HGCA
Grain storage guide for cereals and oilseeds

Third edition

HGCA Grain storage guide

The value of good grain

Introduction

Safe, effective grain storage is key to assuring crop quality and helping prevent loss of premiums through claims and rejections.

HGCA's Grain storage guide was first published in 1999 and has become a key reference for most assurance schemes. This third edition of the guide is the output of a five-year Defra and industry-funded LINK research project to review the previous guide and ensure the recommendations remain robust.

Good storage practice minimises risk throughout the supply chain and safeguards food safety for consumers. The Hazard Analysis and Critical Control Point (HACCP) system is now an integral part of the food and feed industry approach to controlling food-borne safety issues and it is a legal requirement for all food businesses after primary production.

As most UK grain enters the human food chain, either as food, drink or animal feed, adopting a HACCP-based approach to grain storage ensures growers are aligning their businesses with the rest of the supply chain on this critical issue.

This guide combines the information from the previous edition and the results of the five-year research project in a new risk management approach to grain storage based on HACCP principles.

This guide has been endorsed by, among others, AIC, NFU, nabim and MAGB.

Members of the LINK project consortium:

Commercial grain is commonly traded at moisture contents of 15% and above. The food safety risk is partly dependent on temperature but begins to increase above 14.5% moisture content. The impact of any particular temperature and moisture content combination can be assessed using the HGCA safe storage time calculator **www.hgca.com/grainstorage**

Economics of grain storage

The key economic benefit of grain storage is not having to sell grain for harvest movement, as later delivery usually attracts a higher price. Typically, selling feed wheat for November movement will attract a £4/tonne premium over the harvest price, with May movement giving a further £7/tonne.

Understanding the costs involved is important: consider build/rental costs and the opportunity/finance costs of capital tied up in stored grain and crop conditioning costs. With volatile markets the risk is that unpriced grain could be worth less when it comes out of the store than it was going in, when associated costs are taken into account.

Storage in changing conditions

One of the aims of the five-year research project was to challenge the recommendations of the previous editions of the HGCA Grain storage guide in light of the new challenges for grain storage.

– Grain cooling and climate change

Recent research has examined how cooling strategies may be affected in the future as a result of climate change. The research concluded that the predicted rise in temperatures due to climate change will make achieving the cooling targets more difficult in the future, although it will still be possible to reach the target temperature. See pages 20-21.

– Insecticide resistance

Populations of certain pest insects and mites have developed resistance to some currently approved pesticides. Consideration should be given to preventing the development of resistance when applying pesticides. This includes ensuring correct application at the manufacturer's recommended rate and consideration of the use of a product containing an active substance with a different mode of action (MOA) to that used previously. Further information on the classification of insecticide MOAs is available from the UK Insecticide Resistance Action Group (www.pesticides.gov.uk/rags_home.asp).

– Integrated pest management

The key to safe storage of grain is an integrated pest management (IPM) approach. IPM approaches combine different management strategies and practices to limit pest damage by the most economical means possible and with the least environmental impact. As such, the use of chemical pesticides is minimised. Monitoring, prevention and control are integral parts of an IPM approach. See page 22.

storage

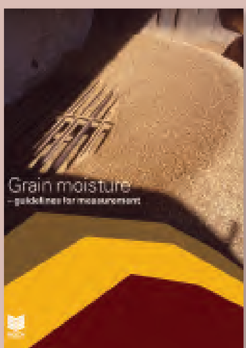
Benefits of a HACCP-based approach to grain storage

- Assures grain quality through best practice
- Prioritises resources by identifying higher risk areas
- Minimises risk throughout the supply chain
- Helps meet relevant customer and legal requirements

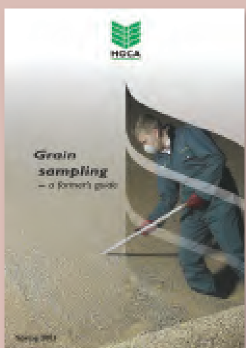
Other related HGCA information

All available online at **www.hgca.com/grainstorage**

Insects and mites in stored grain and grain stores poster

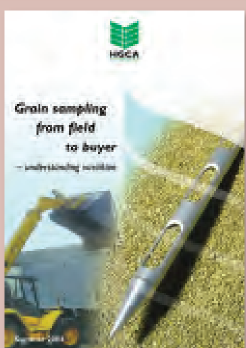


Grain moisture – guidelines for measurement



Grain sampling – a farmer's guide

Rodent control in agriculture – a guide



Grain sampling from field to buyer – understanding variation

Contents

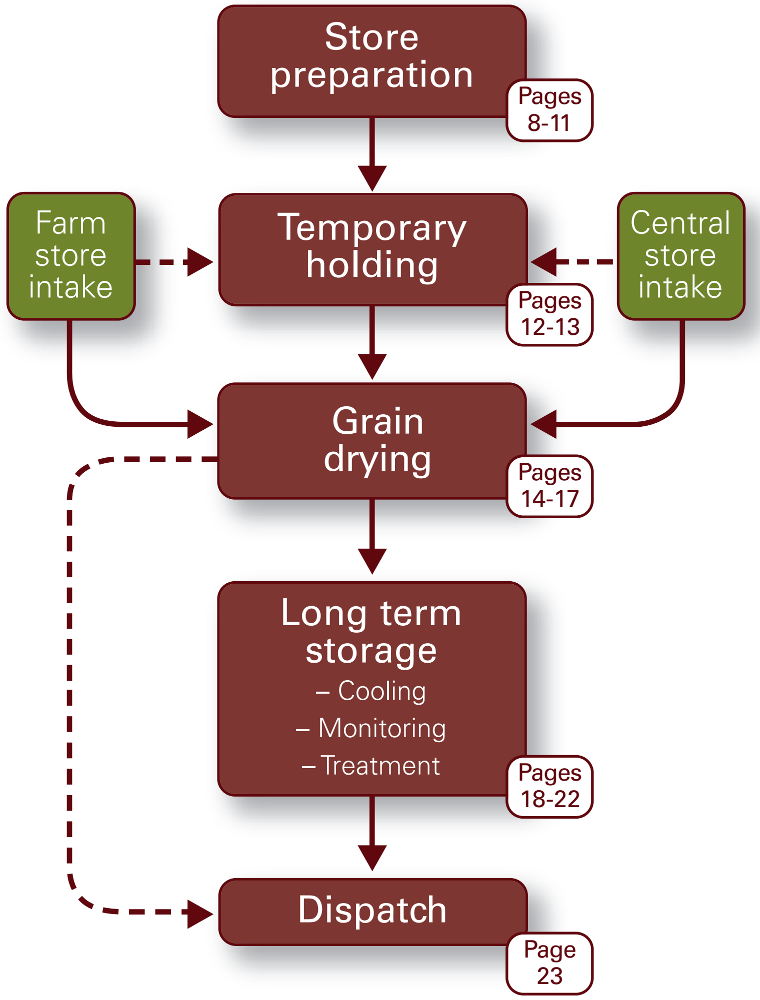
How to use this guide

The grain storage process

The grain storage process, as described in this guide, includes both grain that is produced and stored on farm and storage of grain from different farms in central stores.

The grain storage process has been divided into a number of steps which represent typical grain storage operations, a step being a point, operation or stage in the process.

The key steps as defined for this guide are depicted opposite; individual operations may differ.



A risk-based approach

What is HACCP?

- A system of food safety assurance based on the prevention of food and feed safety problems
- Adopted by the food and feed industry as the most effective means of controlling food-borne safety issues
- Can be used at all stages of the food/feed supply chain from primary production to final product use
- Helps meet market place demands and expectations for safe food and feed

The legal requirement for HACCP in the EU applies to food businesses at any point after primary production. Central grain storage operations are food businesses after primary production and are therefore required to implement procedures based on HACCP principles. The legal requirement for HACCP also applies to animal feed and therefore to crops intended for feed.

In practical terms this means that HACCP is not required for normal on-farm crop production activities, including grain storage. The principles of HACCP are, however, still advantageous for determining risk and have been used in this guide.

HACCP involves the identification and analysis of hazards associated with all stages in a production operation. The significance of hazards may be determined by quantifying risk. Critical Control Points (CCPs) are identified and appropriate preventative measures put in place to prevent the occurrence of the hazard. Monitoring procedures for these control measures are designated with appropriate corrective actions.

The HACCP system also requires that hazard identification is correct and that control measures are suitable and can be effectively managed. The good practice, as defined in this guide, will help provide evidence that a grain store HACCP is technically correct.

Terms used in this guide

Hazard: A biological, chemical or physical agent in food or feed with the potential to cause an adverse health effect. Examples in grain include *Salmonella* (biological), pesticide residues (chemical) and glass (physical).

Hazard analysis: The process of collecting and evaluating information on the presence of hazards in order to decide which are significant and should be addressed in the HACCP plan. The significance of hazards in this guide has been determined by a numerical assessment of the risk.

Preventative measure: Any action or activity that can be used to prevent or eliminate a food safety hazard or reduce it to an acceptable level (also referred to as a 'control measure').

Monitoring procedure: A planned sequence of observations or measurements of preventative measures. The records of monitoring provide evidence that the control is effective (also referred to as 'checking procedures').

Corrective action: Any action to be taken when the results of monitoring indicate a loss of control or trend towards loss of control, hence, increased risk. The corrective action should include consideration of how to regain control and what to do with potentially unsafe product.

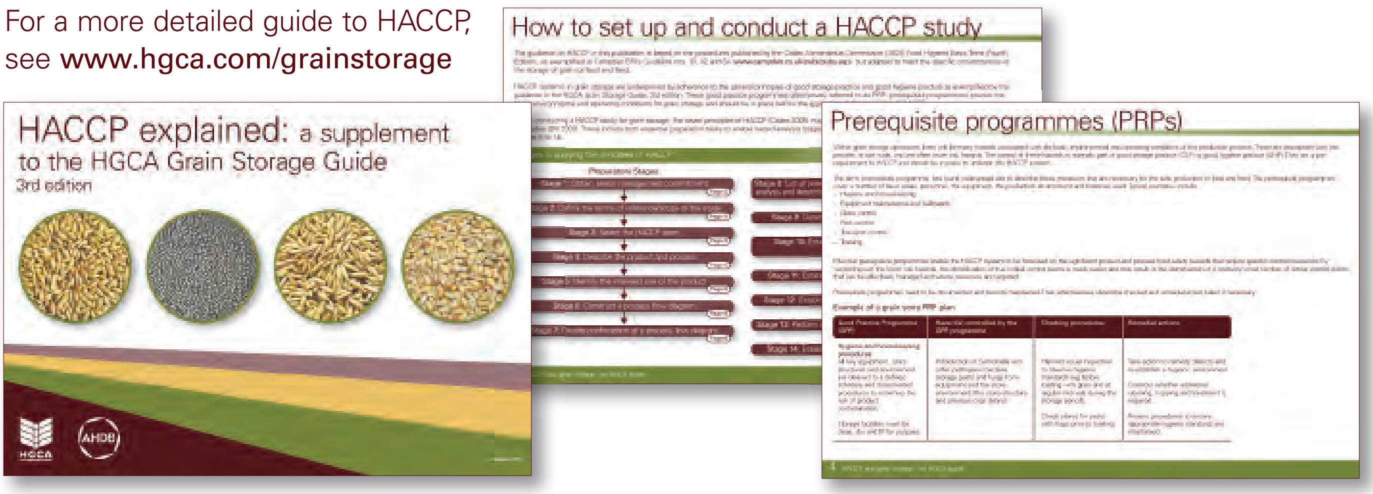
Risk: A factor determined by multiplying the likelihood and the severity of the hazard in the absence of preventative control measures.

Each hazard in this guide was scored for likelihood and severity and the overall significance of the hazard converted into a high risk ★★★, medium risk ★★ or low risk ★ rating. A high risk rating represents a significant food safety hazard and CCP.

Critical Control Point (CCP): CCP A process step at which control can be applied and that is essential to prevent or eliminate a food safety hazard or reduce it to an acceptable level. If the controls fail at this point food safety risk is increased.

HACCP (Hazard Analysis and Critical Control Point): A system which identifies, evaluates and controls hazards significant for food and feed safety.

For a more detailed guide to HACCP, see **www.hgca.com/grainstorage**



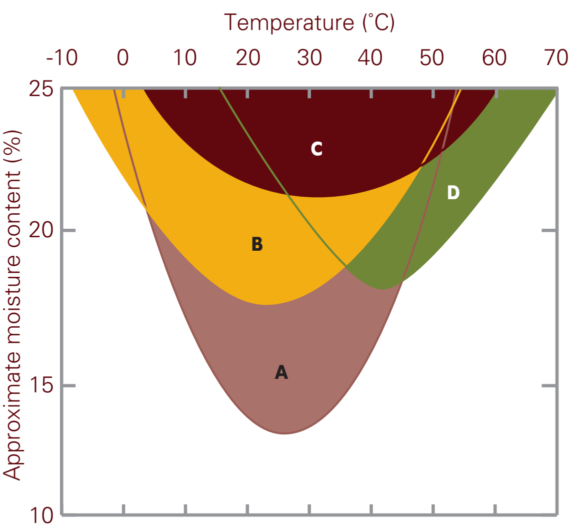
The main causes of spoi

The principal causes of spoilage in stored grain are fungi, insects and mites. The fungi and insects that are found in the field are different to those that cause problems in the storage environment. Recent research has shown some stored product insects and mites are able to carry fungal spores, including those of *Penicillium verrucosum* , which can produce ochratoxin A.

Fungi and mycotoxins

Storage fungi can grow on cereals from about 14.5% moisture content (mc) (7.5-8% mc in oilseed rape) upwards and can cause heating and loss of germinative capacity.

Different types of fungi thrive at different moisture contents and temperatures in stored grain



A – *Aspergillus* species which may damage germination and cause slow heating.

B – *Penicillium* species, including those that produce mycotoxins.

C – Advanced decay/field fungi, eg *Fusarium* species and heating organisms, eg *Absidia* species which may be pathogenic causing, for instance, farmers' lung.

D – Thermophilic fungi, which thrive at very high temperatures, such as those that occur in compost bins.

The main fungus with the potential to cause problems in stored grain in the UK is *Penicillium verrucosum*. Under appropriate conditions (18% mc and above) this fungus can produce the **mycotoxin**, **ochratoxin A (OTA)**. EU regulations set permissible levels for OTA at 5 parts per billion (ppb) for cereals at intake. **Where grain is stored above 18% mc, these levels can be exceeded in two weeks if the temperature is sufficiently high.**

Do not sniff mouldy grain - spores can cause "farmers' lung".

The principal method by which storage fungi can be controlled is through **drying and cooling**.

No storage fungi will grow below 14.5% mc. They continue to grow slowly at near 0°C, so **cooling alone is not sufficient to prevent growth in damp grain**. However, the lower the temperature, the slower the rate of growth.

Chemical treatment to prevent fungal growth can only be used on grain for animal feed.

Mycotoxins formed before harvest, for example by *Fusarium* species, are stable and likely to remain during storage but not increase. See **www.hgca.com/mycotoxins** for the fusarium mycotoxin risk assessment.

Mites

Storage mites are very small (<0.5mm long) and breed rapidly under favourable conditions. However, they are prone to water loss and die at low relative humidity (rh). **Most species do not breed below 65% rh.** Numbers at the surface may decline naturally if the surface moisture content falls below 65% relative humidity in the spring.

Mites can cause direct damage to the grain by eating the germ or hollowing out oilseeds and may also cause taint. They are strongly allergenic, although allergic reactions are generally only seen when in contact with very large populations of mites. Predatory mites may also be present where there are large populations of storage mites.

Physical control methods are used for the control of mites. **If grain is dried to 14.5% mc mites are unable to breed.** Cooling the grain to 5°C also prevents a build up of mites.

While this protects the grain bulk, in the winter months the mc of the surface layer of the grain may increase and mites can become a problem in this surface layer.

Chemical methods (see page 22) can also be used to control mites but resistance to common residual insecticides is widespread and could lead to control failures.

Mites pose the biggest threat to oilseed rape. Oilseed rape is less susceptible to insect attack than cereals.

lage

Insects

Stored product insects are specialised for the grain storage environment and can breed at relatively low temperatures and moisture contents. Even a single insect in a 1kg sample may represent a potentially serious infestation.

Primary storage pests can survive on grain residues from the previous harvest and will then infest new grain as it is placed into the store. **Good store hygiene is, therefore, an important first step in eliminating insect presence and infestation problems.**

Secondary insect pests such as the foreign grain beetle, spider beetles and booklice only damage poorly conditioned grain and are primarily fungus feeders. **Good hygiene is, again, the key to their prevention.**

A range of species infest grain stored in the UK, the two principal primary species being the **saw-toothed grain beetle**, *Oryzaephilus surinamensis*, and the **grain weevil**, *Sitophilus granarius*.

The **grain weevil** develops inside the grain, making early detection difficult. The larva hollows out the inside of the grain as it feeds and eventually emerges as an adult.

The other species develop outside of the grain itself and generally require the presence of broken grains to survive.

There may be a succession of insect infestations within a store. Weevils breed at relatively low temperatures. When left unmanaged, this can cause ‘hotspots’ where activity of the last larval stage can raise grain temperature locally and damage grain allowing saw-toothed grain beetles to breed. Further temperature increases encourage rust-red grain beetles. Mould-feeding beetles, mites and booklice may follow as moisture content increases.

Correct identification of insects found is important. Both the building structure and the stored grain should be monitored for insect presence using traps wherever possible. Traps should be positioned 4-5 metres apart.

Traps within the grain bulk should be positioned both on the surface and approx. 5-10cm below the surface to monitor for insect species with different behaviours.

Examples of physical, biological and chemical hazards

Type of hazard	Description	Examples
Biological	Pathogenic micro-organisms that may cause infection or food poisoning in consumers. Contamination of grain may be from people, equipment, store fabric or environment (eg pests, previous uses, including housing of livestock, adjacent operations).	*E. coli, Salmonella*
Chemical	Residues of chemical substances that may render the product unacceptable or illegal where statutory maximum residue levels (MRLs) have been exceeded.	Residues of pesticides†, mineral oils, polycyclic aromatic hydrocarbons (PAHs), cleaning agents
	Residues of mycotoxins formed as a result of growth of fungal moulds in stored grain.	Ochratoxin A (OTA)†
Physical	Foreign bodies that may contaminate grain. These may cause harm to the consumer or make the grain unacceptable to the customer.	Glass, metal (eg nuts and bolts), stones, brick and concrete, wood, animal contaminants (eg rodent or bird faeces), shotgun cartridges, lead, clay pigeons
	Foreign materials (allergens) that may contaminate grain from products stored previously or nearby and cause an allergic reaction in susceptible consumers.	Soybeans, nuts, peanuts
	Storage pests that may contaminate grain and increase in store and make the grain unacceptable to the customer.	Insects and mites

† Exceeding Statutory Maximum Residue Levels (MRL)/Permissable Levels

Store preparation

Store preparation is a key stage in ensuring safe grain storage, whether the grain is to be held for a temporary period or for longer. Combining different management strategies and practices to limit pest damage by the most economical means possible and with the least environmental impact, will enable the use of chemical pesticides to be minimised.

Cleaning alone will not eliminate all pests in empty stores nor will pesticide treatment. Good store preparation works in conjunction with reaching and maintaining the target temperature and moisture content to ensure safe grain storage.

Store hygiene

Store hygiene is important for eliminating sources of contamination from storage fungi, insects and mites. Stored product insects and mites are most likely to be introduced from the store structure and equipment.

Primary insect pests can be present in empty stores – even small quantities of grain from previously stored crops can provide a food source.

Stores should be thoroughly cleaned prior to intake. Use an industrial vacuum cleaner to remove debris. Ensure that rubbish, including vacuum cleaner contents, is removed immediately after cleaning and is disposed of well away from the store.

Conveyor systems have been shown to harbour appreciable amounts of the storage fungus, ***Penicillium verrucosum***, in comparison to other areas of the store. This fungus can produce the mycotoxin **ochratoxin A (OTA)** under appropriate conditions. To minimise the risk, particular attention is needed to remove debris and thoroughly clean machinery (including combine harvesters, conveyor systems etc) and harder-to-reach areas of the store, while maintaining safe working practices.

Campaign for Responsible Rodenticide Use

- Always have a planned approach
- Always record quantity of bait and where it is placed
- Always use enough baiting points
- Always collect and dispose of rodent bodies
- Never leave bait exposed to non-target animals and birds
- Never fail to inspect bait regularly
- Never leave bait down at the end of the treatment

THINK WILDLIFE
Campaign for Responsible Rodenticide Use

www.thinkwildlife.org.uk

Monitoring

Place insect traps in corners and at wall/floor junctions every 4-5 metres around the store and check them weekly. If stored product insects or mites are found, place additional traps to pinpoint the source of the infestation and use additional hygiene measures to eliminate the source. If pests are persistent or widespread, consider applying an approved pesticide to the fabric of the building. Replace traps two days after treatment to monitor efficacy.

Treatment

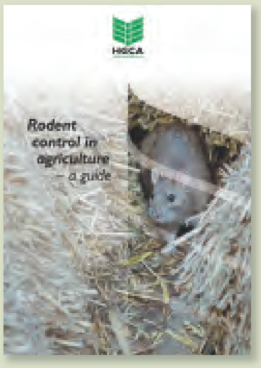
Products currently approved for use in the UK either as structural treatments or treatments of grain can be found on the Chemicals Regulation Directorate (CRD) website **www.pesticides.gov.uk**

When using any chemical treatment it is imperative that appropriate safety measures are taken and that correct personal protective equipment (PPE) is worn.

Rodent control

Always use secure, commercially approved bait boxes and ensure that vermin bait cannot contaminate stored grain. Place bait boxes outside the store not inside, to avoid encouraging vermin to enter the store.

For more information on rodent control, see HGCA's guide.



Key features of a good grain store

- ✓ Clean
- ✓ Dry
- ✓ Well-ventilated
- ✓ Shatter-proof covers for lights and shatter-resistant bulbs
- ✓ Correctly functioning equipment
- ✓ Proofed against rodent and bird entry
- ✓ Watertight roof (no leaks or broken guttering)
- ✓ No physical contaminants
- ✓ Secure

During cleaning, loading and unloading adequate personal protective equipment (PPE) should be worn.

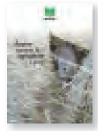
Key hazards and the preventative measures to be taken

Hazards	Risk score	Preventative measures	Monitoring procedure	Corrective action
Presence of fungi with potential to cause mycotoxins	★★	Clean equipment and store	Visual inspection of cleanliness	Targeted cleaning
Presence of insects and mites	★★	Clean equipment and store and monitor	Monitor using traps	Apply pesticide at recommended rate if insects and/or mites are found
Presence of pesticide residues	★	Use approved products in recommended manner	Check records of pesticide application	Review applications and practices
Presence of rodents and rodent faeces	★	Clean store, remove potential harbourages and prevent entry	Check for rodent presence	Application of rodenticides in approved manner; targeted cleaning and proofing
Presence of birds and bird faeces	★	Clean store and prevent entry	Check for bird presence	Targeted cleaning and proofing
Introduction of glass	★	Glass control procedures	Check for compliance with procedures	Remove and replace or protect glass

HACCP risk rating: high risk ★★★ medium risk ★★ low risk ★

Store preparation

Pre-harvest store preparation

✓ Is the store weatherproof?	Check and repair leaks in the roof, broken guttering and other areas of potential ingress, protect external fans to prevent direct water ingress.
✓ Is the store proofed against rodent entry?	Check doors are well sealed and refer to HGCA's Rodent control in agriculture – a guide (2002). 
✓ Is the store well ventilated?	Ensure there will be adequate space above grain for ventilation.
✓ Is the store thoroughly cleaned?	Remove all grain debris from the store and equipment and dispose of well away from the store.
! Has the store previously housed livestock?	Disinfect with an appropriate food-approved disinfectant/ sanitiser and leave to dry before storing grain.

The cleaning products and previous store use may depend on supply chain restrictions and the ultimate use of the grain – check for approval and suitability before use.

Monitoring and treatment

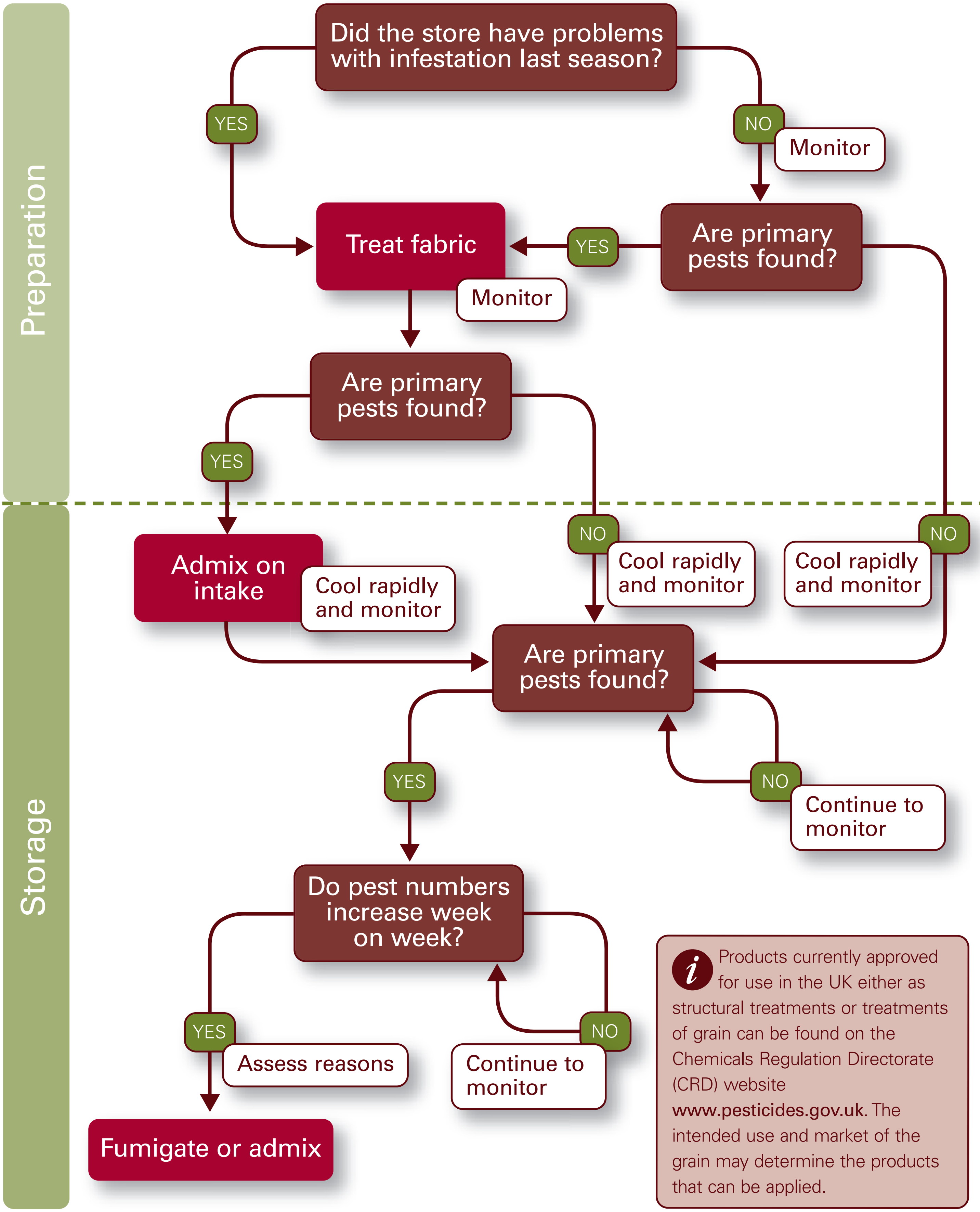
- After cleaning, the presence of insect pests should be monitored using traps, such as the PC floor trap or the bait bag, positioned in corners and at wall/floor junctions every 4-5 metres around the store
- Where an infestation is detected, placement of additional traps will help pinpoint the source
- Further hygiene measures at the infestation source may help eliminate the problem but if insect presence is persistent or widespread, consider applying an approved pesticide to the fabric of the building at the manufacturer's recommended rate
- Application of a residual insecticide by trained personnel will provide protection over a prolonged period, dependent on the type of surface and the temperature
- The efficacy of the treatment can be monitored by replacing traps two days after treatment
- Details of all treatments should be documented

Ensure that insect bait traps do not contain allergens eg nuts.

Floor trap

PC trap

Choosing pesticide treatment



Products currently approved for use in the UK either as structural treatments or treatments of grain can be found on the Chemicals Regulation Directorate (CRD) website **www.pesticides.gov.uk**. The intended use and market of the grain may determine the products that can be applied.

Temporary holding

If there are backlogs after harvest and newly-harvested grain needs to be stored temporarily prior to drying, the grain could become contaminated by fungi, insects or mites if not handled correctly. Insect traps should be used in this area both prior to and during the temporary holding.

Under certain conditions of temperature and moisture content, fungal growth may occur rapidly and may lead to the production of the mycotoxin **ochratoxin A (OTA)**. Fungal growth and insect and mite development can be reduced at lower temperatures and moisture contents.

Prepare the area as outlined in pages 8-11

Determine moisture content and temperature of grain immediately after harvesting

Equipment used to measure the temperature and moisture content should be accurate, with moisture meters calibrated annually, see pages 14-15

Priority

At or above 18% mc

Commence drying immediately to dry to below 18% mc

Below 18% mc

Use HGCA safe storage time calculator to prioritise grain for drying
www.hgca.com/grainstorage

Consider cooling grain to 15°C to prevent the crop from heating up and to prolong safe storage time before drying

This may be possible using ambient air and use of temporary ducts, pedestals or, for small bulks, a cooling spear; the use of grain stirrers could also be considered, see pages 16-17

Dry grain within storage time indicated to 14.5% mc

NB. The times indicated by the calculator commence immediately after harvest and not once grain is put into the store – times indicate a safe storage period not an immediate risk

Oilseeds should be dried to 7.5-8% mc as soon as possible

> “Drying grain **below 18% mc** within the shortest possible time is necessary to **prevent the risk** of mycotoxin formation”

Key hazards and the preventative measures to be taken

Hazards	Risk score	Preventative measures	Monitoring procedure	Corrective action
Production of ochratoxin A	★★★ CCP	Commence drying of grain above 18% mc immediately; dry grain to 14.5% mc	Measure temperature and moisture content and refer to the HGCA safe storage time calculator	Investigate any significant changes in moisture content; review practices and grain condition
Introduction of fungi with potential to cause mycotoxins	★★	Clean equipment and store area	Inspect for presence of mouldy grains	Dry grain to 14.5% mc; commence drying of grain above 18% mc immediately
Introduction of insects and mites from store fabric	★★	Clean area and equipment	Monitor insect/mite presence using traps	Consider need for pesticide treatment if pest insects and/or mites are found
Growth and development of insects and mites	★	Cool and dry to recommended levels	Monitor insect/mite presence using traps; measure temperature and moisture content	Investigate any significant changes in moisture content; review practices and grain condition

HACCP risk rating high risk ★★★ medium risk ★★ low risk ★

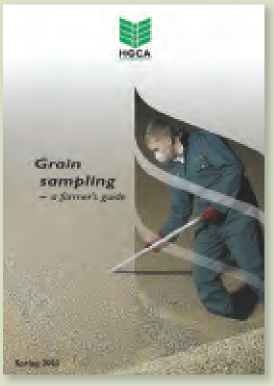
CCP Critical Control Point A process step at which control can be applied and that is essential to prevent or eliminate a food safety hazard or reduce it to an acceptable level. If controls fail at this point food safety risk is increased.

Sampling

Take at least one sample from each trailer load for determination of moisture content (mc).

If it is not possible to collect a sample during tipping, samples should be taken from the tipped pile using a spear sampler.

Also collect a composite sample and determine moisture content and temperature to aid decisions on the need and priority of different batches to be made.



For more information see HGCA's *Grain sampling – a farmer's guide*

An assessment of the safety of personnel during sample collection must be made.

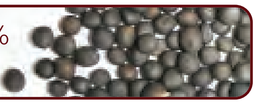
Grain drying

- Ensuring equipment is properly cleaned prior to use will help prevent contamination with fungal spores, insects or mites
- If stored product pests are found during grain cleaning and handling, consider the need for appropriate treatment
- Admixture treatments should only be made using currently approved pesticides at the manufacturer's recommended rate and recognising any limitations by subsequent users
- Ensure that the correct rate is applied by servicing and calibrating application equipment

Moisture

Moisture management is vital to prevent spoilage by fungi and mites.

Oilseeds should be dried to 7.5-8% mc as soon as possible



Grain at or above 18% mc → Commence drying immediately → 14.5% mc (cereals) ← Dry within safe time ← Below 18% mc

The safe time to achieve the recommended moisture content will depend on the grain temperature: a combination of high moisture content and high temperature results in a greater risk of fungal development and mycotoxin formation. The grain surface absorbs moisture in winter. Even when bulk mc is low, increases in surface mc can lead to very high mite populations.

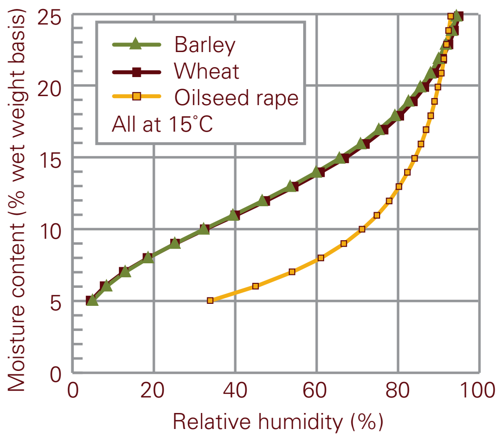
For a given moisture content, grain is safer to store at a lower temperature. This is because the grain exchanges water with the surrounding air and, in enclosed spaces, this continues until a balance (the equilibrium relative humidiy, erh) is reached. As the temperature decreases, so does the erh.

Mould growth and mite reproduction stop below 65% erh.

Moisture content	Wheat temperature		
	5°C	15°C	25°C
16.5% mc	68% erh	74% erh	76% erh
15.5% mc	62% erh	69% erh	71% erh
14.5% mc	56% erh	64% erh	66% erh
13.5% mc	49% erh	58% erh	60% erh

At 5˚C, wheat at 14.5% mc has an erh of 56%. The same grain stored at 25˚C at the same mc has an erh of 66%.

Cereals and oilseeds have different relationships between moisture content and equilibrium relative humidity, hence the recommendations for the target moisture content are different.



The HGCA safe storage time calculator will help to identify grain in most urgent need of attention **www.hgca.com/grainstorage**

Moisture measurement

Moisture measurements can be indirect or direct. In the standard direct method (ISO/BSI 'Oven method') a known weight of ground grain is dried at 130˚C until dry matter weight remains constant. Grinding and temperature control are both critical.

Moisture meters measure moisture content indirectly using either grain resistance or capacitance. They are less accurate than the standard direct method and annual calibration is essential.

An HGCA-funded project to look at moisture measurement showed that at 18% or above meters tended to under-read by as much as 1%.

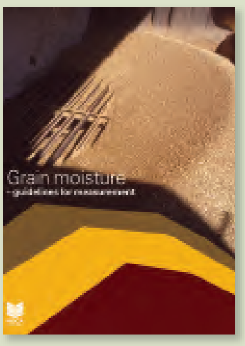
Greater variability was seen with freshly-harvested grain than with grain stored for some time. Repeat testing of the sample gave meter readings within ±0.3%, so taking sufficient sub-samples to achieve a representative composite sample is important. Allowing a safety margin is advised. Errors are frequently ±0.5% and can be greater in very wet, very dry or freshly harvested grain.

Take as many samples as possible and determine moisture content without delay. Keep samples in a watertight container with minimum free air space and at an even air temperature. Mix each sample thoroughly before testing.

Key hazards and the preventative measures to be taken

Hazards	Risk score	Preventative measures	Monitoring procedure	Corrective action
Production of ochratoxin A	★★★ CCP	Commence drying of grain above 18% mc immediately; dry grain to 14.5% mc	Measure temperature and moisture content	Investigate any significant changes in moisture content; review practices and grain condition
Introduction of fungi during grain cleaning	★★	Clean area and equipment	Visually inspect for mouldy grains	Dry grain to 14.5% mc; commence drying of grain above 18% mc immediately
Pesticides exceed maximum residue levels due to incorrect admixture	★★	Use only approved products and conform to manufacturer's guide for use; check condition and calibration of spray equipment	Check records of pesticide application	Review applications and practices
Introduction of hydrocarbons from direct fired drying systems	★★	Use appropriate grade oil; ensure efficient combustion and adequate ventilation	Check before use	Remedy defects
Introduction of rodent faeces during grain cleaning	★	Clean store and proof to prevent ingress of rodents	Check for presence	Check proofing measures; consider control options

For more information see HGCA's Grain moisture – guidelines for measurement.



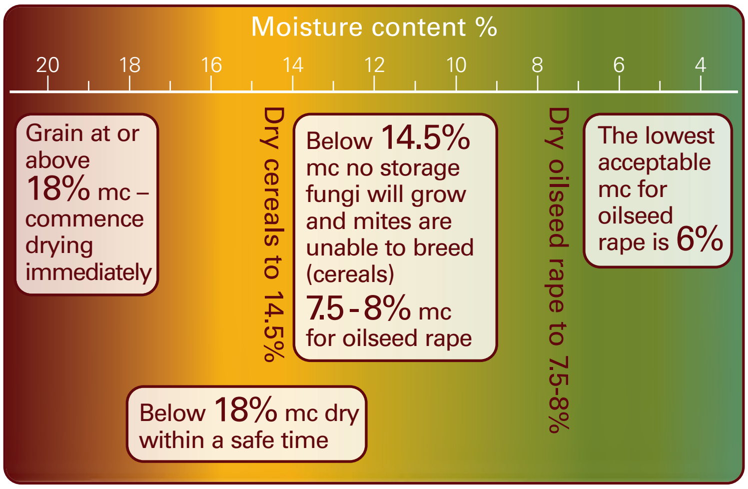
HACCP risk rating high risk ★★★ medium risk ★★ low risk ★

CCP Critical Control Point A process step at which control can be applied and that is essential to prevent or eliminate a food safety hazard or reduce it to an acceptable level. If controls fail at this point food safety risk is increased.

The HGCA weight loss during grain drying calculator will calculate the weight loss from the drying process based on the initial and final moisture readings from a sample of grain **www.hgca.com/grainstorage**

Grain drying

Moisture effects



Drying

There are two basic methods of drying grain – high temperature drying and near-ambient air drying.

High temperature drying uses air heated to 40°C or higher and is fast and independent of the weather but has a higher capital cost.

Near-ambient air drying is used for bulk grain stored in bins or on-floor and works by blowing air, up to 5°C warmer than the grain, through the bulk. This is slower than high temperature drying with a higher risk of spoilage but a lower risk of over-heated grain.

Rapeseed becomes very brittle at low mc so over-drying can be a problem. Free fatty acid content increases rapidly in broken seed and may cause oil degradation after crushing. There is little leeway between the safest mc for prolonged, stable storage (7.5-8%) and the lowest acceptable mc (6%). Good practice requires careful drying and accurate moisture meter calibration.

High temperature drying

Method:	Air heated to 40°C or higher Heat can be generated from oil or gas Either batch or continuous dryers can be used Grain is generally moved during the process to limit over-drying and heat damage
Capital costs:	High
Speed of drying:	Fast – grain is in a shallow layer with high airflow
Management skills:	Follow manufacturer's instructions
Weather:	Independent of weather conditions
Drying temperatures must be set carefully:	Max of 65˚C at 20% mc, reducing by 1˚C for every 1% increase in initial mc For feed grain: Max of 120˚C for 1 hour or 100˚C for 3 hours
Risks of spoilage:	Low risk of slow drying Risk of over-heated grain Some risk of over-drying
	Maltsters, millers and seed producers require that grain temperatures should not exceed 50°C
	After drying, grain must be cooled to prevent breeding of insects and mites

Polycyclic aromatic hydrocarbons (PAHs)

If a direct drying system uses an oil-fired energy source it is important to avoid hydrocarbon contamination.

This can be achieved by ensuring that the fuel meets commercial ISDN/ISO fuel standards and that there is efficient combustion (by setting air:fuel ratios to manufacturer's recommendations).

It is also important to ensure there is adequate ventilation to prevent the recirculation of burner exhaust gasses into the intake cowling which can generate a taint which can render the grain unsuitable for sale. An additional risk is the development of polycyclic aromatic hydrocarbons (PAHs) if combustion is incomplete.

Near-ambient air drying

Method:	Air, up to 5°C warmer than the grain, is blown through it; recommended airflow is $180m^3$/hr/tonne or $6357ft^3$/hr/tonne
Capital costs:	Low
Speed of drying:	Slow – typically 10 days with recommended airflows of $180m^3$/hr/tonne
Management skills:	Need to respond to moisture content and weather conditions
Weather:	Wet weather slows drying
Initial moisture content:	Drying capacity is reduced if initial moisture content is high
Risks of spoilage:	Higher risk of slow drying Low risk of over-heated grain Some risk of over-drying
!	Drying occurs in a layer that develops at the air intake and then moves through the bulk – grain ahead of the drying zone remains wet and may also be warm, increasing the risk of spoilage
!	Different seeds present different resistances to airflow so bed depth is a critical factor – check airflow is adequate by taking measurements at several points using an anemometer

Grain stirrers

In most years, on-floor drying can be effective and economical but in some seasons an on-floor system will incur considerable costs and may not achieve good enough results. Grain stirrers can be used to mix the grain vertically, resulting in a mix of dry and undried layers.

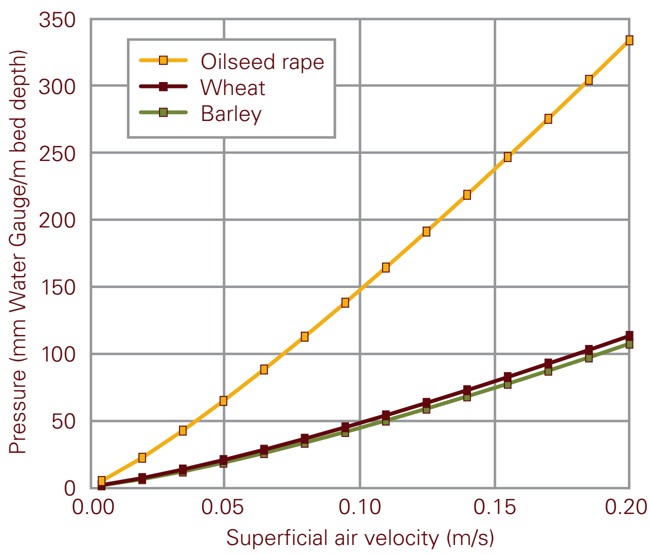
An HGCA project, to be completed in 2012, is examining the potential benefits of grain stirrers with an emphasis on reducing costs and drying time.

Although in its early stages, the project has demonstrated that stirring reduces the length of time that the upper layers of the grain spend at the initial moisture content if there are sufficient stirring augers to be effective for the whole bed.

Grain stirrers

Grain depth

Spoilage risk increases as grain depth exceeds a fan's design maximum. Airflow will be seriously reduced and drying zone advance will be slowed. For example, if grain is normally stored at 2.8m deep, this depth should be reduced by 0.5m for each percentage point increase in initial grain moisture above 20%.



Long-term storage

Temperatures above 15˚C increase the risk of insect and mite populations developing. Cooling of grain should commence as soon as the grain comes into store.

Preparation

Prepare the area as outlined in pages 8-11
Dry grain to 14.5% mc, dry oilseeds to 7.5-8% mc (pages 14-17)

Cooling

Target: within 2 weeks of harvest

Cool by low volume aeration to below 15°C to prevent saw-toothed grain beetles completing their life cycle

→

Target: within 3-4 months of harvest

Cool to below 12˚C to prevent grain weevils completing their life cycle

→

Target: end-December

Cool to below 5˚C to kill surviving adult insects and prevent mites increasing

Malting barley is often not cooled to below 10°C, otherwise secondary dormancy may be induced

The use of **differential thermostats** on cooling fans at a differential setting of 4-6˚C provides the most rapid, cost-effective and carbon-efficient cooling

Weekly monitoring

Monitor temperature, moisture content and traps for the presenceof insects and mites

Insects or mites found

- Increase number of traps to determine extent of infestation, consider the need for treatment
- The type of treatment may depend on the end use of the grain and specific restrictions imposed by a customer further along the supply chain based on their product market

If a residual pesticide treatment is used, this must have approved usage for admixture to the grain and be applied at the manufacturer's recommended rate.

Increase in mc in a localised area of 2% or more in a week

- Identify cause and take necessary action

This may indicate condensation, leaks, hot spots or insects.

Increase in temperature

- Identify cause and take necessary action

This may indicate presence of fungi, sprouting or development of grain weevils.

Positioning insect traps both on the surface of the grain and approx. 5-10cm below the surface approx. 4-5 metres apart will ensure the greatest likelihood of detecting all species of stored product insects and mites at the earliest opportunity

Key hazards and the preventative measures to be taken

Hazards	Risk score	Preventative measures	Monitoring procedure	Corrective action
Production of ochratoxin A	★★★ CCP	Store grain below 14.5% mc and 5°C, except malting barley, which should not be stored below 10°C	Check temperature and moisture content regularly	Investigate any significant changes; review practices and grain condition
Development of insect and mite populations	★★★ CCP	Store grain below 14.5% mc and 5°C, except malting barley, which should not be stored below 10°C; store oilseed at 7.5-8% mc and <5°C	Position traps and check traps correctly; check temperature and moisture content regularly	Investigate source of infestation and any significant changes in mc or temperature; review grain condition and practices; consider need for treatment
Introduction of pesticide residues	★★	Use only approved products and conform to manufacturer's guide for use; check condition and calibration of spray equipment	Check records of pesticide application	Review applications and practices
Introduction of bird and rodent faeces	★	Keep store clean and proof to prevent entry	Check for bird and rodent presence	Check proofing measures; consider control options
Introduction of glass	★	Glass control procedures	Check for compliance with procedures	Remove and replace or protect

HACCP risk rating: high risk ★★★ medium risk ★★ low risk ★

CCP Critical Control Point: A process step at which control can be applied and that is essential to prevent or eliminate a food safety hazard or reduce it to an acceptable level. If controls fail at this point food safety risk is increased.

Record keeping, either electronically or on paper, will illustrate due diligence and enable changes in grain condition to be readily identified. This can provide an early warning of potential problems.

Long-term storage

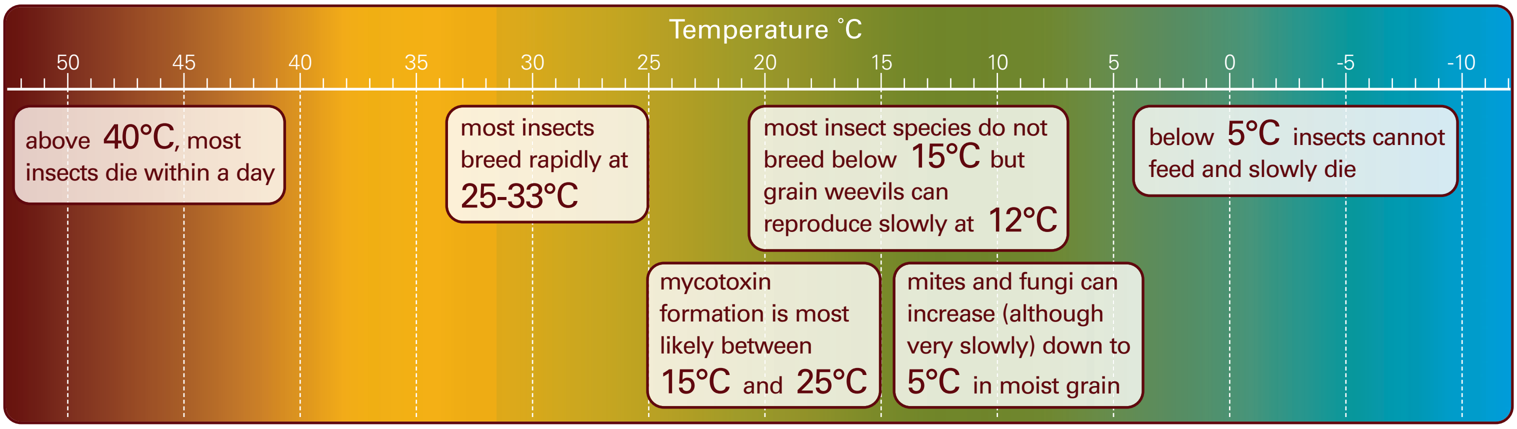
Cooling using low volume ventilation

Temperatures above 15°C increase the risk of insect and mite populations developing. Grain will be relatively warm post-harvest and is a good insulator, so heat will be lost very slowly. Cooling permits grain to be stored at slightly higher moisture contents and effectively increases the safe storage time. It will also even out or equalise temperature gradients and prevent moisture translocation.

Low volume aeration (10m^3/hour/tonne or 6ft^3/min/tonne) should be used to cool the grain and cooling should start as soon as ducts are covered.

Use HGCA safe storage time calculator to determine the safe storage time for individual batches or bulks of grain **www.hgca.com/grainstorage**

Temperature effects



> “Temperatures fall more rapidly and to lower levels when using automatic compared to manual fan control”

Differential controls

Differential controls have been shown to result in more efficient grain cooling. A differential controller will only switch the cooling fan on when the air temperature is lower than the grain temperature.

This method ensures that cooling systems have the potential to run whenever air of a temperature to permit cooling is available and are automatically switched off once the grain reaches the ambient temperature. This results in a reduction in the number of fan hours to reach the target temperature in comparison with manual control of the fans leading to a reduction in energy costs.

The ambient sensor should be placed close to the fan inlet but in a position where it is not affected by any heat generated from the fan.

The grain probe should be placed in the region of the grain bulk that is the slowest to cool and should not be placed too close to the surface to avoid tracking of the ambient temperature. The effectiveness of differential controllers with a 4-6˚C differential has been demonstrated in both computer simulations and practical trials.

If blowing with cooler air using a differential thermostat (4-6˚C difference), it is not possible to dampen grain.

For grain to become damp from blowing, you need a combination of:

– Excessive aeration rates

– Condensation around ducts in spring

– Rain driven into uncovered external fans

– Successive days of condensing fog

Sucking air through grain may increase natural dampening at the grain surface during winter – this front may extend to 1/3 of grain depth.

Grain bed depth

– An important factor when determining cooling strategy

– If the depth is too great, cooling success may be reduced

Oilseed rape has a much higher resistance to airflow than cereals. If using an aeration system designed for conventional cereals storage it is necessary to reduce the bed depth by 50-70% if storing oilseed rape.

Airflow

– Fans need sufficient pressure to overcome resistance due to the crop, the depth and the duct characteristics

– Ducts need to be of sufficient diameter and have sufficient perforated area to minimise resistance

– Measure using an anemometer in a measuring duct of appropriate diameter and length placed in front of or after the fan

– A floatmeter should not be used to measure airflow for low volume aeration

Distance between ducts and grain depth (m)

Grain depth (m)	2.0	3.0	4.0	5.0	6.0	7.0	8.0
Duct centres (m)	7.6	6.3	5.5	5.0	4.4	4.0	3.7

This example is typical of commercial systems using a 250mm diameter by 920mm high perforated metal duct served by a fan working at 70mm wg designed to cool about 95 tonnes of grain in 100 hours of ventilation. Follow suppliers' recommendations for specific products.

Vertical aeration

Vertical aeration systems can be just as effective as horizontal systems. The advantages of vertical systems are that the capital costs are lower and the risk of damaging ducts during unloading in flat stores is reduced. Spacing of ducts will depend on grain depth but generally placing ducts 4-8 metres apart is suitable for an average flat store of grain. Blowing air into the duct will cool 20% more grain than sucking. Sucking air through grain may increase dampening at the grain surface during winter and this dampening front may extend to one-third of the grain depth. This may increase the risk of storage mite infestations and storage mycotoxins, depending on the temperature. See HGCA Project Report 269 for further information.

Upward versus downward aeration

Blowing air up through grain is preferable to sucking air down because:

– Blowing improves air distribution

– 'Problems' rise to the surface

– Fan heating reduces relative humidity of blown air

– Warm, damp air is flushed from the building

– Cooling can start as soon as ducts are covered

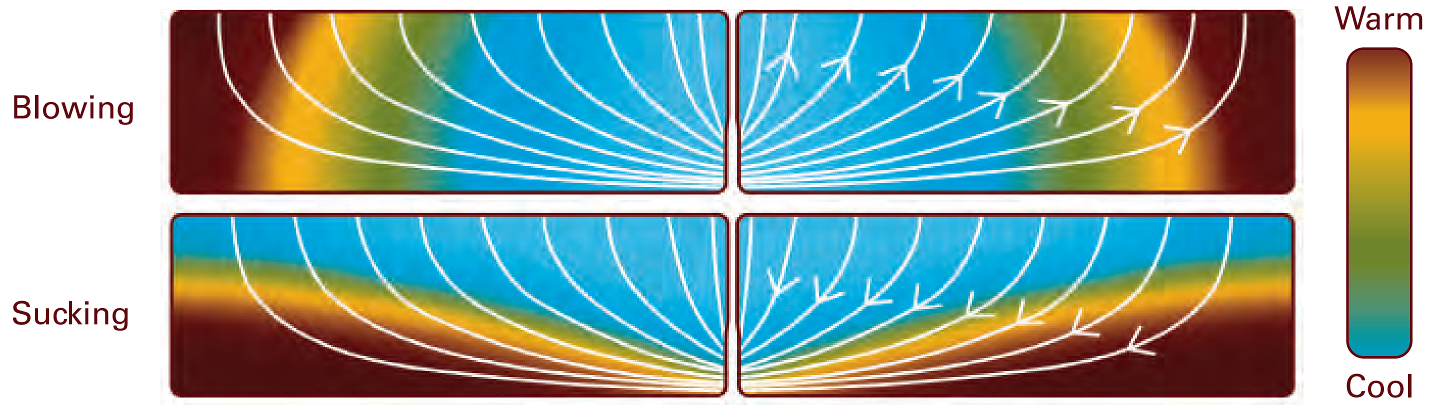
Suction can be useful if:

– Condensation on the inside of roofs is a problem, although good ventilation can overcome this (*NB suction may dampen grain surface layers)*

– There is a risk of water entering aeration ducts

– Grain depth is so great that excessive temperature rise would occur with blowing

Progress of grain cooling with blowing and sucking systems after 100 hours of ventilation in a bed 3m deep (arrows indicate air-flow paths)



Long-term storage

Monitoring

Temperature

– Monitor every few days until target reached, weekly thereafter

– Always record at the same location

– Measurements MUST be taken where cooling takes longest eg furthest from the fan in blowing systems, usually 0.5m beneath the surface and centrally between ducts

– Use a calibrated grain temperature probe (thermocouples or thermistors)

Moisture

– Monitor at several locations (same each time)

– Record at least once each month during winter

– Allow a safety margin: errors are frequently ±0.5% and can be greater in very wet, very dry or freshly harvested grain

Insects and mites

– Early detection is important to prevent rising populations

– Traps have been shown to be more than ten times as effective as sampling for detecting low level populations

– Some traps are designed for use in the store, others for use within the grain bulk

– When monitoring using traps, position them both at and below the surface (eg a combination of probe and pitfall traps, or PC traps in pairs) to target different insect species with different behaviours

– Lay traps out across the grain bulk in a 4-5 metre grid

– Monitor weekly until grain reaches the target temperature (5°C) then monthly providing grain remains at the target temperature, until spring when temperatures rise and insects become more active. Revert to weekly monitoring

– Monitor the structure of the building

– Traps should be accounted for each time they are examined and a permanent record of the contents should be kept

Control measures

Residual insecticides

– Offer some protection over a prolonged period after application

– May take time to control an existing infestation

– Control may take longer to achieve at lower temperatures depending on the active ingredient

Fumigants

– No lasting activity but penetrate and disinfect static bulks

– Will control all stages of infestation in one treatment if correctly applied

Diatomaceous earth (DE)

– Acts by desiccating insects and mites

– Can be slow acting

– Not accepted by some supply chains due to health and safety concerns (dust) and the inability to remove it from the grain, which can affect machinery: check with the buyer

Traps v sampling

– A simple relationship between actual insect numbers and the quantities caught in traps cannot be accurately determined due to complex environmental conditions and insect behaviour

– Traps do provide an indication of population trends

– Sampling grain and subsequent examination can be used to detect insects and mites but is less reliable than traps

– It may be appropriate to check for storage mites in the surface layer of the grain

i Products currently approved for use in the UK either as structural treatments or treatments of grain can be found on the Chemicals Regulation Directorate (CRD) website **www.pesticides.gov.uk**. The intended use and market of the grain may determine the products that can be applied.

Apply pesticides correctly to prevent exceeding maximum residue limits. Incorrect application can contribute to pesticide resistance.

Take appropriate safety measures when using any chemical treatment and wear correct PPE.

Dispatch

Dispatch

Throughout the dispatch and transportation process it is important that the premises, equipment and transportation vehicles remain as clean as possible. Grain residues in vehicles can be a source of stored product insects and mites, therefore, care should be taken to remove deposits of grain in the vehicle as soon as possible after transportation.

If taken to another storage facility then the steps previously described will be necessary. Depending on the moisture content and temperature of the grain at dispatch, the optimal conditions for storage may be reached more quickly.

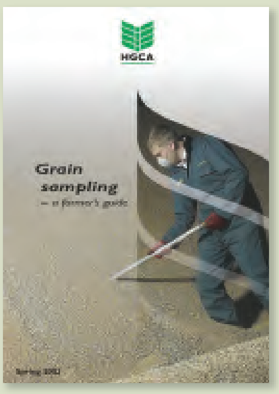
Key hazards and the preventative measures to be taken

Hazards	Risk score	Preventative measures	Monitoring procedure	Corrective action
Introduction of storage fungi	★	Clean outloading equipment and transport	Visually inspect	Targeted cleaning
Introduction of insect and mite populations	★	Clean outloading equipment and transport	Visually inspect	Targeted cleaning

HACCP risk rating: high risk ★★★ medium risk ★★ low risk ★

Grain sampling

Representative samples of the grain should be taken. The specific tests and measurements that need to be carried out on the grain sample will depend on the end market. Further details on grain sampling can be found in HGCA's Grain sampling - a farmer's guide.



“Care should be taken to remove deposits of grain in the vehicle as soon as possible after transportation”

Pest identification

It is important that any pests found are correctly identified. Field insects may be found in the grain shortly after harvest but these will die out in the store.

Common primary insect pests

Can increase rapidly and damage grain stored at temperatures above 15˚C.

Grain weevil

Sitophilus granarius

Develops inside the grain. Causes heating. Difficult to find.

Saw-toothed grain beetle

Oryzaephilus surinamensis

Only develops on damaged surface of grain. Very active and easy to trap.

Rust-red grain beetle

Cryptolestes ferrugineus

Penetrates grain through minute cracks. Can fly in hot UK summers.

Other primary insect pests

Occasionally found on UK grain but require high temperatures and do not overwinter well.

Rice and maize weevils

Sitophilus oryzae/zeamais

Mainly associated with imported feedstuffs.Can move into stored grain. Eggs laid inside grain.

Lesser grain borer

Rhyzopertha dominica

Eggs laid on grain surface, larvae burrow inside to develop.

Rust-red flour beetle

Tribolium castaneum

Requires a high proportion of damaged grains to thrive. Frequently found in animal feed mills.

Secondary insect pests

Cannot complete their life cycles at 14.5% moisture content or below. Feed primarily on fungi. Can invade grain stores in large numbers from outside and feed directly on grain.

Hairy fungus beetle

Typhaea stercorea

Associated with stored straw, hay and damp residues. Develops inside the grain. Causes heating. Difficult to find.

Foreign grain beetle

Ahasverus advena

Increasingly common in UK. Very mobile and a common cause of rejection.

Fungus beetles

eg *Cryptophagus* species

Frequent in damp, mouldy residues and can wander into stored grain.

Australian spider beetle

Ptinus tectus

Seldom found in UK grain, but survives in structure of warmer stores.

White-marked spider beetle

Ptinus fur

Numbers can take years to build up. Can survive long periods in an inactive form.

Plaster beetle

Lathridiidae

Very small black beetles which flourish in damp, mouldy residues.

Pest mites

Normally only a problem on damper surface of dry bulk if moisture content targets are met in the rest of the bulk.

Flour mite *Acarus siro*

Indicates bulk moisture content is higher than recommended. Internal feeder which can build up massive populations.

Cosmopolitan food mite

Lepidoglyphus destructor

Surface feeder usually present in low to moderate numbers.

Grainstack mite *Tyrophagus longior*

Initial infestations often occur during bulk drying operations. Requires high mc and temperature.

Predatory & other mites

Large numbers indicate high temperatures and previous infestations.

Predatory mite

Large numbers indicate high temperatures and previous infestations.

Gamasidae

Long-legged fast movers may prey on pest mites. Individuals may also be blood feeders on rodents.

Moths

May be seen flying in summer. Webbing produced by larvae may clump grains together. Mainly occur on surface of bulk, also infest and breed in debris.

Brown house moth

Hofmannophila pseudospretella

Often associated with animal feeds.

White-shouldered house moth

Endrosis sarcitrella

Slow to develop in old grain or feed residues.

Moth larva

Distinguished from beetle larvae by dark head capsule.

Booklice

Considerable numbers may build up at grain surface, mainly in winter. Can be clearly seen running over storage structures.

– wingless

Require damper conditions, ubiquitous in UK.

– winged

Can be found in spectacular numbers, especially around edges of grain bulk. Pest status not clear.

Non-pest species

Clover weevil

Sitona species

Other non-damaging species include the ground beetle and the narrow-necked harvest beetle.

Further information

HGCA information

HGCA publications are freely available to download from www.hgca.com/publications

Drying and Cooling

G37 Grain moisture – guidelines for measurement (2008)
PP13 On-floor drying to minimise grain spoilage (2006)
TS89 Drying and storing rapeseed successfully (2006)
TS78 Drying and cooling grain: an update (2004)
TS60 Ensuring good germination in malting barley (2002)
TS53 Vertical ventilation for cooling grain (2002)
TS16 Bulk storage drying of grain and oilseeds (1998)

Sampling

G18 Grain sampling from field to buyer – understanding variation (2004)
G17 Grain sampling – a farmer's guide (2003)
TS83 Sampling grain during outloading (2005)
P04 Grain sampling on-farm
GSG2009 Grain sampling guidelines (2009)
GSWV1 Grain sampling worksheet

Pests

G09 Rodent control in agriculture – a guide (2002)
TS79 Insect and mite control in empty grain stores using DE (2004)
TS62 Preventing and controlling mites in stored cereals (2002)
TS8 Effective phosphine fumigation of grain (1998)
P01 Insects and mites in stored grain and grain stores
P03 Inspecting grain for defects and impurities

Fusarium mycotoxins

G34 Guidelines to minimise risk of fusarium mycotoxins in cereals (2010)
TS108 HGCA risk assessment for fusarium mycotoxins in wheat (2011)

HGCA Research Reviews

RR42 Alternatives to organophosphorous compounds for the control of storage mites (2000)
RR38 Bulk storage drying of grain and oilseeds (1998)
RR27 Methods of distributing phosphine in bulk grain (1994)
RR OS6 Drying and storage of oilseed rape in the UK (1992)

The HGCA safe storage time calculator is available at **www.hgca.com/grainstorage**

HGCA Project Reports

PR464 Food safety review of UK cereal grain for use in malting, milling and animal feed (2009)
PR454 BulkDryRape: Interactive computer-based tool (2009)
PR443 Assessing and addressing the impact of warmer autumns on the success of grain cooling (2008)
PR440 Validation of a model to avoid conditions favouring Ochratoxin A production during ambient air-drying (2008)
PR437 Evaluation of rapid test kits as potential screening tools for Ochratoxin A determination in wheat and barley (2008)
PR426 Research to develop practical user guidelines to maximise the accuracy of moisture meters (2008)
PR407 Assessment of three commercial automatic grain samplers fitted to front loader buckets (2006)
PR399 Practical strategies for minimising the production of Ochratoxin A in damp cereals (2006)
PR396 Improved detection and monitoring of beetle pests in stored grain through use of a multi-species lure (2006)
PR386 Monitoring contaminants in wheat grain (2006)
PR380 Review of food safety issues relating to the supply and market acceptability of UK malting barley and UK malt (2006)
PR269 Optimising the performance of vertical aeration systems (2002)

Websites

Agricultural Industries Confederation (AIC): **www.agindustries.org.uk**

Campaign for Responsible Rodenticide Usage: **www.thinkwildlife.org.uk**

Food Standards Agency: **www.food.gov.uk**

Grain and Feed Trade Association (GAFTA): **www.gafta.com**

HGCA: **www.hgca.com/grainstorage**

Insecticide Resistance Action Group (IRAG-UK): **www.pesticides.gov.uk/rags_home.asp**

Maltsters' Association of Great Britain: **www.ukmalt.com**

National Association of British and Irish Millers (nabim): **www.nabim.org.uk**

NFU: **www.nfuonline.com**

Red Tractor Farm Assurance: **www.assurance.redtractor.org.uk**

Scottish Quality Cereals (SQC): **www.sfqc.co.uk**

The Food and Environment Research Agency: **www.fera.defra.gov.uk**

Other information

Legislation (www.legislation.gov.uk)

The following list is not exhaustive, but highlights the key pieces of agricultural, environmental and food/feed safety legislation which must be understood and complied with:

UK Acts:

- Agriculture Act 1947
- Prevention of Damage by Pests Act 1949
- Pests Act 1954
- Health and Safety at Work Act 1974
- Control of Pollution Act 1974
- Wildlife and Countryside Act 1981
- Food and Environment Protection Act 1985 (Part iii)
- Food Safety Act 1990
- Environmental Protection Act 1990
- Wild Mammals (Protection) Act 1996

UK Statutory Instruments:

- The Control of Pesticides Regulations 1986 (SI 1986 No. 1510)
- The Spring Traps Approval Order 1995 (SI 1995 No. 2427)
- The Management of Health and Safety at Work Regulations 1992 (SI 1992 No. 2051)
- The Control of Substances Hazardous to Health Regulations 1994 (SI 1994 No. 3246)
- The Food Safety (General Food Hygiene) Regulations 1995 (SI 1995 No. 1763)
- The Plant Protection Products (Basic Conditions) Regulations 1997 (SI 1997 No. 189)
- Transmissible Spongiform Encephalopathies (No. 2) Regulations 2006 (SI 2006 No.1228)
- The Feed (Hygiene and Enforcement)(England) Regulations 2005 (SI 2005 No. 3280)
- The Official Feed and Food Controls (England) Regulations 2006 (SI 2006 No. 15)
- The Feeding Stuffs (England) Regulations 2005 (SI 2005 No. 3281)
- The Feeding Stuffs (England) (Amendment) Regulations 2006 (SI 2006 No. 2808)
- The Feed (Specified Undesirable Substances) (England) Regulations 2006 (SI 2006 No. 3120)
- The Food Hygiene (England) Regulations (SI 2006 No. 14)
- The Contaminants in Food (England) Regulations 2006 (SI 2006 No. 1464)

EU Legislation:

- Biocidal Products Directive (98/008/EEC)
- Feed Hygiene Regulation (EC No. 183/2005)
- Food Hygiene Regulation (EC No. 852/2004)
- General Food Hygiene Requirements (EC No. 178/2002)
- EU Legislation (Directive 2007/68/EC)
- Directive 2003/89 Annex IIIa – Food Labelling Amendment
- Commission Regulation (EC No 466/2001) setting maximum levels for certain contaminants in foodstuffs
- Regulation 1829/2003 EC on GM food and Feed
- Regulation 1830/2003 EC on Traceability and Labelling of Feed Products Derived from GMOs
- Commission Directive 200/26/EC on sampling methods and methods of analysis for the official control of the levels of Ochratoxin A in foodstuffs

British and International Standards

BS EN ISO 712:2009 Cereals and cereal products – Determination or moisture content – Reference method

BS 4317-18: 1988 Methods of test for cereals and pulses. Determination of hidden insect infestation

BS ISO 7701-1:2008 Food products – Checking the performance of moisture meters in use Part 1: Moisture meters for cereals

BS 4317-26: 1991 (ISO 4112:1990) Methods of test for cereals and pulses. Measurement of temperature of grain during bulk storage

BS 6219:1996 (ISO 5223:1995) Test sieves for cereals

BS6279-2:2001 (ISO 6322-2:2000) Storage of cereals and pulses. Practical recommendations

BS EN ISO 243333:2009 Cereals and cereal products – sampling

Defra Publication

Code of practice for the control of *Salmonella* during the production, storage and transport of compound feeds, premixtures, feed materials and feed additives
www.defra.gov.uk

FSA Publications

Code of Good Agricultural Practice for the reduction of mycotoxins in UK cereals

The UK Code of Good Storage Practice to Reduce Ochratoxin A in Cereals
www.food.gov.uk

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