Australian Export Grains Innovation Centre

Sprouted wheat for dairy and beef cattle
– a technical bulletin for grain traders

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Contents

Key messages

- Sprouted grain kernels are equivalent to unsprouted kernels in nutritional value for cattle, unless they have reached an advanced stage of sprouting.
- Cattle feeding studies found no differences in animal performance or conversion efficiency when cattle were fed wheat with up to 60% of all kernels sprouted.
- Wheat harvested and stored with greater than 12.5% moisture content will be at risk of mould growth and mycotoxins, regardless of the extent of sprouting, test weight or other quality characteristics.
- To manage the risk of mould growth and mycotoxins when feeding sprouted wheat to cattle, it is wise to take precautions:
    - introduce sprouted wheat gradually into the ration over 2 weeks, including initially at no more than 20% of the total ration on a dry matter basis;
    - monitor animals for any productivity and health problems; and
    - include a buffer, rumen modifier and mycotoxin binder in the ration.
- Wheat storage facilities must be well ventilated and provide low moisture and low temperature conditions to ensure grain remains dormant.
- Sprouted wheat should be processed the same as non-sprouted wheat.
- Like all grains, sprouted grains should be fed by weight, not by volume.
- When buying wheat that may be weather damaged, inspect it carefully and obtain a full history of the conditions under which it was harvested and stored before buying. Be very wary of sprouted grain that has been stored for long periods. Follow these steps:
    - collect a representative sample;
    - visually inspect for extent of sprouting and any mould growth;
    - if any concerns, do a total mould and yeast count and test for mycotoxins;
    - conduct a Falling Number test and measure test weight and moisture content; and
    - conduct other routine physical quality checks and test for moisture, metabolisable energy (ME), crude protein (CP) and neutral detergent fibre (NDF).

Introduction

For many centuries, in human food production, numerous grains have been put through a sprouting (germination) process to soften the kernel, improve its nutritional value and palatability, and reduce the content of anti-nutritional factors. In human nutrition, sprouts are considered functional foods that are good sources of flavonoids, other polyphenols, glucosinolates, isothiocyanates, proteins, vitamins and minerals. Recently, in dairy cattle production, hydroponic systems for fully sprouting grains have been developed and trialled for feeding as fresh fodder, based on potential nutritional benefits. So there is nothing inherently negative about sprouted grains.

The wet conditions experienced by grain growers in many regions immediately before and during the 2021 wheat harvest have resulted in large quantities of sprouted wheat destined for use in animal feeding. What happens to wheat kernels physically and chemically when they sprout (germinate)? What is the feed value of sprouted wheat compared to sound, unsprouted wheat? How well do dairy and beef cattle perform on it? What are the key considerations with storing and processing sprouted wheat and feeding it to dairy and beef cattle? How should a pre-purchase assessment of sprouted wheat be conducted? These questions are addressed in this technical bulletin.

What happens when wheat kernels sprout?

In wet conditions just before or during harvest, some wheat kernels may absorb moisture and, if the temperature is suitable and the oxygen supply is adequate, begin to sprout (germinate) just as they would if planted in soil. Germination involves a series of physical and chemical changes to the wheat kernel.

Physical changes

Swelling (due to water absorption)

↘

Splitting of the outer covering of the germ (pericarp)

↘

Growth in the germ area

↘

Emergence of roots and a shoot from the germ

↘

Growth of the shoot beyond the contour of the germ

All these stages can be seen in Figure 1. When assessing grain samples, be aware that roots and sprouts may have broken off.

Figure 1. Wheat kernels at various stages of germination

Source: Dr J Barrero, CSIRO

For more photos of sprouting wheat, go to:

- The GTA Visual Recognition Standards Guide (2021), page 65. https://www.graintrade.org.au/sites/default/files/VRSG%202021-2022%20(Web%20Version).pdf
- The Grains Canada Commission webpage https://grainscanada.gc.ca/en/grain-quality/grain-grading/grading-factors/grading-factors-wheat/sprout-damage.html

Chemical changes

In germinating wheat kernels, amylases catalyze the hydrolysis of starch in the endosperm to simple sugars, providing energy for growth of the primary root, one or two pairs of smaller roots and then the shoot. At first, chemical changes are minimal. However, from about 48 hours after germination begins, the fibre content increases slightly over the next 5 days. The crude protein (CP) content increases slightly as germination progresses, as do the levels of essential amino acids. Fats present in the kernel are converted to sugars. When sprouting is well advanced, changes in phytate and mineral levels also occur in the wheat kernel. Phytate content decreases, increasing phosphorus bioavailability in the kernel. Calcium concentration is reduced and the magnesium concentration increased. β-carotene concentration in the kernel is also increased (Table 1).

Table 1. Changes in the nutritional value of wheat kernels when sprouting is well advanced.

Nutritional parameter	Change
Starch	↘↘
Water soluble carbohydrates (WSC)	↗↗
Neutral detergent fibre (NDF)	↗
Acid detergent fibre (ADF)	↗
Crude protein (CP)	↗
Calcium	↘
Fat	↘
Phosphorus	↗
Magnesium	↗
B-carotene	↗

Feeding sprouted wheat to dairy and beef cattle

Feed value - nutritional and economic

Laboratory experiments conducted as part of the Australian Premium Grains for Livestock Program (PGLP), in which kernels of wheat and barley samples were germinated for periods of 16 to 48 hours and then dried to stop germination, showed that germination did not significantly alter the starch content of the grains, but significantly reduced the Falling Number values to about 60 seconds. The results indicate that germination increases the accessibility of both rumen microbial and animal digestive enzymes to starch and increases the rate of starch digestion for all cereal grains (Black, 2008). Results from the PGLP studies suggest that the metabolisable energy (ME) value of sprouted wheat kernels for cattle is not decreased, and in some circumstances may be increased, when compared with sound, non-sprouted kernels.

Within a certain range, test weight is not a direct indicator of a parcel of wheat's nutritional value. A parcel of wheat with a small proportion of sprouted kernels has a slightly lower test weight than sound, unsprouted wheat of the same grade. However, if many kernels have progressed to an advanced stage of sprouting, with a sprout that has grown well beyond the contour of the germ, the grain parcel's test weight will be substantially lower and its metabolisable energy (ME) value reduced. Like all grains, sprouted grains should be fed by weight, not by volume.

Animal feeding studies in beef cattle conducted in Canada (University of Alberta) and the USA (University of Idaho, Kansas State University, Washington State University) found no differences in animal performance or conversion efficiency when cattle were fed wheat with up to 60% of all kernels sprouted. However, a study at Michigan State University indicated that including sprouted wheat at greater than 20% of a beef ration on a dry matter basis may affect palatability.

For end-users, parcels of wheat downgraded due to sprouted kernels (Falling Number test) therefore represent an opportunity to buy wheat of comparable nutritional value with the same animal performance potential at a lower price per unit metabolisable energy (ME) and per unit crude protein (CP). The value of alternative grain parcels may be assessed with some straightforward calculations, based on feed laboratory analysis of each parcel's dry matter (DM), ME and CP contents:

❶ Calculate the wheat price on a dry matter basis:

[$/tonne as fed] × 10 ÷ [% DM] = [cents/kg DM]

❷ Calculate the cost per unit Metabolisable Energy (ME):

[cents/kg DM] ÷ [MJ ME/kg] = [cents/MJ ME]

❸ Calculate the cost per unit crude protein (CP):

[cents/kg DM] ÷ [% CP] = [$/kg CP]

Example: A wheat parcel priced at $370/tn has been tested at 88% DM, 12.8 MJ ME and 10% CP.

Price on a dry matter basis = 370 × 10 ÷ 88 = 42 cents/kg DM

Cost per unit Metabolisable Energy (ME) = 3.3 cents/MJ ME

Cost per unit crude protein (CP) = $4.20/kg CP

Potential risks to animal productivity and health

Moulds and mycotoxins

Sprouted grains may have a moisture content greater than 12.5%. If so, spoilage and mould growth may occur during storage. Mould growth has two effects. First, it may lead to production of toxins called mycotoxins, which can be harmful to animal productivity and health. Mycotoxins can lead to damage to the liver, kidneys and other organs. Visible symptoms of mycotoxin poisoning depend on the specific mycotoxin involved. Symptoms may be few or many. They are usually subtle rather than dramatic, and may include reduced feed intake, a drop in milk yield and/or milk fat and protein test, ill-thrift, diarrhoea, rough hair coat, and reproductive problems. Immune suppression may lead to increased incidence of diseases. Second, mould growth tends to reduce the starch and protein content of the grain over time, and increase its fibre content. If present in feed, small amounts of particular mycotoxins (alfatoxins) may be transferred into the milk of dairy cows, presenting a human health risk.

Ruminal acidosis

If a substantial proportion of the wheat kernels to be fed is sprouted, the potential risk of ruminal acidosis in cattle may be increased, particularly if a large amount of wheat is to be fed per animal per day relative to bodyweight. This is because, as discussed above, germination increases the accessibility of rumen microbial enzymes to starch and increased the rate of starch digestion in these grains. Ruminal acidosis management steps should deal with this risk.

Processing

Sprouted wheat should be processed on farm or at the feedmill the same as unsprouted wheat, and not present any special problems for the farmer or stockfeed manufacturer when processing using a roller-mill, disc mill or hammer-mill. However, thin and/or light grain kernels may be problematic in roller mills as they tend to be squashed rather than broken. Steam-pelleting may be more difficult if many kernels are at a very advanced stage of sprouting, as less starch will be present to be gelatinised under high heat and pressure.

Inclusion in rations

Sprouted wheat may be fed by farm managers at the same inclusion level in rations as sound, unsprouted wheat. However, to manage the risks of mould growth and mycotoxins, and ruminal acidosis, it is wise to take precautions:

- introduce sprouted wheat gradually into the ration over 2 weeks, including it initially at no more than 20% of the total ration on a dry matter basis. Monitor animals closely for any feed rejection, ill-thrift, fall in milk production, change in milk composition, diarrhoea or other changes in animal productivity and health;
- include buffers and rumen modifiers in the ration as required and take other measures to manage the herd’s ruminal acidosis risk;
- include a mycotoxin binder feed additive in the ration;
- avoid feeding grain that may have mould growth to young or pregnant/lactating animals; and
- continue to monitor animals for any feed rejection, ill-thrift, fall in milk production, change in milk composition, diarrhoea or other changes in animal productivity and health.

Pre-purchase assessment of weather-damaged wheat

When buying weather-damaged grain from a grain grower, inspect it carefully and obtain a full history of the conditions under which it was harvested and stored before buying. Be very wary of grain that has been stored for long periods.

Follow these steps:

1. **Collect a representative sample**
   It is critical that any sample of wheat assessed is truly representative of the quantity and quantity of wheat it is taken from.

For static grain sampling from road trucks, the method described in section 5.2 of the GTA Wheat Trading Standards 2020/21 should be followed.
https://www.graintrade.org.au/sites/default/files/Section%2002%20-%20Wheat%20Trading%20Standards%20202021%20includes%20WQA.pdf

The Australian Grain Industry Code of Practice Technical Guideline Document No. 21 (All Sampling Scenarios used during the storage and transport of grain) (GTA, 2021) provides details on sampling equipment, locations and number of probes.
https://www.graintrade.org.au/sites/default/files/TGD%20No_21%20-%20Grain%20Sampling%20All%20Scenarios.pdf

2. **Conduct a visual assessment**
The following procedure may be used.

(i) Count out 300 wheat kernels onto a flat surface

(ii) Assess the extent of sprouting
It is important to quantify the extent of sprouting in terms of the proportion of all kernels that have sprouted and the stage that sprouting has advanced to. GTA defines sprouted kernels as those in which the covering of the germ is split and those in more advanced stages of germination. Kernels that have had the germ knocked off or scalloped out due to header damage or grains with pin holes are not defined as sprouted grains. While kernels with pinholes are not considered sprouted, their presence may indicate that sprouted kernels are present in the sample, so look carefully.

(iii) Assess kernels for any mould growth
Wheat kernels infected with moulds typically are pink to white or black to grey in colour (Figure 2). These grey to black kernels tend to have visible mould growing on the surface, which you may be able to rub off. Be sure to distinguish mouldy kernels from those with dark brown to black staining of the germ which cannot be rubbed off ('black tip' or 'black point'). Mouldy kernels may smell off or musty. They may also be soft when pressed between your fingers.

If concerned about mould growth on a parcel of wheat, the first step is to submit a sample to a feed laboratory for a 'Total mould and yeast count' as an initial check of likely risk level (costs $25-30/sample). More sophisticated laboratory tests are available to then test for the presence of specific mycotoxins. The most important mycotoxins in wheat are mainly Fusarium toxins, such as deoxynivalenol (DON), zearalenone (ZEA), nivalenol (NIV), fumonisins (FUM), T-2, and HT-2 toxins.

Figure 2. Mouldy wheat kernels.

3. **Conduct Falling Number test**
   The Falling Number (FN) test is used to predict the ability of grain to make good bread and noodles. In the germ of sound wheat kernels a very small concentration of the enzyme alpha-amylase is present. When germination commences and proceeds, the concentration of alpha-amylase present in the kernel increases dramatically. Kernels at an advanced stage of sprouting contain alpha-amylase at a concentration several thousand times greater than kernels just starting to germinate.

   When wheat kernels with an elevated alpha-amylase concentration are mixed in water the resultant wheat meal paste has a lower viscosity. This is the basis for the FN test. The test uses an instrument to measure the time it takes for a plunger to fall to the bottom of a glass tube filled with a heated paste of wheat-meal and water. Most grades of wheat that are sound have a FN of at least 300 seconds. Samples of sprouted wheat grains typically have an FN less than 200 seconds. While the FN is useful for assessing the extent of germination and wheat's suitability for baking, it does not have any direct value as an indicator of wheat's suitability as a cattle feed.

4. **Measure Test Weight**
   The test weight of the grain sample, expressed as kilograms per hectolitre (kg/hL), should be measured using the method described in section 5.8-5.10 of the GTA Wheat Trading Standards 2020/21.
   https://www.graintrade.org.au/sites/default/files/Section%2002%20-%20Wheat%20Trading%20Standards%20202021%20includes%20WQA.pdf

   Be wary of wheat with a test weight that is 5 or more kg/hL below the 2020/21 GTA standard for that grade.

5. **Measure moisture content**
Wheat harvested and stored with a moisture level of greater than 12.5% will be at risk of mould growth and mycotoxins, irrespective of the extent of sprouting, test weight and other quality characteristics. The higher the moisture content, the greater the risk. Moisture tests off the paddock may be misleading and moisture can vary depending on the degree of sprouting. Steps should be taken to reduce the moisture level prior to storage or store the sprouted grain so as to limit spoilage.

6. **Conduct other quality checks**
Other routine physical quality checks for grains include % screenings, presence of insects, weed seeds and foreign matter. Generally, sprouted grain doesn't present any additional risk of insect infestation during storage versus sound, unsprouted grain, provided that the moisture level is less than 12.5%.

   A feed test conducted on-site using an NIR or at a feed laboratory provides information on the grains' chemical composition. The four most useful parameters to measure are Moisture/Dry Matter, Metabolisable Energy (ME), Crude Protein (CP), and Neutral Detergent Fibre (NDF).

Storing high moisture grain

Grain kernels respire, absorbing oxygen and breaking down starch and sugars to produce carbon dioxide, water and heat. To ensure the grains in storage remain dormant and bacterial, fungal and insect growth are minimised, storage facilities must be well ventilated and provide low moisture and low temperature conditions. Good ventilation helps prevent moisture migrating within the grain mass and leading to damp spots where moulds may thrive.

Blending of high moisture grain with lower moisture grain is a means to achieve the required maximum 12.5% moisture content overall. However, if the grain is to be stored for more than a few weeks, the grain should be aerated to ensure that the moisture throughout the whole stack is uniform; otherwise areas of high moisture could cause problems.

Other methods available to deal with high moisture grain are:

- drying, using large volumes of heated air to remove moisture from the grain, and
- aeration, in which air is forced through the grain using a ducting system, enabling safe storage of high moisture grain until it can be blended, dried or processed.