FEEDLOT DESIGN AND CONSTRUCTION

# 29. Grain processing equipment

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## Introduction

Grain is processed mainly to improve the digestibility of its starch. Processing improves starch digestibility by 8–15%, speeds digestion through the gut, increases caloric intake, improves animal productivity and reduces costs of production.

Grain processing may also reduce manure production through lower intakes of feed dry matter per unit of liveweight gain, while reducing the level of undigested starch in the manure may also reduce odour.

Processing may simply crack, or open, the seed coat of the grain, or totally disrupt the grain kernel to expose the starch and increase its overall surface area.

Grain processing can be broadly categorised as 'wet' (e.g. steam flaking, reconstitution or tempering) or 'dry' (e.g. rolling or grinding).

Smaller feedlots may find it more economical to obtain processed grain off site, either as a single commodity or in the form of a pre-prepared ration or pre-mix. Larger feedlots need a processing system on site because of the large quantities of grain and other feed commodities required each day. Steam flaking and reconstitution systems require the most costly infrastructure, followed by tempering, rolling and grinding.

The decision about whether or not to process grain and, if so, what type of processing to use is an economic one based on the expected improvement in processing efficiency - compared to the capital and operational costs of the processing system.

## Design objectives

The objectives of grain processing are to

- Enhance the nutritive value from a given type of grain.
- Break open the grain coating to expose the starch to direct contact with the digestive system.
- Improve the digestibility and/or caloric intake of existing grain starch.
- Improve the performance of cattle.
- Produce a good quality feed product.
- Reduce waste.

## Design choices

The order of response of different grains to the extent of processing is sorghum > corn > barley > triticale > wheat. Sorghum and corn need more aggressive processing technologies, such as steam flaking or extended fermentation, and this requires higher capital and operational costs. The improvement in grain digestibility for wheat, triticale and barley is less - but still worthwhile. These grains may be effectively processed with rolling - with or without tempering.

Selection of a grain processing method also requires investigation into the ease of installation, quality assurance programs, customer perception (for a custom feedlot), grain inventories, roughage inventories, diet consistency, available skilled people and accuracy of diet manufacturing. Although these factors do not usually fit into an economic evaluation, they may affect the overall decision.

For grain processing to be effective, the benefits of improved cattle performance must be balanced against the capital, operating and maintenance costs of the processing equipment, labour availability and skill level, energy efficiency and cattle management practices.

Grain processing techniques currently being practised, or available for use, in the Australian feedlot industry include dry rolling, grinding, tempering, steam flaking, reconstitution and high moisture grain. Dry rolling and grinding are the two most commonly used methods.

Processing methods are categorised in Table 1.

*Table 1. Grain processing methods*

| Category | Processes | | | | |
|---|---|---|---|---|---|
| Cold processing (no heat) | Grinding | Dry rolling | | | |
| Cold processing (with water) | Tempering | | | | |
| Dry processing (with heat) | Micronising | Roasting | Popping | Exploding | Extruding |
| Hydrothermal (heat and water) | Steam flaking | Pelleting | Pressure flaking | Steam rolling | |
| Other | Reconstitution | High-moisture | Acid-treated | Chemical conditioning | Enzyme treatment |

The four basic physical principles involved with breaking up the grain are

- Compression
- Impact
- Attrition
- Shear.

Most processing equipment uses a combination of these principles and this ultimately defines equipment suitability for certain situations.

*A single electric belt-drive roller mill. Grain is conveyed to the hopper above the rollers and then to a holding bin.*

## Dry rolling

Grain is passed through rotating rollers that are usually grooved on the surface. The design of roller mills may vary depending on application. These are often named by the type of work they do, such as crackers, flakers, crushers or - more simply - rollers.

Grain passing between the rollers is sheared and compressed to break open the grain. The two rollers may operate at different speeds ,depending on the function. The higher the speed differential, the greater the shear force applied to the grain. High oil seeds (e.g soybeans and canola) and high moisture grains are typically processed more easily with a higher differential speed, as shearing promotes self-cleaning between the rollers.

Roller mills produce particles with a cubic shape. Particle size varies from very small to very coarse and is influenced by roller weight, size of grooves, pressure and spacing, moisture content of the grain and rate of grain flow.

Dry rolling produces a less dusty product with a more uniform particle size than grinding, which shatters grain by impact.

*Two single roller mills paired to increase capacity, or to mill two different grains at the same time.*

*A completely-sealed single roller.*

*An open spiral mixing auger to convey and mix the grain from the storage silo past the grain-wetting station to the tempering silos.*

Dry rolling is considered to be more energy efficient than grinding, but energy efficiency depends on the operating speeds and target particle size.

Roller mills are more energy efficient for producing a product with large particle sizes (+1800 microns), but similar to hammer mills when the target particle size is 600 microns or below.

Roller mills with no roller speed differential are used to process tempered, steam-flaked or steam-rolled grain. Roller mills generally perform well with common grains, including corn, sorghum or wheat, depending on moisture content. However, they do not process fibrous materials efficiently and are not generally used for finely processing oats, barley and other fibrous grains or ingredients.

A roller mill with differential speed rollers can generally handle high moisture grain more readily than a hammermill, depending on the particle size desired. However, with more moisture, the endosperm of grain becomes elastic and absorbs the impact - or crushing energy - by deforming rather than shattering.

## Grinding

A hammermill is usually used for grinding. There are many grinding chamber designs, including a half circle, a full circle, a teardrop and a split screen. Hammers, either fixed or free swinging, are attached to the rotor assembly. As the assembly rotates, the hammers impact and shatter the grain when they reach a critical 'tip speed'. Final particle size is determined by the hole size in the screen.

Hammermills produce more spherical particles than roller mills, but also generate more dust.

Grain moisture content will greatly affect the performance of a hammermill. With more moisture, the endosperm of grain becomes elastic and deforms rather than shatters. Heat due to friction will result in loss of moisture. Excessive moisture can clog the screens.

Factors influencing the fineness of the end product include screen size, hammermill size, power and speed, type of grain and moisture content of grain.

## Tempering

Grain tempering uses water and time to temper (soften) the grain. Bran outer layers become more flexible and more readily separated from the endosperm during rolling.

An open spiral mixing auger conveys and mixes the grain from the in-loading storage silos, past a grain wetting station and to the tempering silos. At the grain wetting station, a precise amount of water (or water with surfactants) is added and then allowed to penetrate the grain in the tempering silo for up to 24 hours before rolling.

Tempering improves feed efficiency by 5–10%, increases roller efficiency and reduces dust.

Tempered grain has a moisture content of about 18% final moisture, but this may rise to 22% with further wet processing – such as steam flaking.

## Steam flaking

Steam flaking uses moisture, heat and pressure to rupture the starch granules - rendering them more digestible. The degree of rupture depends on factors such as steaming time, temperature, grain moisture, roller size and gap between the rollers, processing rate and type and variety of grain.

Grain for steam flaking is first tempered, then passes through a steam chest (e.g. for 30–60 minutes at 95–110°C), before being flaked between two rotating corrugated rollers. The flakes are regularly sampled and weighed to determine density.

Steam flaked grain has a moisture content of about 22%, as much water can be lost as escaping steam. *Section 4 – Water requirements* outlines the estimated water requirements for grain processing.

Steam flaking requires energy to generate steam, drive the augers and for rolling. Steam may be generated using gas (LPG, natural or butane), coal or oil.

Steam generation is the single biggest consumer of energy in a feed processing facility and this may range from 240 to 315MJ/t grain processed.

## Reconstitution

Reconstitution first came to the industry as a means of storing grains that were harvested with excessive moisture levels.

Reconstitution now adds water to the grain (reconstituting) to bring the moisture content to 28–32%.

The grain is first tempered before more moisture is added and the grain transferred to the reconstitution silos.

This high moisture grain must be stored in an airtight facility for at least 14 days before feeding — basically ensiling it to increase its digestibility. The grain is then rolled before being fed to animals.

Reconstituting grain uses less energy than steam flaking.

## High moisture grain

High moisture grains can be an economical feed source because harvested grain yields are higher and there is no cost for drying the grain.

An optimum moisture content for corn and grain sorghum will allow easy harvest and low field loss, but is still adequate for correct fermentation and near maximum animal performance. Cereal grains are physiologically mature when the moisture content of the grain drops below 38–40% and will be acceptable for high moisture grain at between 25% and 33%.

Corn is the main grain harvested and stored in high moisture form, although sorghum and wheat have been used. Earlage is ensiled corn grain, cobs and - in some cases - a portion of the stalk.

High moisture grains that are ground may be stored in bunkers, pits, upright structures or even in large silage bags. Whole grains are often stored in upright oxygen-limiting structures.

*Flaked grain.*

*Steam-flaking - grain is transferred to green holding bins above the steam chest. After conditioning in the steam chest, grain enters the flaking mill.*

*Boiler for the steam-flaking process. Steam generation is the largest single consumer of energy in a feed processing facility.*

*Characteristic blue-coloured 'Harvestore' silos are commonly used to reconstitute grain.*

For storage in bunker pits, the preferred harvesting moisture level is above 27%. Corn stored in bunkers should be ground or rolled and then thoroughly packed into the pit to eliminate any trapped air. As correct packing depends on moisture and particle size, corn to be stored in a bunker silo can be coarsely ground with as much as 20% whole corn. A range of particle sizes will give the best compaction.

A disadvantage of high moisture grain is that the year's supply of product needs to be purchased, processed and stored at harvest time. Unlike silage, high moisture grain is an expensive commodity and this results in high inventory costs during the year.

See *Section 32 – Silage storage* for further information about silage storage design choices.

## Quick tips

- For grain processing to be nutritionally and cost effective, any improved cattle performance must be balanced against the capital, operational and maintenance costs of the processing equipment, labour availability and skill level, energy efficiency and cattle management practices.
- Each processing method differs in nutritional efficacy.
- Depending on type, grain can be rolled or ground to improve nutrient digestibility and cattle performance.
- Roller mills are less efficient at processing fibrous materials and are not generally used for finely processing oats, barley or other fibrous ingredients.
- Steam flaking uses significant energy to generate steam.
- Reconstituting grain has high capital, but low operational, costs. It requires a higher level of management to ensure a consistent quality product than steam flaking.
- Processing and storage of high moisture grain can result in high inventory costs.

## Further reading


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