Federal Grain Inspection Service
Technology and Science Division
Overview and Updates

Timothy Norden, Acting Director
Technology and Science Division

Grain Inspection Advisory Committee Meeting
September 5, 2018
Technology and Science Division Overview

- FGIS – Technology and Science Division (TSD) is responsible for developing, improving, and supporting all official grain inspection methods

- Organization: Four branches plus administrative support
  - Analytical Chemistry Branch
  - Biotechnology and Analytical Services Branch
  - Inspection Instrumentation Branch
  - Board of Appeals and Review Branch
  - Office of the Director
    - Administrative Support Team
    - Digital Media Team

- Current employees: 60 with 15 vacancies = 75 total
Analytical Chemistry Branch (ACB)

• Develops and evaluates new or improved chemical and physicochemical methods for food safety and end-use quality factors

• Provides centralized official inspection and quality assurance services

• **Key programs:**
  • mycotoxins, pesticide residue, falling number and wheat varietal identification
Biotechnology and Analytical Services (BASB)

• Develops and provides cutting-edge technology for determining genetic, nutritional, and intrinsic quality factors in grain and grain products

• Provides research, harmonization, and centralized testing services

• **Key programs:**
  • biotechnology and commodities testing; moisture, protein, and oil reference methods
Inspection Instrumentation Branch (IIB)

- Develops and maintains calibrations and procedures for approved inspection instruments
- Administers instrument evaluation and quality control programs
- **Key programs:**
  - Moisture meter, near infrared (NIR) protein, oil and starch; and nuclear magnetic resonance (NMR) oil
Board of Appeals and Review (BAR)

• Directs and oversees the integrity and alignment of all visual inspections throughout the nation

• Provides procedures and centralized quality assurance services for inspection equipment

• **Key programs:**
  
  • Subjective Testing and Evaluation Process (STEP), training and licensing, Board Appeals, and equipment check testing
TSD Branch Updates

• Brian Adam
  • Chairman, Board of Appeals and Review

• Cathleen Brenner
  • Chief, Inspection Instrumentation Branch

• Tom Weber
  • Chief, Analytical Chemistry Branch

• Tandace Bell
  • Chief, Biotechnology and Analytical Services Branch
Determining HVAC in Durum Wheat

Brian Adam, Chief
Board of Appeals and Review Branch
Grain Inspection Advisory Committee Meeting
September 5, 2018
Hard and Vitreous Kernels of Amber Color (HVAC)

- **HVAC (100% Hard and Vitreous of Amber Color)** - Vitreous is the characteristic which gives the wheat kernels a hard, glossy appearance.

- **NON-HVAC** – Soft durum kernels that lack the hard vitreous characteristic, or semi-hard kernels that contain soft chalky spots.

- **How HVAC is Determined** - Visual inspection on a 15 gram portion cut out from the representative sample.
Durum wheat is divided into three sub-classes based on the percentage of HVAC in the representative lot.

**Hard Amber Durum Wheat**  Durum wheat with 75 percent or more of hard and vitreous kernels of amber color

**Amber Durum Wheat**  Durum wheat with 60 percent or more, but less than 75 percent of hard and vitreous kernels of amber color

**Durum Wheat**  Durum wheat with less than 60 percent of hard and vitreous kernels of amber color

Even though durum is certified by subclass, contracts may dictate specific limits to be met or penalties may be assessed.
• Durum has many uses, the most common being pasta which is made from durum
• Semolina is durum wheat ground into a coarse granular product
• Semolina content determines the end use. The amount of flour in the blend affects the color of the product
Vitreous and Non-Vitreous Kernels

HVAC

Non-HVAC or Soft
Non-HVAC Kernels with Soft Spots
Readily Identifiable HVAC Samples

Hard Amber Durum

Easy to detect soft kernels
Challenges with HVAC Inspection

• Time constraints lead to inconsistency between online inspectors, and industry keeps pushing to load faster.

• If adequate time is not given to online inspection personnel to analyze this highly subjective factor, accuracy may be compromised.

• Growing conditions can mask the appearance of the true kernel characteristics making HVAC determinations very difficult.
Difficult HVAC sample

- Weather-affected kernels
- Require more time and possibly cross-sectioning of kernels
- Samples of this appearance are more subjective and can result in more inconsistencies
Board of Appeals and Review and Field Office Monitoring Programs

• Monitoring programs are in place for inspectors and Quality Assurance Specialists (QAS)
• Referee samples used to assess inspector and QAS ability
• Conduct annual grain grading seminars for QASs
• Provide on-site training for inspectors and elevator personnel
• Conduct research on alternative methods for HVAC determination
QAS Alignment to the BAR
FY18 to Date

- Durum HVAC 96%
- HRS DHV 93%

Subjective Testing Evaluation Process (STEP) is a monitoring program used to align QASs to the BAR
Natural vs Conditioned

Natural

Bleached w/ Potassium Hydroxide (KOH)
Potential Benefits of Bleaching

• Produces a bright vibrant kernel
• Makes difficult weather-affected kernels easier to separate
• Potentially minimizes inspector variation and increases accuracy and consistency
• Collaborating with the Inspection Instrumentation Branch (IIB) to explore using the bleach method with imaging technology
Questions?
Inspection Instrumentation Branch Updates

Cathy Brenner, Chief
Inspection Instrumentation Branch
Grain Inspection Advisory Committee Meeting
September 5, 2018
LED Study
The Advisory Committee commends FGIS for its work with updating inspection laboratory lighting standards; and recommends **continued work on lighting advancements and testing for grain inspection**. The committee would also like to encourage FGIS to **review how other governmental or industry groups** involved in human-sorting-of objects **are utilizing** new technologies in **LED lighting** for inspection purposes.
FGIS Specifications

Fluorescent Emitter Specifications

<table>
<thead>
<tr>
<th>Lamp Radiation</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000 to 2499 Lumens</td>
<td>Color Rendering Index &gt; 92</td>
</tr>
<tr>
<td></td>
<td>Color Temperature 7500 °K</td>
</tr>
<tr>
<td></td>
<td>Rated Average Life &gt; 15,000 Hours</td>
</tr>
<tr>
<td>Or</td>
<td></td>
</tr>
<tr>
<td>&gt;= 2500 Lumens</td>
<td>Color Rendering Index &gt; 87</td>
</tr>
<tr>
<td></td>
<td>Color Temperature 7500 °K</td>
</tr>
<tr>
<td></td>
<td>Rated Average Life &gt; 12,000 Hours</td>
</tr>
</tbody>
</table>
Lighting Research

https://www.nist.gov/image/composite-color-preference.png

Illuminating Engineering Society Task Group
National Institute of Standards and Technology
Office of Energy Efficiency & Renewable Energy, Department of Energy
Study Design

• 30 Training Boxes

• 4 Test Lights

• 3 pairs of BAR Inspectors

• Number of kernels that changed determination
### Results – Difference between Test Light and approved Fluorescent Light

<table>
<thead>
<tr>
<th>Inspector</th>
<th>Test Light A</th>
<th>Test Light B</th>
<th>Test Light C</th>
<th>Office Light</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Chi-square</td>
<td>0.10</td>
<td>1.66</td>
<td>6.80</td>
<td>7.62</td>
</tr>
<tr>
<td>p-value</td>
<td>0.75</td>
<td>0.20</td>
<td>0.01</td>
<td>0.01</td>
</tr>
</tbody>
</table>

Chi-Square < 3.84 and p-value > 0.05 results are not significantly different at the 95% confidence level.
Light Color Composition

Approved
Fluorescent, CRI = 93

Light A, CRI = 93
Conclusions

- LED can be used for official inspection
  - Task Light only commercially available light that is not significantly different.

- Variations observed in the R9 (red) and R12 (blue) for all LEDs tested warrant further investigation for developing LED specifications.
Next Steps

- Review Training Boxes with final selection
- Test Lights for new study
  - Review commercially available
  - Canadian Grain Commission approved LED
- Establish study timeline with BAR
- Completed by December 2018
NIR Equivalency Field Study
Previous Studies

• 2015 Cooperative Agreement with Iowa State University (ISU)
  • 3 National Type Evaluation Program (NTEP) Approved models and calibrations
  • Not equivalent
  • FGIS field benchmark was almost twice the lab reproducibility for wheat protein on the approved instrument

• 2016 Cooperative Agreement with ISU
  • Common sample set for wheat protein
  • Updated calibrations improved reproducibility
October 2016 Resolution –

The Advisory Committee recommends that new equipment must be equal to or better than the old equipment in precision and repeatability in order to be approved as official. *Performance of equivalent instruments should match or exceed* that of the *existing approved instrument in the same field environment*. The Advisory Committee recommends GIPSA continue work with NIR Equivalence by continuing focus on improving performance in test instrument field studies. GIPSA should also consider including *all NTEP approved instruments in the field studies to determine equivalency*. 
Study Design

• 4 NTEP Approved Models
  • Barley, Corn, Soybeans, and Wheat

• 3 - 5 Specified Service Points per grain type

• Minimum 50 samples per location per grain type plus Standard Reference Samples
Status

• FOSS Infratec Nova approved as equivalent September 2017

• One participating manufacturer developed process to match raw instrument data to FOSS Infratec 1241.
  • Not achievable in a field setting

• Report in review process
Next Step

• Final report to be completed by December 2018
FGIS Approval Process

For Equipment, Instruments, and Test Kits
U.S. Grain Standards Act

§ 79b – Testing of equipment

- Periodic testing of all equipment used in inspection
- Ensure accuracy and integrity of equipment
- Prohibits use of non-approved equipment for grain inspecting
Regulations under USGSA

§800.215 (c) (4) – “...proposed equipment is tested to determine whether the equipment will improve the performance of activities under the Act.”

§800.217 (d) – Testing may occur when:

(1) At request of interested party with concurrence of Administrator

(2) Upon determination of need by the Service
FGIS Current Process

• Evaluate benefit to grain inspection

• Develop performance specifications and criteria (as needed)

• Assign resources and evaluate
Agricultural Marketing Service
Creating Opportunities for American Farmers and Businesses

Questions?
Moisture Meter Performance

Request for information to assure industry that official moisture results are consistent and accurate.
Moisture Meter Models

• Do not directly measure moisture
  • Dielectric characteristics closely related to moisture content

• Requires calibration
  • Based on historical data
Annual Moisture Calibration Process

- Air Oven Reference Method
- UGMA Master System
- DICKEY-john GAC2500-UGMA
- Perten AM5200A
Calibration Implementation Dates

• May 1 for Spring/Summer crops
• August 1 for Fall crops

• [https://www.gipsa.usda.gov/fgis/moisture.aspx](https://www.gipsa.usda.gov/fgis/moisture.aspx)
  • 5 year performance
  • Explanatory Notes of impact for any updates
  • Calibration bundles
Performance Data

Corn Grain Group: 2013 - 2017
- Samples: 505, Mean: -0.04, SDD: 0.3

Soybean Grain Group: 2013 - 2017
- Samples: 348, Mean: 0.08, SDD: 0.19
Impact of Change (Explanatory Notes)

Corn - 2017

- DICKEY-john

- Perten

Corn - 2017

Samples: 100
Mean: -0.04

Samples: 100
Mean: -0.16
Quality Control – Checktest

• Twice a year

• Scale Tolerances
  • Accuracy = ± 0.5 grams
  • Range = 1.0 grams

• Moisture Tolerances
  • Accuracy = ± 0.15 % moisture
  • Range = 0.26 % moisture
Moisture Checktest - Average Moisture
January - July 2018
Quality Control – Sample Inspection & Monitoring System (SIMS)

- Tolerances by grain and/or moisture
- Selected from file samples
- Domestic Inspection Operations Office
- Quality Assurance & Compliance Division
Soybean SIMS Difference Graph

Bias = -0.01  Std. Deviation = 0.25  Samples = 1284  OK = 1201  Warnings = 58  Actions = 25
SIMS Date Range: 1/1/2018 to 7/31/2018
Commodity = (YSB,XSB,SB)  Factor = (M)

Difference by Supervisory Office
* NGC_OK
* NGC_Warning
* NGC_Action
• OSP_OK
• OSP_Warning
• OSP_Action

Difference: Original - Supervision

Inspected Date

12/31/2017  2/19/2018  4/10/2018  5/30/2018  7/19/2018
July 2014 Resolution –

The Advisory Committee recommends the GIPSA review and update all quality assurance tolerances utilized in the official system. Specifically, the Advisory Committee recommends that the first to be reviewed reflect the Unified Grain Moisture Algorithm (UGMA) technology for moisture measurement.
April 2015 Resolution –

The Advisory Committee commends FGIS for its work in implementing and testing of UGMA moisture meters; and recommends that for the Sample Information Monitoring System (SIMS) that FGIS provide on their website a listing by grains for the approved UGMA moisture meters the following information: the moisture standard deviation, ± warning limit, ± action limit, and the moisture range for which these limits are applicable.
Commercial Rice Mill Study
October 2015 Resolution –

The Advisory Committee encourages FGIS to initiate a study with rough rice to determine the effectiveness of the Grainman Miller No. 65 for predicting commercial rice milling yield. Factors to consider in addition to milling yield are total broken kernels, whiteness and chalkiness. Newer rice hybrids along with their harvest and drying history should be included in the study.
Objective

• To evaluate the consistency of milling yield results between the official FGIS laboratory mill and commercial milling operations.
Cooperative Agreement

• University of California, Davis
  • California Agri Inspection Co., Ltd
  • 2 Participating Mills in Arkansas
  • 1 Participating Mill in California
  • 1 Participating Mill in Louisiana

• Completed first year of planned 2 year study
## Commercial mill sample collection

<table>
<thead>
<tr>
<th>Mill</th>
<th>Location</th>
<th>Rice Types (Variety Type)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1</td>
<td>California</td>
<td>Long (Pure)</td>
</tr>
<tr>
<td>M2</td>
<td>Arkansas</td>
<td>Long (Pure &amp; Hybrid)</td>
</tr>
<tr>
<td>M3</td>
<td>Louisiana</td>
<td>Long (Pure &amp; Mixed)</td>
</tr>
<tr>
<td>M4</td>
<td>Arkansas</td>
<td>Long (Hybrid &amp; Mixed)</td>
</tr>
</tbody>
</table>
### FGIS Milling Procedures

<table>
<thead>
<tr>
<th>Type of rice</th>
<th>Milling cycle</th>
<th>Duration</th>
<th>Brushing cycle</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long-grain</td>
<td>2 pounds</td>
<td>30 sec</td>
<td>0 pounds</td>
<td>30 sec</td>
</tr>
<tr>
<td>Medium-grain</td>
<td>7 pounds</td>
<td>30 sec</td>
<td>0 pounds</td>
<td>30 sec</td>
</tr>
<tr>
<td>Short-grain</td>
<td>10 pounds for Western production</td>
<td>30 sec</td>
<td>2 pounds for Western production</td>
<td>30 sec</td>
</tr>
</tbody>
</table>
Milling Yield

Total rice yield (TRY) or Total Rice (TR) and head rice yield (HRY) or percent whole kernels (WK)
## Results from First Year

<table>
<thead>
<tr>
<th>Category</th>
<th>No Significant Difference</th>
<th>FGIS Less Than Commercial</th>
<th>FGIS Greater Than Commercial</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRY</td>
<td>29%</td>
<td>29%</td>
<td>42%</td>
</tr>
<tr>
<td>HRY</td>
<td>35%</td>
<td>16%</td>
<td>49%</td>
</tr>
</tbody>
</table>
Results

Milling yield – Total rice yield (TRY) - Fourth quarter

![Bar chart showing total rice yield for different rice types and varieties, with Commercial and FGIS Lab data compared. The chart includes labels for M1-LP-A202, M1-MP-M208, M1-SP-S102, M2-LP-C151, M2-LH-X745, M2-MP-Jupiter-L1, M2-MP-Jupiter-L2, and M3-LP-CL-111. The data is presented in percentages.]
Results

Milling yield – Head rice yield (HRY) - Fourth quarter

![Bar chart showing the comparison of head rice yield between Commercial and FGIS Lab for different rice types and varieties. The chart includes annotations indicating significance levels (A, B).]
Conclusion

• The first year data shows no consistent trend in the difference in the milling yield between the FGIS lab and commercial mills.
Next Steps

• Final (second) year sample collection in process
  • Determine if the findings from first year are seen in the second year
  • Make conclusive statements with high confidence about the agreement between FGIS and commercial mills

• Final Report due April 2019
Agricultural Marketing Service
Creating Opportunities for American Farmers and Businesses

Questions?
Falling Number and Mycotoxin Testing

Tom Weber, Chief
Analytical Chemistry Branch

Grain Inspection Advisory Committee Meeting
September 5, 2018
Falling Number (FN) Method

- Indirect measurement of alpha-amylase activity
- Alpha-amylase breaks down starch
- High activity adversely effects end-use quality
- Important factor in domestic and international trade of wheat
- Internationally standardized and most widely accepted method
- FN is the time required to mix and drop rod through heated wheat meal / water slurry
- FN inversely proportional to alpha-amylase activity
Pacific Northwest 2016

• Low falling number values
  • 44% soft white, 42% club wheat samples < 300 sec*
  • High frequency of discounts applied
  • Complaints that FN test too variable

• October 2016 Advisory Committee Resolution
  • FGIS should continue its efforts to reduce FN testing variation and increase oversight and training of official service providers

*M. Weaver. Capital Press. 8/2/2018
Two Opportunities to Reduce Variation

1. Implement new correction based on barometric pressure
2. Require use of Shakematic
Correcting FN to Sea Level

• Increase elevation leads to increase in FN

• Current FGIS procedure
  • Correct to sea level at locations 2000 ft. and above
  • Cereal Chem. 1994, 71(3), 269–271
  • Correction needed below 2000 ft. to remove bias

• New FGIS procedure
  • FGIS engaged USDA Agricultural Research Service
  • Correct to sea level using barometric pressure
  • Cereal Chem. 2018, 00, 1–8
Effect of Elevation on Falling Number

Example: FN = 300 sec at sea level

Barometric Pressure (in Hg)

Predicted FN (sec)

Elevation (ft.)

+12 sec Kansas City, MO
+18 sec Devil’s Lake, ND
+37 sec Great Falls, MT

Portland, OR
Comparison of Correction Procedures
2,545 Inspection Monitoring Results

Current Correction

Mean RD = -3.75%
Standard Deviation = 8.21

New Correction

Mean RD = 0.53%
Standard Deviation = 8.63

Error bars represent +/- 3 standard deviations
Impact of Implementing New Correction

• Reduced variation that promotes fair trade
• Allow tighter tolerances in inspection monitoring
• Lower FN for locations below 2000 ft.
• Higher FN for locations at 2000 ft. and above
• Magnitude of change depends on elevation and falling number
Sample Shaking Method

• Sample / water homogenization required
• FGIS allows shaking by hand or Shakematic
• FGIS compared the two shaking methods
  • Shakematic gives 3–5% lower FN results
• FGIS recommends requiring Shakematic
  • Eliminates fatigue
  • Provides more consistent mixing
  • Most official service providers use Shakematic
Recommendations

- Implement barometric pressure correction
- Require use of Shakematic

Implementation Plan

- Fall 2018 – notify stakeholders
- Update FGIS Program Directive 9180.38
- Target effective date of May 1, 2019
  - Allow time for industry to prepare
  - Ready for start of 2019 crop harvest
Mycotoxin Testing
Topics of Concern

• What is the expected variation between official labs?
• Why not use one test kit for all official agencies?
• Are uniform procedures established?
• Are procedures are available to industry?
Variation in Measurements

- Some variation is expected
- More variables lead to more variation
- Variation also dependent on concentration

<table>
<thead>
<tr>
<th>Conditions for Smaller Variation</th>
<th>Conditions for Larger Variation</th>
</tr>
</thead>
<tbody>
<tr>
<td>One analyst</td>
<td>Multiple analysts</td>
</tr>
<tr>
<td>One lab</td>
<td>Multiple labs</td>
</tr>
<tr>
<td>One method</td>
<td>Multiple methods</td>
</tr>
<tr>
<td>One ground sample</td>
<td>Multiple whole grain samples</td>
</tr>
<tr>
<td>High concentration</td>
<td>Low concentration</td>
</tr>
</tbody>
</table>
Prediction of Variation

• Horwitz function*
  • Internationally-accepted method
  • Between-lab variation
  • Used in FGIS inspection monitoring to flag erroneous results

*Horwitz, W. et al. J. AOAC. 1984, 63, 1344 – 1354
Agreement between Labs

• Use predicted variation to determine acceptable range

• Example: Labs A and B analyze same ground sample
  
  • A = 1.2 ppm DON; B = 2.5 ppm DON
  
  • Mean = 1.85 ppm
  
  • Predicted RSD = 14.49%; SD = 0.27 ppm
  
  • Results should be \(1.85 \pm 0.54\) ppm (i.e., 1.31 – 2.39 ppm) 95% of the time
  
  • Results from Labs A and B are outside this range
Test Kit Selection

• Official agencies can use any FGIS-certified test kit
• Mycotoxin Test Kit Evaluation Program
  • Performance-based approval of test kits
  • Test kit must meet FGIS accuracy requirements
Use and Availability of Procedures

- Official, written instructions issued by FGIS
- All official service providers are required to follow these official instructions
- Training and licensing is required
- Procedures available to industry on FGIS website
October 2016 Advisory Committee Resolution

“The Advisory Committee recommends looking into and addressing what could be the root cause of variances in testing results i.e., particle size, test kit performance, sample splitting, etc.”

• Investigated contributors to unexpected variation
• Developing a plan to minimize overall variation
Questions?