UK FLOUR MILLERS BRIEFING DOCUMENT

Ergot and ergot alkaloids

Revised November 2020

Summary

Ergot (*Claviceps purpurea*) is a fungal disease that affects wheat, barley, oats, rye, triticale and a wide range of grasses, particularly black-grass. The disease has little direct effect on the crop but the ergot fruiting bodies (sclerotia) contain mycotoxins (ergot alkaloids) which can be harmful to humans and animals if consumed in large quantities.

Following a scientific opinion from the European Food Safety Authority, the European Commission (EC) set maximum levels for sclerotia. In addition to these maximum levels for sclerotia, the Commission has set maximum levels for ergot alkaloids in processed cereal products, including flour, which will apply from July 2021.

Background

Ergot is a fungal disease that affects wheat, barley, oats, rye, triticale and a wide range of grasses, particularly black-grass. Wheat and other cereals are less severely affected than rye. It infects the ear at flowering and replaces a few spikelets with a characteristically shaped black sclerotium. These can be up to 2cm in length and are very obvious in grain owing to their contrasting colour.

The disease is spread by ergot sclerotia in seed or by ergots contaminating the soil from previously infected crops. These produce ascospores that are carried to nearby crops by the wind. Secondary infection resulting from conidia produced in the florets of infected grasses pose a risk to wheat at the crop/margin interface. The maximum survival of ergot spores in the soil is reported to be one year.

Seasonal variation in temperature or rainfall has a major impact on levels of infection; the development of ergot in a crop has been historically linked to extremely cold winters that are followed by warm summers. The optimum temperatures for growth of ergot are 18 - 30^{o}C and it favours wet conditions during the flowering periods. The trigger for ergot development is critical and probably a combination of environmental factors, temperature, day length and humidity.

Varietal differences in openness of flowering are unlikely to be major determinants of the relative susceptibility of varieties to ergot in the field and 'tissue resistance' is likely to be of greater significance. Although there is evidence of genetic resistance in the north European winter wheat gene pool (e.g. cv. Robigus) there are no recorded differences in susceptibility for varieties on the current Recommended List.

Control of ergot in crops is challenging with no fungicides providing significant protection. Farmers have limited options for the control of this cereal disease. The AHDB website contains information on risk factors for ergot and how growers can try to address them.

Impact on human health

Ergot has little direct effect on the host plant other than to reduce the grain sites on infected plants but ergot sclerotia contain toxic ergot alkaloids (mycotoxins). There are six principal alkaloids produced by ergot sclerotia which are ergocristine, ergotamine, ergocryptine, ergometrine, ergosine and ergocornine. Each also occurs in epimeric forms.

These ergot alkaloids (and their epimers) have a number of harmful effects on humans and other mammals, including effects on the circulatory system and neurotransmission. Acute symptoms include hallucinations, convulsions, uterine contractions, nausea, seizures, whilst chronic effects (at high levels) include loss of limbs, unconsciousness and even death. The increased scientific understanding and improvements in agricultural practices and milling techniques (grading, sieving and sorting) has eliminated the severe epidemic outbreaks of ergotism seen in previous centuries.

In 2012 the European Food Safety Authority (EFSA) established a tolerable daily intake for ergot alkaloids of 0.63µg/kg of body weight and 1.0µg/kg of body weight for the group reference dose. In 2013 the Federal Institute of Risk Assessment (BfR) in Germany assessed a risk to consumers from eating cereal-based products containing more than 64µg ergot alkaloids per kg of product.

Legislation

There was interest from the EC relating to setting maximum levels for ergot alkaloids since testing standards became widely available for them in 2008. However, as no rapid tests were available to detect alkaloids, the focus had largely been on maximum levels for ergot sclerotia.

In December 2015, the EC set maximum levels of ergot sclerotia in all unprocessed cereals (except corn & rice) at 0.5g/kg (0.05% w/w). This level applies to unprocessed cereals placed on the market for 'first-stage processing'. First-stage processing means any physical or thermal treatment. However, cleaning, including scouring, sorting and drying are not considered to be 'first-stage' processing in so far as the whole grains remain intact after cleaning and sorting.

Since those sclerotia maximum levels were set, the EC began to focus on setting maximum levels for ergot alkaloids. These discussions took place from 2016 to 2020 and the EC has now agreed the maximum levels, which are due to come into effect from July 2021. The maximum levels apply to cereal milling products (i.e. flour) and cereal-based infant food, but not wheat and finished cereal-based products (bread). Separate levels apply to white flours (ash content <900mg/100g) and wholemeal flours (ash content ≥900mg/100g). The level for white flours is due to drop from 100ppb to 50ppb from July 2023. Separate, higher levels apply to unprocessed rye grain and rye flour.

Additionally, the maximum level for ergot sclerotia in unprocessed cereals will be reduced to 0.2g/kg (0.02% w/w).

Sclerotia	Maximum limit (applying from July 2021)
Unprocessed wheat*	0.2g/kg (0.02%w/w)
Unprocessed rye*	0.5g/kg (0.05%w/w) (dropping to 0.02g/kg from July 2023)

Ergot alkaloids	Maximum limit (applying from July 2021)
White flour (ash <900mg/100g)	100µg/kg (dropping to 50µg/kg from July 2023)
Wholemeal flour (ash ≥900mg/100g)	150µg/kg
Processed cereal based food for infants and young children	20µg/kg
Rye flour	500µg/kg

* applies to unprocessed cereals placed on the market before first-stage processing. Drying and cleaning (including scouring and sorting) are not considered to be first-stage processing insofar as the whole grain remains intact.

UK Flour Millers strategy

In order to prepare for the forthcoming changes, **UK Flour Millers** encouraged AHDB to fund new work within the Contaminants Monitoring Project. This was done in 2009 and 2010 as a study to determine levels of alkaloids in samples of wheat rejected at intake where sclerotia had been seen. Additionally, from 2012 approximately 50 samples of milling wheat, accepted at intake, have been analysed annually to provide more information about levels and types of ergot alkaloids in the UK.

The studies in 2009 & 2010 of 27 samples rejected for the presence of ergot sclerotia showed that less than half of the samples had levels of alkaloids above the Limit of Quantification (LOQ) of 10µg/kg. The highest total alkaloid content was 339µg/kg. Ergosine, ergotamine and ergocryptine were the most commonly found alkaloids.

The annual analysis of intake milling wheat carried out since 2012 shows that in most years, the majority of samples do not contain alkaloids above the limit of detection. Where alkaloids were detected, the average levels were low relative to the upcoming maximum levels for white and wholemeal flours. It is important to note that the intake wheat is tested before it has been cleaned and cleaning has been shown to significantly reduce the ergot alkaloid content of grain.

Harvest Year	Total samples	% samples tested positive	Mean* (µg/kg)	Median (µg/kg)	Minimum (µg/kg)	Maximum (µg/kg)
2012	51	25%	75	<60	<60	1,424
2013	76	49%	64	<12	<12	1,381
2014	75	45%	60	<12	<12	1,738
2015	75	41%	2,267	<12	<12	78,769
2015 (no outlier)	74	41%	174	<6	<6	4,415
2016	51	71%	79	<6	<6	1,435
2017	50	78%	90	8	<6	938
2018	50	28%	38	<6	<6	765
2019	50	46%	49	<6	<6	429
2020	50	40%	33	<6	<6	468

* To calculate the mean, the middle bound of results below the LOD was used (where a result is <LOD, it is assumed to be half the LOD).

Given the proposal to set maximum levels **UK Flour Millers** undertook testing of ergot alkaloids in flours across a number of crop years. Across each year, the average alkaloid level was comfortably below the upcoming maximum level for that flour type.

White flour

Year	Samples (n)	% samples tested positive	Mean level (µg /kg)	Median level (µg /kg)	Maximum level (µg /kg)
2018	5	100	34	25	88
2016	30	80	25	11	119
2015	32	53	7	1	55
2013	50	64	17	4	279
TOTAL	117	67	17	4	279

Wholemeal flour

Year	Samples (n)	% samples tested positive	Mean level (µg /kg)	Median level (µg /kg)	Maximum level (µg /kg)
2018	31	100	66	35	427
2017	50	76	37	12	155
2016	30	87	67	31	421
2015	19	79	25	13	85
TOTAL	130	85	49	22	427

Rye flour

Year	Samples (n)	% samples tested positive	Mean level (µg/kg)	Median level (µg /kg)	Maximum level (µg /kg)
2015	4	100	91	47	264
2013	14	93	166	12	1,967
TOTAL	18	94	149	15	1,967

There is ongoing work to develop a rapid test kit for ergot alkaloids that can be used by growers, merchants and millers to detect the level of contamination within a batch of grain. At the time of writing, no rapid test kits (<15minutes) are commercially available, although some are in development. There are reference testing methods that give an accurate ergot alkaloid concentration result, however these take 8-10 days to complete and so would not be viable for intake testing.

The best control method for millers remains accurate testing of sclerotia at intake followed by good grain cleaning practices, which are commonplace amongst UK mills. **UK Flour Millers** surveyed its members and produced a standardised 'best practice' method for the examination of intake samples for ergot sclerotia, which was accepted by the Cereals and Cereal Applications Testing Working Group at Campden BRI (CCAT Method 30). This method is required within the **UK Flour Millers**

intake code of practice and ensures there is an accurate and repeatable method in use by mill intake laboratories.