Soya beans and soya bean byproducts for dairy cattle

Incorporating soya beans and their byproducts in the rations of dairy cattle is a fairly common practice. They are an excellent source of essential amino acids and complement most forages. Depending on how they have been processed, soya beans can provide high quality degradable, undegradable and soluble protein, energy, fat and fibre.

However, as with any feed, there are some limitations that need to be recognised so their full benefits to the dairy cow can be achieved.

Raw soya beans
Soya beans that have not been heat-treated can be incorporated successfully into dairy cattle rations. They provide a source of degradable and soluble protein as well as energy in the form of fat. The suggested feeding level is 10% of the total ration dry matter. For lactating cows, the suggested feeding level would probably be no more than 1.8 to 2.3kg as-fed.

Raw soya beans do contain enzymes that may result in some deterioration in the fat portion of the beans. These enzymes include lipase and lipoxidase. Lipase may result in the hydrolytic rancidity or liberation of free fatty acids from the oil present in the soya beans. They can be inactivated at temperatures greater than 79.4°C. Lipoxidase promotes oxidative rancidity or peroxide formation. Peroxides may be toxic to the rumen microbes at high levels of intake. Young calves appear to be especially susceptible to peroxide toxicity and therefore raw soya beans should be avoided in rations for calves less than four months of age.

Lipoxidases are destroyed at temperatures exceeding 48.9°C. To avoid problems associated with lipase and lipoxidase, i.e. rancidity, it is recommended to store raw soya beans whole. If they are not going to be fed whole, they should be rolled, crushed, or ground prior to inclusion in a grain mix. Ideally the grain mixture should be prepared every two weeks in winter and weekly during summer.

Raw soya beans also contain the enzyme urease, which hydrolyses ammonia from urea. For this reason, it is generally not recommended to include urea in a complete feed containing raw beans. Urea that is in contact with raw cracked or raw ground soya beans, can release ammonia in a relatively short period of time. Cows are fairly sensitive to gaseous ammonia, so when too much nitrogen is present in the ration as ammonia, a drop in dry matter intake can occur.

In a total mixed ration (TMR) system, if whole raw soya beans were used rather than raw cracked or raw ground beans, it is doubtful that urea would be as an additive can be used with raw beans since little or no urea remains as such after normal ensiling.

Raw soya beans do contain a trypsin inhibitor and possibly other anti-enzymes, which may reduce protein digestion and utilisation by single-stomached animals. Soyin, a protein, is also present in raw beans. This is toxic to some single-stomached animals. These factors in raw beans, however, do not appreciably affect cattle, because of their unique rumen metabolism.

Heat-treated soya beans
Heat-treated soya beans, on a dry matter basis, can range between 33 to 44% crude protein, 15 to 22% fat, and generally have a moisture content of 12%. An average rumen undegradable protein (RUP) value as a percentage of crude protein for properly heated soya beans is 50%. The two most common methods of heat treatment are roasting and extrusion. They both have their advantages and disadvantages.

Roasted soya beans
Roasted soya beans are a very popular way of feeding soya beans, supplying both RUP and fat. They work well in most forage type rations with the greatest benefits being observed in heavy haycrop silage diets. They can be included in the ration up to 18% of the total ration dry matter. However, in many situations, when used with other concentrate ingredients, RUP and/or fat will limit the amount of beans that can be fed.

Two main types of roasters are used in the field – a drum roaster and high temperature air dryers where soya beans are conveyed over a perforated floor through which hot air is blown. With drum roasters soya beans are dropped into a

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rotating drum where air temperatures may range from 204.4°C to 315.5°C. Soya beans will remain about one minute in the hot air environment before exiting. If beans remain in the roaster longer than one minute, they can get scorched. The amount of damage to scorched beans typically is minimal.

Equipment that conveys soya beans across a perforated floor through which hot air is blown causes less scorching and may be more energy efficient than the drum roaster. This type of equipment usually is more expensive.

The main objective in the roasting process is to achieve even heating and allowing the beans to be steamed or held without cooling for additional time. Soya beans passed through a drum roaster can produce a fairly consistent product. The most commonly used method is open-flame roasting. This is where more variation occurs with respect to RUP levels.

Factors affecting RUP levels when using open-flame roasters are moisture content of the beans, how clean the beans are, and the environmental temperature. It is not unusual to see RUP range from 40 to 65% of the crude protein. This may explain some of the variable results observed in milk production response in both controlled research and field trials.

Measuring for proper heat treatment
Some of the variation in animal production responses when roasted soya beans have been fed may be from improper roasting procedures. If soya beans are roasted with too little heat, the amount of RUP supplied in the ration may be greatly reduced.

When too much heat is used Maillard products can be produced, which makes the protein unavailable in the small intestine. The amount of lysine available post-ruminally can also be diminished due to improper roasting procedures. For these reasons, it is necessary to implement some quality control measures so dairy producers know that they are purchasing a high-quality product.

There are tests available to determine whether the heat treatment has been adequate and not excessive. A common method is the urease activity test. It is expressed as increased units of pH. Beans with values of 0.05 to 0.30 are considered to have reasonable evidence of proper cooking. If used in a TRM or a high moisture grain mix containing urea, a range of 0.05 to 0.10 is preferred.

Particle size of roasted soya beans
Most research indicates that there is an influence of particle size on the protein degradability characteristics of roasted soya beans.

Particle size of roasted soya beans can affect how the high producing dairy cow utilises the protein. The concern is that the protein in small particles is likely to degrade more rapidly in the rumen than the protein in large particles.

Researchers from the University of Wisconsin looked in the response of lactating dairy cows to increasing levels of whole roasted soya beans. Cows were fed a ration containing a 50:50 forage to concentrate ratio with 0, 12, 18, and 24% of the diet dry matter as whole roasted soya beans. Production and milk composition are listed in Table 1. The researchers found that milk production was improved by supplementing the roasted beans at 12-18% of the diet dry matter.

Based on several good studies it has been concluded that feeding roasted soya beans as whole/half and half/quarter is the optimum particle size to retain the RUP value of the feed. In TRM the whole/half particle size should result in little or no separation, however, in grain mixtures or supplements, a half/quarter particle size may work better. If the goal of feeding roasted soya beans is to supply RUP, then grinding and pelleting is not recommended.

Extruded soya beans
Extruded soya beans are exposed to high temperatures, with the exit temperature of the beans ranging between 132.2°C to 148.9°C. Extrusion has a consistent, uniform type of heating. In the process, soya beans are ground, heated, and pressed through a screw, producing a ribbon-like product. Heat penetration is facilitated by physically shattering the seed. Because this process ruptures the fat vesicles within the soya bean, there can be a rapid release of the oil in the rumen when fed to dairy cattle. Feeding extruded soya beans can result in milk fat depression.

Table 2 contains a summary of published and unpublished studies where roasted and extruded soya beans were compared to soya bean meal and unheated soya beans in dairy diets. The average milk production

| Table 1: Production and milk composition from cows fed different levels of whole roasted soya beans. |

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Milk, pounds/day</th>
<th>Milk fat, pounds/day</th>
<th>Milk protein, pounds/day</th>
<th>Whole roasted soya beans, % dry matter basis 0</th>
<th>Whole roasted soya beans, % dry matter basis 12</th>
<th>Whole roasted soya beans, % dry matter basis 18</th>
<th>Whole roasted soya beans, % dry matter basis 24</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole roasted soya beans, % dry matter basis 0</td>
<td>76.7 c</td>
<td>82.5 b</td>
<td>2.46 c</td>
<td>85.4 a</td>
<td>2.55 a</td>
<td>2.57 b</td>
<td>2.57 a</td>
</tr>
<tr>
<td>Whole roasted soya beans, % dry matter basis 12</td>
<td>82.5 b</td>
<td>2.62 a</td>
<td>2.47 a</td>
<td>85.4 a</td>
<td>2.55 a</td>
<td>2.57 b</td>
<td>2.57 a</td>
</tr>
<tr>
<td>Whole roasted soya beans, % dry matter basis 18</td>
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<td>2.55 a</td>
<td>2.57 b</td>
<td>2.57 a</td>
</tr>
</tbody>
</table>

| Table 2: Summary of animal response to feeding heated soya beans. |

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Milk, lbs/d</th>
<th>Change in milk fat, %</th>
<th>Change in milk protein, %</th>
<th>Dry matter intake, lbs/d</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roasted soya beans</td>
<td>3.5 (14) 2</td>
<td>+0.06 (16)</td>
<td>-0.07 (16)</td>
<td>-0.2 (16)</td>
</tr>
<tr>
<td>Extruded soya beans</td>
<td>2.9 (20) 1</td>
<td>-0.17 (19)</td>
<td>-0.06 (17)</td>
<td>+0.2 (18)</td>
</tr>
</tbody>
</table>
response is an increase of 1.36 to 1.58kg of milk daily. This may be an underestimate, because under-heated soya beans were used in many of the comparisons.

**Soya bean meal**
Soya bean meal is palatable, nutrient dense, high in digestibility, and a relatively consistent source of protein. It has an excellent amino acid profile. It is a concentrated source of protein and energy and is lower in fibre than most other oilseed meals.

There are two main types of soya bean meal. One is solvent extracted soya bean meal, which contains 44% crude protein. The other is dehulled, solvent extracted soya bean meal, which contains 48% crude protein. There are also high RUP soya bean meal products, which have been heat treated and supply RUP in dairy cattle rations. The incorporation of soya bean meal type products should be evaluated based on what they supply to the ration and their price per unit of nutrient provided.

**Making decisions on which product works best should be based on a review of controlled research data.**

**Solvent-extracted meal**
This product contains either 44% or 48% crude protein on an as-fed basis (50% and 54.5% on a dry matter basis, respectively). The 48% meal contains about 8% neutral detergent fibre (NDF) whereas the 44% meal is adjusted to 14% NDF by blending it with toasted ground soya bean hulls.

Soya bean meal is made by grinding soya beans, removing the fat with an organic solvent such as hexane, resulting in a low-fat soya product. This is the most common product on the market and utilised by the feed industry.

**Expeller-extraction**
Soya bean meal is produced by mechanically squeezing out the oil. Less oil is removed in this process and cows may find it more palatable because of less dustiness and fines. Because this product contains more oil compared to solvent-extracted, the energy value is slightly higher. Product availability is usually limited.

**High RUP soya bean meal**
The inclusion of regular soya bean meal in a ration usually supplies a source of degradable protein. Only a small amount of soya bean meal protein escapes the rumen. Heating or processing soya bean meal initiates chemical reactions between sugars and amino acids, which increases its RUP value. Depending on the process used to treat soya bean meal, RUP can range from 50 to 70%.

Fewer lactation studies have been conducted using heat-treated soya bean meal than with heat treated soya beans. Minimal information is available regarding optimum heating conditions for soya bean meal.

Commercial methods for producing high RUP soya bean meal include cooker-expeller processed, extruder-expeller processed, and non-enzymatically browned. Making decisions on which product works best should be based on a review of controlled research data. Also, consider the impact the level of RUP will have on the feed and economic value of the soya bean meal product.

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