some producers even take dry potato products such as dehydrated mashed potatoes and French fries and re-constitute them with water to create thick potato slurry that is then stored to be used as an ingredient in their rations.

Liquid wheat starch

Liquid wheat starch is a cornerstone ingredient used in swine liquid feeding in Europe. The use of wheat to produce glucose is very common in Europe and creates a large volume of liquid wheat starch. Liquid wheat starch has many different varieties and trade names, each one with
unique properties. Liquid wheat starch provides protein to rations and much like potato products helps to keep the mix in suspension when it is delivered to the pens. This product is also quite acidic and is palatable to pigs at proper feeding levels.

**Sugar based liquids**

Sugar based liquids would include products such as juice and colas that are primarily an energy source and do not provide a significant amount of protein or minerals. Chocolate products, jams, and syrups such as high fructose corn syrup are other high sugar based liquid products that can be used in liquid feeding. These products are taken directly from the human food industry either as “expired” product or ‘off spec’ during manufacturing. Sugar based liquids are typically benchmarked against corn in swine diets and as a result must contain enough energy to replace corn and be priced accordingly. Sugar based products could effectively replace corn in swine diets and could be a valuable ingredient as energy sources increase in price.

**Sauces**

Sauces such as ketchup, mayonnaise, pasta sauce and others could be a potential ingredient in swine diets. These products could provide energy and flavor to feeds but would need to be fed in very small amounts due to their high sodium contents. Mayonnaise and dip sauce components are usually quite high in fat and are devoid of any valuable proteins. They can also contain significant amounts of sugar which adds to the energy value. Ketchup and pasta sauce would be a less energy dense ingredient as they are lower in fat and sugar but could still provide nutrients to pigs if priced appropriately.

**Table 2. Nutrient composition and recommended feeding rates of potential Ontario co-products.**

<table>
<thead>
<tr>
<th></th>
<th>DM(%)</th>
<th>CP(%)</th>
<th>ME (MJ/kg)</th>
<th>Max Inclusion(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat Starch</td>
<td>20-30</td>
<td>17-20</td>
<td>15-16</td>
<td>15</td>
</tr>
<tr>
<td>Potato</td>
<td>13-20</td>
<td>8-15</td>
<td>14-22</td>
<td>10</td>
</tr>
<tr>
<td>High Sugar Products</td>
<td>10-60</td>
<td>0-8</td>
<td>14.75-19</td>
<td>5</td>
</tr>
<tr>
<td>Sauces</td>
<td>20-60</td>
<td>0-2</td>
<td>NA</td>
<td>2-3</td>
</tr>
</tbody>
</table>

1 Based on DE values from Co-Product Feeds (Crawshaw, 2001).

**STORAGE AND HANDLING**

One of the most overlooked elements of co-product usage is the storage and handling of that product. In Ontario the typical liquid fed farm has 2-4 underground concrete tanks capable of holding up to 40 MT of liquid each. The contents of these tanks are typically agitated using a manure pump and recirculation valve at the time of mixing. This system is quite economical but is far from optimal. In Northern Europe liquid storage is almost exclusively done in above ground concrete or polyester tanks that are no more than 3.5 x 3.5 m in width and can be up to 6 m deep depending on the need for storage. The tanks are open topped for easy viewing of the products being stored and have top mounted agitators in the centre of the tanks with multiple wheels or paddles spaced throughout the depth of the tank and ending as close to the bottom as possible. This is to ensure proper mixing of the co-product by allowing for no dead spots in the tank where product can avoid agitation. Concrete tanks are coated in epoxy to prevent acidic products from damaging them and are cleaned after each load of product is fed out to the
animals. Two tanks are dedicated to each co-product to allow for this to be done on a rotational basis. Products that are at risk for contamination, spoiling or dry matter losses due to yeast such as whey, brewer’s yeast and potato products are acidified immediately using a blend of organic and inorganic acids to ensure pH is lowered and pathogens are killed. Brewer’s yeast can be stored in the same style of storage vessels as the other liquid co-products but care must be taken that it does not come in contact with them until the time of mixing. Brewer’s yeast is an active live culture that is typically killed using heat, mechanical means, or chemical treatment. Most farms would find it easiest to chemically treat the yeast with an acidic preservative. Again, this preservative must contain a combination of organic and inorganic acids in order to kill the yeast and halt their growth. If this is not achieved the yeast cultures will continue to ferment and produce CO$_2$ and alcohol. With ingredients such as colas, pH is approximately 3.5-4.0 and will require no additional preservative. Products like jams and liquid sugars use the high sugar content and its subsequent high osmotic pressure to keep bacteria away and preserve the product (Crawshaw, 2001). As always, freshness is key and all products used on farm should be fed out in approximately one week to minimize potential spoilage to maintain maximum nutrient availability and palatability.

Ingredients should be agitated for 5 minutes prior to each feeding to ensure a homogenous mix. Co-products such as CDS, brewer’s yeast and whey are more prone to settling in tanks, the fat fraction rises to the top in CDS and solids drop to the bottom with brewer’s yeast and whey. Sugar based liquids and potato products tend to stay in solution much better and require less agitation. In order to save on the number of pumps used and pipe needed in a feed kitchen the products can be pumped to a central line with a stone catcher and dividing station and sent via a single feed line to the mix tank. When taking this approach proper sequencing is essential in order to get the proper proportions of ingredients in the mix tank.

Proper testing of ingredients will help with storage and handling decisions as well as allowing for proper formulation to be done using co-products. Up to date proximate analysis on almost all co-products in the province do not exist and this leaves the onus on producers to ensure they are aware of the nutrient profiles of their ingredients. Routine lab testing done by certified labs will help monitor variability in key nutrients over time but there are simple on farm tests that can be done as well. Upon arrival each load of co-product should be tested for dry matter using either a dry matter oven or an infrared dry matter tester; these are easily found on the internet both new and used. If an ingredient is off by even a couple percentage points of dry matter it can have a profound impact on growth and the feed value of the product. Another simple on farm test is to measure the pH of the incoming product. Portable pH meters are inexpensive and very user friendly.

**Determining Feed Value**

When deciding on the purchase and use of a new ingredient or simply monitoring the key characteristics of current ingredients many factors should be evaluated to help in the decision making process. What is the availability of the product, will it be a short term or long supply and how often can it be accessed? Does it require specialized handling and storage? What is the nutrient profile? These will all help determine if a product will be a valuable feed ingredient. When looking at the nutrient profile the first thing to know is the dry matter content. Even the highest quality ingredients when diluted with enough moisture will no longer be economically feasible. This is mostly due to the high cost of transporting liquids to farms. Simple on farm
methods of analysis are listed above. Another common problem is variability of the product. Monitoring variability of key nutrients in an ingredient can help determine if a supplier is doing a good job of ensuring a uniform product.

When lab analysis is done and nutrient contents confirmed there are multiple methods to determine the maximum value for the product. One method is to use a simple simultaneous equation which uses information such as energy, lysine and phosphorus to determine the value of a feedstuff relative to common ingredients such as corn, soy and dicalcium phosphate (OMAFRA, 2011). These equations are fast and easy but are not as detailed as the linear regression equations used in most formulation software. The more detail used in evaluation of ingredients will allow for a full of understanding of its usefulness on farm. Some ingredients are solely energy sources while others can contribute both protein and minerals. It is now also possible to take an ingredient and see its effect on growth performance and carcass characteristics by using it in a swine model. By doing this you can simulate the growth performance of the animal with the nutrients provided by the new feed ingredient and have a whole picture of its potential on farm. Ingredients are now more scrutinized than ever before and by taking full advantage of the knowledge and services available from your nutrition supplier you make the most informed and profitable decisions possible for your farm business.

CONCLUSIONS

Based on currently available co-products and potential co-products Ontario swine producers find themselves in a very unique position. With proper management practices and minor investments in infrastructure they stand to benefit from an abundance of economically advantageous ingredients that are at their disposal. As grain and protein crops continue to rise in price it will be interesting to see just how new alternative ingredients are adopted into liquid fed swine diets.

REFERENCES