1. Biomarkers in animals

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Abbreviations

|  |  |
| --- | --- |
| 15AcDON | 15 Acetyl Deoxynivalenol |
| 3AcDON | 3-Acetyldeoxynivalenol |
| AFalb | Aflatoxin-Alb |
| AFB1 | Aflatoxin B1 |
| AFB1alb | Aflatoxins B1-Alb |
| AFB1lys | Aflatoxins B1-Lysin |
| AFB1N7guanine | Aflatoxins B1-N7-Guanine |
| AFB2 | Aflatoxin B2 |
| AFs | Aflatoxins |
| AFG1 | Aflatoxin G1 |
| AFG2 | Aflatoxin G2 |
| AFM1 | Aflatoxin M1 |
| alloTeA | Allo-Tenuazonic Acid |
| AST | Aspartate Aminotransferase |
| αZAL | α-Zearalanol |
| αZEL | α-Zearalenol |
| BCRP | Breast Cancer Resistance Protein |
| BEA | Beauvericin |
| BM | Biomarker |
| bw | Body Weight |
| βZAL | β-Zearalanol |
| βZEL | β-Zearalenol |
| βZEL14Glc | β-Zearalenol-14-Glucoside |
| CFU | Colony Forming Unit |
| CIT | Citrinin |
| CKD | Chronic Kidney Disease |
| DAS | Diacetoxyscirpenol |
| DM | Dry Matter |
| DMI | Dry Matter Intake |
| DOM1 | De-Epoxy-Deoxynivalenol |
| DOM1glucuronide | De-Epoxy-Deoxynivalenol-Glucuronide |
| DOM3S | De-Epoxy Deoxynivalenol-3-Sulphate |
| DON | Deoxynivalenol |
| DONGlcA | Deoxynivalenol-Glucuronide |
| DON3G | Deoxynivalenol-3-Glucoside |
| DON3glucuronide | Deoxynivalenol-3-Glucuronide |
| DON3S | Deoxynivalenol-3-Sulphate |
| EDTA | Ethylenediaminetetraacetic Acid |
| ELISA | Enzyme-Linked Immunosorbent Assay |
| ENNA | Enniatin A |
| ENNB | Enniatin B |
| ENNB1 | Enniatin B 1 |
| ENNs | Enniatins |
| EU | European Union |
| FB1 | Fumonisin B1 |
| FB2 | Fumonisin B2 |
| FBs | Fumonisins |
| FFQ | Food Frequency Questionnaire |
| FLD | Fluorescence Detection |
| FUMzyme | Carboxylesterase Fumonisin D |
| GAPs | Good Agricultural Practices |
| GSPE | Grape Seed Proanthocyanidin Extract |
| HA | Humic Acid |
| HFB1 | Hydrolysed Fumonisin B1 |
| HPLC | High Performance Liquid Chromatography |
| HSCAS | Hydrated Sodium Calcium Alimunosilicate |
| H T2 | Toxin HT 2 |
| I.p. | Intraperitonal |
| I.v. | Intravenous |
| LC | Liquid Chromatography |
| LOD | Limit Of Detection |
| LOQ | Limit Of Quantification |
| MS | Mass Spectrometry |
| NIV | Nivalenol |
| OTA | Ochratoxin A |
| OTα | Ochratoxin α |
| OTP | Oxidised Tea Polyphenols |
| P-gp | P-Glycoprotein |
| pHFB1 | Partially Hydrolysed Fumonsin B1 |
| RIA | Radio-Immune Assay |
| Sa | Sphinganine |
| So | Sphingosine |
| STC | Sterigmatocystin |
| T2 | Toxin T2 |
| TD | Toxicodynamics |
| TeA | Tenuazonic Acid |
| TK | Toxicokinetics |
| TLC | Thin Layer Chromatography |
| UV | UV Detector |
| VFM | Velasco Fluorotoxinmeter |
| YCW | Yeast Cell Wall |
| ZAN | Zearalanone |
| ZEN | Zearalenone |
| ZEN14G | Zearalenone-14-Glucoside |
| ZEN14S | Zearalenone -14-Sulfate |
| ZEN16G | Zearalenone-16-Glucoside |
| ZENSulf | Zearalenone Sulfate |

Supplementing Tables

Table K1. AFs\_List of single biomarker, substrate, and animal reported in the different substrate of the associated animal.

| Mycotoxin | Substrate | | Analytical Technique | Kynd of Study | | Animal | Trial Description (a) | | | Range of Values (a) | | Reference |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| AFB1 | | Animal milk | HPLC-FLD | | BM of exposure | Buffalo | | Day 1,2,3,4,5,6,7,8,9; naturally contaminated corn meal (217 μg AFB1/buffalo/day) diet without AFB1 | 0.24-5.89 ug/kg (LOQ-) | | Giangolini, 2013 | |
| AFB1 | | Faeces | ELISA | | Tox studies with data on BM | Rats | | AFB1 group; AFB1 plus OTP1; AFB1 plus OTP2 | 20-220 µg/kg (LOQ-) | | Hao Lu, 2016 | |
| HPLC-FLD | | Tox studies with data on BM | Cow | | AFB1 100 µg/kg DMI\_no clay; AFB1 100 µg/kg DMI\_0.5% clay; AFB1 100 µg/kg of DMI\_1%clay; FB1 100 µg /kg DMI\_2%clay; control group | 1.48-2.78 ng/g (LOQ-) | | Sulzberger, 2017 | |
| LC–MS/MS | | Tox studies with data on BM | Cow | | Days: 1, 2. feeding: yeast -/+; starch low (13% DM)/high (30.8% DM) | 6.7-23.41 µg/day (LOQ-) | | Pantaya, 2016 | |
| HPLC-FLD | | Tox studies with data on BM | Mice | | Lactobacillus per gavage; AFB1+viable lactob; AFB1+heated-killed lactobacillus; lactobacillus group; control group | 0.341-3.199 µg/g (LOQ-) | | Huang, 2017 | |
| AFB1 | | Plasma | HPLC-FLD | | Tox studies with data on BM | Mice | | I.p. admin. AFB1 at 20 mg/kg | 23.45 ng/ml (LOQ 0.5 ng/ml) | | Tras, 2017 | |
| AFB1 | | Rumen fluid | HPLC-FLD | | Tox studies with data on BM | Cow | | AFB1 100 µg/kg DMI\_no clay; AFB1 100 µg/kg DMI\_0.5% clay; AFB1 100 µg/kg of DMI\_1% clay; FB1 100 µg /kg DMI\_2 %clay; control group | 0.02-0.10 ng/g (LOQ-) | | Sulzberger, 2017 | |
| ELISA | | BM of exposure | Cow | | Various countries and localities (Romania) | 0.98-0.99 µg/day (LOD 0.5 ng/l) | | Simion, 2010 | |
| AFalb | | Urine | ELISA | | Tox studies with data on BM | Rats | | AFB1 group; AFB1 plus OTP1; AFB1 plus OTP2 | 3-5 ng/ml (LOQ-) | | Hao Lu, 2016 | |
| AFB1lys | | EDTA plasma | LC–MS/MS | | BM of exposure | Pig | | 7 day AFB1-contaminated diets; 42 day AFB1-contaminated diets | 24.78-37.4 ng/ml (LOQ 10.31 ng/ml) | | Carraro Di Gregorio, 2017 | |
| AFB1lys | | Plasma | LC–MS/MS | | BM of exposure | Pig | | 7 day AFB1-contaminated diets; 42 day AFB1-contaminated diets | <LOQ-264.24 ng/ml (LOQ 10.31 ng/ml) | | Carraro Di Gregorio, 2017 | |
| AFB1lys | | Serum | LC–MS/MS | | BM of exposure | Pig | | 7 day AFB1-contaminated diets; 42 day AFB1-contaminated diets | 49.32-252.07 ng/ml (LOQ 9.01 ng/ml) | | Carraro Di Gregorio, 2017 | |
| LC–MS/MS | | Tox studies with data on BM | Pig | | Feed AFB1 1.1 mg/kg \_day 7/14/21; Feed AFB1 1.1 mg/kg + 0.5% HSCAS \_day 7/14/21 | 1.65-7.85 ng/mg albumin (LOQ 10.3 ng/ml) | | Carraro Di Gregorio, 2017 | |
| AFB1N7guanine | | Urine | HPLC | | Tox studies with data on BM | Mice | | Lactobacillus per gavage; AFB1+viable lactobacillus; AFB1+heated-killed lactobacillus; lactpbacillus group; control group | 0.0953-0.0953 ng/ml (LOQ-) | | Huang, 2017 | |
| AFM1 | | Animal milk | ELISA | | Tox studies with data on BM | Buffalo | | Low/high AFB1 intake; binder +/- | 5.6-14.6 ng/g (LOQ-) | | Aslam, 2015 | |
|  | |  | LC–MS/MS | | BM of exposure | Cow | | Mild/late lactation; 86 µg AFB1 day 7 | 0.013-0.21(max) µg/kg (LOQ 0.01 µg/kg) | | Britzi, 2013 | |
|  | |  | LC–MS/MS | | BM of exposure | Cow | | (-) | 0.071-0.112 ng/g (LOQ 0,01 ng/g) | | Britzi, 2013 | |
|  | |  | HPLC-FLD | | BM of exposure | Buffalo | | Day 1, 2, 3 ,4, 5, 6, 7, 8, 9; day 6 naturally contaminated corn meal (217 μg AFB1/buffalo/d); diet without AFB1 | 6.65-70.01 ng/kg (LOQ-) | | Giangolini, 2013 | |
|  | |  | ELISA | | Tox studies with data on BM | Cow | | High, normal quality milk plant South, Central, North Italy | 13-16.7 ng/kg (LOQ 5 ng/kg) | | Kerekes, 2016 | |
|  | |  | ELISA | | BM of exposure | Cow | | Milk treatment (pasteurized, raw, organic, UHT) | 0.035-0.4 µg/kg (LOQ 5 ng/kg) | | Kos, 2014 | |
|  | |  | ELISA | | BM of exposure | Cow | | Sampling period: summer/winter | 0.08-0.12 ng/g (LOQ -) | | Mahmoudi, 2014 | |
|  | |  | ELISA | | BM of exposure | Cow | | Sampling farm: rural/peri urban | 0.011-0.062 ng/g (LOQ 8.4 ng/kg); | | Makau, 2016 | |
|  | |  | HPLC-FLD | | BM of exposure | Cow  Buffalo  Cow  Goat  Sheep | | Sampling farm: rural/urban/semi urban | 0.012-0.042 ng/g;  0.008-0.030 ng/g;  0.005-0.022 ng/g ;  0.014-0.042 ng/g  (LOD 0.005 µg/l) | | Nile, 2015 | |
|  | |  | RIA | | Tox studies with data on BM | Cow | | Feeding: 1.725 μg AFB1; 1.725 μg AFB1 + 20 g/d of 3 sequestering agents | 0.73-0.74 ng/g;  (LOD -) | | Ogunade, 2016 | |
|  | |  | HPLC-FLD | | BM of exposure | Cow | | Sampling farms: 1-20; carry over rate from feed to milk | 0.0018-0.0462 mg/l (LOD -) | | Polat, F. and Aksu, T, 2015 | |
|  | |  | ELISA | | BM of exposure | Cow | | Sampling farm: 1-6; Sampling period: Jen-Dic 2012 | <LOD (5 ng/g)-9.3 ng/kg | | Schirone, 2015 | |
|  | |  | ELISA | | BM of exposure | Cow | | Various countries and localities (Romania) | <LOD-42 µg/l (LOQ 5 µg/l) | | Simion, 2010 | |
|  | |  | ELISA | | BM of exposure | Cow | | Sampling period: winter/spring/autumn/summer 2014 | 0.039-0.358 µg/l (LOD 0.02 µg/kg) | | Tomašević, 2015 | |
| AFM1 | | Faeces | LC–MS/MS | | Tox studies with data on BM | Cow | | Days: 1, 2; Feeding: yeast -/+; starch low/high | 32.89-54.83 µg/day (LOQ -) | | Pantaya, 2016 | |
| AFM1 | | Urine | LC–MS/MS | | Tox studies with data on BM | Cow | | Days: 1, 2; Feeding: yeast -/+; starch low/high | 0.31-26.31 µg/day (LOQ -) | | Pantaya, 2016 | |
|  | |  | HPLC-FLD | | BM of exposure | Pig | | Control group; binders (2 commercial/4 agricultural bioproduct) admin. | 0.27-1.15 ng/ml (LOD 0.16 ng/ml) | | Gambacorta, 2016 | |
|  | |  | HPLC-FLD | | Tox studies with data on BM | Cow | | AFB1 100 µg/kg DMI\_no clay; AFB1 100 µg/kg DMI\_0.5% clay; AFB1 100 µg/kg of DMI\_1% clay; FB1 100 µg /kg DMI\_2% clay; Control group | 4.38-27.81 µg/kg (LOQ -) | | Sulzberger, 2017 | |
| Aflatoxin total | | Rumen fluid | ELISA | | BM of exposure | Cow | | Various counties and localities (Romania) | <LOQ (2.23 µg/l) (LOD 2.17 ng/l) | | Simion, 2010 | |

1. (a) Unless specified, range of values or mean±standard deviation is reported. OTP = oxidised tea polyphenols OTP1 (10 m/ ml), OTP2 (5 m/ ml). DMI = dry matter intake. DM = dry matter. I.p. admin. = intraperitoneal administration

Table K2. OTA\_List of single biomarker, substrate, and animal reported in the different substrate of the associated animal.

| Mycotoxin | Substrate | Analytical Technique | Kynd of Study | Animal | Trial Description (a) | Range of Values (a) | Reference |
| --- | --- | --- | --- | --- | --- | --- | --- |
| OTA | Bile | HPLC | BM of exposure | Chicken | Control group; 10 mg/kg OTA diet; 200 mg/kg OTA diet | <LOQ (1 ng/ml)-139 ng/ml | Armorini, 2015 |
| OTA | Blood | HPLC-FLD | BM of exposure | Broilers | 1 mg/kg OTA; 1 mg/kg OTA+MDP 0.2%; 2 mg/kg OTA; 2 mg/kg OTA+MDP 0.2%. 5 weeks | 2.58-6.25 ng/ml (LOQ -) | Joo, 2013 |
| OTA | Faeces | LC–MS/MS | Tox studies with data on BM | Cow | Days: 1, 2; Feeding: yeast -/+ low/high starch | 3.05-11 µg/day (LOQ -) | Pantaya, 2016 |
|  |  | HPLC-FLD | BM of exposure | Broilers | 1 mg/kg OTA; 1 mg/kg OTA+MDP 0.2%; 2 mg/kg OTA; 2 mg/kg OTA+MDP 0.2%. 5 weeks | 197.53-3156.92 ng/g (LOQ 0.7 ng/g) LOD 0.2 ng/g) | Joo, 2013 |
| OTA | Kidney | HPLC-FLD | BM of exposure | Broilers | 1 mg/kg OTA; 1 mg/kg OTA+MDP 0.2%; 2 mg/kg OTA; 2 mg/kg OTA+MDP 0.2%. 5 weeks | 30.18-40.48 ng/g (LOQ 0.7 ng/g) (LOD 0.2 ng/g) | Joo, 2013 |
|  |  | HPLC-FLD | BM of exposure | Wild boar | (-) | 1.77-2.34 ng/g (LOQ-) | Grajewski, 2012 |
|  |  | HPLC-FLD | BM of exposure | Rats | G1: 10 mg OTA/kg diet; G2: 10 mg OTA/kg diet+100 mg quercetin/kg feed | 1.44-1.42 µg/g (LOQ 1 µg/g) | Abbas, 2013 |
| OTA | Liver | HPLC-FLD | BM of exposure | Broilers | 1 mg/kg OTA; 1 mg/kg OTA+MDP 0.2%; 2 mg/kg OTA; 2 mg/kg OTA+MDP 0.2%. 5 weeks | 20.32-20.28 ng/g (LOQ 0.7 ng/g) | Joo, 2013 |
|  |  | HPLC-FLD | BM of exposure | Rats | G1: 10 mg OTA/kg diet; G2: 10 mg OTA/kg diet+100 mg quercetin/kg feed | 1.10-1.12 µg/g (LOQ 1 µg/g) | Abbas, 2013 |
| OTA | Liver | HPLC-FLD | BM of exposure | Rats | G1: 10 mg OTA/kg diet; G2: 10 mg OTA/kg diet+100 mg quercetin/kg feed | 0.48-0.53 µg/g (LOQ 1 µg/g) | Abbas, 2013 |
| OTA | Plasma | HPLC-FLD | Tox studies with data on BM | Rats | G1: 10 mg OTA/kg diet; G2: 10 mg OTA/kg diet+100 mg quercetin/kg feed | 10.91-11.27 µg/ml (LOQ 1 µg/ml) | Abbas, 2013 |
|  |  | HPLC-FLD | BM of exposure | Dog | Healthy, chronic kidney disease, IRIS stage 1, IRIS stage 2, IRIS stage 3, IRIS stage 4 | 0.008-0.58 ng/ml (LOQ 0.025 ng/ml) | Meucci, 2017 |
|  |  |  | BM of exposure | Cow | 5 μg, 50 μg, 100 μg OTA/kg DM | <LOQ (0.1 μg /kg) | Hashimoto, 2016 |
| OTA | Rumen fluid | ELISA | BM of exposure | Cow | Various countries and localities (Romania) | 23.91-24.98 µg/l (LOQ -) | Simion, 2010 |
| OTA | Serum | HPLC-FLD | BM of exposure | Pig | 4 locations in Brazil | 0.16(min)-115(max) mg/ml (LOQ -) | Kruger, 2010 |
|  |  |  | BM of exposure | Wild boar | (-) | 1.77-6.14 ng/ml (LOQ -) | Grajewski, 2012 |
|  |  | HPLC-FLD | BM of exposure | Pig | Conventional/organic farm | 0.16-1.32 ng/ml (LOQ 0.1 ng/ml) | Pozzo, 2010 |
| OTA | Urine | LC–MS/MS | Tox studies with data on BM | Cow | Days: 1, 2; Feeding: yeast -/+ low/high starch | <LOQ-1.3 µg/day (LOQ -) | Pantaya, 2016 |
|  |  | HPLC-FLD | BM of exposure | Pig | Control group; binders (2 commercial/4 agricultural bioproduct) admin. | 0.59-0.82 ng/ml (LOQ 0.01 ng/ml) | Gambacorta, 2016 |
| OTα | Faeces | HPLC-FLD | BM of exposure | Broilers | 1 mg/kg OTA; 1 mg/kg OTA+MDP 0.2%; 2 mg/kg OTA; 2 mg/kg OTA+MDP 0.2%. 5 weeks | 197.53-3156.95 ng/g (LOQ 0.7 ng/g) | Joo, 2013 |
| OTα | Kidney | HPLC-FLD | BM of exposure | Rats | G1: 10 mg OTA/kg diet; G2: 10 mg OTA/kg diet+100 mg quercetin/kg feed | <LOQ (1 ng/g) |  |
| OTα | Liver | HPLC-FLD | BM of exposure | Rats | G1: 10 mg OTA/kg diet; G2: 10 mg OTA/kg diet+100 mg quercetin/kg feed | <LOQ (1 µg/g) |  |
| OTα | Muscle | HPLC-FLD | BM of exposure | Rats | G1: 10 mg OTA/kg diet; G2: 10 mg OTA/kg diet+100 mg quercetin/kg feed | <LOQ (1 µg/g) |  |
| OTα | Plasma | HPLC-FLD | BM of exposure | Rats | G1: 10 mg OTA/kg diet; G2: 10 mg OTA/kg diet+100 mg quercetin/kg feed | <LOQ (1 µg/ml) |  |
| OTα | Urine | LC–MS/MS | Tox studies with data on BM | Cow | Days: 1, 2; Feeding: yeast -/+ low/high starch | 802-1400 µg/day (LOQ -) | Pantaya, 2016 |

1. (a) Unless specified, range of values or mean±standard deviation is reported. DM = dry matter. IRIS = guidelines on the basis of plasma creatinine concentration as follows: stage 1, <1.4 mg/dl (<123.7 μmol/l); stage 2, 1.4 to 2.0 mg/dl (123.7 to 176.8 μmol/l); stage 3, 2.1 to 5.0 mg/dl (185.6 to 442 μmol/l); and stage 4, >5.0 mg/dl (>442 μmol/l). MDP = Mycotoxins Deactivator Product
2. Table K3. DON\_List of single biomarkers, substrate, animal reported in the different substrate of the associated animal

| Mycotoxin | Substrate | Analytical Technique | Kind of Study | Animal | Trial Description (a) | Range Of Values (a) | Reference |
| --- | --- | --- | --- | --- | --- | --- | --- |
| DON | Bile | LC–MS/MS | BM of exposure | Chicken | 0.4 µg/kg DON breed LB; 0.4 µg/kg DON breed LSL; 9.9 µg/kg DON breed LB; 9.9 µg/kg DON breed LSL | <LOQ(-)-3.40 ng/g (median) | Ebrahem, 2014 |
|  |  | LC–MS/MS | Tox studies with data on BM | Pig | I.v. admin. 250 ug/kg bw DON; i.v. 750 ug/kg bw DON; control group | 1.80(min)-26.1(max) ng/ml (LOQ 2 ng/ml) | Deng, 2015 |
| DON | Egg | LC–MS/MS | BM of exposure | Chicken | 0.4 µg/kg DON breed LB; 0.4 µg/kg DON breed LSL; 9.9 µg/kg DON breed LB; 9.9 µg/kg DON breed LSL | <LOQ(-)-0.263 ng/g (median) | Ebrahem, 2014 |
| DON | Excreta | LC–MS/MS | Tox studies with data on BM | Turkey  Chicken | DON group (spiked 1.5–1.7 mg/kg DON); DOM group (equimolar DOM); Control group (0.2–0.3 mg/kg DON) | 0-5.5 µg DON equivalent (LOQ 195 ng/g)  0-17 µg DON equivalent (LOQ 195 ng/g) | Schwartz-Zimmermann, 2015 |
| DON | Faeces | HPLC-UV | BM of exposure | Pig | 0-8h/8-24h; Control group; DON3G per gavage 116 µg/kg bw; DON per gavage: 75 µg/kg bw; DON i.v: 15.5 µg/kg bw | 3.65 mg/day (LOQ 0.01 mg/kg) | Nagl, 2014 |
|  |  | LC–MS/MS | Tox studies with data on BM | Cow | Days: 1, 2; Feeding: yeast -/+ low/high starch | 97-531 µg/day (LOQ -) | Pantaya, 2016 |
|  |  | LC–MS/MS | Tox studies with data on BMs | Rat | 0-24h/24-48h; 3 treatments (water, DON 2.0 mg/kg bw, DON3G 3.1 mg/kg bw) | 1.8-200 nmol (LOQ 3.6 ng/ml) | Nagl, 2012 |
| DON | Plasma | LC–MS/MS | Tox studies with data on BM | Chicken | 0.4 µg/kg DON breed LB; 0.4 µg/kg DON breed LSL; 9.9 µg/kg DON breed LB; 9.9 µg/kg DON breed LSL | <LOQ-0.366 ng/ml (-) | Ebrahem, 2014 |
|  |  | LC–MS/MS | Tox studies with data on BM | Chicken | Detoxifying bolus model 1/2/3; detox Agent1/2; Control group | 8.22-23.74 (Cmax) ng/ml (LOQ 1 ng/ml) | Devreese, 2012 |
|  |  | LC–MS/MS | BM of exposure | Cow | Group CON (ZEN/DON 0/0 mg per kg DM), group FUS-50 (ZEN/DON 0.25/2.45 mg per kg DM), group FUS-100 (ZEN/DON 0.5/4.9 mg per kg DM) | <LOQ (0.65 ng/ml)-3.64 | Winkler, 2014 |
|  |  | LC–MS/MS | Tox studies with data on BM | Pig | I.v. admin. 250 ug/kg bw DON; i.v. 750 ug/kg bw DON; control group | <LOQ (2 ng/ml)-26.8 ng/ml (max) | Deng, 2015 |
|  |  | LC–MS/MS | BM of exposure | Pig | DON in feed/day (4 weeks): 280 μg/kg; 560 μg/kg; 840 μg/kg; Control group | <LOQ (0.5 ng/ml)- 1 ng/ml | Hopton, 2012 |
| DON | Plasma Protein fraction | LC–MS/MS | BM of exposure | Pig | DON in feed/day (4 weeks): 280 μg/kg; 560 μg/kg; 840 μg/kg; Control group | 0.8-1.8 µg/l (LOD 0.5 ng/ml) | Hopton, 2012 |
| DON | Serum | HPLC-FLD | BM of exposure | Pig | Control group (DON feed 0.9 mg/kg); DON group (DON feed 0.9 mg/kg feed+DON bolus 0.28 mg/kg bw) | 168 ±16 µg/ml (LOD 50 µg/ml) | Alizadeh, 2015 |
| DON | Urine | LC–MS/MS | BM of exposure | Pig | 0-8h/8-24h; Control group; DON3G per gavage 116 µg/kg bw; DON per gavage: 75 µg/kg bw; DON i.v: 15.5 µg/kg bw | <LOQ (8.0 ng/ml)-880 nmol | Nagl, 2014 |
|  |  | LC–MS/MS | Tox studies with data on BM | Pig | Positive control (PC); PC+ detoxifying agent1; negative control (NC, DON 4 mg/kg); NC+ 1%detoxifying agent1; NC+ 1%detoxifying agent2 | 0.52-3.65 mg/day (LOQ 0.01 mg/kg) | Frobose, 2017 |
|  |  | LC–MS/MS | BM of exposure | Pig | Control group; binders (2 commercial/4 agricultural bioproduct) admin. | 204.9-346.4 ng/ml (LOD 0.8 ng/ml) | Gambacorta, 2016 |
|  |  | LC–MS/MS | Tox studies with data on BM | Rat | 0-24h/24-48h; 3 treatments (water, DON 2.0 mg/kg bw, DON3G 3.1 mg/kg bw) | 1.3-79 nmol (LOQ 6.9 ng/ml) | Nagl, 2012 |
| DOM1 | Bile | LC–MS/MS | BM of exposure | Chicken | 0.4 µg/kg DON breed LB; 0.4 µg/kg DON breed LSL; 9.9 µg/kg DON breed LB; 9.9 µg/kg DON breed LSL | <LOQ(-) | Ebrahem, 2014 |
| DOM1 | Egg | LC–MS/MS | BM of exposure | Chicken | 0.4 µg/kg DON breed LB; 0.4 µg/kg DON breed LSL; 9.9 µg/kg DON breed LB; 9.9 µg/kg DON breed LSL | <LOQ(-)-0.263 ng/g (median) | Ebrahem, 2014 |
| DOM1 | Faeces | LC–MS/MS | BM of exposure | Pig | All groups: 0-8h/8-24h; Control group; DON3G per gavage 116 µg/kg bw; DON per gavage: 75 µg/kg bw; DON i.v: 15.5 µg/kg bw | <LOQ (10.8 ng/ml) | Nagl, 2014 |
|  |  | LC–MS/MS | Tox studies with data on BM | Cow | Days: 1, 2 | 86-436 µg/day (LOQ -) | Pantaya, 2016 |
|  |  | LC–MS/MS | Tox studies with data on BMs | Rat | 0-24h/24-48h; 3 treatments (water, DON 2.0 mg/kg bw, DON3G 3.1 mg/kg bw) | <LOQ (8.5 ng/ml) -120 nmol | Nagl, 2012 |
| DOM1 | Plasma | LC–MS/MS | Tox studies with data on BM | Chicken | 0.4 µg/kg DON breed LB; 0.4 µg/kg DON breed LSL; 9.9 µg/kg DON breed LB; 9.9 µg/kg DON breed LSL | <LOQ (-) | Ebrahem, 2014 |
|  |  | LC–MS/MS | BM of exposure | Cow | Group CON (ZEN/DON 0/0 mg per kg DM), group FUS-50 (ZEN/DON 0.25/2.45 mg per kg DM), group FUS-100 (ZEN/DON 0.5/4.9 mg per kg DM)) | 2.62-54.04 ng/ml (LOQ 0.31 ng/ml) | Winkler, 2014 |
| DOM1 | Urine | LC–MS/MS | BM of exposure | Pig | 0-8h/8-24h; Control group; DON3G per gavage 116 µg/kg bw; DON per gavage: 75 µg/kg bw; DON i.v: 15.5 µg/kg bw | <LOQ(3.7 ng/ml)-125 nmol | Nagl, 2014 |
|  |  | LC–MS/MS | Tox studies with data on BM | Pig | Positive control (PC); PC+ detoxifying agent1; negative control (NC, DON 4 mg/kg); NC+ 1%detoxifying agent1; NC+ 1%detoxifying agent2 | 0.18-0.54 mg/day (LOQ 0.01 mg/kg) | Frobose, 2017 |
|  |  | LC–MS/MS | BM of exposure | Pig | Control group; binders (2 commercial/4 agricultural bioproduct) admin. | 2.6-8.6 ng/ml (LOD 0.5 ng/ml) | Gambacorta, 2016 |
|  |  | LC–MS/MS | Tox studies with data on BM | Rat | 0-24h/24-48h; 3 treatments (water, DON 2.0 mg/kg bw, DON3G 3.1 mg/kg bw) | <LOQ (17 ng/ml)-15 nmol | Nagl, 2012 |
| DON3S | Excreta | LC–MS/MS | Tox studies with data on BM | Turkey Chicken | DON group (spiked 1.5–1.7 mg/kg DON); DOM group (equimolar DOM); Control group (0.2–0.3 mg/kg DON) | 27-144 µg DON equivalent (LOD 59 ng/g);  71-450 µg DON equivalent (LOD 51 ng/g) | Schwartz-Zimmermann, 2015 |
| DOM3S | Excreta | LC–MS/MS | Tox studies with data on BM | Turkey Chicken | DON group (spiked 1.5–1.7 mg/kg DON); DOM group (equimolar DOM); Control group (0.2–0.3 mg/kg DON) | LOQ- 149 µg DON equivalent (LOD 98 ng/g)  LOQ-321 µg DON equivalent (LOD 98 ng/g) | Schwartz-Zimmermann, 2015 |
| DON3G | Faeces | LC–MS/MS | BM of exposure | Pig | 0-8h/8-24h; Control group; DON3G per gavage 116 µg/kg bw; DON per gavage: 75 µg/kg bw; DON i.v: 15.5 µg/kg bw | <LOQ (8.7 ng/ml) | Nagl, 2014 |
|  |  | LC–MS/MS | Tox studies with data on BMs | Rat | 0-24h/24-48h; 3 treatments (water, DON 2.0 mg/kg bw, DON3G 3.1 mg/kg bw) | <LOQ (8.5 ng/ml) -1.9 nmol | Nagl, 2014 |
| DON3G | Urine | LC–MS/MS | BM of exposure | Pig | 0-8h/8-24h; Control group; DON3G per gavage 116 µg/kg bw; DON per gavage: 75 µg/kg bw; DON i.v: 15.5 µg/kg bw | <LOQ (8.7 ng/ml)-44 nmol | Nagl, 2014 |
|  |  | LC–MS/MS | Tox studies with data on BM | Rat | 0-24h/24-48h; 3 treatments (water, DON 2.0 mg/kg bw, DON3G 3.1 mg/kg bw) | <LOQ (2.1 ng/ml)-6.9 nmol | Nagl, 2014 |
| DONglucuronide | Urine | LC–MS/MS | Tox studies with data on BM | Rat | 0-24h/24-48h; 3 treatments (water, DON 2.0 mg/kg bw, DON3G 3.1 mg/kg bw) | 1.1-180 nmol (LOD 3.0 ng/ml) | Nagl, 2014 |
| DONglucuronide | Faeces | LC–MS/MS | Tox studies with data on BM | Rat | 0-24h/24-48h; 3 treatments (water, DON 2.0 mg/kg bw, DON3G 3.1 mg/kg bw) | <LOQ (20 ng/ml) | Nagl, 2014 |
| DON15glucuronide | Faeces | HPLC-UV | BM of exposure | Pig | 0-8h/8-24h; Control group; DON3G per gavage 116 µg/kg bw; DON per gavage: 75 µg/kg bw; DON i.v: 15.5 µg/kg bw | <LOQ (20 ng/ml) | Nagl, 2014 |
| DON15glucuronide | Urine | HPLC-UV | BM of exposure | Pig | 0-8h/8-24h; Control group; DON3G per gavage 116 µg/kg bw; DON pergavage: 75 µg/kg bw; DON i.v: 15.5 µg/kg bw | <LOQ (20 ng/ml)-280 nmol | Nagl, 2014 |
| DON3glucuronide | Faeces | HPLC-UV | BM of exposure | Pig | 0-8h/8-24h; Control group; DON3G per gavage 116 µg/kg bw; DON per gavage: 75 µg/kg bw; DON i.v: 15.5 µg/kg bw | <LOQ (20 ng/ml) | Nagl, 2014 |
| DON3glucuronide | Urine | HPLC-UV | BM of exposure | Pig | 0-8h/8-24h; Control group; DON3G per gavage 116 µg/kg bw; DON per gavage: 75 µg/kg bw; DON i.v: 15.5 µg/kg bw | <LOQ(37.3 ng/ml)-280 nmol | Nagl, 2014 |

1. Unless specified, range of values or mean±standard deviation is reported. DM = dry matter. I.v. admin. = Intravenous administration

Table K4. FBs\_List of single biomarker, substrate, and animal reported in the different substrate of the associated animal

| Mycotoxin | Substrate | Analytical Technique | Kynd of Study | Animal | Trial Description | Range of Values (a) | Reference |
| --- | --- | --- | --- | --- | --- | --- | --- |
| FB1 | Faeces | LC–MS/MS  LC–MS/MS | Tox study with data on BM  Tox study with data on BM | Turkey  Pig  Cow | Days: 0, 14, 28, 42. Control group; FUM group (15 mg/kg FB1+FB2); FUM+FUMzyme group (15 mg/kg FB1+FB2 and 15 U/kg FUMzyme)  Days: 0, 14, 28, 42. Control group; FUM group (2 mg/kg FB1+FB2); FUM+FUMzyme group (2 mg/kg FB1+FB2 and 60 U/kg FUMzyme); FUMzyme group (60U/kg FUMzyme)  Days: 1, 2  Feeding: yeast -/+ low/high starch | <LOQ (480 ng/g) -  26902 ng/g  <LOQ (480 ng/g) -  14900 ng/g  1241-6420 µg /day (LOQ -) | Masching, 2016  Pantaya, 2016 |
| FB1 | Urine | LC–MS/MS | BM of exposure | Pig | Control group; binders (2 commercial/4 agricultural byproduct) admin. | 29.7-69.6 µg/l (LOQ 0.05 µg/l) | Gambacorta, 2016 |
| HFB1 | Faeces | LC–MS/MS | Tox study with data on BM | Turkey  Pig | Days: 0, 14, 28, 42. Control group; FUM group (15 mg/kg FB1+FB2); FUM+FUMzyme group (15 mg/kg FB1+FB2 and 15 U/kg FUMzyme)  Days: 0, 14, 28, 42. Control group; FUM group (2 mg/kg FB1+FB2); FUM+FUMzyme group (2 mg/kg FB1+FB2 and 60 U/kg FUMzyme); FUMzyme group (60U/kg FUMzyme) | <LOQ (120 ng/g) -  1650 ng/g  <LOQ (120 ng/g) -  1820 ng/g | Masching, 2016 |
| pHFB1a | Faeces | LC–MS/MS | Tox study with data on BM | Turkey  Pig | Days: 0, 14, 28, 42. Control group; FUM group (15 mg/kg FB1+FB2); FUM+FUMzyme group (15 mg/kg FB1+FB2 and 15 U/kg FUMzyme)  Days: 0, 14, 28, 42. Control group; FUM group (2 mg/kg FB1+FB2); FUM+FUMzyme group (2 mg/kg FB1+FB2 and 60 U/kg FUMzyme); FUMzyme group (60U/kg FUMzyme) | <LOQ (80 ng/g) -  62.4 ng/g  <LOQ (80 ng/g) -  1170 ng/g |  |
| pHFB1a | Faeces | LC–MS/MS | Tox study with data on BM | Turkey  Pig | Days: 0, 14, 28, 42. Control group; FUM group (15 mg/kg FB1+FB2); FUM+FUMzyme group (15 mg/kg FB1+FB2 and 15 U/kg FUMzyme)  Days: 0, 14, 28, 42. Control group; FUM group (2 mg/kg FB1+FB2); FUM+FUMzyme group (2 mg/kg FB1+FB2 and 60 U/kg FUMzyme); FUMzyme group (60U/kg FUMzyme) | <LOQ (220 ng/g) -  407 ng/g  <LOQ (220 ng/g) -  983 ng/g |  |
| Sa  So  Sa/So | Serum | LC–MS/MS | Tox study with data on BM | Turkey | Days: 0, 14, 28, 42. Control group; FUM group (15 mg/kg FB1+FB2); FUM+FUMzyme group (15 mg/kg FB1+FB2 and 15 U/kg FUMzyme) | Sa: 6.61-8.03 ng/ml (LOQ 4.5 ng/ml) -  So: 34.5-42.1 ng/ml (LOQ 4.5 ng/ml) -  Sa/So: 0.16-0.24 |  |

1. Unless specified, range of values or mean±standard deviation is reported. Admin. = administration

Table K5. ZEN\_List of single biomarker, substrate, animal reported in the different substrate of the associated animal

| Mycotoxin | **Substrate** | **Analytical Technique** | **Kynd of Study** | **Animal** | **Trial Description** | **Range of Values** (a) | **Reference** |
| --- | --- | --- | --- | --- | --- | --- | --- |
| ZEN | Bile | HPLC–FLD | BM of exposure | Pig | Treatment: β-glucuronidase-/ β-glucuronidase+/ ß-glucuronidase/arylsulfatase+  Groups: G1, 4 μg/kg diet ZEN; G2, 88 μg/kg diet ZEN; G3, 235 μg/kg diet ZEN; G4 358 μg/kg diet ZEN | 52.1-311 ng/g (LOQ 1 ng/g) | Ueberschär, 2016 |
| ZEN | Cardiac Muscle | LC–MS | BM of exposure | Wild Boar | Groups: G1 (ZEN per os at 150 mg/kg bw); G2 (ZEN at 50 mg/kg bw/day in feed); G0 control | 0.851-1.542 ng/g (LOD 0.01 ng/g) | Gajecka, 2016 |
| ZEN | Faeces | LC–MS/MS  LC–MS/MS | BM of exposure  BM of exposure | Pig  Horse | Per gavage  ZEN 10 g/kg bw  ZEN14S 12.5 g/kg bw  ZEN14G 12.5 g/kg bw  ZEN16G 12.5 g/kg bw  Per gavage  Day: 2, 11 | 32-88 nmol (LOD 0.33 ng/ml)  3.63-33.81 µg/kg (LOQ 0.1 µg/kg) | Binder, 2017  Songsermsakul, 2013 |
| ZEN | Kidney | LC–MS | BM of exposure | Wild Boar | Groups: G1 (ZEN per os at 150 mg/kg bw); G2 (ZEN at 50 mg/kg bw/day in feed); G0 control | 0.627-2.57 ng/g (LOD 0.01 ng/g) | Gajecka, 2016 |
| ZEN | Liver |  |  |  |  | 1.744-5.101 ng/g (LOD 0.01 ng/g) |  |
| ZEN | Lung |  |  |  |  | 0.825-3.125 ng/g (LOD 0.01 ng/g) |  |
| ZEN | Muscle |  |  |  |  | 2.086-2.848 ng/g (LOD 0.01 ng/g) |  |
| ZEN | Ovary |  |  |  |  | 0.504-2.832 ng/g (LOD 0.01 ng/g) |  |
| ZEN | Spleen |  |  |  |  | 1.545-4.176 ng/g (LOD 0.01 ng/g) |  |
| ZEN | Uterus |  |  |  |  | 1.312-2.856 ng/g (LOD 0.01 µg/kg) |  |
| ZEN | Plasma | LC–MS  LC–MS/MS | BM of exposure | Cow  Horse | Groups: control (ZEN/DON 0/0 mg per kg DM), FUS-50 (ZEN/DON 0.25/2.45 mg per kg DM), FUS-100 (ZEN/DON 0.5/4.9 mg per kg DM)  Groups: DON/ZEN 0/0 mg/kg; DON/ZEN 4.9/0.5 mg/kg; DON/ZEN 2.45/0.25 mg/kg | 0.07-0.15 ng/ml (LOQ 0.03 ng/ml)  0.23-2.46 µg/l (LOQ 0.1 µg/l) | Winkler, 2014  Songsermsakul, 2013 |
| ZEN | Urine | HPLC  HPLC  LC–MS/MS  ELISA  LC–MS/MS  LC–MS/MS  HPLC | BM of exposure  BM of exposure  BM of exposure  BM of exposure  BM of exposure  BM of exposure  BM of exposure | Cow  Cow  Horse  Pig  Pig  Pig  Pig | Herd 1/2 (control group); day1, day14 16  33 mg/kg of ZEN in feed  1mg ZEN/day days 1-5; 2mg ZEN/day days 6-16.  Day1\_24h; day10\_24h  Male/Female  Per gavage  ZEN 10 g/kg bw  ZEN14S 12.5 g/kg bw  ZEN14G 12.5 g/kg bw  ZEN16G 12.5 g/kg bw  Control group; binders (2 commercial/4 agricultural bioproduct) admin.  Treatment: β-glucuronidase-/ β-glucuronidase+/ ß-glucuronidase/arylsulfatase+  Groups: G1, 4 μg/kg diet ZEN; G2, 88 μg/kg diet ZEN; G3, 235 μg/kg diet ZEN; G4 358 μg/kg diet ZEN | 843-22300 pg/mg creatinina (LOQ -)  0.25-19.06 µg/l (LOQ 0.01 µg/l)  27.78-84.21 µg/l (LOQ 0.1 µg/l)  187-238 µg/l (LOQ0.1 µg/l)  33-55 nmol (LOD 0.33 ng/ml)  13-34.3 ng/ml (LOQ 0.03 µg/l)  28.5-58.5 ng/g (LOD 1 ng/g) | Hasunuma, 2012  Salvat, 2015  Songsermsakul, 2013  Pleadin, 2015  Binder, 2017  Gambacorta, 2016  Ueberschär, 2016 |
| ZAN | Faeces | LC–MS/MS | BM of exposure | Horse | Day: 2, 11 | <LOD (0.5 µg/kg)-1.01 µg/kg | Songsermsakul, 2013 |
| ZAN | Plasma | LC–MS/MS | BM of exposure | Cow | Groups:control (ZEN/DON 0/0 mg per kg DM), FUS-50 (ZEN/DON 0.25/2.45 mg per kg DM), FUS-100 (ZEN/DON 0.5/4.9 mg per kg DM) | <LOD (0.07 ng/ml) all groups | Winkler, 2014 |
| ZAN | Urine | HPLC  LC–MS/MS | BM of exposure | Cow  Cow | 33 mg/kg of ZEN in feed  1mg ZEN/day: days 1-5; 2mg ZEN/day: days 6-16.  Day: 2, 11 | 0.95-5.85 mg/l (LOQ 0.01 µg/l)  1.34-3.16 µg/l (LOQ 0.1 µg/l) | Salvat, 2015  Songsermsakul, 2013 |
| ZEN14Oglucuronide | Faeces | LC–MS/MS | BM of exposure | Pig | Per gavage  ZEN 10 g/kg bw  ZEN14S 12.5 g/kg bw  ZEN14G 12.5 g/kg bw  ZEN16G 12.5 g/kg bw | <LOQ (0.19 ng/ml) | Binder, 2017 |
| ZEN14Oglucuronide | Urine | LC–MS/MS | BM of exposure | Pig | Per gavage  ZEN 10 g/kg bw  ZEN14S 12.5 g/kg bw  ZEN14G 12.5 g/kg bw  ZEN16G 12.5 g/kg bw | <18-44 nmol (LOQ 2.4 ng/ml) |  |
| ZEN14S | Faeces | LC–MS/MS | BM of exposure | Pig | Per gavage  ZEN 10 g/kg bw  ZEN14S 12.5 g/kg bw  ZEN14G 12.5 g/kg bw  ZEN16G 12.5 g/kg bw | <LOQ (0.7 ng/ml) |  |
| ZEN14S | Urine | LC–MS/MS | BM of exposure | Pig | Per gavage  ZEN 10 g/kg bw  ZEN14S 12.5 g/kg bw  ZEN14G 12.5 g/kg bw  ZEN16G 12.5 g/kg bw | <LOQ (LOQ 2.4 ng/ml) |  |
| ZEN14G | Faeces | LC–MS/MS | BM of exposure | Pig | Per gavage  ZEN 10 g/kg bw  ZEN14S 12.5 g/kg bw  ZEN14G 12.5 g/kg bw  ZEN16G 12.5 g/kg bw | <LOQ (0.7 ng/ml) |  |
| ZEN14G | Urine | LC–MS/MS | BM of exposure | Pig | Per gavage  ZEN 10 g/kg bw  ZEN14S 12.5 g/kg bw  ZEN14G 12.5 g/kg bw  ZEN16G 12.5 g/kg bw | <LOQ (LOQ 0.18 ng/ml) |  |
| αZAL | Faeces | LC–MS/MS | BM of exposure | Horse | Day: 2, 11 | 1.02-1.09 mg/l (LOD 0.5 µg/l) | Songsermsakul, 2013 |
| αZAL | Plasma | LC–MS/MS | BM of exposure | Cow | CON (ZEN/DON 0/0 mg per kg DM), FUS-50 (ZEN/DON 0.25/2.45 mg per kg DM), FUS-100 (ZEN/DON 0.5/4.9 mg per kg DM) | <LOQ (0.12 ng/ml) all groups | Winkler, 2014 |
| αZAL | Urine | HPLC  LC–MS/MS | BM of exposure | Cow  Cow | 33 mg/Kg of ZEN in feed  1 mg ZEN/day: days 1-5; 2 mg ZEN/day: days 6-16  Day:  1\_24h, 10\_24h | 0.3-6.63 mg/l (LOQ -)  2.14-6.21 µg/l (LOD 0.2 µg/l) | Salvat, 2015  Songsermsakul, 2013 |
| αZEL | Bile | HPLC–FLD | BM of exposure | Pig | Treatment: β-glucuronidase-/ β-glucuronidase+/ ß-glucuronidase/arylsulfatase+  Groups: G1, 4 μg/kg diet ZEN; G2, 88 μg/kg diet ZEN; G3, 235 μg/kg diet ZEN; G4 358 μg/kg diet ZEN | 21.1-347 ng/g (LOQ 1 ng/g) | Ueberschär, 2016 |
| αZEL | Cardiac Muscle | LC–MS | BM of exposure | Wild Boar | Groups: G1 (ZEN per os at 150 mg/kg bw); G2 (ZEN at 50 mg/kg bw/day in feed); G0 control | 2.899-10.387 ng/g (LOD -) | Gajecka, 2016 |
| αZEL | Faeces | LC–MS/MS | BM of exposure | Pig  Horse | Per gavage  ZEN 10 g/kg bw  ZEN14G 12.5 g/kg bw  ZEN16G 12.5 g/kg bw  Day: 2, 11 | 14-40 nmol (LOD 0.28 ng/ml)  31.81-38.64 µg/kg (LOQ 0.1 µg/kg) | Binder, 2017  Songsermsakul, 2013 |
| αZEL | Kidney | LC–MS | BM of exposure | Wild Boar | Groups: G1 (ZEN per os at 150 mg/kg bw); G2 (ZEN at 50 mg/kg bw/day in feed); G0 control | 3.001-7.248 ng/g (LOD -) | Gajecka, 2016 |
| αZEL | Liver | LC–MS |  |  |  | 4.226-5.371 ng/g (LOD -) |  |
| αZEL | Lung | LC–MS |  |  |  | 1.475-6.608 ng/g (LOD -) |  |
| αZEL | Muscle | LC–MS |  |  |  | 1.836-2.4248 ng/g (LOD -) |  |
| αZEL | Ovary | LC–MS |  |  |  | <LOQ-3.744 ng/g (LOQ -) |  |
| αZEL | Spleen | LC–MS |  |  |  | 4.332-7.504 ng/g (LOD -) |  |
| αZEL | Uterus | LC–MS |  |  |  | 2.771-4.218 ng/g (LOD -) |  |
| αZEL | Plasma | LC–MS  LC–MS/MS | BM of exposure | Cow  Horse | Groups: control (ZEN/DON 0/0 mg per kg DM), FUS-50 (ZEN/DON 0.25/2.45 mg per kg DM), FUS-100 (ZEN/DON 0.5/4.9 mg per kg DM)  Day1\_24h; day10\_24h | <LOQ (0.51 ng/ml) all groups  0.28-0.33 µg/l (LOQ 0.1 µg/l) | Winkler, 2014  Songsermsakul, 2013 |
| αZEL | Urine | HPLC  LC–MS/MS  LC–MS/MS  LC–MS/MS  HPLC | BM of exposure  BM of exposure  BM of exposure  BM of exposure  BM of exposure  BM of exposure | Cow  Horse  Pig  Pig  Pig | 33 mg/Kg of ZEN in feed  1mg ZEN/day: days 1-5; 2mg ZEN/day: days 6-16.  Day1\_24h; day10\_24h  Per gavage  ZEN 10 g/kg bw  ZEN14S 12.5 g/kg bw  ZEN14G 12.5 g/kg bw  ZEN16G 12.5 g/kg bw  Control group; binders (2 commercial/4 agricultural bioproduct) admin.  Treatment: β-glucuronidase-/ β-glucuronidase+/ ß-glucuronidase/arylsulfatase+  Groups: G1, 4 μg/kg diet ZEN; G2, 88 μg/kg diet ZEN; G3, 235 μg/kg diet ZEN; G4 358 μg/kg diet ZEN | 0.04-5.86 mg/l (LOQ -)  51.90-171.46 mg/l (LOD 0.1 µg/l)  <LOQ (0.1 µg/l)-19 nmol  5-14.1 nmol (LOD 0.2 ng/ml)  4 -19.3 ng/g (LOD 1 ng/g) | Salvat, 2015  Songsermsakul, 2013  Binder, 2017  Gambacorta, 2016  Ueberschär, 2016 |
| βZAL | Faeces | LC–MS/MS | BM of exposure | Horse | Day: 2, 11 | 1.03-1.04 µg/kg (LOD 0.5 µg/kg) | Songsermsakul, 2013 |
| βZAL | Plasma | LC–MS/MS | BM of exposure | Cow | Groups: control (ZEN/DON 0/0 mg per kg DM), FUS-50 (ZEN/DON 0.25/2.45 mg per kg DM), FUS-100 (ZEN/DON 0.5/4.9 mg per kg DM) | <LOQ (0.11 ng/ml) all groups | Winkler, 2014 |
| βZAL | Urine | HPLC  LC–MS/MS | BM of exposure  BM of exposure | Cow  Horse | 33 mg/Kg of ZEN in feed  1mg ZEN/day: days 1-5; 2mg ZEN/day: days 6-16.  Day: 1\_24h, 10\_24h | 0.03-4.75 mg/l (LOQ -)  <LOD-2.40 µg/l (LOD 0.2 µg/l) | Salvat, 2015  Songsermsakul, 2013 |
| βZEL | Bile | HPLC–FLD | BM of exposure | Pig | Treatment: β-glucuronidase-/ β-glucuronidase+/ ß-glucuronidase/arylsulfatase+  Groups: G1, 4 μg/kg diet ZEN; G2, 88 μg/kg diet ZEN; G3, 235 μg/kg diet ZEN; G4 358 μg/kg diet ZEN | 4 ng/g (LOD 1 µg/kg) | Ueberschär, 2016 |
| βZEL | Cardiac Muscle | LC–MS | BM of exposure | Wild Boar | Groups: G1 (ZEN per os at 150 mg/kg bw); G2 (ZEN at 50 mg/kg bw/day in feed); G0 control G0 control | <LOQ-3.539 ng/g (LOD -) | Gajecka, 2016 |
| βZEL | Faeces | LC–MS/MS  LC–MS/MS | BM of exposure  BM of exposure | Pig  Horse | Per gavage:  ZEN 10 g/kg bw  ZEN14G 12.5 g/kg bw  ZEN16G 12.5 g/kg bw  Day: 2, 11 | <LOQ (0.3 ng/ml)  17.5-21.51 µg/kg (LOQ 0.1 µg/kg) | Binder, 2017  Songsermsakul, 2013 |
| βZEL | Kidney | LC–MS | BM of exposure | Wild Boar | Groups:G1 (ZEN per os at 150 mg/kg bw); G2 (ZEN at 50 mg/kg bw/day in feed); G0 control | 0.889-4.816 ng/g (LOD -) | Gajecka, 2016 |
| βZEL | Liver |  |  |  |  | 1.337-1.989 ng/g (LOD -) |  |
| βZEL | Lung |  |  |  |  | <LOD-4.224 ng/g (LOD -) |  |
| βZEL | Muscle |  |  |  |  | 0.96-4.017 ng/g (LOD -) |  |
| βZEL | Ovary |  |  |  |  | <LOQ (LOQ -) |  |
| βZEL | Plasma | LC–MS/MS | BM of exposure  BM of exposure | Cow  Horse | Groups: control (ZEN/DON 0/0 mg per kg DM), FUS-50 (ZEN/DON 0.25/2.45 mg per kg DM), FUS-100 (ZEN/DON 0.5/4.9 mg per kg DM)  Day1\_24h; day10\_24h | <LOQ (0.57 ng/ml)  <LOQ-6.13 µg/l (LOQ 0.1 µg/l) | Winkler, 2014  Songsermsakul, 2013 |
| βZEL | Spleen | LC–MS | BM of exposure | Wild Boar | Groups: G1 (ZEN per os at 150 mg/kg bw); G2 (ZEN at 50 mg/kg bw/day in feed); G0 control | 0.709-8.133 ng/g (LOD -) | Gajecka, 2016 |
| βZEL | Uterus |  |  |  |  | <LOQ-5.291 ng/g (LOD -) |  |
| βZEL | Urine | HPLC  LC–MS/MS  LC–MS/MS  LC–MS/MS  HPLC | BM of exposure  BM of exposure  BM of exposure  BM of exposure  BM of exposure | Cow  Horse  Pig  Pig  Pig | 33 mg/Kg of ZEN in feed  1mg ZEN/day: days 1-5; 2mg ZEN/day: days 6-16.  Day1\_24h; day10\_24h  Per gavage  ZEN 10 g/kg bw  ZEN14S 12.5 g/kg bw  ZEN14G 12.5 g/kg bw  ZEN16G 12.5 g/kg bw  Control group; binders (2 commercial/4 agricultural bioproduct) admin.  Treatment: β-glucuronidase-/ β-glucuronidase+/ ß-glucuronidase/arylsulfatase+  Groups: G1, 4 μg/kg diet ZEN; G2, 88 μg/kg diet ZEN; G3, 235 μg/kg diet ZEN; G4 358 μg/kg diet ZEN | 0.94-36.3 mg/l (LOQ -)  40.62-237.30 µg/l (LOD 0.1 µg/l)  <LOQ (0.54 µg/l)  0.17-0.79 ng/ml (LOD 0.2 ng/ml)  4 ng/g (LOD 4 µg/kg) | Salvat, 2015  Songsermsakul, 2013  Binder, 2017  Gambacorta, 2016  Ueberschär, 2016 |
| αZELglucuronide | Urine | LC–MS/MS | BM of exposure | Pig | Per gavage  ZEN 10 g/kg bw  ZEN14G 12.5 g/kg bw  ZEN16G 12.5 g/kg bw | <LOD 2.4 ng/ml | Binder, 2017 |
| βZELglucuronide | Urine | LC–MS/MS | BM of exposure | Pig | Per gavage  ZEN 10 g/kg bw  ZEN14G 12.5 g/kg bw  ZEN16G 12.5 g/kg bw | <LOD 1.4 ng/ml |  |

1. Unless specified, range of values or mean±standard deviation is reported. DM = dry matter. I.v. admin. = Intravenous administration. I.p. = Intraperitoneal administration

Table K6. NIV and T2\_List of single biomarker, substrate, animal reported in the different substrate of the associated animal.

| Mycotoxin | Substrate | Analytical Technique | Kynd of Study | Animal | Trial Description | Range of Values (a) | Reference |
| --- | --- | --- | --- | --- | --- | --- | --- |
| NIV | Colon | LC–MS/MS | Tox studies with data on BM | Broiler | 1h, 3h, 6h, 12h, 24h. Admin. dose 0.8 mg/kg bw (Group A i.v. admin.; Group B oral) | 16.4-1987.5 ng/g (LOQ -) | Kongkapan. 2016 |
|  | Heart |  |  |  |  | <LOQ-40.6 ng/g (LOQ 2.0 ng/g) |  |
|  | Intestine |  |  |  |  | 15-186.5 ng/g (LOQ 2.0 ng/g) |  |
|  | Kidney |  |  |  |  | <LOQ-229.8 ng/g (LOQ 2.0 ng/g) |  |
|  | Liver |  |  |  |  | <LOQ-11.9 ng/g (LOQ 2.5 ng/g) |  |
|  | Muscle |  |  |  |  | <LOQ-50.3 ng/g (LOQ 2.5 ng/g) |  |
|  | Plasma |  |  |  |  | <LOQ(1 ng/ml)-62.56 ng/ml |  |
| T2 | Plasma | LC–MS/MS | Tox studies with data on BM | Pig | I.v admin. dose of 1 mg/kg bw | 2736 µg/l (max) (LOQ 0.3 µg/l) | Sun, 2014 |
| T2 | Urine |  |  |  | I.v admin. dose of 0.5 mg/kg bw | 30.9 ng/ml (LOQ 0.3 ng/ml) |  |
| HT2 | Plasma |  |  |  | I.v admin. dose of 1 mg/kg bw | 208.1 µg/l (max) (LOQ 2 µg/l) |  |
| HT2 | Urine |  |  |  | I.v admin. dose of 0.5 mg/kg bw | <LOQ (LOQ 2 ng/ml) ng/ml |  |
| T2triol | Plasma |  |  |  | I.v admin. dose of 1 mg/kg bw | 116.3 µg/l (max) (LOQ 0.6 µg/l) |  |
| T2triol | Urine |  |  |  | I.v admin. dose of 0.5 mg/kg bw | 306 ng/ml (LOQ 5 ng/ml) |  |

1. Unless specified, range of values or mean±standard deviation is reported. I.v. admin. = Intravenous administration

Table K7. ENNs, BEA and STC\_List of single biomarker, substrate, animal reported in the different substrate of the associated animal.

| Mycotoxin | Substrate | Analytical Technique | Kynd of Study | Animal | Trial Description (a) | Range of Values (a) | Reference |
| --- | --- | --- | --- | --- | --- | --- | --- |
| ENA | Faeces | LC–MS/MS | Tox studies with data on BM | Rats | Week: 1, 2, 3465 mg ENNA/kg food | <LOQ (6 ng/g) | Juan, 2014 |
|  | Serum |  |  |  | Week: 1, 2, 3  465 mg ENNA/kg food | 1.70-4.76 (5.4 ng/ml) |  |
|  | Urine |  |  |  | Week: 1, 2, 3  465 mg ENNA/kg food | <LOQ (6 ng/ml) |  |
| ENNB1 | Plasma | LC–MS/MS  HPLC-FLD | Tox studies with data on BM | Pig | ENN B1 (0.05 mg/kg bw) per gavage or i.v. admin. | 29.69(Cmax)-89.51(C0) µg/l (LOQ 0.2 µg/l) | Devreese, 2014 |
| ENNB | Brain | LC–MS/MS | Tox studies with data on BM | Mice | I.p. admin. 5 mg/kg (short time exposure) | 0.1 µg/kg (LOQ 0.15 µg/kg | Rodríguez-Carrasco, 2016 |
|  | Cervical cancer tumor |  |  |  | Tumor induced; i.p. admin.: 5 mg/kg/bw (long time exposure) | 2.8 µg/kg (LOQ 0.15 µg/kg) |  |
|  | Colon |  |  |  | I.p. admin. 5 mg/kg (short time exposure) | 0.9 µg/kg (LOQ 0.1 µg/kg) |  |
|  | Fat |  |  |  | I.p. admin. 5 mg/kg (short time exposure) | 2.5 µg/kg (LOQ 0.05 µg/kg) |  |
|  | Kidney |  |  |  | I.p. admin. 5 mg/kg (short time exposure) | 0.1 µg/kg (LOQ 0.05 µg/kg) |  |
|  | Liver |  |  |  | I.p. admin. 5 mg/kg (short time exposure) | 2.9 µg/kg (LOQ 0.05 µg/kg) |  |
|  | Muscle |  |  |  | I.p. admin. 5 mg/kg (short time exposure) | 0.12 µg/kg (LOQ 0.1 µg/kg) |  |
| ENNB | Plasma | HPLC-FLD | Tox studies with data on BM | Broilers | I.v. admin. dose 0.2 mg/kg bw | 50.35 ng/nl (min) (LOQ 0.025 ng/ml) | Fraeyman, 2016 |
| ENNB | Serum | LC–MS/MS | Tox studies with data on BM | Mice | Tumor induced, 5 mg/kg/bw i.p. admin.;  I.p. admin. 5 mg/kg (short/long time exposure) | 0.45-5.4 µg/kg (LOQ 0.05 µg/kg) | Rodríguez-Carrasco, 2016 |
|  | Urine |  | Tox studies with data on BM | Mice | I.p. admin. 5 mg/kg (short time exposure) | <LOQ (0.05 µg/kg) | Rodríguez-Carrasco, 2016 |
| BEA | Brain | LC–MS/MS | Tox studies with data on BM | Mice | 5 mg/kg injected | 1 µg/kg (LOQ 0.15 µg/kg) | Rodríguez-Carrasco, 2016 |
|  | Cervical cancer tumor |  |  | Mice | Tumor induced; i.p. admin.: 5 mg/kg/bw (long time exposure) | 3.4 µg/kg (LOQ 0.05 µg/kg) | Rodríguez-Carrasco, 2016 |
|  | Colon |  |  | Mice | I.p. admin. 5 mg/kg (short time exposure) | 25.4 µg/kg (LOQ 0.05 µg/kg) | Rodríguez-Carrasco, 2016 |
|  | Fat |  |  | Mice | I.p. admin. 5 mg/kg (short time exposure) | 33 µg/kg (LOQ 0.15 µg/kg) | Rodríguez-Carrasco, 2016 |
|  | Kidney |  |  | Mice | I.p. admin. 5 mg/kg (short time exposure) | 11.4 µg/kg (LOQ 0.15 µg/kg) | Rodríguez-Carrasco, 2016 |
|  | Liver |  |  | Mice | I.p. admin. 5 mg/kg (short time exposure) | 41.7 µg/kg (LOQ 0.1 µg/kg) | Rodríguez-Carrasco, 2016 |
|  | Muscle |  |  | Mice | I.p. admin. 5 mg/kg (short time exposure) | 0.5 µg/kg (LOQ 0.15 µg/kg) | Rodríguez-Carrasco, 2016 |
|  | Serum |  |  | Mice | Tumor induced, 5 mg/kg/bw i.p. admin.;  I.p. admin. 5 mg/kg (short/long time exposure) | <LOQ (0.1 µg/kg) | Rodríguez-Carrasco, 2016 |
|  | Urine |  |  | Mice | I.p. admin. 5 mg/kg (short time exposure) | <LOQ (0.05 µg/kg) | Rodríguez-Carrasco, 2016 |
| STC | Urine | LC–MS/MS | BM of exposure | Cow | Herd 1/2; mycotoxin adsorbent 1/2; control group; day 16 | 62-292 pg/mg creatinine (LOQ 0.01 mg/kg) | Fushimi, 2014 |

Table K8. Poultry\_List of single biomarker, substrate, animal reported in the different substrate and the associated animal.

| Biomarker/Type of study | **Biomarker** | **Sample description** | **Experimental** | **Substrate** | **Range of Values a)** | **Analytical method** | **Results/Conclusion** | **Reference** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| AFB1/Biomarkers of exposure | AFB1 | Broilers; 20 each group; 1 day old | Feed AFB1 40 µg/kg; 14 days | Liver | 36.61 µg/kg | ELISA (LOD 0.1 µg/kg) | LAB strains show enhancing the growth of broilers and the detoxification metabolism of AFB1 to AFM1 | Liu, 2017 |
|  |  | Kidney | 24.34 µg/kg |
|  |  | Serum | 6.64 µg/l |
|  |  | Ilea digesta | 53.77 µg/kg |
|  |  | Excreta | 40.58 µg/kg |
| AFM1 | Broilers; 20 each group; 1 day old | Feed AFB1 40 µg/kg; 14 days | Liver | 3.83 µg/kg |
|  |  | Kidney | 5.15 µg/kg |
|  |  | Serum | 1.02 µg/l |
|  |  | Ilea digesta | 10.09 µg/kg |
|  |  | Excreta | 7.42 µg/kg |
| AFB1 | Broilers; 20 each group; 1 day old | Feed AFB1 40 µg/kg + LAB 3 × 1010 cfu/kg; 14 days | Liver | 16.53 µg/kg |
|  |  | Kidney | 13.48 µg/kg |
|  |  | Serum | 4.62 µg/l |
|  |  | Ilea digesta | 36.58 µg/kg |
|  |  | Excreta | 32.07 µg/kg |
| AFM1 | Broilers; 20 each group; 1 day old | Feed AFB1 40 µg/kg + LAB 3 × 1010 cfu/kg; 14 days | Liver | 7.59 µg/kg |
|  |  | Kidney | 13.09 µg/kg |
|  |  | Serum | 2.74 µg/l |
|  |  | Ilea digesta | 12.02 µg/kg |
|  |  | Excreta | 9.95 µg/kg |
| AFB1 | Broilers; 20 each group; 1 day old | Feed AFB1 40 µg/kg 35 days | Liver | 52.34 µg/kg |
|  |  | Kidney | 41.64 µg/kg |
|  |  | Serum | 8.76 µg/l |
|  |  | Ilea digesta | 77.50 µg/kg |
|  |  | Excreta | 67.50 µg/kg |
| AFM1 | Broilers; 20 each group; 1 day old | Feed AFB1 40 µg/kg; 35 days | Liver | 16.33 µg/kg |
|  |  | Kidney | 14.13 µg/kg |
|  |  | Serum | 1.02 µg/l |
|  |  | Ilea digesta | 16.21 µg/kg |
|  |  | Excreta | 13.58 µg/kg |
| AFB1  AFM1 | Broilers; 20 each group; 1 day old | Feed AFB1 40 µg/kg + LAB 3 × 1010 cfu/kg; 35 days | Liver | 37.22 µg/kg |
|  |  | Kidney | 26.00 µg/kg |
|  |  | Serum | 3.78 µg/l |
|  |  | Ilea digesta | 56.22 µg/kg |
|  |  | Excreta | 50.79 µg/kg |
| Broilers; 20 each group; 1 day old | Feed AFB1 40 µg/kg + LAB 3 × 1010 cfu/kg; 35 days | Liver | 17.34 µg/kg |
|  |  | Kidney | 18.73 µg/kg |
|  |  | Serum | 2.47 µg/l |
|  |  | Ilea digesta | 16.98 µg/kg |
|  |  | Excreta | 16.28 µg/kg |
| AFB1/Biomarkers of exposure | AFB1 | Broilers; 40 each group | Feed control diet;  42 days | Liver | < LOD | HPLC MS/MS (LOD 0.025 µg/kg) | Humic acid (HA) showed protective effects against liver damage and some of the hematological and serum biochemical changes associated with aflatoxin toxicity. | Arafat, 2017 |
|  | Feed AFB1 100 μg/kg; 42 days | Liver | 1.00 ±0.48 µg/kg |
|  | Feed AFB1 100 μg/kg + HA 0.1%; 42 days | Liver | 0.42 ±0.15 µg/kg |
|  | Feed AFB1 100 μg/kg + HA 0.2%; 42 days | Liver | 0.22 ± 0.11 µg/kg |
|  | Feed AFB1 100 μg/kg + HA 0.3%; 42 days | Liver | 0.17 ± 0.10 µg/kg |
| AFB1/Biomarkers of exposure | AFB1 | Broilers; 60 each group; 3 days old | Feed control diet; 28 days | Liver | < LOD | HPLC-FLD  (LOQ -) | The supplementation of grape seed proanthocyanidin extract (GSPE) (250 and 500 mg/kg) to AFB1 contaminated diet reduced AFB1 residue in the liver and significantly mitigated AFB1 negative effects | Rajput, 2017 |
|  | Feed AFB1 1mg/kg; 28 days | Liver | 0.33 µg/kg |
|  | Feed GSPE 250 mg/kg; 28 days | Liver | < LOD |
|  | Feed AFB1 1mg/kg +GSPE 250 mg/kg; 28 days | Liver | 0.16 µg/kg |
|  | Feed AFB1 1mg/kg +GSPE 500 mg/kg; 28 days | Liver | 0.18 µg/kg |
| FUM/Biomarker of effect | Sa/So (ratio) | Broilers; 3 males each group; 1 day old | Feed control diet; 42 days | Liver | 0.17 ± 0.3 | HPLC FD (LOQ -) | Nanosilicate clay platelets (NSCP) were concluded as a safe and effective agent FB1 detoxification as effectively improved the growth per mance and ameliorated FB1 toxicosis including oxidative stress, Sa/So ratio, and AST activity. | Yuan, 2017 |
|  |  | Serum | 0.67 ± 0.07 |
|  | Feed FB1 50 mg/kg; 42 days | Liver | 0.63 ± 0.11 |
|  |  | Serum | 1.53 ± 0.11 |
|  | Feed NSCP 1000 mg/kg; 42 days | Liver | 0.22 ± 0.02 |
|  |  | Serum | 0.63 ± 0.06 |
|  | Feed FB1 50 mg/kg of feed + NSCP 1000 mg/kg; 42 days | Liver | 0.34 ± 0.06 |
|  |  | Serum | 1.04 ± 0.15 |
| FUM/Biomarker of effect | Sa/So (ratio) | Broilers; 6 males each group; 7 day old | Feed control diet; 14 days | Serum | 0.12 | HPLC-MS/MS LOQ 0.3 μg/g | The analysis of the sphingoid base content showed an increase of the Sa/So ratio in the serum and liver of birds fed a FB-contaminated diet compared to birds fed with uncontaminated diet. Addition of FUMzyme significantly reduced the increase of the Sa/So ratios in the serum and liver and is able to hydrolyze FB in the gastro-intestinal tract of chickens | Grenier, 2017 |
|  |  |  | Liver | 0.10 |
|  |  | Feed 8.2 FB1 + 2.8 FB2 mg/kg; 14 days | Serum | 0.16 |
|  |  |  | Liver | 0.28 |
|  |  | Feed 7.8 FB1 + 2.4 FB2 mg/kg + 78.5 FUMzyme R; 14 days | Serum | 0.20 |
|  |  |  | Liver | 0.17 |
| FB1 |  | Feed control diet; 14 days | Excreta | < LOQ |
| pHFB1a |  |  | Excreta | < LOQ |
| pHFB1b |  |  | Excreta | < LOQ |
| HFB1 |  |  | Excreta | < LOQ |
| FB1 |  | Feed 8.2 FB1 + 2.8 FB2 mg/kg 14 days | Excreta | 7.9 nmol/g |
| pHFB1a |  |  | Excreta | 0.2 nmol/g |
| pHFB1b |  |  | Excreta | 0.2 nmol/g |
| HFB1 |  |  | Excreta | < LOQ |
| FB1 |  | Feed 7.8 FB1 + 2.4 FB2 mg/kg + 78.5 FUMzyme R 14 days | Excreta | 3 nmol/g |
| pHFB1a |  |  | Excreta | 0.5 nmol/g |
| pHFB1b |  |  | Excreta | 2.4 nmol/g |
| HFB1 |  |  | Excreta | 3 nmol/g |
| OTA /Biomarkers of exposure | OTA | Chicken; 24 males each group | Control diet 20 days | Faeces | < LOD | HPLC-MS/MS (LOD 0.025 ng/g) | OTA in the diet reduced growth performance and give alteration of the serum biochemical, organ weight, and histological parameters. Mixed adsorbent reduce adverse effects. | Daofeng, 2017 |
|  | Kidney | < LOD |
|  | Liver | < LOD |
| Feed 2 mg/kg OTA | Faeces | 8.35±1.21 ng/g |
|  | Kidney | 4.42±0.82 ng/g |
|  | Liver | 1.79±0.32 μg/kg |
| Feed 2 mg/kg OTA +Na-MMT | Faeces | 9.89±1.33 ng/g |
|  | Kidney | 2.78±0.73 ng/g |
|  | Liver | 1.68±0.21 μg/kg |
| Feed 2 mg/kg OTA+Na-MMT+YCW | Faeces | 12.38±1.24 μg/kg |
|  | Kidney | 1.86±0.42 μg/kg |
|  | Liver | 1.15±0.11 μg/kg |
| OTA /Biomarkers of exposure | OTA | Lying hens; 15 each group | Control diet; 6 weeks | Bile | < LOD | HPLC FLD (LOD 0.5ng/ml LOQ 1.0 ng/ml) | Carry-over evaluation: costant ratio between OTA in bile of laying hens and OTA ingested. Bile might be useful substrate to predict the amount of ingested OTA. | Armorini, 2015 |
|  |  |  | Kidney | < LOD |
|  |  |  | Liver | < LOD |
|  |  |  | Feed 2 mg/kg OTA 6 weeks | Bile | 6.37±5.45 ng/ml |  |  |  |
|  |  |  |  | Kidney | 0.45±0.45 ng/g |  |  |  |
|  |  |  |  | Liver | < LOD |  |  |  |
|  |  |  | Feed 200 mg/kg OTA, 6 weeks | Bile | 139.47±83.45 µg/l |  |  |  |
|  |  |  |  | Kidney | 1.04±0.63 µg/kg |  |  |  |
|  |  |  |  | Liver | 0.47±0.47 µg/kg |  |  |  |
| OTA/Biomarkers of exposure | OTA | Chicken; 10 males 5 weeks old each group | Feed 1 mg/kg OTA +MDP 0.2%; 5 weeks | Blood | 1.92±0.09 ng/ml | HPLC-FLD (LOD 0.2 ng/g) | OTA content in liver and kidney is a good indicator and a suitable biomarker of exposure of broilers to OTA. Presence of mycotoxin deactivator in contaminated diets significantly decreased the OTA accumulation in organs. Fecal excretion of OTA and its metabolite OTα were significantly increased by feeding the mycotoxin deactivator (MDP). | Joo, 2013 |
|  |  |  | Faeces | 416.16±22.73 ng/g |
| OTα |  |  | Faeces | 353.28±46.0 ng/g |
| OTA |  |  | Kidney | 11.96±2.27 ng/g |
|  |  |  | Liver | 10.64±1.26 ng/g |
|  |  |  | Blood | 2.58±0.50 ng/ml |
|  |  |  | Faeces | 310.03±8.20 ng/g |
| OTα |  | Feed 1 mg/kg OTA 5 weeks | Faeces | 197.53±29.43 ng/g |
| OTA |  |  | Kidney | 30.18±4.27 ng/g |
|  |  |  | Liver | 20.28±2.74 ng/g |
|  |  | Feed 2 mg/kg OTA +MDP 0.2% 5 weeks | Blood | 4.80±0.48 ng/ml |
|  |  |  | Faeces | 629.56±22.99 ng/g |
| OTα |  |  | Faeces | 439.52±9.95 ng/g |
| OTA |  |  | Kidney | 23.09±2.04 ng/g |
|  |  |  | Liver | 26.21±1.49 ng/g |
|  |  | Feed 2 mg/kg OTA 5 weeks | Blood | 6.25±0.77 ng/ml |
|  |  |  | Faeces | 482.79±52.90 ng/g |
| OTα |  |  | Faeces | 316.92±32.42 ng/g |
| OTA |  |  | Kidney | 40.48±1.67 ng/g |
|  |  |  | Liver | 31.02±0.82 ng/g |
| DON/Toxicokinetic study with data on biomarkers | DON | Broilers and laying hens; 4 each group | Blank feed Model 1 | Plasma | Cmax 8.22±2.69 ng/mL | LC-MS/MS (LOQ 1 ng/ml, LOD 0.1 ng/ml) | Plasma concentrations of the main metabolite of DON, DOM-1, were not detected. Moreover, the concentration of DON in all samples of the positive control group (DONþAC) were below LOQ and, therefore, no toxicokinetic parameters could be calculated. | Devreese, 2012 |
|  | Blank feed Model 2 | Plasma | Cmax 14.13±2.25 ng/mL |
|  | Blank feed Model 3 | Plasma | Cmax 12.22±7.42 ng/mL |
|  | Detoxifying Agent 1 Model 1 | Plasma | Cmax 23.74±12 ng/mL |
|  | Detoxifying Agent 1 Model 2 | Plasma | Cmax 19.26±7.25 ng/mL |
|  | Detoxifying Agent 1 Model 3 | Plasma | Cmax 9.83±4.06 ng/mL |
|  | Detoxifying Agent 2 Model 1 | Plasma | Cmax 15.21±6.11 ng/mL |
|  | Detoxifying Agent 2 Model 2 | Plasma | Cmax 22.56±10.53 ng/mL |
|  | Detoxifying Agent 2 Model 3 | Plasma | Cmax 9.68±6.28 ng/mL |
| DON/Toxicokinetic study with data on biomarkers | DON, DOM1 | Laying hens bred LB; 10 each group | Feed 0.4 µg/kg DON | Plasma | < LOD | LC-MS/MS method (LOD -) | No differences in DON levels or in carry-over rates between the two tested breeds. Very low levels of DON were transferred into eggs. | Ebrahem, 2014 |
| DON, DOM1 | Laying hens bred LB; 5 each group | Feed 0.4 µg/kg DON | Bile | < LOD |
| DON, DOM1 | Laying hens bred LB; 10 each group | Feed 0.4 µg/kg DON | Egg | < LOD |
| DON, DOM1 | Laying hens bred LS 10 each group | Feed 0.4 µg/kg DON | Plasma | < LOD |
| DON, DOM1 | Laying hens bred LS 5 each group | Feed 0.4 µg/kg DON | Bile | < LOD |
| DON, DOM1 | Laying hens bred LS 10 each group | Feed 0.4 µg/kg DON | Egg | < LOD |
| DON | Laying hens bred LB; 10 each group | Feed 9.9 µg/kg DON | Plasma | median 0.366 μg/l |
| DON | Laying hens bred LB; 5 each group | Feed 9.9 µg/kg DON | Bile | median 3.40 μg/l |
| DON | Laying hens bred LB; 10 each group | Feed 9.9 µg/kg DON | Egg | median 0.189 μg/kg |
| DOM1 | Laying hens bred LB; 10 each group | Feed 9.9 µg/kg DON | Plasma | < LOD |
| DOM1 | Laying hens bred LB; 5 each group | Feed 9.9 µg/kg DON | Bile | < LOD |
| DOM1 | Laying hens bred LB; 10 each group | Feed 9.9 µg/kg DON | Egg | < LOD |
| DON | Laying hens bred LS; 10 each group | Feed 9.9 µg/kg DON | Plasma | median 0.312 μg/l |
| DON | Laying hens bred LS; 5 each group | Feed 9.9 µg/kg DON | Bile | median 2.62 μg/l |
| DON | Laying hens bred LS; 10 each group | Feed 9.9 µg/kg DON | Egg | median 0.263 μg/kg |
| DOM1 | Laying hens bred LS; 10 each group | Feed 9.9 µg/kg DON | Plasma | < LOD |
| DOM2 | Laying hens bred LS; 5 each group | Feed 9.9 µg/kg DON | Bile | < LOD |
| DOM3 | Laying hens bred LS; 10 each group | Feed 9.9 µg/kg DON | Egg | < LOD |
| DON/Toxicokinetic study with data on biomarkers | NIV | Broilers; 5 female; 3-week-old- | single dose orally via intracrop bolus; NIV 0.8 mg/kg bw | Plasma | Cmax 62.56±30.86 ng/mL | LC–MS/MS (LOQ 1 ng/ml) | NIV is poorly absorbed orally and rapidly eliminated via feces. NIV can penetrate into small intestine, kidney, heart, liver and muscle. | Kongkapanet, 2016 |
| DON/Toxicokinetic study with data on biomarkers | DON3S | Pullet; 9; 12 weeks old; | Control diet (0.2 mg/kg DON); *A. galli* infection | Excreta | 2.0±1.0 μg/g DON equivalent | LC-MS/MS  (LOQ DON3S 102 ng/g)  (LOQ DOM3S 147 ng/g)  (LOQ DON 391 ng/g)  (LOQ DOM 800 ng/g)  (LOD DON3S 59 ng/g)  (LOD DOM3S 98 ng/g)  (LOD DON 196 ng/g) (LOD DOM 300 ng/g) | Excreta and chyme samples of turkeys, chickens, pullets, and roosters confirmed DON3S as the major DON metabolite. DOM3S after oral administration of DOM both in turkeys and in chickens. Pullets and roosters metabolized DON into DOM3sulfate. | Schwartz-Zimmermann, 2015 |
| DOM3S, DON |  |  | Excreta | < LOQ |
| DON3S |  | Control diet (0.2 mg/kg DON); No *A. galli* infection | Excreta | 1.83±0.34 μg/g DON equivalent |
| DOM3S, DON |  |  | Excreta | < LOQ |
| DON3S | Turkey; 4; 11 weeks old | Control diet (0.3 mg/kg) | Excreta | 29± 7 μg DON equivalent |
| DOM3S, DON |  |  | Excreta | < LOD |
| DON3S | Chicken; 4; 5 weeks old | Control diet (0.4 mg/kg DON) | Excreta | 71±15 μg DON equivalent |
| DOM3S, DON |  |  | Excreta | < LOD |
| DON3S | Turkey; 4; 11 weeks old | Feed 1.5 mg/kg DOM1, 1 day | Excreta | 27± 13 μg DON equivalent |
| DOM3S |  |  | Excreta | 149±67 μg DON equivalent |
| DON |  |  | Excreta | 1±1.4 μg DON |
| DON3S |  |  | Excreta | 144±40 μg DON equivalent |
| DOM3S |  |  | Excreta | 0.7±0.8 μg DON equivalent |
| DON |  |  | Excreta | 5.2±1.2 μg DON |
| DON3S | Chicken; 4; 5 weeks old | Feed 1.7 mg/kg DOM1, 1 day | Excreta | 72±5 μg DON equivalent |
| DOM3S |  |  | Excreta | 321±30 μg DON equivalent |
| DON |  |  | Excreta | 1±3 μg DON |
| DON3S |  |  | Excreta | 450±112 μg DON equivalent |
| DOM3S |  |  | Excreta | < LOD |
| DON |  |  | Excreta | 17±12 μg DON |
| DON3S | Roosters; 8 adult | Feed 11 mg/kg DON, 9 days | Excreta | 29±3 μg/g |
| DOM3S |  |  | Excreta | 15±3 μg/g DON equivalent |
| DON |  |  | Excreta | < LOQ |
| DON3S | Pullet; 9; 12 weeks old | Feed 4.4 mg/kg DON 2 weeks; *A. galli* infection | Excreta | 20.3±1.8 μg/g DON equivalent |
| DOM3S |  |  | Excreta | 2.49± 1.02 μg/g DON equivalent |
| DON |  |  | Excreta | < LOQ |
| DON3S | Pullet; 9; 12 weeks old | Feed 4.4 mg/kg DON 2 weeks; No *A. galli* infection | Excreta | 22.9±0.8 μg/g DON equivalent |
| DOM3S |  |  | Excreta | 3.47±014 μg/g DON equivalent |
| DON |  |  | Excreta | < LOQ |

1. Unless specified, range of values or mean±standard deviation is reported. LAB = Lactobacillus

Table K9. Suidae\_List of single biomarker, substrate, animal reported in the different substrate and the associated animal.

| Biomarker/Type of study | Biomarker | Sample description | Experimental | substrate | Range of Values (a) | Analytical method | Results/Conclusion | Reference |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| OTA /Biomarkers of exposure | OTA | 205 pigs; 11 conventional farms; 10 animals each farm; September 2006 to March 2009 | Feeding: conventional feed OTA (0.22 µg/kg - 3.66 µg/kg) | Serum | 0.03–0.87 μg/l | HPLC-FLD (LOQ 1.0 ng/ml) | None of the feed samples contained more than the EU maximum level. The OTA contamination of organic feed and serum samples was found to be significantly higher than that of conventional feed and serum samples. | Pozzo, 2010 |
| 80 pigs; 4 organic farms; 10 animals each farm; September 2006 to March 2009 | Feeding: organic feed OTA (0.43 µg/kg to 38.4 µg/kg) |  | 0.15–6.24 μg/l |
| OTA /Biomarkers of exposure | OTA | Hunted wild boars | 39 wild boars hunted 2006 | Serum | 6.14±1.57 μg/l | HPLC-FLD (LOQ -) | Higher level of OTA in the kidneys of wild boars in both 2006 and 2007 than the levels present in the kidneys of pigs. The content of OTA in the serum and kidneys of wild boars changed with year and region. | Grajewski, 2012 |
|  |  | Kidney | 1.77±0.57 μg/kg |
| Hunted wild boars | 39 wild boars hunted 2007 | Serum | 5.91±1.12 μg/l |
|  |  | Kidney | 2.34±0.22 μg/kg |
| 20 pigs | Control group | Serum | 1.91±0.41 μg/l |
|  |  | Kidney | 0.59±0.09 μg/kg |
| OTA /Biomarkers of exposure | OTA | French pigs 26 week old | 28 pigs organic farming | Liver | 0.16 μg/kg | HPLC-MS/MS (LOQ 0.10 μg/kg) | OTA concentration in each sample “liver–muscle” pair was systematically lower in the muscle than in the liver; OTA liver concentration=2.9×OTA muscle concentration. | Hort, 2018 |
| 12 pigs label Rouge farming | Liver | 0.12 μg/kg |
| 30 pigs conventional farming | Liver | 0.14 μg/kg |
| OTA /Biomarkers of exposure | OTA | 100 pigs each Region | Slaughtered swine, Region Santa Catarina State | Serum | 60% positive samples; (4.01-75.4 mg/l) | HPLC-FLD (LOD 0.1 ng/ml) | Swine serum samples reflected the toxin content of the ingested feed | Kruger, 2010 |
|  | Slaughtered swine Region Mato Grosso State | Serum | 75% positive samples; (0.17-46.79 mg/l) |
|  | Slaughtered swine Region Bahia State | Serum | 36% positive samples; (2.72-4.13 mg/l) |
|  | Slaughtered swine Region Rio de Janeiro State | Serum | 68% positive samples; (0.16-115 mg/l) |
| AFB1lys/ Toxicokinetic study with data on biomarkers | AFB1lys | 6 pigs; Feeding AFB1 1.1 mg/kg | 7 days treatment | Serum | 4.00±1.32 ng/mg albumin | LC-MS/MS (LOQ 10.3 ng/ml) | Results indicated that AFB1lysine has potential as an AFB1 specific biomarker diagnostic purposes and evaluating the efficacy of chemoprotective interventions in pigs. | Carraro Di Gregorio, 2017 |
|  | 14 days treatment | Serum | 4.32 ± 1.27 ng/mg albumin |
|  | 21 days treatment | Serum | 7.85±4.65 ng/mg albumin |
| 6 pigs; Feeding AFB1 1.1 mg/kg+0.5 % hydrated sodium calcium aluminosilicate | 7 days treatment | Serum | 1.87±0.29 ng/mg albumin |
|  | 14 days treatment | Serum | 1.65±0.65 ng/mg albumin |
|  | 21 days treatment | Serum | 2.76±0.57 ng/mg albumin |
| AFB1lys/ Biomarkers of exposure | AFB1lys | 3 pigs; feeding 1.1 mg/kg AFB1 7 days | Pig 1 | Serum | 49.32 ±4.05 ng/ml | LC-MS/MS (LOQ 9.01/ng/ml)  EDTA plasma (LOQ 11.31ng/ml) Heparinized plasma ( LOQ 10.31ng/ml) | All animals had lower levels of AFB1-lys in EDTA plasma samples, when compared to serum or heparinized plasma. Determination of AFB1-lys in serum and heparinized plasma is an approach to assess an individual’s exposure of swine to AFB1. | Carraro Di Gregorio, 2017 |
|  | EDTA plasma | 24.98±0.78 ng/ml |
| Pig 2 | serum | 59.82±3.33 ng/ml |
|  | EDTA plasma | 27.86±1.52 |
| Pig 3 | serum | 74.24±6.49 ng/ml |
|  | EDTA plasma | 27.97±2.63 ng/ml |
| 2 pigs; feeding 1.1 mg/kg AFB1 42 days | Pig 4 | serum | 190.62±7.28 ng/ml |
|  | Heparinized plasma | 176.81±16.64 ng/ml |
|  | EDTA plasma | 37.40±3.85 ng/ml |
| Pig 5 | serum | 252.07±10.08 ng/ml |
|  | Heparinized plasma | 264.24±23.57 ng/ml |
|  | EDTA plasma | 24.78±1.47 ng/ml |
| DON/Biomarkers of exposure | DON | 10 weanling piglets; 4 week treatment | Feeding: control diet | Serum | < LOD | LC-MS/MS (LOD 0.5ng/ml) | Plasma DON was detected and found to be associated with the plasma protein fraction. The nature of the association remains unknown, but is not likely to be a covalent interaction. A modest trend was observed between plasma glucose concentration and DON ingestion. | Hopton, 2012 |
| plasma protein- DON |  | Serum | 0.8±0.3 μg/l |
| DON | Feeding: 280 μg/kg DON | Serum | 0.4±0.3 μg/l |
| plasma protein-DON |  | Serum | 1.0±0.2 μg/l |
| DON | Feeding: 560 μg/kg DON | Serum | 0.8±0.5 μg/l |
| plasma protein- DON |  | Serum | 1.8±0.9 μg/l |
| DON | Feeding: 840 μg/kg DON | Serum | 1.0±0.2 μg/l |
| plasma protein- DON |  | Serum | 2.1±0.7 μg/l |
| DON /Biomarkers of exposure | DON | 3 piglets; i.v. adm: 15 µg/kg bw DON | Time period 0-8 h | Urine | 12±24 nmol | LC-MS/MS (LOQ -) | Oral supplementation DON and DON3G. In urine, 84.8% and 40.3% of the dose were detected, respectively. Orally administered DON3G excreted in form of DON, DON15GlcA, DOM1 and DON3GlcA. Urinary DON3G accounted for only 2.6 %. In feces, trace of metabolites found. Intravenously DON3G was almost exclusively excreted in unmetabolized form via urine. DON3G is nearly completely hydrolyzed in the intestinal tract of pigs, while the toxin seems to be stable after systemic absorption. Compared to DON, the oral bioavailability of DON3G and its metabolites seems to be reduced by a factor of up to 2, approx. | Nagl, 2014 |
| DON3G |  |  | Urine | 16±11 nmol |
| DON3glucuronide |  |  | Urine | < LOD |
| DON15glucuronide |  |  | Urine | < LOD |
| DOM1 |  |  | Urine | < LOD |
| DON |  | Time period 8–24 h | Urine | 410±27 nmol |
| DON3G |  |  | Urine | < LOD |
| DON3glucuronide |  |  | Urine | < LOD |
| DON15glucuronide |  |  | Urine | < LOD |
| DOM1 |  |  | Urine | < LOD |
| DON | 3 piglets; gavage adm: 75 µg/kg bw DON | Time period 0-8 h | Urine | 880±220 nmol |
| DON3G | Urine | < LOD |
| DON3glucuronide | Urine | 280±240 nmol |
| DON15glucuronide | Urine | 280±50 nmol |
| DOM1 | Urine | < LOD |
| DON | Time period 8–24 h | Urine | 310±91 nmol |
| DON3G | Urine | < LOD |
| DON3glucuronide | Urine | 170±65 nmol |
| DON15glucuronide | Urine | 62±40 nmol |
| DOM1 | Urine | < LOD |
| DON | 3 piglets; gavage admin: 116 µg/kg bw DON | Time period 0-8 h | Urine | 140±150 nmol |
| DON3G | Urine | 44±33 nmol |
| DON3glucuronide | Urine | 27±35 nmol |
| DON15glucuronide | Urine | 44±70 nmol |
| DOM1 | Urine | 125±52 nmol |
| DON | Time period 8–24 h | Urine | 330±52 nmol |
| DON3G | Urine | 15±130 nmol |
| DON3glucuronide | Urine | 45±11 nmol |
| DON15glucuronide | Urine | 100±34 nmol |
| DOM1 | Urine | < LOD |
| All biomarker | All groups | Time period 0-8 h and 8-24 h | Faeces | < LOD |
| DON/Toxicokinetic study with data on biomarkers/ | DON | 17 days experiment with 8 pigs per treatment | Feeding analyzed diet (DON 4.0 mg/kg+DOM1 1.0 mg/kg) | Urine | 3.65 mg/day | LC-MS/MS | SMB appears promising to restore performance in pelleted DON contaminated diets. Degradation of DON-sulfonate back to the parent DON was observed as pigs fed NC + SMB excreted more DON than they consumed (164% of daily DON intake), greater (P < 0.001) than pigs fed the NC (59%) or NC + Product V (48%). The stability of DON-sulfonate shall be established. | Frobose, 2017 |
| DOM1 |  | Urine | 0.54 mg/day |
| DON | Diet+absorbent clays and preservatives; DON 4.63 mg/kg+DOM1 0.73 mg/kg | Urine | 3.29 mg/day |
| DOM1 | Urine | 0.39 mg/day |
| DON | Diet + sodium metabisulfite; DON 0.22 mg/kg+DOM1 5.67 mg/kg | Urine | 0.52 mg/day |
| DOM1 | Urine | 0.18 mg/day |
| DON/Biomarkers of exposure | DON | 10 animals | Feed (DON 0.9 mg/kg)+DON bolus 0.28 mg/kg bw | Serum | 168 ng/ml | HPLC-UV (LOQ -) | Effects of a short-term, low-dose DON exposure on gut health parameters in pigs. The low dose of DON in the diet negatively affected weight gain and induced histomorphological alterations in the duodenum and jejunum. Low-level exposure to DON, considered as acceptable in animal feeds, produced clinically-relevant changes in markers of gut health and integrity | Alizadeh, 2015 |
| DON/Biomarkers of exposure | DON | Feed (DON 0.9 mg/kg) | Serum | 0.05 ng/ml |
| DON/Toxicokinetic study with data on biomarkers | DON | 5 | Control group | Plasma | 9.22 ng/ml | LC–MS/MS (LOQ 2 ng/ml) | The distribution of DON in plasma, bile and 27 tissues after i.v. administration (250 ug/kg bw and 750 ug/kg bw) was explored. Concentrations of DON in tissues differ when pigs are exposured to various dosages and DON causes lesions in many pig tissues | Deng, 2015 |
| 5 | DON i.v. 250 μg/kg bw | Plasma | 26.8 ng/ml |
| 5 | DON i.v. 750 μg/kg bw | Plasma | <LOD |
| 5 | Control group | Bile | 9.14 ng/ml |
| 5 | DON i.v. single dose 250 μg/kg bw | Bile | 26.1 ng/ml |
| 5 | DON i.v. single dose 750 μg/kg bw | Bile | <LOQ |
| T2-HT2/ Toxicokinetic study with data on biomarkers | T2 | 6 pigs; single dose i.v. (1 mg/kg bw) | 4 h after admin | Plasma | Cmax 2736±236.3 ng/ml | LC–MS/MS (LOQ T2 1 ng/ml)  LC–MS/MS (LOQ HT2 2 ng/ml)  LC–MS/MS (LOQ T2triol 5 ng/ml) | T-2 toxin is rapidly absorbed and quickly eliminated in the plasma. Excretion study: <7% of the administered dose was excreted into the urine, 0.25% in the faeces | Sun, 2014 |
| HT2 |  | Plasma | Cmax 208.1±25.3 ng/ml |
| T2triol |  | Plasma | Cmax 116.3±14.5 |
| T2 | 6 pigs; single i.v. dose (0.5 mg/kg bw) | 4 h after admin | Urine | 30.9±2.1 ng/ml |
| HT2 |  | Urine | 614.4±177 ng/ml |
| T2triol |  | Urine | 306±70 ng/ml |
| FMs/Biomarker of exposure | FB1 | 10 piglets feeding negative control diet | 14 days treatment | Faeces | 2350±1960 ng/g | HPLC-MS/MS  (LOD, FB1 170 ng/g, pHFB1a 30 ng/g, pHFB1b 30 ng/g,  HFB1 40 ng/g) | Exposure of piglets to 2 mg/kg FB1+FB2 caused significantly elevated serum Sa/So ratios compared to the control group. Supplementation with FUMzyme (60 U/kg) resulted in gastrointestinal degradation of FB1 and unaffected Sa/So ratios. Thus, the carboxylesterase FumD represents an effective strategy to detoxify FB1 in the digestive tract of pigs. | Masching, 2016 |
| pHFB1a |  | Faeces | 314±174 ng/g |
| pHFB1b |  | Faeces | 366±221 ng/g |
| HFB1 |  | Faeces | 355±190 ng/g |
| FB1 | 28 days treatment | Faeces | < LOD |
| pHFB1a |  | Faeces | < LOD |
| pHFB1b |  | Faeces | < LOD |
| HFB1 |  | Faeces | < LOD |
| FB1 | 42 days treatment | Faeces | 3170±235 ng/g |
| pHFB1a |  | Faeces | < LOQ |
| pHFB1b |  | Faeces | 256±43.2 ng/g |
| HFB1 |  | Faeces | < LOD |
| FB1 | 10 piglets feeding 2 mg/kg FB1+FB2 | 14 days treatment | Faeces | 6870±815 ng/g |
| pHFB1a |  | Faeces | 275±153 ng/g |
| pHFB1b |  | Faeces | 244±177 ng/g |
| HFB1 |  | Faeces | 305±225 ng/g |
| FB1 | 28 days treatment | Faeces | 11900±1300 ng/g |
| pHFB1a |  | Faeces | < LOD |
| pHFB1b |  | Faeces | 106±26.5 ng/g |
| HFB1 |  | Faeces | < LOQ |
| FB1 | 42 days treatment | Faeces | 14900±860 ng/g |
| pHFB1a |  | Faeces | 251±95.9 ng/g |
| pHFB1b |  | Faeces | 326±40.5 ng/g |
| HFB1 |  | Faeces | 349±298 ng/g |
| FB1 | 10 piglets feeding 2 mg/kg FB1+FB2 + 60 U/kg FUMzyme | 14 days treatment | Faeces | 1980±394 ng/g |
| pHFB1a |  | Faeces | 844±223 ng/g |
| pHFB1b |  | Faeces | 929±246 ng/g |
| HFB1 |  | Faeces | 1520±269 ng/g |
| FB1 | 28 days treatment | Faeces | 2020±442 ng/g |
| pHFB1a |  | Faeces | 689±201 ng/g |
| pHFB1b |  | Faeces | 703±213 ng/g |
| HFB1 |  | Faeces | 1510±212 ng/g |
| FB1 | 42 days treatment | Faeces | 5650±1390 ng/g |
| pHFB1a |  | Faeces | 1170±113 ng/g |
| pHFB1b |  | Faeces | 983±104 ng/g |
| HFB1 |  | Faeces | 1820±293 ng/g |
| FB1 | 10 piglets feeding 60 U/kg FUMzyme | 14 days treatment | Faeces | 1580±609 ng/g |
| pHFB1a |  | Faeces | < LOD |
| pHFB1b |  | Faeces | 142±41.8 ng/g |
| HFB1 |  | Faeces | 231±72.1 ng/g |
| FB1 | 28 days treatment | Faeces | < LOD |
| pHFB1a |  | Faeces | < LOD |
| pHFB1b |  | Faeces | 122±30.9 ng/g |
| HFB1 |  | Faeces | < LOD |
| FB1 | 42 days treatment | Faeces | 549±322 ng/g |
| pHFB1a |  | Faeces | < LOD |
| pHFB1b |  | Faeces | 175±26.6 ng/g |
| HFB1 |  | Faeces | 321±153 ng/g |
| ENNB/ Toxicokinetic study with data on biomarkers | ENNB1 | 3 pigs | Per os 0.05 mg toxin/kg bw | Plasma | Cmax 29.69±5.904 ng/mL | LC–MS/MS (LOQ 0.2 ng/ml) | ENNB1 is rapidly absorbed after oral administration and rapidly distributed and eliminated. The absolute oral bioavailability is high (90.9%) indicating a clear systemic exposure. After intravenous administration, the mycotoxin is distributed and eliminated rapidly, in accordance with oral administration. | Devreese, 2014 |
| ZEN/ Biomarkers of exposure | αZEL | 4 castratedmalesweaning piglets 33-35 days | ZEN 10 ug/kg b.w. per gavage | Faeces | 14±6 nmol | LC-MS/MS (LOQ -) (LOQ -) | The biological recovery of ZEN in urine was 26%, the total biological recovery in excreta was 40%. Intact ZEN14sulfate, ZEN14ObGlucoside and ZEN16ObGlucoside were neither detected in urine nor in feces. After ZEN14sulfate application, 19% of the administered dose was recovered in urine. No ZEN metabolites were detected in feces. The total biological recoveries of ZEN14ObGlucoside and ZEN16ObGlucoside in the form of their metabolites in urine were 19% and 13%, respectively. The total biological recoveries in urine and feces amounted to 48% and 34%. An explanation for the low biological recoveries could be extensive metabolization by intestinal bacteria to yet unknown metabolites. In summary, ZEN14sulfate, ZEN14ObGlucoside, and ZEN16ObGlucoside were completely hydrolyzed in the gastrointestinal tract of swine, thus contributing to the overall toxicity of ZEN. | Binder, 2017 |
| ZEN |  | 31±9 nmol |
| ZEN14Oglucuronide | Faeces | < LOD |
| ZEN16G | Faeces | < LOD |
| ZEN14S | Faeces | < LOD |
| ZEN total | Faeces | 45±14 nmol |
| αZEL | Urine | < LOD |
| βZEL | Urine | < LOD |
| ZEN | Urine | 33±12 nmol |
| ZEN16G | Urine | < LOD |
| αZELglucuronide | Urine | < LOD |
| ZEN14S | Urine | < LOD |
| ZEN14Oglucuronide | Urine | 53±44 nmol |
| βZELglucuronide | Urine | < LOD |
| ZEN total | Urine | 78±31 nmol |
| αZEL | ZEN14G 12.5 g/kg b.w. Per gavage period of excreta collection 0-48h | Faeces | 40±19 nmol |
| βZEL | Faeces | < LOD |
| ZEN | Faeces | 88±21 nmol |
| ZEN14Oglucuronide | Faeces | < LOD |
| ZEN16G | Faeces | < LOD |
| ZEN14S | Faeces | < LOD |
| ZEN total | Faeces | 127±42 nmol |
| αZEL | Urine | 17±9 nmol |
| βZEL | Urine | < LOD |
| ZEN | Urine | 52±15 nmol |
| ZEN16G | Urine | < LOD |
| ZEN14S | Urine | < LOD |
| αZELglucuronide | Urine | < LOD |
| βZELglucuronide | Urine | < LOD |
| ZEN14Oglucuronide | Urine | 57±45 nmol |
| ZEN total | Urine | 85±46 nmol |
| βZEL | ZEN14S 12.5 ug/kg b.w. Per gavage; collection 0-48h | Faeces | < LOD |
| ZEN | Faeces | 55±19 nmol |
| ZEN16G | Faeces | < LOD |
| ZEN14S | Faeces | < LOD |
| αZEL | Urine | 8 nmol |
| ZEN14Oglucuronide | Urine | 44 nmol |
| ZEN total | Urine | 68±19 nmol |
| βZEL | Urine | < LOD |
| ZEN | Urine | 45±19 nmol |
| ZEN16G | Urine | < LOD |
| ZEN14S | Urine | < LOD |
| αZELglucuronide | Urine | < LOD |
| βZELglucuronide | Urine | < LOD |
| ZEN16G | ZEN16S 12.5 ug/kg b.w. Per gavage; collection 0-48h | Faeces | 22±7 nmol |
| ZEN16G | Faeces | < LOD |
| ZEN16G | Faeces | 62±21 nmol |
| ZEN16G | Faeces | < LOD |
| ZEN16G | Faeces | < LOD |
| ZEN16G | Faeces | < LOD |
| ZEN16G | Faeces | 84±23 nmol |
| αZEL | Urine | 19±3 nmol |
| βZEL | Urine | < LOD |
| ZEN | Urine | 36±19 nmol |
| ZEN16G | Urine | < LOD |
| ZEN14S | Urine | < LOD |
| αZELglucuronide | Urine | < LOD |
| βZELglucuronide | Urine | < LOD |
| ZEN14Oglucuronide | Urine | 18±3 nmol |
| ZEN total | Urine | 51±28 nmol |
| ZEN/Biomarkers of exposure | βZEL | 3 sows; Feeding 4 ng ZEN/g feed | Addition β-glucuronidase | Urine | 4 ng/g | HPLC-FLD (LOD ng/g, βZEL 4, αZEL 1, ZEN 1) | ZEN and its metabolite αZEL nearly exclusively conjugated to glucuronic or sulfuric acid in bile and urine. The percentage of the free. ZEN and αZEL (1 - 6 %). Proportion of glucuronidated conjugates of ZEN in bile and urine >95 %. No sulfated conjugates. Relation of glucuronidated to sulfated conjugates of αZEL 82 to 17 % in bile. in urine sulfated (62 %) form of αZEL was predominant to glucuronidated (33 %) form. | Ueberschär, 2016 |
| βZEL | Collection 0-48h | Urine | < LOD |
| αZEL |  | Urine | 4 ng/g |
| ZEN |  | Urine | 58.5 ng/g |
| ZEN+βZEL+αZEL |  | Urine | 66.5 ng/g |
| βZEL | Addition of β-glucuronidase/arylsulfatase | Urine | 4 ng/g |
| αZEL |  | Urine | 10.2 ng/g |
| ZEN |  | Urine | 52.2 ng/g |
| ZEN+βZEL+αZEL |  | Urine | 70.4 ng/g |
| βZEL | Addition of β-glucuronidase | Bile | 4 ng/g |
| αZEL |  | Bile | 26.9 ng/g |
| ZEN |  | Bile | 73.9 ng/g |
| ZEN+βZEL+αZEL |  | Bile | 105 ng/g |
| βZEL | Addition of β-glucuronidase /arylsulfatase | Bile | 4 ng/g |
| αZEL |  | Bile | 24.1 ng/g |
| ZEN |  | Bile | 52.2 ng/g |
| ZEN+βZEL+αZEL |  | Bile | 80.2 ng/g |
| βZEL | 3 sows; Feeding 88 ng ZEN/g feed | Addition of β-glucuronidase | Urine | 4 ng/g |
| αZEL |  | Urine | 4.7 ng/g |
| ZEN |  | Urine | 30 ng/g |
| ZEN+βZEL+αZEL |  | Urine | 66.5 ng/g |
| βZEL | Addition of β-glucuronidase /arylsulfatase | Urine | 4 ng/g |
| αZEL |  | Urine | 13.3 ng/g |
| ZEN |  | Urine | 38.7 ng/g |
| ZEN+βZEL+αZEL |  | Urine | 56 ng/g |
| βZEL | Addition of β-glucuronidase | Bile | 4 ng/g |
| αZEL |  | Bile | 65.2 ng/g |
| ZEN |  | Bile | 104 ng/g |
| ZEN+βZEL+αZEL |  | Bile | 173 ng/g |
| βZEL | Addition of β-glucuronidase /arylsulfatase | Bile | 4 ng/g (2.6% of βZEL+αZEL+ZEN) |
| αZEL |  | Bile | 75.3 ng/g |
| ZEN |  | Bile | 99.9 ng/g |
| ZEN+βZEL+αZEL |  | Bile | 179 ng/g |
| βZEL | 3 sows; Feeding 235 ng ZEN/g feed | Addition of β-glucuronidase | Urine | 4 ng/g |
| αZEL |  | Urine | 8.2 ng/g (19.3% of βZEL+αZEL+ZEN) |
| ZEN |  | Urine | 31 ng/g |
| ZEN+βZEL+αZEL |  | Urine | 43.5 ng/g |
| βZEL | Addition of β-glucuronidase /arylsulfatase | Urine | 4 ng/g |
| αZEL |  | Urine | 19.3 ng/g |
| ZEN |  | Urine | 28.5 ng/g |
| ZEN+βZEL+αZEL |  | Urine | 51.8 ng/g |
| βZEL | Addition of β-glucuronidase | Bile | 4 ng/g |
| αZEL |  | Bile | 121 ng/g |
| ZEN |  | Bile | 141 ng/g |
| ZEN+βZEL+αZEL |  | Bile | 266 ng/g |
| βZEL | Addition of β-glucuronidase /arylsulfatase | Bile | 4 ng/g |
| αZEL |  | Bile | 153 ng/g |
| ZEN |  | Bile | 149 ng/g |
| ZEN+βZEL+αZEL |  | Bile | 306 ng/g |
| βZEL | 3 sows; Feeding 358 ng ZEN/g feed | Addition of β-glucuronidase | Urine | 4 ng/g |
| αZEL |  | Urine | 16.8 ng/g |
| ZEN |  | Urine | 53.3 ng/g |
| ZEN+βZEL+αZEL |  | Urine | 74.1 ng/g |
| βZEL | Addition of β-glucuronidase /arylsulfatase | Urine | 4 ng/g |
| αZEL |  | Urine | 48 ng/g |
| ZEN |  | Urine | 51.4 ng/g |
| ZEN+βZEL+αZEL |  | Urine | 103 ng/g |
| βZEL | Addition of β-glucuronidase | Bile | 4 ng/g |
| αZEL |  | Bile | 291 ng/g |
| ZEN |  | Bile | 311 ng/g |
| ZEN+βZEL+αZEL |  | Bile | 606 ng/g |
| βZEL | β-glucuronidase /arylsulfatase | Bile | 4 ng/g |
| αZEL |  | Bile | 347 ng/g |
| ZEN |  | Bile | 308 ng/g |
| ZEN+βZEL+αZEL |  | Bile | 659 ng/g |

1. Unless specified, range of values or mean±standard deviation is reported. I.v. admin. = intravenous administration

Table K10. Bovidae\_List of single biomarker, substrate, animal reported in the different substrate and the associated animal.

| **Biomarker/Type of study** | **Biomarker** | **Sample description** | **Experimental (a)** | **substrate** | **Mean ± SD (a)** | **Analytical method** | **Results/Conclusion** | **Reference** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **AFB1/Biomarkers of exposure** | AFM1 | Ten multiparous rumen-cannulated Holstein cows | Feeding: 100 μg of AFB1/kg DMI of spiked corn | Urine | 6.5 µg/kg | HPLC-FLD (LOQ -) | Concentrations of AFM1 in milk, AFB1 in faeces and AFB1 in rumen fluid were reduced in cows fed clay compared with positive control with no clay | Sulzberger, 2017 |
| Milk | 0.80 µg/kg |
| AFB1 | Urine | 2.78 µg/kg |
| Rumen fluid | 0.1 µg/kg |
| **AFB1/ Biomarkers of exposure** | AFM1 | 102 samples of fresh cow milk | \_ | Milk | 0.020-0.142 µg/kg | HPLC-FLD  (LOQ 0.037 µg/l) |  | Shuib, 2017 |
| **AFB1/Biomarkers of exposure** | AFM1 | 8 non lactating dairy cows  (feed 0.05, 0.2, 0.24, and 0.56 mg of AFB1, OTA, DON, and FB1 per kg of feed, admin 400 g ruminal cannula) | High-starch diet+feed | Urine | day1: 25.6 µg/d  day2: 7.7 µg/d | LC-MS/MS  (LOQ -) | The effects of low ruminal pH on the bioavailability of 4 major mycotoxins AFB1, OTA, DON, FB1. | Pantaya, 2016 |
|  | Low-starch diet + feed+ yeast | Urine | day1: 8.24 µg/d  day2: 6.28 µg/d |
|  | High-starch diet+ feed | Urine | day1: 18.35 µg/d  day2: 16.85 µg/d |
|  | Low-starch diet + feed+ yeast | Urine | day1: 26.21 µg/d  day2: 19.36 µg/d |
| **OTA/Biomarkers of exposure** | OTA | High-starch diet+ feed | Urine | day1: 0.31 µg/d  day2: 0.0 µg/d |
|  | High-starch diet + feed + yeast | Urine | day1: 0.19 µg/d  day2: 0.18 µg/d |
|  | High-starch diet+ feed | Urine | day1: 1.3 µg/d  day2: 0.66 µg/d |
|  | High-starch diet + feed + yeast | Urine | day1: 1.09 µg/d  day2: 0.56 µg/d |
| OTα | High-starch diet + feed | Urine | day1:1170 µg/d  day2: 825 µg/d |
|  | Low-starch diet + feed+ yeast | Urine | day1: 1341 µg/d  day2: 886 µg/d |
|  | High-starch diet + feed | Urine | day1: 1066 µg/d  day2: 892 µg/d |
|  | Low-starch diet + feed+ yeast | Urine | day1: 1400 µg/d  day2: 928 µg/d |
| **AFB1/Biomarkers of exposure**  **AFB1/Biomarkers of exposure** | AFB1 | High-starch diet + feed | Faeces | day1: 12.18 µg/d  day2: 23.35 µg/d |
|  | Low-starch diet + feed+ yeast | Faeces | day1: 10.65 µg/d  day2: 23.41 µg/d |
|  | High-starch diet + feed | Faeces | day1: 6.70 µg/d  day2: 17.98 µg/d |
|  | Low-starch diet + feed+ yeast | Faeces | day1: 9.76 µg/d  day2: 18.08 µg/d |
| AFM1 | High-starch diet + feed | Faeces | day1: 39.44 µg/d  day2: 47.38 µg/d |
|  | Low-starch diet + feed+ yeast | Faeces | day1: 32.89 µg/d  day2: 36.96 µg/d |
|  | High-starch diet + feed | Faeces | day1: 44.10 µg/d  day2: 49.59 µg/d |
|  | Low-starch diet + feed+ yeast | Faeces | day1: 54.83 µg/d  day2: 49.60 µg/d |
| **OTA/Biomarkers of exposure** | OTA | High-starch diet + feed | Faeces | day1: 11.00 µg/d  day2: 5.76 µg/d |
|  | Low-starch diet + feed+ yeast | Faeces | day1: 10.98 µg/d  day2: 9.78 µg/d |
|  | High-starch diet + feed | Faeces | day1: 3.05 µg/d  day2: 5.41 µg/d |
|  | Low-starch diet + feed+ yeast | Faeces | day1: 4.31 µg/d  day2: 6.33 µg/d |
| **DON/Biomarkers of exposure** | DON | High-starch diet + feed | Faeces | day1: 471 µg/d  day2: 109 µg/d |
|  | Low-starch diet + feed+ yeast | Faeces | day1: 451 µg/d  day2: 97 µg/d |
|  | High-starch diet + feed | Faeces | day1: 530 µg/d  day2: 247 µg/d |
|  | Low-starch diet + feed+ yeast | Faeces | day1: 531 µg/d  day2: 425 µg/d |
| DOM1 | High-starch diet + feed | Faeces | day1: 305 µg/d  day2: 181 µg/d |
|  | Low-starch diet + feed+ yeast | Faeces | day1: 289 µg/d  day2: 86 µg/d |
|  | High-starch diet + feed | Faeces | day1: 385 µg/d  day2: 347 µg/d |
|  | Low-starch diet + feed+ yeast | Faeces | day1: 436 µg/d  day2: 380 µg/d |
| **FB/Biomarkers of exposure** | FB1 | High-starch diet + feed | Faeces | day1: 6050 µg/d  day2: 1241 µg/d |
|  |  | Low-starch diet + feed+ yeast | Faeces | day1: 6420 µg/d  day2: 1542 µg/d |
|  |  | High-starch diet + feed | Faeces | day1: 4894 µg/d  day2: 2617 µg/d |
|  |  | Low-starch diet + feed+ yeast | Faeces | day1: 4145 µg/d  day2: 3323 µg/d |
| **OTA/Biomarkers of exposure** | OTA | 9 cows divided into three groups | Diet with 5 µg OTA /Kg of DM | Blood plasma | <0.1 µg/kg | HPLC  (LOQ 0.1 µg/kg) | OTA appears not to be carried over into milk and tissues of cows when dietary concentrations of OTA are within the range of 5–100 μg/kg. | Hashimoto, 2016 |
|  | Diet with 50 µg OTA /Kg of DM | Blood plasma | <0.1 µg/kg |
|  | Diet with 100 µg OTA /Kg of DM | Blood plasma | <0.1 µg/kg |
| **AF/Biomarkers of exposure** | AFM1 | 150 Buffalo cows (different areas, feed, fodder supplement and grazing conditions) | 50 cows in urban area | Milk | 0.012±0.005 µg/L | HPLC  (LOD 0.005 µg/l) | AFM1 in 16% buffalo, 44% cow, 10% goat, and 12% sheep milk samples was above the maximum tolerance limit accepted by the European Union. | Nile, 2015 |
|  | 50 cows in semi-urban area | Milk | 0.042±0.078 µg/L |
|  | 50 cows in rural area | Milk | 0.025±0.065 µg/L |
|  | 150 cows (different areas, feed, fodder supplement and grazing conditions) | 50 cows in urban area | Milk | 0.008±0.012 µg/L |
|  | 50 cows in semi-urban area | Milk | 0.030±0.018 µg/L |
|  | 50 cows in rural area | Milk | 0.018±0.010 µg/L |
|  | 150 goats (different areas, feed, fodder supplement and grazing conditions) | 50 goats in urban area | Milk | 0.016±0.046 µg/L |
|  | 50 goats in semi-urban area | Milk | 0.022±0.032 µg/L |
|  | 50 goats in rural area | Milk | 0.005±0.002 µg/l |
|  | 150 sheep (different areas, feed, fodder supplement and grazing conditions) | 50 sheep in urban area | Milk | 0.042±0.073 µg/l |
| 50 sheep in semi-urban area | Milk | 0.018±0.025 µg/l |
| 50 sheep in rural area | Milk | 0.014±0.065 µg/l |
| AFM1 | 200 milk sample from different species | Buffalos | Milk | 42.1±3.4 ng/l | ELISA (LOQ -) |
|  | Cows | Milk | 30.2±1.8 ng/l |
|  | Goats | Milk | 38.6±2.1 ng/l |
|  | Sheep | Milk | 25.7 ± 1.6 ng/l |
| **AF/Biomarkers of exposure** | AFM1 | 120 milk samples collected from individual cows | Rural dairy farm | Milk | 0.011 ± 0.010 µg/l | ELISA  (LOQ 8.42 ng/kg) | All milk samples from the rural dairy system had AFM1 contamination levels below the EU limits of 0.05 μg/l ranging between 0 and 0.041 μg/l | Makau, 2016 |
|  | Peri-urban dairy farm | Milk | 0.062 ± 0.019 µg/l |
| **AF/Biomarkers of exposure** | AF Total | Cows and sheep treated with 0.5 mg AFB1/kg | 3/10 samples | Ruminal fluid | 2.1-2.2 µg/kg | ELISA  (LOD 0.5 µg/kg) | The analysis by ELISA and CSS for ZEN and AFB1 of 10 samples of bile collected from bovids, the results were negative for all analyses, none of these mycotoxins being detected using the specified methods. | Simion, 2010 |
| AFB1 | 3/10 samples | Ruminal fluid | 0.98-0.99 µg/kg |
| OTA | 4/10 samples | Ruminal fluid | 23.91 µg/kg (non diluted)  25.06 (diluted) µg/kg |
|  | AFM1 | 4/48 samples | Ruminal fluid | 42 µg/kg |
| **ZEN/Biomarkers of exposure** | ZEN | 30 cows | 10 cows control: 0.02 mg ZEN +0.07DON/kg DM | Plasma | 0.05-0.11 ng/ml | HPLC  (LOQ 0.03 ng/ml) | Linear relationship between toxin concentration in blood and toxin intake was established. Thus, DON and ZEN close to the current guidance values did not exert negative effects on performance parameters and milk compositions. | Winkler, 2014 |
|  | 10 cows FUS-50: 0.33 mg ZEN +2.62 mg DON/kg DM | Plasma | 0.07-0.15 ng/ml |
|  | 10 cows FUS-100: 0.66mg ZEN +5.24 mg DON/kg DM | Plasma | 0.09-0.18 ng/ml |
| **DON/Biomarkers of exposure** | DON | 30 cows | 10 cows control: 0.02mg ZEN +0.07DON/kg DM | Plasma | 0.27-0.88 ng/ml | HPLC  (LOD 0.19 ng/ml  LOQ 0.65 ng/ml) |
|  | 10 cows FUS-50: 0.33mg ZEN +2.62 mg DON/kg DM | Plasma | 0.41-1.69 ng/ml |
|  | 10 cows FUS-100: 0.66mg ZEN +5.24 mg DON/kg DM | Plasma | 0.83-5.06 ng/ml |
| **DON/Biomarkers of exposure** | DOM1 | 30 cows | 10 cows control: 0.02mg ZEN +0.07DON/kg DM | Plasma | 1.2-5.9 ng/ml | HPLC  (LOD 0.09 ng/mL  LOQ 0.31 ng/ml) |
|  |  | 10 cows FUS-50: 0.33mg ZEN +2.62 mg DON/kg DM | Plasma | 3.7-22.4 ng/ml |
|  |  | 10 cows FUS-100: 0.66mg ZEN +5.24 mg DON/kg DM | Plasma | 4.6-61.7 ng/ml |
| **AFB1/Biomarkers of exposure** | AFM1 | 6 cows in mid- lactation | AFB1 intake  86.4±1.1 µg/Kg | Milk | 0.13±0.007 µg/kg | LC-MS/MS  (LOQ 1 µg/kg) | To ensure compliance with the regulatory MRL (0.05 μg/kg AFM1) applied in Israel, the daily AFB1 exposure of the Israeli cow has to be below 1.4 μg/kg DM feed. | Britzi, 2013 |
|  | AFB1 intake  87.2±1.3 µg/Kg | Milk | 0.07±0.012 µg/kg |
|  | AFB1 intake  87.4±1.2 µg/Kg | Milk | 0.12±0.019 µg/kg |
|  | AFB1 intake  86.2±1.5µg/Kg | Milk | 0.21±0.046 µg/kg |
|  | AFB1 intake  86.5±1.1 µg/Kg | Milk | 0.06±0.015 µg/kg |
|  | AFB1 intake  85.9±1.8 µg/Kg | Milk | 0.08±0.036 µg/kg |
| 6 cows in late - lactation | AFB1 intake  87.4±2.1 µg/Kg | Milk | 0.09±0.016 µg/kg |
|  | AFB1 intake  86.5±2.4 µg/Kg | Milk | 0.09±0.018 µg/kg |
|  | AFB1 intake  87.5±2.3 µg/Kg | Milk | 0.06±0.018 µg/kg |
|  | AFB1 intake  85.3±2.3µg/Kg | Milk | 0.21±0.046 µg/kg |
|  | AFB1 intake  86.7±3.3 µg/Kg | Milk | 0.07±0.036 µg/kg |
|  | AFB1 intake  86.7±1.6 µg/Kg | Milk | 0.03±0.016 µg/kg |
| **ZEN/Biomarkers of exposure** | ZEN | 6 cows fed with new rice straw | day1: 33.7 ng/g | Urine | 15951±4178 pg/mg creat | ELISA  (LOQ -) | The field trials indicate that the rice straw fed to the cows was naturally contaminated with ZEN, and that the monitoring of urinary ZEN concentrations could prove to be a useful tool for detecting the exposure of cattle to ZEN contamination at the farm level. | Hasunuma, 2012 |
|  | day14: 46 ng/g | Urine | 843±67 pg/mg  creat |
| 4 cows control group fed with old rice straw | day1: >4.536 ng/g | Urine | 20555±2808 pg/mg creat |
|  | day 4: >4.536 ng/g | Urine | 22300±2949 pg/mg creat |

1. Unless specified, range of values or mean±standard deviation is reported.

| Biomarker/Type of study | Biomarker | Sample description | Experimental | Substrate |  | Analytical method | Results/Conclusion | Reference |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| AFB1/Toxicological studies with data on biomarkers | AFB1 | Male ICR mice 15; 6 weeks' old | Feeding 300 μg AFB1/kg bw; first day 1h | Faeces | 1.016±0.053 μg/g | HPLC-UV (LOQ -) | L. plantarum lactobacillus with good AFB1-binding ability in vitro increased faecal AFB1 excretion, reduce lipid peroxidation, and reverse deficits in antioxidant defence systems to alleviate AFB1 toxicity. | Huang, 2017 |
|  |  | Feeding 300 μg AFB1/kg bw; first day 3h | Faeces | 1.369±0.041 μg/g |
|  |  | Feeding 300 μg AFB1/kg bw; first day 7h | Faeces | 0.341±0.038 μg/g |
| AFB1N7guanine |  | Feeding 300 μg AFB1/kg bw; first day urine 7h | Urine | 0.0953±0.004 ng/ml |
| AFB1 |  | Feeding 300 μg AFB1/kg bw+4.0×1010 CFU/kg bw Viable C88 L. plantarum strain; first day 1h | Faeces | 2.723±0.051 μg/g |
|  |  | Feeding 300 μg AFB1/kg bw+4.0×1010 CFU/kg bw Viable C88 L. plantarum strain; first day 3h | Faeces | 1.218±0.053 μg/g |
|  |  | Feeding 300 μg AFB1/kg bw+4.0×1010 CFU/kg bw Viable C88 L. plantarum strain; first day 7h | Faeces | 1.101±0.039 μg/g |
| AFB1N7guanine |  | Feeding 300 μg AFB1/kg bw+4.0×1010 CFU/kg bw Viable C88 L. plantarum strain; first day urine 7h | Urine | 0.0583±0.005 ng/ml |
| AFB1 |  | Feeding 300 μg AFB1/kg bw+4.0×1010 CFU/kg bw heat-killed C88 L. plantarum strain; first day 1h | Faeces | 3.199±0.056 μg/g |
|  |  | Feeding 300 μg AFB1/kg bw+4.0×1010 CFU/kg bw heat-killed C88 L. plantarum strain; first day 3h | Faeces | 1.385±0.049 μg/g |
|  |  | Feeding 300 μg AFB1/kg bw+4.0×1010 CFU/kg bw heat-killed C88 L. plantarum strain; first day 7h | Faeces | 1.111±0.045 μg/g |
| AFB1N7guanine |  | Feeding 300 μg AFB1/kg bw+4.0×1010 CFU/kg bw heat-killed C88 L. plantarum strain; first day urine 7h | Urine | 0.0678±0.008 ng/ml |
| AFB1/Toxicological studies with data on biomarkers | AFB1 | Mice 8 | I.p. admin. AFB1 (20 mg/kg) | Plasma | 23.45±13.84 ng/ml | HPLC-FLD  Plasma LOQ 0.5 ng/ml  Brain LOQ 1ng/g | Both prazosin and zosuquidar significantly reduced the brain concentration of AFB1 but not the plasma concentration of this molecule. AFB1 may be a substrate of both BCRP and P-gp. Inducers of transmembrane proteins, such as prazosin, can be life-saving during acute poisoning with AFB1, based on the overall health status and brain concentrations of AFB1 in mice. | Tras, 2017 |
|  |  |  |  | Brain | 181.23±89.4 ng/g |
|  |  |  | I.p. admin AFB1 (20 mg/kg) +prazosin (0.3 mg/kg bw) | Plasma | 15.53±10.1 ng/ml |
|  |  |  |  | Brain | 6.69±1.81 ng/g |
|  |  |  | I.p. admin AFB1 (20 mg/kg) + zosuquidar (25 mg/kg bw) | Plasma | 31.96±14.28 ng/ml |
|  |  |  |  | Brain | 24.07±19.64 ng/g |
|  |  |  | I.p. admin AFB1 (20 mg/kg) + zosuquidar (25 mg/kg bw)+prazosin (0.3 mg/kg bw) | Plasma | 13.37±9.5 ng/ml |
|  |  |  |  | Brain | 24.85±11.66 ng/g |
| ENNB-Bea/ Toxicological studies with data on biomarkers | ENNB | Mice 2; severe combined immunodeficiency mice | Short-time exposure experiment; injection of 0.5 mg/kg on two (Enn B) or three (Bea) days | Liver | 2.9±0.6 ng/g | LC-MS/MS  EN and BEA: liver, kidney, fat. Cervical cancer (LOD 0.05ng/g)  colon, urine, serum (LOD 0.1 ng/g)  brain (LOD 0.15 ng/g) | The distribution pattern for Enn B: liver>fat >serum>colon≈muscle≈kidney≈brain, and and for BEA were: liver>fat>colon>kidney>muscle≈brain≈serum. ENNB and BEA are rapidly cleared from the blood stream by hepatobiliary excretion. Some phase I metabolites were identified in liver and in colon suggesting a potential contribution of hepatic and intestinal metabolism. | Rodríguez-Carrasco, 2016 |
| Kidney | 0.1±0.01 ng/g |
| Colon | 0.15±0.02 ng/g |
| Fat | 2.5±0.9 ng/g |
| Brain | 0.1±0.02 ng/g |
| Muscle | 0.12±0.03 ng/g |
| Urine | < LOD |
| Serum | 0.45±0.01 ng/g |
| BEA | Liver | 41.7±13.4 ng/g |
| Kidney | 11.4±5 ng/g |
| Colon | 23.4±23.9 ng/g |
| Fat | 33±22.1 ng/g |
| Brain | 1±0.7 ng/g |
| Muscle | 1.5±0.9 ng/g |
| Urine | < LOD |
| Serum | 1.3±0.2 ng/g |
| ENN | Mice 4; cervical cancer tumors | Long term study; intraperitoneal admin. of Enn B or Bea | Cervical cancer tumor | 2.8±0.8 ng/g |
| Serum | 5.4±0.2 ng/g |
| BEA | Cervical cancer tumor | 3.4±0.4 ng/g |
| Serum | 2.6±0.6 ng/g |
| ENNA/ Toxicological studies with data on biomarkers | ENNa | Wistar rats 5 | Admin ENNA 465 mg/kg feed; 2 week | Serum | 1.70±1.70 µg/ml | LC-MS/MS  Serum (LOQ 5.4 ng/ml )  Urine (LOQ 6 ng/ml)  Faeces (LOQ 7 ng/g) | Levels in serum might be associated with the absorption and distribution of ENN A, its distribution and possibility of accumulation in some organs could explain the levels of ENN A in serum. | Juan, 2014 |
|  | Admin of ENNA 465 mg/kg feed; 3 week | Serum | 2.20±0.8 µg/ml |
|  | Admin of ENNA 465 mg/kg feed; 4 week | Serum | 4.76±0.5 µg/ml |
|  | Admin of ENNA 465 mg/kg feed; during all treatment period | Faeces and urine | <LOD |
| OTA/biomarkers of exposure | OTA | Fisher rats, 9 | Feeding 10 mg OTA/kg diet; 6 days | Plasma | 11.27 ± 2.07 μg/ml | HPLC-FLD  Tissues (LOD 1 ng/g)  Plasma and urine (LOD 1 ng/ml) | In urine, OTA was mainly excreted as OTα (93%), and only a small part (6–7%) appeared in its original form. in faeces, OTα and OTA accounted for 94% and 6%, respectively. Quercetin supplementation had no effect on feed consumption, OTA-intake, water intake and body weight gain. Faecal and urinary excretion of OTA and OTα and concentrations of OTA in all tissues were not affected by quercetin supplementation. | Abbas, 2013 |
|  | Kidney | 1.44 ± 0.22 μg/g |
|  | Liver | 1.12 ± 0.31 μg/g |
|  | Muscle | 0.48 ± 0.09 μg/g |
|  | Brain | 0.13 ± 0.02 μg/g |
| OTα | All tissues | <LOD |
|  | Plasma | 13.5 ± 2.8 ng/ml |
| OTA | Urine | 1.1 ± 0.2 intake in % |
| OTα | Urine | 15.7±1.7 v |
| OTA | Faeces | 1.1±0.4 intake in % |
| OTα | Faeces | 13.3±1.4 intake in % |
| OTA + OTα | Urine + faeces | 30.0 ±1.5 intake in % |
| OTA |  | Feeding 10 mg OTA/kg diet+100 mg quercetin/kg feed; 6 days | Plasma | 10.91±2.38 μg/ml |
|  | Kidney | 1.42±0.15 μg/g |
|  | Liver | 1.10 ±0.14 μg/g |
|  | Muscle | 0.53 ± 0.07 μg/g |
|  | brain | 0.14 ± 0.02 μg/g |
| OTα | All tissues | <LOD |
|  | Plasma | 13.9 ± 12.3 ng/ml |
| OTA | Urine | 1.0±0.1 intake in % |
| OTα | Urine | 14.4±2.4 intake in % |
| OTA | Faeces | 0.9±0.2 intake in % |
| OTAα | Faeces | 14.0±4.2 intake in % |
| OTA + OTAα | Urine + faeces | 29.5±5.1 intake in % |
| DON/biomarkers of exposure | DON | Rats 6; control group | Water oral admin (0-24h) | Urine | 1.3±0.7 nmol | LC MS/MS  Urine  DON (LOD 0.6 ng/ml)  DON3G (LOD 0.6 ng/m)  l DONglucuronide (LOD 3.0 ng/ml)  DOM1( LOD 5.1 ng/ml)    Faeces  DON (LOD 1.6 ng/ml )  DON3G (LOD 0.6 ng/ml)  DOM1 (LOD 2.7 ng/ml) | After administration of DON3G, 3.7% of the given dose were found in urine in the form of analyzed analytes, compared to 14.9% after administration of DON, and only 0.3±0.1% were detected in the form of urinary DON3G. The majority of administered DON3G was recovered as DON and DOM1 in feces. These results suggest that DON3G is little bioavailable hydrolysed to DON during digestion, and partially converted to DOM1 and DONGlcA prior to excretion. | Nagl, 2012 |
|  | Urine | 1.9±1.6 nmol |
| DON3G | Urine | <LOD |
|  | Urine | <LOD |
| DONglucuronide | Urine | 1.2±0.8 nmol |
|  | Urine | 1.1±0.7 nmol |
| DOM1 | Urine | <LOD |
|  | Urine | <LOD |
| DON | Rats 6 each group | Oral admin 2.0 mg/kg bw DON (0-24h) | Urine | 79±28 nmol |
|  | Urine | 10±2.0 nmol |
| DON3G | Urine | <LOD |
|  | Urine | <LOD |
| DONglucuronide | Urine | 180±72 nmol |
|  | Urine | 16±5.9 nmol |
| DOM1 | Urine | 14±6 nmol |
|  | Urine | 4.3±1.6 nmol |
| DON |  | Oral admin. 3.1 mg/kg bw DON3G (0 – 24h) | Urine | 26±4.9 nmol |
|  | Urine | 2.4±1.7 nmol |
| DON3G | Urine | 6.9±2.2 nmol |
| G | Urine | 0.2±0.1 nmol |
| DONglucuronide | Urine | 24±5 nmol |
|  | Urine | 24±1.1 nmol |
| DOM1 | Urine | 15±7.3 nmol |
|  | Urine | 4.7±1.7 nmol |
| DON |  | Water oral admin (0-24h) | Faeces | 1.9±0.8 nmol |
|  | Faeces | 1.8±0.4 nmol |
| DON3G | Faeces | <LOD |
|  | Faeces | <LOD |
| DONglucuronide | Faeces | <LOD |
|  | Faeces | <LOD |
| DOM1 | Faeces | <LOD |
|  | Faeces | <LOD |
| DON |  | Oral admin. 2.0 mg/kg bw DON (0 – 24h) | Faeces | 77±57 nmol |
|  | Faeces | 5.6±2.3 nmol |
| DON3G | Faeces | <LOD |
|  | Faeces | <LOD |
| DONglucuronide | Faeces | <LOD |
|  | Faeces | <LOD |
| DOM1 | Faeces | 120±29 nmol |
|  | Faeces | 53±15 nmol |
| DON |  | Oral admin. 3.1 mg/kg bw DON3G (0 – 24h) | Faeces | 200±130 nmol |
|  | Faeces | 5.5±3.9 nmol |
| DON3G | Faeces | 1.9±.5 nmol |
|  | Faeces | <LOD |
| DONglucuronide | Faeces | <LOD |
|  | Faeces | <LOD |
| DOM1 | Faeces | 120±33 nmol |
|  | Faeces | 46±25 nmol |
| AFB1/Toxicological studies with data on biomarkers | AFB1-alb | Rats 4; Sprague–Dawley | Oral admin AFB1 100 µg/kg; 1 day | Urine | 5 ng/ml | ELISA (LOQ -) | AFB1 can be complexed with OTP and the absorption of the complexed AFB1 is inhibited in rats. | Hao Lu, 2016 |
|  | Oral admin AFB1 100 µg/kg + oxidised tea polyphenols (OTP) 400 mg kg; 1 day | Urine | 3 ng/ml |
|  | Oral admin of AFB1 100µg/kg + oxidised tea polyphenols (OTP) 200 mg kg; 1 day | Urine | 3.5 ng/ml |
| AFB1 |  | oral admin of AFB1 100µg/kg; 1 day | Faeces | 20 ng/ml |
|  | oral admin of AFB1 100µg/kg + oxidised tea polyphenols (OTP) 400 mg kg; 1 day | Faeces | 220 ng/ml |
|  | oral admin of AFB1 100µg/kg + oxidised tea polyphenols (OTP) 200 mg kg; 1 day | Faeces | 120 ng/ml |

Table K11. Rat and mice\_List of single biomarker, substrate, animal reported in the different substrate and the associated animal.

| Biomarker/Type of study | Biomarker | Sample description | Experimental | Substrate |  | Analytical method | Results/Conclusion | Reference |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| AFB1/Toxicological studies with data on biomarkers | AFB1 | Male ICR mice 15; 6 weeks' old | Feeding 300 μg AFB1/kg bw; first day 1h | Faeces | 1.016±0.053 μg/g | HPLC-UV (LOQ -) | L. plantarum lactobacillus with good AFB1-binding ability in vitro increased faecal AFB1 excretion, reduce lipid peroxidation, and reverse deficits in antioxidant defence systems to alleviate AFB1 toxicity. | Huang, 2017 |
|  |  | Feeding 300 μg AFB1/kg bw; first day 3h | Faeces | 1.369±0.041 μg/g |
|  |  | Feeding 300 μg AFB1/kg bw; first day 7h | Faeces | 0.341±0.038 μg/g |
| AFB1N7guanine |  | Feeding 300 μg AFB1/kg bw; first day urine 7h | Urine | 0.0953±0.004 ng/ml |
| AFB1 |  | Feeding 300 μg AFB1/kg bw+4.0×1010 CFU/kg bw Viable C88 L. plantarum strain; first day 1h | Faeces | 2.723±0.051 μg/g |
|  |  | Feeding 300 μg AFB1/kg bw+4.0×1010 CFU/kg bw Viable C88 L. plantarum strain; first day 3h | Faeces | 1.218±0.053 μg/g |
|  |  | Feeding 300 μg AFB1/kg bw+4.0×1010 CFU/kg bw Viable C88 L. plantarum strain; first day 7h | Faeces | 1.101±0.039 μg/g |
| AFB1N7guanine |  | Feeding 300 μg AFB1/kg bw+4.0×1010 CFU/kg bw Viable C88 L. plantarum strain; first day urine 7h | Urine | 0.0583±0.005 ng/ml |
| AFB1 |  | Feeding 300 μg AFB1/kg bw+4.0×1010 CFU/kg bw heat-killed C88 L. plantarum strain; first day 1h | Faeces | 3.199±0.056 μg/g |
|  |  | Feeding 300 μg AFB1/kg bw+4.0×1010 CFU/kg bw heat-killed C88 L. plantarum strain; first day 3h | Faeces | 1.385±0.049 μg/g |
|  |  | Feeding 300 μg AFB1/kg bw+4.0×1010 CFU/kg bw heat-killed C88 L. plantarum strain; first day 7h | Faeces | 1.111±0.045 μg/g |
| AFB1N7guanine |  | Feeding 300 μg AFB1/kg bw+4.0×1010 CFU/kg bw heat-killed C88 L. plantarum strain; first day urine 7h | Urine | 0.0678±0.008 ng/ml |
| AFB1/Toxicological studies with data on biomarkers | AFB1 | Mice 8 | I.p. admin. AFB1 (20 mg/kg) | Plasma | 23.45±13.84 ng/ml | HPLC-FLD  Plasma LOQ 0.5 ng/ml  Brain LOQ 1ng/g | Both prazosin and zosuquidar significantly reduced the brain concentration of AFB1 but not the plasma concentration of this molecule. AFB1 may be a substrate of both BCRP and P-gp. Inducers of transmembrane proteins, such as prazosin, can be life-saving during acute poisoning with AFB1, based on the overall health status and brain concentrations of AFB1 in mice. | Tras, 2017 |
|  |  |  |  | Brain | 181.23±89.4 ng/g |
|  |  |  | I.p. admin AFB1 (20 mg/kg) +prazosin (0.3 mg/kg bw) | Plasma | 15.53±10.1 ng/ml |
|  |  |  |  | Brain | 6.69±1.81 ng/g |
|  |  |  | I.p. admin AFB1 (20 mg/kg) + zosuquidar (25 mg/kg bw) | Plasma | 31.96±14.28 ng/ml |
|  |  |  |  | Brain | 24.07±19.64 ng/g |
|  |  |  | I.p. admin AFB1 (20 mg/kg) + zosuquidar (25 mg/kg bw)+prazosin (0.3 mg/kg bw) | Plasma | 13.37±9.5 ng/ml |
|  |  |  |  | Brain | 24.85±11.66 ng/g |
| ENNB-Bea/ Toxicological studies with data on biomarkers | ENNB | Mice 2; severe combined immunodeficiency mice | Short-time exposure experiment; injection of 0.5 mg/kg on two (Enn B) or three (Bea) days | Liver | 2.9±0.6 ng/g | LC-MS/MS  EN and BEA: liver, kidney, fat. Cervical cancer (LOD 0.05ng/g)  colon, urine, serum (LOD 0.1 ng/g)  brain (LOD 0.15 ng/g) | The distribution pattern for Enn B: liver>fat >serum>colon≈muscle≈kidney≈brain, and and for BEA were: liver>fat>colon>kidney>muscle≈brain≈serum. ENNB and BEA are rapidly cleared from the blood stream by hepatobiliary excretion. Some phase I metabolites were identified in liver and in colon suggesting a potential contribution of hepatic and intestinal metabolism. | Rodríguez-Carrasco, 2016 |
| Kidney | 0.1±0.01 ng/g |
| Colon | 0.15±0.02 ng/g |
| Fat | 2.5±0.9 ng/g |
| Brain | 0.1±0.02 ng/g |
| Muscle | 0.12±0.03 ng/g |
| Urine | < LOD |
| Serum | 0.45±0.01 ng/g |
| BEA | Liver | 41.7±13.4 ng/g |
| Kidney | 11.4±5 ng/g |
| Colon | 23.4±23.9 ng/g |
| Fat | 33±22.1 ng/g |
| Brain | 1±0.7 ng/g |
| Muscle | 1.5±0.9 ng/g |
| Urine | < LOD |
| Serum | 1.3±0.2 ng/g |
| ENN | Mice 4; cervical cancer tumors | Long term study; intraperitoneal admin. of Enn B or Bea | Cervical cancer tumor | 2.8±0.8 ng/g |
| Serum | 5.4±0.2 ng/g |
| BEA | Cervical cancer tumor | 3.4±0.4 ng/g |
| Serum | 2.6±0.6 ng/g |
| ENNA/ Toxicological studies with data on biomarkers | ENNa | Wistar rats 5 | Admin ENNA 465 mg/kg feed; 2 week | Serum | 1.70±1.70 µg/ml | LC-MS/MS  Serum (LOQ 5.4 ng/ml )  Urine (LOQ 6 ng/ml)  Faeces (LOQ 7 ng/g) | Levels in serum might be associated with the absorption and distribution of ENN A, its distribution and possibility of accumulation in some organs could explain the levels of ENN A in serum. | Juan, 2014 |
|  | Admin of ENNA 465 mg/kg feed; 3 week | Serum | 2.20±0.8 µg/ml |
|  | Admin of ENNA 465 mg/kg feed; 4 week | Serum | 4.76±0.5 µg/ml |
|  | Admin of ENNA 465 mg/kg feed; during all treatment period | Faeces and urine | <LOD |
| OTA/biomarkers of exposure | OTA | Fisher rats, 9 | Feeding 10 mg OTA/kg diet; 6 days | Plasma | 11.27 ± 2.07 μg/ml | HPLC-FLD  Tissues (LOD 1 ng/g)  Plasma and urine (LOD 1 ng/ml) | In urine, OTA was mainly excreted as OTα (93%), and only a small part (6–7%) appeared in its original form. in faeces, OTα and OTA accounted for 94% and 6%, respectively. Quercetin supplementation had no effect on feed consumption, OTA-intake, water intake and body weight gain. Faecal and urinary excretion of OTA and OTα and concentrations of OTA in all tissues were not affected by quercetin supplementation. | Abbas, 2013 |
|  | Kidney | 1.44 ± 0.22 μg/g |
|  | Liver | 1.12 ± 0.31 μg/g |
|  | Muscle | 0.48 ± 0.09 μg/g |
|  | Brain | 0.13 ± 0.02 μg/g |
| OTα | All tissues | <LOD |
|  | Plasma | 13.5 ± 2.8 ng/ml |
| OTA | Urine | 1.1 ± 0.2 intake in % |
| OTα | Urine | 15.7±1.7 v |
| OTA | Faeces | 1.1±0.4 intake in % |
| OTα | Faeces | 13.3±1.4 intake in % |
| OTA + OTα | Urine + faeces | 30.0 ±1.5 intake in % |
| OTA |  | Feeding 10 mg OTA/kg diet+100 mg quercetin/kg feed; 6 days | Plasma | 10.91±2.38 μg/ml |
|  | Kidney | 1.42±0.15 μg/g |
|  | Liver | 1.10 ±0.14 μg/g |
|  | Muscle | 0.53 ± 0.07 μg/g |
|  | brain | 0.14 ± 0.02 μg/g |
| OTα | All tissues | <LOD |
|  | Plasma | 13.9 ± 12.3 ng/ml |
| OTA | Urine | 1.0±0.1 intake in % |
| OTα | Urine | 14.4±2.4 intake in % |
| OTA | Faeces | 0.9±0.2 intake in % |
| OTAα | Faeces | 14.0±4.2 intake in % |
| OTA + OTAα | Urine + faeces | 29.5±5.1 intake in % |
| DON/biomarkers of exposure | DON | Rats 6; control group | Water oral admin (0-24h) | Urine | 1.3±0.7 nmol | LC MS/MS  Urine  DON (LOD 0.6 ng/ml)  DON3G (LOD 0.6 ng/m)  l DONglucuronide (LOD 3.0 ng/ml)  DOM1( LOD 5.1 ng/ml)    Faeces  DON (LOD 1.6 ng/ml )  DON3G (LOD 0.6 ng/ml)  DOM1 (LOD 2.7 ng/ml) | After administration of DON3G, 3.7% of the given dose were found in urine in the form of analyzed analytes, compared to 14.9% after administration of DON, and only 0.3±0.1% were detected in the form of urinary DON3G. The majority of administered DON3G was recovered as DON and DOM1 in feces. These results suggest that DON3G is little bioavailable hydrolysed to DON during digestion, and partially converted to DOM1 and DONGlcA prior to excretion. | Nagl, 2012 |
|  | Urine | 1.9±1.6 nmol |
| DON3G | Urine | <LOD |
|  | Urine | <LOD |
| DONglucuronide | Urine | 1.2±0.8 nmol |
|  | Urine | 1.1±0.7 nmol |
| DOM1 | Urine | <LOD |
|  | Urine | <LOD |
| DON | Rats 6 each group | Oral admin 2.0 mg/kg bw DON (0-24h) | Urine | 79±28 nmol |
|  | Urine | 10±2.0 nmol |
| DON3G | Urine | <LOD |
|  | Urine | <LOD |
| DONglucuronide | Urine | 180±72 nmol |
|  | Urine | 16±5.9 nmol |
| DOM1 | Urine | 14±6 nmol |
|  | Urine | 4.3±1.6 nmol |
| DON |  | Oral admin. 3.1 mg/kg bw DON3G (0 – 24h) | Urine | 26±4.9 nmol |
|  | Urine | 2.4±1.7 nmol |
| DON3G | Urine | 6.9±2.2 nmol |
| G | Urine | 0.2±0.1 nmol |
| DONglucuronide | Urine | 24±5 nmol |
|  | Urine | 24±1.1 nmol |
| DOM1 | Urine | 15±7.3 nmol |
|  | Urine | 4.7±1.7 nmol |
| DON |  | Water oral admin (0-24h) | Faeces | 1.9±0.8 nmol |
|  | Faeces | 1.8±0.4 nmol |
| DON3G | Faeces | <LOD |
|  | Faeces | <LOD |
| DONglucuronide | Faeces | <LOD |
|  | Faeces | <LOD |
| DOM1 | Faeces | <LOD |
|  | Faeces | <LOD |
| DON |  | Oral admin. 2.0 mg/kg bw DON (0 – 24h) | Faeces | 77±57 nmol |
|  | Faeces | 5.6±2.3 nmol |
| DON3G | Faeces | <LOD |
|  | Faeces | <LOD |
| DONglucuronide | Faeces | <LOD |
|  | Faeces | <LOD |
| DOM1 | Faeces | 120±29 nmol |
|  | Faeces | 53±15 nmol |
| DON |  | Oral admin. 3.1 mg/kg bw DON3G (0 – 24h) | Faeces | 200±130 nmol |
|  | Faeces | 5.5±3.9 nmol |
| DON3G | Faeces | 1.9±.5 nmol |
|  | Faeces | <LOD |
| DONglucuronide | Faeces | <LOD |
|  | Faeces | <LOD |
| DOM1 | Faeces | 120±33 nmol |
|  | Faeces | 46±25 nmol |
| AFB1/Toxicological studies with data on biomarkers | AFB1-alb | Rats 4; Sprague–Dawley | Oral admin AFB1 100 µg/kg; 1 day | Urine | 5 ng/ml | ELISA (LOQ -) | AFB1 can be complexed with OTP and the absorption of the complexed AFB1 is inhibited in rats. | Hao Lu, 2016 |
|  | Oral admin AFB1 100 µg/kg + oxidised tea polyphenols (OTP) 400 mg kg; 1 day | Urine | 3 ng/ml |
|  | Oral admin of AFB1 100µg/kg + oxidised tea polyphenols (OTP) 200 mg kg; 1 day | Urine | 3.5 ng/ml |
| AFB1 |  | oral admin of AFB1 100µg/kg; 1 day | Faeces | 20 ng/ml |
|  | oral admin of AFB1 100µg/kg + oxidised tea polyphenols (OTP) 400 mg kg; 1 day | Faeces | 220 ng/ml |
|  | oral admin of AFB1 100µg/kg + oxidised tea polyphenols (OTP) 200 mg kg; 1 day | Faeces | 120 ng/ml |

1. Unless specified, range of values or mean±standard deviation is reported. DM = dray matter. CFU = colony forming unit. I.p. admin = intraperitoneal administration

Table K12. Horse and dog\_List of single biomarker, substrate, animal reported in the different substrate and the associated animal.

| **Biomarker/Type of study** | **Biomarker** | **Sample description** | **Experimental** | **Substrate** |  | **Analytical method** | **Results/Conclusion** | **Reference** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **ZEN/Biomarkers of exposure** | ZEN | 6 horses;  Feeding naturally contaminated oats: 1 ppm of ZEN and 12 ppm of DON. | Day 1 treatment | Urine | 27.78±18.19μg/l | LC-MS/MS  Urine/plasma LOD  ZEN 0.1 μg/l  αZEL 0.1 μg/l  βZEL 0.1 μg/l  ZAN 0.2 μg/l  αZAL 0.2 μg/l  βZAL 0.2 μg/l  Faeces LOD  αZEL 0.1 μg/l  βZEL 0.1 μg/l  ZAN 0.5 μg/l  αZAL 0.5 μg/l  βZAL 0.5 μg/l | Plasma: βZEL was detected at high levels on day 10 of the study. Urine: βZEL and αZEL were the major metabolites. ZEN, βZEL and αZEL were predominantly found in faeces.  ZEN also detected in urine and faeces. The degree of glucuronidation was established in all sample types, approximately 100% in urine and plasma. Low % of glucuronidation (4–15%) was found in faeces samples. The results indicate the main conversion of ZEN into βZEL in horse. This could explain why horse is not susceptible to ZEN in comparison with swine, which produce αZEL as a predominant metabolite. | Songsermsakul, 2013 |
| αZEL | 51.90±37.74μg/l |
| βZEL | 40.62±25.04 μg/l |
| ZAN | 1.34±0.52 μg/l |
| αZAL | 2.14±0.66 μg/l |
| βZAL | < LOD |
| ZEN | Plasma | 2.46±0.62 μg/l |
| αZEL | 0.28±0.06 μg/l |
| βZEL | 0.81±0.3 μg/l |
| ZEN | Day 10 treatment | Urine | 84.21±31.74 μg/l |
| αZEL | 171.46±67.55 μg/l |
| βZEL | 237.30±108.44 μg/l |
| ZAN | 3.16±1.58 μg/l |
| αZAL | 6.21±2.06 μg/l |
| βZAL | 2.40±0.72 μg/l |
| ZEN | Plasma | 0.23±0.06 μg/kg |
| αZEL | 0.33±0.09 μg/kg |
| βZEL | 6.13±1.33 μg/kg |
| ZEN | Day 2 treatment | Faeces | 33.81±8.79 µg/kg |
| αZEL | 38.64±5.37 µg/kg |
| βZEL | 17.5±3.27 µg/kg |
| ZAN | < LOQ |
| αZAL | 1.09±0.05 µg/kg |
| βZAL | 1.04±0.04 µg/kg |
| ZEN | Day 11 treatment | 23.63±7.14 µg/kg |
| αZEL | 31.81±6.67 µg/kg |
| βZEL | 21.53±3.85 µg/kg |
| ZAN | 1.01±0.16 µg/kg |
| αZAL | 1.02±0.21 µg/kg |
| βZAL | 1.03±0.05 µg/kg |
| OTA/Biomarkers of exposure | OTA | dogs with recorded history and a complete clinical evaluation | 23 healthy dog | Plasma | < LOD-0.27ng/ml | HPLC-FLD  LOD  0.0125 ng/ml  LOQ  0.025 ng/ml | OTA plasma levels are considered a short-term biomarker with a high within-subject variability; OTA measurements can be used to characterize populations or subgroups of subjects | Meucci, 2017 |
|  | 23 dogs  with CKD | < LOD-1.05ng/ml |
|  | 5 dogs IRIS stage 1 | 0.007-1.05 ng/ml |
|  | 5 dogs IRIS stage 2 | < LOD-0.686 ng/ml |
|  | 6 dogs IRIS stage 3 | 0.031-0.683 ng/ml |
|  | 7 dogs IRIS stage 4 | 0.061-0.725 ng/ml |

References

Abbas Z, Blank R, Wein S, Wolffram S. 2013. Effect of quercetin on the toxicokinetics of ochratoxin A in rats. Food Addit Contam Part A Chem Anal Control Expo Risk Assess 30:861-866.

Rajput SA, Sun L, Zhang N, Mohamed Khalil M, Gao X, Ling Z, Zhu L, Khan FA, Zhang J, Qi D. 2017. Ameliorative Effects of Grape Seed Proanthocyanidin Extract on Growth Performance, Immune Function, Antioxidant Capacity, Biochemical Constituents, Liver Histopathology and Aflatoxin Residues in Broilers Exposed to Aflatoxin B1 . [Toxins (Basel).](https://www.ncbi.nlm.nih.gov/pubmed/29140290) 15;9 (11)

Alizadeh A, Braber S, Akbari P, Garssen J, Fink-Gremmels J. 2015. Deoxynivalenol Impairs Weight Gain and Affects Markers of Gut Health after Low-Dose, Short-Term Exposure of Growing Pigs. Toxins (Basel) 7:2071-2095.

Arafat RY, Khan SH. 2017. Evaluation of Humic Acid as an Aflatoxin Binder in Broiler Chickens. Annals of Animal Science 17:241-255.

Armorini S, Al-Qudah KM, Altafini A, Zaghini A, Roncada P. 2015. Biliary ochratoxin A as a biomarker of ochratoxin exposure in laying hens: An experimental study after administration of contaminated diets. Res Vet Sci 100:265-270.

Aslam N, Rodrigues I, McGill DM, Warriach HM, Cowling A, Haque A, Wynn PC. 2015. Transfer of aflatoxins from naturally contaminated feed to milk of Nili-Ravi buffaloes fed a mycotoxin binder. Animal Production Science.

Binder SB, Schwartz-Zimmermann HE, Varga E, Bichl G, Michlmayr H, Adam G, Berthiller F. 2017. Metabolism of Zearalenone and Its Major Modified Forms in Pigs. Toxins (Basel) 9.

Britzi M, Friedman S, Miron J, Solomon R, Cuneah O, Shimshoni JA, Soback S, Ashkenazi R, Armer S, Shlosberg A. 2013. Carry-over of aflatoxin B1 to aflatoxin M1 in high yielding Israeli cows in mid- and late-lactation. Toxins (Basel) 5:173-183.

Carraro Di Gregorio M, Jager AV, Costa AA, Bordin K, Rottinhghaus GE, Petta T, Souto PC, Budino FE, Oliveira CA. 2017. Determination of Aflatoxin B1-Lysine in Pig Serum and Plasma by Liquid Chromatography-Tandem Mass Spectrometry. J Anal Toxicol 41:236-241.

Carraro Di Gregorio M, Vincenzi Jager A, Maggio Castro Souto Pollyana C, Costa AA, George Edwin Rottinghaus DP, Lemos Budiño FE, Corassin CH, Fernandes Oliveira CA. 2017. Determination of serum aflatoxin B1-lysine to evaluate the efficacy of an aflatoxin-adsorbing feed additive in pigs fed an aflatoxin B1-contaminated diet. Mycotoxin Res, 93-102.

Danicke S. 2017. Ergot Alkaloids in Fattening Chickens (Broilers): Toxic Effects and Carry over Depending on Dietary Fat Proportion and Supplementation with Non-Starch-Polysaccharide (NSP) Hydrolyzing Enzymes. Toxins (Basel) 9.

Daofeng Q, Huang X, Han J, Man N, 2017. Efficacy of mixed adsorbent in ameliorating ochratoxicosis in broilers fed ochratoxin A contaminated diets. Italian Journal of Animal Science 16(4):573-579

Deng X-b, Din H-z, Huang X-h, Ma Y-j, Fan X-l, Yan H-k, Lu P-c, Li W-c, Zeng Z-l. 2015. Tissue distribution of deoxynivalenol in piglets following intravenous administration. Journal of Integrative Agriculture 14:2058-2064.

Devreese M, Broekaert N, De Mil T, Fraeyman S, De Backer P, Croubels S. 2014. Pilot toxicokinetic study and absolute oral bioavailability of the Fusarium mycotoxin enniatin B1 in pigs. Food Chem Toxicol 63:161-165.

Devreese M, Osselaere A, Goossens J, Vandenbroucke V, De Baere S, Eeckhout M, De Backer P, Croubels S. 2012. New bolus models for in vivo efficacy testing of mycotoxin-detoxifying agents in relation to EFSA guidelines, assessed using deoxynivalenol in broiler chickens. Food Addit Contam Part A Chem Anal Control Expo Risk Assess 29:1101-1107.

Directive 2002: Directive 2002/32/Ec of the European Parliament and of the Council, of 7 May 2002on undesirable substances in animal feed (OJ L 140, 30.5.2002, p. 10)

Carraro Di Gregorio M, Jager AV, Costa AA, Bordin K, Rottinhghaus GE, Petta T, Souto PC, Budino FE, Oliveira CA. 2017. Determination of Aflatoxin B1-Lysine in Pig Serum and Plasma by Liquid Chromatography-Tandem Mass Spectrometry. J Anal Toxicol 41:236-241.

Carraro Di Gregorio M et al. 2017. Determination of serum aflatoxin B1-lysine to evaluate the efficacy of an aflatoxin-adsorbing feed additive in pigs fed an aflatoxin B1-contaminated diet. Mycotoxin Res :93-102.

Ebrahem M, Kersten S, Valenta H, Breves G, Danicke S. 2014. Residues of deoxynivalenol (DON) and its metabolite de-epoxy-DON in eggs, plasma and bile of laying hens of different genetic backgrounds. Arch Anim Nutr 68:412-422.

Fraeyman S, Devreese M, Antonissen G, De Baere S, Rychlik M, Croubels S. 2016. Comparative Oral Bioavailability, Toxicokinetics, and Biotransformation of Enniatin B1 and Enniatin B in Broiler Chickens. J Agric Food Chem 64:7259-7264.

Frobose HL, Stephenson EW, Tokach MD, DeRouchey JM, Woodworth JC, Dritz SS, Goodband RD. 2017. Effects of potential detoxifying agents on growth performance and deoxynivalenol (DON) urinary balance characteristics of nursery pigs fed DON-contaminated wheat. J Anim Sci 95:327-337.

Fushimi Y, Takagi M, Uno S, Kokushi E, Nakamura M, Hasunuma H, Shinya U, Deguchi E, Fink-Gremmels J. 2014. Measurement of sterigmatocystin concentrations in urine for monitoring the contamination of cattle feed. Toxins (Basel) 6:3117-3128.

Gambacorta L, Pinton P, Avantaggiato G, Oswald IP, Solfrizzo M. 2016. Grape Pomace, an Agricultural Byproduct Reducing Mycotoxin Absorption: In Vivo Assessment in Pig Using Urinary Biomarkers. J Agric Food Chem 64:6762-6771.

Gajęcka M, Sławuta P, Nicpoń J, Kołacz R, Kiełbowicz Z, Zielonka Ł, Dąbrowski M, Szweda W, Gajęcki M, Nicpoń J.2016. Zearalenone and its metabolites in the tissues of female wild boars exposed per os to mycotoxins. Toxicon. 2016 May; 114:1-12.(912)

Giangolini G, Filippetti F, Rosati R, and Amatiste S. 2013. Excretion of Aflatoxin M1 buffolo milk XX. 32:1119-1122.

Grajewski J, Twarużek M, Kosicki R. 2012. High levels of ochratoxin A in blood serum and kidneys of wild boarsSus scrofain Poland. Wildlife Biology 18:272-279.

Grenier B, Schwartz-Zimmermann H E, Gruber-Dorninger, Dohnal I, Aleschko M, Schatzmayr G, Moll W D, Applegate T J, 2017. Enzymatic hydrolysis of fumonisins in the gastrointestinal tract of broiler chickens. Poult Sci. 96(12):4342–4351.

Hao Lu FL, Qiangqiang Zhu, Mengmeng Zhang, Tong Li, Jiming Chen, Yewei Huang, XuanjunWanga, and Jun Shenga. 2016. Aflatoxin B1 can be complexed with oxidised tea polyphenols and the absorption of the complexed aflatoxin B1 is inhibited in rats. J Sci Food Agric :1910–1915

Hashimoto Y, Katsunuma Y, Nunokawa M, Minato H, Yonemochi C. 2016. Influence of repeated ochratoxin A ingestion on milk production and its carry-over into the milk, blood and tissues of lactating cows. Anim Sci J 87:541-546.

Hasunuma H, et al. 2012. Natural contamination of dietary rice straw with zearalenone and urinary zearalenone concentrations in a cattle herd. J Anim Sci 90:1610-1616.

Hopton RP, Oswald IP, Hardie LJ, Turner PC, Fisher J. 2012. Nuclear Magnetic Resonance Analysis of Glucose Levels in Weanling Piglets Plasma as a Function of Deoxynivalenol Exposure. ISRN Analytical Chemistry 2012:1-5.

Hort V, Nicolas M, Minvielle B, Maleix C, Desbourdes C, Hommet F, Dragacci S, Dervilly-Pinel G, Engel E, Guerin T. 2018. Ochratoxin A determination in swine muscle and liver from French conventional or organic farming production systems. J Chromatogr B Analyt Technol Biomed Life Sci 1092:131-137.

Huang L, Duan C, Zhao Y, Gao L, Niu C, Xu J, Li S. 2017. Reduction of Aflatoxin B1 Toxicity by Lactobacillus plantarum C88: A Potential Probiotic Strain Isolated from Chinese Traditional Fermented Food "Tofu". PLoS One 12:e0170109.

Joo YD, Kang CW, Byoung Ki An, Ahn JS, Borutova R. 2013. Effects of ochratoxin A and preventive action of a mycotoxin-deactivation product in broiler chickens. Vet Med Zoot 61. 2013. Effects of ochratoxin A and preventive action of a mycotoxin-deactivation product in broiler chickens. Vet Med Zoot 61.

Juan C, Manyes L, Font G, Juan-Garcia A. 2014. Evaluation of immunologic effect of Enniatin A and quantitative determination in feces, urine and serum on treated Wistar rats. Toxicon 87:45-53.

Kerekes K, Bonilauri P, Serraino A, Giacometti F, Piva S, Zambrini V, Canever A, Farkas Z, Ambrus A. 2016. An effective self-control strategy for the reduction of aflatoxin M1 content in milk and to decrease the exposure of consumers. Food Addit Contam Part A Chem Anal Control Expo Risk Assess 33:1840-1849.

Kongkapan J, Giorgi M, Poapolathep S, Isariyodom S, Poapolathep A. 2016. Toxicokinetics and tissue distribution of nivalenol in broiler chickens. Toxicon 111:31-36.

Kos J, Lević J, Đuragić O, Kokić B, Miladinović I. 2014. Occurrence and estimation of aflatoxin M1 exposure in milk in Serbia. Food Control 38:41-46.

Kruger CD, Cavaglieri LR, Direito GM, Keller KM, Dalcero AM, da Rocha Rosa CA. 2010. Ochratoxin A in serum of swine from different Brazilian states. J Vet Diagn Invest 22:753-756.

Liu N, Ding K, Wang JQ, Jia SC, Wang JP, Xu TS. 2017. Detoxification, metabolism, and glutathione pathway activity of aflatoxin B1 by dietary lactic acid bacteria in broiler chickens. J Anim Sci 95:4399-4406.

Mahmoudi R, Norian R. 2014. Aflatoxin B1 and M1 contamination in cow feeds and milk from Iran. Food and Agricultural Immunology 26:131-137.

Makau CM, Matofari JW, Muliro PS, Bebe BO. 2016. Aflatoxin B1 and Deoxynivalenol contamination of dairy feeds and presence of Aflatoxin M1 contamination in milk from smallholder dairy systems in Nakuru, Kenya. International Journal of Food Contamination 3.

Masching S, Naehrer K, Schwartz-Zimmermann HE, Sarandan M, Schaumberger S, Dohnal I, Nagl V, Schatzmayr D. 2016. Gastrointestinal Degradation of Fumonisin B(1) by Carboxylesterase FumD Prevents Fumonisin Induced Alteration of Sphingolipid Metabolism in Turkey and Swine. Toxins (Basel) 8.

Meucci V, Luci G, Vanni M, Guidi G, Perondi F, Intorre L. 2017. Serum levels of ochratoxin A in dogs with chronic kidney disease (CKD): a retrospective study. J Vet Med Sci 79:440-447.

Nagl V, Schwartz H, Krska R, Moll WD, Knasmuller S, Ritzmann M, Adam G, Berthiller F. 2012. Metabolism of the masked mycotoxin deoxynivalenol-3-glucoside in rats. Toxicol Lett 213:367-373.

Nagl V, Woechtl B, Schwartz-Zimmermann HE, Hennig-Pauka I, Moll WD, Adam G, Berthiller F. 2014. Metabolism of the masked mycotoxin deoxynivalenol-3-glucoside in pigs. Toxicol Lett 229:190-197.

Nile SH, Park SW, Khobragade CN. 2015. Occurrence and analysis of aflatoxin M1 in milk produced by Indian dairy species. Food and Agricultural Immunology 27:358-366.

Ogunade IM, Arriola KG, Jiang Y, Driver JP, Staples CR, Adesogan AT. 2016. Effects of 3 sequestering agents on milk aflatoxin M1 concentration and the performance and immune status of dairy cows fed diets artificially contaminated with aflatoxin B1. J Dairy Sci 99:6263-6273.

Pantaya D, Morgavi DP, Silberberg M, Chaucheyras-Durand F, Martin C, Suryahadi, Wiryawan KG, Boudra H. 2016. Bioavailability of aflatoxin B1 and ochratoxin A, but not fumonisin B1 or deoxynivalenol, is increased in starch-induced low ruminal pH in nonlactating dairy cows. J Dairy Sci 99:9759-9767.

Pleadin J, Mihaljevic Z, Barbir T, Vulic A, Kmetic I, Zadravec M, Brumen V, Mitak M. 2015. Natural incidence of zearalenone in Croatian pig feed, urine and meat in 2014. Food Addit Contam Part B Surveill 8:277-283.

Polat F, Aksu T, 2015. Determination of aflatoxin levels of feeds used in dairy cow farms and their effects on blood parameters and milk aflatoxin levels in Hatay Province. Atatuerk Ueniversitesi Veteriner Bilimleri Dergisi 10(3):146-155.

Pozzo L, Cavallarin L, Nucera D, Antoniazzi S, Schiavone A. 2010. A survey of ochratoxin A contamination in feeds and sera from organic and standard swine farms in northwest Italy. J Sci Food Agric 90:1467-1472.

Recomendation, 2006: Commission Recommendation of 17 August 2006 on the presence of deoxynivalenol, zearalenone, ochratoxin A, T-2 and HT-2 and fumonisins in products intended for animal feeding (Text with EEA levance) Official Journal of the European Union L 229/7

Rodriguez-Carrasco Y, Heilos D, Richter L, Sussmuth RD, Heffeter P, Sulyok M, Kenner L, Berger W, Dornetshuber-Fleiss R. 2016. Mouse tissue distribution and persistence of the food-born fusariotoxins Enniatin B and Beauvericin. Toxicol Lett 247:35-44.

Salvat AE, Comerio RM, Balbuena O, Rosello Brajovich JE, Ricca A, Rojas D, Cristos D, Ronco S, Salerno JC. 2015. Zeranol and urinary metabolites of zearalenone in beef cattle. Revista de Investigaciones Agropecuarias 41(2):149-154.

Schirone M, Visciano P, Olivastri A M A, Tofalo R, Perpetuini G Suzzi, G. 2015. A one-year survey on aflatoxin M1 in raw milk. Italian Journal of Food Science 27(2):271-276.

Shuib NS, Makahleh A, Salhimi SM, Saad B. 2017. Natural occurrence of aflatoxin M 1 in fresh cow milk and human milk in Penang, Malaysia. Food Control 73:966-970.

Schwartz-Zimmermann HE, Fruhmann P, Danicke S, Wiesenberger G, Caha S, Weber J, Berthiller F. 2015. Metabolism of deoxynivalenol and deepoxy-deoxynivalenol in broiler chickens, pullets, roosters and turkeys. Toxins (Basel) 7:4706-4729.

Simion VE, Gmdl, Negreanu C, Amfim A, Mitranescu E. 2010. Analysis of Mycotoxins from Biological Fluids in Bovids. Pages 277-282. Bulletin UASVM, Veterinary Medicine 67(1)/2010.

Songsermsakul P, Bohm J, Aurich C, Zentek J, Razzazi-Fazeli E. 2013. The levels of zearalenone and its metabolites in plasma, urine and faeces of horses fed with naturally, Fusarium toxin-contaminated oats. J Anim Physiol Anim Nutr (Berl) 97:155-161.

Sulzberger SA, Melnichenko S, Cardoso FC. 2017. Effects of clay after an aflatoxin challenge on aflatoxin clearance, milk production, and metabolism of Holstein cows. J Dairy Sci 100:1856-1869.

Sun Y, Zhang G, Zhao H, Zheng J, Hu F, Fang B. 2014. Liquid chromatography-tandem mass spectrometry method for toxicokinetics, tissue distribution, and excretion studies of T-2 toxin and its major metabolites in pigs. J Chromatogr B Analyt Technol Biomed Life Sci 958:75-82.

Tomasevic I , Miocinovic J, Petrovic J, Jovetic M, Raicevic S, Milojevic Mi, 2015. Two years survey on the occurrence and seasonal variation of aflatoxin M1 in milk and milk products in Serbia. FOOD CONTROL, Vol. 56, pp. 64-70.

Tras BGC, Uney K, Dik B, Corum O, Atalay S. 2017. Effects of BCRP and P-gp Modulators on the Penetration of Aflatoxin B1 into the Mouse Brain. Kafkas Univ Vet Fak Derg 23 95-100.

Ueberschär HK, Brezina U, and Dänicke S. 2016. Zearalenone (ZEN) and ZEN metabolites in feed, urine and bile of sows: Analysis, determination of the metabolic pro le and evaluation of the binding forms. Appl Agric Forestry Res (66):21-28.

Yuan CW, Huang JT, Chen CC, Tang PC, Huang jw, Lin jj, Huang SY, Chen SE, 2017. Evaluation of Efficacy and Toxicity of Exfoliated Silicate Nanoclays as a Feed Additive for Fumonisin Detoxification. J. Agric. Food Chem. 65(31):6564-6571.

Wang L, Zhang Q, Yan Z, Tan Y, Zhu R, Yu D, Yang H, Wu A. 2018. Occurrence and Quantitative Risk Assessment of Twelve Mycotoxins in Eggs and Chicken Tissues in China. Toxins (Basel) 10.

Winkler J, Kersten S, Meyer U, Engelhardt U, Danicke S. 2014. Residues of zearalenone (ZEN), deoxynivalenol (DON) and their metabolites in plasma of dairy cows fed Fusarium contaminated maize and their relationships to performance parameters. Food Chem Toxicol 65:196-204.