Annual Report

The surveillance programme for feed materials, complete and complementary feed in Norway 2018 - Mycotoxins, fungi

Veterinærinstituttet
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The surveillance programme for feed materials, complete and complementary feed in Norway 2018 – Mycotoxins and fungi

Content

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Summary

The surveillance programme in 2018 included several mycotoxins and fungi in oats and barley, aflatoxins in maize and in compound feed for ruminants, and several mycotoxins in compound feed for pig. A total of 46 % of the oat samples had total mould counts higher than the guidance values, whereas barley had significantly less total mould. The levels of storage mould, yeast and *Fusarium* were similar between oats and barley. The levels of total mould, storage mould and yeast were higher than the previous two years, whereas *Fusarium* levels were lower with less occurrence of the major mycotoxin producing species *F. graminearum* and *F. langsethiae*. Oats had higher levels of trichothecene mycotoxins than barley, and DON (deoxynivalenol) and T-2 and HT-2 toxin were the major toxins detected. Compared with previous two decades, DON with related compounds were found at very low levels and T-2+HT-2 toxin at moderate levels. Zearalenone (ZEN) was found only in trace concentrations in a few samples of oats and barley, while ochratoxin A (OTA) and ergot alkaloids were not found. No regional differences in fungi or mycotoxins levels were discernible in 2018. Aflatoxin B1 was found in some samples of maize but below the maximum limit. Aflatoxins were found at low concentrations in some samples of feed for ruminants but below the maximum limit. In compound feed for pigs, DON was found in 50 % of the samples, but DON-related compounds were hardly detected. T-2 + HT-2 toxin was found in 20 % of the pig feed samples, while ZEN was found at low levels in some samples. Compared with the last two years, the 2018-levels of DON and T-2 + HT-2 toxin in pig feed were lower, whereas levels of ZEN were unchanged. All trichothecenes and ZEN were below the recommended levels for pig feed in Norway. OTA was found in one sample, above the recommended level in pig feed in Norway. Ergot alkaloids were not detected in pig feed.

Sammendrag

I overvåkingsprogrammet for mykotoksiner og sopp i fôrråvarer og ferdig fôr i 2018 ble forskjellige mykotoksiner og sopp målt i havre og bygg, aflatoksiner målt i mais og i kraftfôr til drøvtyggere, og forskjellige mykotoksiner målt i kraftfôr/tørrfôr til gris. I havre var 46 % av prøvene over veiledende grenseverdi for total muggsopp, mens bygg hadde lavere nivå av total muggsopp. Nivåene av lagringsmuggsopp, gjærsopp og *Fusarium* var på same nivå i havre og bygg. Nivåene av total mugg, lagringmugg og gjær var relativt høye sammenlignet med de siste to foregående årene, mens *Fusarium*-nivået var lavere og med lavere forekomst av de viktige mykotoksinproduserende artene *F. graminearum* og *F. langsethiae*. Havre hadde høyere nivåer av trichothecen-mykotoksiner enn bygg, og DON (deoksynivalenol) og T-2 og HT-2 toksin var de hyppigst påviste toksinene. DON med relaterte forbindelser ble påvist i veldig lave konsentrasjoner og T-2+HT-2 toksin i moderate konsentrasjoner når man sammenligner med resultater fra de siste to tiårene. Zearalenon (ZEN) ble kun påvist som sporkonsentrasjoner i noen få prøver av havre og bygg, og okratoksin A (OTA) og meldrøyealkaloider ble ikke påvist. Sopp og mykotoksiner viste ingen regionale forskjeller i 2018. Aflatoksin B1 ble påvist i noen prøver av mais, men ingen over maksimumsgrensen. Aflatoksiner ble også påvist i lave konsentrasjoner i noen prøver av fôr til drøvtyggere, men ingen over grenseverdien. I kraftfôr til gris ble DON påvist i 50 % av prøvene, men DON-relaterte forbindelser ble så å si ikke påvist. T-2+HT-2 toksin ble påvist i 20 % av prøvene av grisefôret, og ZEN ble også påvist i lave konsentrasjoner i noen prøver. Nivåene av DON og T-2+HT-2 toksin i grisefôr fra 2018 var lavere enn nivåene fra de foregående to årene, mens ZEN var på samme nivå. Alle trichothecener og ZEN var under anbefalte grenseverdier i fôr til gris i Norge. Meldrøyealkaloider ble ikke påvist i grisefôret.

Introduction

The annual surveillance programme for mycotoxins and fungi in feed materials and complete feed is a collaboration between the Norwegian Food Safety Authority (NFSA) and the Norwegian Veterinary Institute (NVI). NFSA decides the extent of the programme based on scientific advices from NVI, NFSA is responsible for collecting the samples and NVI for analysing and reporting of the results.

Mould can roughly be divided into field fungi and storage fungi. Field fungi invade the seeds before harvest, and may affect the appearance and quality of seed or grain. Common field fungi in Norwegian grain include species of *Fusarium*, *Alternaria*, *Microdocchium*, *Cladosporium*, *Acremonium*, *Epicoccum*, *Phoma* etc. Storage fungi usually occur in small amount before harvest, and under improper storage conditions, this small amount can increase rapidly leading to significant problems. The most common storage fungi are species of *Penicillium*, *Aspergillus* and Mucorales.

Fusarium species are the most important mycotoxin-producing field fungi. They produce important mycotoxins such as the trichothecenes deoxynivalenol (DON), T-2 toxin (T-2) and HT-2 toxin (HT-2), as well as zearalenone (ZEN). Two decades of surveillance in Norwegian cereals have found DON to occur in high concentrations, particularly in oats and wheat. DON is a health hazard when ingested by animals and humans [1]. Reduced feed intake and stunted growth rate in pigs caused by exposure to DON are well-documented gastrointestinal disorders. T-2 and HT-2 are usually only present in levels of concern in oats and oat products. T-2 and HT-2 have similar but potentially stronger toxic effects than DON, in causing gastrointestinal lesions as well as immune suppression [1]. The oestrogenic mycotoxin ZEN produced by the same *Fusarium* species as DON, is not very common in Norwegian cereals based on limited available occurrence data [1].

Ergot alkaloids are emerging mycotoxins of considerable interest in EU and data on their occurrence are of great interest [2]. They have moderate acute toxicity, such as neurotoxic effects, they inhibit blood circulation and can interfere with hormone levels. Ergot alkaloids is produced by *Claviceps purpurea*, and this mould is found manly in rye, but also occur in other cereal species. Barley seems to be more susceptible to *Claviceps purpurea* than oats [3,4].

Species of genera *Penicillium* and *Aspergillus* are the most important mycotoxin-producing storage fungi. *Penicillium* species generally grow and produce mycotoxins at lower temperatures than species of *Aspergillus*, and are therefore of main concern under Norwegian storage conditions. Ochratoxin A (OTA) is an important mycotoxin produced by several species of both *Penicillium* and *Aspergillus*. The most prominent livestock effect of OTA is nephrotoxicity in pigs. The toxin may also suppress the immune function and performance [1]. As far as we know, OTA has not caused problems for Norwegian husbandry, but active surveillance of OTA is important because of import of feed ingredients [1]. Aflatoxins, produced by some Aspergilli, are also regarded as potential import problems for Norway. To minimize human health risks via consumption of animal products, the carcinogenic and liver toxic aflatoxins in feed must remain at low levels. Aflatoxins in feed for dairy cattle can lead to the presence of an active aflatoxin metabolite in milk.

Aims

The aims of the programme are to provide reliable documentation on the occurrence of important mycotoxins and selected fungi in feed cereal materials, and complete and complementary feed in Norway, and to use the data to assess adverse animal health risks related to these agents in feed and to human exposure of transmissible agents via animal products.

Materials and methods

In 2018, the surveillance programme for feed consisted of the following samples shown in Table 1.

Table 1. Samples in the surveillance programme for feed 2018.

MAtrix	Planned	Sampled	Analyses*
Oats	45	46	Total mould, *Fusarium*, storage mould, yeast, trichothecenes, ZEN, OTA, ergot alkaloids
Barley	45	48	
Maize/maize gluten	15	9	Aflatoxins
Complementary compound feed for ruminants	50	50	Aflatoxins
Complete compound feed for pigs	20	20	Trichothecenes, ZEN, OTA, ergot alkaloids

* ZEN = Zearalenone, OTA = Ochratoxin A.

Samples of oat and barley from mills in grain production areas were sampled during autumn. Maize samples from imported batches from third countries and samples of compound feed for ruminants and pigs from the feed industries were sampled throughout the year. Sampling followed EU Regulation 691/2013 to ensure samples were representative.

Quantitative determination of total mould, *Fusarium*, storage fungi and yeast

Quantitative determinations of mould, *Fusarium* and storage mould in oats and barley were performed using by NMKL method No 98 and using Malt-yeast-extract-sucrose-agar (MYSA) as growth medium. In addition, a qualitative determination of the composition of the mycoflora was performed by counting *Fusarium*, storage mould and yeast separately. The detection limit was 50 colony-forming units per gram (cfu/g).

Chemical analysis

The novel multi-mycotoxin liquid chromatography-high-resolution mass spectrometry (LC-HRMS/MS) method was used for the simultaneous determination of mycotoxins [5]. The method was validated 'in house' in order to ensure the quality and reliability of collected data. The performance parameters linearity, selectivity, limit of detection (LOD) and limit of quantification (LOQ) were assessed. According to the validation data, considerable matrix effects were demonstrated for all selected mycotoxins, varying from 27 % to 96 %. Reasonable levels of signal suppression or signal enhancement (70 - 120 %) were achieved for only 20 % of targeted mycotoxins. Therefore, in order to improve the accuracy of the method, stable-isotope labelled internal standards (IS) were introduced for nine of the analysed mycotoxins including DON, and its' related compounds 3-acetyl-DON (3-Ac-DON), 15-acetyl-DON (15-Ac-DON) and DON-3-glucoside (DON-3-G), as well as nivalenol (NIV), HT-2, T-2, ZEN and OTA. For quantitative analysis of ergot alkaloids, semisynthetic ergot derivatives were used for the preparation of IS calibrations. Statistics from a proficiency test provided for the national reference laboratories (NRLS) and appointed official control laboratories (OCLS) confirmed the applicability of this approach.

The accuracy of the method was assessed by determining recovery by spiking experiments and precision in terms of total within laboratory precision (RSiR) considering intra and inter day variabilities together (Table 2). Considering the negligible noise in the extracted high-resolution mass chromatograms, the LODs of the targeted mycotoxins were calculated based on the standard deviation of the y-intercept of the respective calibration curves and their corresponding slopes (m) as *LOD = 3 x SD/m* (Table 2). The extraction methodology was based on the two-step extraction (MeCN:H_2O:HCOOH, 80:19.9:0.1, v/v/v and MeCN:H2O:HCOOH, 20:79.9:0.1, v/v/v) in order to improve extraction with respect to polar and non-polar compounds.

The LC-HRMS analyses were performed on a Q-Exactive™ Hybrid Quadrupole-Orbitrap mass spectrometer equipped with a heated electrospray ion source (HESI-II) and coupled to a Vanquish UHPLC system (Thermo Scientific). The Q-Exactive HRMS/MS was operated in full scan (FS) mode with the inclusion of targeted fragmentation (data-dependent MS/MS: dd-MS2).

Table 2. Performance validation parameters for multi-analyte LC-HRMS/MS method.

	LOD, µg/kg	*Total within laboratory precision (%)*			*Recovery ± SD (%)*		
		Oats	Barley	Feed	Oats	Barley	Feed
NIV	30	5	15	5	95±10	89±10	72±23
DON	66	2	3	1	57±3	95±8	106±6
DON-3G	79	1	10	1	95±6	85±12	62±25
Ergonovine*	55	12	3	7	135±30	89±5	62±2
3-Ac-DON	15	3	3	1	87±14	82±8	110±14
HT-2	22	1	1	3	106±9	84±6	111±20
OTA	21	7	2	5	47±23	78±4	94±18
Ergosine*	13	1	6	5	159±48	76±6	114±24
Ergotamine*	39	5	13	5	92±19	54±1	122±46
T-2	13	0	1	2	91±10	86±9	123±24
Ergocornine*	12	2	13	9	156±31	57±5	151±9
α-Ergocryptine*	185	7	18	11	140±24	54±6	129±29
Ergocristine*	24	4	5	9	105±14	62±7	138±34
ZEN	10	1	3	1	82±6	85±7	115±19
15-Ac-DON	52	1	1	1	97±10	75±13	82±26

*Validation data cover ergot alkaloids and the corresponding -inine epimers

All samples positive for OTA by the multi-mycotoxin method was analysed using immunoaffinity clean up followed by determination by HPLC with fluorescence detection for verification. The LOD for OTA was 0.05 µg/kg.

Aflatoxins (B1, B2, G1, G2) were analysed using immunoaffinity columns clean up followed by determination by HPLC using fluorescence detection after post-column derivatisation. The LOD for aflatoxins were: B1: 0.25 µg/kg, B2: 0.10 µg/kg, G1: 0.20 µg/kg, G2: 0.15 µg/kg.

Statistical analysis

Categorical linear regression was used to determine significance in statistical differences between groups. To investigate possible linear correlation between two contaminants in the same feed type, scatter plots, and Pearson correlations with p values was determined. Half detection limits specific to an agent was used for calculation purposes when no higher levels could be measured.

Results and discussion

Cereals

Fungi in oats and barley

In oats, total mould counts were above guidance value (500,000 cfu/g) [6], indicating poor hygienic quality, in 46 % of the samples (Table 3). Barley had significantly less total mould than oats (p=0.001); 13 % of the barley samples were above guidance value. In general, unhygienic feed can cause reduced growth and health problems in animals [7]. However, fresh grain from the field, not yet sufficiently dried, should be emphasized milder than stored grain.

Fusarium and storage mould were found in most samples, and yeast in all samples, without significant differences between cereal species. Total *Fusarium* levels above a level of 25,000 cfu/g, potentially causing health problems, were found in five samples each of oats and barley. For storage mould, four samples of oats (9 %) and one of barley (2 %) were above the guidance value (100,000 cfu/g) [6]. No cereal samples were above the guidance value for yeast (10,000,000 cfu/g) [6].

The levels of total mould in 2018 for oats and barley were higher than in 2017 (30 % and 2 % of the samples of oats and barley, respectively, above the guidance value [3]), but were similar to the situation in 2016 [4]. Also the levels of storage mould and yeast were relatively higher in 2018, while the levels of total *Fusarium* were somewhat lower than in 2016 and 2017 [3,4].

Table 3. Occurrence of fungi (cfu/g of total mould, total *Fusarium*, storage mould and yeast) and mycotoxins (µg/kg of trichothecenes (deoxynivalenol (DON), 3-acetyl-DON (3-Ac-DON), 15-acetyl-DON (15-Ac-DON), DON-3-glucoside (DON-3-G), sum of HT-2 and T-2 toxin, nivalenol (NIV)) and zearalenone (ZEN)) in oats and barley sampled in Norway in 2018.

	Total mould	Total *Fusarium*	Storage mould	Yeast	DON	3-Ac-DON	15-Ac-DON	DON-3-G	T-2+ HT-2	NIV	ZEN
Oats (n = 46)											
Mean	1 062 500	11 600	39 100	960 700	176	19	<52	<80	132	32	<10
Median	470 000	8 900	9 600	680 000	128	<16	<52	<80	91	<30	<10
Min-max	27 000 / 9 100 000	<50 / 50 000	<50 / 430 000	27 000 / 3 500 000	<66 / 843	<16 / 71	<52	<80 / 124	<36 / 437	<30 / 303	<10 / 29
St. deviation	1 712 800	13 500	75 800	872 600	183	16	0	19	115	52	4
% samples above detection limit	100	93	91	100	76	48	0	11	78	16	2
% samples above guidance values	46		9	0	0				0		0
Barley (n = 48)											
Mean	213 700	11 200	40 000	1 024 700	<66	<16	<52	<80	<36	<30	<10
Median	86 500	5 000	2 000	885 000	<66	<16	<52	<80	<36	<30	<10
Min-max	10 000 / 1 800 000	<50 / 100 000	<50 / 1 600 000	15 000 / 3 600 000	<66 / 395	<16 / 18	<52	<80 / 113	<36 / 72	<30 / 51	<10 / 45
St. deviation	305 900	17 400	230 200	818 600	69	1	0	11	9	5	8
% samples above detection limit	100	94	85	100	8	2	0	2	4	2	4
% samples above guidance values	13		2	0	0				0		0

Table 4. Correlation coefficients between counts of the various groups of fungi in oats and barley sampled in Norway in 2018. Significant correlation coefficients are presented in bold (p<0.05).

	Total mould	Total *Fusarium*	Storage mould	Yeast
Oats (n = 46)				
Total mould	1.000			
Total *Fusarium*	**0.371**	1.000		
Storage fungi	0.214	-0.059	1.000	
Yeast	**0.307**	**0.554**	-0.123	1.000
Barley (n = 48)				
Total mould	1.000			
Total *Fusarium*	0.215	1.000		
Storage fungi	**0.301**	-0.060	1.000	
Yeast	0.111	0.201	-0.183	1.000

In oats, the levels of total mould, total *Fusarium* and yeast were significantly positively correlated, whereas storage mould were not correlated with other fungi (Table 4). This was the same correlation pattern for oats as found in 2017 [3]. In barley, the levels of total mould and storage mould were positively correlated (p=0.04), whereas other combinations were not. For barley the results were somewhat different from 2017, and the correlation between total and storage mould is most likely due to higher prevalence of storage mould in 2018.

Table 5 shows the frequency of *Fusarium* species found in oats and barley. In oats, *F. poae* was the dominating species, whereas *F.avenaceum* and *F. poae* dominated in barley. The DON-producing *F. graminearum* and the T-2/HT-2 producing *F. langsethiae* were far less prevalent. This was somewhat different from the corresponding results in 2017 where *F. graminearum and F. langsethiae* were the most common species in oats, and also more dominating in barley [3]. *F. poae* may produce NIV and ZEN and other secondary fungal metabolites but is not reported to produce DON [8]. *F. avenaceum* does not produce trichothecenes, but less important mycotoxins such as moniliformin, enniatins and others [1].

Table 5. The frequency of *Fusarium* species found in oats and barley in 2018.

Species	Number of samples (and %) detected	Number of samples with most dominant species
Oats (n = 46)		
F. poae	31 (67 %)	23
F. langsethiae	10 (22 %)	9
F. avenaceum	7 (15 %)	4
F. graminearum	4 (9 %)	3
F. tricinctum	3 (7 %)	4
Fusarium sp. (not identified)	4 (9 %)	
No *Fusarium* occurrence	3 (7 %)	
Barley (n = 48)		
F. avenaceum	24 (50 %)	17
F. poae	23 (48 %)	19
F. graminearum	9 (19 %)	6
F. tricinctum	5 (10 %)	3
F. culmorum	5 (10 %)	1
F. langsethiae	2 (4 %)	1
F. sporotrichoides	1 (2 %)	0
F. torulosum	1 (2 %)	1
Fusarium sp. (not identified)	5 (10 %)	
No *Fusarium* occurrence	3 (6 %)	

Levels of mycotoxins in oats and barley

The levels of trichothecenes were as usual significantly higher in oats than in barely (Table 3), and the results reflects the occurrence of *Fusarium* species (Table 4). In 2018, DON and DON-related compounds were found at very low levels. No feed samples exceeded the limit for DON recommended by EU and Norway (8000 µg/kg) [6, 10].

The DON-related compounds included in the analysis were the acetylated precursor compounds (3-Ac-DON and 15-Ac-DON) and a glucoside metabolite (DON-3-G). Like DON, the related compounds occur primarily in oats. 3-Ac-DON was found at low levels in about half of the samples, whereas DON-3-G was found in fewer samples. 15-Ac-DON was undetectable as usual in Norwegian samples. DON and 3-Ac-DON were significantly positively correlated in oats (Figure 1). In general, the related compounds contribute substantially to the total DON concentration [9].

T-2 and HT-2 for which recommendations exist as the sum of T-2 + HT-2 in EU and Norway [6,11] were primarily found in oats (Table 3) at a similar level as in 2016 and 2017 [3,4]. These two compounds were highly correlated in oats (r=0.868).

The concentrations of DON and T-2 + HT-2 in oats have been determined in surveillance programs since 2002 and Figure 2 illustrates that mean DON concentration in 2018 was at the lower end of the scale. In fact, the DON concentrations have been relatively low during the last years since the peak DON level in 2012. Figure 2 also shows that mean concentration of T-2+HT-2 in 2018 was at an average level.

Nivalenol was only detected in a few samples of oats and even fewer samples of barley (Table 3). This is as usual in Norway.

*Z*EN was detected in a few cereal samples at levels far below the recommended limit (2000 µg/kg) in EU and Norway (Table 3) [6,10].

OTA was not detected in oats (<21 µg/kg) but a trace of OTA was found in one sample of barley (22 µg/kg).

Ergot alkaloids were not detected in oats or barley in 2018 (Table 6). In 2016 and 2017 such compounds were found sporadically in barley at levels of possible health concern [3,4].

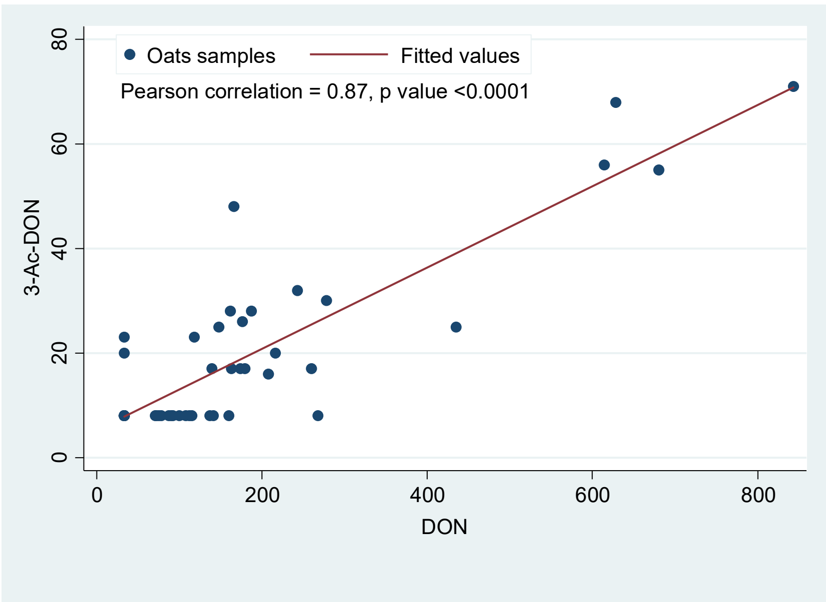

Figure 1. Correlation between DON and 3-acetyl-DON in oats (N=46). A regression line fitted to the points allows predictions of levels of 3-Ac-DON given the level of DON detected and vice versa.

Table 6. Concentrations (µg/kg) of ergot alkaloids (ergonovine/ergonovinine, ergosine/ergosinine, ergotamine/ergotaminine, ergocornine/ergocorninine, alpha-ergocryptine/alpha-ergocryptinine, ergocristine/ergocristinine and sum ergot alkaloids in oats and barley sampled in Norway in 2018.

	Ergo-novine/-inine	Ergo-sine/-inine	Ergot-amine/-inine	Ergo-cornine/-inine	α-Ergo-cryptine/-inine	Ergo-cristine/-inine	Σ Ergot alkaloids
Oats (n = 46)							
Mean	<56	<12	<40	<12	<190	<24	<332
Median	<56	<12	<40	<12	<190	<24	<332
Min-max	<56	<12	<40	<12	<190	<24	<332
St. deviation	0	0	0	0	0	0	0
% samples above detect. limit	0	0	0	0	0	0	0
Barley (n = 48)							
Mean	<56	<12	<40	<12	<190	<24	<332
Median	<56	<12	<40	<12	<190	<24	<332
Min-max	<56	<12	<40	<12	<190	<24	<332
St. deviation	0	0	0	0	0	0	0
% samples above detect. limit	0	0	0	0	0	0	0

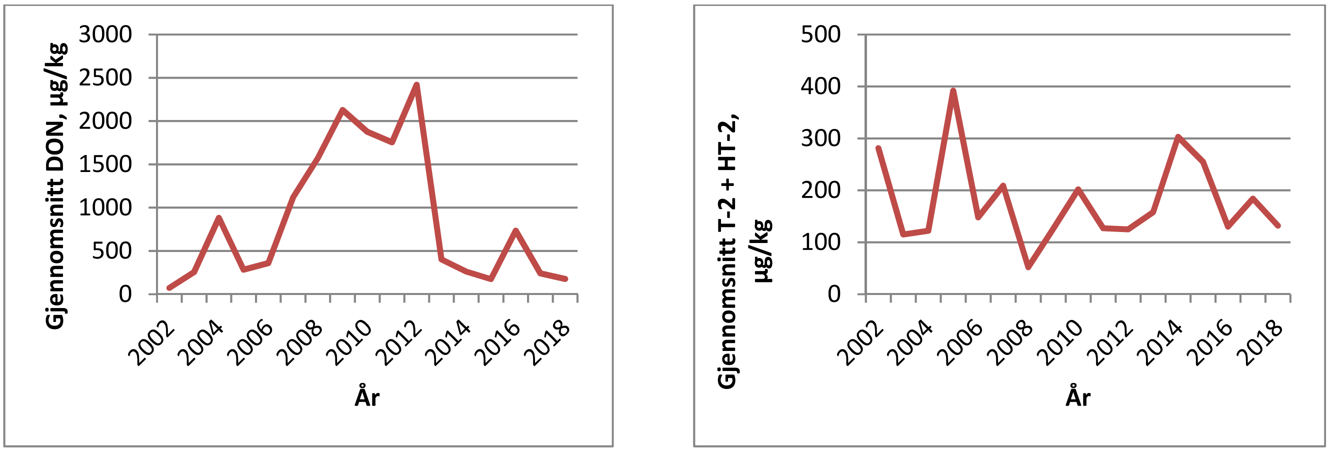

Figure 2. Mean concentration of deoxynivalenol (DON) (left) and the sum of T-2 toxin and HT-2 toxin (right) in 30-60 samples of oats per year in the Norwegian surveillance programme for feed.

Regional differences of fungi and mycotoxins in cereals

There were no significant regional differences in levels of fungi in oats or barley (Table 7). The mean levels may look different but were due to a few extreme outliers.

Regarding mycotoxins, only DON and T-2+HT-2 were tested for regional differences. No significant differences were found either for oats or barely. The presence of T-2 and HT-2 in region Midt (Trøndelag, Møre and Romsdal) is a relatively new finding. Numerically, the levels of T-2+HT-2 in oats in region Midt was below the levels in the other regions but without statistical significance (p=0.06). In 2017, the T-2+HT-2 level in region Midt was significantly lower than in other regions [3] and in previous years these toxins were not found at all in region Midt [4,12]. The differences between Midt and other regions of Norway were probably due to colder climate in Midt. The responsible fungi, *F. langsethiae*, was previously documented in Midt at a similar level as further south [12]. Several studies indicate that T-2 and HT-2 are produced at relatively warm and dry climate [13,14]. In 2017 and particularly 2018, Midt experienced warmer growing seasons [15]. As anticipated [3]: with warmer climate, previous regional differences on T-2 and HT-2 may disappear.

Table 7. Survey between regions Øst (counties Buskerud, Vestfold, Telemark, Hedmark, Oppland), Stor-Oslo (Akershus, Oslo, Østfold) and Midt (Trøndelag and Møre/Romsdal) on fungi (total mould, *Fusarium* spp., storage mould and yeast (cfu/g) and trichothecenes (deoxynivalenol (DON), sum of T-2 and HT-2 toxin, nivalenol) and zearalenone (all toxin concentrations µg/kg) in oats and barley sampled in Norway in 2018. No significant differences between regions are found ($p<0.05$).

		Total mould	Total *Fusarium*	Storage mould	Yeast	DON	T-2+ HT-2	NIV	ZEN
Oats									
Øst n=16	Mean	1 552 900	10 400	28 800	1 082 400	213	175	51	<10
	St. dev.	2 372 300	11 800	42 100	851 500	185	130	84	0
Stor-O n=22	Mean	970 900	10 400	50 900	739 000	121	128	<30	<10
	St. dev.	1 360 500	12 500	94 500	702 100	93	104	15	0
Midt n=8	Mean	333 300	17 700	27 100	132 7000	253	59	<30	<10
	St. dev.	251300	18 900	73 900	1 233 300	312	80	26	8
Barley									
Øst n=14	Mean	207 500	18 400	3 700	1 283 200	<66	<36	<30	<10
	St. dev.	209 500	27 700	7 000	791 500	97	3	10	0
Stor-O n=20	Mean	193 500	5 300	11 200	997 000	<66	<36	<30	<10
	St. dev.	218 400	6 200	13 800	732 700	11	2	0	0
Midt n=10	Mean	238 000	13 300	161 100	556 000	79	<36	<30	13
	St. dev.	549 300	14 900	505 600	583 000	98	9	0	16
Sør og Vest n=4	Mean	275 800	9 900	8 100	1 430 000	<66	<36	<30	<10
	St. dev.	241 900	5 900	14 600	1 447 500	0	27	0	0

The weather during the growing season is a key factor for the *Fusarium* and mycotoxin contents of cereal grains. Of particular importance is the level of precipitation and humidity during flowering (usually in July), as well as temperature and precipitation up to harvest in autumn [1]. In 2018, the early summer and July were unusually warm with very low precipitation in all sampled regions [15]. August was very humid in all regions, and September relatively warm and humid. The low *Fusarium* and DON level in 2018 were attributable to the warm July, whereas T-2 and HT-2 were not reduced by this special summer weather. The humid and relatively warm autumn may explain that the cereals ended up with relatively high levels of storage mould and yeast.

Aflatoxins in maize

Aflatoxins were detectable in three of nine analysed maize samples, with highest concentrations of aflatoxin B1 and B2 detected at 10.6 and 1.0 µg/kg, respectively. No samples exceeded the maximum limit of aflatoxin B1 (20 µg/kg) [16].

Complete and complementary feed

Feed for ruminants

The main purpose of the analysis of aflatoxins in complementary compound feed for ruminants is to monitor and control the risk of aflatoxin metabolites in milk and dairy products for human consumption. Ten samples contained detectable trace levels of aflatoxin B1 with maximum 0.81 µg/kg, while aflatoxin G1 was detected in another sample (0.40 µg/kg). The findings imply a higher prevalence of aflatoxins in complementary feed for ruminants than previously observed. Most previous years, the surveillance programme has resulted in no finding of aflatoxins at the same limit of detection. No samples exceeded the maximum limit of aflatoxin B1 in complete or complementary feed for lactating ruminants (5 µg/kg) [16].

Feed for pigs

Table 8 shows the levels of mycotoxins in complete compound feed for pigs. DON was detected in 50 % of the samples and all samples were below the recommended limit for feed for pig in Norway (500 µg/kg) [6]. Co-occurrence of DON-related compounds were mostly undetectable, only a trace amount of 3-Ac-DON was found in a single sample. Related compounds of DON can be an additional factor to the total DON exposure and EFSA considers their toxic effects like that of DON [9].

NIV was undetectable. The sum of T-2 and HT-2 was present in 20 % of the pig feed samples, but was not above the recommended limit (250 µg/kg) [6,11]. The levels of DON and T-2/HT-2 were lower than in 2016 and 2017 [3,4].

ZEN was present at low levels in five samples. All samples below the recommended level for pig feed in Norway (250 µg/kg) [6], which are similar as the findings in 2016 and 2017 [3,4].

Table 8. Complete compound feed for pigs 2018. Concentrations of deoxynivalenol (DON), 3-acetyl-DON, 15-acetyl-DON, DON-3-glucoside, sum of T-2 and HT-2 toxin, nivalenol, zearalenone and sum of ergot alkaloids (µg/kg).

	DON	3-Ac-DON	15-Ac-DON	DON-3-G	T-2+ HT-2	NIV	ZEN	Σ Ergot alkaloids
Number	20	20	20	20	20	20	20	20
Mean	82	<16	<52	<80	<36	<30	14	< 330
Median	<66	<16	<52	<80	<36	<30	<10	< 330
Min-max	<66 / 234	<16 / 53	<52	<80	<36 / 114	<30	<10 / 67	< 330
St. deviation	59	10	0	0	31	0	20	0
% samples above detection limit	50	5	0	0	20	0	25	0
% samples above guidance values	0				0		0	

OTA was detected in one sample. The concentration was 26 µg/kg, which is above the recommended level for pig feed in Norway (10 µg/kg) [6].

Ergot alkaloids were not detected in pig feed in 2018.

Conclusions

Feed ingredients

- Fungi: In oats, 46 % of the samples had higher total mould counts than the guidance values. Barley had significantly less total mould. The levels of storage mould, yeast and *Fusarium* were similar in oats and barley. The levels of total mould, storage mould and yeast were relatively high compared to previous years, whereas *Fusarium* levels were somewhat lower with less prevalence of major mycotoxin producing species (*F. graminearum* and *F. langsethiae*).
- Trichothecenes: Oats had higher levels of trichothecenes than barely. DON and T-2 and HT-2 were the major toxins detected. Compared with last two decades, DON with related compounds were at very low levels and T-2+HT-2 at moderate level.
- Other toxins: Traces of zearalenone (ZEN) was detected in a few samples of oats and barley, ochratoxin A (OTA) and ergot alkaloids were not detected.
- Regional differences: No regional differences in fungi or mycotoxins levels were detected in 2018. This may be partially explained by the particularly warm crop growing season in all regions in 2018.
- Aflatoxins in maize: The maximum concentration of aflatoxin B1 was 10.6 µg/kg but no samples exceeded the maximum limit (20 µg/kg).

Feed

- Complementary compound feed for ruminants: Aflatoxins were found in low concentrations (up to 0.81 µg B1/kg; maximum limit in feed for lactating ruminants is 5 µg/kg).
- Compound feed for pig: DON was detected in 50 % of the samples, while DON-related compounds were mostly undetectable. T-2 + HT-2 was present in 20 % of the pig feed samples, while ZEN was found at low levels in some samples. The levels of DON and T-2 + HT-2 were lower than the two previous years, whereas ZEN was at a similar level. All trichothecenes and ZEN were below the recommended upper level in pig feed in Norway. OTA was found in one sample, above the recommended level in pig feed in Norway. Ergot alkaloids were not detected.

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Appendix

Appendix Table 1. Concentrations of fungi (total mould, *Fusarium*, storage mould, yeast) and mycotoxins in **oats** (46 samples) and **barley** (48 samples) in individual samples from different districts and regions 2018. Concentration of fungi in cfu/g. Concentrations of mycotoxins in µg/kg. DON=deoxynivalenol, 3-Ac-DON=3-acetyl-DON, 15-Ac-DON=15-acetyl-DON, DON-3-G=DON-3-glucoside, T-2=T-2 toxin, HT-2=HT-2 toxin, NIV=nivalenol, ZEN=zearalenone.

Jnr.	Mould	*Fusarium*	Storage mould	Yeast	DON	3-Ac DON	15-Ac DON	DON-3-G	T-2	HT-2	NIV	ZEN	Ergo-novine/-inine	Ergo-sine/-inine	Ergot-amine/-inine	Ergo-cornine/-inine	α-Ergo-cryptine/-inine	Ergo cristine/-inine	OTA
OATS Region Midt																			
2018-23-213-1	230000	15000	<50	450000	614	56	<52	99	<14	<22	89	29	<56	<12	<40	<12	<190	<24	<21
2018-23-214-1	910000	45000	5000	3500000	166	48	<52	<80	79	172	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-214-2	320000	50000	1000	2500000	<66	<16	<52	<80	27	40	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-239-2	46000	7700	<50	59000	843	71	<52	97	<14	<22	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-239-3	300000	10000	<50	77000	<66	<16	<52	<80	14	<22	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-271-3	220000	2000	500	1800000	<66	<16	<52	<80	<14	<22	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-271-4	290000	10000	500	1500000	268	<16	<52	<80	<14	<22	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-289-1	350000	2000	210000	730000	<66	<16	<52	<80	<14	50	<30	<10	<56	<12	<40	<12	<190	<24	<21
BARLEY Region Midt																			
2018-23-214-3	70000	10000	1000	1100000	<66	<16	<52	<80	<14	<22	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-214-4	25000	1000	5000	300000	<66	<16	<52	<80	<14	<22	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-230-1	110000	45000	<50	1400000	<66	<16	<52	<80	15	31	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-231-1	45000	5000	<50	45000	<66	<16	<52	<80	<14	<22	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-239-1	50000	6800	<50	130000	<66	<16	<52	<80	<14	<22	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-239-4	61000	30000	<50	240000	<66	<16	<52	<80	<14	<22	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-247-1	60000	500	100	360000	<66	<16	<52	<80	<14	<22	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-271-1	82000	25000	5000	350000	287	18	<52	<80	<14	<22	<30	45	<56	<12	<40	<12	<190	<24	<21
2018-23-271-2	77000	5000	<50	1600000	<66	<16	<52	<80	<14	<22	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-315-1	1800000	5000	1600000	35000	240	<16	<52	113	<14	<22	<30	40	<56	<12	<40	<12	<190	<24	22
OATS Region Stor-Oslo																			
2018-23-232-2	1100000	5000	6000	550000	162	28	<52	<80	42	65	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-233-1	950000	25000	100000	680000	118	23	<52	<80	37	127	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-240-2	290000	1000	<50	450000	216	20	<52	84	32	45	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-241-2	570000	250	180000	1000000	163	17	<52	<80	25	61	<30	<10	<56	<12	<40	<12	<190	<24	<21

2018-23-242-2	850000	10000	50000	1000000	435	25	<52	<80	<14	<22	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-249-2	330000	3000	15000	320000	148	25	<52	<80	22	77	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-250-2	500000	<50	5000	730000	208	16	<52	<80	19	33	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-252-1	240000	3000	1150	140000	137	<16	<52	<80	64	122	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-253-1	470000	10000	37000	680000	<66	23	<52	<80	26	59	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-255-2	400000	20000	9100	640000	187	28	<52	<80	<14	64	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-256-2	330000	500	14000	190000	<66	20	<52	<80	29	66	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-257-2	470000	<50	430000	27000	<66	<16	<52	<80	170	265	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-265-2	2000000	10000	6000	2000000	75	<16	<52	<80	26	58	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-266-2	6400000	50000	25000	3100000	115	<16	<52	<80	26	50	38	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-279-1	210000	<50	5000	380000	90	<16	<52	<80	<14	<22	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-282-1	2600000	10000	77000	1600000	<66	<16	<52	<80	59	188	58	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-286-2	350000	23000	46500	600000	174	17	<52	<80	70	181	55	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-287-2	320000	2000	5500	340000	71	<16	<52	<80	71	205	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-291-1	450000	5000	35000	820000	<66	<16	<52	<80	67	162	58	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-292-2	300000	10000	5300	410000	<66	<16	<52	<80	27	52	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-294-1	630000	30000	16000	190000	78	<16	<52	<80	19	37	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-295-1	1600000	10000	51000	410000	87	<16	<52	<80	<14	<22	<30	<10	<56	<12	<40	<12	<190	<24	<21
BARLEY Region Stor-Oslo																			
2018-23-232-1	210000	14000	1000	2000000	<66	<16	<52	<80	<14	<22	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-233-2	310000	1500	1600	910000	<66	<16	<52	<80	<14	22	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-240-1	70000	350	10000	490000	<66	<16	<52	<80	<14	<22	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-241-1	630000	5000	2000	1400000	84	<16	<52	<80	<14	<22	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-242-1	54000	200	10000	260000	<66	<16	<52	<80	<14	<22	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-249-1	65000	2300	500	320000	<66	<16	<52	<80	<14	<22	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-250-1	42000	<50	8200	120000	<66	<16	<52	<80	<14	<22	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-251-1	10000	500	250	180000	<66	<16	<52	<80	<14	<22	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-254-1	36000	500	8400	260000	<66	<16	<52	<80	<14	<22	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-255-1	190000	18000	9100	1400000	<66	<16	<52	<80	<14	<22	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-256-1	73000	<50	21000	550000	<66	<16	<52	<80	<14	<22	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-257-1	200000	18000	5000	2900000	<66	<16	<52	<80	<14	<22	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-265-1	140000	5500	9100	770000	<66	<16	<52	<80	<14	<22	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-266-1	220000	10000	10500	1800000	<66	<16	<52	<80	<14	<22	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-274-1	68000	<50	30000	360000	<66	<16	<52	<80	<14	<22	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-279-2	50000	1000	1000	1400000	<66	<16	<52	<80	<14	<22	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-282-2	410000	10000	5500	1500000	<66	<16	<52	<80	<14	<22	<30	<10	<56	<12	<40	<12	<190	<24	<21

2018-23-286-1	860000	9000	40000	1500000	<66	<16	<52	<80	<14	<22	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-287-1	41000	10000	<50	820000	<66	<16	<52	<80	<14	<22	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-292-1	190000	1000	50000	1000000	<66	<16	<52	<80	<14	<22	<30	<10	<56	<12	<40	<12	<190	<24	<21
OATS Region Øst																			
2018-23-237-2	560000	5000	50	2900000	139	17	<52	<80	81	247	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-248-2	470000	1000	15000	860000	243	32	<52	<80	120	317	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-259-2	1000000	15000	32000	820000	108	<16	<52	<80	26	105	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-260-2	280000	5000	5000	1200000	176	26	<52	<80	40	103	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-261-2	590000	15000	17000	2500000	100	<16	<52	<80	36	62	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-263-2	600000	5000	5500	410000	92	<16	<52	<80	41	58	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-264-2	630000	5000	1500	1100000	160	<16	<52	<80	<14	<22	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-277-1	27000	2300	950	27000	278	30	<52	<80	44	65	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-277-2	310000	18000	41000	1200000	179	17	<52	<80	49	129	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-277-3	200000	1000	100	91000	680	55	<52	124	70	160	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-280-2	9100000	14000	150000	500000	628	68	<52	92	64	347	303	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-297-1	4500000	10000	60000	2300000	141	<16	<52	<80	86	209	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-298-2	3700000	50000	100000	1600000	<66	<16	<52	<80	<14	<22	210	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-299-1	550000	5000	10000	400000	112	<16	<52	<80	20	52	55	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-299-2	730000	5000	16000	590000	72	<16	<52	<80	33	54	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-299-3	1600000	10000	6000	820000	260	17	<52	<80	46	98	71	<10	<56	<12	<40	<12	<190	<24	<21
BARLEY Region Øst																			
2018-23-237-1	150000	10000	900	990000	<66	<16	<52	<80	<14	<22	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-237-3	15000	2000	7300	15000	<66	<16	<52	<80	<14	<22	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-238-1	410000	40000	1000	1600000	<66	<16	<52	<80	<14	<22	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-238-2	680000	100000	100	1400000	395	<16	<52	<80	<14	<22	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-248-1	260000	5000	26500	910000	<66	<16	<52	<80	<14	22	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-259-1	140000	50000	6000	1200000	<66	<16	<52	<80	<14	<22	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-260-1	36000	2000	800	840000	<66	<16	<52	<80	<14	<22	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-261-1	91000	10000	2000	2300000	<66	<16	<52	<80	14	<22	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-263-1	91000	5000	50	750000	<66	<16	<52	<80	<14	<22	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-264-1	320000	10000	100	3300000	<66	<16	<52	<80	<14	<22	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-280-1	550000	15000	2000	1000000	<66	<16	<52	<80	<14	<22	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-297-2	50000	250	500	1000000	<66	<16	<52	<80	<14	<22	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-298-1	82000	3500	100	860000	<66	<16	<52	<80	<14	<22	51	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-299-4	30000	5000	5000	1800000	<66	<16	<52	<80	<14	<22	<30	<10	<56	<12	<40	<12	<190	<24	<21
BARLEY Region Sør og Vest																			

2018-23-181-1	360000	5000	<50	3600000	<66	<16	<52	<80	<14	<22	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-267-1	580000	15000	30000	640000	<66	<16	<52	<80	<14	65	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-267-2	68000	4500	50	730000	<66	<16	<52	<80	<14	<22	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-23-278-1	95000	15000	2500	750000	<66	<16	<52	<80	<14	<22	<30	<10	<56	<12	<40	<12	<190	<24	<21

Appendix Table 2. Concentrations of mycotoxins in individual samples of **complete feed for pigs** (20 samples) 2018. All concentrations in µg/kg. DON=deoxynivalenol, 3-Ac-DON=3-acetyl-DON, 15-Ac-DON=15-acetyl-DON, DON-3-G=DON-3-glucoside, T-2=T-2 toxin, HT-2=HT-2 toxin, NIV=nivalenol, ZEN=zearalenone, OTA=ochratoxin A.

Jnr.	Type of feed	DON	3-Ac-DON	15-Ac-DON	DON-3-G	T-2	HT-2	NIV	ZEN	Ergo-novine /-inine	Ergo-sine/-inine	Ergot-amine/ -inine	Ergo-cornine /-inine	α-Ergo-cryptine/ -inine	Ergo-cristine/-inine	OTA
2018-21-5-1	Format Laktasjon	234	53	<52	<80	<14	106	<30	13	<56	<12	<40	<12	<190	<24	<21
2018-21-6-1	Ideal 50	<66	<16	<52	<80	<14	107	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-21-28-1	Fiskå Opti Vekst Våt	<66	<16	<52	<80	<14	<22	<30	30	<56	<12	<40	<12	<190	<24	26
2018-21-30-1	Format Purke	157	<16	<52	<80	14	60	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-21-31-1	NF Ideal Junior	<66	<16	<52	<80	<14	<22	<30	28	<56	<12	<40	<12	<190	27	<21
2018-21-42-1	Fullfor til svin	<66	<16	<52	<80	<14	<22	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-21-44-1	Format Kvikk 140	110	<16	<52	<80	<14	<22	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-21-44-3	Format Purke	111	<16	<52	<80	14	24	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-21-44-5	Format Vekst 110	<66	<16	<52	<80	<14	22	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-21-50-1	Svin Opti Norm	<66	<16	<52	<80	<14	<22	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-21-55-1	Fiskå Opti Drektig Våt	<66	<16	<52	<80	<14	<22	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-21-55-2	Fiskå Opti Vital Pluss	<66	<16	<52	<80	<14	<22	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-21-88-1	Fullfor til Smågris	<66	<16	<52	<80	<14	<22	<30	67	<56	<12	<40	<12	<190	<24	<21
2018-21-88-2	Format Vekst	<66	<16	<52	<80	<14	<22	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-21-120-1	Format Purke	106	<16	<52	<80	<14	<22	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-21-123-4	Format Vekst 110	132	<16	<52	<80	<14	<22	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-21-125-1	Format Drektig	131	<16	<52	<80	<14	<22	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-21-126-1	Format Purke	158	<16	<52	<80	<14	<22	<30	<10	<56	<12	<40	<12	<190	<24	<21
2018-21-127-1	Ideal Junior	106	<16	<52	<80	<14	<22	<30	67	<56	<12	<40	<12	<190	<24	<21
2018-21-128-1	Tilskuddsfor til svin	71	<16	<52	<80	<14	<22	<30	<10	<56	<12	<40	<12	<190	<24	<21

Appendix Table 3. Concentrations of aflatoxin B1, B2, G1 and G2 in individual samples of **complementary compound feed for ruminants** (50 samples) 2018. All concentrations in µg/kg.

Jnr.	Type of feed	Afla B1	Afla B2	Afla G1	Afla G2
2018-21-16-1	Drøv Energirik	<0,25	<0,10	<0,20	<0,15
2018-21-18-1	Melketopp N	0,81	<0,10	<0,20	<0,15
2018-21-22-1	Melketopp N	<0,25	<0,10	<0,20	<0,15
2018-21-23-1	Drøv kjøtt	0,61	<0,10	<0,20	<0,15
2018-21-24-1	Drøv Energirik	0,81	<0,10	<0,20	<0,15
2018-21-27-1	Fiskå Nor 50	<0,25	<0,10	<0,20	<0,15
2018-21-30-2	Formel Energi	<0,25	<0,10	<0,20	<0,15
2018-21-32-1	Formel Elite	<0,25	<0,10	<0,20	<0,15
2018-21-32-2	Formel Biff	<0,25	<0,10	<0,20	<0,15
2018-21-34-1	Formel Elite 80	<0,25	<0,10	<0,20	<0,15
2018-21-34-2	Formel Sau	<0,25	<0,10	<0,20	<0,15
2018-21-34-3	Formel Sau Ekstra	0,35	<0,10	<0,20	<0,15
2018-21-35-1	Drøv Genial	0,55	<0,10	<0,20	<0,15
2018-21-41-1	Drøv Energirik	<0,25	<0,10	<0,20	<0,15
2018-21-42-2	Forblanding til drøvtyggere	0,34	<0,10	<0,20	<0,15
2018-21-43-1	Tilskuddsfôr drøvtyggere	0,26	<0,10	<0,20	<0,15
2018-21-44-2	Formel Elite 80	<0,25	<0,10	<0,20	<0,15
2018-21-44-4	Format Energi Premium 80	<0,25	<0,10	<0,20	<0,15
2018-21-46-1	FK Proammon bygg	<0,25	<0,10	<0,20	<0,15
2018-21-47-1	Fiskå Melketopp Nøytral	0,37	<0,10	<0,20	<0,15
2018-21-47-2	Fiskå Nor500	<0,25	<0,10	<0,20	<0,15
2018-21-48-1	Tiskuddsfôr drøvtyggere	<0,25	<0,10	<0,20	<0,15
2018-21-49-1	Tilskuddsfôr drøvtyggere	<0,25	<0,10	<0,20	<0,15
2018-21-49-2	Tilskuddsfôr drøvtyggere	<0,25	<0,10	<0,20	<0,15
2018-21-49-3	Tilskuddsfôr drøvtyggere	<0,25	<0,10	<0,20	<0,15
2018-21-50-2	Drøv 118 Nøytral	<0,25	<0,10	<0,20	<0,15
2018-21-59-1	Drøv Kjøttfe	<0,25	<0,10	<0,20	<0,15
2018-21-85-1	Drøv Middelslått	<0,25	<0,10	<0,20	<0,15
2018-21-85-2	Drøv Lam	<0,25	<0,10	<0,20	<0,15
2018-21-86-1	FORMEL Fiber Grovform	<0,25	<0,10	<0,20	<0,15
2018-21-86-2	FORMEL Elite80	<0,25	<0,10	<0,20	<0,15
2018-21-86-3	FORMEL Biff intensiv	<0,25	<0,10	<0,20	<0,15
2018-21-87-1	Drøv Energirik	0,28	<0,10	<0,20	<0,15
2018-21-87-2	Drøv Fiber Storfe	<0,25	<0,10	<0,20	<0,15
2018-21-94-1	Drøv tilvekst m levende gjær	<0,25	<0,10	<0,20	<0,15
2018-21-115-1	Tilskuddsfor drøvtyggere	<0,25	<0,10	<0,20	<0,15
2018-21-115-2	Tilskuddsfor drøvtyggere	<0,25	<0,10	<0,20	<0,15
2018-21-115-3	Tilskuddsfor drøvtyggere	<0,25	<0,10	<0,20	<0,15
2018-21-116-1	Drøv tilvekst	<0,25	<0,10	<0,20	<0,15
2018-21-121-1	Formel biff	<0,25	<0,10	<0,20	<0,15
2018-21-121-2	FK reinfôr bas-B13543	<0,25	<0,10	<0,20	<0,15
2018-21-121-3	Formel geit 80-B 10063	<0,25	<0,10	<0,20	<0,15
2018-21-122-1	Maxammon behandlet Bygg	<0,25	<0,10	<0,20	<0,15
2018-21-122-2	Maxammon behandlet Havre	<0,25	<0,10	<0,20	<0,15
2018-21-123-1	Formel Sau varenr 10870	0,37	<0,10	<0,20	<0,15
2018-21-123-2	Formel sau, varenr 10202	<0,25	<0,10	<0,20	<0,15
2018-21-123-3	Biff intensiv, varenr 10300	<0,25	<0,10	0,40	<0,15
2018-21-124-1	Formel Sau	<0,25	<0,10	<0,20	<0,15
2018-21-124-2	Formel Elite 90	<0,25	<0,10	<0,20	<0,15
2018-21-129-1	Drøvtyggerfôr uspesifisert	<0,25	<0,10	<0,20	<0,15

Appendix Table 4. Concentrations of aflatoxin B1, B2, G1, G2 in individual samples of **maize** (9 samples) in 2018. All concentrations in µg/kg.

Jnr.	Afla B1	Afla B2	Afla G1	Afla G2
2018-21-4-1	<0,25	<0,10	<0,20	<0,15
2018-21-12-1	<0,25	<0,10	<0,20	<0,15
2018-21-21-1	4,59	0,47	<0,20	<0,15
2018-21-25-1	0,28	<0,10	<0,20	<0,15
2018-21-29-1	<0,25	<0,10	<0,20	<0,15
2018-21-51-1	<0,25	<0,10	<0,20	<0,15
2018-21-56-1	10,58	1,01	<0,20	<0,15
2018-21-117-1	<0,25	<0,10	<0,20	<0,15
2018-21-118-1	<0,25	<0,10	<0,20	<0,15

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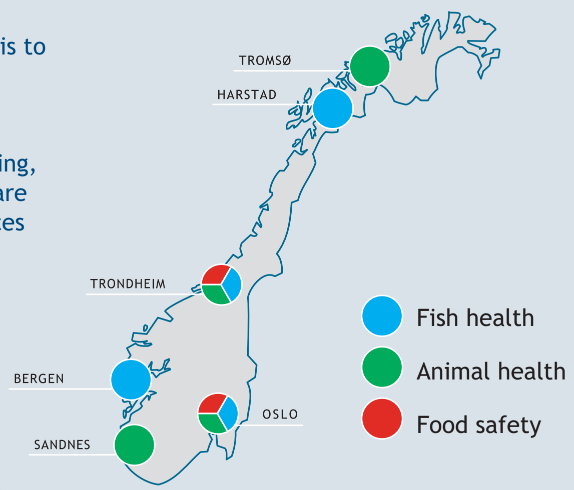

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