DSM World Mycotoxin Survey

The Global Threat
January – December 2021

ANIMAL NUTRITION AND HEALTH

- ESSENTIAL PRODUCTS
- PERFORMANCE SOLUTIONS + BIOMIN®
- PRECISION SERVICES

DSM
BRIGHT SCIENCE. BRIGHTER LIVING.

DSM World Mycotoxin Survey* 2021

* previously known as Biomin World Mycotoxin Survey

DSM
BRIGHT SCIENCE. BRIGHTER LIVING.

World Overview

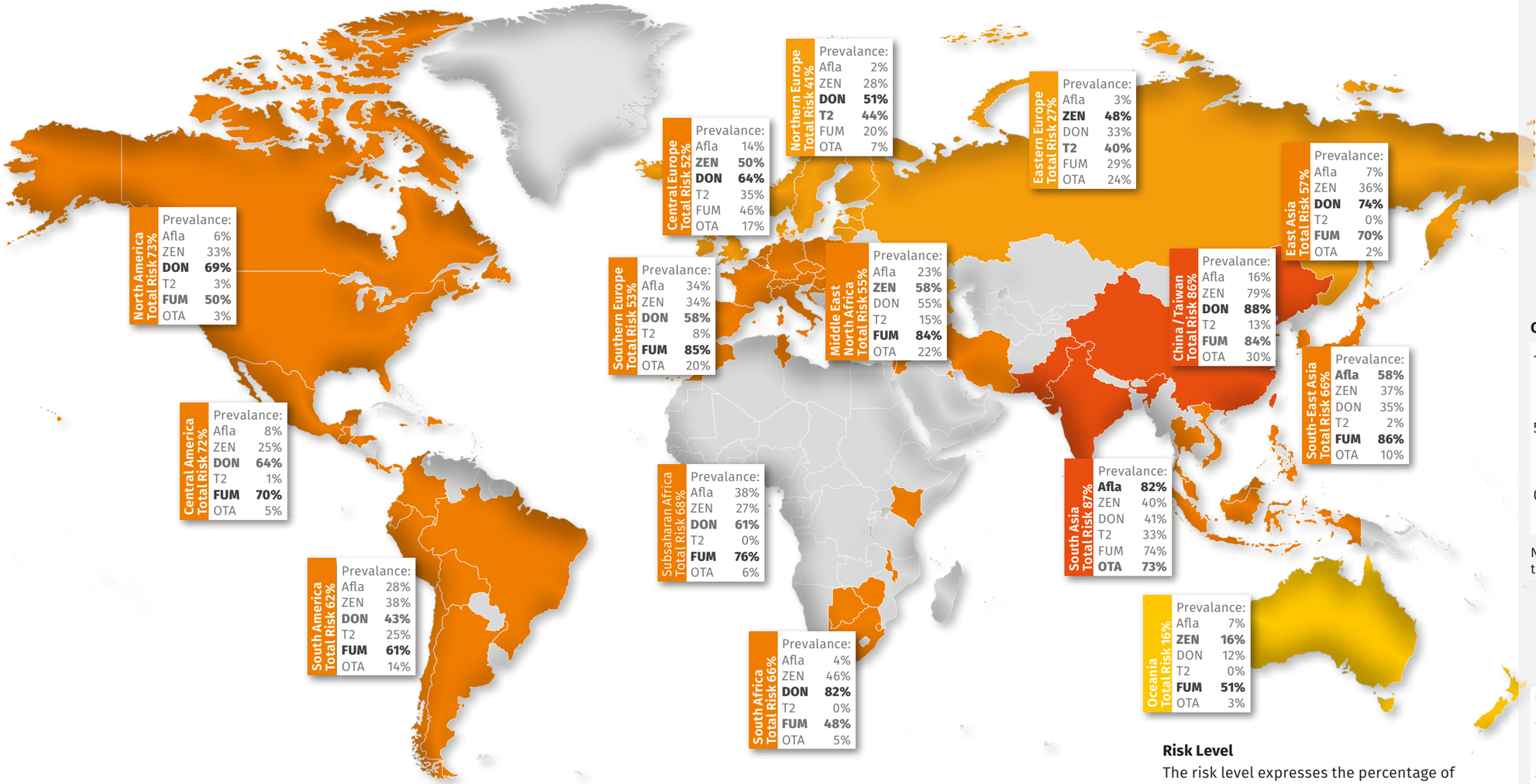


Figure 1. *Global map of mycotoxin prevalence and risk in different regions.*

0 – 25% | 26 – 50% | 51 – 75% | 76 – 100%

of samples above risk threshold

No samples tested

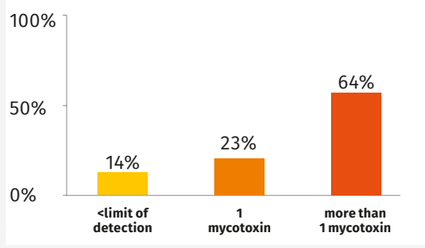
Moderate risk → **Extreme risk**

24 069 Samples

112 634 Analyses

75 Countries

Co-contamination



Number of mycotoxins per sample based on samples tested for 3 or more mycotoxins.

Risk Level

The risk level expresses the percentage of samples testing positive for at least one mycotoxin above the threshold level in parts per billion (ppb).

Recommended risk threshold of major mycotoxins in ppb

Afla	ZEN	DON	T-2	FUM	OTA
2	50	150	50	500	10

DISCLAIMER

DSM and the authors had no influence on the sampling process of the investigated samples. Therefore, the contamination levels found in the samples do not necessarily reflect the actual contamination level of these regions/commodities. However, the samples provide more insight into the range and levels of mycotoxins which can be found in diverse commodities of various regions.

Mycofix® is not available in the US and Canada.

ACKNOWLEDGEMENTS

Special thanks go to Biofarma Feedlab Argentina, Labocea France and Dr. Susanna Oswald, Tiergesundheitsdienst Bayern e.V. for sharing their mycotoxin analysis results as part of this survey. Mycotoxin Report is published by DSM Austria GmbH, Erber Campus, 3131 Getzersdorf, Austria, Tel: +43 2782 8030, www.dsm.com/anh

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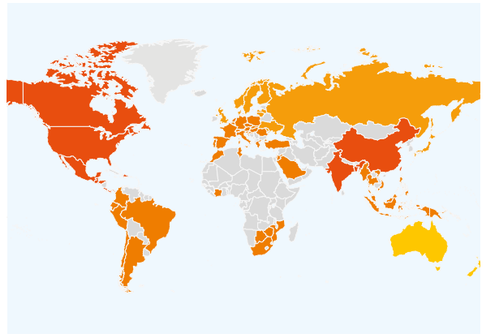
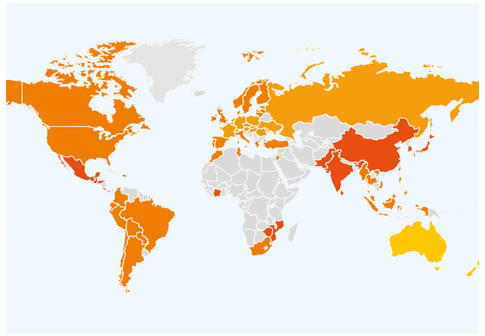
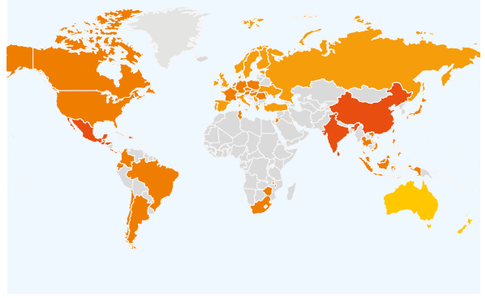
Mycotoxin Trends



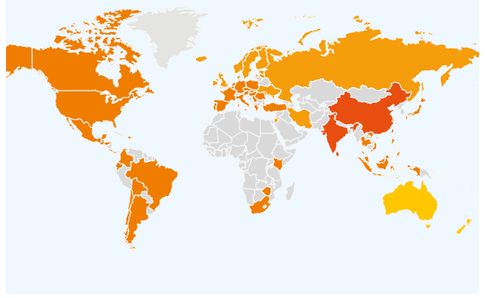
January – June 2020



July – December 2020



January – June 2021

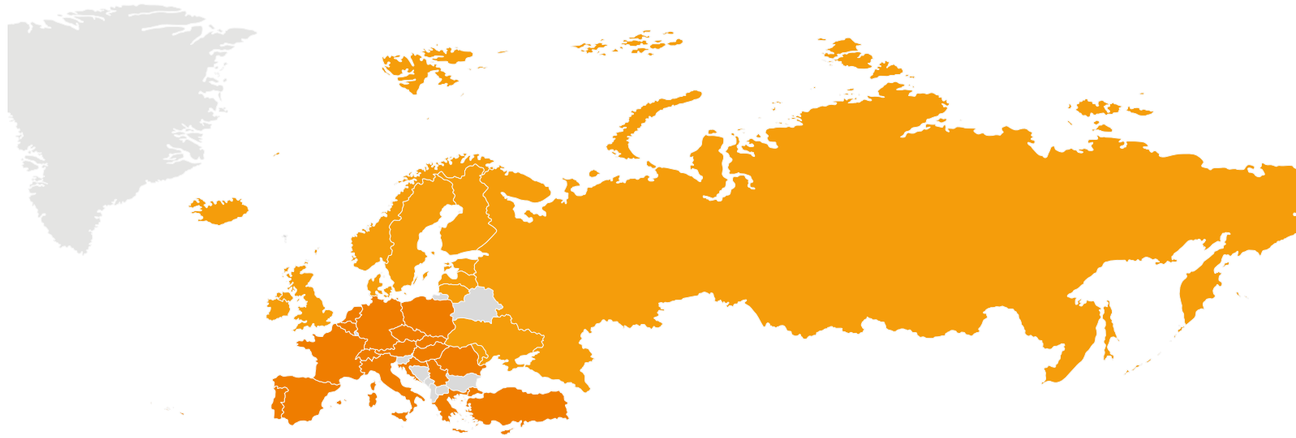


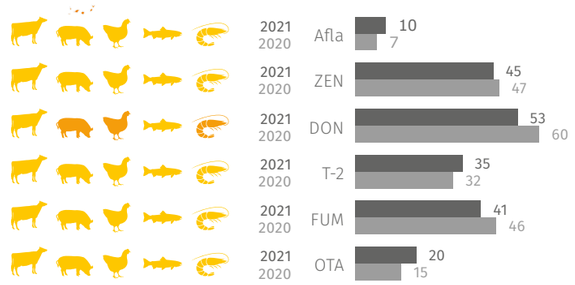
July – December 2021

A regional overview

Changes in risk for half year from 2020 to 2021 indicate the changes that happen with the main crop harvests. The region South America remains at severe risk in both years. Central America shows extreme risk during 2020 and a slight decrease in risk only in the second half of 2021. For North America, risk was slightly decreasing from extreme to severe from the first half of 2020 to the second half of the same year and remains severe throughout 2021. China and Taiwan as well as South Asia show extreme risk throughout the semesters. Risk stays constantly severe in South East Asia. In East Asia, risk is also severe (apart from extreme risk in the second half of 2020. Risk in South Africa remains severe through all semesters.

Europe





Animal colours indicate the risk posed to this species by the prevalence and concentration of each mycotoxin in all samples from this region (yellow=moderate to red=extreme see color code page 2)

% Contaminated samples January–December 2021 ■ and January–December 2020 ■

	Total samples: 7 165	Afla	ZEN	DON	T-2	FUM	OTA
Total Samples	Number of samples tested	4 411	6 771	7 054	4 868	4 801	4 380
	% Contaminated samples	10%	45%	53%	35%	41%	20%
	Average of positive (ppb)	5	62	551	47	781	8
	Median of positive (ppb)	2	24	249	15	129	3
	Maximum (ppb)	133	4 980	79 265	6 617	27 009	686
Corn	Number of samples tested	516	815	838	533	712	504
	% Contaminated samples	13%	49%	65%	44%	60%	15%
	Average of positive (ppb)	10	123	720	99	2011	9
	Median of positive (ppb)	3	48	434	18	458	4
	Maximum (ppb)	76	3 110	11 637	6 617	27 009	156
Cereals*	Number of samples tested	1 047	2 377	2 517	1 413	1 162	1 047
	% Contaminated samples	8%	26%	46%	42%	9%	11%
	Average of positive (ppb)	3	68	549	51	331	19
	Median of positive (ppb)	3	29	242	28	208	5
	Maximum (ppb)	20	3282	22 395	856	2 869	686

*Cereals include: wheat, barley, rye, oats, rice, sorghum, millet.

All samples

DON is most prevalent, followed by **ZEN** and **FUM**

T-2 prevalence and average concentrations slightly increased

Cereals

DON still main threat reaching a maximum of 22 395 ppb

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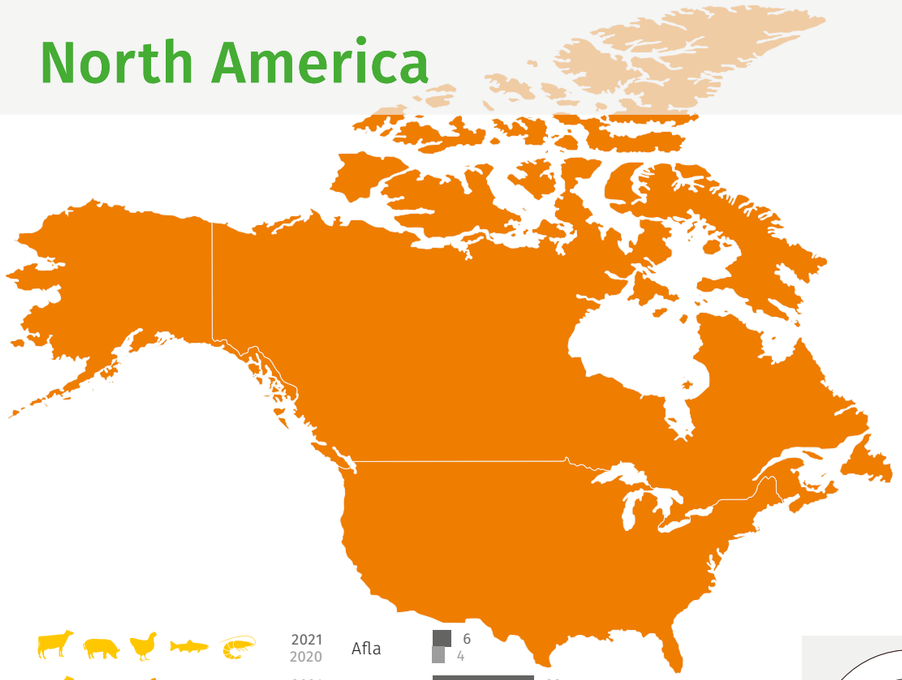
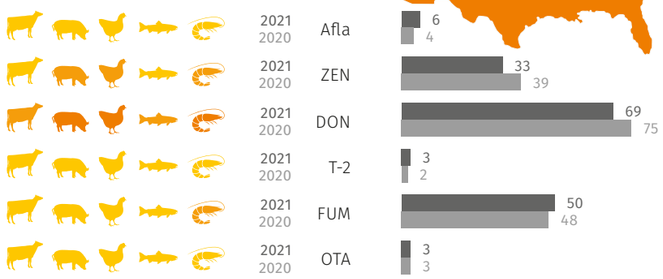
North America





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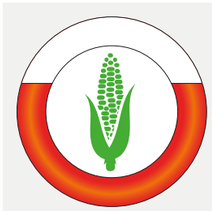
% Contaminated samples January–December 2021 ■ and January–December 2020 ■



Corn

DON (70%) and FUM (69%) are most prevalent

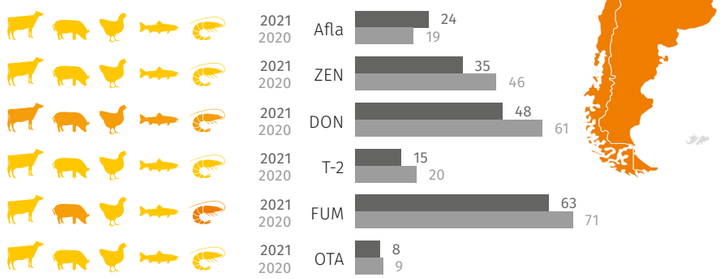
Average of positives **concentrations** of **DON** and **FUM** increased compared to 2020

70%

	Total samples: 1 860	Afla	ZEN	DON	T-2	FUM	OTA
Total Samples	Number of samples tested	1 791	1 798	1 798	1 790	1 828	1 791
	% Contaminated samples	6%	33%	69%	3%	50%	3%
	Average of positive (ppb)	42	256	989	90	1 816	7
	Median of positive (ppb)	4	114	461	65	600	2
	Maximum (ppb)	1 319	12 165	41 300	834	31 672	158
Corn	Number of samples tested	454	454	454	454	454	454
	% Contaminated samples	8%	31%	70%	3%	69%	1%
	Average of positive (ppb)	55	300	1 117	83	2588	45
	Median of positive (ppb)	22	104	446	70	947	18
	Maximum (ppb)	405	5 563	30 044	200	31 672	158
Cereals*	Number of samples tested	46	46	46	46	46	46
	% Contaminated samples	4%	17%	57%	2%	13%	9%
	Average of positive (ppb)	5	542	604	2	254	3
	Median of positive (ppb)	5	84	323	2	164	3
	Maximum (ppb)	7	3 650	6 300	2	534	3

*Cereals include: wheat, barley, rye, oats, sorghum.

South and Central America



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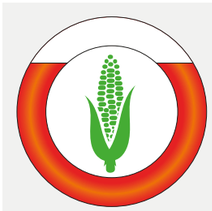
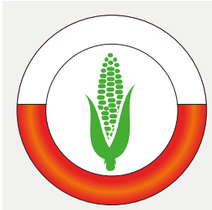
% Contaminated samples January–December 2021 ■ and January–December 2020 ■



Corn

FUM is most prevalent **(79%)** reaching a maximum of 83 800 ppb!

79%



Corn silage

ZEN found in **60%** of the samples (average of positives 193 ppb)

60%

	Total samples: 9 144	Afla	ZEN	DON	T-2	FUM	OTA
Total Samples	Number of samples tested	7 548	7 222	6 881	3 995	6 979	2 488
	% Contaminated samples	24%	35%	48%	15%	63%	8%
	Average of positive (ppb)	6	100	549	34	1 309	1
	Median of positive (ppb)	2	57	380	28	720	7
	Maximum (ppb)	2 630	4 603	6 910	1 311	83 800	320
Corn	Number of samples tested	3 234	2 742	2 526	978	3 071	439
	% Contaminated samples	18%	27%	48%	13%	79%	4%
	Average of positive (ppb)	10	106	555	31	1 645	5
	Median of positive (ppb)	2	48	372	29	942	4
	Maximum (ppb)	2 630	2 199	6 910	108	83 800	20
Cereals*	Number of samples tested	242	238	190	147	188	111
	% Contaminated samples	43%	29%	49%	18%	12%	24%
	Average of positive (ppb)	4	73	636	46	502	22
	Median of positive (ppb)	3	48	438	32	305	8
	Maximum (ppb)	80	932	3 814	168	5 000	320

*Cereals include: wheat, barley, rye, oats, rice, sorghum.

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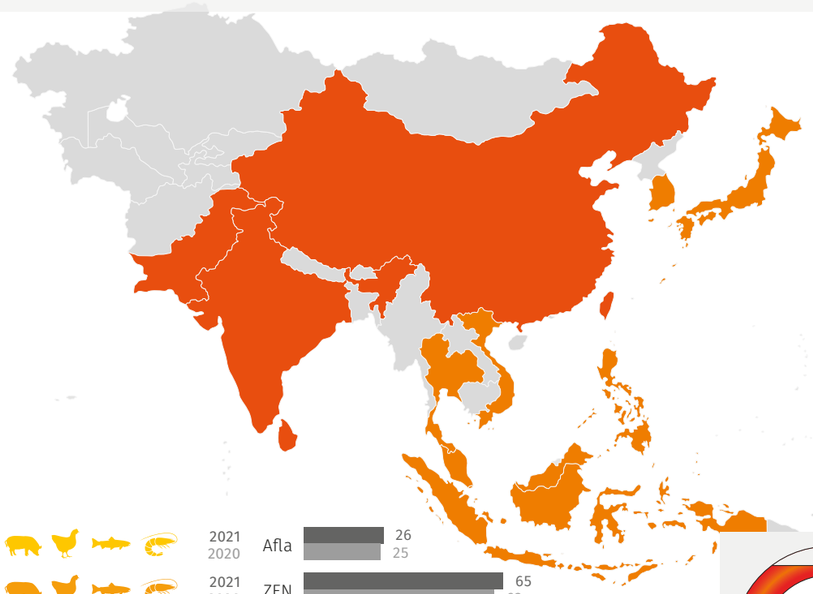
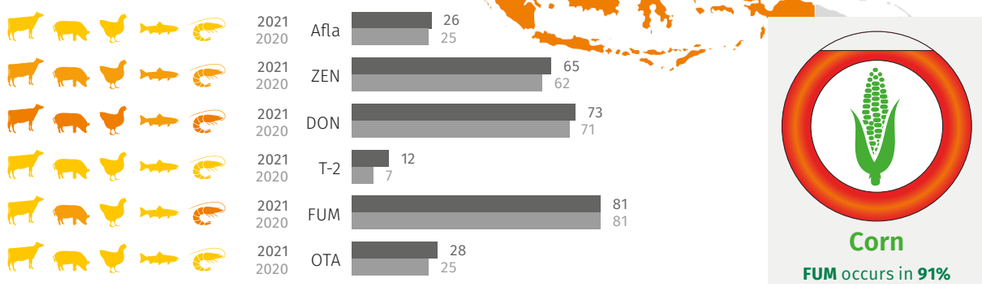
Asia





Animal colours indicate the risk posed to this species by the prevalence and concentration of each mycotoxin in all samples from this region (yellow=moderate to red=extreme see color code page 2)

% Contaminated samples January–December 2021 ■ and January–December 2020 ■

	Total samples: 4 382	Afla	ZEN	DON	T-2	FUM	OTA
Total Samples	Number of samples tested	4 380	4 222	4 327	4 159	4 180	4070
	% Contaminated samples	26%	65%	73%	12%	81%	28%
	Average of positive (ppb)	47	249	942	33	1 546	8
	Median of positive (ppb)	6	70	570	22	548	5
	Maximum (ppb)	1 560	28 066	56 818	1 619	17 1491	347
Corn	Number of samples tested	1 069	1 068	1 069	1 066	1 069	947
	% Contaminated samples	24%	73%	83%	21%	91%	62%
	Average of positive (ppb)	78	251	1178	20	3 113	6
	Median of positive (ppb)	23	95	860	16	1395	5
	Maximum (ppb)	1 560	13 932	14 890	96	171 491	141
Cereals*	Number of samples tested	388	340	388	340	358	351
	% Contaminated samples	9%	46%	58%	34%	38%	26%
	Average of positive (ppb)	30	175	1 099	43	269	8
	Median of positive (ppb)	5	38	594	34	77	5
	Maximum (ppb)	456	14 049	19 870	130	8 486	82

*Cereals include: wheat, barley, oats, rice, sorghum, millet.

Corn

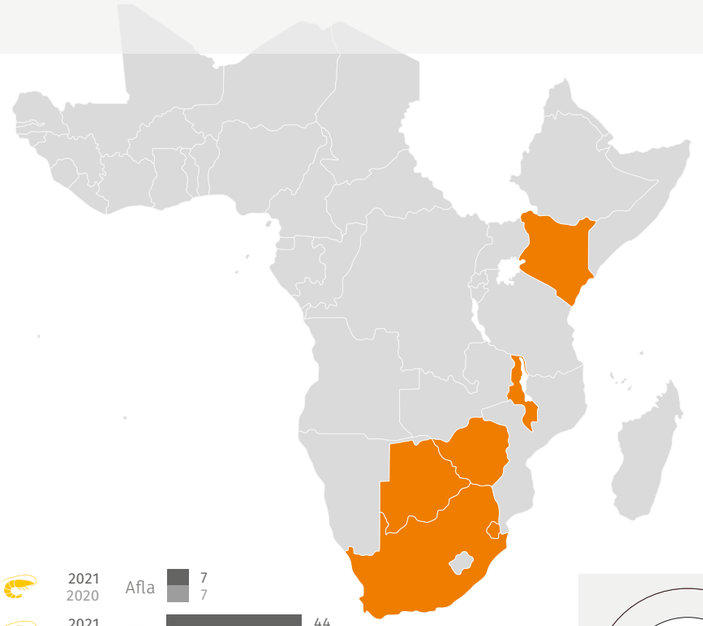
FUM occurs in **91%** and **DON** in **83%** of the samples!

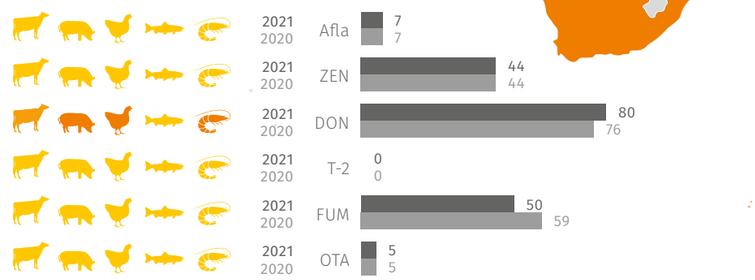
91%

All samples

Afla remains a risk for animals (average of positives **47 ppb**)

Africa





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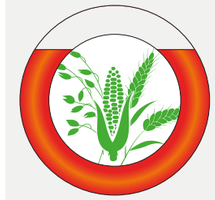
% Contaminated samples January–December 2021 ■ and January–December 2020 ■

	Total samples: 1 354	Afla	ZEN	DON	T-2	FUM	OTA
Total Samples	Number of samples tested	1 354	1 354	1 354	1 354	1 354	1 354
	% Contaminated samples	7%	44%	80%	0%	50%	5%
	Average of positive (ppb)	11	78	538	7	402	9
	Median of positive (ppb)	2	19	294	7	110	3
	Maximum (ppb)	424	14 353	8439	7	8344	171
Corn	Number of samples tested	573	573	573	573	573	573
	% Contaminated samples	2%	42%	90%	0%	48%	1%
	Average of positive (ppb)	24	43	576	-	430	4
	Median of positive (ppb)	1	14	331	-	121	2
	Maximum (ppb)	150	415	8 439	0	8 344	9
Cereals*	Number of samples tested	73	73	73	73	73	73
	% Contaminated samples	12%	33%	77%	0%	19%	14%
	Average of positive (ppb)	16	74	379	-	42	16
	Median of positive (ppb)	7	10	228	-	43	2
	Maximum (ppb)	41	1 320	2 610	0	73	112

*Cereals include: wheat, barley, sorghum, millet.



All samples

DON is most prevalent **(80%),** followed by FUM.

80%

Cereals

DON frequently found **(77%),** a maximum of 2 610 ppb was detected

77%

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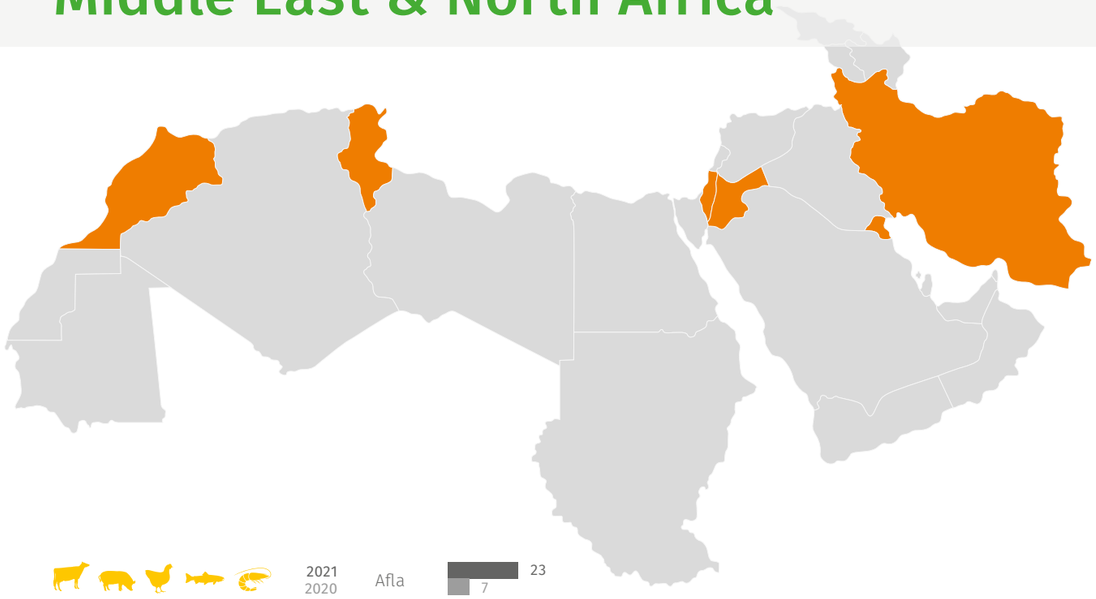
Middle East & North Africa



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% Contaminated samples January–December 2021 ■ and January–December 2020 ■

	Total samples: 163	Afla	ZEN	DON	T-2	FUM	OTA
Total Samples	Number of samples tested	162	162	162	162	162	162
	% Contaminated samples	23%	58%	55%	15%	84%	22%
	Average of positive (ppb)	2	92	619	20	896	5
	Median of positive (ppb)	1	28	265	14	310	3
	Maximum (ppb)	6	754	4 060	58	16 805	26
Corn	Number of samples tested	22	22	22	22	22	22
	% Contaminated samples	23%	50%	77%	14%	95%	0%
	Average of positive (ppb)	2	261	1213	16	3 140	-
	Median of positive (ppb)	1	199	625	13	730	-
	Maximum (ppb)	4	732	4060	25	1 6805	0
Finished Feed	Number of samples tested	60	60	60	60	60	60
	% Contaminated samples	20%	82%	72%	18%	98%	20%
	Average of positive (ppb)	3	25	212	9	331	5
	Median of positive (ppb)	1	18	160	7	224	4
	Maximum (ppb)	6	167	837	19	3 623	16

All samples

Fusarium mycotoxins are highly abundant in this region

Focus: major grain & soy producing countries

Corn

Country		Afla	ZEN	DON	T2	FUM	OTA
USA	Number of samples	422	422	422	422	422	422
	% Contaminated samples	8	31	68	1	72	1
	Average of positives (ppb)	57	312	1143	36	2637	45
	Median of positives (ppb)	24	110	435	6	955	18
	Maximum (ppb)	405	5563	30044	131	31672	158
Argentina	Number of samples	1152	1152	497	233	701	38
	% Contaminated samples	33	40	50	16	64	24
	Average of positives (ppb)	2	87	981	26	2383	4
	Median of positives (ppb)	1	41	670	22	1520	4
	Maximum (ppb)	76	1147	6910	88	83800	5
Brazil	Number of samples	1564	1072	1511	227	1852	15
	% Contaminated samples	9	15	43	33	80	13
	Average of positives (ppb)	29	112	415	33	1377	2
	Median of positives (ppb)	7	35	330	30	776	2
	Maximum (ppb)	2630	2199	2770	77	13850	2
Ukraine	Number of samples	20	25	25	25	25	22
	% Contaminated samples	15	60	80	68	28	27
	Average of positives (ppb)	2	145	1114	27	504	4
	Median of positives (ppb)	2	47	810	20	513	4
	Maximum (ppb)	2	556	3727	80	941	5

Wheat

Country		Afla	ZEN	DON	T2	FUM	OTA
Russia	Number of samples	204	204	204	204	204	204
	% Contaminated samples	0	15	43	18	4	7
	Average of positives (ppb)		61	265	50	27	15
	Median of positives (ppb)		5	46	8	15	3
	Maximum (ppb)	0	1441	12179	576	54	92
USA	Number of samples	28	29	29	28	29	28
	% Contaminated samples	0	7	93	0	10	46
	Average of positives (ppb)		1853	835		461	2
	Median of positives (ppb)		1853	611		275	2
	Maximum (ppb)	0	3650	6300	0	984	4
France	Number of samples	203	239	239	203	205	203
	% Contaminated samples	0	58	90	15	0	0
	Average of positives (ppb)		85	634	8	18	31
	Median of positives (ppb)		13	211	2	18	31
	Maximum (ppb)	0	2194	16081	104	18	31

Soybean

Country		Afla	ZEN	DON	T2	FUM	OTA
Brazil	Number of samples	415	497	779	99	447	19
	% Contaminated samples	6	16	32	22	6	11
	Average of positives (ppb)	5	53	758	40	502	2
	Median of positives (ppb)	4	31	640	34	58	2
	Maximum (ppb)	33	536	2740	92	3067	2
USA	Number of samples	68	68	68	68	68	68
	% Contaminated samples	1	12	16	1	44	7
	Average of positives (ppb)	1	26	76	1	74	1
	Median of positives (ppb)	1	8	18	1	26	1
	Maximum (ppb)	1	163	353	1	566	2
Argentina	Number of samples	868	1032	420	475	344	66
	% Contaminated samples	61	75	21	41	12	50
	Average of positives (ppb)	2	61	639	27	683	4
	Median of positives (ppb)	2	58	615	26	490	4
	Maximum (ppb)	58	225	4640	91	2500	7

DSM World Mycotoxin Survey 2021

Multiple Mycotoxin Overview

Spectrum 380® and Spectrum Top®50

Only analyzing for single mycotoxins can lead to underestimation of the detrimental effects of mycotoxins on animal health and performance. Our long-term monitoring of mycotoxins in different commodities shows that co-occurrence of mycotoxins is state-of-the-art. Here we need support of state-of the art analytical methods based on LC-MS/MS. These allow to detect multiple mycotoxins in one run. The high sensitivity of the method is important, as already moderate levels of mycotoxins can have a detrimental effect. This is especially true in case of co-contamination.

Spectrum 380®:

The most advanced and comprehensive mycotoxin analysis available

It detects > 500 different mycotoxins (including masked and modified forms and emerging mycotoxins), fungal metabolites as well as plant and bacterial toxins and metabolites.

This is not a routine analysis but it is done in special cases and/or also of course as part of research of future objectives.

Spectrum 380® is developed and conducted by the world's leading independent mycotoxin research lab at the Department of Agrobiotechnology (IFA-Tulln) at the University of Natural Resources and Life Sciences Vienna and offered through cooperation with Performance Solutions plus Biomin.

Spectrum Top®50:

The most comprehensive mycotoxin analysis commercially available

It detects > 50 different mycotoxins (including masked and modified forms), emerging mycotoxins and fungal metabolites.

The Spectrum Top® 50 method was developed by scientists of Romer Labs, a leading global supplier of diagnostic solutions for food and feed safety.

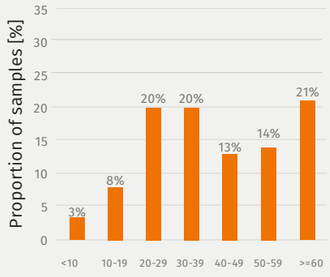
Multiple Mycotoxin Overview: Spectrum 380®

Overview of:

- the most frequently found mycotoxins, their masked and modified forms
- emerging mycotoxins
- other fungal metabolites
- plants and bacterial toxins and metabolites in all samples analyzed

Multiple mycotoxin occurrence

Spectrum 380® results January to December 2021: the most comprehensive mycotoxin analysis available



42
average number
of Mycotoxins and Metabolites per sample

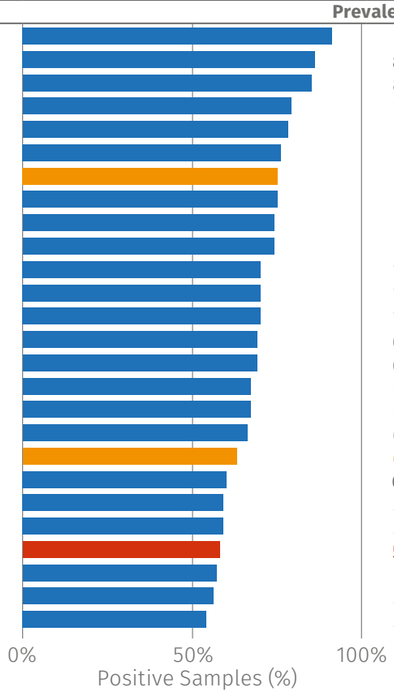
9,8
out of
10
samples contaminated with *Fusarium* toxins

Contained
10
or more mycotoxins and metabolites

Total: 861 samples tested from 31 countries; 430 500 points of analysis

Mycotoxins & metabolites

Metabolite	Prevalence	Average	Maximum
cyclo(L-Pro-L-Tyr)	91%	375	8 801
Tryptophol	86%	260	17 830
Aurofusarin	85%	294	20 816
Culmorin	79%	735	11 650
Abscisic acid	78%	169	4 555
15-Hydroxyculmorin	76%	371	15 580
Deoxynivalenol	75%	463	16 081
cyclo(L-Pro-L-Val)	75%	1 285	13 255
Moniliformin	74%	55	1 759
Enniatin B	74%	55	1 999
Altersetin	70%	63	6 607
Infectopyron	70%	2 014	76 720
Beauvericin	70%	23	842
Enniatin B1	69%	30	644
Siccanol	69%	1 337	95 123
Equisetin	67%	36	2 840
Fellutanine A	67%	30	395
Brevianamid F	66%	63	1 642
Zearalenone	63%	53	2 194
Bikaverin	60%	27	966
Nivalenol	59%	100	1 679
Rugulusovin	59%	55	913
DON-3-glucoside	58%	114	1 634
Antibiotic Y	57%	145	9 404
Butenolid	56%	166	4 654
Enniatin A1	54%	13	310



Positive Samples [%] for metabolites present in more than 50% of samples (orange bars indicate regulated or guideline mycotoxins; red bar indicates a masked mycotoxin). Cut off for all metabolites 1 ppb (except for aflatoxins 0.5 ppb).

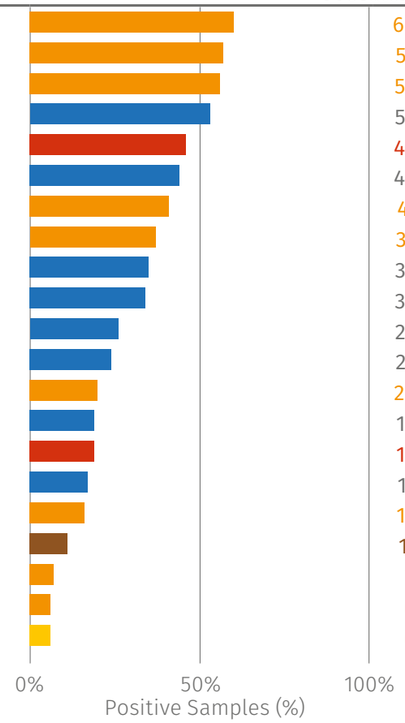
DSM World Mycotoxin Survey 2021

Multiple Mycotoxin Overview: Spectrum Top®50

Overview of the most frequently found mycotoxins, their masked and modified forms as well as emerging mycotoxins in all samples and finished feed

ALL samples (n=3 470)

Metabolite	Prevalence	Average	Maximum
Deoxynlvalenol	60%	503	19 275
Fumonisin B2	57%	172	15 486
Fumonisin B1	56%	489	39 917
Moniliformin	53%	136	3 114
Deoxynivalenol 3-Glucoside	46%	91	2 084
Beauvericin	44%	23	4 562
Fumonisin B3	41%	87	4 979
Zearalenone	37%	124	14 353
Alternariol	35%	113	16 663
Enniatin B1	34%	77	8 130
Enniatin A1	26%	29	2 121
Enniatin B	24%	283	79 782
Aflatoxin B1	20%	32	1 477
Sterigmatocystin	19%	6	477
15-Acetyl-Deoxynivalenol	19%	179	1 927
Enniatin A	17%	10	1 304
Ochratoxin A	16%	6	347
Nivalenol	11%	134	2 143
HT-2 Toxin	7%	76	1 711
Aflatoxin B2	6%	11	254
Ergotamine	6%	32	795



Positive Samples [%] for metabolites present in more than 50% of samples (orange bars indicate regulated or guideline mycotoxins; red bar indicates a masked mycotoxin). Cut off for all metabolites 1 ppb (except for aflatoxins 0.5 ppb).

Regulated or guideline mycotoxins

Masked and modified myoctoxins

15-Acetyl-DON: fungal metabolite of DON; shown to be converted to DON in intestinal tract of pigs and chickens

DON-3-glucoside: plant metabolite of DON (masked DON); less toxic than DON, but it converted back to DON in the gastrointestinal tract of mammals.

Ergot alkaloids

Nivalenol: Type B trichothecene, more cytotoxic than DON in intestinal cells of pigs and ruminants (*in vitro*)

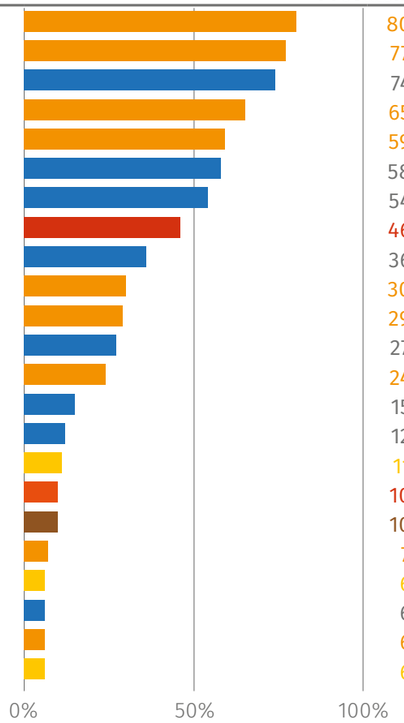
3 470 Samples

183 910 Analysis points

58 Countries

FINISHED FEED (n=1261)

Metabolite	Prevalence	Average	Maximum
Fumonisin B1	80%	303	8 315
Fumonisin B2	77%	101	2 524
Moniliformin	74%	89	2 829
Deoxynlvalenol	65%	287	4 118
Fumonisin B3	59%	51	1 046
Beauvericin	58%	17	1 408
Alternariol	54%	31	1 355
Deoxynivalenol 3-Glucoside	46%	54	621
Enniatin B1	36%	35	1 756
Aflatoxin B1	30%	13	311
Zearalenone	29%	56	810
Enniatin A1	27%	12	296
Ochratoxin A	24%	3	32
Sterigmatocystin	15%	5	77
Enniatin A	12%	6	73
Ergotamine	11%	17	795
15-Acetyl-Deoxynivalenol	10%	92	390
Nivalenol	10%	60	436
Aflatoxin B2	7%	4	30
alpha-Ergocryptine	6%	18	160
Enniatin B	6%	20	474
HT-2 Toxin	6%	36	334
Ergosine	6%	15	68



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Emerging myotoxins

Emerging myotoxins: frequently found on agricultural commodities, not regulated; toxicity is under investigation, but toxic effects suggested in some scientific literature; EFSA started to publish reports to do a risk assessment for these toxins.

Moniliformin: broiler very susceptible, genotoxic, immunosuppressive; causes heart damage, muscular weakness, respiratory distress

Alternariol: no acute toxicity, cytotoxic and mutagenic *in vitro*, effects on reproductive & immune system *in vitro*.

Beauvericin and Enniatins: effects on immune system: accumulation in fat-rich tissue.

Sterigmatocystin: precursor of aflatoxins; causes similar effects as aflatoxin B_1 in animals, but lower acute toxicity; negative effects incl. bloody diarrhea, less milk production, less feed intake, hepatotoxicity, nephrotoxicity

Mycofix®

MYCOTOXIN RISK MANAGEMENT

Absolute protection

Powered by science to actively defend against multiple mycotoxins*

With 3 combined strategies

- ADSORPTION
- BIOTRANSFORMATION
- BIOPROTECTION

***If not us, who? If not now,* when?**

WE MAKE IT POSSIBLE

*Authorized by EU Regulations No 1060/2013, 1016/2013, 1115/2014, 2017/913, 2017/930, 2018/1568 and 2021/363 for the reduction of contamination with fumonisins, aflatoxins and trichothecenes.

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