Feed and Processing Options for Heavily Downgraded Wheat

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Need to know:
1. Types (how many)
2. Levels
3. Safety

Moulds = Mycotoxins
They are everywhere!
FAO estimates that 20 - 40% of Food is WASTED

- 25% of all cereals with mycotoxins
- 500 MMT/yr
- @365 kg/p = 1.4 B persons
Effectively, this means we waste 20-40% of:

- Energy / fuel used to grow and make food
- Land base used to grow food
- Water
- Labour / handling / disposal

What does this cost the grain / food and animal industry and can we better utilise animals to reduce these losses
Losses of ingredients and feeds associated with mycotoxins must be minimised to reduce WASTE.
Safe / permissible levels of mycotoxins

• What is a safe level?
  • “There is no safe level”
  • Impact of levels may be different between farms
• Can a contaminated grain source be fed safely to other animals?
• What will be the risk / economic impact of a given level of contamination?
Fusarium Damaged Kernels (FDK)

- FDK is associated with:
  - Lower yield
  - Lower quality as food or malt
    - Tolerance for No 2 wheat dropped from 2% FDK to 1%
    - Prystupa and Paliwal (2011) estimate FHB costs $80M/yr to Canadian farmers due to lower grade and yield.
  - Lower grade / price
  - Potential for mycotoxins / food, malt & feed safety
    - Recall concerns
  - Effectively eliminated Durum planting in Manitoba
CONTROL OF THE ADVERSE EFFECTS OF MYCOTOXINS
Methods of reducing toxicity

- Genetic selection for resistance
- Agronomic practices to reduce infection (i.e., fungicides, tillage practices, crop rotations) (McMullot et al., 2012)
- Dilution of contaminated grains to permissible levels
  - <4% for export feed
  - Some EU countries have 0 tolerance for mycotoxins
- Removal of outer coat of contaminated grain by abrasion
- Chemical and physical detoxification
  - Alkaline treatments; processing temperatures
- Use of additives
  - Binders (reduce bioavailability)
  - Detoxifiers (reduce bioactivity and/or negative health effects)
  - Enzymes
- Biocontrol: use of other microflora to competitively exclude or destroy toxins (Palumbo et al., 2008)
- Employing a postgraduate student to manually remove contaminated seeds (you can’t afford anyone else)
“For all the medical literature about the toxic effects of mycotoxins on humans and animals, for all the knowledge about the chemistry and modes of action, for all the cost to the world and all the tea in China, reliable solutions are still few and far between. As plant pathologists, this problem is still on our plate after almost 30 years of research. Economically effective solutions are those that are agricultural technology based that exclude the fungi from the host and/or block the production of mycotoxins in the host substrates.”
SKNIR

• Indicates that NIR is capable of identifying FDK and DON to a moderate degree
• Does not necessarily measure the fungi or the toxin directly, but estimates it based on other changes to the kernel

• Capacity, 1 seed / sec.
• May have use in:
  • Selection for resistant strains of grain
  • Grading grains, as an assessment of both damage and toxin
TECHNOLOGY! WHERE WOULD WE BE WITHOUT IT?
NOW HOW DO WE SORT 500 MMT OF GRAIN?
Gravitational beds

• Increase fan speed of combines and blow FDK & DON out the back
• Gravitational sorting
  • Lighter material sorted out and estimate this would decrease FDK and DON
Color sorters

- Delwiche et al. (2005) indicated that color sorters have been used to remove FDK
  - Results in ~50% decrease in FDK and DON
  - Capacity up to 10 MT/h
- Have seen operation that used gravitational sorted material and sorted this with color sorter to remove ergot.
- FDK seeds are structurally modified by the infection.
- K-Max system utilizes the scatter of light off the kernel as a means of identifying FDK.

Spectrum Agricultural Inc (David Prystupa, Manitoba)
DON Concentrations Before and After Separation of FDK

![Graph showing DON concentrations before and after separation of FDK](Image)

- **Y-axis:** DON (ppm)
- **X-axis:** Sample
- **Legend:**
  - Blue: Before
  - Yellow: After
Spectrum Agricultural Inc (David Prystupa, Manitoba)

- Modular design
  - 5 modules process 1 MT/hr (42 mg/K)
  - Design life 80,000 h
  - Truck / Trailer mobile (18 MT/h)
  - 93% of FDK removed
  - DON reduced by 84%

- Kmax Economics
  - ~ Capital cost = $350K

- Operating Costs (/MT)
  - Amortization $1.70 – 3.40
  - Labor $1.25
  - Electricity $0.65
  - Maintenance $1.30
  - Total $4.90 – 6.60
What are we going to do with high fusarium sorted grains?

• Burn it?
  • If 5% of seeds are removed, this is 50,000 MT/1MMT sorted (@ $250 = $12.5M/MMT)

• Ethanol?
  • Mycotoxins are concentrated in the DDGS (3 fold)
  • Some indications that some bacteria are able to detoxify some mycotoxins
    • Why ruminants tend to be less impacted
Meal worms grown on DON-contaminated flour (5ppm; NL, 2014)

- NO effect on larvae growth or survival
- No DON or metabolites measurable in the larvae or faeces.
- What happened to it?
Decontamination of ingredients

- dilution with sound grain
- washing – dehulling – polishing
- separation (by screens, blowers, sieves)
- heat treatment (autoclaving, roasting, microwave heating)
  - Some mycotoxins can withstand temperatures > 400°C
- density segregation – flotation
- color sorting (50% DON decrease)
- solvent extraction
- UV radiation
Chemical detoxification

- Detoxify or inactivate mycotoxins
  - Ozone
  - Ammonia, ammonia hydroxide
  - Sodium bisulfite
  - Peroxide acids
  - Formaldehyde
  - Bases, calcium hydroxide

- Issues with
  - Safety / Regulatory
  - Palatability
  - Efficacy
  - Equipment damage
Detoxification / Decontamination
MUST act quickly in the gut

- Rapid transit / rapid absorption
- Mycotoxin levels must be reduced within 30 minutes of digesta becoming solubilised
- Is activity possible in dry dietary form?
  - Combating secondary effects may be by different routes after absorption of mycotoxin
Mycotoxin adsorbents – Factors to be considered:

• Able to adsorb a wide range of mycotoxins
• Low inclusion rate
  • Reduce cost, dilution effect, but harder to mix evenly
• Easy to mix uniformly
• Heat and storage stability
• No affinity for vitamins, minerals, etc.
• Functional under pH ranging from 2-7
• Biodegradability after excretion
• Safe for animals and humans
• Palatability
• No potential for other sources of contaminants
Sausages, political agreements and adsorbents in vitro tests.

Do Not ask how they are made!
Fink-Gremmels (2013)

• Mitigated adverse effects of DON on epithelial cell wall integrity with “non-digestible” carbohydrates (GOS; Galactooligosaccharides)
  • In vitro
    • Trans Epithelial Electrical Resistance / tight junction
    • CXCL8 / Interleukin 8 / chemokine reduced
      • reduced inflammation
  • In vivo
    • Improvement of intestinal villus architecture
Effect of DON grain, spray dried animal plasma, and clays on average daily gains
Beaulieu et al. Prairie Swine Centre, Saskatoon

ADG (kg)

Day 0-3  Day 3-11  Day 0-20

Control  DON  Clay  SDAP  Clay+SDAP

a,b,c P-value<0.05
Nutritional Modifications

• Fortify diets (counter oxidative stress)
  • Methionine
  • Selenium
  • Vitamins (possibly to account for binding)
  • Fat source (PUFA in cell membranes more susceptible)

• Supplements
  • Antioxidants
    • Polyphenols
    • Peptides
    • Ethoxyquin
Summary

• To my knowledge there is no silver bullet – yet!
• Reductions in chronic effects must be achieved by:
  • Controlling and knowing exposure
    • “There is absolutely nothing easy about detecting, prevention, or managing a mycotoxin challenge” Bunting / ADM
  • Monitoring and maintaining health of animals
  • Supporting and understanding research to mitigate chronic loss of mycotoxins
1. Changing weather conditions (climate change) require adaptations in crop management, land use and agricultural practices to manage the risk of mycotoxins in major staple crops.

2. Effective pre- and post-harvest management systems are key in reducing mycotoxins and crop loss. Such schemes require an integrated approach taking into account observations at the cellular/molecular level as well as on countryside scale.

3. Regulations should not aim to restrict access to feed and food but should be an incentive to introduce the necessary changes in crop management, land use and agricultural practices to manage the risk of mycotoxins in major staple crops worldwide.

4. Rapid high throughput screening of mycotoxins at critical control points on-site is now feasible and attractive but account shall be taken of adequate SAMPLING!

5. MS-based metabolomics enables to recognise changes in the plant metabolome after treatment with trichothecenes = important to understand plant-pathogen interactions in a functional genomics context as a basis for improved resistance breeding.
THANK YOU
ACIDF / CIGI / SASK MINISTRY OF AGRICULTURE / UNITY SCIENTIFIC / WESTERN ECONOMIC DEVELOPMENT

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