Feed Grain Partnership

TECHNOTE

TechNote 9

Dairy cow feeding:

Processing grain to optimise milk income over feed costs and feed efficiency

Key points:

- Grain processing improves nutrient digestibility and therefore milk income over feed costs and feed efficiency.
- The method and extent of grain processing alters the rate and site of starch digestion in the cow's gastro-intestinal tract.
- If grain is under-processed, some starch may be excreted in the manure, and some of the grain's energy value lost.
- If grain is over-processed, starch digestion in the rumen may be too fast, leading to reduced fibre digestion and ruminal acidosis.
- Sorghum and corn require a higher degree of processing than other grains to make starch more available to the rumen microbes. Sorghum is best managed with moisture and heat.
- It may be better to buy crushed grain, a grain mix or pelleted feed rather than process grain yourself on farm.

Increasing milk income over feed costs and feed efficiency

Grain and concentrates support approximately 25-30% of milk produced on the average Australian dairy farm. Based on data from Dairy Australia's latest national farmer survey (2014), the average Australian dairy farm feeds 1.6 tonnes of grain and concentrates per cow per year. Grain and grain-based concentrates can therefore represent the largest cash cost on most Australian dairy farms.

When considering the economics of feeding grain (or any other feedstuff) to their herd, dairy farmers should aim to achieve the highest margin of milk income over all feed costs (i.e. both purchased and home-grown feeds). Achieving acceptable feed conversion efficiency (i.e. kg milk produced per kg grain fed) for the feeding system used on the farm is also important, as it impacts directly on feed cost per litre of milk.

Grain can be processed in a number of ways to help increase milk income over feed costs and feed conversion efficiency by improving starch digestibility. Grain processing can also help increase grain consumption, and reduce separation and sorting during feeding.

Grain as a source of starch

Before we discuss grain processing, here are a few key facts about grain:

- Grain is predominantly starch, a potent source of energy for milk production and other purposes. When you buy and feed grain, you are really buying and feeding starch.
- Grain types vary in terms of their starch content. Maize is about 70-75% of dry matter, wheat and sorghum about 65-70%, barley about 55-60% and oats about 45-50%.

- 50% to 95% of grain starch eaten by the cow is fermented by microbes in the rumen into volatile fatty acids (mainly propionate) which are absorbed by the cow into her bloodstream and used as an energy source. The rate at which grain starch is fermented in the rumen varies with grain type, with Wheat > Triticale > Barley > Oats > Maize > Sorghum. The rate of rumen fermentation of grain starch also varies between varieties of a given type of grain.
- Depending on the type of grain fed, and the rate at which feed particles escape the rumen per hour (which is faster in higher producing cows which are eating more than lower producing cows), a substantial proportion of the starch eaten by the cow may escape the rumen undigested and be digested, fermented and absorbed in the small and large intestines.
    - Starch is digested and absorbed in the small intestine as glucose, a more efficient process for capturing the energy in grain than microbial fermentation in the rumen and large intestine.
    - Some of the starch eaten may not be digested at all and be excreted in the manure.
- Whole grain kernels are digested by the dairy cow very slowly. Processing grain by various methods before it is fed breaks open the outer coat of the grain kernel (called the pericarp), making the starch on the inside (called the endosperm) more accessible for digestion in the rumen and intestines by rumen microbes and gut enzymes.
- The method and extent of grain processing used can alter the dairy cow's daily feed intake (including grazed forages), and the proportion and extent of starch digestion in her rumen versus intestines. This in turn affects the volumes of volatile fatty acids and microbial protein produced in the rumen, rumen fibre digestion, and the amount of glucose produced from intestinal starch digestion. These are all key factors involved in driving milk income over feed costs and feed efficiency.

Grain processing methods

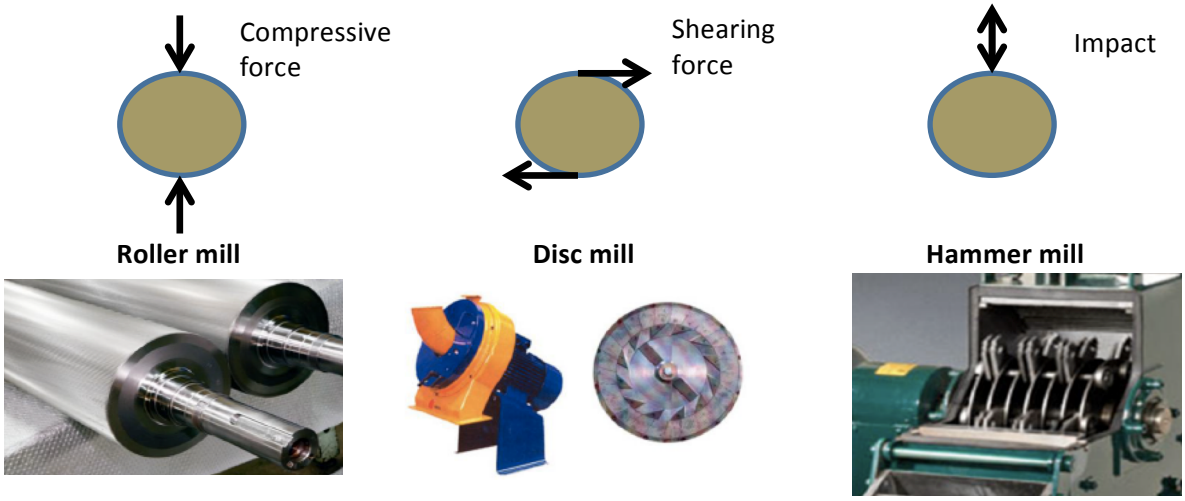
There are two main ways of processing cereal grains:

1. Reducing particle size
2. Applying moisture and heat

1. Reducing particle size

Three types of mills are commonly used to reduce grain particle size in stockfeed mills and on dairy farms which mill their own grain. These are roller mills, disc mills and hammer mills. Dry rolling mills are being replaced by disc mills on many Australian dairy farms which choose to buy whole grain and mill it themselves. Each of these mills applies different forces to the grain kernels to break them and reduce their particle size, as shown in Figure 1. Grain kernels may be compressed, flattened or broken up into particles of varying sizes.

Figure 1.Commonly used mills and the forces they apply to grain kernels

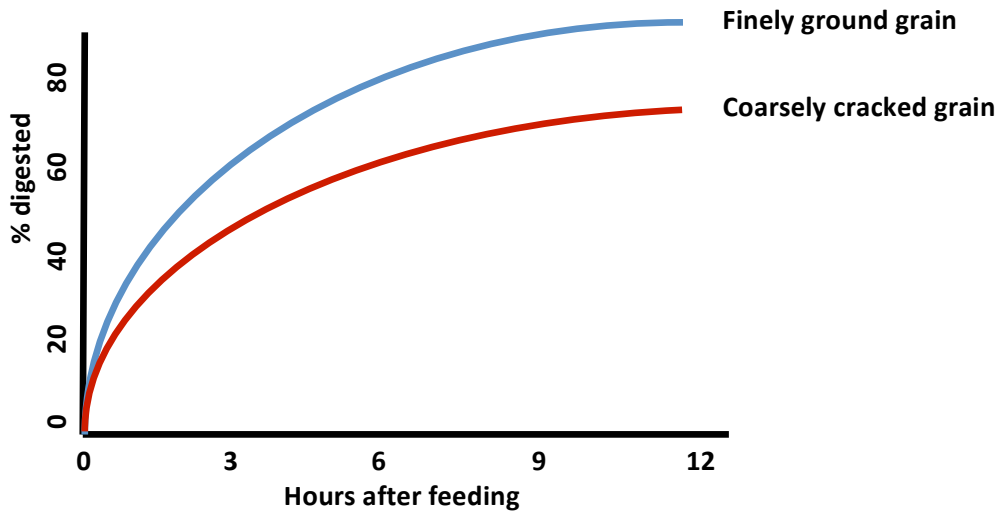


(Source: Sopade et al, report to CRC for High Integrity Aust. Pork, 2011)

As found by P. Sopade, M. Gibney and J Black in a study for the CRC for High Integrity Aust. Pork (reported in 2011), the particle size distributions of grains processed in these three types of mills differ. Roller mills tend to produce a narrow range of particle sizes, while hammer mills produce a wide range of particle sizes. Particle size distributions of disc mills can vary, depending on the grain type, internal moisture content and disc setting. To varying extents, the particle distribution of grain processed in a given mill is also determined by the adjustments made by the operator to the mill's rollers / discs / sieves, and the physical characteristics of the grain itself (type, variety, moisture content).

This is important because, in addition to the grain type fed, the extent to which its particle size is reduced also alters the rate at which the grain is digested in the rumen (see Figure 2) and therefore the proportions of the grain eaten which are digested in the rumen, small and large intestines, and excreted in the manure..

Figure 2. Example showing effect of grain particle size on rate of rumen digestion



2. Applying moisture and / or heat

Applying moisture and / or heat to grains improves their digestibility through the process of gelatinisation, in which the crystalline starch granules, which are held within a protein matrix in the endosperm, swell and break apart.

Figure 3. Popcorn

Gelatinisation is seen in its most dramatic form when you apply moisture and heat to corn grains to make popcorn (Figure 3).

There are many grain processing methods available which apply moisture and heat (often also with some mechanical force and pressure), and gelatinise grain to varying degrees, including:

- Steam pelleting
- Steam rolling or flaking
- Roasting
- Popping
- Micronising
- Expanding
- Extruding

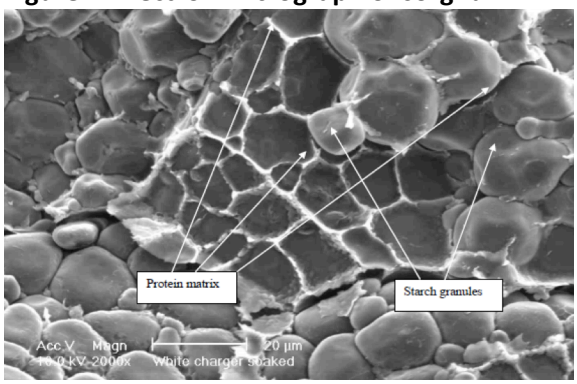
These methods are more complex and costly than hammer milling and rolling to reduce grain particle size. They are therefore mainly used by stockfeed and pet food manufacturers, and some large beef feedlots.

While they are high in starch, sorghum and corn require a higher degree of processing then other grains to make the starch more available to the rumen microbes. This is due to the strong protein matrix in which the starch granules are imbedded which must first be digested before the starch can be accessed. See Figure 4.

Experiments conducted as part of the Australian 'Premium Grains for Livestock' project (J Black, 2008) have found that only those milling processes which involve some degree of starch gelatinisation (such as steam-flaking, steam-pelleting, extrusion, microwaving or cooking) result in major improvements in the rumen and total tract digestion of starch in sorghum, by significantly disrupting the protein matrix.

However, with maize, milling processes which reduce particle size can significantly increase its rumen and total tract digestibility.

Figure 4. Electron micrograph of sorghum



(Source: J Black, PGLP final report, 2008)

Starch digestibility and cow performance

The effects of altering the rate and site of starch digestion in the cow's gastro-intestinal tract on milk production vary depending on many cow, feed and management factors. Seek advice from a professional nutrition adviser.

Two Australian experiments to assess the effects of grain processing on dairy cow performance were conducted at NSW DPI's Wollongbar Agricultural Institute in 1999 to 2002 (B. Granzin, unpublished). Barley and maize grains were processed in a number of different ways before being fed at 5 - 6 kgs / cow / day for several weeks with pasture. Steam-flaked barley produced slightly more milk than hammer-milled or rolled barley. Fine-rolling maize resulted in significantly higher yields of milk and milk protein than other forms of processing but lower milk fat content. Cows fed coarse-rolled maize had much higher faecal starch levels than cows fed maize processed other ways. No effects on cow liveweight or pasture intake were observed in either experiment.

A more recent study at the University of Queensland (A Anstis et al, 2012) showed a significant increase in feed conversion efficiency when popped sorghum grain was fed versus disc milled sorghum grain. However, milk yield and composition did not increase.

Potential problems from feeding under or over processed grain

If under-processed	If over-processed
• May result in reduced starch digestibility in the rumen and total digestive tract. This may lead to reduced milk production, feed efficiency and milk income over feed costs	• May result in excessively fast rumen starch digestion. This may lead to ruminal acidosis, with reduced milk production, feed efficiency and milk income over feed costs
• Look for: o Undigested grain pieces in manure (visual test) o Starch in manure (chemical test done by feed laboratory)	• Look for: o Reduced fibre digestion o Reduced feed intake in some cows o Mild milk fat suppression o Possible scouring and laminitis

If concerned, seek advice from a professional nutrition adviser.

DIY or leave it to someone else?

Buying whole grain direct, farm to farm, brings with it the decision to process the grain yourself. You need to consider the capital and depreciation costs, maintenance, repairs, power and labour costs, and allow for losses of 1-5% in grain during storage and processing. It may be preferable to pay someone else to do it for you, i.e. buy crushed grain, a grain-mix or a pelleted feed.