# Understanding Molds and Mycotoxins in Corn and DDGS

Dr. Jerry Shurson
Department of Animal Science
University of Minnesota

# Introduction

- What are mycotoxins?
  - Compounds produced in grain by specific molds as secondary metabolites that may or may not be toxic to animals and humans.

# Introduction

| | Known | Postulated |
|---|---|---|
| Mold species | 1,100 | 1,500,000 |
| Secondary metabolites | 3,200 | 3,000,000 |
| Mycotoxins | > 300 | 30,000 |

# Introduction

- Approximately 300 - 400 mycotoxins have been identified
  - Only a few cause detrimental effects when fed to livestock
    - Aflatoxin
    - Deoxynivalenol (vomitoxin)
    - Zearalenone
    - Fumonisin
    - Ochratoxin
    - T-2 toxin
    - Ergot

# Introduction

- Presence of molds does not automatically result in presence of mycotoxins

- Primary fungi that produce mycotoxins detrimental to livestock are:
  - Aspergillus
  - Penicillium
  - Gibberella
  - Fusarium

# Aspergillus

Appears as a grayish-green powdery mold that may begin at the tip of the ear or follow insect injury tracks. Infected kernels are brownish, lightweight, and shrunken. The fungus **produces aflatoxin and ochratoxin**.

Source: Pioneer CropFocus

# Penicillium

Green or blue-green powdery mold that occurs between the kernels usually at the ear tip. Infected kernels can appear bleached or streaked. This **mold produces mycotoxins (ochratoxin)**.

Source: Pioneer CropFocus

# Gibberella

Develops as a red or pink mold that almost always begins at the tip of the ear. The silks and husks may stick to the ear due to mold growth. In severe cases, the pink mold is visible on the outside of the husks at the ear tip. The fungus **produces vomitoxin**.

Source: Pioneer CropFocus

# Fusarium

Symptoms include a white to pink, cottony mold that can begin anywhere on the ear but often begins with insect-damaged or split kernels. Usually the entire ear is not rotted and affected kernels are scattered across the ear. Infected kernels are usually tan or brown or have white streaks. The fungus **produces vomitoxin, zearalenone, T-2 toxin, and fumonisin**.

Source: Pioneer CropFocus

# Cladosporium

Dark green or black powdery mold that also causes black streaks on kernels. It usually forms first where kernels are attached to the cob. This mold **is not** a concern for mycotoxins.

Source: Pioneer CropFocus

# Trichoderma

Dark green mold that grows on or between kernels and often covers the entire ear. This disease typically is not economically damaging because it only occurs on scattered ears. This mold **is not** a concern for mycotoxins.

Source: Pioneer CropFocus

# Diplodia

Initially appears as a white mold beginning at the base of the ear but eventually becomes grayish-brown and rots the entire ear. The mold may be apparent on the outside of the husk or on the shank. There may be raised black bumps on the moldy husk or kernels. This mold **is not a concern for mycotoxins.**

Source: Pioneer CropFocus

# Primary Toxogenic Molds and Mycotoxins They Produce

- Fusarium
  - Deoxnivalenol
  - Zearalenone
  - T-2 toxin
  - Fumonisins
  - Moniliformin
  - Nivalenol
  - Diacetoxyscirpenol
  - Butenolide
  - Neosolaniol
  - Fusaric acid
  - Fusarochromanone
  - Wortmannin

# Primary Toxogenic Molds and Mycotoxins They Produce

- Aspergillus
  - Aflatoxin
  - Ochratoxin
  - Sterigmatocystin
  - Fumitremorgens
  - Fumigaclavines
  - Fumitoxins
  - Cyclopiazonoic acid
  - Gliotoxin

# Primary Toxogenic Molds and Mycotoxins They Produce

- Penicillium
  - Ochratoxin
  - PR toxin
  - Patulin
  - Penicillic acid
  - Citrinin
  - Penetrem
  - Cyclopiazonic acid

# Introduction

- Mycotoxin production can occur during:
  - Plant growth
  - Maturity
  - Harvesting
  - Storage
  - Grain processing
- Damaged, immature, drought stricken, or stressed plants are more susceptible to mold growth

# Primary Mechanisms Through Which Mycotoxins Affect Animals

- Reduction in feed intake

- Suboptimal nutrition
  - Reduce nutrient content of feed
  - Reduce nutrient absorption
  - Alter nutrient metabolism

- Suppress the immune system
- Hormonal effects (primarily estrogenic)
- Antibiotic effects
- Cellular death

# Aflatoxins

- Many types
  - B1, B2, G1, G2, M1, M2
- Produced by *Aspergillus flavus* under ideal production conditions:
  - 82° to 90° F
  - Grain moisture 22% to 26%
- More of a problem in the SE U.S.
- Occur in the Midwest during drought conditions

# Aflatoxins

- Only mycotoxin regulated by FDA
  - Carcinogenic
- No more than 20 ppb allowed for interstate shipment
- Grains with > 20 ppb can not be used for human food consumption and dairy feeds
  - Should not be used in feeds for young animals

# Aflatoxins

- At 20 to 200 ppb
  - Reduces appetite and growth rate
  - Suppresses the immune system
  - Decreases milk production

- > 1000 ppb
  - Death

# FDA Action Levels for Aflatoxins

| | |
|---|---|
| • finishing beef cattle | < 300 ppb |
| • finishing swine (>100 lbs) | < 200 ppb |
| • breeding beef cattle | < 100 ppb |
| • breeding swine | < 100 ppb |
| • mature poultry | < 100 ppb |
| • immature animals, dairy cattle, or intended use is not known | < 20 ppb |

# Deoxynivalenol (vomitoxin)

- Produced by *Fusarium graminearum*
  - White or reddish fungus
- Ideal growing conditions
  - Cool, damp weather
- More common in upper Midwest and Canada
- Reduces feed consumption and causes vomiting at high levels

# FDA Action Levels for DON

- Beef cattle > 4 mo. of age < 10 ppm
- Chickens < 10 ppm
  - these ingredients should be > 50% of the diet of cattle and chickens
- All other animals < 5 ppm
  - these ingredients not exceed 40% of the diet of cattle and chickens
- Swine < 5 ppm
  - these ingredients not exceed 20% of the diet

# Zearalenone

- Produced by *Fusarium graminearum* and may be present with DON
- More likely to be produced during grain storage
- Mimics the action of estrogen and should NOT be fed to breeding animals
- Causes
  - Abortions
  - Prolapses
  - Shrunken ovaries
  - Decreased fertility

# FDA Action Levels for Zearalenone

- None
- Swine
  - Finishing pigs < 3 ppm
  - Breeding herd < 2 ppm
  - Young growing pigs < 1 ppm

# Fumonisins

- Types B1 (75%), B2, and B3
- Produced by *Fusarium moniliforme*
- Found in corn in upper Midwest
- Carcinogenic
- Causes:
  - Weakened immune system
  - Pulmonary edema
  - Reduced brain, liver and lung function

# FDA Action Levels for Fumonisins

- Poultry being raised for slaughter — < 100 ppb
  - < than 50% of the diet
- Ruminants raised for slaughter — < 60 ppb
  - < 50% of the diet
- Breeding ruminants and poultry — < 30 ppb
  - < 50% of the diet
- Swine — < 20 ppb
  - < 50% of the diet
- All other species or classes of livestock and pets — < 10 ppb
  - < 50% of the diet
- Horses and rabbits — < 5 ppb
  - < 20% of the diet

# Mycotoxin Adsorbents

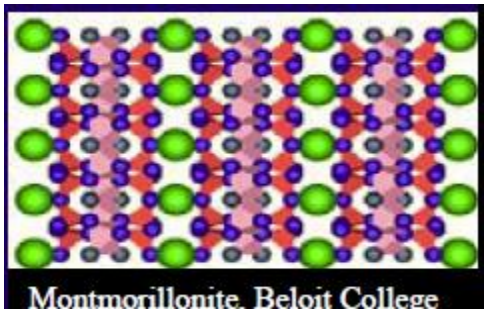
- An ideal mycotoxin adsorbent should effectively sequester mycotoxin(s) to prevent toxicity in the gastrointestinal tract and prevent absorption across the gut wall when added to the diet.

# A Mycotoxin Adsorbent Should:

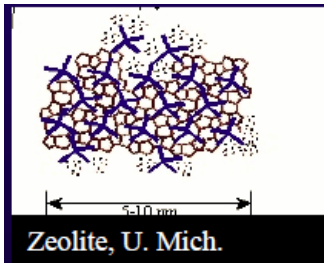
- Effectively adsorb mycotoxins of interest
- Reduce mycotoxin availability/activity
- Reduce animal toxicity and tissue residues
- Not be detrimental to the animal of food products
- Have verifiable positive results
- Have verifiable inclusion in diets
- Resistant to physical effects of feed manufacturing
- Cost effective

# Mycotoxin Adsorbents

- Silicate products
  - Phyllosilicates (silicate sheets)
    - Clays
      - Montmorillonite
      - Bentonite
      - Smectite (HSCAS)
      - Sepiolite




  - Tectosilicate (silicate frameworks)
    - Zeolites
    - Clinoptiliolite



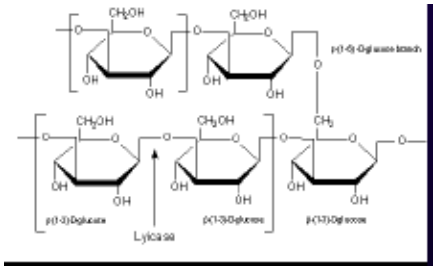

- Chemically treated silicates

# Mycotoxin Adsorbents

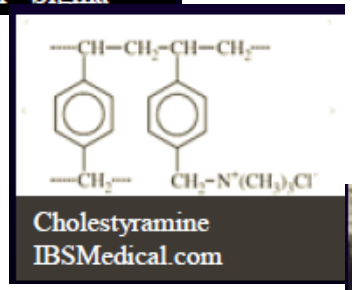
- Carbon products
  - Activated or superactivated charcoal

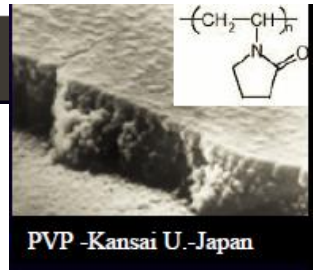

Activated charcoal, OHSU

- Glucan products


Yeast 1,3 *B* Glucan - Sigma

- Inorganic polymers
  - Cholestyramine
  - Polyvinylpyrrolidone (PVP)


Cholestyramine
IBSMedical.com


PVP -Kansai U.-Japan

# Effectiveness of Mycotoxin Adsorbents (Positive Responses/Trials)

| Mycotoxin | Carbon | Glucan | Clay | Zeolite | PVP | Bacteria | Clay/Enzyme |
|---|---|---|---|---|---|---|---|
| Aflatoxin | **6/8** | **7/9** | **35/35** | **11/16** | **1/2** | - | - |
| DON | - | - | 0/1 | - | - | - | - |
| Zearalenone | **1/1** | 0/1 | **1/2** | **2/3** | - | - | - |
| T-2 | **3/3** | **1/1** | 0/5 | 0/1 | - | - | - |
| "Fusarium" | - | **5/9** | **1/2** | 0/1 | - | - | 0/2 |
| Aflatoxin + "Fusarium" | - | **2/2** | **1/1** | - | - | **1/1** | - |

> 50% positive responses

# Are there any effective commercial products for vomitoxin?

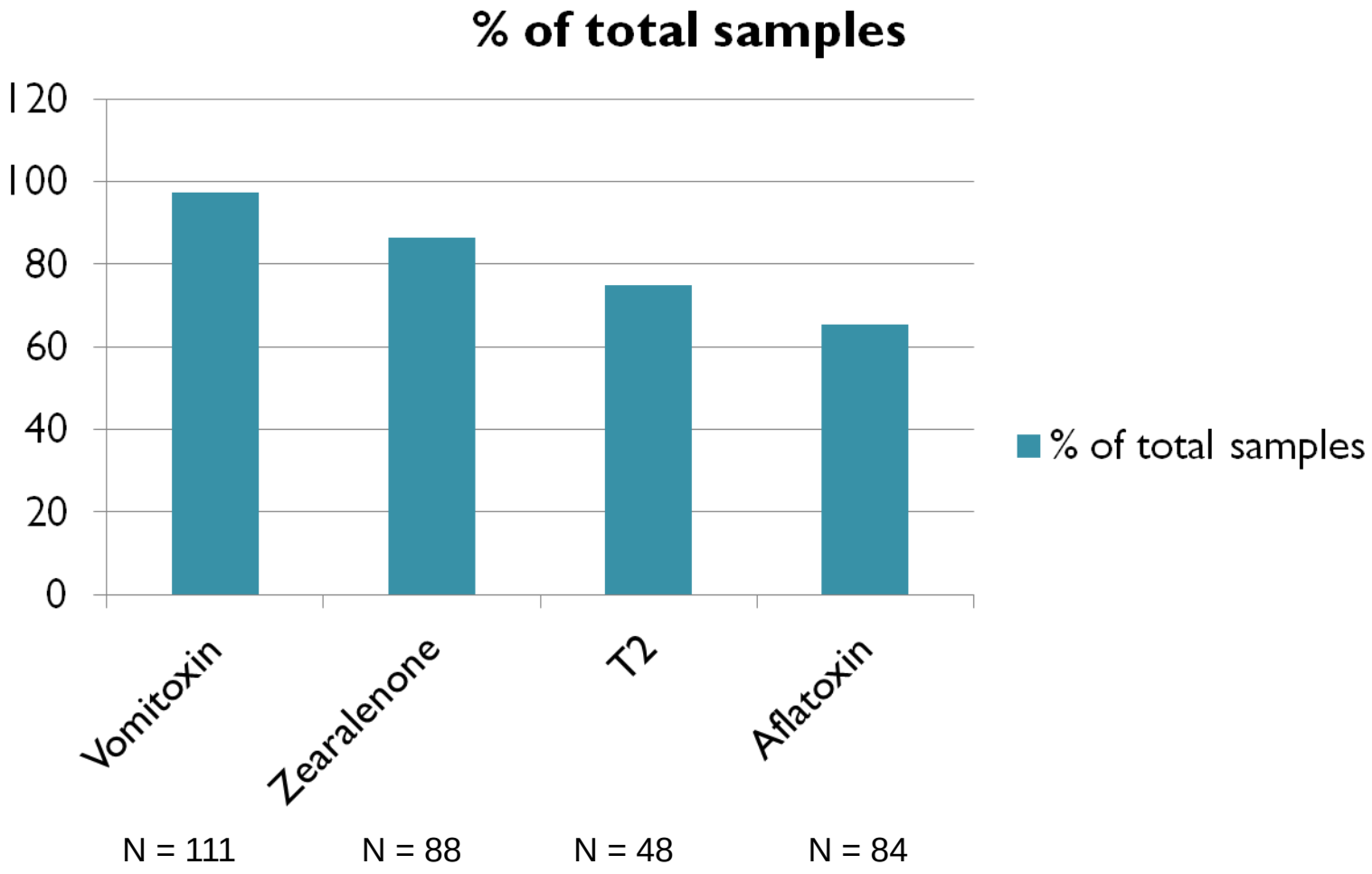
- Very little published information
  - Field experience is about the only source
- Several products are being used that can't be legally called mycotoxin binders
- Hydrolyzed yeast (glucan) products provide some effectiveness depending on level of DON
  - No benefits in feeds with > 5 ppm DON
  - Some benefits in feeds with < 5 ppm DON
  - Greater benefits in feeds with < 3 ppm DON

# Summary of Mycotoxin Adsorbents

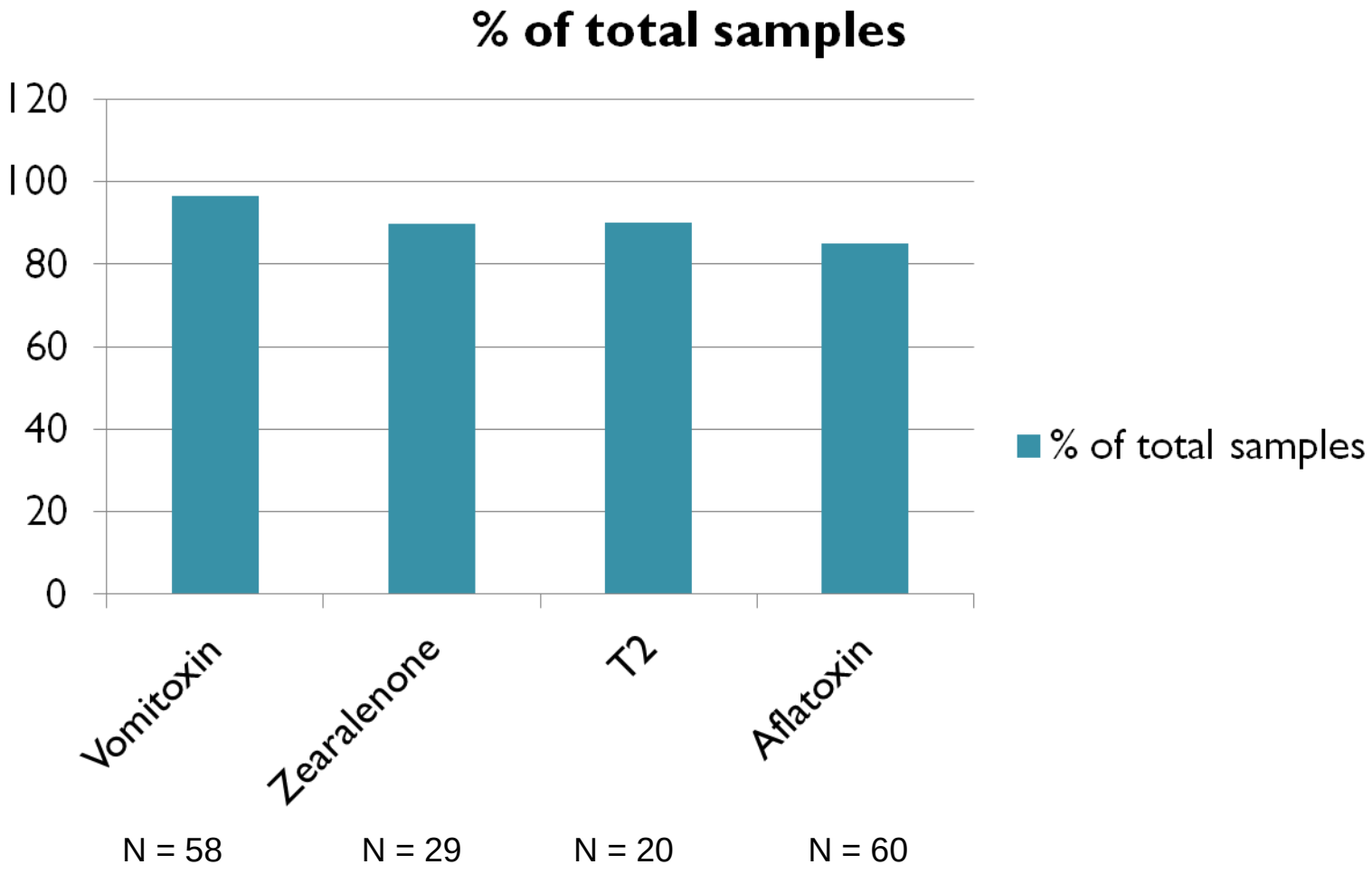
- Responses to adsorbents similar across species
- Some adsorbents are mycotoxin specific
- No adsorbent has been shown to be effective across all mycotoxins
- Adsorption varies with adsorbent types
- Most studies have been done on silicates and aflatoxin
- Limited data for inorganic polymers (PVP & cholysteramine)
- Research on bacterial adsorption is beginning and promising


510

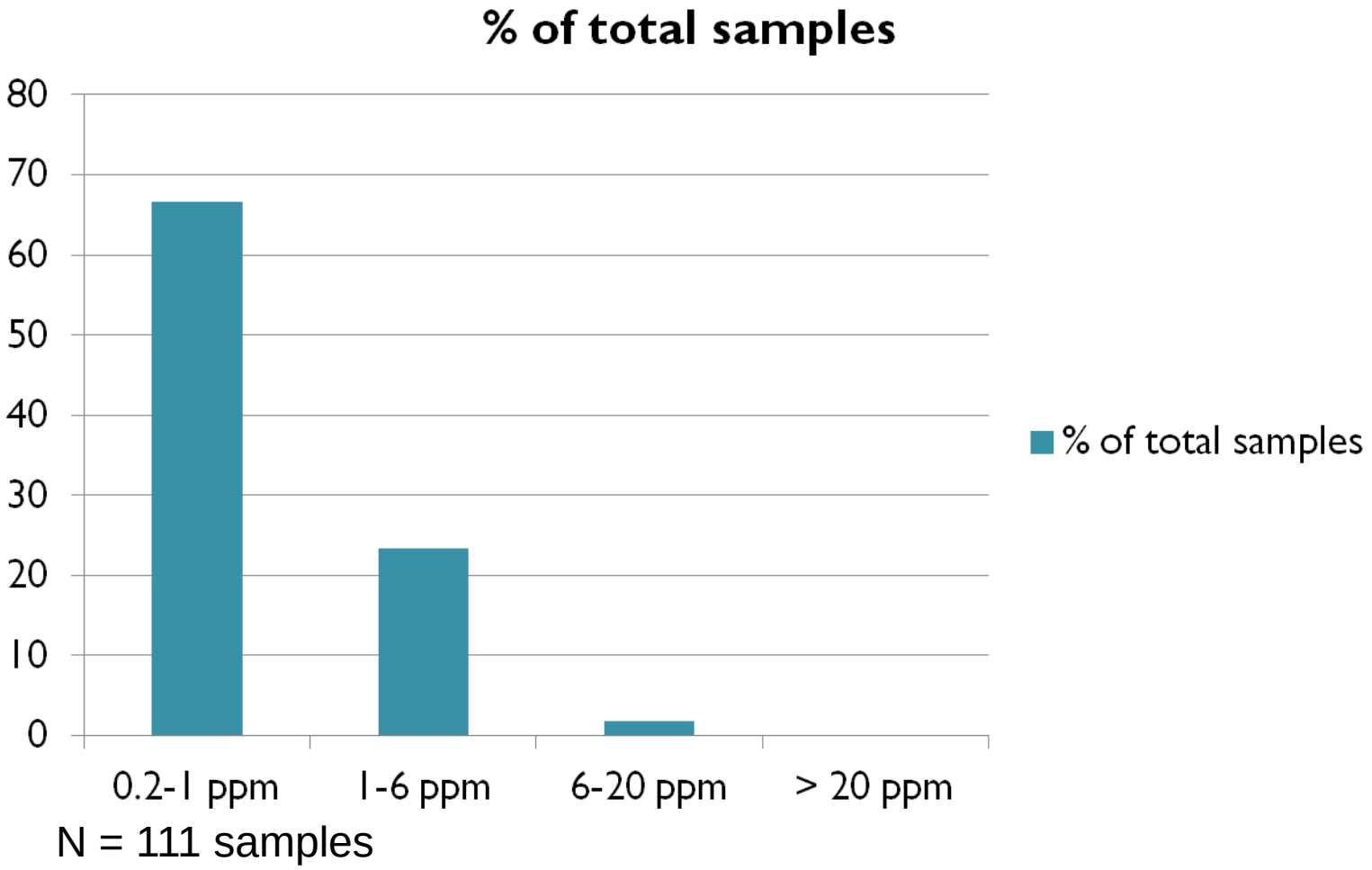
# Percentage of Corn Samples Testing Positive for Mycotoxins (Dairyland Laboratories, Inc. 8/1/11 -12/12/11)



# Percentage of DDGS Samples Testing Positive for Mycotoxins (Dairyland Laboratories, Inc. 8/1/11 -12/12/11)

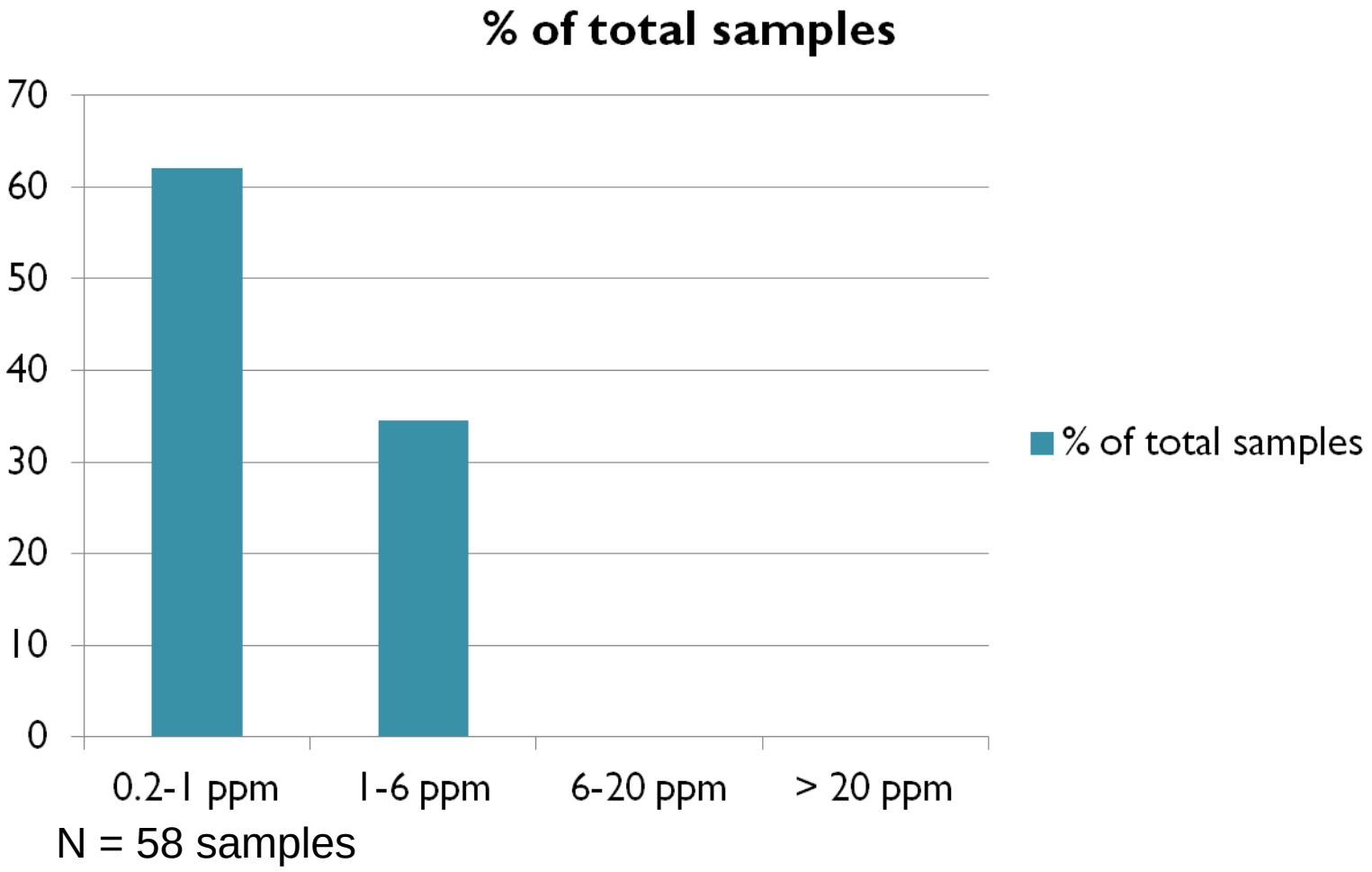


# % of Corn Samples Containing Various Levels of Vomitoxin (Dairyland Laboratories, Inc. 8/1/11 -12/12/11)



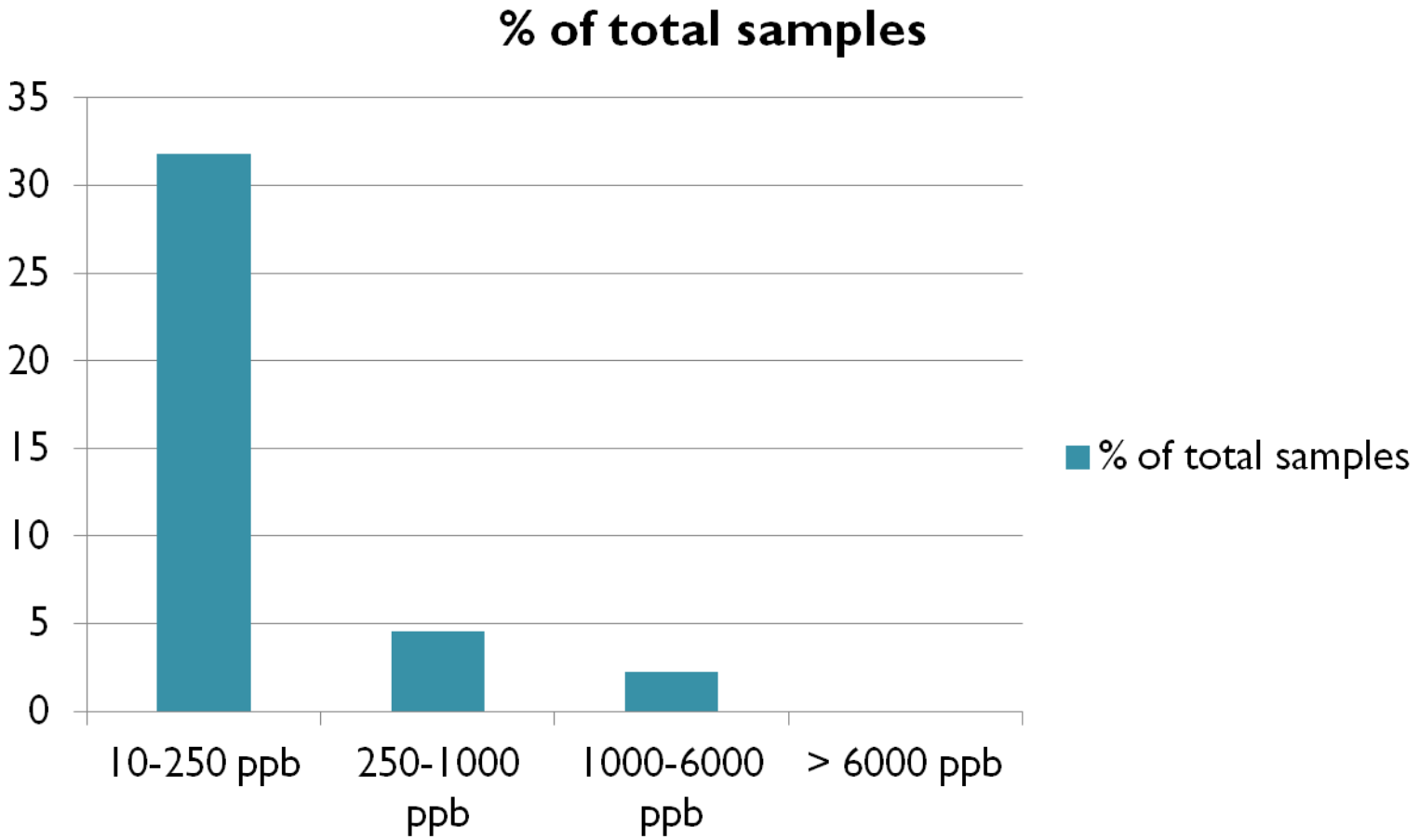

N = 111 samples

# % of DDGS Samples Containing Various Levels of Vomitoxin (Dairyland Laboratories, Inc. 8/1/11 -12/12/11)



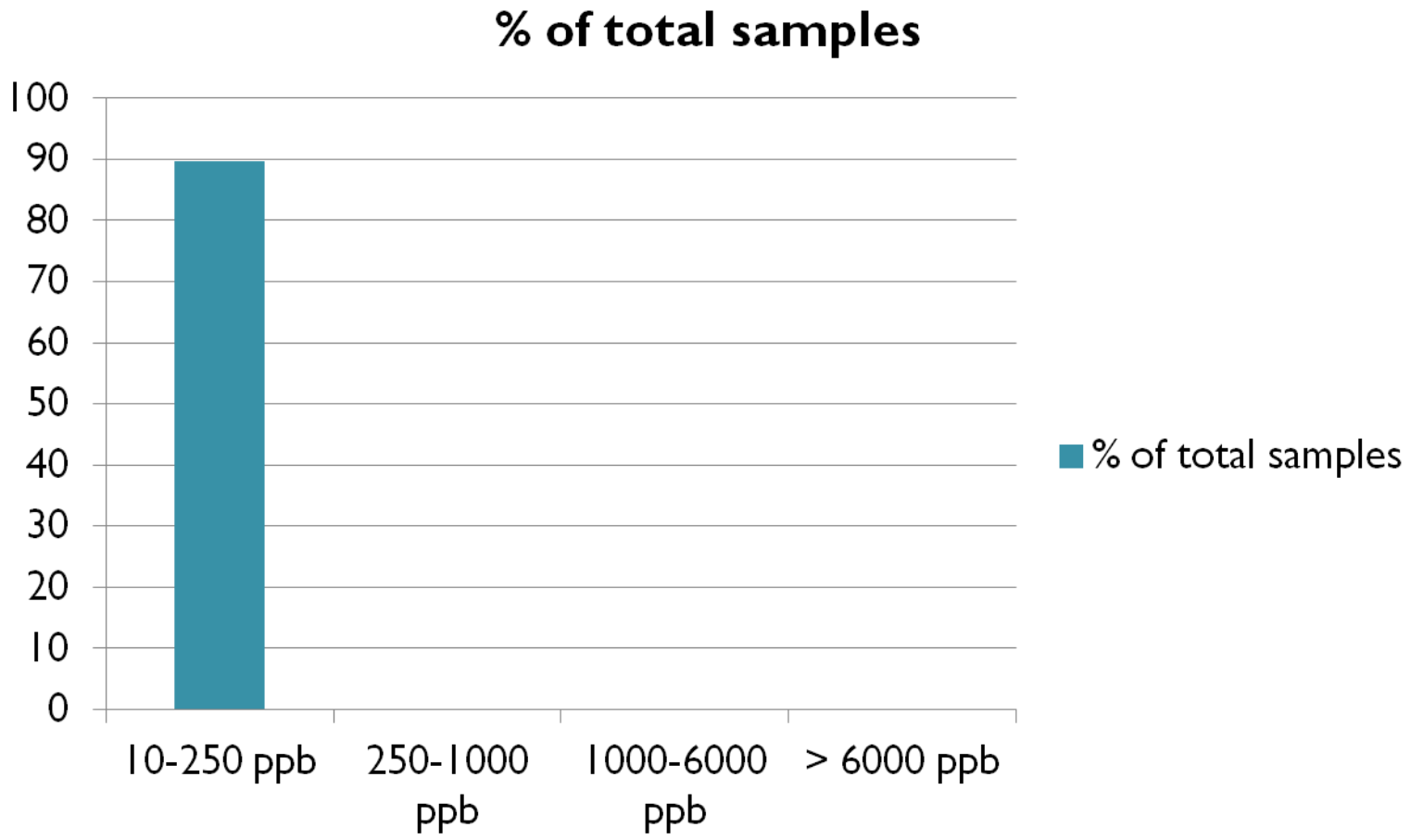

N = 58 samples

# % of Corn Samples Containing Various Levels of Zearalenone (Dairyland Laboratories, Inc. 8/1/11 -12/12/11)



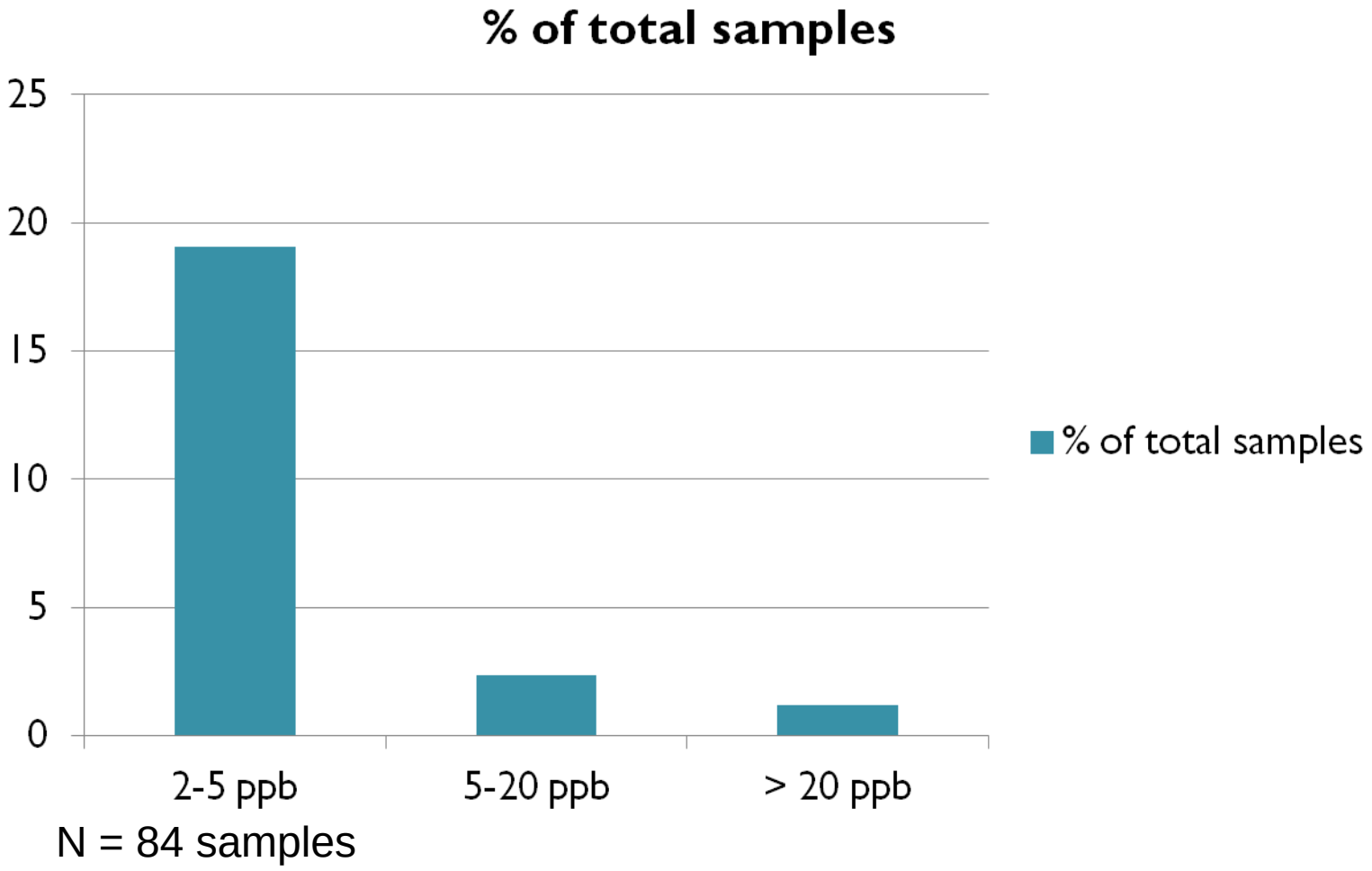

N = 88 samples

# % of DDGS Samples Containing Various Levels of Zearalenone (Dairyland Laboratories, Inc. 8/1/11 -12/12/11)



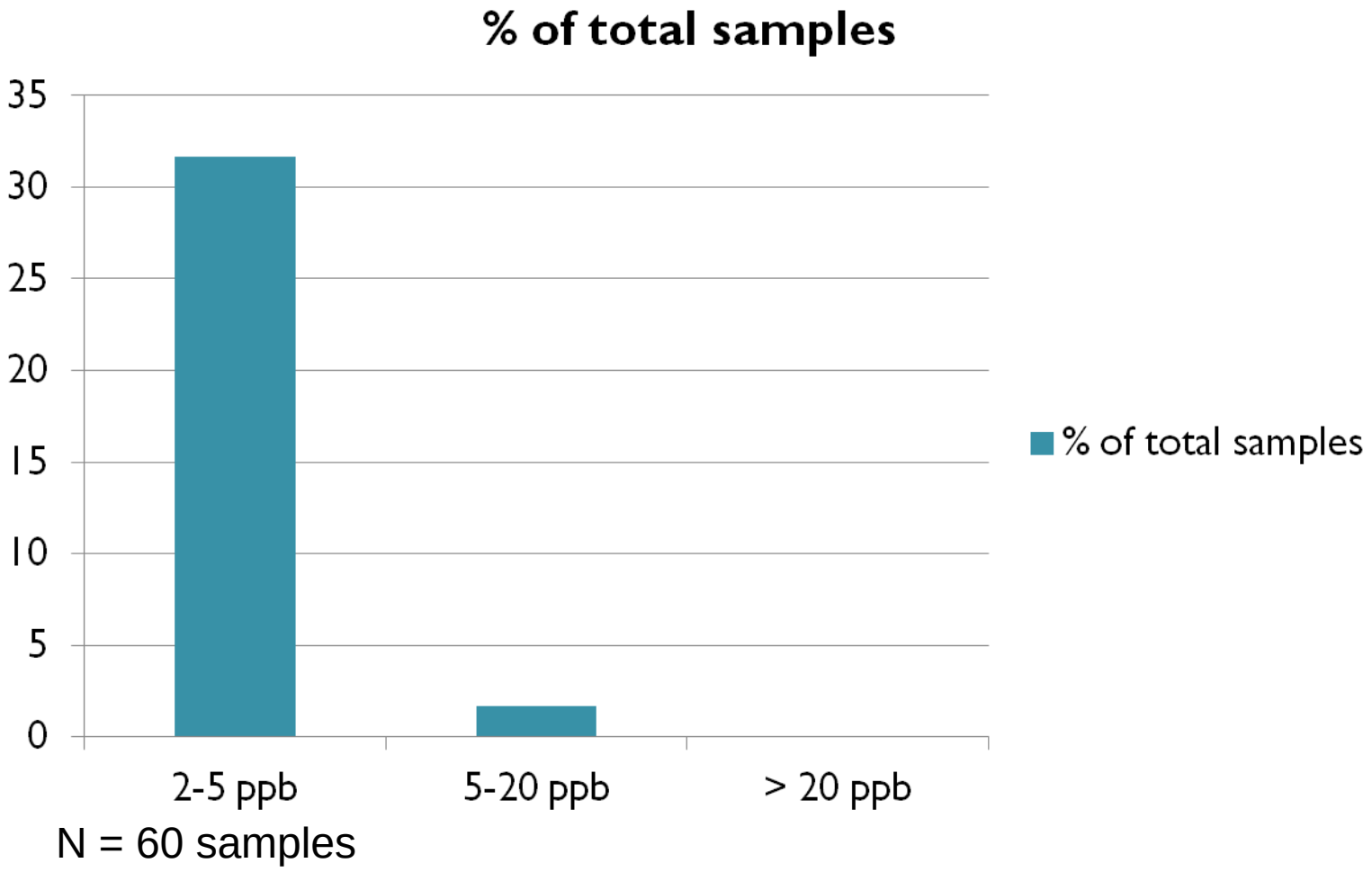

N = 29 samples

# % of Corn Samples Containing Various Levels of Aflatoxin (Dairyland Laboratories, Inc. 8/1/11 -12/12/11)



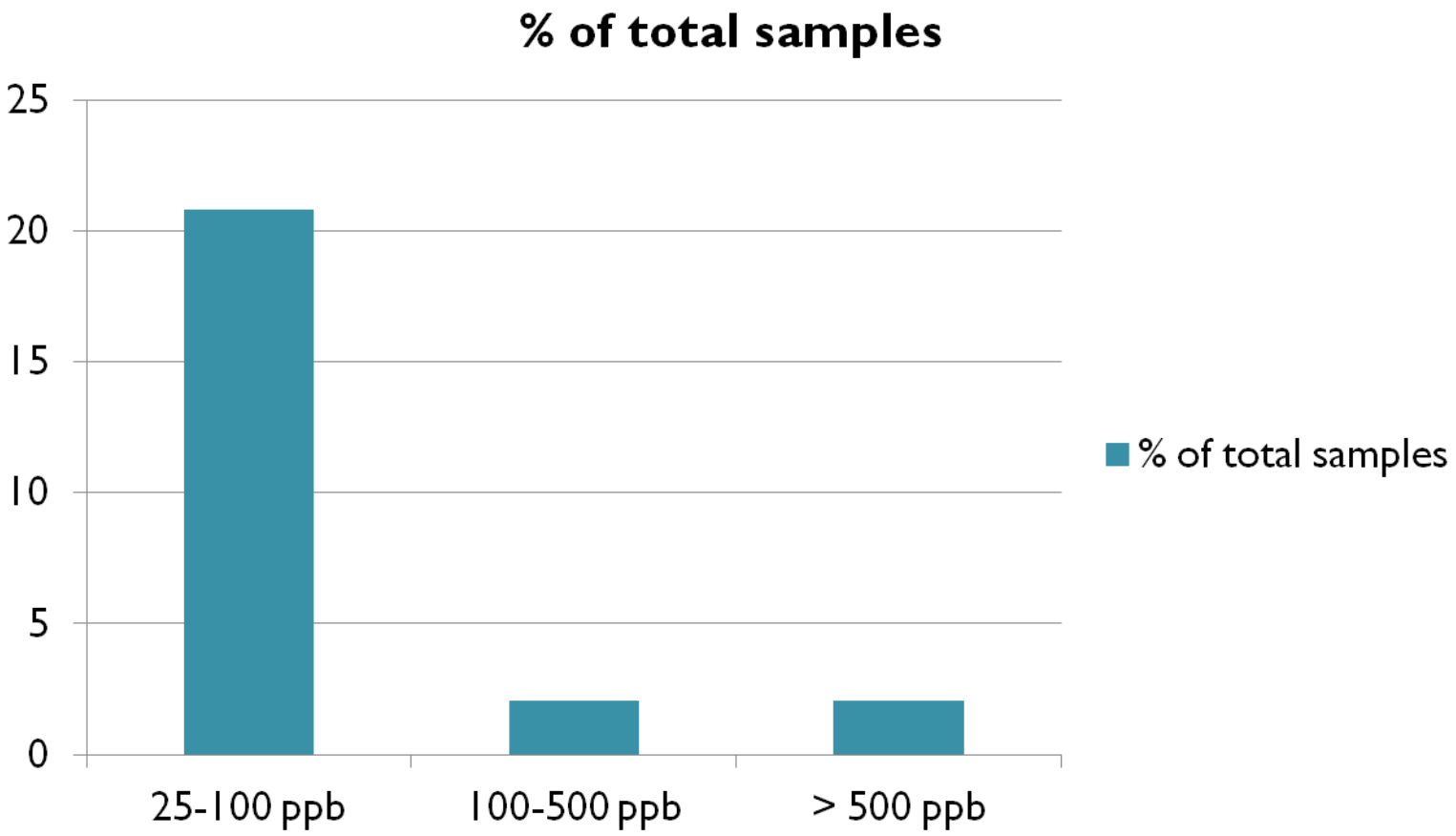

N = 84 samples

# % of DDGS Samples Containing Various Levels of Aflatoxin (Dairyland Laboratories, Inc. 8/1/11 -12/12/11)



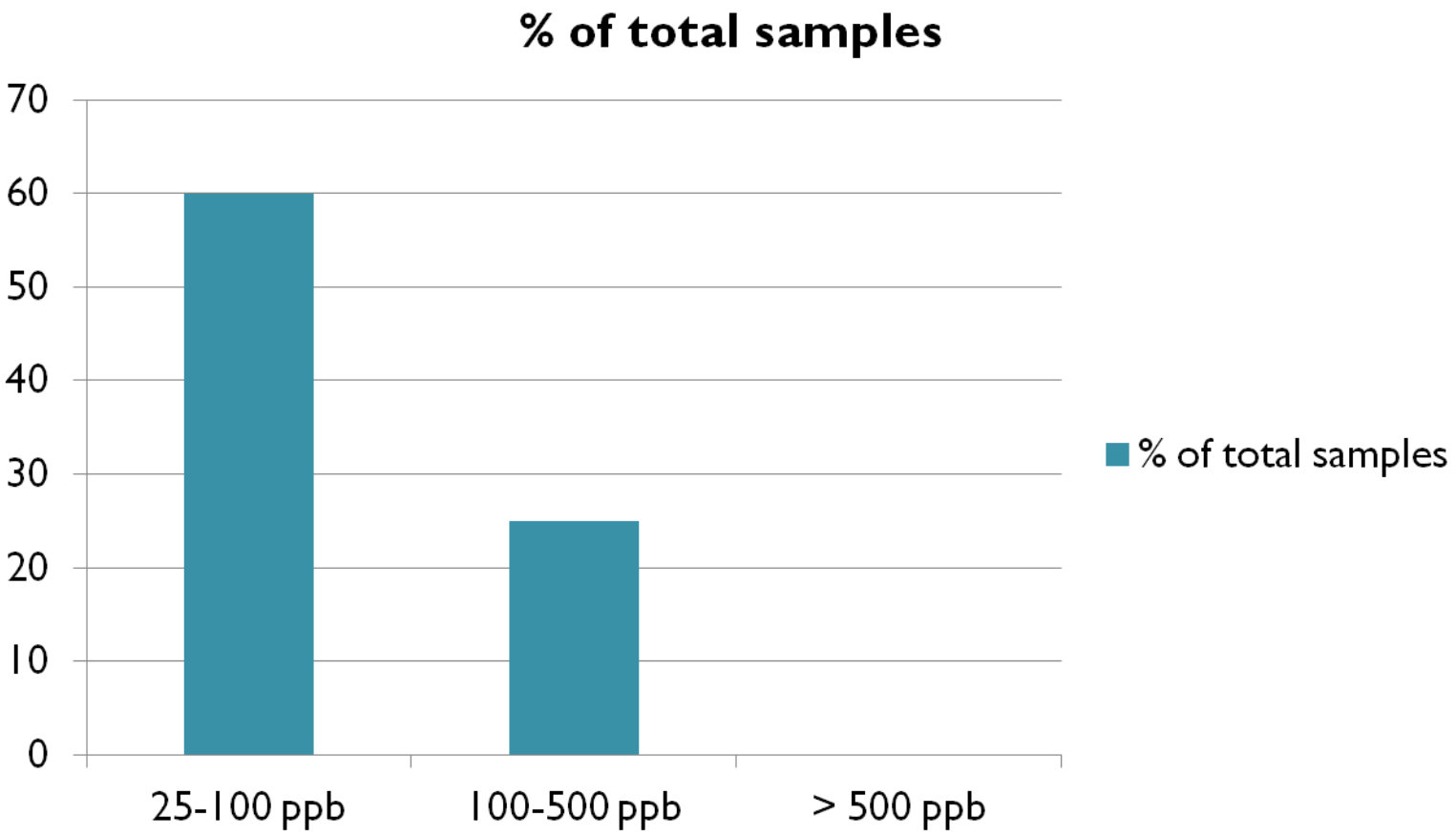

N = 60 samples

# % of Corn Samples Containing Various Levels of T2 Toxin (Dairyland Laboratories, Inc. 8/1/11 -12/12/11)




N = 48 samples

# % of DDGS Samples Containing Various Levels of T2 Toxin (Dairyland Laboratories, Inc. 8/1/11 -12/12/11)




N = 20 samples

# Mycotoxin Testing Laboratories

Veterinary Diagnostic Services Laboratory

Van Es Laboratories

North Dakota State University

Fargo, ND 58105

(701) 231-8307

Minnesota Valley Testing Laboratories, Inc.

1126 North Front Street

New Ulm, MN 56073

(800) 782-3557

# Mycotoxin Testing Laboratories

Eurofins Scientific
3507 Delaware/PO Box 1292
Des Moines, IA  50313/50305
Phone: 515-265-1461
Fax: 515-266-5453

# Aflatoxin Testing Kits for DDGS (Approved by GIPSA)

| Brand Name | Manufacturer | Test Range |
|---|---|---|
| Veratox Aflatoxin | Neogen Corporation | 5 – 50 ppb |
| Ridascreen FAST SC | R-Biopharm | 5 – 100 ppb |
| Aflatest | Vicam | 5 – 100 ppb |
| FluroQuant® Afla IAC | Romer | 5 – 100 ppb |

# Fumonisin Testing Kits for DDGS (Approved by GIPSA)

| Brand Name | Manufacturer | Test Range |
|---|---|---|
| AgraQuant Total Fumonisin 0.25/5.0 | Romer | 0.5 – 5 ppm |

# Zearalenone Testing Kits for DDGS (Approved by GIPSA)

| Brand Name | Manufacturer | Test Range |
|---|---|---|
| ROSA® Zearalenone | Charm Sciences, Inc. | 50 – 1000 ppb |