Cargill World Mycotoxin Report January – December 2023











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Global Mycotoxin Performance Risk



Cargill Performance Risk Thresholds: Cargill's performance risk thresholds are based upon extensive in vivo research and equations that model performance loss determined by mycotoxin levels found in feed ingredients. Low $\approx 0.5\%$ performance loss; Medium $\approx 1\%$ performance loss; and High $\approx 2\%$ performance loss.*

- Analyses: 361,084	Samples: 145,742	Countries: 43
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Toxins Tested	Total Analyses	Total Analyses by Ingredient Group							
Aflatoxin (AFL)	98,113	Corn	Cereals	Oilseeds	Forage	Other			
Fumonisin (FUM)	48,982		KI			_0_			
Ochratoxin (OTA)	16,437	NI I		696	Er with				
T2 toxin (T2)	21,744				L' WY				
Vomitoxin (DON)	119,118			B		I			
Zearalenone (ZEN)	56,690	232,375	85,252	24,505	16,988	1,964			

Total Analyses by Region

As	sia	Cent South A	tral & America	Ch	nina	Eur	ope	Middl & A	e East frica	North A	America	Rus	ssia
ALL	29,914	ALL	58,518	ALL	84,998	ALL	47,825	ALL	7,251	ALL	115,413	ALL	16,797
AFL	15,042	AFL	12,935	AFL	28,449	AFL	8,433	AFL	1,623	AFL	28,526	AFL	3,008
FUM	2,858	FUM	11,136	FUM	1,030	FUM	4,315	FUM	1,201	FUM	27,362	FUM	1,027
OTA	2,450	OTA	4,749	OTA	234	OTA	3,908	OTA	1,012	OTA	1,115	OTA	2,916
T2	2,686	T2	7,186	T2	256	T2	3,795	T2	1,073	T2	3,287	T2	3,408
DON	3,313	DON	11,893	DON	30,628	DON	21,651	DON	739	DON	47,544	DON	3,295
ZEN	3,565	ZEN	10,619	ZEN	24,401	ZEN	5,723	ZEN	1,603	ZEN	7,579	ZEN	3,143

See page 23 for Cargill Performance Risk Thresholds.

*Local laws and regulations related to mycotoxins thresholds and binders vary, for example, mycotoxin binders are not available in the United States.

Global Mycotoxin Prevalence

Abov	Percent <i>i</i> ve Cargill Risk Th	Analyses Performa reshold	ance														
★ La S	ess than 1 evere Ris ligh Risk	00 analys k 75- 50-	ses 100% 74%	Multiple Contam of samp 1, 2 or 3	Mycotoxin hination: % ples with 0, 3 or more	47	6% %	16%	# of myco in the tes	otoxins fo ted samp	ound ole	Above	Cargill P	A: erformar	sia nce Risk	Threshol	d: 39%
N	loderate	Risk 25-	49%	mycoto (For som	xins	, 4 7	⁷⁰ 3	51%	1			AFL	FUM	OTA	T2	DON	ZEN
S	light Risk	0-2	4%	3 or more	e mycotoxins)				3 or m	ore		51%	34%	12%	17%	34%	32%
	Cer	ntral & So	uth Ame	erica		China			Europe								
Above	e Cargill P	erforman	ce Risk ⁻	Threshol	d: 33%	Above	Cargill Pe	erformar	nce Risk ⁻	Threshol	d: 41%	Above Cargill Performance Risk Threshold: 38%					
AFL	FUM	OTA	T2	DON	ZEN	AFL	FUM	OTA	T2	DON	ZEN	AFL	FUM	OTA	T2	DON	ZEN
6%	62%	0%	23%	37%	53%	6%	54%	0%	7%	70%	44%	2%	37%	1%	12%	65%	31%
	N	1iddle Eas	st & Afric	ca				North	America					Ru	ssia		
Above	e Cargill P	erforman	ce Risk	Threshol	d: 23%	Above	Cargill P	erformar	nce Risk	Threshol	d: 41%	Above	Cargill P	erformar	nce Risk	Threshol	d: 20%
AFL	FUM	OTA	T2	DON	ZEN	AFL	FUM	OTA	T2	DON	ZEN	AFL	FUM	OTA	T2	DON	ZEN
8%	37%	0%	32 %	11%	43%	2%	46%	3%	16%	64%	41%	2%	19%	2%	49%	22%	22%
				Total Analyse	es	% C Ana Det	ontamina lyses Ab ection Li	ated ove mit	% Cont Cargi Ris	aminate Il Perforr k Threst	d Above nance nold	, Cor	Average ntaminatio (ppb)	on	Ν	/laximum Result (ppb)	٦
Aflato	xin (AFL)			98,113	3		62%			11%			7.6			500.0	
Fumo	nisin (FUI	VI)		48,98	2		78%			47%			1,076.0			92,810.0)
Ochra	atoxin (OT	A)		16,437	7		57%			3%			46.7			10,000.0)
T2 tox	(T2)			21,744	1		46%			23%			23.3			3,190.0	
Vomit	oxin (DOI	V)		119,11	8		78%			61%			750.4		1	25,832.6	6

56,690

361,084

Zearalenone (ZEN)

Total

73%

70%

16,374.3

76.2

Global Analyses by Mycotoxin and Ingredient

CORN (corn and corn	Mycotoxin Analyzed	Analyses	% Contaminated Analyses Above Detection Limit	% Contaminated Analyses Above Cargill Risk Threshold	Average Contamination (ppb)
byproducts)	Aflatoxin (AFL)	66,579	60%	6%	3.9
	Fumonisin (FUM)	41,255	84%	53%	1,203.4
	Ochratoxin (OTA)	8,131	58%	1%	1.7
N	T2 toxin (T2)	11,621	53%	30%	31.0
	Vomitoxin (DON)	69,305	79%	64%	913.9
	Zearalenone (ZEN)	35,484	79%	47%	90.0
CEREALS (wheat, barley,	Mycotoxin Analyzed	Analyses	% Contaminated Analyses Above Detection Limit	% Contaminated Analyses Above Cargill Risk Threshold	Average Contamination (ppb)
oat, rice, sorghum,	Aflatoxin (AFL)	21,966	68%	23%	16.4
triticale, byproducts,	Fumonisin (FUM)	2,907	40%	9%	192.8
other)	Ochratoxin (OTA)	4,398	45%	5%	129.2
De la companya de la comp	T2 toxin (T2)	4,200	48%	27%	22.4
	Vomitoxin (DON)	39,357	83%	61%	420.7
	Zearalenone (ZEN)	12,424	61%	23%	31.4
OILSEEDS (soybean, rapeseed,	Mycotoxin Analyzed	Analyses	% Contaminated Analyses Above Detection Limit	% Contaminated Analyses Above Cargill Risk Threshold	Average Contamination (ppb)
OILSEEDS (soybean, rapeseed, canola, sunflower, cottonseed, palm	Mycotoxin Analyzed Aflatoxin (AFL)	Analyses 7,815	% Contaminated Analyses Above Detection Limit 62%	% Contaminated Analyses Above Cargill Risk Threshold 19%	Average Contamination (ppb) 16.4
OILSEEDS (soybean, rapeseed, canola, sunflower, cottonseed, palm kernel, byproducts, other)	Mycotoxin Analyzed Aflatoxin (AFL) Fumonisin (FUM)	Analyses 7,815 2,859	% Contaminated Analyses Above Detection Limit 62% 44%	% Contaminated Analyses Above Cargill Risk Threshold 19% 9%	Average Contamination (ppb) 16.4 165.0
OILSEEDS (soybean, rapeseed, canola, sunflower, cottonseed, palm kernel, byproducts, other)	Mycotoxin Analyzed Aflatoxin (AFL) Fumonisin (FUM) Ochratoxin (OTA)	Analyses 7,815 2,859 2,227	% Contaminated Analyses Above Detection Limit 62% 44% 67%	% Contaminated Analyses Above Cargill Risk Threshold 19% 9% 3%	Average Contamination (ppb) 16.4 165.0 59.2
OILSEEDS (soybean, rapeseed, canola, sunflower, cottonseed, palm kernel, byproducts, other)	Mycotoxin Analyzed Aflatoxin (AFL) Fumonisin (FUM) Ochratoxin (OTA) T2 toxin (T2)	Analyses 7,815 2,859 2,227 2,585	% Contaminated Analyses Above Detection Limit 62% 44% 67% 46%	% Contaminated Analyses Above Cargill Risk Threshold 19% 9% 3% 12%	Average Contamination (ppb) 16.4 165.0 59.2 14.9
OILSEEDS (soybean, rapeseed, canola, sunflower, cottonseed, palm kernel, byproducts, other)	Mycotoxin Analyzed Aflatoxin (AFL) Fumonisin (FUM) Ochratoxin (OTA) T2 toxin (T2) Vomitoxin (DON)	Analyses 7,815 2,859 2,227 2,585 4,258	% Contaminated Analyses Above Detection Limit62%44%67%46%36%	% Contaminated Analyses Above Cargill Risk Threshold 19% 9% 3% 12% 9%	Average Contamination (ppb) 16.4 165.0 59.2 14.9 67.3
OILSEEDS (soybean, rapeseed, canola, sunflower, cottonseed, palm kernel, byproducts, other)	Mycotoxin Analyzed Aflatoxin (AFL) Fumonisin (FUM) Ochratoxin (OTA) T2 toxin (T2) Vomitoxin (DON) Zearalenone (ZEN)	Analyses 7,815 2,859 2,227 2,585 4,258 4,258 4,761	% Contaminated Analyses Above Detection Limit62%44%67%46%36%75%	% Contaminated Analyses Above Cargill Risk Threshold 19% 3% 3% 12% 9% 47%	Average Contamination (ppb) 16.4 165.0 59.2 14.9 67.3 59.1
OILSEEDS (soybean, rapeseed, canola, sunflower, cottonseed, palm kernel, byproducts, other)	Mycotoxin Analyzed Aflatoxin (AFL) Fumonisin (FUM) Ochratoxin (OTA) T2 toxin (T2) Vomitoxin (DON) Zearalenone (ZEN) Mycotoxin Analyzed	Analyses 7,815 2,859 2,227 2,585 4,258 4,258 4,761 Analyses	% Contaminated Analyses Above Detection Limit62%44%67%46%36%75%% Contaminated Analyses Above Detection Limit	% Contaminated Analyses Above Cargill Risk Threshold 19% 9% 3% 12% 9% 47% % Contaminated Analyses Above Cargill Risk Threshold	Average Contamination (ppb) 16.4 165.0 59.2 14.9 67.3 67.3 59.1 Average Contamination (ppb)
OILSEEDS (soybean, rapeseed, canola, sunflower, cottonseed, palm kernel, byproducts, other)	Mycotoxin Analyzed Aflatoxin (AFL) Fumonisin (FUM) Ochratoxin (OTA) T2 toxin (T2) Vomitoxin (DON) Zearalenone (ZEN) Mycotoxin Analyzed Aflatoxin (AFL)	Analyses 7,815 2,859 2,227 2,585 4,258 4,258 4,761 Analyses 1,382	% Contaminated Analyses Above Detection Limit 62% 44% 67% 46% 36% 75% % Contaminated Analyses Above Detection Limit 45%	% Contaminated Analyses Above Cargill Risk Threshold 19% 9% 3% 12% 9% 42% 9% 47% % Contaminated Analyses Above Cargill Risk Threshold 1%	Average Contamination (ppb) 16.4 165.0 59.2 14.9 67.3 67.3 59.1 Average Contamination (ppb) 1.2
OILSEEDS (soybean, rapeseed, canola, sunflower, cottonseed, palm kernel, byproducts, other)	Mycotoxin Analyzed Aflatoxin (AFL) Fumonisin (FUM) Ochratoxin (OTA) T2 toxin (T2) Vomitoxin (DON) Zearalenone (ZEN) Mycotoxin Analyzed Aflatoxin (AFL) Fumonisin (FUM)	Analyses 7,815 2,859 2,227 2,585 4,258 4,258 4,761 Analyses 1,382 1,763	% Contaminated Analyses Above Detection Limit 62% 44% 67% 46% 36% 75% % Contaminated Analyses Above Detection Limit 45% 58%	% Contaminated Analyses Above Cargill Risk Threshold 19% 9% 3% 12% 9% 47% 47% % Contaminated Analyses Above Cargill Risk Threshold 1% 39%	Average Contamination (ppb) 16.4 165.0 59.2 14.9 67.3 67.3 59.1 Average Contamination (ppb) 1.2 1,105.5
OILSEEDS (soybean, rapeseed, canola, sunflower, cottonseed, palm kernel, byproducts, other)	Mycotoxin Analyzed Aflatoxin (AFL) Fumonisin (FUM) Ochratoxin (OTA) T2 toxin (T2) Vomitoxin (DON) Zearalenone (ZEN) Mycotoxin Analyzed Aflatoxin (AFL) Fumonisin (FUM) Ochratoxin (OTA)	Analyses 7,815 2,859 2,227 2,585 4,258 4,258 4,761 Analyses 1,382 1,763 1,496	% Contaminated Analyses Above Detection Limit 62% 44% 67% 46% 36% 75% % Contaminated Analyses Above Detection Limit 45% 58% 68%	% Contaminated Analyses Above Cargill Risk Threshold 19% 9% 3% 12% 9% 47% 47% % Contaminated Analyses Above Cargill Risk Threshold 1% 39% 1%	Average Contamination (ppb)16.4165.059.214.967.359.1Average Contamination (ppb)1.21,105.51.4
OILSEEDS (soybean, rapeseed, canola, sunflower, cottonseed, palm kernel, byproducts, other)	Mycotoxin Analyzed Aflatoxin (AFL) Fumonisin (FUM) Ochratoxin (OTA) T2 toxin (T2) Vomitoxin (DON) Zearalenone (ZEN) Mycotoxin Analyzed Aflatoxin (AFL) Fumonisin (FUM) Ochratoxin (OTA) T2 toxin (T2)	Analyses 7,815 2,859 2,227 2,585 4,258 4,258 4,761 Analyses 1,382 1,763 1,496 3,158	% Contaminated Analyses Above Detection Limit62%44%67%46%36%75%% Contaminated Analyses Above Detection Limit45%58%68%12%	% Contaminated Analyses Above Cargill Risk Threshold19%9%3%12%9%47%% Contaminated Analyses Above Cargill Risk Threshold1%1%39%1%4%	Average Contamination (ppb) 16.4 165.0 59.2 14.9 67.3 59.1 Average Contamination (ppb) 1.2 1,105.5 1.4 3.4
OILSEEDS (soybean, rapeseed, canola, sunflower, cottonseed, palm kernel, byproducts, other)	Mycotoxin Analyzed Aflatoxin (AFL) Fumonisin (FUM) Ochratoxin (OTA) T2 toxin (T2) Vomitoxin (DON) Zearalenone (ZEN) Mycotoxin Analyzed Aflatoxin (AFL) Fumonisin (FUM) Ochratoxin (OTA) T2 toxin (T2) Vomitoxin (DON)	Analyses 7,815 2,859 2,227 2,585 4,258 4,258 4,761 Analyses 1,382 1,763 1,496 3,158 5,626	% Contaminated Analyses Above Detection Limit62%44%67%46%36%75%% Contaminated Analyses Above Detection Limit45%58%68%12%72%	% Contaminated Analyses Above Cargill Risk Threshold 19% 3% 12% 9% 47% % Contaminated Analyses Above Cargill Risk Threshold 1% 39% 1% 4% 666%	Average Contamination (ppb) 16.4 165.0 59.2 14.9 67.3 59.1 Average Contamination (ppb) 1.2 1,105.5 1.4 3.4 1,586.5



2023 Global Mycotoxin Trends

By Clement Soulet, *Global Anti-Mycotoxin Agents Category Lead, Cargill Animal Nutrition Businesses*

2023 Cargill Global Mycotoxins Survey Overview

Each year, Cargill Animal Nutrition (CAN) captures more than 350,000 analyses from 145,000+ raw material samples taken across 150+ global feed plants, farms, and ingredient storage locations. Throughout the past eight years, the tool has enabled Cargill to host the largest and most comprehensive mycotoxin contamination database in the world. The database enables CAN to accurately review and monitor mycotoxins distribution, contamination levels, and challenges our customers face around the globe. In this year's report we extended the database to include forage samples. In 2023, Cargill captured 17,000+ forage mycotoxin analyses globally which are especially important for ruminant mycotoxin risk evaluation.

Cargill generates a critical mass of information to understand regional, species and/or ingredient risk in real time. We determine risk level based upon:

- **1. Contamination rate** The percentage of analyses contaminated with at least one mycotoxin.
- **2. Contamination level** Mycotoxin concentration level (parts per billion).
- **3. Species sensitivity** See species performance risk thresholds on page 23.

2023 Global Trends

With these inputs in mind, we saw noteworthy data trends in 2023, including:

- **1. Slightly lower pressure** compared to last year, though the percentage of positive sample remains high with 70% above detection limit and 37% of the analyses above Cargill performance risk thresholds.
- 2. Top three mycotoxins to watch out for regarding prevalence and risk levels are Deoxynivalenol (DON; Vomitoxin), Fumonisin (FUM) and Zearalenone (ZEN). Over the past year, FUM analyses above performance risk increased (+7%) while DON (-1%) and ZEN (-9%) decreased.
- **3. Co-occurrence is still the rule** with 47% of the samples tested showing contamination with three or more mycotoxins.

Year-Over-Year Contamination

In 2023, we observed variations in mycotoxin contamination levels. From 2022, positive analyses above the detection limit decreased 5% and analyses above Cargill performance threshold decreased 2%. ZEN and T2 toxins pressure decreased while FUM increased, and Ochratoxin (OTA), DON and Aflatoxin (AFL) remained stable in 2023.

Factors that Influence Increased Contamination

Changing weather patterns continue to impact mycotoxin distribution and prevalence. In 2023, we witnessed extreme weather events and record high global average surface temperatures. High temperatures can elevate certain mycotoxin prevalence, like FUM (which increases under warm and dry conditions) or AFL (which thrives in warm and humid conditions). While cold fronts and floods may favor ZEN, DON and T2 prevalence. Crop flowering and maturation may also influence mycotoxin contamination, as early flowering & maturation can favor DON prevalence.



2023 Global Mycotoxins Trends (cont.)

Ingredient Group Trends

CORN	73% of corn-based ingredient (including all byproducts) analyses were positive for at least one mycotoxin and 40% were above Cargill performance risk thresholds. DON (64%), FUM (53%), ZEN (47%) and T2 (30%) were most frequently above performance risk levels in corn group analyses. In 2023, we observe higher average levels for DON (913 ppb) and FUM (1203 ppb) compared to 2022.
CEREALS	71% of cereal-based ingredient analyses were positive for at least one mycotoxin and 40% were above Cargill performance risk thresholds. In 2023, DON (61%), T2 (27%), AFL (23%), and ZEN (23%) were most frequently above performance risk levels in cereal group analyses.
OILSEEDS	57% of oilseeds-based ingredient analyses were positive for at least one mycotoxin and 20% were above Cargill performance risk thresholds. ZEN presented the highest level (47%) over Cargill performance risk thresholds.
FORAGE	55% of forage analyses were positive for at least one mycotoxin and 36% were above Cargill performance risk thresholds for ruminants. In 2023, DON (66%), ZEN (46%), and FUM (39%) were most frequently above performance risk levels in forage analyses. Average mycotoxin levels were high compared to the other ingredient groups: DON: 1586 ppb; FUM: 1105 ppb; and ZEN: 110 ppb.

Regional Trends

Regions with the highest mycotoxin prevalence and performance risk levels include China, South Asia, Europe and North America. Performance risk rates in East Europe and Canada increased compared to previous year. In West Europe, Middle East & Africa performance risk decreased compared to 2022. In China, South Asia, North America, Central & South America overall performance risk remains similar compared to last year. Specific regional mycotoxins distribution and contamination level trends are:



2023 Global Mycotoxins Trends (cont.)

ASIA	AFL remains the number one risk in most ingredients. Other mycotoxins of concern are DON in corn and cereals, FUM & ZEN in corn.
CENTRAL & SOUTH AMERICA	Mycotoxins to watch include: FUM, mainly in corn and ZEN in all ingredients. FUM performance risk increased from 48% in 2022 to 62% in 2023.
CHINA	DON remains the number one mycotoxin for performance risk in all ingredient groups followed by FUM & ZEN. FUM performance risk is high in corn (67%) and forage (52%). ZEN performance risk is high in forage (96%).
EUROPE	DON is the number one mycotoxin in terms of performance risk followed by FUM & ZEN. FUM and DON performance risks increased 4% compared to 2022.
MIDDLE EAST & AFRICA	Highest performance risk levels are with ZEN and FUM. T2 is the third mycotoxin of concern despite a lower risk level in 2023 compared to 2022.
NORTH AMERICA	DON, FUM and ZEN are the leading mycotoxins of concern with increased performance risk for FUM (+7%) and DON (+1%). ZEN performance risk decreased (-7%) compared to last year.
RUSSIA	T2 is at high performance risk (+6% compared to 2022). DON and ZEN showed high contamination levels in corn and forage.

Mitigate Your Risk with Data

To mitigate mycotoxins and protect animal health, proactive risk management is key. Mitigation success is driven by informed and targeted plans that quickly identify and anticipate mycotoxin threat levels and minimize risk. Cargill Animal Nutrition helps customers implement the right mycotoxin mitigation strategy at the right place and the right time. If you are interested in learning more about your unique mycotoxin risk, reach out to mycotoxins@cargill.com and anticipate mycotoxin threat levels while minimizing risk. Cargill's animal nutrition business helps customers implement the right mycotoxin mitigation strategy at the right place and right time.



Regional Data: Asia



An	Total 29,	914	Analyses Above Detection Limit	25,427
% Analyses Above Carg Performand Risk Threshold	s Gel 399	%	Percent Contaminated Analyses Above Detection Limit	85%
Toxin	Toxin Total % Contamir Toxin Analyses A Detection I		% Contaminated Analyses Above Perf. Risk Threshold	Year-Over-Year Analyses Cont. Above Cargill Perf. Risk Thres. Trend
AFL	15,042	94%	51%	₩3%
FUM	2,858	76%	34%	↓ 3%
ΟΤΑ	2,450	76%	12%	1 0%
Т2	2,686	79%	17%	(same)
DON	3,313	69%	34%	1 5%
ZEN	3,565	79%	32%	↓ 7%

Analysis by Main Feed Material

TOTAL

29,914

Ø	Total Analyses	% Contaminated Above Detection Limit	% Analyses Above Cargill Perf. Risk Thres.	Avg. Contamination (ppb)	Max. Contamination (ppb)
AFL	6,921	93%	39%	17.3	481
FUM	1,290	96%	70%	2,777.1	39,016
ΟΤΑ	724	62%	3%	3.9	446
T2	1,109	75%	21%	18.8	513.1
DON	1,196	82%	59%	1,130.9	13,980
ZEN	1,301	91%	54%	285.7	10273

Ø	Total Analyses	% Contaminated Above Detection Limit	% Analyses Above Cargill Perf. Risk Thres.	Avg. Contamination (ppb)	Max. Contamination (ppb)
AFL	6,159	96%	68%	51.3	374.6
FUM	606	67%	9%	188.9	4,170
ΟΤΑ	799	76%	23%	705.4	9,900
Т2	669	83%	17%	13.4	108.1
DON	1,177	73%	32%	232.7	10,000
ZEN	1,093	73%	23%	30.9	490

	Total Analyses	% Contaminated Above Detection Limit	% Analyses Above Cargill Perf. Risk Thres.	Avg. Contamination (ppb)	Max. Contamination (ppb)
AFL	1,794	92%	41 %	20.7	458
FUM	809	52%	2%	66.2	3,253
ΟΤΑ	750	88%	7%	171.9	10,000
T2	808	81%	12%	14.5	253
DON	789	48%	3%	35.2	630
ZEN	1,013	74%	12%	18.5	490

↓ 1%

85%

En m	Total Analyses	% Contaminated Above Detection Limit	% Analyses Above Cargill Perf. Risk Thres.	Avg. Contamination (ppb)	Max. Contamination (ppb)
AFL	57	68%	0%	1.2	6.7
FUM	57	60%	5%	127.3	1,041.2
ΟΤΑ	54	52%	6%	2.8	40.2
T2	0	0%	0%	0	0
DON	57	44%	9%	58.7	982.9
ZEN	57	54%	28%	38.8	440.4

Cargill Performance Risk Level By Species**



% Analyses Contaminated Within Cargill Performance Risk Thresholds: 📕 Minimum Risk 📕 Low Risk 📕 Medium Risk 📕 High Risk

*Based on Cargill research, low, medium and high risk equate to an estimated 0.5%, 1% and 2% performance loss respectively. **Cargill performance risk by species data is shown starting at 50% of all samples captured for the toxin and species.

Regional Data: Central & South America



An	Total 58,5	518	Total Contaminated Analyses Above Detection Limit	38,037
% Analyses Above Carg Performand Risk Threshold	s gill ce 33 °	%	Percent Contaminated Analyses Above Detection Limit	65%
Toxin	Total Analyses	% Contaminated Analyses Above Detection Limit	% Contaminated Analyses Above Perf. Risk Threshold	Year-Over-Year Analyses Cont. Above Cargill Perf. Risk Thres. Trend
AFL	12,935	60%	6%	↓ 1%
FUM	11,136	82%	62%	1 4%
ΟΤΑ	4,749	67%	0%	(same)
T2	7,186	48%	23%	个 9%
DON	11,893	59%	37%	↓ 2%
ZEN	10,619	73%	53%	↓ 10%
TOTAL	58,518	65%	33%	1%

Analysis by Main Feed Material

Ø	Total Analyses	% Contaminated Above Detection Limit	% Analyses Above Cargill Perf. Risk Thres.	Avg. Contamination (ppb)	Max. Contamination (ppb)
AFL	9,294	62%	2%	2.5	460
FUM	8,792	88%	73%	1,560.9	44,000
ΟΤΑ	4,214	69%	0%	1.1	340
Т2	5,572	55%	27%	15.9	3,190
DON	8,798	63%	43%	380.6	11,544
ZEN	8,559	71%	51%	78.9	5,000

Ø	Total Analyses	% Contaminated Above Detection Limit	% Analyses Above Cargill Perf. Risk Thres.	Avg. Contamination (ppb)	Max. Contamination (ppb)
AFL	1,170	61%	1%	1.7	370
FUM	730	52%	13%	244.7	3,000
ΟΤΑ	367	49%	0%	0.5	7.5
T2	451	38%	11%	6.9	220.6
DON	1,364	72%	37%	359.1	11,410
ZEN	922	75%	49%	102.9	2,242.4

	Total Analyses	% Contaminated Above Detection Limit	% Analyses Above Cargill Perf. Risk Thres.	Avg. Contamination (ppb)	Max. Contamination (ppb)
AFL	2,060	58%	25%	35.4	420
FUM	1,233	65%	19%	303.9	8,500
ΟΤΑ	168	51%	0%	0.6	4.9
T2	783	18%	7%	8.3	387
DON	1,329	34%	8%	59.3	2,100
ZEN	1,121	84%	76%	79.7	681.5

Et my	Total Analyses	% Contaminated Above Detection Limit	% Analyses Above Cargill Perf. Risk Thres.	Avg. Contamination (ppb)	Max. Contamination (ppb)
AFL	400	8%	0%	0.2	5.3
FUM	381	54%	22%	319.9	4,790
ΟΤΑ	0	0%	0%	0	0
T2	380	11%	10%	7.5	222.8
DON	387	3%	2%	12.4	1440
ZEN	5	40%	40%	96.6	377.1

Cargill Performance Risk Level By Species**



% Analyses Contaminated Within Cargill Performance Risk Thresholds: 📕 Minimum Risk 📕 Low Risk 📕 Medium Risk 📕 High Risk

*Based on Cargill research, low, medium and high risk equate to an estimated 0.5%, 1% and 2% performance loss respectively. **Cargill performance risk by species data is shown starting at 50% of all samples captured for the toxin and species.

Regional Data: Greater China

Pe Pe	rcent Analyses Above Cargill rformance Risk ör Any Toxin*	
	75-100%	A PARTICIPATION OF
	50-74%	
	25-49%	
	0-24%	

An	Total 84,9	998	I	Total Contaminated Analyses Above Detection Limit	67,998		
% Analyses Above Cargill Performance Risk Threshold 41%				Percent Contaminated Analyses Above Detection Limit	80%		
Toxin	Total Analyses	% Contaminate Analyses Above Detection Limi	e t	% Contaminated Analyses Above Perf. Risk Threshold	Year-Over-Year Analyses Cont. Above Cargill Perf. Risk Thres. Trend		
AFL	28,449	58%		6%	↓ 1%		
FUM	1,030	80%		54%	↓ 9%		
ΟΤΑ	234	42%		42%		0%	↓ 1%
T2	256	41%		7%	个 6%		
DON	30,628	92%		70%	↓ 2%		

Analysis by Main Feed Material

ZEN

TOTAL

24,401

84,998

Ø	Total Analyses	% Contaminated Above Detection Limit	% Analyses Above Cargill Perf. Risk Thres.	Avg. Contamination (ppb)	Max. Contamination (ppb)
AFL	17,143	53%	4%	2.4	500
FUM	787	92%	66%	1,319.6	27,964.5
ΟΤΑ	59	46%	0%	1	8.59
Т2	54	56%	11%	10.3	184
DON	17,862	94%	74%	564.6	21,736.7
ZEN	17,378	94%	47%	68.4	6246

Ø	Total Analyses	% Contaminated Above Detection Limit	% Analyses Above Cargill Perf. Risk Thres.	Avg. Contamination (ppb)	Max. Contamination (ppb)
AFL	9,696	67%	8%	3.5	450
FUM	114	49%	15%	216.2	792.19
ΟΤΑ	118	24%	0%	0.3	4.9
Т2	117	22%	1%	1.6	31.8
DON	11,336	91%	67%	403.9	4,200
ZEN	5,606	86%	29%	29.8	2,688.4

	Total Analyses	% Contaminated Above Detection Limit	% Analyses Above Cargill Perf. Risk Thres.	Avg. Contamination (ppb)	Max. Contamination (ppb)
AFL	839	59%	11%	7.1	454.9
FUM	102	14%	7%	64.9	949.5
ΟΤΑ	28	75%	0%	1.1	4.73
T2	55	35%	2%	3.1	25.83
DON	708	46%	12%	69.5	1,326.3
ZEN	701	86%	36%	38.4	574.6

92%

80%

↓ 4%

↓ 2%

E m m	Total Analyses	% Contaminated Above Detection Limit	% Analyses Above Cargill Perf. Risk Thres.	Avg. Contamination (ppb)	Max. Contamination (ppb)
AFL	683	59%	1%	1.4	45.1
FUM	27	100%	52 %	691.1	2,129.1
ΟΤΑ	29	79%	0%	1.8	4
T2	28	100%	32%	19.7	39.9
DON	636	99%	91%	1,148.3	15,874.2
ZEN	631	99%	96%	322.6	10,335.8

Cargill Performance Risk Level By Species**



% Analyses Contaminated Within Cargill Performance Risk Thresholds: 📕 Minimum Risk 📕 Low Risk 📕 Medium Risk 📕 High Risk

*Based on Cargill research, low, medium and high risk equate to an estimated 0.5%, 1% and 2% performance loss respectively. **Cargill performance risk by species data is shown starting at 50% of all samples captured for the toxin and species.

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Regional Data: Europe

2	Ť	
Pe / Pe	rcent Analyses Above Cargill rformance Bisk	
F	or Any Toxin*	
	75-100%	
	50-74%	
	25-49%	
	0-24%	

	Analyses 47,023 % Analyses Above Cargill Performance Risk Threshold 38%			Percent Contaminated Analyses Above Detection Limit 666%		
	Toxin	Total Analyses	% Contaminated Analyses Above Detection Limit	% Contaminated Analyses Above Perf. Risk Threshold	Year-Over-Year Analyses Cont. Above Cargill Perf. Risk Thres. Trend	
	AFL	8,433	55%	2%	(same)	
	FUM	4,315	50%	37%	1 4%	
	ΟΤΑ	3,908	45%	1%	个 1%	
	T2	3,795	26%	12%	(same)	
	DON	21,651	87%	65%	个 4%	
	ZEN	5,723	59%	31%	1 %	
	TOTAL	47,825	66%	38%	1 3%	

Total Contaminated

↑ 3%

Analysis by Main Feed Material

Ø	Total Analyses	% Contaminated Above Detection Limit	% Analyses Above Cargill Perf. Risk Thres.	Avg. Contamination (ppb)	Max. Contamination (ppb)
AFL	6,127	61%	2%	1.7	130
FUM	2,273	60%	45%	1,922.4	55,800
ΟΤΑ	1,780	37%	1%	1.2	152.18
T2	1,803	32%	18%	20.6	1,090
DON	8,348	90%	80%	1,862.5	24,636
ZEN	2,215	58%	33%	93.2	12,175

Ø	Total Analyses	% Contaminated Above Detection Limit	% Analyses Above Cargill Perf. Risk Thres.	Avg. Contamination (ppb)	Max. Contamination (ppb)
AFL	1,601	44%	1%	1.2	95
FUM	608	7%	2%	39.1	2,377
ΟΤΑ	706	17%	0%	0.5	43
Т2	560	23%	9%	8.4	585.5
DON	10,627	88%	56%	321.6	15,272
ZEN	1,739	37%	6%	22.7	8,000

009) 00	Total Analyses	% Contaminated Above Detection Limit	% Analyses Above Cargill Perf. Risk Thres.	Avg. Contamination (ppb)	Max. Contamination (ppb)
AFL	545	28%	1%	0.7	86
FUM	236	8%	1%	16.9	1,019.1
ΟΤΑ	231	24%	0%	0.9	116
Т2	232	17%	4%	6.5	394
DON	619	46%	21%	114	2,302
ZEN	496	46%	24%	36.5	3,000

(I W W	Total Analyses	% Contaminated Above Detection Limit	% Analyses Above Cargill Perf. Risk Thres.	Avg. Contamination (ppb)	Max. Contamination (ppb)
AFL	112	50%	2%	1.3	11.7
FUM	1,192	61%	47%	1,489.1	25,659
ΟΤΑ	1,185	77%	0%	1.3	37.54
T2	1,190	21%	4%	4.2	311
DON	1,978	82%	67%	896.7	16,512
ZEN	1,209	99%	66%	82.8	1,878

Cargill Performance Risk Level By Species**



% Analyses Contaminated Within Cargill Performance Risk Thresholds: 📕 Minimum Risk 📕 Low Risk 📕 Medium Risk 📕 High Risk

*Based on Cargill research, low, medium and high risk equate to an estimated 0.5%, 1% and 2% performance loss respectively. **Cargill performance risk by species data is shown starting at 50% of all samples captured for the toxin and species.

Regional Data: Middle East & Africa



An	Total alyses 7,2	51	Total Contaminated Analyses Above Detection Limit 3,843			
% Analyses Above Cargill Performance Risk Threshold 23%			Percent Contaminated Analyses Above Detection Limit 53%			
Toxin	Total Analyses	% Contaminated Analyses Above Detection Limit	% Contaminated Analyses Above Perf. Risk Threshold	Year-Over-Year Analyses Cont. Above Cargill Perf. Risk Thres. Trend		
AFL	1,623	53%	8%	↑ 5%		
FUM	1,201	62%	37%	1 4%		
ΟΤΑ	1,012	60%	0%	↓ 1%		
Т2	1,073	46%	32%	↓ 32%		
DON	739	35%	11%	↓ 16%		
ZEN	1,603	55%	43%	↓ 11%		

Analysis by Main Feed Material

TOTAL

7251

Ø	Total Analyses	% Contaminated Above Detection Limit	% Analyses Above Cargill Perf. Risk Thres.	Avg. Contamination (ppb)	Max. Contamination (ppb)
AFL	766	43%	7%	3.9	250
FUM	808	76%	53%	1,122.3	20,000
ΟΤΑ	232	58%	0%	1.7	30
T2	650	48%	34%	58.7	1,954
DON	329	42%	20%	458.4	16,324
ZEN	803	40%	24%	30.8	587

Ø	Total Analyses	% Contaminated Above Detection Limit	% Analyses Above Cargill Perf. Risk Thres.	Avg. Contamination (ppb)	Max. Contamination (ppb)
AFL	217	40%	0%	0.7	7.0
FUM	147	33%	2%	93.2	3,000
ΟΤΑ	146	40%	0%	0.6	6.7
Т2	150	39%	32%	30.5	457.5
DON	76	33%	11%	87.5	1,121
ZEN	149	35%	12%	15.9	200

	Total Analyses	% Contaminated Above Detection Limit	% Analyses Above Cargill Perf. Risk Thres.	Avg. Contamination (ppb)	Max. Contamination (ppb)
AFL	629	71%	13%	3.9	21.1
FUM	235	29%	2%	74.7	3,000
ΟΤΑ	627	66%	0%	1.6	13
T2	266	44%	28%	47.5	394
DON	323	27%	0%	21.2	190
ZEN	639	78%	74%	99.6	343.4

23%

↓ 7%

53%

Em my	Total Analyses	% Contaminated Above Detection Limit	% Analyses Above Cargill Perf. Risk Thres.	Avg. Contamination (ppb)	Max. Contamination (ppb)
AFL	5	40%	20%	2.3	10.73
FUM	5	100%	80%	1,293.6	2,242
ΟΤΑ	3	0%	0%	0	0
T2	3	100%	67%	39.7	56.3
DON	5	80%	20%	213.8	513
ZEN	5	100%	100%	140.8	202

Cargill Performance Risk Level By Species**



% Analyses Contaminated Within Cargill Performance Risk Thresholds: 📕 Minimum Risk 📕 Low Risk 📕 Medium Risk 📕 High Risk

*Based on Cargill research, low, medium and high risk equate to an estimated 0.5%, 1% and 2% performance loss respectively. **Cargill performance risk by species data is shown starting at 50% of all samples captured for the toxin and species.

Regional Data: North America

Percent Analyses Above Cargill Performance Risk For Any Toxin*	
75-100%	
50-74%	
25-49%	
0-24%	

An	Total alyses	5,413	Total Contaminated Analyses Above Detection Limit	79,635
% Analyses Above Cargill Performance Risk Threshold 40%		%	Percent Contaminated Analyses Above Detection Limit 69%	
Toxin	Total Analyses	% Contaminated Analyses Above Detection Limit	% Contaminated Analyses Above Perf. Risk Threshold	Year-Over-Year Analyses Cont. Above Cargill Perf. Risk Thres. Trend
AFL	28,526	58%	2%	↓ 1%
FUM	27,362	82%	46%	个 6%
ΟΤΑ	1,115	48%	3%	1 2%
T2	3,287	29%	16%	(same)

76%

50%

69%

(same)

↓ 7%

1%

Analysis by Main Feed Material

DON

ZEN

TOTAL

47,544

7,579

115,413

Ø	Total Analyses	% Contaminated Above Detection Limit	% Analyses Above Cargill Perf. Risk Thres.	Avg. Contamination (ppb)	Max. Contamination (ppb)
AFL	25,438	58%	2%	2.3	415.3
FUM	26,663	84%	47%	963.6	92,810
ΟΤΑ	374	53%	2%	3.6	100
T2	1,286	42%	26 %	32.9	1,154.9
DON	31,687	74%	61%	1,016.3	25,560.2
ZEN	4,265	60%	50%	150.6	10,860.7

Ø	Total Analyses	% Contaminated Above Detection Limit	% Analyses Above Cargill Perf. Risk Thres.	Avg. Contamination (ppb)	Max. Contamination (ppb)
AFL	1,430	61%	6%	3.9	200
FUM	552	42%	13%	371.7	15,887
ΟΤΑ	548	51%	3%	2.2	84
Т2	480	68%	30%	22.5	332
DON	13,036	85%	72%	594.7	22,450
ZEN	1,207	41%	19%	32.6	2,810

	Total Analyses	% Contaminated Above Detection Limit	% Analyses Above Cargill Perf. Risk Thres.	Avg. Contamination (ppb)	Max. Contamination (ppb)
AFL	1,592	55%	6%	5.7	315.9
FUM	89	10%	2%	158.7	2,626
ΟΤΑ	50	82%	6%	4.4	41
T2	46	80%	49%	37.5	120
DON	102	13%	8%	289	3,231
ZEN	398	91%	83%	124.2	403

Et m m	Total Analyses	% Contaminated Above Detection Limit	% Analyses Above Cargill Perf. Risk Thres.	Avg. Contamination (ppb)	Max. Contamination (ppb)
AFL	28	86%	7%	5.9	84
FUM	18	22%	17%	354.6	4,285
ΟΤΑ	142	2%	1%	0.8	100
T2	1,474	0%	0%	0.1	58.3
DON	2,478	70%	70%	2,570.3	25,832.6
ZEN	1,569	11%	10%	51.8	9,710

Cargill Performance Risk Level By Species**



% Analyses Contaminated Within Cargill Performance Risk Thresholds: 📕 Minimum Risk 📕 Low Risk 📕 Medium Risk 📕 High Risk

*Based on Cargill research, low, medium and high risk equate to an estimated 0.5%, 1% and 2% performance loss respectively. **Cargill performance risk by species data is shown starting at 50% of all samples captured for the toxin and species.

Regional Data: Russia



An	Total alyses 16,7	797	Total Contaminated Analyses Above Detection Limit	5,543
% Analyses Above Carg Performand Risk Threshold	s gill ce 209	%	Percent Contaminated Analyses Above Detection Limit	33%
Toxin	Total Analyses	% Contaminated Analyses Above Detection Limit	% Contaminated Analyses Above Perf. Risk Threshold	Year-Over-Year Analyses Cont. Above Cargill Perf. Risk Thres. Trend
AFL	3,008	15%	2%	个 1%
FUM	1,027	36%	19%	个 5%
ΟΤΑ	2,916	42%	2%	个 1%
Т2	3,408	54%	49%	个 6%
DON	3,295	24%	22%	↓ 3%
ZEN	3,143	29%	22%	1 4%
TOTAL	16,797	33%	20%	1 3%

Analysis by Main Feed Material

Ø	Total Analyses	% Contaminated Above Detection Limit	% Analyses Above Cargill Perf. Risk Thres.	Avg. Contamination (ppb)	Max. Contamination (ppb)
AFL	890	28%	2%	1.2	39.5
FUM	642	53%	29%	517.7	5,782.3
ΟΤΑ	748	44%	4%	3.1	138
T2	1,147	77%	73%	115.1	1,954
DON	1,085	56%	54%	599.6	10,715
ZEN	963	54%	42 %	87.8	16,374.3

Ø	Total Analyses	% Contaminated Above Detection Limit	% Analyses Above Cargill Perf. Risk Thres.	Avg. Contamination (ppb)	Max. Contamination (ppb)
AFL	1,693	7%	0%	0.2	18
FUM	150	1%	0%	0.5	75
ΟΤΑ	1,714	40%	1%	1.7	102.7
Т2	1,773	42%	41%	34.9	286
DON	1,741	5%	5%	22	1,466.4
ZEN	1,708	11%	9%	7.6	560

	Total Analyses	% Contaminated Above Detection Limit	% Analyses Above Cargill Perf. Risk Thres.	Avg. Contamination (ppb)	Max. Contamination (ppb)
AFL	356	15%	6%	1.4	21.7
FUM	155	9%	0%	8.2	188
ΟΤΑ	373	55%	1%	4	190
T2	395	41%	13%	10.4	97.3
DON	388	16%	12%	61.5	1,010
ZEN	393	40%	27%	39.1	410

En m	Total Analyses	% Contaminated Above Detection Limit	% Analyses Above Cargill Perf. Risk Thres.	Avg. Contamination (ppb)	Max. Contamination (ppb)
AFL	0	0%	0%	0	0
FUM	30	0%	0%	0	0
ΟΤΑ	30	7%	0%	0.2	3.1
T2	30	43%	43%	43.8	443.5
DON	30	37%	37%	788.3	6,029
ZEN	30	93%	50%	57.8	186.1

Cargill Performance Risk Level By Species**



% Analyses Contaminated Within Cargill Performance Risk Thresholds: 📕 Minimum Risk 📕 Low Risk 📕 Medium Risk 📕 High Risk

*Based on Cargill research, low, medium and high risk equate to an estimated 0.5%, 1% and 2% performance loss respectively. **Cargill performance risk by species data is shown starting at 50% of all samples captured for the toxin and species.

Ruminant Global and Regional Mycotoxin Risk



AFL

FUM

ΟΤΑ

Т2

DON

ZEN

% Analyses Above Cargill Performance Risk Threshold for Ruminants (Dairy)					
	Severe Risk	75-100%			
	High Risk	50-74%			
	Moderate Risk	25-49%			
	Slight Risk	0-24%			

Asia		China		
AFL	36%	AFL	2%	
FUM	15%	FUM	25%	
ΟΤΑ	10%	ΟΤΑ	0%	
Т2	3%	Т2	0%	
DON	17%	DON	27%	
ZEN	18%	ZEN	16%	

k a	Eurc	pe
5%	AFL	0%
5%	FUM	20 %
)%	ΟΤΑ	0%
%	T2	3%
9%	DON	32%
7%	ZEN	14%

Middle East & Africa			Rus
AFL	2%		AFL
FUM	13%		FUM
ΟΤΑ	0%		ΟΤΑ
Т2	13%		Т2
DON	6%		DON
ZEN	25%		ZEN

0%

6%

0%

16%

13%

8%



% Analyses Contaminated Above Ruminant Performance Risk Thresholds (Dairy)

Toxin	Dairy	Calves/ Heifer	Beef Cows
AFL	20	20	20
FUM	2,250	1,750	4,000
ΟΤΑ	250	50	250
T2	100	100	100
DON	700	600	700
ZEN	125	100	125

Toxin	Total Analyses	% Analyses Contaminated Above Dairy Performance Threshold	% Analyses Contaminated Above Calf/Heifer Performance Threshold	% Analyses Contaminated Above Beef Performance Threshold
AFL	98,113	7%	7%	7%
FUM	48,982	13%	18%	5%
ΟΤΑ	16,437	1%	2%	1%
T2	21,744	5%	5%	5%
DON	119,118	28%	32%	28%
ZEN	56, 690	15%	19%	15%
Total	361,084	14%	18%	15%

AFL

FUM

ΟΤΑ

DON

ZEN

Т2

0%

16%

1%

3%

Mycotoxin	Mycotoxin Impact on Ruminants
AFL	 AFL is poorly metabolized in the rumen and reduces ingestion, immunity, and reproduction and alters hepatic activity. Clinical symptoms include liver damage, depression, anorexia, lameness, rough hair coat, dry skin and rectum prolapse. Aflatoxin M1 (AFL metabolite) is excreted into the milk.
FUM	 FUM is poorly degraded in the rumen and leads to decreased appetite, reducing milk production and reproduction and causing growth delays. FUM is particularly toxic to the liver and kidneys and can lead to lethargy.
ΟΤΑ	 In adults, OTA is well metabolized in the rumen. In underperforming rumen or in high contamination scenarios, OTA leads to anorexia, diarrhea, and impaired performance. In calves, it causes depression, lower growth, excessive urine production, dehydration and negative impact on the kidneys and immune system.
T2	 Clinical signs of T2 are bloody diarrhea and reduced feed intake and reproductive performance. It is also associated with gastroenteritis, lesions and hemorrhages in the gastrointestinal tract and death. At low levels, T2 changes metabolism and immunity leading to lower performance.
DON	 DON impairs the rumen, altering pH, decreasing microbial protein synthesis and a decline in cellulolytic bacteria. DON also affects metabolism and immunity. DON causes gastrointestinal problems, diarrhea, and overall performance decrease.
ZEN	 In the rumen, ZEN is mostly converted to α-zearalenol, a more osteogenic metabolite. ZEN induces milk production loss, low conception rate, decrease in embryo survival, changes in reproductive organ morphology, abnormal mammary development, reproductive hormone decrease, feminization of young males, and infertility.

Region	Ruminant Mycotoxins of Concern
Asia	Main performance risk with AFL: 36% analyses above calf performance risk level. ZEN, DON and FUM follow with 18%, 17% and 15% analyses positive above calf performance risk levels respectively.
China	DON and FUM represent the biggest performance risk with respectively 27% and 25% analyses above performance risk. ZEN is the third highest with 16% above performance risk thresholds.
Central & South America	Main performance risk in Central and South America is with ZEN, FUM and DON with respectively 27%, 25% and 19% analyses above calf performance risk levels.
Europe	DON and FUM represent the biggest performance risk with respectively 32% and 20% of analyses above calf performance risk thresholds. ZEN (14%) represents the third performance risk.
Middle East & Africa	ZEN, FUM and T2 represent the biggest ruminant performance risk in Middle East & Africa with 25%, 13%, and 13% analyses above calf performance thresholds.
North America	Main performance risk with DON, ZEN and FUM with 40%, 25% and 16% analyses above calve performance risk thresholds respectively.
Russia	Main performance risk with T2 Toxins and DON with 16% and 13% analyses above calf performance risk levels.

Poultry Global and Regional Mycotoxin Risk

AFL

FUM

ΟΤΑ

DON

ZEN

Т2



% Analyses Above Cargill Performance Risk Threshold for Poultry (Broiler)				
	Severe Risk	75-100%		
	High Risk	50-74%		
	Moderate Risk	25-49%		
	Slight Risk	0-24%		

Asia		China	
AFL	43%	AFL	3%
FUM	35%	FUM	55%
ΟΤΑ	12%	ΟΤΑ	0%
Т2	19%	Т2	7%
DON	23%	DON	44%
ZEN	27%	ZEN	34%

& ca	Europe		
5%	AFL	1%	
2%	FUM	37%	
0%	ΟΤΑ	1%	
3%	T2	12%	
6%	DON	45%	
8%	ZEN	23%	

Middle East & Africa			Russia	
AFL	4%		AFL	19
FUM	37%		FUM	19
ΟΤΑ	0%		ΟΤΑ	29
Т2	32%		T2	49
DON	7%		DON	18
ZEN 070/			ZEN	47



% Analyses Contaminated Above Poultry Performance Risk Thresholds (Broiler)



Performance Risk Thresholds					
Toxin	Broiler	Breeder	Layer		

AFL	15	15	15
FUM	500	1,000	1,000
ΟΤΑ	20	25	25
Т2	25	50	50
DON	400	400	400
ZEN	50	35	35

Toxin	Total Analyses	% Analyses Contaminated Above Broiler Performance Threshold	% Analyses Contaminated Above Breeder Performance Threshold	% Analyses Contaminated Above Layer Performance Threshold
AFL	98,113	8%	8%	8%
FUM	48,982	47%	31%	31%
ΟΤΑ	16,437	3%	2%	2%
Т2	21,744	23%	12%	12%
DON	119,118	44%	44%	44%
ZEN	56,690	34%	42%	42%
Total	361,084	30%	28%	28%

AFL

FUM

ΟΤΑ

DON

ZEN

Т2

1%

3%

16%

Mycotoxin	Mycotoxin Impact on Poultry
AFL	 AFL targets the liver and the immune system. Main symptoms are performance loss (i.e., weight loss, low feed efficiency, reduced egg production, and egg weight), greater disease susceptibility, and lower vaccination efficacy. The liver can also be damaged, and organ weight drastically modified. Carcass bruising and poor pigmentation are common symptoms.
FUM	 FUM causes disruption of sphingolipid metabolism. FUM is poorly absorbed which greatly exposes and disrupts the digestive tract, leading to diarrhea and severe performance loss. The liver and immune system are common targets.
ΟΤΑ	OTA targets the kidneys (neurotoxin) to cause an increase in water consumption. Then it causes a sharp decrease in consumption, growth, egg production, and eggshell quality. Weakens the immune response therefore impacting overall bird health.
T2	 T2 is very problematic and causes visible oral mucosa and digestive tract lesions. T2 can reduce nutrient absorption and impact performance (weight, egg production, size) and disrupt the immune system and cause abnormal feathering.
DON	 DON degrades normal intestine function causing a decrease in nutrient absorption and intestine wall permeability. Causes diarrhea and impacts animal performance. DON decreases immunity, making vaccines less effective and animals more susceptible to disease. It is a predisposing factor for necrotic enteritis.
ZEN	 ZEN has a similar structure to the hormone estrogen. Consequences in reproduction, including reduced fertility and egg hatchability, and eggshell quality decrease. ZEN can also cause ovarian cysts or cloaca enlargement. Reduces growth performance, especially when it is accompanied by other mycotoxins.

Region	Poultry Mycotoxins of Concern
Asia	Main poultry performance risk with AFL, FUM and ZEN with 43%, 35% and 27% analyses above broiler starter performance risk levels respectively.
China	FUM, DON and ZEN represent the biggest poultry performance risk with 55%, 44%, and 34% analyses above performance risk respectively.
Central & South America	Main poultry performance risk in Central and South America is with FUM and ZEN with 62% and 48% analyses above broiler starter performance risk levels respectively. DON follows with 26% of analyses above broiler performance risk thresholds.
Europe	DON and FUM represents the biggest poultry performance risk with respectively 45% and 37% of analyses above broiler starter performance risk thresholds. ZEN (23%) represents the third performance risk.
Middle East & Africa	ZEN, FUM and T2 represent the biggest poultry performance risk in Middle East & Africa with 37%, 37%, and 32% analyses above broiler starter performance thresholds.
North America	Main poultry performance risk with DON, FUM and ZEN with 51%, 46% and 35% analyses above broiler starter performance risk thresholds respectively.
Russia	Main poultry performance risk is with T2 Toxins with 49% analyses above broiler starter performance risk levels. FUM (19%), DON (18%) and ZEN (17%) follow.

Swine Global and Regional Mycotoxin Risk



9 Pe	6 Analyses Abov rformance Risk for Swine (Nur	e Cargill Threshold sery)
	Severe Risk	75-100%
	High Risk	50-74%
	Moderate Risk	25-49%
	Slight Risk	0-24%

AFL

FUM

ΟΤΑ

DON

ZEN

Т2

a	Chi		Centr S. Am	al & erica	
43%	AFL	3%	AFL	5%	AF
27%	FUM	42%	FUM	50%	FU
11%	ΟΤΑ	0%	ΟΤΑ	0%	то
7%	Т2	1%	Т2	4%	Т2
34%	DON	70%	DON	37%	DC
11%	ZEN	6%	ZEN	9%	ZE

Euro	pe	
AFL	1%	
FUM	32%	
ΟΤΑ	0%	
T2	6%	
DON	65%	
ZEN	7%	

AFL

FUM

ΟΤΑ

Т2

DON

ZEN

1%

2%

9%

11%

Middle East & Africa		Rus	sia
AFL	4%	AFL	1%
FUM	31%	FUM	16%
OTA	0%	ΟΤΑ	2%
Г2	24%	T2	41%
DON	11%	DON	22%
7FN	7%	7FN	4%

4%



% Analyses Contaminated Above Swine Performance Risk Thresholds (Nursery)



Toxin	Sow	Hog	Nursery
AFL	20	20	15
FUM	3,000	1,000	750
ΟΤΑ	25	40	25
T2	50	100	50
DON	750	500	200
ZEN	100	300	200

Toxin	Total Analyses	% Analyses Contaminated Above Sow Performance Threshold	% Analyses Contaminated Above Hog Performance Threshold	% Analyses Contaminated Above Nursery Performance Threshold
AFL	98,113	7%	7%	8%
FUM	48,982	8%	31%	37%
ΟΤΑ	16,437	2%	2%	2%
T2	21,744	12%	5%	12%
DON	119,118	26%	37%	61%
ZEN	56,690	19%	4%	8%
Total	361,084	15%	19%	29%

Mycotoxin	Mycotoxin Impact on Swine
AFL	 Low AFL doses result in lower feed intake, growth rate, and vaccination response which can affect liver function and immunity. Nursery pigs are most susceptible as AFL passes through milk. Acute aflatoxicosis can lead to hemorrhages, jaundice, and sudden death.
FUM	 FUM impacts the lungs, heart, and liver tissues. Acute toxicity causes porcine pulmonary edema resulting in respiratory symptoms, cyanosis, and often, death. Chronic toxicity causes lower feed intake, growth rate, vaccination response, and muscle bleeding.
ΟΤΑ	 OTA A is toxic for kidneys and liver and undermines immunity. Significant poisoning results in higher mortality. OTA can cause low growth rate, poor feed efficiency, and altered urine.
T2	 T2 is a strong immunosuppressive toxin with effects at low doses. Acute exposure causes liver/intestinal bleeds and chronic toxicity causes lower feed intake and weight loss. T2 can cause reproductive issues, abnormalities, or birth defects.
DON	 DON impacts protein synthesis and immunity and disrupts neurotransmitter activity. Low dose exposure leads to feed consumption and growth performance decreases. Severe exposure causes vomiting, diarrhea, digestive lesions, and sudden death.
ZEN	ZEN impacts reproduction and can cause vulva swelling/redness and rectal/vaginal prolapses. False pregnancy and early embryo loss may occur. ZEN passes through milk and impacts newborns. ZEN lowers growth performance severely when combined with other toxins.

Region	Swine Mycotoxins of Concern
Asia	Main swine performance risk is with AFL: 43% of analyses were above Cargill nursery performance risk levels Also, significant swine performance risk in Asia with DON (34%) and FUM (27%).
China	Main swine performance risk is with AFL: 43% of analyses were above Cargill nursery performance risk levels. Also, significant swine performance risk in Asia with DON (34%) and FUM (27%).
Central & South America	Main swine performance risk is FUM and DON with 50% and 37% of analyses above nursery performance risk levels respectively.
Europe	DON represents the biggest swine performance risk with 65% of analyses above nursery performance risk levels and FUM follows with 32% above nursery performance risk levels.
Middle East & Africa	Main swine performance risk with FUM: 31% analyses above nursery performance risk levels respectively. T2 follows with 24% above nursery performance risk levels.
North America	DON represents the biggest swine performance risk with 64% above nursery performance risk levels and FUM follows with 35% above nursery performance risk levels.
Russia	Main swine performance risk with T2: 41% analyses above nursery performance risk levels respectively. DON & FUM are also mycotoxins of concern with resspectively 22% and 16% of analyses above nursery performance risk thresholds.



Mycotoxins Impact on Ruminant Health and Productivity

By Thomas Pecqueur, Global Technology Lead for Anti-Mycotoxins Agents, Cargill Animal Nutrition Businesses

The rumen's intricate nature, filled with a diversity of microorganisms, enables ruminants to endure higher mycotoxin levels than monogastric species, like poultry and swine. However, there is often an understatement regarding mycotoxins and their impact on ruminants.

It is commonly thought that the rumen shields cattle from mycotoxin impacts, thanks to the microorganisms hard at work fighting mycotoxins. Unfortunately, this is not the case. In fact, the rumen is far from completely detoxifying mycotoxins ingested by cattle. The rumen can also generate metabolites that are potentially more toxic, potent, and aggressive than the original mycotoxins.

Over the past 50 years, average milk production per cow has increased by 59%¹ which reflects the pressure put upon cattle's metabolism to produce more milk. Several parameters contribute to this spectacular increase such as genetics, farm management and nutrition. However, a highly fermentable diet increases the risk of acidosis and can alter the rumen microbial population. Coupled with a shorter retention time, the rumen therefore has less time and capacity to detoxify mycotoxins.

This pressure also forces us to consider another underestimated factor: stress. Because today's cattle produce more milk and meat than ever before, they are under increased stress. When animals, like humans, are stressed, their defenses are lowered which can elevate mycotoxins' impact.

Assessing Mycotoxin Impact in Ruminants

Mycotoxins, at moderate amounts for short timeframes, can be difficult to detect because cattle often do not show symptoms other than a mild performance decrease. Rather, if they show symptoms, your cattle have likely been exposed to high amounts of mycotoxins or moderate levels for an extended period.

Consumption of mycotoxins cause issues like gastrointestinal problems, soft stools, diarrhea, immunosuppression, infertility, an overall performance decrease, and other symptoms (see page 16 for more details). While mycotoxins have varying levels of potency, generally all lead to ongoing performance reductions without recognizable symptoms. In 2023 forage analysis for mycotoxins (about 15,000 total), three mycotoxins showed elevated risk levels for ruminants, deoxynivalenol (DON; Vomitoxin), Zearalenone (ZEN) and Fumonisin (FUM) with 63%, 46% and 40% of samples above performance risk thresholds* respectively. DON contamination levels increased in 2023 compared to 2022, particularly in corn silage, and FUM, which increased in the second half of 2023.

While all mycotoxins can pose a risk to cattle at certain levels, it is critical to implement a proactive testing program to mitigate and minimize mycotoxin performance risks.



Proactive Testing and Mitigation Plans

For major ingredients in your ration, such as forages like corn silage or grains, performing a mycotoxin analysis every four to eight weeks may be appropriate. If you observe contamination levels above performance risk thresholds, work with your feed partner, like Cargill, to develop an on-farm mitigation strategy. If permitted in your jurisdiction, this could include reformulating the ration to favor low-contamination ingredients or adding a locally approved anti-mycotoxin agent at the manufacturer's recommended amount based on contamination levels.

After several analyses, if your results remain concerning, maintain the analysis rate and your mitigation plan.

Mycotoxins Impact on Ruminant Health and Productivity (cont.)

On the other hand, if several successive analyses show results below performance thresholds, analysis frequency could be reduced to maybe every 10-15 weeks. In this case, the anti-mycotoxin additives can also be reduced or removed. If analyses increase to worrisome levels again, sampling frequency should be increased, and approved anti-mycotoxin additives reinstated. The most crucial factor is to build a dynamic control plan that is cost-efficient and effective in detecting performance loss risks. Ultimately, mycotoxin testing is always less expensive than losing performance.

Consider Ruminant Life Stage

Finally, it is important to consider life stage and output. Calves exhibit heightened sensitivity to mycotoxins than adult cattle. Indeed, during the initial weeks of life, calves operate as monogastric, so their rumen functions at a less-than-optimal level. Exposure to mycotoxins during this time can result in severe adverse effects, including lower growth rate, infertility, and compromised immune system and organ function.

Similarly, dairy cows are more susceptible to mycotoxins than beef cattle. Notably, dairy cattle can excrete mycotoxins, such as aflatoxins, into their milk. Beyond affecting dairy cattle's health, aflatoxins present in milk can be transmitted to both calves and human consumers. Aflatoxin (AFL) regulation implementation assumes a pivotal role in this context. Milk collectors, adhering to these regulations, reserve the right to reject milk loads exhibiting AFL levels above regulatory thresholds. Milk rejection results in financial losses, which include lost milk and the resources invested in dairy cow nutrition and care. Consequently, adopting a proactive mitigation strategy in animal feed emerges as a crucial measure to alleviate and minimize mycotoxins risks.

¹Sustainability and Dairy Production: challenges and Opportunities. D.E. Bauman and J.L. Capper. Cornell Nutrition Conference 2011.

*Cargill's performance risk thresholds are based upon extensive in vivo research and equations that model performance loss determined by mycotoxin levels found in feed ingredients. Low $\approx 0.5\%$ performance loss; Medium $\approx 1\%$ performance loss; and High $\approx 2\%$ performance loss. They may be lower than thresholds set by government regulatory bodies. Local laws and regulations related to mycotoxins thresholds and binders vary, for example, mycotoxin binders are not available in the United States.

Optimize Mycotoxin Mitigation

At Cargill, we offer tools to develop a customized mitigation and approved anti-mycotoxins agent plan, including:

- The world's largest global mycotoxins database with more than 350K analyses per year, allowing us to review previous and current mycotoxins contamination trends
- New mycotoxins risk thresholds, built by robust equations that accurately estimate mycotoxins impact on your animals. Our proprietary equations are backed by scientific literature, research articles, and decades of experience evaluating and understanding mycotoxin performance impacts. See new performance risk thresholds on page 23.
- Our Mycotoxin Impact Calculator, which enables us to leverage regional, global, and your operation's analyses to identify potential performance impacts in your operation and create data-backed mitigation plans specific to your location.

Our recommendation: get started today as mycotoxins could be at work right now reducing your cattle's performance and immune system. Reach out to <u>mycotoxins@cargill.com</u> to get started.





Developing and Refining Feed Mill Mycotoxins Control Plans

By Stephanie Adams, Food Safety Regulatory Associate Director

Mycotoxins, like aflatoxins (AFL), deoxynivalenol (DON), fumonisins (FUM), ochratoxin A (OTA), T2 toxins (T2) and zearalenone (ZEN), are naturally occurring toxins produced from certain molds. These molds can proliferate on agricultural commodities in unfavorable temperature, moisture or growing conditions in the field or in storage.

Feed mills have a responsibility to safeguard animal feed with robust programs to monitor and minimize mycotoxins in feed. By implementing targeted control plans that identify and anticipate mycotoxin risk each year, feed mills can minimize risk to animals.

Developing a Control Plan

Feed mills play a critical role in mycotoxin mitigation and must have an effective, multi-layered control program in place. Here are key steps to develop a successful mycotoxin mitigation plan:



Determine each ingredient's mycotoxin risk likelihood and severity.

When developing a mycotoxin control plan, you must understand each ingredient's mycotoxin susceptibility. First, identify ingredients that have a known contamination risk. It is important to pay close attention to the weather during growing season and reevaluate this risk each harvest. Next, ask ingredient suppliers about testing protocols, if the ingredient is at risk. Leverage scientific information and available reports (like this one) to research each ingredient. Third understand each mycotoxin's animal health impact and ensure you know regulatory mycotoxin limits. At elevated levels, mycotoxins pose food safety hazards for animals that can lead to animal health consequences. At low levels, mycotoxins can impact animal productivity and performance.

Ingredient	Mycotoxin Risk
Corn	AFL, FUM, DON, OTA, T2, ZEN
Wheat	DON, OTA, T2, ZEN
Barley	OTA, T2, DON
Oats	DON, OTA, T2
Rice	AFL, OTA
Cottonseed	AFL
Peanuts/Almonds	AFL
Rye	DON

Assign risk levels -O- for each mycotoxin -O and ingredient.

Once you gather key insights, mycotoxins trend data, and risks for ingredients, assign risk levels to each for the season. At Cargill, we assign risk levels in three categories:

Low Risk: The ingredient is likely not susceptible to mycotoxins and does not require ongoing monitoring. Scientific reports and previous testing demonstrate low or impossible mycotoxin contamination likelihood.

Medium Risk: The ingredient may require monitoring at some defined frequency. Research shows the ingredient may be susceptible to mycotoxin contamination based on weather patterns or growing region.

High Risk: The ingredient requires consistent monitoring and a defined control plan to minimize risk. It is widely known to be susceptible to specific mycotoxin contamination each year.



Developing and Refining Feed Mill Mycotoxins Control Plans (cont.)



Implement a Control Program

For medium and high-risk ingredients, we recommend a written testing and control plan to minimize risk to the finished product. A strategic and written plan will help a feed mill think through which actions to take at what time, including:

Testing Frequency: Decide testing frequency. Leave flexibility to increase testing should risk level go up or reduce frequency should risk levels remain low. Consider testing more during harvest or if you see frequent load rejections and/or elevated mycotoxin concentration levels.

Acceptance Limits: Establish specific acceptance levels for each mycotoxin. This level should not be greater than what regulations allow. Also consider the species consuming the feed as risk levels vary. Communicate your acceptance levels to suppliers and do not use ingredients above these limits.

Sampling Protocol: Mycotoxins are rarely mixed evenly throughout a conveyance; therefore, taking a "scoop" will not give you a representative measurement. Put a plan in place to collect the best sample possible for accurate results. For example, use a pneumatic, automatic, or manual grain probe in 5+ spots to pull a representative sample.

Test Methods: Choose a validated testing method. Rapid test kits are a preferred option for feed mills receiving ingredients, but mixed feed may need to be sent to a laboratory for primary method testing.

Proper Storage: Strategically store ingredients to reduce opportunity for mycotoxin development. Best storage protocols focus on temperature, moisture, and relative humidity. Each element must be carefully managed to protect ingredients from mycotoxins. Interested in more storage tips? Visit the <u>2022 Cargill Global Mycotoxins</u> <u>Report here</u>.

Program Efficacy: Periodically test finished animal feed to measure program efficacy. Testing feed mix helps build programs that evolve as mycotoxin risk changes. If mycotoxins levels are below risk thresholds, your protocols are most likely effective. If they are above risk thresholds, it is important to evaluate possible issues – are samples representative of levels received? Should testing be increased? Are ingredients stored properly? Was there change to ingredients? These questions help determine how to adjust testing strategies.



Other Testing Strategies to Consider

Another way to lower mycotoxin levels in feed mix is smart ingredient formulation. When using formulation as a strategy, it is important to know mycotoxin levels present in ingredients. Note: Some countries have laws that prohibit deliberate feedstuffs mixing to lower elevated mycotoxin levels. Where allowed by regulation, consider anti-mycotoxin agents in your formulation to reduce impact.

We know mycotoxins are just one factor in various inputs and considerations within your operation. When you partner with Cargill Animal Nutrition and Health, you gain an experienced partner and feed producer that has developed and applied quality mycotoxins management strategies for decades. We support your feed mill teams to develop and maintain strong, preventive, mycotoxins testing programs. From the very beginning testing truckloads to the final animal feed product, we work to minimize mycotoxin impact to ensure feed safety and that animals remain healthy and productive.

Interested in learning more? Visit www.mycotoxins.com.



Cargill Performance Risk Thresholds (ppb)



Global		
Aflatoxin (AFL)	10	
Fumonisin (FUM)	500	
Ochratoxin (OTA)	20	
T2 toxin (T2)	25	
Vomitoxin (DON)	200	
Zearalenone (ZEN)	35	





Calves/Heifer	
AFL	20
FUM	1,750
OTA	50
T2	100
DON	600
ZEN	100

Dairy	
AFL	20
FUM	2,250
OTA	250
T2	100
DON	700
ZEN	125

5,7,7

Sow	
AFL	20
FUM	3,000
OTA	25
T2	50
DON	750
ZEN	100

Hog	
AFL	20
FUM	1,000
OTA	40
T2	100
DON	500
ZEN	300

Nursery Pig		
AFL	15	
FUM	750	
OTA	25	
T2	50	
DON	200	
ZEN	200	



Broiler	
AFL	15
FUM	500
OTA	20
T2	25
DON	400
ZEN	50

Breeder	
AFL	15
FUM	1,000
OTA	25
T2	50
DON	400
ZEN	35

Layer	
AFL	15
FUM	1,000
OTA	25
T2	50
DON	400
ZEN	35

Disclaimer: These thresholds may differ from government regulatory levels which vary from one country to another. Cargill Animal Nutrition mycotoxin risk thresholds have been established through in-depth scientific research on the mycotoxin impact on animals' health and performance and are based on an estimated 0.5% loss of performance. These thresholds are likely to evolve as scientific knowledge on mycotoxicosis increases.



We would like to thank our customers, technicians throughout our vast laboratory network, and data scientists, without which this report would not be possible.

Have questions or want to get in touch?

Please visit <u>www.mycotoxins.com</u>.

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