PRACTIONER TECH SHEET | Trichothecenes

Trichothecene mycotoxins are a large family of chemically-related, potently-toxic compounds. They share a common structure which is responsible for their toxicological activity.

Due to their small, amphipathic molecular structure, they can easily move across cell membranes and are therefore highly toxic to humans, pets (including birds), and plants.

Compared to other mycotoxins, trichothecenes are the most toxic, with unique characteristics that set them apart, including potency, absorption, activation, and a range of systemic effects.

Trichothecenes are exceptionally potent. Comparatively, they require far smaller parts per billion exposure than other mycotoxins to exert their biological effects.

Unlike other mycotoxins such as Aflatoxin, trichothecenes don't require metabolic activation. This means that they are active on contact, acting rapidly and directly on target tissues, and potentially causing blistering and bleeding.

Trichothecenes are efficiently absorbed, most notably through the respiratory tract with inhalation, as well as through the skin, eyes, and gastrointestinal system. They quickly enter systemic circulation, with peak detectable levels in blood and plasma in as little as 5 minutes after exposure.

These mycotoxins have been developed as biowarfare agents and are significantly more toxic than other well-known chemical warfare "blister agents", such as mustard gas. It's concerning that these same molecules exist in the breathable air of damp and water-damaged buildings.

Trichothecenes can cause severe health effects, including gastroenteritis, dermal irritation, corneal ulceration, neural toxicity, and hematopoietic suppression, with potential for systemic toxicity to lead to weakness, shock, and even death in cases of significant exposure.

Vomiting and diarrhea are warning signs, as they've been observed at ⅕-1/10 of the lethal dose of trichothecenes. Patients exhibiting these symptoms *must be immediately removed from the environment* to prevent continued exposure and risk of death.

Within the trichothecene family, there is significant variation in toxicity. Macrocyclic trichothecenes, such as roridins, verrucarins, and satratoxins, are generally considered to be among the most toxic trichothecenes.

MOLD SOURCES

Fusarium - Nivalenol, Deoxynivalenol (DON or Vomitoxin), Diacetoxyscirpenol (DAS), Fusarenon, HT-2 toxin, Monoacetylnivalenol, T-2 toxin

Myrothecium & Stachybotrys - Roridin, Satratoxin, Verrucarin

Trichoderma - Harzianum, Trichodermin

Trichothecium - Trichothecin, Trichothecinol

COLOR

Typically darker in color, even black

FAVORITE BUILDING MATERIAL

Wallpaper, wood and wood products, drywall, insulation paper, cardboard, flooring materials including subfloor

SYMPTOMS

Skin irritation, tenderness, redness, itching, desquamation - can be severe
Weakness, muscle loss
Fatigue with lassitude
Cognitive impairment
Dizziness, loss of coordination
Blurred or changing vision
Nasal and throat irritation, pain, itching
Sneezing, runny nose, nosebleeds
Wheezing, cough (potentially bloody)
Difficulty breathing, chest pain
Loss of appetite
Nausea, vomiting (potentially bloody)
Abdominal pain
Diarrhea (potentially bloody)
Altered intestinal permeability
Infertility
Anemia
Hypotension
Inability to mount a fever
Increased susceptibility to infections
Bleeding disorders

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Trichothecenes are not detoxified uniformly due to their unique molecular structures, though the liver is primary and common metabolic pathways exist. Glucuronidation is one of the primary conjugation reactions in Phase II, making these mycotoxins more water-soluble and easier to excrete. Unlike other mycotoxins, the secondary metabolites appear to be less toxic than the original molecule. Therefore, the focus of treatment is to enhance excretion by supporting UDP-glucuronosyltransferase (UGT) activity and providing glucuronic acid precursors.

After metabolism, the toxins and their metabolites are excreted through urine and through feces via bile conjugation. Once rendered water-soluble, the ratio of excretion from urine to feces is more efficient at approximately 3 to 1, depending on the specific trichothecene.

Even though the binding target for trichothecenes is bile to sequester the bile conjugate, it's worth noting that some trichothecenes may be directly excreted into the intestines without prior glucuronidation. Animal models suggest that the microbiome is more effective for ingested exposure than adsorbent binders, with the microbiome playing a crucial role in metabolic alteration for excretion.

HEALTH IMPACTS

Dermatologic, ocular, respiratory, gastrointestinal, multi-organ, and reproductive toxicity, immunotoxic, hematologic toxicity, neurotoxic, genotoxic, protein synthesis inhibition, mitochondria dysfunction.

Dermatological. Cutaneous exposure to airborne trichothecenes can elicit severe dermatological reactions, including acute irritation and potential long-term alterations in skin barrier function and integrity.

Ocular. Ocular toxicity from trichothecene exposure may result in acute irritation, corneal damage, and potential long-term visual impairment, highlighting the vulnerability of ocular tissues to these mycotoxins.

Respiratory. Inhalation of trichothecenes can induce a spectrum of respiratory pathologies, including blistering and chronic inflammatory conditions of the upper and lower airways, potentially leading to long-term pulmonary dysfunction.

Gastrointestinal. Despite the inhalational route of exposure, trichothecenes can induce significant gastrointestinal disturbances, including vomiting and diarrhea with a tendency toward bleeding, potentially due to systemic absorption and circulation.

Immune. Trichothecene exposure may result in significant immunomodulation, characterized by both immunosuppression and aberrant inflammatory responses, potentially precipitating autoimmune sequelae. Immune effects include preventing lymphocyte proliferation, impairing antibody production, and changing dendritic cell growth. They also damage the macrophage system and increase sensitivity to endotoxins.

Hematological. Trichothecene exposure may lead to hematopoietic alterations and hemostatic derangements, suggesting potential for both acute and chronic effects on blood cell production and coagulation cascades.

Neurological. Neurotoxicity arising from trichothecene exposure manifests as a constellation of neurocognitive and neuropsychiatric symptoms, suggesting potential for both acute and chronic neuropathological alterations.

Cardiovascular. While less extensively studied, cardiovascular alterations have been observed following trichothecene exposure, indicating potential for these mycotoxins to impact cardiac function and vascular homeostasis.

Reproductive. Trichothecene exposure has been associated with decreased reproductive capacity in animal models, suggesting potential for these mycotoxins to disrupt endocrine function and gametogenesis.

Systemic. Trichothecenes exhibit multiorgan toxicity, inducing oxidative stress and mitochondrial dysfunction across various tissues, potentially leading to widespread cellular and metabolic perturbations. Chronic exposure to trichothecenes has been associated with a diverse array of systemic manifestations, including chemical sensitivity, chronic fatigue syndrome, and dysautonomia, suggesting complex interactions with multiple physiological systems.

Genetic. Trichothecenes have demonstrated genotoxic potential, forming DNA adducts in both nuclear and mitochondrial genomes, which may contribute to mutagenesis and long-term health consequences.

Protein synthesis inhibition. Potent inhibitors of protein and nucleic acid synthesis, and inducers of apoptosis. This leads to substantial inhibition of proteins, mitochondrial function, cell division, and RNA and DNA synthesis. Once they enter the systemic circulation, regardless of the route of exposure, they affect rapidly proliferating tissues.

Bile malabsorption. Cause bile acid malabsorption in the intestines by down-regulating the expression of bile acid transporters and changing bile acid intestinal kinetics. Results in deficiencies of fat-soluble and bile precursor nutrients.

TREATMENT OPTIONS

*Note: the doses listed are intended for when each item is used as a standalone therapy. When multiple items are combined, they often work synergistically, meaning lower doses can typically achieve similar effectiveness due to their complementary effects.

Therapeutic Diet ~
- Green tea
- Extra-virgin olive oil
- Brassicaceae family (sulforaphanes and other bioactive compounds to induce UGT expression in animal studies.)

Binder. Insoluble fiber or super-fine ground dried okra: 2-4 Tbsp divided daily with food; or other bile sequestrants for bile conjugated trichothecenes.
- Lemongrass powder: 1/8-1/4 tsp twice daily with food, for unconjugated trichothecenes.

Probiotic. Bacillus spp. for intestinal degradation of unconjugated trichothecenes in the gut.

Bioflavonoids.
- Green tea polyphenols. Cytoprotective against multiple trichothecenes.
- Lycopene. Hepatoprotective. (T-2 toxin specific effect.)
- Quercetin. Myoprotective.
- Rutin. Hepatoprotective.
- Hesperidin. Hepatoprotective.

Milk Thistle (Silybum marianum). 750mg daily, best divided.
- Promotes regeneration of the liver via combating tricothecene protein synthesis inhibition.

Black cumin (Nigella sativa). 500mg twice daily.
- Hepatoprotective. (verrucarin, roridin)

Red sage (Salvia miltiorrhiza/Danshen). 500mg up to three times daily.
- Reduces intestinal epithelial cell injury.

Turmeric (Curcuma longa). 500mg up to two times daily. Start lower with sensitive patients.
- Mitigates intestinal barrier disruption.

Melatonin. Highest tolerated dose up to 20mg hs.
- Alleviates damage to spleen and thymus, and oocytes.

Combine CoQ10 and Vitamin E to support glutathione. (Trichothecene-specific effect.)

Selenium. 200mcg twice daily. Immunoprotective. (T-2 toxin)

Glutathione. Up to 450mg liposomal daily. Start very low if still exposed or sensitive. Cytoprotective. (T-2 toxin)

Leucine. 150mg daily.
- Trichothecenes strongly inhibit leucine incorporation in hypothalamus, causing brain protein synthesis inhibition and hypothalamic dysregulation, with a net antipyretic effect.

Taurine. 500mg once to twice daily.
- Hepatoprotective. (T-2 toxin)

REFERENCES

Pitt JI, Wild CP, Baan RA, Gelderblom WCA, Miller JD, Riley RT, Wu F, editors. Improving public health through mycotoxin control. Lyon (FR): International Agency for Research on Cancer; 2012. (IARC Scientific Publications, No. 158)

Cundliffe E, Cannon M, Davies J. Mechanism of inhibition of eukaryotic protein synthesis by trichothecene fungal toxins. Proc Natl Acad Sci U S A. 1974 Jan;71(1):30-4. doi: 10.1073/pnas.71.1.30. PMID: 4521056; PMCID: PMC387925.

McCormick SP, Stanley AM, Stover NA, Alexander NJ. Trichothecenes: from simple to complex mycotoxins. Toxins (Basel). 2011 Jul;3(7):802-14. doi: 10.3390/toxins3070802. Epub 2011 Jul 1. PMID: 22069741; PMCID: PMC3202860.

Janik E, Niemcewicz M, Podogrocki M, Ceremuga M, Stela M, Bijak M. T-2 Toxin-The Most Toxic Trichothecene Mycotoxin: Metabolism, Toxicity, and Decontamination Strategies. Molecules. 2021 Nov 14;26(22):6868. doi: 10.3390/molecules26226868. PMID: 34833960; PMCID: PMC8618548.

Proctor RH, McCormick SP, Kim HS, Cardoza RE, Stanley AM, Lindo L, Kelly A, Brown DW, Lee T, Vaughan MM, Alexander NJ, Busman M, Gutiérrez S. Evolution of structural diversity of trichothecenes, a family of toxins produced by plant pathogenic and entomopathogenic fungi. PLoS Pathog. 2018 Apr 12;14(4):e1006946. doi: 10.1371/journal.ppat.1006946. PMID: 29649280; PMCID: PMC5897003.

Johnsen, Helge. On The Toxicity and Metabolism of the Trichothecene Mycotoxin T-2 Toxin. Norwegian Defence Research Establishment, June 1988. https://apps.dtic.mil/sti/tr/pdf/ADA208537.pdf.

WHO; Environ Health Criteria 105: Selected Mycotoxins: Ochratoxins, Trichothecenes, Ergot (1990). https://www.inchem.org/documents/ehc/ehc/ehc105.htm.

Rocha O, Ansari K, Doohan FM. Effects of trichothecene mycotoxins on eukaryotic cells: a review. Food Addit Contam. 2005 Apr;22(4):369-78. doi: 10.1080/02652030500058403. PMID: 16019807.

Wang J, Bakker W, Zheng W, de Haan L, Rietjens IMCM, Bouwmeester H. Exposure to the mycotoxin deoxynivalenol reduces the transport of conjugated bile acids by intestinal Caco-2 cells. Arch Toxicol. 2022 May;96(5):1473-1482. doi: 10.1007/s00204-022-03256-8. Epub 2022 Feb 28. PMID: 35224661; PMCID: PMC9013688.

Zhang J, Liu X, Su Y, Li T. An update on T2-toxins: metabolism, immunotoxicity mechanism and human assessment exposure of intestinal microbiota. Heliyon. 2022 Jul 20;8(8):e10012. doi: 10.1016/j.heliyon.2022.e10012. PMID: 35928103; PMCID: PMC9344027.

Doi K, Ishigami N, Sehata S. T-2 toxin-induced toxicity in pregnant mice and rats. Int J Mol Sci. 2008 Nov;9(11):2146-2158. doi: 10.3390/ijms9112146. Epub 2008 Nov 5. PMID: 19330064; PMCID: PMC2635623.

Yang GH, Jarvis BB, Chung YJ, Pestka JJ. Apoptosis induction by the satratoxins and other trichothecene mycotoxins: relationship to ERK, p38 MAPK, and SAPK/JNK activation. Toxicol Appl Pharmacol. 2000 Apr 15;164(2):149-60. doi: 10.1006/taap.1999.8888. PMID: 10764628.

Wu X, Murphy P, Cunnick J, Hendrich S. Synthesis and characterization of deoxynivalenol glucuronide: its comparative immunotoxicity with deoxynivalenol. Food Chem Toxicol. 2007 Oct;45(10):1846-55. doi: 10.1016/j.fct.2007.03.018. Epub 2007 Apr 11. PMID: 17507135.

Strassburg CP, Nguyen N, Manns MP, Tukey RH. UDP-glucuronosyltransferase activity in human liver and colon. Gastroenterology. 1999 Jan;116(1):149-60. doi: 10.1016/s0016-5085(99)70239-8. PMID: 9869613.

Awad WA, Ghareeb K, Bohm J, Zentek J. Decontamination and detoxification strategies for the Fusarium mycotoxin deoxynivalenol in animal feed and the effectiveness of microbial biodegradation. Food Addit Contam Part A Chem Anal Control Expo Risk Assess. 2010 Apr;27(4):510-20. doi: 10.1080/19440040903571747. PMID: 20234966.

JC Eya, A Parsons, I Haile, P Jagidi. Effects of dietary zeolites (bentonite and mordenite) on the performance juvenile rainbow trout Onchorhynchus myskis. Australian Journal of Basic and Applied Sciences, 2008.

Yoshizawa T, Morooka N. Comparative studies on microbial and chemical modifications of trichothecene mycotoxins. Appl Microbiol. 1975 Jul;30(1):38-43. doi: 10.1128/am.30.1.38-43.1975. PMID: 1147618; PMCID: PMC187110.

Yao Y, Long M. The biological detoxification of deoxynivalenol: A review. Food Chem Toxicol. 2020 Nov;145:111649. doi: 10.1016/j.fct.2020.111649. Epub 2020 Aug 1. PMID: 32745571.

Adhikari M, Negi B, Kaushik N, Adhikari A, Al-Khedhairy AA, Kaushik NK, Choi EH. T-2 mycotoxin: toxicological effects and decontamination strategies. Oncotarget. 2017 May 16;8(20):33933-33952. doi: 10.18632/oncotarget.15422. PMID: 28430618; PMCID: PMC5464924.

Wannemacher, R.W. JR., and Wiener, S.L. (1997). Chapter 34: Trichothecene Mycotoxins. In R. Zajtchuk (Ed.), Medical Aspects of Chemical and Biological Warfare. Maryland: Office of The Surgeon General.

Illinois Department of Public Health, Emergency Preparedness Response, Bioterrorism Fact Sheet: Trichothecene Mycotoxins. https://dph.illinois.gov/topics-services/emergency-preparedness-response/public-health-care-system-preparedness/trichothecene-mycotoxin.html.

Hemmati AA, Kalantari H, Jalali A, Rezai S, Zadeh HH. Healing effect of quince seed mucilage on T-2 toxin-induced dermal toxicity in rabbit. Exp Toxicol Pathol. 2012 Mar;64(3):181-6. doi: 10.1016/j.etp.2010.08.004. Epub 2010 Sep 15. PMID: 20832267.

Chen Y, Zhang BC, Sun YH, Zhang JG, Sun HJ, Wei ZJ. Physicochemical properties and adsorption of cholesterol by okra (Abelmoschus esculentus) powder. Food Funct. 2015 Dec;6(12):3728-36. doi: 10.1039/c5fo00600g. Epub 2015 Sep 11. PMID: 26359588.

Upadhyay P, Agarwal S, Upadhyay S. Hydrophobically Modified Abelmoschus esculentus Polysaccharide Based Nanoparticles and Applications: A Review. Curr Drug Discov Technol. 2022;19(6):e010822207168. doi: 10.2174/1570163819666220801121857. PMID: 35927911.

Ramasamy T, Varshneya C, Katoch VC. Immunoprotective Effect of Seabuckthorn (Hippophae rhamnoides) and Glucomannan on T-2 Toxin-Induced Immunodepression in Poultry. Vet Med Int. 2010 Dec 1;2010:149373. doi: 10.4061/2010/149373. PMID: 21151701; PMCID: PMC2995906.

Atroshi F, Rizzo A, Biese I, Veijalainen P, Antila E, Westermarck T. T-2 toxin-induced DNA damage in mouse livers: the effect of pretreatment with coenzyme Q10 and alpha-tocopherol. Mol Aspects Med. 1997;18 Suppl:S255-8. doi: 10.1016/s0098-2997(97)00032-0. PMID: 9266532.

Ning C, Xiao W, Liang Z, Wu Y, Fan H, Wang S, Kong X, Wang Y, Wu A, Li Y, Yuan Z, Wu J, Yang C. Melatonin alleviates T-2 toxin-induced oxidative damage, inflammatory response, and apoptosis in piglet spleen and thymus. Int Immunopharmacol. 2024 Mar 10;129:111653. doi: 10.1016/j.intimp.2024.111653. Epub 2024 Feb 13. PMID: 38354511.

Xue R, Li S, Zou H, Ji D, Lv M, Zhou P, Wei Z, Zhang Z, Cao Y. Melatonin alleviates deoxynivalenol-induced apoptosis of human granulosa cells by reducing mutually accentuated FOXO1 and ER stress‡. Biol Reprod. 2021 Aug 3;105(2):554-566. doi: 10.1093/biolre/ioab084. PMID: 33907797.

Lan M, Han J, Pan MH, Wan X, Pan ZN, Sun SC. Melatonin protects against defects induced by deoxynivalenol during mouse oocyte maturation. J Pineal Res. 2018 Aug;65(1):e12477. doi: 10.1111/jpi.12477. Epub 2018 Mar 25. PMID: 29453798.

REFERENCES

Sugiyama K, Kinoshita M, Kamata Y, Minai Y, Sugita-Konishi Y. (-)-Epigallocatechin gallatsuppresses the cytotoxicity induced by trichothecene mycotoxins in mouse cultural macrophages. Mycotoxin Res. 2011 Nov;27(4):281-5. doi: 10.1007/s12550-011-0105-8. Epub 2011 Jun 29. PMID: 23605930.

Kalaiselvi P, Rajashree K, Bharathi Priya L, Padma VV. Cytoprotective effect of epigallocatechin-3-gallate against deoxynivalenol-induced toxicity through anti-oxidative and anti-inflammatory mechanisms in HT-29 cells. Food Chem Toxicol. 2013 Jun;56:110-8. doi: 10.1016/j.fct.2013.01.042. Epub 2013 Feb 11. PMID: 23410590.

Dvorska JE, Pappas AC, Karadas F, Speake BK, Surai PF. Protective effect of modified glucomannans and organic selenium against antioxidant depletion in the chicken liver due to T-2 toxin-contaminated feed consumption. Comp Biochem Physiol C Toxicol Pharmacol. 2007 May;145(4):582-7. doi: 10.1016/j.cbpc.2007.02.005. Epub 2007 Feb 12. PMID: 17350343.

Leal M, Shimada A, Ruíz F, González de Mejía E. Effect of lycopene on lipid peroxidation and glutathione-dependent enzymes induced by T-2 toxin in vivo. Toxicol Lett. 1999 Sep 20;109(1-2):1-10. doi: 10.1016/s0378-4274(99)00062-4. PMID: 10514025.

Huang X, Huang Z, Sun L, Qiu M, Deng Q, Fang Z, Wang Y. Protective mechanisms of three antioxidants against T-2 toxin-induced muscle protein deterioration in shrimp. J Sci Food Agric. 2022 Aug 30;102(11):4883-4891. doi: 10.1002/jsfa.11851. Epub 2022 Mar 15. PMID: 35244220.

Wang X, Chen H, Jiang J, Ma J. Hesperidin Alleviates Hepatic Injury Caused by Deoxynivalenol Exposure through Activation of mTOR and AKT/GSK3β/TFEB Pathways. J Agric Food Chem. 2024 Jun 26;72(25):14349-14363. doi: 10.1021/acs.jafc.4c02039. Epub 2024 Jun 13. PMID: 38869217.

Cao Z, Gao J, Huang W, Yan J, Shan A, Gao X. Curcumin mitigates deoxynivalenol-induced intestinal epithelial barrier disruption by regulating Nrf2/p53 and NF-κB/MLCK signaling in mice. Food Chem Toxicol. 2022 Sep;167:113281. doi: 10.1016/j.fct.2022.113281. Epub 2022 Jul 8. PMID: 35817260.

Ledur PC, Santurio JM. Cytoprotective effects of curcumin and silymarin on PK-15 cells exposed to ochratoxin A, fumonisin B1 and deoxynivalenol. Toxicon. 2020 Oct 15;185:97-103. doi: 10.1016/j.toxicon.2020.06.025. Epub 2020 Jul 2. PMID: 32622693.

Zhang C, Chen F, Wang Y, Zhang K, Yang X, Wang X. Tanshinone IIA protects intestinal epithelial cells from deoxynivalenol-induced pyroptosis. Ecotoxicol Environ Saf. 2024 Jan 1;269:115743. doi: 10.1016/j.ecoenv.2023.115743. Epub 2023 Nov 29. PMID: 38035519.

El-Sawi, N.M. and Gashlan, H.M. 2010. Effect of Nigella sativa oil and activated charcoal as antioxidant on verrucarin J induced hepatotoxicity in male rats. J. Appl. Anim. Res., 37: 285–288.

Safaa Y. Qusti & Nagwa M. El-Sawi Mahmoud (2007) Effect of Nigella sativa L. Oil on Roridin E Toxin Administration on Liver of Male Mice, Journal of Applied Animal Research, 31:2, 161-164, DOI: 10.1080/09712119.2007.9706653

Adhikari M, Negi B, Kaushik N, Adhikari A, Al-Khedhairy AA, Kaushik NK, Choi EH. T-2 mycotoxin: toxicological effects and decontamination strategies. Oncotarget. 2017 May 16;8(20):33933-33952. doi: 10.18632/oncotarget.15422. PMID: 28430618; PMCID: PMC5464924.

Zhang J, Han Y, Song M, Wang Q, Cao Z, Yang X, Li Y. Selenium Improves Bone Microenvironment-Related Hematopoiesis and Immunity in T-2 Toxin-Exposed Mice. J Agric Food Chem. 2023 Feb 8;71(5):2590-2599. doi: 10.1021/acs.jafc.2c08275. Epub 2023 Jan 24. PMID: 36693005.

Li SJ, Zhang G, Xue B, Ding Q, Han L, Huang JC, Wu F, Li C, Yang C. Toxicity and detoxification of T-2 toxin in poultry. Food Chem Toxicol. 2022 Nov;169:113392. doi: 10.1016/j.fct.2022.113392. Epub 2022 Aug 28. PMID: 36044934.

Cannon M, Cranston WI, Hellon RF, Townsend Y. Inhibition, by trichothecene antibiotics, of brain protein synthesis and fever in rabbits. J Physiol. 1982 Jan;322:447-55. doi: 10.1113/jphysiol.1982.sp014048. PMID: 7069625; PMCID: PMC1249681.

Al-Zahrani MH, Balgoon MJ, El-Sawi NM, Alshubaily FA, Jambi EJ, Khojah SM, Baljoon RS, Alkhattabi NA, Baz LA, Alharbi AA, Ahmed AM, Abo Elkhair AM, Ismael M, Gebril SM. A biochemical, theoretical and immunohistochemical study comparing the therapeutic efficacy of curcumin and taurine on T-2 toxin induced hepatotoxicity in rats. Front Mol Biosci. 2023 May 4;10:1172403. doi: 10.3389/fmolb.2023.1172403. PMID: 37214337; PMCID: PMC10192634.