4-28-2017

Economic Analysis of Mycotoxin Testing at High Capacity Grain Markets

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Problem Statement
Feed Mills and Coops have 200-800 semi loads of grain coming into their facilities per day and need to know the total cost to test, the breakeven point between in-house and lab analysis, and the cost per bushel. Contamination occurs in very low quantities, a handful of contaminated kernels can contaminate a whole truckload of grain above acceptable limits. Mycotoxin outbreaks occur in years with the right weather conditions, so some years there is no real need to test frequently, and in bad years it might be required to test every truck load. We produced an Excel spreadsheet that enables the feed production manager to change testing methods and inputs and gives a cost analysis that will help in the decision making process.

Disciplines
Bioresource and Agricultural Engineering | Industrial Technology

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Department of Agricultural and Biosystems Engineering (ABE)

TSM 416 Technology Capstone Project

Economic Analysis of Mycotoxin Testing at High Capacity Grain Markets

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Client: Iowa State University Grain Quality Lab, Address, Ames, IA, 50014, http://www.extension.iastate.edu/grain/

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Erin Bowers, Post-Doctoral Research Associate, erin@iastate.edu, 515-294-6383

1 PROBLEM STATEMENT

Mycotoxins are produced by molds that grow on grains and are the largest health concern for the grain industry. The costs associated with the methods of testing, accuracy, and the frequency are not currently quantified.

Problem Statement

- Feed Mills and Coops have 200-800 semi loads of grain coming into their facilities per day and need to know the total cost to test, the breakeven point between in-house and lab analysis, and the cost per bushel.
- Contamination occurs in very low quantities, a handful of contaminated kernels can contaminate a whole truckload of grain above acceptable limits.
- Mycotoxin outbreaks occur in years with the right weather conditions, so some years there is no real need to test frequently, and in bad years it might be required to test every truck load.
- We produced an Excel spreadsheet that enables the feed production manager to change testing methods and inputs and gives a cost analysis that will help in the decision making process.

- There are many markets that use grain in their products such as ethanol plants, Coops, feed mills, pet food manufactures, and human food production. The model that we created is flexible enough to accommodate input data from all of these facilities.

Business Case Statement – In the future, testing regulations are likely to increase. This creates a need for a complete list of testing options and related costs.

A. We completed a list of fixed and variable costs associated with testing.
B. In years with bad weather conditions that are conducive to mold growth, it can be a widespread problem for the Midwest.
C. Mold growth occurs on grain while in the field, but can become much worse depending on harvesting conditions and storage practices.
D. There is currently no cure for mycotoxin poisoning, so if a cost analysis helps grain handling facilities better deal with procedures and identification, livestock loss can be avoided.
E. By using our analysis to better plan for testing procedures, grain handling facilities can greatly reduce their risks of passing on contaminated grain products to producers. This would save them money in the long run.

2 GOAL STATEMENT

The goal of this project was to develop a way to find the cost per bushel for various methods of testing mycotoxins.

A. We were tasked with creating a tool for grain buyers to use to better help them calculate the costs associated with mycotoxin testing.
B. The improvement is difficult to measure because the costs of not testing for mycotoxins is hard to quality. However, our Excel-based model will increase the grain buyers education of the cost of testing, hopefully increasing the willingness to test and reducing to contamination by mycotoxins.
C. The collection of many variables allowed us to create an excel document.
    - Specific parameters measured are: In-house testing vs in a third party lab, cost of consumables for each tests, frequency of testing, total bushels dumped at facility while testing, cost of labor including during testing and training, time spent multitasking while testing, cost of equipment, cost of corn lost from grinding, and quality control costs.
    - Our main deliverable is an excel document that is broken down into an introduction and overview and then has a separate tab for each main mycotoxin (Aflatoxin, Vomitoxin, Fumonisin, Ochratoxin, Zearalenone)
    - Grain buyers being able to predict how much testing will test will make them more likely to tests because they can see the relatively low cost of minimizing a large risk.
    - The excel document will be given to our client, the grain quality lab, for further refining and then will be made available on the Iowa State's Ag Decision Maker for grain buyers to access freely.

- **Main Objective(s) and Specific Objectives**
    - We gathered all the costs associated with this problem and produced a spread sheet for coops to use in determining the best route of testing.
    - **Specific objectives include**:

    - Finding all variables of testing and associated costs.
    - Automatically updating spreadsheet that is user-friendly.
- **Rationale**
    - Our client can now insert a coops individual information and show them how much it will cost based upon their situation.
    - By removing the unknown cost, convincing coops to test instead of hoping they don't have contaminated grain will be easier.

3 PROJECT PLAN/OUTLINE

A. Methods/Approach

- **Reference Material(s):**
    - Our main reference materials were from Charm and Neogen who are manufactures of various mycotoxin tests. From the costs that they gave to us we were able to find the cost per test as well as compile a list of necessary equipment that is needed to perform testing procedures.
- **Data collection**:
    - Data that was needed to complete the calculations came from the costs given by the manufactures. We also performed the testing procedures ourselves in the grain quality lab. From this we were able to compile a list of steps and the time that it took to perform each step, this data was necessary to find the labor costs per test.
- **Skills**:
    - The main tool that we used was Microsoft Excel. We gain valuable knowledge and experience in the following areas of this program:
        - Macro coding
        - Professional formatting
        - Process organization
        - IF, Vlookup, Round, and IFerror functions
        - Comment boxes, drop down lists, and hyperlinks
- **Solutions**:
    - We found the cost per bushel, total price, breakeven number, and the breakeven price for in-house testing compared to outside lab analysis.
- **Organization:**
    - We met with Dr. Bowers, Dr. Hurburgh, and Dr. Brumm throughout the to ensure that we were meeting their expectations for the project. Through these multiple follow-ups, we made multiple changes to our calculations as well as what we considered in each column. We would save a new version on the excel each time a group member made changes with their name and the date so we knew which version was the most recent.

B. Results/Deliverables

- Our deliverables include an introduction and overview tab that describes in instructions for use, test information, and links to the various mycotoxin tabs. There is also a tab

dedicated to each type of mycotoxin that has an inputs, outputs, and totals column with a graph that finds the breakeven number and cost.
- To aid in the use of this analysis tool we also created an instructional video that describes the features and brief instruction on how to use it.

C. Timeline

- The time spent on this project was mainly in the excel workbook. With all the equations, formatting, VBA, and independent comments it took most of the semester. For the future, there will be an opportunity to edit this workbook and reformat it to suit the clients needs.

4 BROADER OPPORTUNITY STATEMENT

A. This project is important and currently does not appeal directly to the average person, but the safety of our food, pets, exporting is on the rise and is becoming more important with time. So the project's appeal is increasing with time and with our details about mycotoxins, it will help the "average person" to understand the importance of the project.
B. Our project addresses the challenges included with feeding the world and provides a cost analysis of the solutions that are currently offered for this challenge.
C. The food industry deals with similar problems such as the cost of testing for disease or infection in their products and this can help those companies by providing an easier way to decide which method they will use from an economic standpoint.
D. The grain handling/storage industry and the feed mill industry will be able to use the output solution to identify which method will be the most cost effective for their company/industry.
E. The increasing interest in mycotoxins in the grain and feed industry is leading to a higher awareness of mycotoxins, it is predicted that mycotoxins will increase in importance in the future due to all of the variables that lead to the development of mycotoxins.
F. Currently the industry deals with mycotoxins by addressing their existence in grain and feed by:
    - Using one of the multiple varieties of rapid test kits provided by companies.
    - Sending grain/feed samples off to testing labs where the results are returned back to the company in a later time, but with increased accuracy over the rapid test kits.
G. Our solution will lead companies deciding whether or not they want to spend the money on in-house equipment or to send it off to a lab for testing or risk the penalties that can be assessed from spoiled grain/feed. This solution will lead to answering how much testing for mycotoxins will cost long-term.

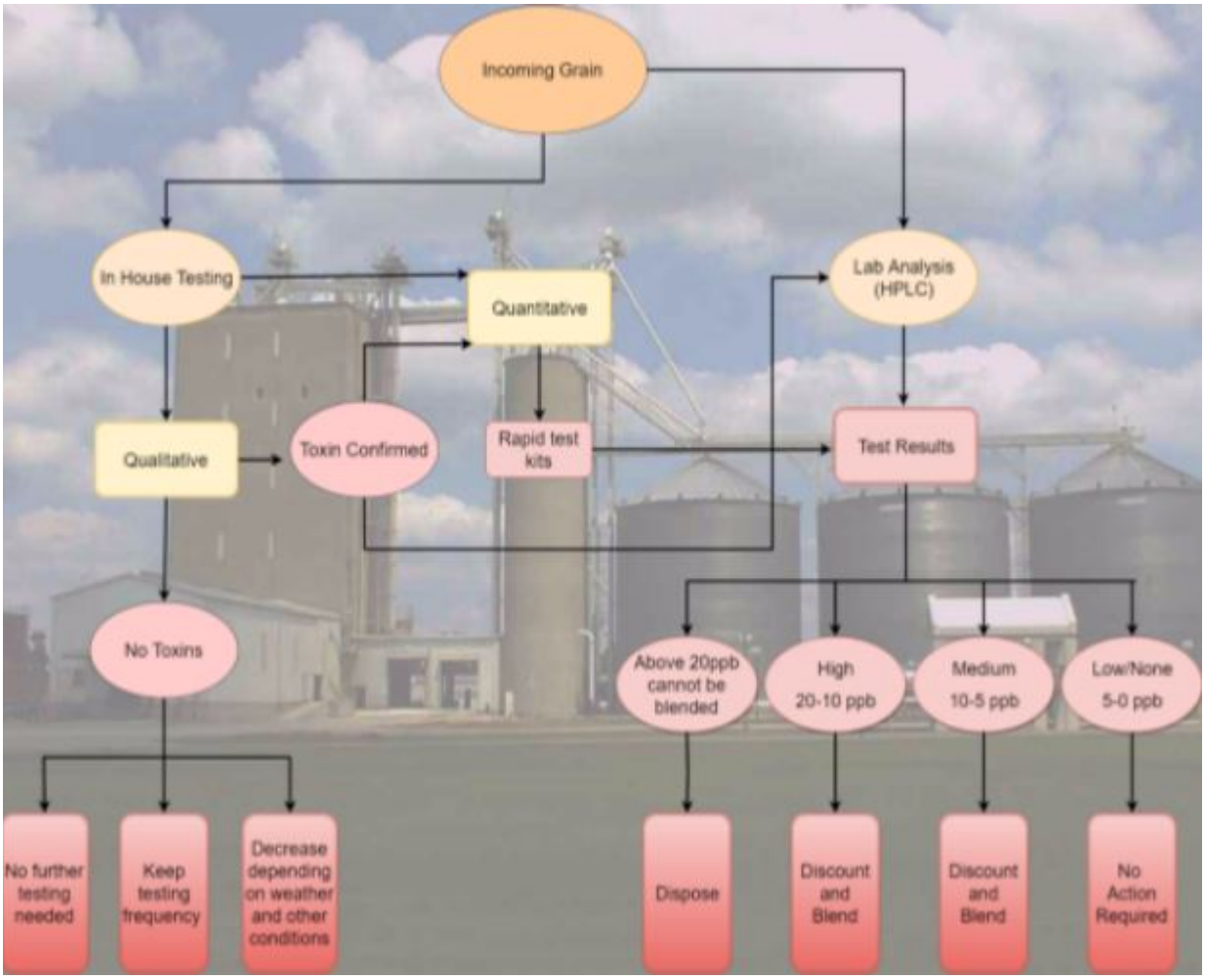
5 PROJECT SCOPE

The beginning steps of this project was compiling a list of inputs that should be considered. Due to the many different facilities and processes, this was a very challenging step.

A. The end steps provide totaling costs and a functional break even between in-house and lab analysis graph to determine the different levels of costs, accuracy, and frequency.
B. Information was gathered through our clients and with Landus.
C. There is suggested testing equipment within the workbook and it is available to add in your own equipment and pricing for each. The sheet will automatically update once the information is provided.

D. There are a series of equations and macro codes in this excel workbook that provide the outputs. Those equations and codes can be found within each tab and also a how-to is provided for changing anything.

6 GRAPHICAL ABSTRACT



7 APPENDIXES

Macro Code

The Macro code that was created for this excel document was based off a series of videos. It was created to help clients with the descriptions of the different tests. This sheet will help guide you through the code and suggest ideas on how it can be changed. There is a different code for each mycotoxin tab with a total of 5 different codes that will be pasted below along with the YouTube links that helped design this specific code.

YouTube Links:

-If Then Statements (https://www.youtube.com/watch?v=C8jtUrXNd_g)

-Select Case (https://www.youtube.com/watch?v=VMlnDEfq-BI)

Useful Tips:

1. To edit the code simply right click on the mouse on the specific tab and click edit code
2. The descriptions are to the left of the MsgBox command and you can click to edit the description. Make sure the description once you edit it is in "____".
3. To change the test description, you must go back to the page where you typed in the new test and copy and paste that cell to the macro code. It won't work it you don't.
4. Always make sure at the top of the code that the cell you are linking is the exact one in the sheet. If the cell in the sheet is combined cells then just choose one of the cells.
5. At the end of the code there must be an "End Select" and an "End If".

Aflatoxin Macro Code

```
Private Sub Worksheet_Change(ByVal Target As Range)

If Target.Address = "$C$8" Then

Select Case Range("C8")

Case "Charm - LF-AFQ-FAST "

MsgBox "In three or five minutes, the LF-AFQ-FAST test enables feed and grain producers to quantitatively detect aflatoxin. This Rapid One Step Assay is a quantitative lateral flow test that is read in the Charm EZ-M system or the ROSA-M Reader."

Case "Charm - LF-AFQ-WETS3"

MsgBox "The LF-AFQ-WET-S3 Aflatoxin Quantitative Test detects aflatoxin rapidly and quantitatively utilizing ROSA (Rapid One Step Assay) lateral flow technology. The WET method uses an extraction powder added to the sample followed by water (e.g., bottled water) to extract aflatoxin. GIPSACharm approved for detecting aflatoxin in corn."

Case "Charm - LF-AFQ-WETS5"

MsgBox "Quantitative Test detects aflatoxin rapidly and gives a Range 0 to 150 ppb, have results in 5 minutes, and eliminates ethanol and methanol solvents."

Case "Neogen - 8030 Veratox for Aflatoxin"

MsgBox "Neogen 8030 is a competitive direct ELISA that provides a quantitative analysis of aflatoxin. "

Case "Neogen - 8085 Reveal Q+ for Aflatoxin"

MsgBox "Neogen 8085 is a single-step lateral flow based on a competitive immunoassay format intended for the quantitative testing of aflatoxin in corn and corn products. "
```

```
Case "Neogen - 8086 Reveal Q+ for Aflatoxin Green"

MsgBox "Neogen 8086 is a single-step lateral flow based on a competitive immunoassay format intended for the quantitative testing of aflatoxin in barley, corn, corn bran, corn flour, corn grits, corn meal, flaking corn grits, hominy, hominy feed, peanuts, popcorn and soy beans."

Case "Neogen - 8088 Reveal Q+ MAX for Aflatoxin"

MsgBox "Neogen 8088 is intended for the quantitative analysis of corn and corn products for aflatoxin. Testing can be complete in 6 minutes after extraction and can detect a wide range (2-300 ppb) of aflatoxin."

Case "None"

MsgBox "None is refered to as an outside lab analysis in the state of Iowa"

End Select

End If

End Sub
```

Vomitoxin Code

```
Private Sub Worksheet_Change(ByVal Target As Range)

If Target.Address = "$B$7" Then

Select Case Range("B7")

Case "Charm - LF-DONQ2"

MsgBox "Charm - LF-DONQ2 is an immunoreceptor assay utilizing ROSA (Rapid One Step Assay) lateral flow technology. For more information regarding this test, refer back to the overview page under Vomitoxin tests. "

Case "Neogen - 8385 Reveal Q+ for DON"

MsgBox "Neogen - 8385 Reveal Q+ for DON is a single-step lateral flow immunochromatographic assay based on a competitive immunoassay format intended for the quantitative testing of DON in corn, barley, DDGS, malted barley, oats and wheat products. "

Case "None"

MsgBox "None is refered to as an outside lab analysis in the state of Iowa"

End Select

End If

End Sub
```

Fumonisin Code

```
Private Sub Worksheet_Change(ByVal Target As Range)

If Target.Address = "$B$6" Then

Select Case Range("B6")

Case "Charm - LF-FUMQ-WETS5"

MsgBox "Charm - LF-FUMQ-WETS5 delivers rapid and accurate results using ROSA (Rapid One Step Assay) lateral flow technology. Water Extraction Technology eliminates ethanol and methanol using an extraction powder and water (e.g. bottled) to quickly and safely extract fumonisin from the sample. "

Case "None"

MsgBox "None is refered to as an outside lab analysis in the state of Iowa"

End Select

End If

End Sub
```

Ochratoxin Code

```
Private Sub Worksheet_Change(ByVal Target As Range)

If Target.Address = "$B$6" Then

Select Case Range("B6")

Case "Charm - LF-OCHRAQ-G"

MsgBox "Charm - LF-OCHRAQ-G is an immunoreceptor assay utilizing ROSA (Rapid One Step Assay) lateral flow technology. Ochratoxin is extracted from the sample using 70% methanol in water. Ochratoxin A interacts with colored beads in the lateral flow test strip and the color intensity in the test and control zones is measured by the ROSA-M Reader and interpreted as parts per billion (ppb) ochratoxin A. For additional Information regaurding Ochratoxin test, the overview page will provide more specifics."

Case "None"

MsgBox "None is refered to as an outside lab analysis in the state of Iowa"

End Select

End If

End Sub
```

Zearalenone Code

```
Private Sub Worksheet_Change(ByVal Target As Range)

If Target.Address = "$B$6" Then

Select Case Range("B6")

Case "Charm - LF-ZEARQ-FAST5"

MsgBox "Charm - LF-ZEARQ-FAST5 test enables grain and feed producers to quantitatively detect zearalenone in a five minute assay. This Rapid One Step Assay is a quantitative lateral flow test that is read in the Charm EZ-M system or the ROSA-M reader. Samples are extracted with 70% methanol. For additional Information regaurding zearalenone test, the overview page will provide more specifics."

Case "None"

MsgBox "None is refered to as an outside lab analysis in the state of Iowa"

End Select

End If

End Sub
```