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Treatments to grain for feeding ruminants

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When feed grains are harvested their moisture content can vary depending on the conditions at harvest. For grain to be stable and not heat or deteriorate in storage, it either requires a moisture content of below 14% or to be preserved in another way. Alternative preservation methods to high dry matter storage involve acids, alkalis or ensilage, but all have drawbacks from the convenience of dried grain, not least the ability to sell. The purpose is to prevent moulds and bacterial decay producing mycotoxins that affect animal health and reduce the nutritional value of the crop. This technical note outlines the options for preserving early harvested and conventionally harvested cereal crops. Some options also enhance nutritional quality of the cereals.

Choice of Cereal Crop

Choosing the cereal crop to grow, will depend on the crop rotation, land quality and soil pH. The decision to grow these crops may vary, but the preservation requirements to store them are similar. Wheat is the most expensive to grow, but it does provide the most energy and protein per hectare, however it does require more care when feeding. The table below shows the feed values for wheat, barley and oats*.

	Wheat	Barley	Oats
Dry Matter (%)	86.0	86.0	87.0
Metabolisable Energy (MJ/kgDM)	13.6	13.2	12.0
Crude Protein (g/kgDM)	115	115	90
Starch (g/kgDM)	670	550	500
NDF (g/kgDM)	92	154	290
Sugar (g/kgDM)	27	35	28
Oil (g/kgDM)	23	28	34

*please note these values will change depending on crop variety and growth stage at harvesting.

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Methods of treatment available

Method	Early harvest	Increases protein
Dry	N	N
Crimped	Y	N
Urea treated	Y	Y
Urea+enzyme	N	Y
Propionic Acid	Y	N
Caustic Treating	Y	N

Example preservation cost of cereal (excluding harvesting related costs)

	Cost/t fresh	Cost/t DM	Assumptions made
Drying grain from 20% to 14% moisture and rolling	£29	£33.72	£2 per 1% moisture reduction+£5/t handling + £12/t for rolling grain
Propionic acid treatment grain at 20% moisture and rolling	£30.50	£38.13	10litres propionic acid at £1.45/ litre + £16/t for rolling grain
Crimping grain using crimping preservative – grain at 35% moisture*	£19.56	£30.09	3litres crimping acid at £2.52/ litre + £12/t to crimp
Urea treated barley at 35% moisture	£14.30	£22.00**	40kg/t of DM 26kg/t fresh (35% moisture barley) urea at £550/t
Alkaline grain treatments	£37.00	£45.12**	18% moisture barley alkaline treatment £21/t + £16/t for rolling grain

*Drier the grain the more preservative will be required adding to the cost.

**Both methods increase the protein of the grain in the form of Non-Protein Nitrogen which can reduce the requirement for additional bought in protein in many systems – nutritional advice should be sought on this.

Note Ag-bag storage adds on around £6/tonne.

Crimping Grain

Crimping is a system for preserving conventionally harvested (combined) grain and other combinable crops e.g., peas and beans for feeding to stock. The system is based on early harvesting and treating the moist grain with an additive and processing it through a crimping machine before sealing and ensiling in a pit. The crimped grain ferments in the fit and the additive aids preservation.

Harvesting for Crimping

The target grain moisture content for crimping is 30-45% for cereals and 25-35% for legumes. Typically, this will be 3-4 weeks earlier than conventional harvest. The following table gives a guide to the appearance of the crops and the texture of the grains.

Appearance of crops at 60% grain dry matter (40% moisture)

Crop	Crop appearance	Grain texture
Barley	Stems pale green, awns turning yellow, heads bending	Soft cheese
Wheat	Few green patches on leaves and nodes	Soft cheese
Oats	Few green patches on leaves and nodes	Soft–hard dough
Peas	Pods plump and full, peas fully formed	Hard dough
Beans	Pods dark brown or black, beans starting to lose their green colour	Hard dough
Lupins	Little green in leaves and stems	Hard dough

Due to the rapid fermentation of moist grain the combine should be completely emptied as soon as harvesting stops to prevent it heating up. Grain should be crimped, and the additive applied as soon as possible after harvesting it. If it is left untreated, the moist grain can heat rapidly as fermentation begins, reducing its feed value. Ideally grain should not be left for more than a few hours.

Crimping Grain	
Advantages	• Harvest three weeks earlier than the main crop. Spreads workload and allows early entry of crops • Grains processed • High quality, non-dusty feed • Higher grain dry matter yields from earlier harvest (less loss from shedding of grains)
Disadvantages	• Relies on availability of contractor • Requires structurally safe, airtight clamp for storage • Crimped grains attract vermin, particularly rodents • Protein of grain is not increased (as in urea treating) • Green straw, need to leave in field to dry before baling or wrap behind combine

Improvements in grain yields due to early harvesting were found at SAC trials (2001) for both autumn and spring sown wheat and barley. The earlier the crop is cut, the higher the ME value of the straw. However, the straw is wetter and will need to be left to dry before baling. In under sown fields and areas in agri-environment schemes that have a high grass content, the straw can be baled and wrapped to ferment like silage.

Feeding Value of Crimped Grain

Crimped grain has a similar feed value on a dry matter basis as conventionally harvested grains. It is still important to ensure that crimped grain is introduced gradually to livestock and that the amount in any one feed is not excessive as it is very palatable. The main difference between crimped grain and normal dried grain is the lower dry matter content at 60-70%. Knowing the dry matter content of the crimped grain is essential for rationing as it affects the nutrition supplied for every kilogram fed.

For example, to replace 1kg 'dried' grain at 86% dry matter (14% moisture) requires:

1.10kg at 80% dry matter (20% moisture)

1.25kg at 70% dry matter (30% moisture)

1.45kg at 60% dry matter 940% moisture)

In all moist grain the vitamin E content will fall during storage and moist grain diets need higher levels of vitamin E and selenium.

Storage of Crimped Grain

- **The clamp can be indoors or outdoors and is best situated on a concrete base**
- **No effluent is produced so no effluent tank is required**
- **Crimped grain should be heavily rolled, especially along the sides and corners of the clamp so it is essential that the walls and safety retaining rails are structurally sound and can withstand the weight of a tractor**
- **Clamp walls can be made of large square bales with additional bales at right angles to the walls during the filling process and then removed after the clamp has stabilised.**

Clamp management

Before harvest starts 1000-gauge plastic sheets should be hung along the side/end walls and 1m along the pit floor. If straw bales are used as pit walls, especially oilseed rape straw, then putting an old 600kg fertiliser bag over the bales first will stop any sharp straw piercing the plastic sheeting. Using bales as pit walls may encourage vermin, so place a pipe (e.g. from the centre of bale wrap) on the ground between bales to put rodent bait in. Sufficient sheeting should be left at the top of the walls to cover the top of the pit and be sealed down the centre (alternatively use a separate top sheet and seal at the edges with the side sheets). A narrow clamp face is desirable to achieve the face moving back by at least 0.3 m/day so reducing deterioration.
As a rough guide to store one tonne of crimped grain will require:

- **For cereals – 1.0m3**
- **For legumes – 0.85m3**

Storing straw on top of the pit should be avoided as this encourages rodents, instead sandbags or tyres should be used. Birds and rodents are extremely attracted to the clamp so appropriate baiting should be carried out and over the winter cover the front of the pit to prevent birds accessing the open face. There are several machines in use in the UK for crimping grain. Essentially, they are a hopper with a pair of large fluted or dimpled rollers in the base where the additive is added, and grains are cracked. Work rates vary between 10-40tonnes per hour and most machines are operated by contractors.

Additives

There are two main categories of additives that can be used to crimp grain:

- **Food preservative salts solution for grains of 45-25% moisture**
- **Preservative salts and acids solution for grains 25% moisture and below**

Some additives are available that comply with EU organic standards and can therefore be used in organic systems.

Urea Treating Cereals (for feeding whole)

Urea treating cereals is a system of preserving and processing moist cereals at 30-40% moisture content by treating whole grain with urea at harvest. The urea is converted to ammonia which preserves the grain, makes the seed coat more digestible (allowing grain to be fed whole to cattle) and increases the crude protein to around 180g/kgDM.

Urea Treated Cereals	
Advantages	• Higher yields per hectare (earlier harvest) • No drying or further processing required • Low treatment and storage costs • Spreads workload at harvest • Increased protein of the grain • Deters vermin
Disadvantages	• Although urea treated cereals have a higher crude protein content (~18% in DM) half of this is from non-protein nitrogen coming from ammonia. Cattle have been shown in trials to give a worthwhile response in gain to the addition of 5% soya. • Good mixing and application are required to ensure no areas are missed that could mould. • Barley is not as suitable as wheat for intensive systems with trials showing poorer animal performance. • For sheep it is not worthwhile urea treating grain as sheep can digest whole dried cereals. However, if urea treating is used for solely preserving the grains for sheep use half the rate of urea as it is not required to soften the seed coat. Note the protein will be lower in the grain than full rate.

Moist grains tend to ferment and heat rapidly after harvest. If the fermentation starts the pH of the grain falls and this inhibits the activity of the urease enzyme which is in the grain and is responsible for the conversion of urea to ammonia. To prevent this, moist grain should be treated as soon as possible after harvest and no more than 12 hours post-harvest.

Application Rates of Urea (whole grain for breaking down seed coat)

The recommended rate of urea is 30kg per tonne dry matter for wheat and oats and 40kg per tonne dry matter for barley and triticale. To convert this to the amount required for fresh weight simply multiply the application rates above by the dry matter percentage of the grain and divide by 100.

For example, barley at 35% moisture (75% dry matter) would be 40kg X 75/100 = 30kg/tonne fresh weight. These rates are designed to improve the digestibility of the seed coat and allow the grains to be fed whole. If the aim is to preserve the grain only, then lower rates of application can be used. It is important that feed grade urea is used, as fertiliser urea may contain heavy metals. Urea treated cereals must be stored in a sealed pit for six weeks prior to use and the pit should not be rolled or consolidated. Pits should be sheeted top and sides. The table below shows the typical feed analysis of urea treated wheat. The analysis is the same as untreated wheat except for the lower DM and higher crude protein.

	Urea wheat
Dry matter (%)	70
ME (MJ/kgDM)	13.6
Crude protein (g/kgDM)	183
Starch (g/kgDM)	580
pH	7-8

Urea + enzyme treatments

There are commercial products available that contain urea and sources of the urease enzyme to treat grains. This treatment preserves the grain and the quantity of urea used softens the seed coat but does not break it down sufficiently for cattle to digest. Therefore, for cattle the grain needs to be processed. The additional urease enzyme enables the reaction to convert urea to ammonia gas to happen quickly and effectively. Some products are a pellet with the urea and enzyme combined and others are two separate products mixed at application. Where the urea and enzyme are separate normal application levels are 15kg of urea with 5kg of enzyme. As well as preserving the grain there is the advantage that the grain becomes alkaline which is good for rumen health and there is an increase in protein of around 35g/kgDM. The normal optimum range of cereal moisture is 16-20%. If grain has a higher moisture, there is a risk of fermentation and heating prior to treatment especially if grain has been sitting in the shed for a few days. Note that the clamp is not to be rolled as air is required to circulate the ammonia gas.

Urea and Enzyme Treatments	
Advantage	• Harvesting can go ahead even if there is surface dampness on the grain (i.e. early mornings, areas under trees, end-rigs etc which could otherwise spoil the total grain for sale • Treated grains roll easier • Better feed value, aids palatability • Less dust • Suitable for all cereals and legumes • Increase in protein by around 35g/kg DM • Saves on bought in protein costs • Can be moved and fed once treated (after 2 weeks under cover) • Can be treated whole (and rolled later if needed or treated rolled) • Alkaline feed = safer for finishing animals and buffers the rumen
Disadvantages	• Storage management needs to be good to avoid spoilage – storage for 3 months maximum at a time if it is rolled or 6months if it is treated whole • As with urea treated grain the additional protein is in the form of non-protein nitrogen (NPN) • Good mixing and application are required • The type of protein (NPN) is not so compatible to be feed with high quality silage

Treating with Propionic Acid

Propionic acid is an organic acid which occurs naturally in the rumen. The acid kills off yeasts, moulds and bacteria provided it is used at the correct rate for the moisture of the grain. Below is an example of rates of application using a propionic acid product and how the level required is dependent on the moisture content of the grain and how long the grain needs to be preserved for. It is recommended for treating cereals and legumes below 25% moisture as higher moistures would require too large a volume of treatment to be cost-effective and practical.

Whole Grain Moisture Content %	Propionic acid litres/tonne Preservation Time (months)		
	1	1-3	3-12
Up to 16	3.80	5.00	6.75
16 – 18	4.25	5.80	8.00
18 – 20	5.00	7.25	9.50
20 – 22	5.80	8.50	10.50
22 – 24	7.25	10.00	12.00

(Note whole grain can be treated whole or rolled and is suitable for sheep whole, but must be rolled for feeding to cattle)

Rolled Grain Moisture Content %	Propionic acid litres/tonne Preservation Time (months) 1	1-3	3-12
Up to 16	4.25	5.50	7.50
16 – 18	4.75	6.50	9.00
18 – 20	5.50	8.00	10.50
20 – 22	6.50	9.50	11.75
22 – 24	8.00	11.00	13.50

Propionic Acid Treatment	
Advantage	• Harvesting can go ahead even if there is surface dampness on the grain (i.e. early mornings, areas under trees, end-rigs etc which could otherwise spoil the total grain for sale • Treated grains roll easier • Better feed value, aids palatability • Less dust • Suitable for all cereals and legumes • Keeps grain cool • Discourages mites and weevil
Disadvantages	• If crop is high moisture this can become costly • Propionic acid only preserves the grain (no increase in protein like urea treatment)

Caustic treating

Caustic treating (soda grain) is more a specialist treatment more commonly used for lactating dairy cows which involves treating the grain with sodium hydroxide to soften the seed coat so it can be fed to livestock without rolling. This is done using a mixer wagon and mixing the grain and the sodium hydroxide. After they are mixed well, water is added (the amount of water depends on the moisture content of the grain and how long it is to be kept for). The maximum level of feeding caustic treated grain is 3-4kg per day, so it is not appropriate for ad-lib feeding systems. Animals fed on caustic treated grain have an increased output of urine, adding to bedding costs.

In conclusion there are many factors to be taken into consideration when choosing a method of preservation and whether it suits your farm, what facilities you have available for storage and what you are trying to achieve with your stock.