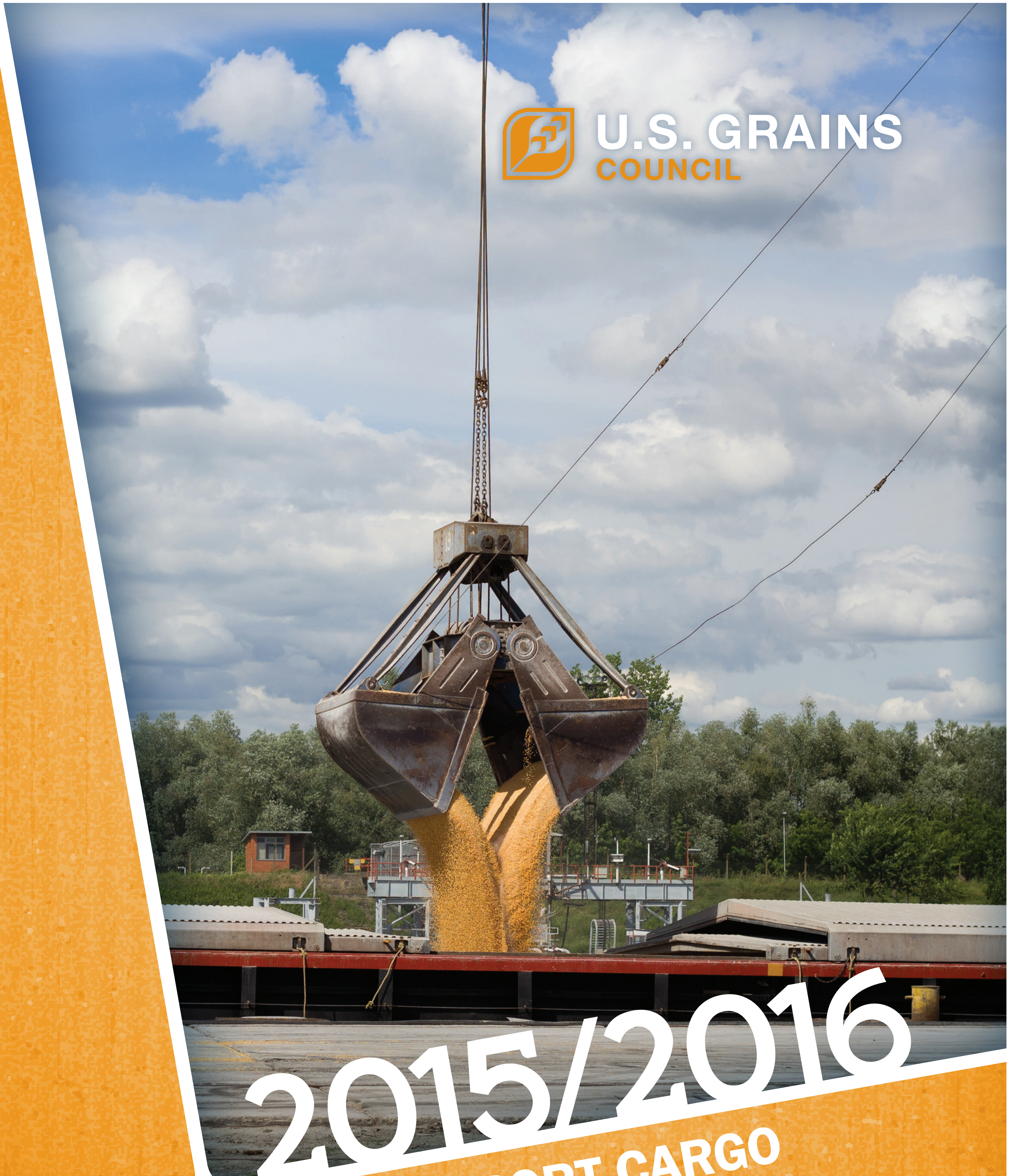
U.S. GRAINS COUNCIL



2015/2016 CORN EXPORT CARGO QUALITY REPORT

ACKNOWLEDGEMENTS

Developing a report of this scope and breadth in a timely manner requires participation by a number of individuals and organizations. The U.S. Grains Council is grateful to Dr. Sharon Bard and Mr. Chris Schroeder of Centrec Consulting Group, LLC for their oversight and coordination in developing this report. They were supported by internal staff along with a team of experts that helped in data gathering, analysis, and report writing. External team members include Drs. Lowell Hill, Marvin Paulsen, and Tom Whitaker. The Illinois Crop Improvement Association's Identity Preserved Grain Laboratory conducted analysis of the collected corn samples.

In particular, we acknowledge the irreplaceable services of the Federal Grain Inspection Service (FGIS) of the U.S. Department of Agriculture. FGIS provided samples from export cargoes along with their grading and aflatoxin test results. The FGIS Office of International Affairs coordinated the sampling process. FGIS field staff, the Washington State Department of Agriculture, and FGIS-designated domestic official service providers collected and submitted the samples that constitute the foundation of this report. We are grateful for the time they devoted during their busy season.

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GREETINGS FROM THE COUNCIL

The U.S. Grains Council is pleased to present its *2015/2016 Corn Export Cargo Quality Report* for use by international customers and other interested parties.

Quality is a vital concern for every stakeholder in the corn value chain: seed companies, growers, traders, handlers, shippers, processors and end-users. The *2015/2016 Corn Export Cargo Quality Report* is an objective survey of the quality of U.S. yellow commodity corn destined for export based on samples taken at the point of loading for international shipment.

This is the second of two reports released by the Council detailing the quality of the 2015/2016 corn crop, following the *2015/2016 Corn Harvest Quality Report* released by the Council late last year. Together, these two reports are intended to provide reliable information on U.S. corn quality from the farm to the customer based on a transparent and consistent methodology.

In addition to providing an early look at grade factors and moisture, which are tracked by the U.S. Federal Grain Inspection Service (FGIS), these reports provide information on additional quality characteristics that has not been reported elsewhere.

The *2015/2016 Corn Harvest Quality Report* and the *2015/2016 Corn Export Cargo Quality Report* are the fifth editions of an ongoing series produced annually. The value of these reports to all stakeholders is increasing over time as the information becomes more familiar and as year-to-year patterns appear in the U.S. corn marketing system.

The Council is committed to continuous export expansion based upon the principles of mutual benefit and increased food security through trade. We hope to serve as a trusted partner and a bridge between U.S. producers and international customers – an endeavor to which reliable and timely information is essential.

We trust that our international partners will find the *2015/2016 Corn Harvest Quality Report* and *2015/2016 Corn Export Cargo Quality Report* informative and useful, and we look forward to ongoing engagement based on the information they provide.

Sincerely,

Alan Tiemann
Chairman, U.S. Grains Council
April 2016

I. EXPORT CARGO QUALITY HIGHLIGHTS

The average aggregate quality of the corn assembled for export early in the 2015/2016 marketing year was better than or equal to U.S. No. 2 on all grade factors, and moisture content was below 2014/2015. Chemical attributes indicated higher oil and starch, and lower protein in 2015/2016 than the average of the previous four marketing years (4YA[1]). Physical attributes of stress cracks were lower with higher percentages of whole kernels; kernel size was smaller, and true density and horneous endosperm were lower, indicating softer corn than in 2014/2015. In addition, the incidences of positive levels of aflatoxin and deoxynivalenol (DON) test results were low, suggesting that average levels of aflatoxins and DON in export shipments were low. Notable U.S. Aggregate quality attributes of the early 2015/2016 export samples include:

GRADE FACTORS AND MOISTURE

- Lower average test weight of 57.3 lb/bu (73.7 kg/hl) than last year and 4YA; however, it still indicates overall good quality with over 95% of the samples above the limit for U.S. No. 1 grade.
- Similar BCFM (3.0%) to 2014/2015 and equal to the maximum limit for U.S. No. 2 grade (3.0%). BCFM predictably increased as the crop moved from harvest through the market channel to export, from 0.8% to 3.0%.
- Lower total damage (1.9%) than 2014/2015 and well below the 3.0% limit for U.S. No. 1 grade.
- Lower average moisture (14.4%) than 2014/2015, but same as 4YA.

CHEMICAL COMPOSITION

- Lower average protein concentration (7.8% dry basis) than 2014/2015, 4YA, and the 2015 harvest average (8.2%).
- Higher starch concentration (73.9% dry basis) than 2014/2015 (73.7%), 4YA (73.8%) and the 2015 harvest average (73.6%).
- Similar oil concentration (3.9% dry basis) to 2014/2015, but higher than 4YA (3.7%), and the 2015 harvest average (3.8%).
- Average protein concentrations were higher for the Pacific Northwest ECA (8.4%) than for the Gulf (7.7%) and Southern Rail (7.7%) ECAs. Average protein concentrations have been consistently higher for the Pacific Northwest ECA than the other two ECAs for each of the last two years and 4YA.

PHYSICAL FACTORS

- Lower average stress cracks (6%) than 2014/2015 and 4YA. The majority of the export samples (96.8%) had less than 15% stress cracks, which should indicate low rates of breakage during handling.
- Lower kernel volume and 100-kernel weight than 2014/2015, indicating smaller kernel sizes in 2015/2016 corn exports than in the previous year.
- The Gulf ECA had the highest true density of the three ECAs for 2015/2016 and 4YA.
- Lower true density (1.275 g/cm^3) and horneous endosperm (80%) than 2014/2015 and 4YA, indicating softer corn in 2015/2016 than previous years.
- Higher whole kernels (89.5%) than 2014/2015 and 4YA. The relatively high percentage of whole kernels, accompanied by low stress cracks, should be favorable for storability.

MYCOTOXINS

- All of the export samples tested below the FDA action level of 20 ppb for aflatoxins. A higher proportion of the export samples had no detectable levels of aflatoxins than 2014/2015.
- 100% of the corn export samples tested below the FDA advisory levels for DON (5 ppm for hogs and other animals and 10 ppm for chicken and cattle). About 99% of the samples had no detectable levels of DON, which was a higher percentage than both the 2014/2015 and 2013/2014 samples.

[1] *4YA represents the simple average of the quality factor's average or standard deviation from the 2011/2012, 2012/2013, 2013/2014, and 2014/2015 Export Cargo Reports.*

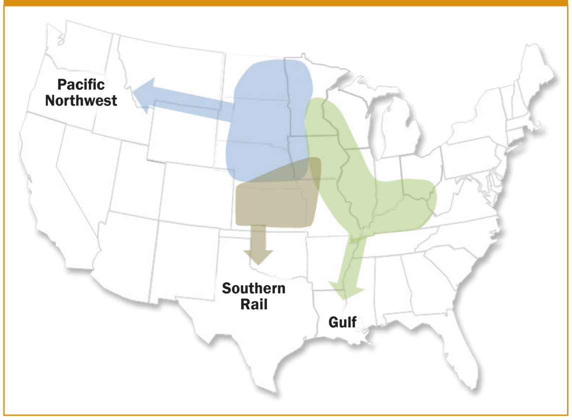
II. INTRODUCTION

Corn quality information is important to foreign buyers and other industry stakeholders as they make decisions about purchase contracts and processing needs for corn for feed, food or industrial use. The *U.S. Grains Council 2015/2016 Corn Export Cargo Quality Report* provides accurate, unbiased information about the quality of U.S. yellow commodity corn as it is assembled for export early in the marketing year. This report provides test results for corn samples collected during the U.S. government-licensed sampling and inspection process for U.S. corn waterborne and rail export shipments.

This *Export Cargo Report* is based on 408 yellow commodity corn samples collected from corn export shipments as they underwent the federal inspection and grading process performed by the U.S. Department of Agriculture's (USDA) Federal Grain Inspection Service (FGIS) or licensed inspectors at interior offices. The sample test results are reported at the U.S. aggregate level (U.S. Aggregate) and by export points associated with three general groupings, which are labeled Export Catchment Areas (ECAs). These three ECAs are identified by the three major pathways to export markets:

1. The Gulf ECA consists of areas that typically export corn through U.S. Gulf ports;
2. The Pacific Northwest ECA includes areas that usually export corn through Pacific Northwest and California ports; and
3. The Southern Rail ECA comprises areas generally exporting corn to Mexico by rail from inland subterminals.

Export Catchment Areas



The sample test results are also summarized by "contract grade" categories ("U.S. No. 2 or better" and "U.S. No. 3 or better") to illustrate the practical quality differences between these two contract specifications.

This report provides detailed information on each of the quality factors tested, including average, standard deviation and distribution for the aggregate of all samples and for each of the three ECAs. The "Quality Test Results" section summarizes the following quality factors:

- Grade Factors: test weight, broken corn and foreign material (BCFM), total damage, and heat damage
- Moisture
- Chemical Composition: protein, starch, and oil
- Physical Factors: stress cracks, stress crack index, 100-kernel weight, kernel volume, kernel true density, whole kernels, and horneous (hard) endosperm
- Mycotoxins: aflatoxins and DON

Details about the testing analysis methods used for this report are provided in the "Testing Analysis Methods" section.

II. INTRODUCTION (continued)

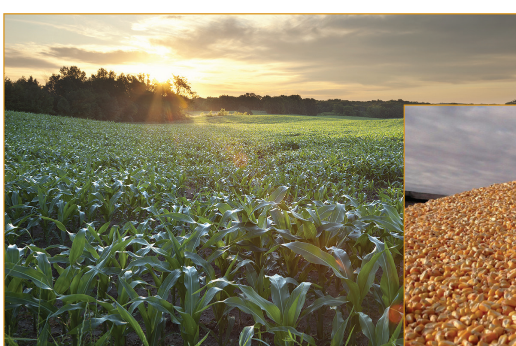
New to this *2015/2016 Export Cargo Report* is a simple average of the quality factors' averages and standard deviations of the previous four *Export Cargo Reports* (*2011/2012, 2012/2013, 2013/2014*, and *2014/2015*). These simple averages are calculated for the U.S. Aggregate and each of the three ECAs, and are referred to as "4YA" in the report.

For the *2015/2016 Export Cargo Report,* FGIS and interior offices collected samples during November 2015 through mid-March 2016 to generate statistically valid results for the U.S. Aggregate and by ECA. The objective was to obtain enough samples to estimate quality factor averages of the corn exports with a relative margin of error (Relative ME) less than ± 10%, a reasonable target for biological data such as these factors. Details of the statistical sampling and analysis methods are presented in the "Survey and Statistical Analysis Methods" section.

This *2015/2016 Export Cargo Report* is the fifth in a series of annual surveys of the quality of the U.S. corn exports early in the marketing year. In addition to the Council reporting the quality of corn exports early in the current marketing year, the cumulative *Export Cargo Report* surveys will provide increasing value to stakeholders. The five years of data enable export buyers and other stakeholders to begin making year-to-year comparisons and assessing patterns in corn quality based on growing, drying, handling, storage and transport conditions.

The *Export Cargo Report* does not predict the actual quality of any cargo or lot of corn after loading or at destination, and it is important for all players in the value chain to understand their own contract needs and obligations. Many of the quality attributes, in addition to grade, can be specified in the buyer-seller contract. In addition, this report does not explain the reasons for changes in quality factors from the *Harvest Report* to the *Export Cargo Report*. Many factors, including weather, genetics, commingling, and grain drying and handling, affect changes in quality in complex ways. Sample test results can vary significantly depending on the origination of the corn, the ways in which a corn lot was loaded onto a conveyance, and the method of sampling used.

A companion report, the *U.S. Grains Council 2015/2016 Corn Harvest Quality Report*, was released in December 2015 and reported on the quality of the corn as it entered the U.S. marketing system. The *2015/2016 Harvest Report* and the *2015/2016 Export Cargo Report* should be studied together so that changes in corn quality occuring between harvest and export can be understood. A review of how corn quality evolves from the field to the ocean vessel or railcar is provided in the "U.S. Corn Export System" section.



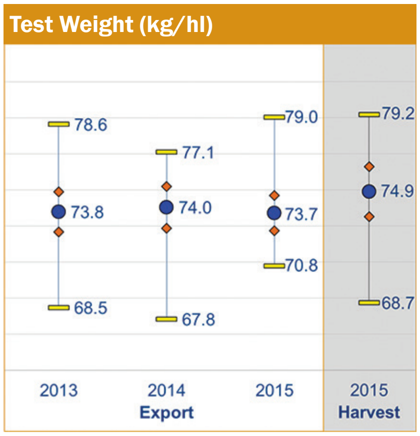
A. Grade Factors

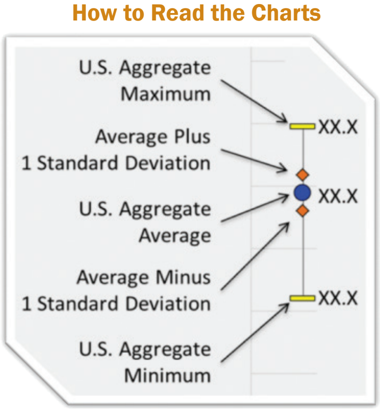
The USDA's Federal Grain Inspection Service (FGIS) has established numerical grades, definitions and standards for grains. The attributes which determine the numerical grades for corn are test weight, broken corn and foreign material (BCFM), total damage, and heat damage. The table for "U.S. Corn Grades and Grade Requirements" is provided on page 51 of this report.

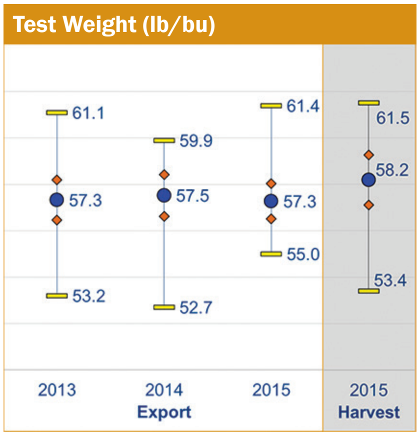
SUMMARY: GRADE FACTORS AND MOISTURE

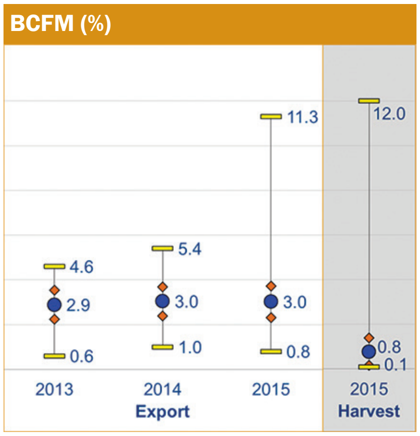
- *Average U.S. Aggregate test weight (57.3 lb/bu or 73.7 kg/hl) was lower than 2014/2015 (57.5 lb/bu) and 4YA (57.7 lb/bu), but well above the limit for U.S. No. 1 grade corn (56 lb/bu).*
- *Average U.S. Aggregate BCFM (3.0%) was the same as in 2014/2015. However, approximately 57.3% of the export samples contained levels at or below the maximum allowed for U.S. No. 2 grade (3%).*
- *Average U.S. Aggregate total damage (1.9%) and heat damage (0.0%) were well below the limits for U.S. No. 1 grade.*
- *Test weight, total damage, and heat damage averages for contracts loaded as U.S. No. 2 o/b and contracts loaded as U.S. No. 3 o/b were better than U.S. No. 1 grade.*
- *BCFM averages were at or below the grade limits of the U.S. No. 2 o/b and U.S. No. 3 o/b contracts.*
- *Average U.S. Aggregate moisture content (14.4%) was lower than 2014/2015 (14.5%), but same as 4YA (14.4%).*
- *Only 26.0% of the 2015/2016 export samples had moistures above 14.5%, compared to 40% in 2014/2015.*

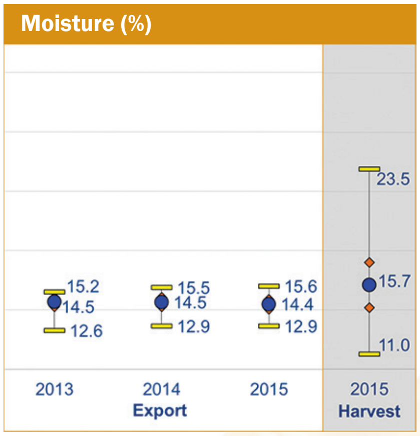
III. QUALITY TEST RESULTS (continued)

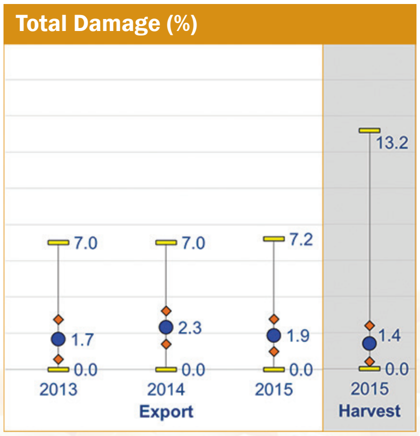












1. Test Weight

Test weight (weight per volume) is a measure of bulk density and is often used as a general indicator of overall quality and as a gauge of endosperm hardness to alkaline cookers and dry millers. It reflects kernel hardness and kernel maturity. Test weight is initially impacted by genetic differences in the structure of the kernel. However, it is also affected by moisture content, method of drying, physical damage to the kernel (broken kernels and scuffed surfaces), foreign material in the sample, kernel size, stress during the growing season, and microbiological damage. High test weight at the export point generally indicates high quality, high percent of horneous (or hard) endosperm, and sound, clean corn.

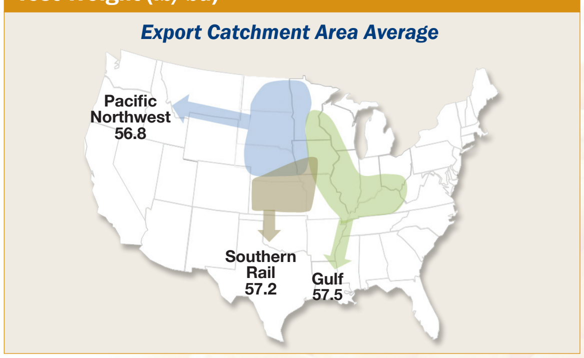
U.S. Grade Minimum Test Weight
No. 1: 56.0 lbs
No. 2: 54.0 lbs
No. 3: 52.0 lbs

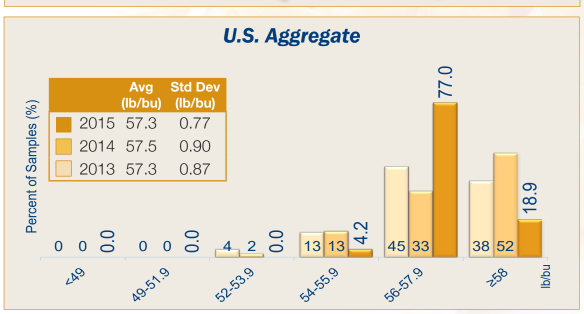
III. QUALITY TEST RESULTS (continued)

RESULTS

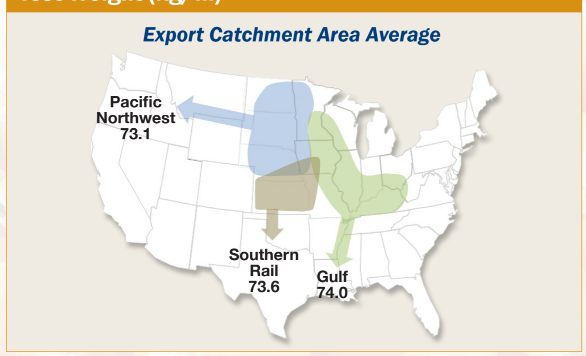
- Average U.S. Aggregate test weight (57.3 lb/bu or 73.7 kg/hl) was lower than 2014/2015 (57.5 lb/bu) and 4YA (57.7 lb/bu), but the same as 2013/2014 (57.3 lb/bu). The average U.S. Aggregate test weight was above the limit for U.S. No. 1 grade (56.0 lb/bu).
- The 2015/2016 export samples had less variation than the 2014/2015 export samples, as indicated by the lower standard deviation (0.77%) compared to 2014/2015 (0.90%). However, the 2015/2016 variation was close to 4YA (0.79%). The range in values was also less than 2014/2015 and 2013/2014.
- Test weight for 95.9% of the samples was at or above the minimum for U.S. No. 1 grade (56 lb/bu), and 100.0% of the samples were at or above the limit for U.S. No. 2 grade (54 lb/bu).
- Test weight at export was lower than at 2015 harvest (58.2 lb/bu or 74.9 kg/hl). Average test weight at export has been consistently lower than at harvest, with 4YA export average (57.7 lb/bu or 74.2 kg/hl) lower than 4YA harvest average (58.1 lb/bu or 74.8 kg/hl).
- The 2015/2016 export samples' variability (standard deviation of 0.77%) was less than the 2015 harvest samples (1.08%). As corn is commingled moving through the market channel, test weight changes and becomes more uniform, with a lower standard deviation and a smaller range between maximum and minimum values than at harvest. At export, 4YA standard deviation was 0.79% compared to 4YA of 1.39% at harvest.
- Test weight was higher in samples from the Gulf (57.5 lb/bu) and Southern Rail (57.2 lb/bu) ECAs in comparison to samples from the Pacific Northwest ECA (56.8 lb/bu).
- Average test weight of corn for contracts loaded as U.S. No. 2 o/b (57.3 lb/bu) was slightly higher than for those contracts loaded as U.S. No. 3 o/b (57.2 lb/bu). Averages for both contracts were above the limit for U.S. No. 1.

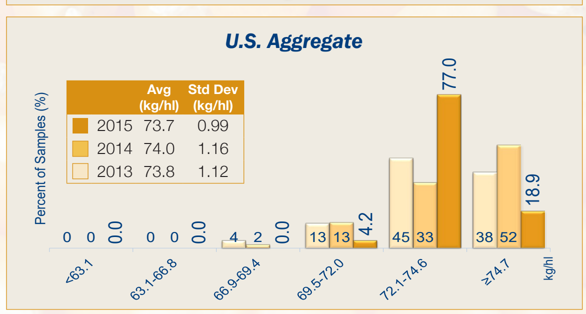
Test Weight (lb/bu)





Test Weight (kg/hl)





2. Broken Corn and Foreign Material (BCFM)

Broken corn and foreign material (BCFM) is an indicator of the amount of clean, sound corn available for feeding and processing. As corn moves from farm deliveries through the market channel, each impact on the grain during handling and transporting increases the amount of broken corn. As a result, the average BCFM in most shipments of corn will be higher at the export point than in deliveries to the local elevator.

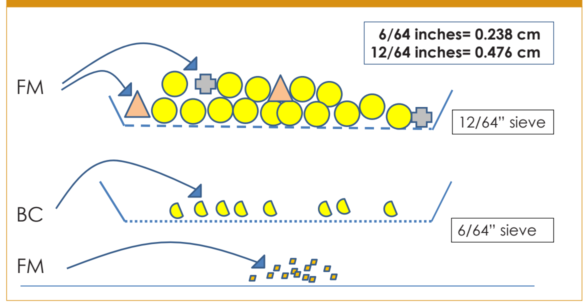
U.S. Grade BCFM Maximum Limits
No. 1: 2.0%
No. 2: 3.0%
No. 3: 4.0%

Broken corn (BC) is defined as corn and any other material (such as weed seeds) small enough to pass through a 12/64th inch round-hole sieve, but too large to pass through a 6/64th inch round-hole sieve.

Foreign material (FM) is defined as any non-corn pieces too large to pass through a 12/64th inch round-hole sieve, as well as all fine material small enough to pass through a 6/64th inch round-hole sieve.

The diagram to the right illustrates the measurement of broken corn and foreign material for the U.S. corn grades.

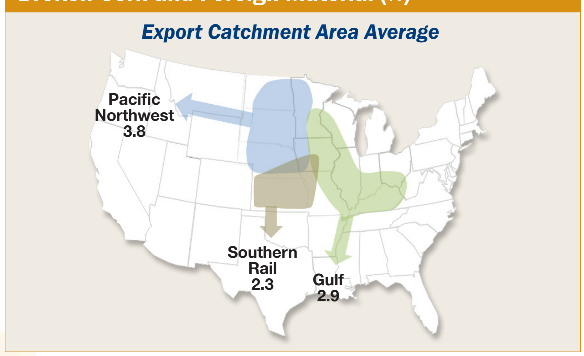
BCFM (Measured as Percent by Weight)

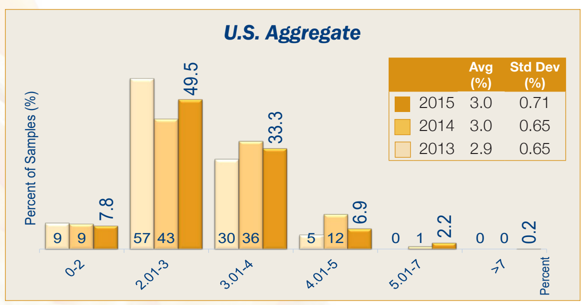


RESULTS

- Average U.S. Aggregate BCFM in export samples (3.0%) was at the maximum for U.S. No. 2 grade. It was the same as 2014/2015 (3.0%), but slightly higher than 2013/2014 (2.9%) and 4YA (2.9%).
- The variability of the 2015/2016 export samples (with a standard deviation of 0.71%) was higher than 2014/2015 (0.65%) and 4YA (0.66%).
- BCFM in the 2015/2016 export samples was distributed with 57.3% of the samples at or below the limit for U.S. No. 2 grade (3%), and 90.6% at or below the limit for U.S. No. 3 grade (4%).
- Average U.S. Aggregate BCFM at export (3.0%) was higher than at harvest (0.8%). This increase is consistent with previous years (4YA harvest average was 0.9%, compared to 4YA export average of 2.9%) and is likely a result of drying and increased breakage occurring with additional handling impacts.

Broken Corn and Foreign Material (%)





- Southern Rail ECA average BCFM (2.3%) was lower than either the Gulf (2.9%) or Pacific Northwest (3.8%) ECAs' average BCFM.
- Average BCFM for contracts loaded as U.S. No. 2 o/b was 2.9%, compared to the average BCFM of 3.4% for contracts loaded as U.S. No. 3 o/b. Corn arriving at the export point is normally commingled from many origins to meet the limits for the contracted grade.

3. Total Damage

Total damage is the percentage of kernels and pieces of kernels that are visually damaged in some way, including damage from heat, frost, insects, sprouting, disease, weather, ground, germ and mold. Most of these types of damage result in some sort of discoloration or change in kernel texture. Damage does not include broken pieces of grain that are otherwise normal in appearance. Mold damage and the associated potential for mycotoxins is the damage factor of greatest concern. Mold damage is usually associated with higher moisture content and high temperature conditions during growing or storage.

U.S. Grade Total Damage Maximum Limits
No. 1: 3.0%
No. 2: 5.0%
No. 3: 7.0%

Corn with low levels of total damage is more likely to arrive at destination in good condition than corn with high levels of total damage. High levels of total damage have the potential to increase moisture and microbiological activity during transport.

RESULTS

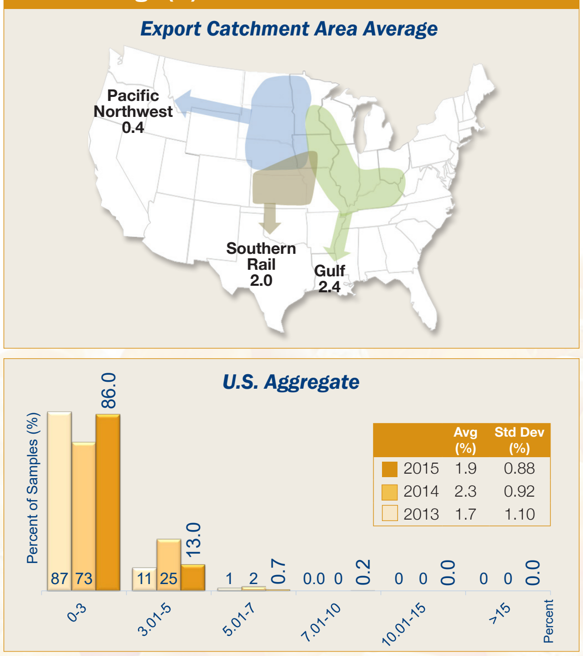
- Average U.S. Aggregate total damage (1.9%) was lower than 2014/2015 (2.3%), same as 4YA (1.9%), and well below the 3.0% limit for U.S. No. 1 grade.

- Variability, as indicated by the standard deviation in the 2015/2016 samples (0.88%), was slightly lower than 2014/2015 (0.92%) and 4YA (1.04%). The 2015/2016 sample range (0.0 to 7.2%) was similar to 2014/2015 and 2013/2014 (both 0.0 to 7.0%).

- Of the export samples, 86.0% had 3.0% or less damaged kernels, meeting the requirement for U.S. No. 1 grade. In addition, 99.0% were below the limit for U.S. No. 2 grade (5.0%).

- The average level of total damage in the market channel increased, from 1.4% at harvest to 1.9% at export. Over the years, there has been consistently higher total damage in samples at export than at harvest (4YA export average of 1.9% and 4YA harvest average of 1.1%). This increase, still leaves the corn well within the grade limits despite the additional time in transport and storage prior to export, and indicates good management practices in the market channel.

Total Damage (%)



- The Pacific Northwest ECA had lower total damage (0.4%) compared to the Gulf (2.4%) and the Southern Rail (2.0%) ECAs.

- The Gulf ECA had a greater increase in total damage (1.7% to 2.4%) between harvest and export than the other ECAs. The Pacific Northwest ECA had the smallest change in total damage (±0.3%) from harvest samples, which has been the pattern in previous years. Lower moisture and cooler temperatures at harvest may be a partial explanation for the consistent pattern of the smaller change in total damage in this ECA.

- Average total damage for contracts being loaded as U.S. No. 2 o/b (1.9%), and as U.S. No. 3 o/b (2.1%), were below the limit for U.S. No. 1 grade (3.0%).

4. Heat Damage

Heat damage is a subset of total damage in corn grades and has separate allowances in the U.S. Grade standards. Heat damage can be caused by microbiological activity in warm, moist grain or by high heat applied during drying. Low levels of heat damage may indicate the corn has been stored at appropriate moisture and temperatures prior to delivery to the export point.

U.S. Grade Heat Damage Maximum Limits
No. 1: 0.1%
No. 2: 0.2%
No. 3: 0.5%

RESULTS

- Average U.S. Aggregate heat damage was 0.0%, same as 2014/2015, 2013/2014 and 4YA.
- Only five samples in the entire sample set showed any heat damage (0.1% for all five samples) in the 2015/2016 export samples. This number has also been well below the limit for U.S. No. 1 grade in previous years, indicating good management of drying and storage of the corn throughout the market channel.

B. Moisture

Moisture content is reported on all official grade certificates, but does not determine which numerical grade will be assigned to the sample. Moisture content is usually specified in the contract by the buyer, independent of the grade. Moisture content is important because it affects the amount of dry matter being sold and purchased. In addition, the average moisture level and variability in a shipment of corn affect its quality upon arrival at its destination. The general guidelines for good quality, clean corn are as follows: a recommended 14% maximum moisture level under aerated storage in U.S. corn-belt conditions for storage up to six to twelve months; and a recommended 13% or less moisture for storage of more than one year.[1]

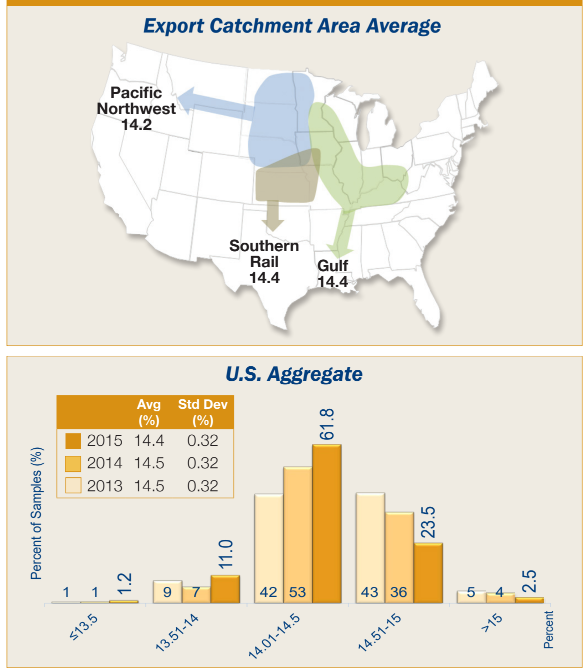
Corn is typically transported in railcars or in closed, nearly airtight holds during the ocean voyage. Few bulk carriers or railcars have the ability to aerate the grain mass during transit. This lack of aeration can create an ideal environment for pockets of high moisture to initiate microbiological activity. In addition, temperature variations in the grain mass can cause moisture migration, resulting in warm, moist air condensing on colder surfaces of grain, near sidewalls, or on the underside of hatch covers, which can lead to development of spoilage or hot spots. Hot spots are small pockets of grain where the moisture content and temperature become abnormally higher than the average for the cargo. Thus, uniformity of moisture content among sublots and average moisture values of 14% or below are important for minimizing the risk of hot spots developing during transit.

[1] *MWPS-13. 1988. Grain drying, handling and storage handbook. Midwest Plan Service No. 13. Iowa State University, Ames, IA. 50011.*

RESULTS

- Average U.S. Aggregate moisture content (14.4%) was similar to 2014/2015 and 2013/2014 (both 14.5%), and same as 4YA (14.4%).
- Moisture content variability among samples for 2015/2016 (standard deviation of 0.32%) was the same as the previous two years (0.32%), and similar to 4YA (0.34%).
- Only 26.0% of the samples had moisture content above 14.5%, compared to 40% in 2014/2015 and 48% in 2013/2014.
- Average moisture content decreased between harvest and export (from 15.7% to 14.4%) and uniformity among samples increased, as indicated by the lower standard deviations at export (0.32%) compared to harvest (1.53%). This increase in uniformity among samples may have resulted from conditioning and commingling in the market channel following harvest.

Moisture (%)



- The Pacific Northwest ECA's average moisture (14.2%) was lower than the Gulf and Southern Rail ECAs average moisture (both 14.4%). The Pacific Northwest ECA at export had the lowest moisture among ECAs for each of last two years and for 4YA.
- Moisture content is not a grade-determining factor. However, average moisture was slightly lower for contracts loaded as U.S. No. 2 o/b (14.3%) than for contracts loaded as U.S. No. 3 o/b (14.5%). The moisture range for U.S. No 2 o/b (13.0 to 15.6%) was wider than the range for U.S. No 3 o/b (13.6 to 15.2%); however, the moisture standard deviations for U.S. No. 2 o/b (0.37%) and U.S. No. 3 o/b (0.39%) were similar.

III. QUALITY TEST RESULTS (continued)

SUMMARY: GRADE FACTORS AND MOISTURE

	2015/2016 Export Cargo					2014/2015 Export Cargo			2013/2014 Export Cargo			4 Year Avg. (2011-2014)	
	No. of Samples	Avg.	Std. Dev.	Min.	Max.	No. of Samples	Avg.	Std. Dev.	No. of Samples	Avg.	Std. Dev.	Avg.	Std. Dev.
U.S. Aggregate													
Test Weight (lb/bu)	408	57.3	0.77	55.0	61.4	411	57.5*	0.90	412	57.3	0.87	57.7	0.79
Test Weight (kg/hl)	408	73.7	0.99	70.8	79.0	411	74.0*	1.16	412	73.8	1.12	74.2	1.02
BCFM (%)	408	3.0	0.71	0.8	11.3	411	3.0	0.65	412	2.9*	0.65	2.9	0.66
Total Damage (%)	408	1.9	0.88	0.0	7.2	411	2.3*	0.92	412	1.7*	1.10	1.9	1.04
Heat Damage (%)	408	0.0	0.01	0.0	0.1	411	0.0	0.01	412	0.0	0.01	0.0	0.01
Moisture (%)	408	14.4	0.32	12.9	15.6	411	14.5*	0.32	412	14.5*	0.32	14.4	0.34
Gulf													
Test Weight (lb/bu)	272	57.5	0.79	55.1	61.4	292	58.0*	0.81	295	57.9*	0.72	58.1	0.69
Test Weight (kg/hl)	272	74.0	1.02	70.9	79.0	292	74.7*	1.04	295	74.5*	0.93	74.8	0.89
BCFM (%)	272	2.9	0.51	0.8	4.8	292	3.1*	0.68	295	2.9	0.71	3.0	0.71
Total Damage (%)	272	2.4	1.01	0.3	7.2	292	2.8*	1.04	295	1.9*	1.08	2.3	1.21
Heat Damage (%)	272	0.0	0.01	0.0	0.1	292	0.0	0.01	295	0.0	0.01	0.0	0.02
Moisture (%)	272	14.4	0.27	13.6	15.2	292	14.5*	0.33	295	14.5*	0.34	14.4	0.35
Pacific Northwest													
Test Weight (lb/bu)	92	56.8	0.68	55.0	58.7	84	55.4*	1.28	82	55.0*	1.37	56.0	1.08
Test Weight (kg/hl)	92	73.1	0.87	70.8	75.6	84	71.3*	1.65	82	70.8*	1.77	72.1	1.39
BCFM (%)	92	3.8	1.25	1.3	11.3	84	3.6	0.65	82	2.9*	0.58	3.1	0.63
Total Damage (%)[1]	92	0.4	0.36	0.0	1.6	84	0.4	0.34	82	0.9*	1.56	0.6	0.71
Heat Damage (%)	92	0.0	0.00	0.0	0.0	84	0.0	0.00	82	0.0	0.00	0.0	0.01
Moisture (%)	92	14.2	0.30	13.0	14.9	84	14.4*	0.22	82	14.4*	0.25	14.2	0.30
Southern Rail													
Test Weight (lb/bu)	44	57.2	0.84	55.6	59.5	35	58.0*	0.79	35	57.8*	0.89	58.1	0.88
Test Weight (kg/hl)	44	73.6	1.08	71.6	76.6	35	74.7*	1.02	35	74.4*	1.14	74.8	1.13
BCFM (%)	44	2.3	0.76	0.9	4.5	35	1.8*	0.47	35	2.7*	0.41	2.3	0.41
Total Damage (%)[1]	44	2.0	1.08	0.2	4.5	35	2.7*	1.15	35	1.6*	0.52	1.8	0.69
Heat Damage (%)	44	0.0	0.00	0.0	0.0	35	0.0	0.00	35	0.0	0.02	0.0	0.01
Moisture (%)	44	14.4	0.59	12.9	15.6	35	14.8*	0.40	35	14.9*	0.31	14.5	0.37

** Indicates that the 2014/2015 Export Cargo averages were significantly different from the 2015/2016 Export Cargo averages, and the 2013/2014 Export Cargo averages were significantly different from the 2015/2016 Export Cargo averages, based on a 2-tailed t-test at the 95% level of confidence.*

[1] *The relative margin of error (Relative ME) for predicting the 2015/2016 Export Cargo population average exceeded ±10%.*

SUMMARY: GRADE FACTORS AND MOISTURE

	Export Cargo Samples for Contract Loaded as U.S. No. 2 o/b					Export Cargo Samples for Contract Loaded as U.S. No. 3 o/b					2015 Harvest				
	No. of Samples	Avg.	Std. Dev.	Min.	Max.	No. of Samples	Avg.	Std. Dev.	Min.	Max.	No. of Samples[1]	Avg.	Std. Dev.	Min.	Max.
U.S. Aggregate															
Test Weight (lb/bu)	271	57.3	0.75	55.3	59.8	125	57.2	0.85	55.0	61.4	620	58.2**	1.08	53.4	61.5
Test Weight (kg/hl)	271	73.7	0.97	71.2	77.0	125	73.6	1.09	70.8	79.0	620	74.9**	1.38	68.7	79.2
BCFM (%)	271	2.9	0.45	0.9	4.1	125	3.4	0.84	0.8	6.7	620	0.8**	0.61	0.1	12.0
Total Damage (%)	271	1.9	0.80	0.2	5.7	125	2.1	1.07	0.0	7.2	620	1.4**	1.00	0.0	13.2
Heat Damage (%)	271	0.0	0.01	0.0	0.1	125	0.0	0.01	0.0	0.1	620	0.0**	0.00	0.0	0.0
Moisture (%)	271	14.3	0.37	13.0	15.6	125	14.5	0.39	13.6	15.2	620	15.7**	1.53	11.0	23.5
Gulf															
Test Weight (lb/bu)	230	57.5	0.71	55.3	59.8	37	57.5	1.08	55.1	61.4	577	58.3**	1.10	53.4	61.5
Test Weight (kg/hl)	230	74.0	0.92	71.2	77.0	37	74.0	1.38	70.9	79.0	577	75.0**	1.41	68.7	79.2
BCFM (%)	230	2.9	0.35	1.6	3.6	37	3.3	0.91	0.8	4.8	577	0.8**	0.63	0.1	12.0
Total Damage (%)	230	2.4	0.93	0.3	5.7	37	2.4	1.43	0.8	7.2	577	1.7**	1.17	0.0	13.2
Heat Damage (%)	230	0.0	0.01	0.0	0.1	37	0.0	0.02	0.0	0.1	577	0.**	0.00	0.0	0.0
Moisture (%)	230	14.4	0.23	13.6	15.0	37	14.6	0.35	13.9	15.2	577	15.7**	1.51	11.0	23.3
Pacific Northwest															
Test Weight (lb/bu)	5	56.7	0.84	55.5	57.4	86	56.8	0.68	55.0	58.7	329	57.9**	1.02	53.4	61.2
Test Weight (kg/hl)	5	73.0	1.08	71.4	73.9	86	73.1	0.87	70.8	75.6	329	74.6**	1.31	68.7	78.8
BCFM (%)	5	3.4	0.59	2.8	4.1	86	3.7	0.99	1.3	6.7	329	0.8**	0.66	0.1	12.0
Total Damage (%)	5	0.5	0.20	0.2	0.7	86	0.4	0.37	0.0	1.6	329	0.5**	0.53	0.0	4.9
Heat Damage (%)	5	0.0	0.00	0.0	0.0	86	0.0	0.00	0.0	0.0	329	0.0	0.00	0.0	0.0
Moisture (%)	5	14.0	0.60	13.0	14.5	86	14.3	0.27	13.6	14.9	329	15.7**	1.55	11.0	23.5
Southern Rail															
Test Weight (lb/bu)	36	57.1	0.79	55.6	58.9	2	56.6	0.14	56.5	56.7	402	58.4**	1.08	53.4	61.5
Test Weight (kg/hl)	36	73.5	1.01	71.6	75.8	2	72.9	0.18	72.7	73.0	402	75.1**	1.38	68.7	79.2
BCFM (%)	36	2.3	0.64	0.9	3.4	2	3.6	0.35	3.3	3.8	402	0.7**	0.46	0.1	12.0
Total Damage (%)	36	1.9	1.12	0.2	4.5	2	2.9	0.57	2.5	3.3	402	1.5**	1.01	0.0	11.1
Heat Damage (%)	36	0.0	0.00	0.0	0.0	2	0.0	0.00	0.0	0.0	402	0.0	0.00	0.0	0.0
Moisture (%)	36	14.5	0.58	13.3	15.6	2	14.6	0.71	14.1	15.1	402	15.6**	1.57	11.0	23.3

*** Indicates that the 2015 Harvest averages were significantly different from the 2015/2016 Export Cargo averages, based on a 2-tailed t-test at the 95% level of confidence.*

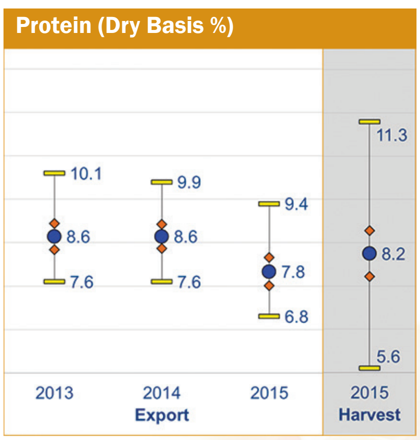
[1] *Due to the Harvest ECA results being composite statistics, the sum of the sample numbers from the three ECAs is greater than the U.S. Aggregate.*

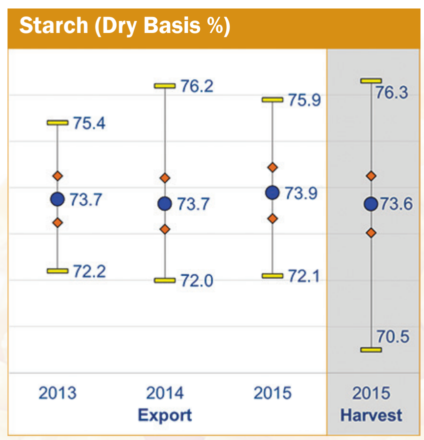
C. Chemical Composition

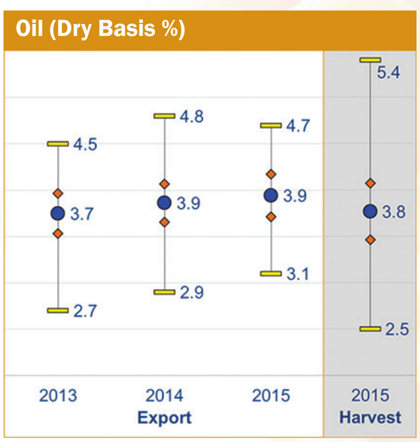
The chemical composition of corn consists primarily of protein, starch, and oil. Although they are not grade factors, these attributes are of significant interest to end users. They provide information related to nutritional value for livestock and poultry feeding, for wet milling uses, and for other processing uses of corn. Unlike many physical attributes, chemical composition values are not expected to change significantly during storage or transit.

SUMMARY: CHEMICAL COMPOSITION

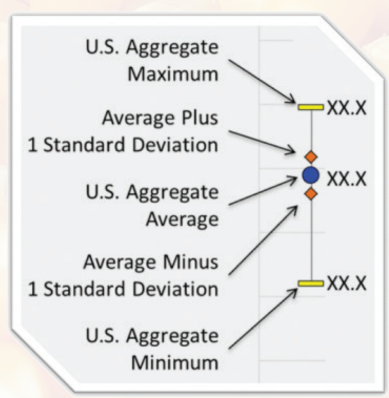
- *Average U.S. Aggregate protein concentration at export (7.8%) was lower than 2014/2015 (8.6%), 4YA (8.8%), and the 2015 harvest average (8.2%).*
- *Average U.S. Aggregate starch concentration (73.9%) was higher than 2014/2015 (73.7%), 4YA (73.8%), and the 2015 harvest average (73.6%).*
- *Average U.S. Aggregate oil concentration (3.9%) was same as 2014/2015, but higher than 4YA (3.7%), and the 2015 harvest average (3.8%).*
- *Among ECAs, average protein concentrations for 2015/2016 export were higher for the Pacific Northwest ECA (8.4%) than the Gulf (7.7%) and Southern Rail (7.7%) ECAs. Average protein concentrations have been consistently higher for the Pacific Northwest ECA than for the other two ECAs for each of the last two years and 4YA.*







How to Read the Charts



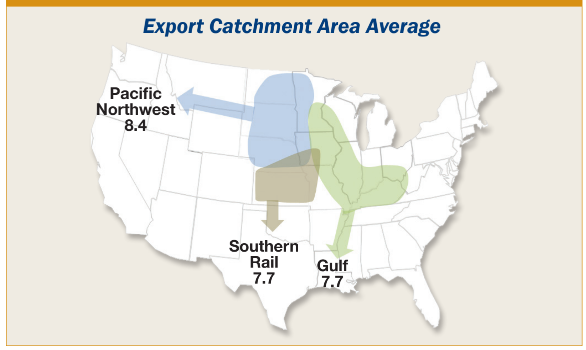
1. Protein

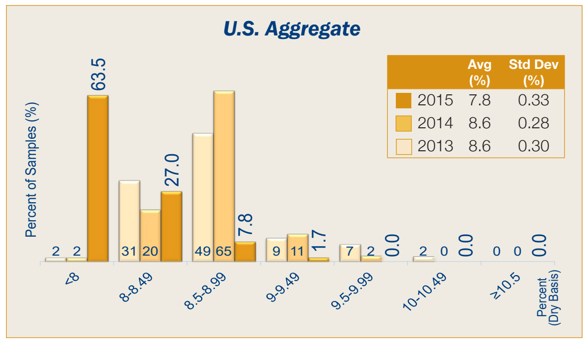
Protein is very important for poultry and livestock feeding, as it supplies essential sulfur-containing amino acids and helps to improve feed conversion efficiency. Protein is usually inversely related to starch concentration. Results are reported on a dry basis.

RESULTS

- Average U.S. Aggregate protein concentration (7.8%) was lower than 2014/2015 and 2013/2014 (both 8.6%), and 4YA (8.8%). The 2015 harvest average (8.2%) was also the lowest in 5 years, believed to be due, in part, to relatively high yields in 2015.
- The 2015/2016 export samples (standard deviation of 0.33%) were more uniform than the 2015 harvest samples (standard deviation of 0.53%). In addition, the range of protein concentration at export (6.8 to 9.4%) was narrower than at harvest (5.6 to 11.3%). The uniformity is due, in part, to grains becoming more homogenous as they are aggregated from numerous harvest level sources.
- Protein concentrations in the 2015/2016 export samples were distributed with 90.5% below 8.5%, compared to 22% of the 2014/2015 samples and 33% of the 2013/2014 samples below 8.5%.
- The Pacific Northwest ECA had higher average protein concentration (8.4%) than the Gulf (7.7%) and Southern Rail (7.7%) ECAs. Average protein concentrations have consistently been higher for the Pacific Northwest ECA than for the other two ECAs for each of the last two years and 4YA.
- Protein concentration averages were slightly higher for contracts loaded as U.S. No. 2 o/b (7.9%) than for contracts loaded as U.S. No. 3 o/b (7.8%).

Protein (%)





III. QUALITY TEST RESULTS (continued)

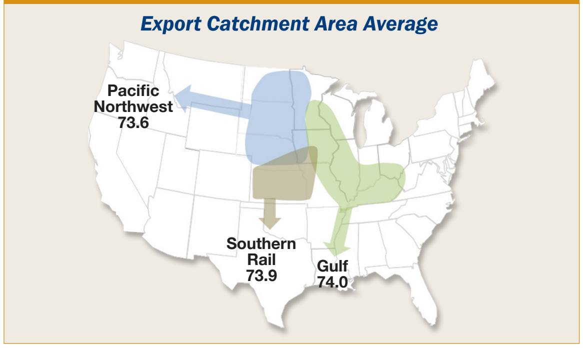
2. Starch

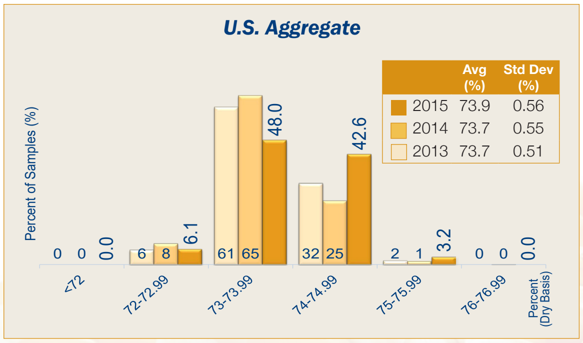
Starch is an important factor for corn used by wet millers and dry-grind ethanol manufacturers. High starch concentration is often indicative of good kernel maturation/filling conditions and reasonably high kernel densities. Starch is usually inversely related to protein concentration. Results are reported on a dry basis.

RESULTS

- Average U.S. Aggregate starch concentration (73.9%) was higher than 2014/2013 (73.7%) and 4YA (73.8%).
- Average starch concentration at export was higher than at harvest (73.6%). The higher starch reflects the typical inverse relationship between starch and protein.
- The standard deviation for starch concentration of the 2015/2016 export samples (0.56%) was lower than the standard deviation of the 2015 harvest samples (0.61%).
- Starch concentrations were distributed with 45.8% at or above 74.0%, compared to 26% of the 2014/2015 and 34% of the 2013/2014 samples at or above 74.0%. This indicates more 2015/2016 samples had at least 74% starch than in the previous two years.
- The Pacific Northwest ECA, with highest average protein, also had the lowest average starch concentration (73.6%), in comparison to the Gulf (74.0%) and Southern Rail (73.9%) ECAs.

Starch (%)





- Average starch concentration for contracts loaded as U.S. No. 2 o/b (73.8%) was lower than that for contracts loaded as U.S. No. 3 o/b (73.9%). It should be noted that contracts loaded as U.S. No. 2 o/b had higher protein than contracts loaded as U.S. No. 3 o/b, which again shows an inverse relationship between starch and protein.

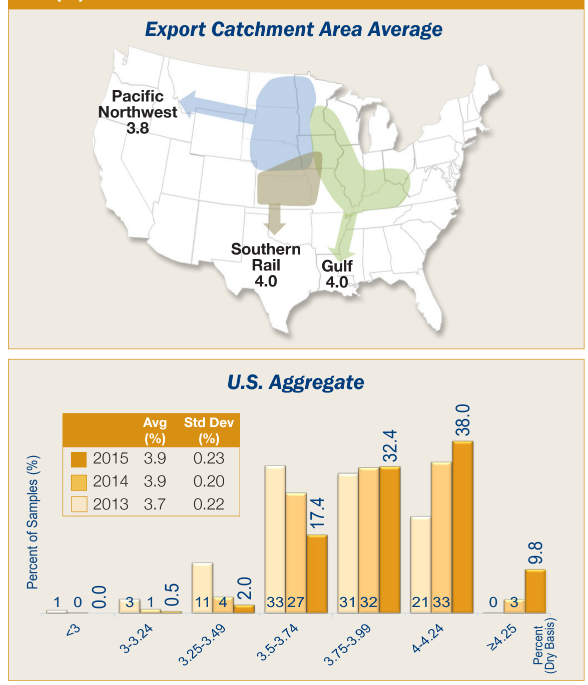
3. Oil

Oil is an essential component of poultry and livestock rations. It serves as an energy source, enables fat-soluble vitamins to be utilized, and provides certain essential fatty acids. Oil is also an important co-product of corn wet and dry milling. Results are reported on a dry basis.

RESULTS

- U.S. Aggregate oil concentration (3.9%) was same as 2014/2015 but higher than 4YA (3.7%).
- The average oil concentration for the 2015/2016 export samples was higher than for the 2015 harvest samples (3.8%), while the standard deviation at export (0.23%) was lower than at harvest (0.30%).
- Average oil concentration for the Pacific Northwest ECA (3.8%) was lower than for the Gulf and Southern Rail ECAs (both 4.0%). The Pacific Northwest ECA also had the lowest oil concentration in 2014/2015, 2013/2014 and 4YA, and for the 2015 harvest of the three ECAs.
- Approximately 80% of the 2015/2016 samples contained at least 3.75% oil, in contrast to 68% in 2014/2015 and 52% in 2013/2014. This indicates that a higher percentage of samples had above 3.75% oil than in the previous two years.
- Average U.S. Aggregate and Gulf ECA oil concentrations for contracts loaded as U.S. No. 2 o/b (3.9%) were slightly lower than contracts loaded as U.S. No. 3 o/b (4.0%).

Oil (%)



III. QUALITY TEST RESULTS (continued)

SUMMARY: CHEMICAL COMPOSITION

	2015/2016 Export Cargo					2014/2015 Export Cargo			2013/2014 Export Cargo			4 Year Avg. (2011-2014)	
	No. of Samples	Avg.	Std. Dev.	Min.	Max.	No. of Samples	Avg.	Std. Dev.	No. of Samples	Avg.	Std. Dev.	Avg.	Std. Dev.
U.S. Aggregate													
Protein (Dry Basis %)	408	7.8	0.33	6.8	9.4	411	8.6*	0.28	412	8.6*	0.30	8.8	0.30
Starch (Dry Basis %)	408	73.9	0.56	72.1	75.9	411	73.7*	0.55	412	73.7*	0.51	73.8	0.53
Oil (Dry Basis %)	408	3.9	0.23	3.1	4.7	411	3.9*	0.20	412	3.7*	0.22	3.7	0.21
Gulf													
Protein (Dry Basis %)	272	7.7	0.35	6.8	8.8	292	8.6*	0.22	295	8.5*	0.23	8.7	0.24
Starch (Dry Basis %)	272	74.0	0.54	72.1	75.9	292	73.7*	0.56	295	73.8*	0.52	73.8	0.54
Oil (Dry Basis %)	272	4.0	0.22	3.1	4.7	292	3.9*	0.20	295	3.8*	0.21	3.7	0.21
Pacific Northwest													
Protein (Dry Basis %)	92	8.4	0.30	7.8	9.4	84	8.9*	0.46	82	9.3*	0.46	9.1	0.46
Starch (Dry Basis %)	92	73.6	0.57	72.3	75.0	84	73.5*	0.55	82	73.4*	0.44	73.6	0.55
Oil (Dry Basis %)	92	3.8	0.25	3.1	4.4	84	3.6*	0.24	82	3.5*	0.24	3.6	0.22
Southern Rail													
Protein (Dry Basis %)	44	7.7	0.27	7.2	8.4	35	8.6*	0.28	35	8.4*	0.44	8.9	0.36
Starch (Dry Basis %)	44	73.9	0.62	72.5	75.6	35	73.5	0.51	35	73.8*	0.55	73.6	0.42
Oil (Dry Basis %)	44	4.0	0.26	3.4	4.6	35	4.0*	0.17	35	3.9*	0.20	3.8	0.18

** Indicates that the 2014/2015 Export Cargo averages were significantly different from the 2015/2016 Export Cargo averages, and the 2013/2014 Export Cargo averages were significantly different from the 2015/2016 Export Cargo averages, based on a 2-tailed t-test at the 95% level of confidence.*

SUMMARY: CHEMICAL COMPOSITION

	Export Cargo Samples for Contract Loaded as U.S. No. 2 o/b					Export Cargo Samples for Contract Loaded as U.S. No. 3 o/b					2015 Harvest				
	No. of Samples	Avg.	Std. Dev.	Min.	Max.	No. of Samples	Avg.	Std. Dev.	Min.	Max.	No. of Samples[1]	Avg.	Std. Dev.	Min.	Max.
U.S. Aggregate															
Protein (Dry Basis %)	271	7.9	0.35	6.9	9.2	125	7.8*	0.29	7.0	9.4	620	8.2	0.53	5.6	11.3
Starch (Dry Basis %)	271	73.8	0.53	72.1	75.6	125	73.9*	0.51	72.3	75.9	620	73.6**	0.61	70.5	76.3
Oil (Dry Basis %)	271	3.9	0.24	3.1	4.7	125	4.0	0.22	3.1	4.4	620	3.8**	0.30	2.5	5.4
Gulf															
Protein (Dry Basis %)	230	7.7	0.35	6.9	8.8	37	7.6	0.30	7.0	8.2	577	8.1	0.52	6.0	11.3
Starch (Dry Basis %)	230	74.0	0.53	72.1	75.6	37	74.1	0.51	73.5	75.9	577	73.7**	0.62	70.7	76.3
Oil (Dry Basis %)	230	4.0	0.22	3.1	4.7	37	4.0	0.22	3.5	4.4	577	3.8**	0.32	2.5	5.4
Pacific Northwest															
Protein (Dry Basis %)	5	8.7	0.41	8.3	9.2	86	8.4	0.28	7.8	9.4	329	8.7	0.58	5.6	11.3
Starch (Dry Basis %)	5	73.2	0.47	72.6	73.6	86	73.7*	0.56	72.3	75.0	329	73.5**	0.60	70.5	75.6
Oil (Dry Basis %)	5	3.8	0.27	3.5	4.2	86	3.8	0.25	3.1	4.4	329	3.7**	0.28	2.5	4.6
Southern Rail															
Protein (Dry Basis %)	36	7.7	0.27	7.2	8.4	2	7.6	0.28	7.4	7.8	402	8.3**	0.48	6.4	11.3
Starch (Dry Basis %)	36	73.9	0.62	72.5	75.6	2	73.6	0.42	73.3	73.9	402	73.5**	0.60	71.7	76.3
Oil (Dry Basis %)	36	3.9	0.26	3.4	4.6	2	4.2	0.21	4.0	4.3	402	3.8**	0.30	2.5	4.6

** Indicates the averages for samples with Grade "3" or "3 or better" were significantly different from the averages for the samples with Grade "2" or "2 or better," based on a 2-tailed t-test at the 95% level of confidence.*

*** Indicates that the 2015 Harvest averages were significantly different from the 2015/2016 Export Cargo averages, based on a 2-tailed t-test at the 95% level of confidence.*

[1] Due to the Harvest ECA results being composite statistics, the sum of the sample numbers from the three ECAs is greater than the U.S. Aggregate.

D. Physical Factors

Corn Kernel

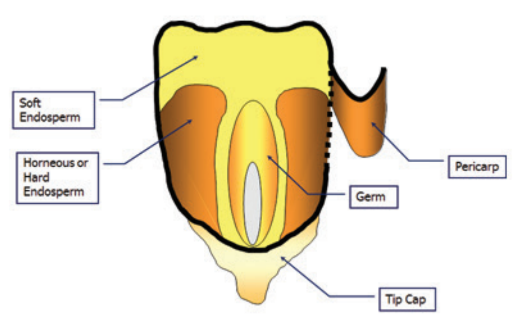
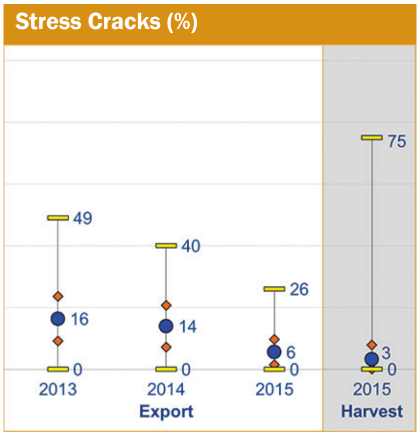


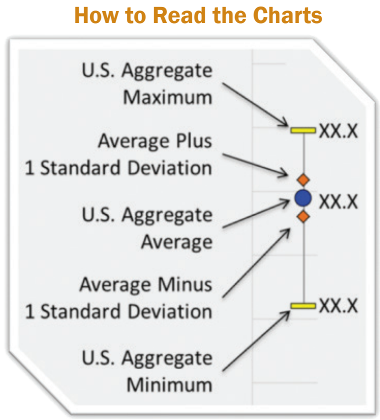
Illustration courtesy of K. D. Rausch, University of Illinois

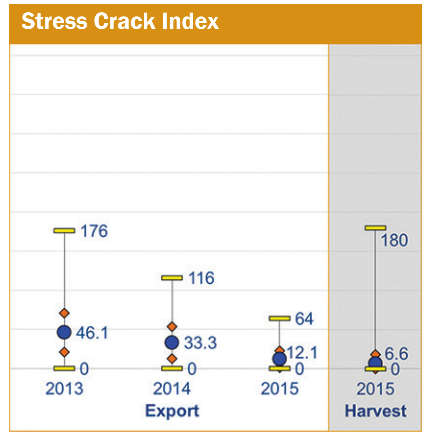
Physical factors are other quality attributes that are neither grading factors nor chemical composition. Physical factors include stress cracks, kernel weight, volume and density, percent whole kernels, and percent horneous (hard) endosperm. Tests for these physical factors provide additional information about the processing characteristics of corn for various uses, as well as corn's storability and potential for breakage in handling. These quality attributes are influenced by the physical composition of the corn kernel, which is in turn affected by genetics, as well as growing and handling conditions. Corn kernels are made up of four parts: the germ or embryo, the tip cap, the pericarp or outer covering, and the endosperm. The endosperm represents about 82% of the kernel and consists of soft (also referred to as floury or opaque) endosperm and of horneous (also called hard or vitreous) endosperm, as shown above. The endosperm contains primarily starch and protein; the germ contains oil and some proteins, and the pericarp and tip cap are mostly fiber.

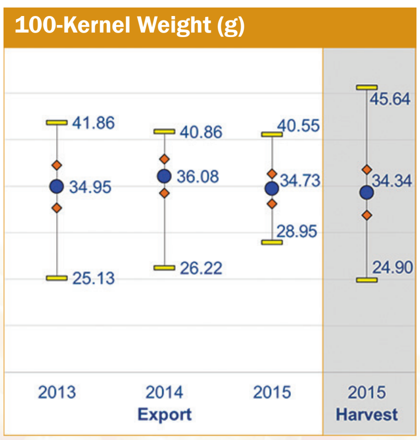
SUMMARY: PHYSICAL FACTORS

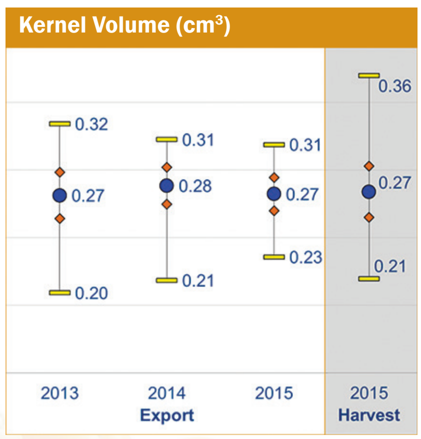
- *Average U.S. Aggregate stress cracks (6%) was lower than 2014/2015 (14%) and 4YA (12%). The low stress cracks percentage in 2015/2016 was likely a result of good field drying conditions and softer endosperm corn. The majority of the export samples (96.8%) had less than 15% stress cracks, and should have low rates of breakage during handling.*
- *At export, only 20.3% had SCI of 20 or higher, indicating fewer kernels in 2015/2016 had double or multiple stress cracks than in 2014/2015.*
- *Average U.S. Aggregate 100-kernel (100-k) weight was lower than 2014/2015 and 4YA, indicating smaller kernel sizes in 2015/2016 corn exports than in the previous year.*
- *Average kernel volumes at export and at harvest were essentially the same (0.27 cm^3) in 2015/2016 and 4YA.*
- *Average 100-k weight and kernel volume were lower for the Pacific Northwest ECA than for the other ECAs for 2015/2016, 2014/2015, 2013/2014, and 4YA, indicating smaller kernel sizes over time for the Pacific Northwest ECA than for the other ECAs.*
- *Average U.S. Aggregate true density (1.275 g/cm^3) was lower than 2014/2015 (1.295 g/cm^3) and 4YA (1.292 g/cm^3).*
- *Average U.S. Aggregate true densities, test weights, and kernel volume were lower for 2015/2016 than for 2014/2015.*
- *The average percentage of whole kernels at export (89.5%) was higher than 2014/2015 (88.4%) and 4YA (88.6%).*
- *Average U.S. Aggregate horneous endosperm (80%) was lower than 2014/2015 (82%) and 4YA (83%). The true density and horneous endosperm test results indicate the 2015/2016 corn will be softer than in previous years.*
- *Horneous endosperm at export in 2015/2016 and the previous two years was within ±1% of the average horneous endosperm percentage at harvest.*

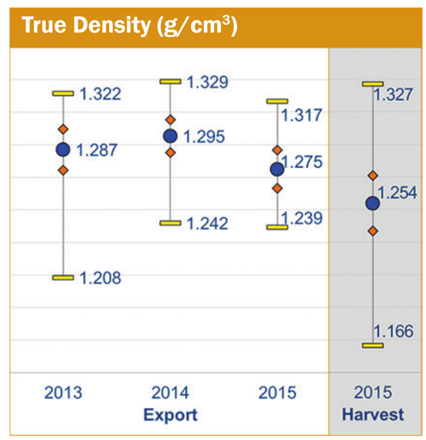

Stress Cracks (%)
49
16
0
40
14
0
26
6
0
75
3
0
2013
2014
Export
2015
2015
Harvest

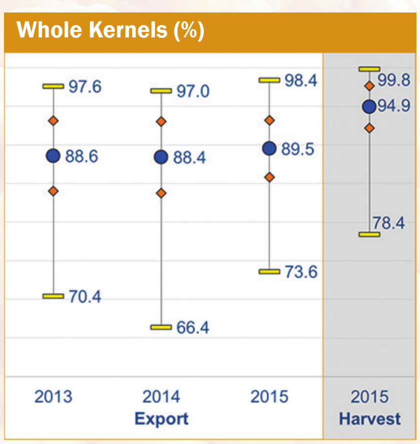

How to Read the Charts
U.S. Aggregate Maximum
Average Plus 1 Standard Deviation
U.S. Aggregate Average
Average Minus 1 Standard Deviation
U.S. Aggregate Minimum
XX.X
XX.X
XX.X

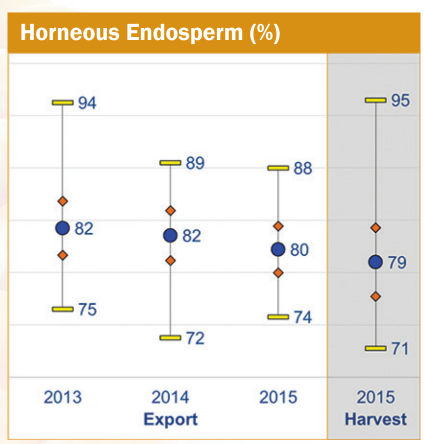

Stress Crack Index
176
46.1
0
116
33.3
0
64
12.1
0
180
6.6
0
2013
2014
Export
2015
2015
Harvest


100-Kernel Weight (g)
41.86
34.95
25.13
40.86
36.08
26.22
40.55
34.73
28.95
45.64
34.34
24.90
2013
2014
Export
2015
2015
Harvest


Kernel Volume (cm³)
0.32
0.27
0.20
0.31
0.28
0.21
0.31
0.27
0.23
0.36
0.27
0.21
2013
2014
Export
2015
2015
Harvest


True Density (g/cm³)
1.322
1.287
1.208
1.329
1.295
1.242
1.317
1.275
1.239
1.327
1.254
1.166
2013
2014
Export
2015
2015
Harvest


Whole Kernels (%)
97.6
88.6
70.4
97.0
88.4
66.4
98.4
89.5
73.6
99.8
94.9
78.4
2013
2014
Export
2015
2015
Harvest


Horneous Endosperm (%)
94
82
75
89
82
72
88
80
74
95
79
71
2013
2014
Export
2015
2015
Harvest

III. QUALITY TEST RESULTS (continued)

1. Stress Cracks and Stress Crack Index (SCI)

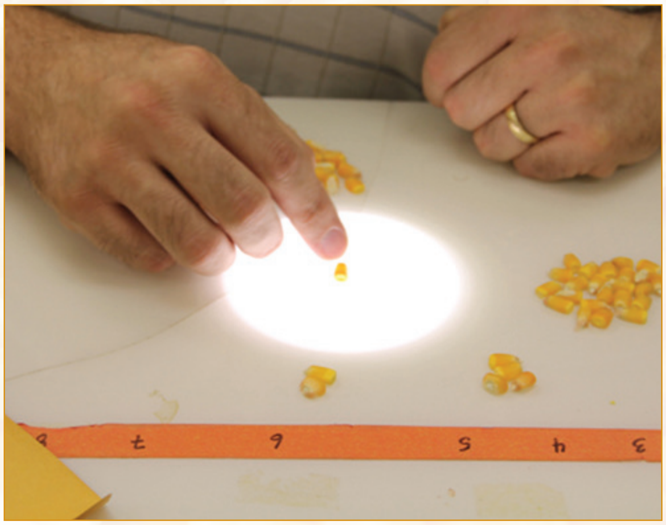
Stress cracks are internal fissures in the horneous (hard) endosperm of a corn kernel. The pericarp (or outer covering) of a stress-cracked kernel is typically not damaged, so the kernel may appear unaffected at first glance even if stress cracks are present.

The cause of stress cracks is pressure buildup due to moisture and temperature differences within the kernel's horneous endosperm. This can be likened to the internal cracks that appear when an ice cube is dropped into a lukewarm beverage. The internal stresses do not build up as much in the soft, floury endosperm as in the horneous endosperm; therefore, corn with higher percentages of horneous endosperm is more susceptible to stress cracking than softer grain. A kernel may vary in severity of stress cracking and can have one, two or multiple stress cracks. The impact of high levels of stress cracks on various uses include:

- General: Increased susceptibility to breakage during handling, leading to increased broken corn needing to be removed during cleaning operations for processors and possible reduced grade/value.
- Wet Milling: Lower starch yield because the starch and protein are more difficult to separate. Stress cracks may also alter steeping requirements.
- Dry Milling: Lower yield of large flaking grits (the prime product of many dry milling operations).
- Alkaline Cooking: Non-uniform water absorption leading to overcooking or undercooking, which affects the process balance.

High-temperature drying is the most common cause of stress cracks. Growing conditions will affect crop maturity, timeliness of harvest and the need for artificial drying, which will influence the degree of stress cracking found from region to region. Then, as corn moves through the market channel, some stress-cracked kernels break, which increases the proportion of broken corn. Concurrently, impacts of kernels on other kernels or on metal surfaces during handling may cause new cracks in kernels. As a result, the percentage of kernels with stress cracks may not remain constant throughout the merchandising channel.

Stress crack measurements include "stress cracks" (the percentage of kernels with at least one crack) and stress crack index (SCI), which is the weighted average of single, double and multiple stress cracks. "Stress cracks" measures only the number of kernels with stress cracks, whereas SCI shows the severity of cracking. For example, if half the kernels have only single stress cracks, "stress cracks" is 50% and the SCI is 50 (50 x 1). However, if half the kernels have multiple stress cracks (more than two cracks), indicating a higher potential for handling issues, "stress cracks" remain at 50% but the SCI becomes 250 (50 x 5). Lower values for "stress cracks" and the SCI are always more desirable. In years with high levels of stress cracks, the SCI is particularly relevant because high SCI values (perhaps 300 to 500) indicate the sample had a very high percentage of multiple stress cracks. Kernels with multiple stress cracks are more susceptible to breakage during subsequent handling.



RESULTS: STRESS CRACKS

- Average U.S. Aggregate stress cracks (6%) were lower than 2014/2015 (14%) and 4YA (12%). The low stress cracks in 2015/2016 may be due to less heated-air drying and a greater prevalence of soft endosperm corn.

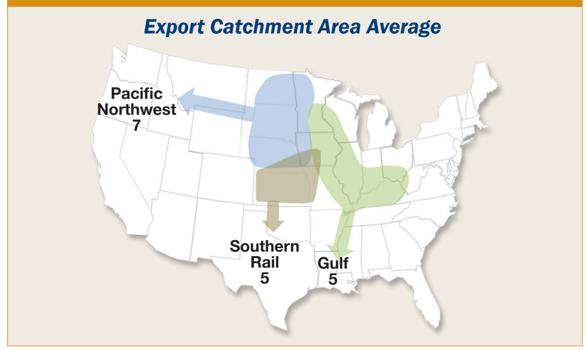
- Average U.S. Aggregate stress cracks (6%) was higher than for the 2015 harvest samples (3%).

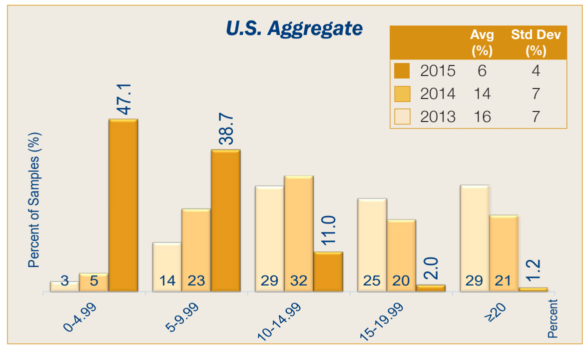
- Stress cracks in the export samples (with a range of 0 to 26% and a standard deviation of 4%) were more uniform than the 2015 harvest samples (with a range of 0 to 75% and a standard deviation of 5%).

- Of the 2015/2016 export samples, 96.8% had less than 15% stress cracks, compared to 60% in 2014/2015. Samples with less than 15% stress cracks should have relatively low rates of breakage during handling.

- Stress cracks averages were 5%, 7%, and 5% for the Gulf, Pacific Northwest, and Southern Rail ECAs, respectively. The variability of stress cracks (standard deviation) was nearly the same (4 to 6%) across all ECAs.

Stress Cracks (%)





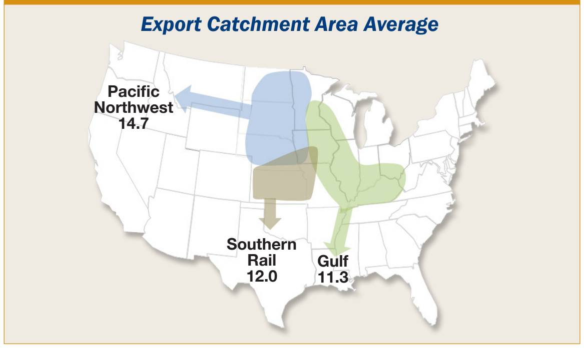
- Stress cracks for contracts loaded as U.S. No. 2 o/b (6%) were the same as those for contracts loaded as U.S. No. 3 o/b (6%).

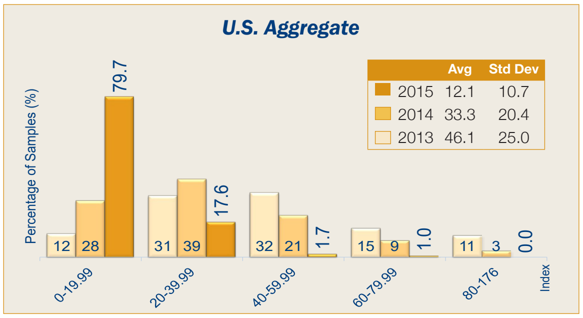
III. QUALITY TEST RESULTS (continued)

RESULTS: STRESS CRACK INDEX (SCI)

- Average U.S. Aggregate stress crack index (SCI) (12.1) was lower than 2014/2015 (33.3) and 4YA (34.0).
- SCI ranged from 0 to 64, with a standard deviation of 10.7.
- SCI at export was higher than the SCI found at harvest (6.6).
- Average SCI for the Gulf ECA (11.3) was lower than the average SCI for the Pacific Northwest (14.7) and Southern Rail (12.0) ECAs.
- SCI standard deviations across ECAs were 9.7, 10.9, and 14.9 for the Gulf, Pacific Northwest, and Southern Rail ECAs, respectively.
- At export, 20.3% of the samples had SCI of 20 or higher, compared to 72% of the 2014/2015 samples having a SCI of 20 or higher. This would indicate fewer kernels had double or multiple stress cracks in 2015/2016 than in 2014/2015.

Stress Crack Index (SCI)





- SCI for contracts loaded as U.S. No. 2 o/b (12.6) was lower than contracts loaded as U.S. No. 3 o/b (14.1).

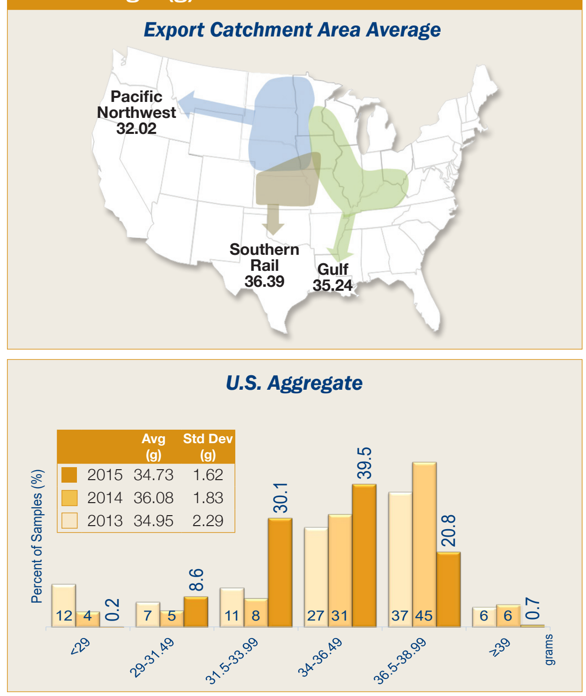
2. 100-Kernel Weight

100-kernel (100-k) weight (reported in grams) indicates larger kernel size as 100-k weights increase. Kernel size affects drying rates. As kernel size increases, the volume-to-surface area ratio becomes higher, and as this ratio gets higher, drying becomes slower. In addition, large uniform-sized kernels often enable higher flaking grit yields in dry milling. Kernel weights tend to be higher for specialty varieties of corn that have high amounts of horneous (hard) endosperm.

RESULTS

- Average U.S. Aggregate 100-k weight (34.73 g) was lower than 2014/2015 (36.08 g) and 4YA (35.51 g).
- The 100-k weight values for the 2015/2016 samples ranged from 28.95 to 40.55 g.
- 100-k weight was higher at export than for the 2015 harvest corn (34.34 g). Higher average 100-k weight at export than at harvest has occurred for the past two years and 4YA. Since the 100-k weights are based on 100 fully intact kernels, any breakage occurring in transit could have self-selected out smaller kernels that might have been soft or more prone to breakage.
- The 2015/2016 export samples had a lower standard deviation (1.62 g) than the 2015 harvest samples (2.43 g), indicating greater uniformity at export.
- The average 100-k weight was lowest for the Pacific Northwest ECA (32.02 g) in comparison to the Gulf (35.24 g) and Southern Rail (36.39 g) ECAs. The Pacific Northwest ECA had the lowest average 100-k weight of the three ECAs in the previous two years and for 4YA.
- Of the 2015/2016 export samples, 78.4% had 100-k weight of less than 36.5 g, compared to 48% of the 2014/2015 and 57% of the 2013/2014 samples, indicating smaller kernels in 2015/2016 than in the previous two years.

100-k Weight (g)



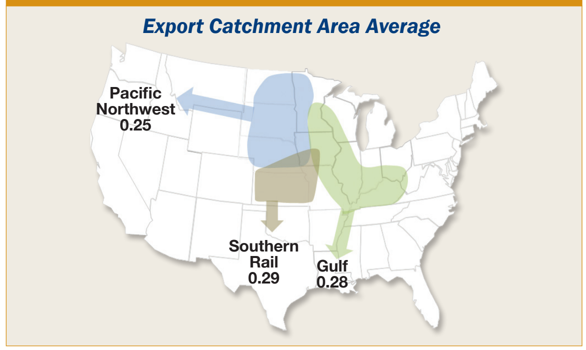
3. Kernel Volume

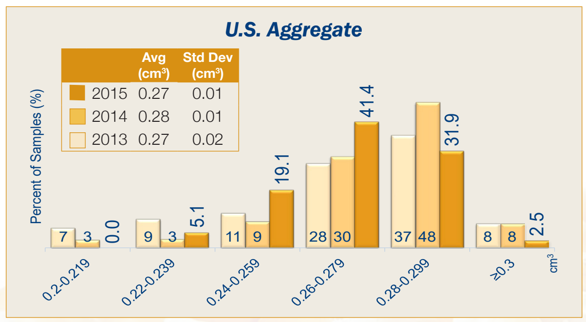
Kernel volume in cubic centimeters (cm^3) is often indicative of growing conditions. Small or round kernels are more difficult to degerm. Additionally, small kernels may lead to increased cleanout losses for processors and higher yields of fiber.

RESULTS

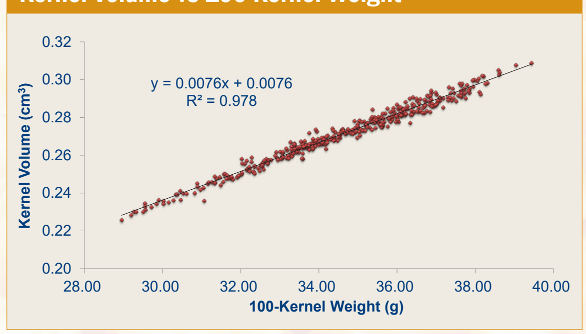
- Average U.S. Aggregate kernel volume (0.27 cm^3) was the same as 4YA (0.27 cm^3), but slightly lower than 2014/2015 (0.28 cm^3).
- Kernel volume range (0.23 to 0.31 cm^3) was similar to the 2014/2015 range (0.21 to 0.31 cm^3) and the 4YA range (0.20 to 0.32 cm^3).
- The kernel volume standard deviation (0.01 cm^3) was the same as 2014/2015 and 4YA.
- Average U.S. Aggregate kernel volumes at export and at harvest were essentially the same (0.27 cm^3) in 2015/2016 as for 2014/2015, 2013/2014, and 4YAs.
- Average kernel volume was smaller for the Pacific Northwest ECA (0.25 cm^3) than for the Gulf (0.28 cm^3) and Southern Rail (0.29 cm^3) ECAs. The Pacific Northwest ECA also had the lowest kernel volume for the previous two years, 4YA, and the 2015 harvest samples.
- Of the 2015/2016 export samples, 34.4% had kernel volumes equal to or greater than 0.28 cm^3, compared with 56.0% in 2014/2015, which indicates a lower percentage of large kernels in 2015/2016 than in the previous year.
- There is a positive relationship for the 2015/2016 export corn between kernel volume and 100-kernel weight, as shown in the adjacent figure (the correlation coefficient is 0.99).

Kernel Volume (cm^3)





Kernel Volume vs 100-Kernel Weight



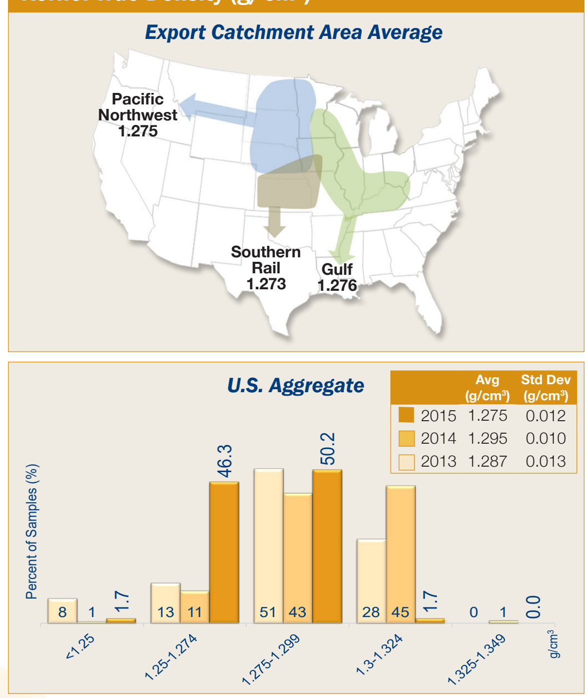
4. Kernel True Density

Kernel true density is calculated as the weight of a 100-k sample divided by the volume, or displacement, of those 100 kernels and is reported as g/cm³. True density is a relative indicator of kernel hardness, which is useful for alkaline processors and dry millers. True density may be affected by the genetics of the corn hybrid and the growing environment. Corn with higher density is typically less susceptible to breakage in handling than lower density corn, but it is also more at risk for the development of stress cracks if high-temperature drying is employed. True densities above 1.30 g/cm³ indicate very hard corn, which is typically desirable for dry milling and alkaline processing. True densities near the 1.275 g/cm³ level and below tend to be softer, but process well for wet milling and feed use.

RESULTS

- Average U.S. Aggregate kernel true density (1.275 g/cm³) was lower than 2014/2015 (1.295 g/cm³) and 4YA (1.292 g/cm³).
- Average kernel true density for the 2015/2016 export samples was higher than for the 2015 harvest samples (1.254 g/cm³), and also in 2014/2015 and 2013/2014. The 4YA export true density (1.292 g/cm³) was also higher than the 4YA harvest true density (1.265 g/cm³). The higher true density found at export is likely due, in part, to the higher 100-k weights that were also found each year at export.
- For the 2015/2016 export samples, only 51.9% had kernel true densities equal to or above 1.275 g/cm³, compared with 89% found in 2014/2015. This indicates a higher percentage of kernels with soft endosperm in 2015/2016 than in the previous year.
- Average kernel true densities were essentially the same for the Gulf (1.276 g/cm³), Pacific Northwest (1.275 g/cm³) and Southern Rail (1.273 g/cm³) ECAs.

Kernel True Density (g/cm³)



5. Whole Kernels

Though the name suggests some inverse relationship between whole kernels and BCFM, the whole kernels test conveys different information than the broken corn portion of the BCFM test. Broken corn is defined solely by weight percentage of material passing through a screen. Whole kernels, as the name implies, is the percent of fully intact kernels in the sample with no pericarp damage or kernel pieces chipped away.

The exterior integrity of the corn kernel is very important for two key reasons. First, it affects water absorption for alkaline cooking and steeping operations. Kernel nicks or pericarp cracks allow water to enter the kernel faster than for fully intact or whole kernels. Too much water uptake during cooking can result in loss of solubles, non-uniform cooking, expensive shutdown time, and/or products that do not meet specifications. Secondly, intact whole kernels are less susceptible to mold invasion during storage and to breakage during handling. Some companies pay contracted premiums for corn delivered above a specified level of whole kernels.

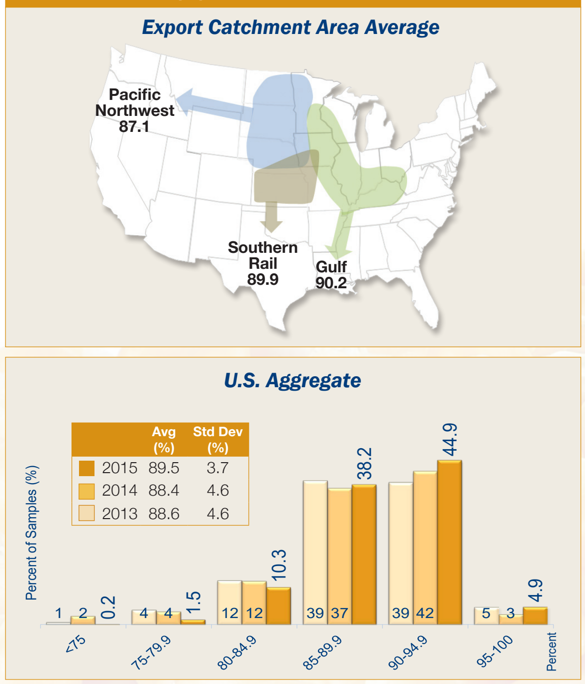
RESULTS

- Average U.S. Aggregate whole kernels (89.5%) was higher than 2014/2015 (88.4%) and 4YA (88.6%).

- The average percentage of whole kernels at export was lower than at harvest (94.9%). Whole kernels for the 4YA export samples (88.6%) was also lower than for the 4YA harvest samples (93.5%). The reduction in whole kernels from harvest to export is likely caused by the added handling in transport to export loading locations.

- The 2015/2016 export samples had a range of 73.6 to 98.4% (with a standard deviation of 3.7%), while the 2015 harvest samples had a narrower range (78.4 to 99.8%) and a lower standard deviation (2.7%). The percentage of whole kernels declined and the standard deviation of whole kernels increased from harvest to export, which occurred not only in 2015/2016, but also in 2014/2015, 2013/2014, and 4YA.

Whole Kernels (%)



- The Gulf ECA (90.2%) had a higher whole kernel average compared to the Southern Rail (89.9%) and Pacific Northwest (87.1%) ECAs.

- The percentage of 2015/2016 export samples with whole kernel percentages greater than or equal to 90% was 49.8%, compared to 45% for the 2014/2015 export samples, and 93.6% for the 2015 harvest samples. The reduction in percentages of whole kernels from harvest to export is most likely due to handling.

- The whole kernel percentages for contracts loaded as U.S. No. 2 o/b were 89.6%, which was very close to the 90.0% found for contracts loaded as U.S. No. 3 o/b.

6. Horneous (Hard) Endosperm

The horneous (hard) endosperm test measures the percent of horneous or hard endosperm out of the total endosperm in a kernel, with a potential value from 70 to 100%. The greater the amount of horneous endosperm relative to soft endosperm, the harder the corn kernel is said to be. The degree of hardness is important depending on the type of processing. Hard corn is needed to produce high yields of large flaking grits in dry milling. Medium-high to medium hardness is desired for alkaline cooking. Moderate to soft hardness is used for wet milling and livestock feeding.

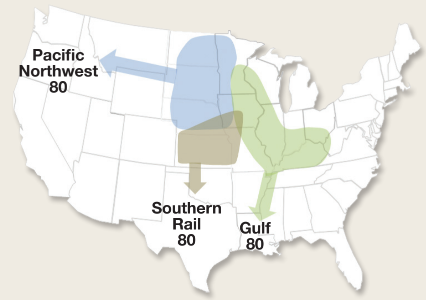
Hardness has been correlated to breakage susceptibility, feed utilization/efficiency, and starch digestibility. As a test of overall hardness, there is no good or bad value for horneous endosperm; there is only a preference by different end users for particular ranges. Many dry millers and alkaline cookers would like greater than 90% horneous endosperm, while wet millers and feeders would typically prefer values between 70 and 85%. However, there are certainly exceptions in user preference.

RESULTS

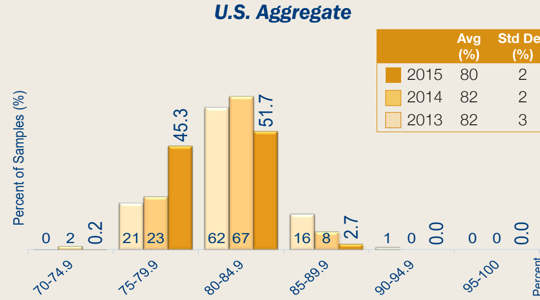
- Average U.S. Aggregate horneous endosperm (80%) was lower than 2014/2015 (82%) and 4YA (83%).
- Average horneous endosperm for the 2015/2016, 2014/2015, and 2013/2014 export samples were within ±1% of the average horneous endosperm for the 2015, 2014 and 2013 harvest samples, respectively.
- The 2015/2016 export samples for horneous endosperm had a smaller range (74 to 88%) and standard deviation (2%) than the 2015 harvest samples. This same pattern of increased uniformity between export and harvest samples occurred in the previous two years of export samples when compared to the 2014 and 2013 harvest samples, respectively.
- Average horneous endosperm for the Pacific Northwest ECA (80%) was same as for the Gulf and Southern Rail ECAs (both 80%).

Horneous Endosperm (%)

Export Catchment Area Average



U.S. Aggregate



	Avg (%)	Std Dev (%)
2015	80	2
2014	82	2
2013	82	3

- Average horneous endosperm for contracts loaded as U.S. No. 2 o/b (80%) was similar to contracts loaded as U.S. No. 3 o/b (81%).
- Only 54.4% of the 2015/2016 export samples had at least 80% horneous endosperm in contrast to 75% of the 2014/2015 and 79% of the 2013/2014 export samples, indicating many of the 2015/2016 samples had a lower percentage of hard corn than in the two previous years.

III. QUALITY TEST RESULTS (continued)

SUMMARY: PHYSICAL FACTORS

	2015/2016 Export Cargo					2014/2015 Export Cargo			2013/2014 Export Cargo			4 Year Avg. (2011-2014)	
	No. of Samples	Avg.	Std. Dev.	Min.	Max.	No. of Samples	Avg.	Std. Dev.	No. of Samples	Avg.	Std. Dev.	Avg.	Std. Dev.
U.S. Aggregate													
Stress Cracks (%)	408	6	4	0	26	411	14*	7	412	16*	7	12	6
Stress Crack Index	408	12.1	10.7	0	64	411	33.3*	20.4	412	46.1*	25	34.0	22.0
100-Kernel Weight (g)	408	34.73	1.62	28.95	40.55	411	36.08*	1.83	412	34.95	2.29	35.51	1.79
Kernel Volume (cm^3)	408	0.27	0.01	0.23	0.31	411	0.28*	0.01	412	0.27	0.02	0.27	0.01
True Density (g/cm^3)	408	1.275	0.012	1.239	1.317	411	1.295*	0.010	412	1.287*	0.013	1.292	0.011
Whole Kernels (%)	408	89.5	3.7	73.6	98.4	411	88.4*	4.6	412	88.6*	4.6	88.6	3.9
Horneous Endosperm (%)	408	80	2	74	88	411	82*	2	412	82*	3	83	2
Gulf													
Stress Cracks (%)	272	5	4	0	22	292	15*	7	295	16*	7	13	7
Stress Crack Index	272	11.3	9.7	0	62	292	37.7*	21.6	295	47.2*	26	38.8	25.1
100-Kernel Weight (g)	272	35.24	1.66	30.88	38.61	292	37.05*	1.57	295	36.26*	2.12	36.45	1.63
Kernel Volume (cm^3)	272	0.28	0.01	0.24	0.31	292	0.28*	0.01	294	0.28*	0.02	0.28	0.01
True Density (g/cm^3)	272	1.276	0.012	1.240	1.310	292	1.303*	0.010	295	1.297*	0.010	1.299	0.010
Whole Kernels (%)	272	90.2	3.4	75.4	98.4	292	88.0*	5.4	295	88.5*	4.6	88.3	4.2
Horneous Endosperm (%)	272	80	2	76	88	292	82*	2	295	83*	3	84	2
Pacific Northwest													
Stress Cracks (%)[1]	92	7	4	1	25	84	12*	6	82	18*	7	11	5
Stress Crack Index[1]	92	14.7	10.9	1	61	84	24.4*	16.2	82	45.3*	22	25.5	16.2
100-Kernel Weight (g)	92	32.02	1.51	28.95	35.92	84	31.95	3.03	82	28.94*	2.81	31.56	2.31
Kernel Volume (cm^3)	92	0.25	0.01	0.23	0.28	84	0.25	0.02	82	0.23*	0.02	0.25	0.02
True Density (g/cm^3)	92	1.275	0.010	1.246	1.317	84	1.273	0.013	82	1.253*	0.020	1.272	0.014
Whole Kernels (%)	92	87.1	4.1	73.6	95.0	84	88.0	3.3	82	89.3*	4.1	89.4	3.4
Horneous Endosperm (%)	92	80	2	75	85	84	79*	3	82	79*	3	82	2
Southern Rail													
Stress Cracks (%)[1]	44	5	6	0	26	35	12*	7	35	16*	7	10	5
Stress Crack Index[1]	44	12.0	14.9	0	64	35	23.0*	20.2	35	41.3*	21	21.7	15.0
100-Kernel Weight (g)	44	36.39	1.60	33.27	40.55	35	37.20*	1.39	35	36.91	2.45	36.74	1.86
Kernel Volume (cm^3)	44	0.29	0.01	0.26	0.31	35	0.29	0.01	35	0.29	0.02	0.28	0.01
True Density (g/cm^3)	44	1.273	0.014	1.239	1.298	35	1.289*	0.009	35	1.287*	0.013	1.292	0.010
Whole Kernels (%)	44	89.9	3.8	80.2	98.0	35	91.2	2.8	35	87.8*	5.2	88.8	3.7
Horneous Endosperm (%)	44	80	2	74	84	35	82*	2	35	83*	2	83	2

** Indicates that the 2014/2015 Export Cargo averages were significantly different from the 2015/2016 Export Cargo averages, and the 2013/2014 Export Cargo averages were significantly different from the 2015/2016 Export Cargo averages, based on a 2-tailed t-test at the 95% level of confidence.*

[1] The relative margin of error (Relative ME) for predicting the 2015/2016 Export Cargo population average exceeded ±10%.

SUMMARY: PHYSICAL FACTORS

	Export Cargo Samples for Contract Loaded as U.S. No. 2 o/b					Export Cargo Samples for Contract Loaded as U.S. No. 3 o/b					2015 Harvest				
	No. of Samples	Avg.	Std. Dev.	Min.	Max.	No. of Samples	Avg.	Std. Dev.	Min.	Max.	No. of Samples[1]	Avg.	Std. Dev.	Min.	Max.
U.S. Aggregate															
Stress Cracks (%)	271	6	4	0	22	125	6	6	0	26	620	3**	5	0	75
Stress Crack Index	271	12.6	9.7	0	63	125	14.1	15.8	0	64	620	6.6**	11.7	0	180
100-Kernel Weight (g)	271	34.57	1.63	29.54	39.04	125	34.72	1.40	28.95	37.84	620	34.34**	2.43	24.90	45.64
Kernel Volume (cm^3)	271	0.27	0.01	0.23	0.31	125	0.27	0.01	0.23	0.30	620	0.27	0.02	0.21	0.36
True Density (g/cm^3)	271	1.274	0.011	1.239	1.304	125	1.276	0.009	1.246	1.310	620	1.254**	0.017	1.166	1.327
Whole Kernels (%)	271	89.6	3.5	75.4	98.4	125	90.0	3.2	77.8	97.4	620	94.9**	2.7	78.4	99.8
Horneous Endosperm (%)	271	80	2	74	88	125	81	2	75	88	620	79**	3	71	95
Gulf															
Stress Cracks (%)	230	5	4	0	22	37	4	4	0	20	577	3**	5	0	75
Stress Crack Index	230	11.7	9.3	0	58	37	8.9	11.5	0	62	577	7.0**	12.4	0	180
100-Kernel Weight (g)	230	35.33	1.67	30.88	38.61	37	35.01	1.49	32.15	37.84	577	34.64**	2.47	24.90	45.64
Kernel Volume (cm^3)	230	0.28	0.01	0.24	0.31	37	0.27	0.01	0.25	0.30	577	0.28	0.02	0.21	0.36
True Density (g/cm^3)	230	1.276	0.011	1.252	1.304	37	1.275	0.011	1.253	1.310	577	1.255**	0.017	1.166	1.327
Whole Kernels (%)	230	90.1	3.3	75.4	98.4	37	91.5*	3.6	79.0	97.4	577	95.0**	2.8	78.4	99.8
Horneous Endosperm (%)	230	80	2	76	88	37	81*	2	76	88	577	79**	3	71	95
Pacific Northwest															
Stress Cracks (%)	5	7	3	3	10	86	7	4	1	25	329	3**	4	0	75
Stress Crack Index	5	15.6	8.0	5	22	86	14.4	10.9	1	61	329	6.6**	11.9	0	159
100-Kernel Weight (g)	5	31.24	1.68	29.54	33.19	86	32.08	1.51	28.95	35.92	329	33.08**	2.29	26.03	44.66
Kernel Volume (cm^3)	5	0.25	0.01	0.23	0.26	86	0.25	0.01	0.23	0.28	329	0.26**	0.02	0.21	0.35
True Density (g/cm^3)	5	1.272	0.009	1.259	1.282	86	1.275	0.009	1.246	1.292	329	1.249**	0.017	1.174	1.318
Whole Kernels (%)	5	88.0	3.6	83.2	92.4	86	87.2	3.9	77.8	95.0	329	94.8**	2.6	78.4	99.8
Horneous Endosperm (%)	5	81	2	78	84	86	80	2	75	85	329	79**	3	71	91
Southern Rail															
Stress Cracks (%)	36	5	5	0	21	2	16	15	5	26	402	3**	3	0	50
Stress Crack Index	36	12.1	13.4	0	63	2	35.5	40.3	7	64	402	4.7**	8.2	0	180
100-Kernel Weight (g)	36	36.11	1.41	33.27	39.04	2	37.19	0.89	36.57	37.82	402	35.09**	2.49	24.90	45.64
Kernel Volume (cm^3)	36	0.28	0.01	0.26	0.31	2	0.29	0.01	0.28	0.29	402	0.28**	0.02	0.21	0.36
True Density (g/cm^3)	36	1.270	0.014	1.239	1.298	2	1.285*	0.002	1.283	1.286	402	1.255**	0.017	1.166	1.327
Whole Kernels (%)	36	89.7	4.0	80.2	98.0	2	87.8*	0.8	87.2	88.4	402	94.9**	2.8	79.8	99.8
Horneous Endosperm (%)	36	80	2	74	84	2	79	0	79	80	402	79	3	71	93

** Indicates the averages for samples with Grade "3" or "3 or better" were significantly different from the averages for the samples with Grade "2" or "2 or better," based on a 2-tailed t-test at the 95% level of confidence.*

*** Indicates that the 2015 Harvest averages were significantly different from the 2015/2016 Export Cargo averages, based on a 2-tailed t-test at the 95% level of confidence.*

[1] *Due to the Harvest ECA results being composite statistics, the sum of the sample numbers from the three ECAs is greater than the U.S. Aggregate.*

E. Mycotoxins

Mycotoxins are toxic compounds produced by fungi that occur naturally in grains. When consumed at elevated levels, mycotoxins may cause sickness in humans and animals. While several mycotoxins have been found in corn grain, aflatoxins and deoxynivalenol (DON or vomitoxin) are considered to be two of the important mycotoxins.

The U.S. grain merchandising industry implements strict safeguards for handling and marketing grain with elevated levels of mycotoxins. All stakeholders in the corn value chain – seed companies, corn growers, grain marketers, and grain handlers, as well as U.S. corn export customers – are interested in understanding how mycotoxin infection is influenced by growing conditions and the subsequent storage, drying, handling, and transport of the grain as it moves through the U.S. corn export system.

1. Assessing the Presence of Aflatoxins and DON

To assess the effect of these conditions on aflatoxins and DON development, this report summarizes the results from official USDA Federal Grain Inspection Service (FGIS) aflatoxin tests and from independent DON tests for all the export samples collected as part of this survey. Details on the testing methodology employed in this study for the mycotoxins are in the "Testing Analysis Methods" section.

RESULTS: AFLATOXINS

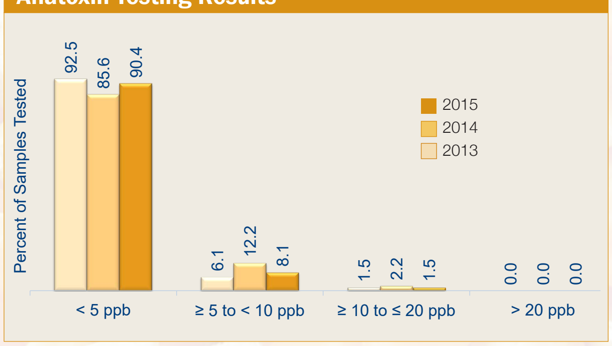
A total of 408 export samples were tested for aflatoxins for the *2015/2016 Export Cargo Report*. Results of the 2015/2016 survey testing are as follows:

- Of the 408 samples, 369 samples, or 90.4%, had no detectable levels of aflatoxins (defined as less than 5.0 ppb or the FGIS lower reporting level referred to as the "Lower Conformance Level" (LCL)). This 90.4% is greater than the 2014/2015 export samples (85.6%) and less than the 2013/2014 export samples (92.5%).

Aflatoxins

	Percent of Total Samples				
	< 5 ppb	≥ 5 to < 10 ppb	≥ 10 to ≤ 20 ppb	> 20 ppb	Total
U.S. Aggregate	90.4%	8.1%	1.5%	0.0%	100.0%
By ECA					
Gulf	85.7%	12.1%	2.2%	0.0%	100.0%
Pacific Northwest	100.0%	0.0%	0.0%	0.0%	100.0%
Southern Rail	100.0%	0.0%	0.0%	0.0%	100.0%

Aflatoxin Testing Results



- Aflatoxin levels greater than or equal to 5.0 ppb, but less than 10 ppb, were found in 33 samples, or 8.1% of the 408 samples tested in 2015/2016. This percentage is less than the 2014/2015 export samples (12.2%) and greater than the 2013/2014 export samples (6.1%).

- Only 6 samples, or 1.5% of the 408 samples tested, in 2015/2016 had aflatoxin levels greater than or equal to 10.0 ppb, but below or equal to the FDA action level of 20 ppb. This 1.5% is less than the 2014/2015 export samples (2.2%), but is the same as the 2013/2014 export samples (1.5%).

- 100% of the samples tested in 2015/2016 were below or equal to the FDA action level of 20 ppb, which is the same as that reported in the *2014/2015* and *2013/2014 Export Cargo Reports*.

Comparison of the aflatoxin results in the 2015/2016 export survey with the aflatoxin results in the 2014/2015 and 2013/2014 export surveys suggest fewer incidents of aflatoxins in the 2015/2016 export samples than in the 2014/2015 export samples, but slightly more incidents than in the 2013/2014 export samples. Also, the percentage of all samples below 10 ppb in 2015/2016 was about the same as 2013/2014, but greater than 2014/2015. The percentage of the 2015/2016 export samples (90.4%) below the FGIS LCL of 5.0 ppb is less than the percentage of the 2015 harvest samples (100%) below the FGIS LCL of 5.0 ppb.

RESULTS: DON (DEOXYNIVALENOL OR VOMITOXIN)

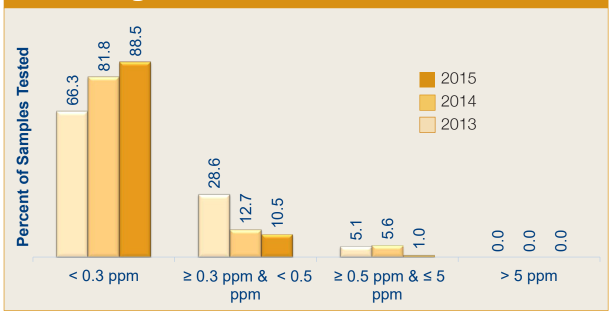
A total of 408 export samples were tested for DON for the *2015/2016 Export Cargo Report*. Results of the testing are shown below:

- DON levels of less than 0.3 ppm were found in 361 samples, or 88.5% of the 408 samples tested. This 88.5% is greater than both the 2014/2015 export samples (81.8%) and the 2013/2014 export samples (66.3%).
- 43 samples, or 10.5% of the 408 samples tested, had DON levels greater than or equal to 0.3 ppm, but less than 0.5 ppm (the FGIS LCL for DON). This 10.5% is less than the 2014/2015 export samples (12.7%) and the 2013/2014 export samples (28.6%).
- Only four samples, or 1.0% of the 408 samples tested, had DON levels greater than or equal to 0.5 ppm, but less than or equal to the FDA advisory level of 5 ppm. This 1.0% is less than the 2014/2015 export samples (5.6%), as well as the 2013/2014 export samples (5.1%).

DON

	Percent of Total Samples				
	< 0.3 ppm	≥ 0.3 to < 0.5 ppm	≥ 0.5 to ≤ 5.0 ppm	> 5.0 ppm	Total
U.S. Aggregate	88.5%	10.5%	1.0%	0.0%	100.0%
By ECA					
Gulf	86.8%	12.5%	0.7%	0.0%	100.0%
Pacific Northwest	100.0%	0.0%	0.0%	0.0%	100.0%
Southern Rail	75.0%	20.5%	4.5%	0.0%	100.0%

DON Testing Results



- 100% of the samples tested were below or equal to the FDA advisory level of 5.0 ppm, which is the same as that reported in the *2014/2015* and *2013/2014 Export Reports*.

Comparison of the 2015/2016 DON export survey results with the 2014/2015 and 2013/2014 DON export survey results indicate fewer DON incidents in the 2015/2016 export samples than in the samples from the two previous years. All samples were below or equal to 5.0 ppm for all three marketing seasons. The percentage of samples less than 0.5 ppm in the *2015/2016 Export Report* (99.0%) was much higher than the DON results reported for the *2015/2016 Harvest Report* (87.0%).

2. Background: General

The levels at which the fungi produce mycotoxins are influenced by the fungus type and the environmental conditions under which the corn is produced and stored. Because of these differences, mycotoxin production varies across the U.S. corn-producing areas and across years.

Humans and livestock are sensitive to mycotoxins at varying levels. As a result, the U.S. Food and Drug Administration (FDA) has issued action levels for aflatoxins and advisory levels for DON by intended use.

Action levels specify precise limits of contamination above which the agency is prepared to take regulatory action. Action levels are a signal to the industry that FDA believes it has scientific data to support regulatory and/or court action if a toxin or contaminant is present at levels exceeding the action level if the agency chooses to do so. If import or domestic feed supplements are analyzed in accordance with valid methods and found to exceed applicable action levels, they are considered adulterated and may be seized and removed from interstate commerce by FDA.

Advisory levels provide guidance to the industry concerning levels of a substance present in food or feed that are believed by the agency to provide an adequate margin of safety to protect human and animal health. While FDA reserves the right to take regulatory enforcement action, enforcement is not the fundamental purpose of an advisory level.

A source of additional information is the National Grain and Feed Association (NGFA) guidance document titled "FDA Mycotoxin Regulatory Guidance" found at *http://www.ngfa.org/wp-content/uploads/NGFAComplianceGuide-FDARegulatoryGuidanceforMycotoxins8-2011.pdf*.

3. Background: Aflatoxins

The most important type of mycotoxin associated with corn grain is aflatoxins. There are several types of aflatoxins produced by different species of the *Aspergillus* fungus, with the most prominent species being *A. flavus*. Growth of the fungus and aflatoxin contamination of grain can occur in the field prior to harvest or in storage. However, contamination prior to harvest is considered to cause most of the problems associated with aflatoxin. *A. flavus* grows well in hot, dry environmental conditions or where drought occurs over an extended period of time. It can be a serious problem in the southern United States, where hot and dry conditions are more common. The fungus usually attacks only a few kernels on the ear and often penetrates kernels through wounds produced by insects. Under drought conditions, it also grows down silks into individual kernels.

There are four types of aflatoxins naturally found in foods – aflatoxins B1, B2, G1 and G2. These four aflatoxins are commonly referred to as "aflatoxins" or "total aflatoxins." Aflatoxin B1 is the most commonly found aflatoxins in food and feed and is also the most toxic. Additionally, dairy cattle will metabolize aflatoxins to a different form of aflatoxins called aflatoxin M1, which may accumulate in milk.

Aflatoxins express toxicity in humans and animals primarily by attacking the liver. The toxicity can occur from short-term consumption of very high doses of aflatoxin-contaminated grain or long-term ingestion of low levels of aflatoxins, possibly resulting in death in poultry and ducks, the most sensitive of the animal species. Livestock may experience reduced feed efficiency or reproduction, and both humans' and animals' immune systems may be suppressed as a result of ingesting aflatoxins.

The FDA has established action levels for aflatoxin M1 in milk intended for human consumption and for total aflatoxins in human food, grain and livestock feed products (see table below).

Aflatoxins Action Level	Criteria
0.5 ppb (Aflatoxin M1)	Milk intended for human consumption
20 ppb	For corn and other grains intended for immature animals (including immature poultry) and for dairy animals, or when the animal's destination is not known
20 ppb	For animal feeds, other than corn or cottonseed meal
100 ppb	For corn and other grains intended for breeding beef cattle, breeding swine or mature poultry
200 ppb	For corn and other grains intended for finishing swine of 100 pounds or greater
300 ppb	For corn and other grains intended for finishing (i.e., feedlot) beef cattle and for cottonseed meal intended for beef cattle, swine or poultry

Source: FDA and USDA GIPSA, http://www.gipsa.usda.gov/Publications/fgis/broch/b-aflatox.pdf

FDA has established additional policies and legal provisions concerning the blending of corn with levels of aflatoxins exceeding these threshold levels. In general, FDA currently does not permit the blending of corn containing aflatoxins with uncontaminated corn to reduce the aflatoxin content of the resulting mixture to levels acceptable for use as human food or animal feed.

Corn exported from the United States must be tested for aflatoxins according to Federal law. Unless the contract exempts this requirement, testing must be conducted by FGIS. Corn above the FDA action level of 20 ppb cannot be exported unless other strict conditions are met. These requirements result in relatively low levels of aflatoxins in exported grain.

4. Background: DON (Deoxynivalenol) or Vomitoxin

DON is another mycotoxin of concern to some importers of corn grain. It is produced by certain species of *Fusarium*, the most important of which is *F. graminearum* (*Gibberella zeae*) which also causes Gibberella ear rot (or red ear rot). Gibberellazeae can develop when cool or moderate and wet weather occurs at flowering. The fungus grows down the silks into the ear, and in addition to producing DON, it produces conspicuous red discoloration of kernels on the ear. The fungus can also continue to grow and rot ears when corn is left standing in the field. Mycotoxin contamination of corn caused by Gibberellazeae is often associated with excessive postponement of harvest and/or storage of high-moisture corn.

DON is mostly a concern with monogastric animals where it may cause irritation of the mouth and throat. As a result, the animals may eventually refuse to eat the DON-contaminated corn and may have low weight gain, diarrhea, lethargy and intestinal hemorrhaging. It may cause suppression of the immune system resulting in susceptibility to a number of infectious diseases.

The FDA has issued advisory levels for DON. For products containing corn, the advisory levels are:

- 5 ppm in grains and grain co-products for swine, not to exceed 20% of their diet,
- 10 ppm in grains and grain co-products for chickens and cattle, not to exceed 50% of their diet, and
- 5 ppm in grains and grain co-products for all other animals, not to exceed 40% of their diet.

FGIS is not required to test for DON on corn bound for export markets, but it will perform either a qualitative or quantitative test for DON at the buyer's request.

IV. U.S. CORN EXPORT SYSTEM

This *U.S. Grains Council 2015/2016 Corn Export Cargo Quality Report* provides advance information about corn quality by evaluating and reporting quality attributes when the corn is ready to be loaded onto the ocean-going vessel or railcar for export. Corn quality includes a range of attributes that can be categorized as:

- Intrinsic quality characteristics – Protein, oil and starch concentration, hardness, and density are all intrinsic quality characteristics; that is, they are contained within and are of critical importance to the end user. Since they are nonvisual, they can only be determined by analytical tests.

- Physical quality characteristics – These attributes are associated with outward visible appearance of the kernel or measurement of the kernel characteristics. Characteristics include kernel size, shape, and color, moisture, test weight, total damaged and heat-damaged kernels, broken kernels, and stress cracks. Some of these characteristics are measured when corn receives an official USDA grade.

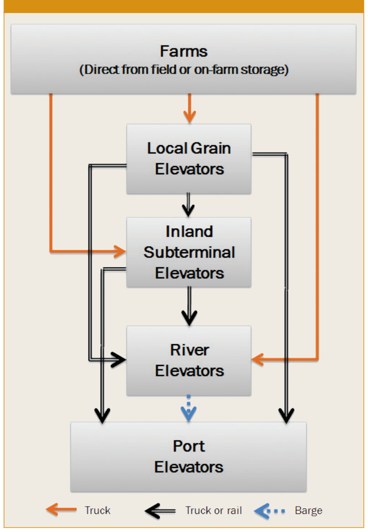
- Sanitary quality characteristics – These characteristics indicate the cleanliness of the grain. Attributes include presence of foreign material, odor, dust, rodent excreta, insects, residues, fungal infection, and non-millable materials.

The intrinsic quality characteristics are impacted significantly by genetics and growing season conditions and typically do not change at the aggregate level as corn moves through the marketing system. If the measured values of the intrinsic characteristics differ between harvest and export at the aggregate level, the differences can be due, in part, to normal random variation in sampling. On the other hand, the physical and sanitary characteristics can change as corn moves through the market channel. The parties involved in corn marketing and distribution use technologies (such as cleaning, drying, and conditioning) at each step in the channel to increase uniformity, prevent or minimize the loss of physical and sanitary quality, and meet contract specifications. The *Harvest Report* assesses the quality of the recently harvested corn crop as it enters the marketing system. The *Export Cargo Report* provides information on the impact of the subsequent practices including cleaning, drying, handling, blending, storing, and transporting of the crop at the point where it is being loaded for export. To provide the backdrop for this assessment, the following sections describe the market channel from farm to export, the practices applied to corn as it moves through the market channel, and the implication of these practices on corn quality. Lastly, the inspection and grading services provided by the U.S. government are reviewed.

A. U.S. Corn Export Flow

As corn is harvested, farmers transport grain to on-farm storage, end users, or commercial grain facilities. While some producers feed their corn to their own livestock, the majority of the corn moves to other end users (feed mills or processors) or commercial grain handling facilities such as local grain elevators, inland subterminal or river elevators, and port elevators. Local grain elevators typically receive most of their grain directly from farmers. Inland subterminal or river elevators collect grains in quantities suitable for loading on unit trains and barges for further transport. These elevators receive more than half of their corn from other elevators (usually local grain elevators) and are often located where the transport of bulk grain can be easily accommodated by unit trains or barges. Local grain, inland subterminal and river elevators provide functions such as drying, cleaning, blending, storing, and merchandising grain. River elevators and the larger inland subterminals supply most of the corn destined for export markets. The figure to the right conveys the flow of U.S. corn destined for export markets.

U.S. Corn Export Flow



B. Impact of the Corn Market Channel on Quality

While the U.S. corn industry strives to prevent or minimize the loss of physical and sanitary quality as corn moves from the farm to export, there are points in the system where quality changes inevitably occur due to the biological nature of the grain. The following sections provide some insight on why corn quality may change as corn moves from the field to the vessel or railcar.

1. Drying and Conditioning

Farmers often harvest corn at moistures ranging from about 18 to 30%. This range of moisture contents exceeds safe storage levels, which are usually about 13 to 14%. Thus, wet corn at harvest must be dried to a lower moisture to become safe for storage and transport. Conditioning is the use of aeration fans to control temperatures and moisture, both of which are important to monitor for storage stability. Drying and conditioning may occur either on a farm or at a commercial facility. When corn is dried, it can be dried by systems using natural air, low-temperature, or high-temperature drying methods. The high-temperature drying methods will often create more stress cracks in the corn and ultimately lead to more breakage during handling than natural air or low-temperature drying methods. However, high-temperature drying is often needed to facilitate timely harvesting of grain.

2. Storage and Handling

In the United States, corn storage structures can be broadly categorized as upright metal bins, concrete silos, flat storage inside buildings, or flat storage in on-ground piles. Upright bins and concrete silos with fully perforated floors or in-floor ducts are the most easily managed storage types because they allow aeration with uniform airflow through the grain. Flat storage can be used for short-term storage. This occurs most often when corn production is higher than normal and surplus storage is needed. However, it is more difficult to install adequate aeration ducts in flat types of storage, and they often do not provide uniform aeration. In addition, on-ground piles are sometimes not covered and may be subjected to weather elements that can result in mold damage.

Handling equipment can involve vertical conveying by bucket elevators and/or horizontal conveying, usually by belt or en-masse conveyors. Regardless of how the corn is handled, some corn breakage will occur. The rate of breakage will vary by types of equipment used, severity of the grain impacts, grain temperature, and moisture content, and by corn quality factors such as stress cracks or hardness of endosperm. As breakage levels increase, more fines (broken pieces of corn) are created, which leads to less uniformity in aeration and ultimately to higher risk for fungal invasion and insect infestation.

3. Cleaning

Cleaning corn involves scalping or removing large non-corn material and sieving to remove small, shriveled kernels, broken pieces of kernels and fine materials. This process reduces the amount of broken kernels and foreign material found in the corn. The potential for breakage and initial percentages of broken kernels, along with the desired grade factor, dictate the amount of cleaning needed to meet contract specifications. Cleaning can occur at any stage of the market channel where cleaning equipment is available.

4. Transporting Corn

The U.S. grain transportation system is arguably one of the most efficient in the world. It begins with farmers transporting their grain from the field to on-farm storage or local grain and river elevators using either large wagons or trucks. Corn is then transported by truck, rail, or barge to its next destination. Once at export facilities, corn is loaded onto vessels or railcars. As a result of this complex yet flexible marketing system, corn may be loaded and unloaded several times, increasing its susceptibility to broken kernels and breakage.

Corn quality changes during shipment in much the same manner as it changes during storage. Causes of these changes include moisture variability (non-uniformity) and moisture migration due to temperature differences, high humidities and air temperatures, fungal invasion, and insect infestation. However, there are some factors affecting grain transportation that make quality control during transport more difficult than in fixed storage facilities. First, there are few modes of transport equipped with aeration, and as a result, corrective actions for heating and moisture migration cannot take place during transport. Another factor is the accumulation of fine material (spout lines) beneath the loading spout when loading railcars, barges, and vessels. This results in whole kernels tending to roll to the outer sides, while fine material segregates in the center. A similar segregation occurs during the unloading process at each step along the way to final destination.

5. Implications on Quality

The intrinsic quality attributes such as protein cannot be altered within a corn kernel. However, as corn moves through the U.S. corn market channel, corn from multiple sources is mixed together. As a result, the average for a given intrinsic quality characteristic is affected by the quality levels of the corn from the multiple sources. The above-described marketing and transportation activities inevitably alter the various physical and sanitary quality characteristics. The quality characteristics that can be directly affected include test weight, damaged kernels, broken kernels, kernel size, stress crack levels, moisture contents and variability, foreign material, and mycotoxin levels.

C. U.S. Government Inspection and Grading

1. Purpose

Global corn supply chains need verifiable, predictable, and consistent oversight measures that fit the diverse needs of all end users. Oversight measures, implemented through standardized inspection procedures and grading standards, are established to provide:

- Information for buyers about grain quality prior to arrival at destination; and
- Food and feed safety protection for the end users.

The United States is recognized globally as having a combination of official grades and standards that are typically used for exporting grains and referenced in export contracts. U.S. corn sold by grade and shipped in foreign commerce must be officially inspected and weighed by the USDA's Federal Grain Inspection Service (FGIS) or an official service provider delegated or designated by FGIS to do so (with a few exceptions). In addition, all corn exports must be tested for aflatoxins, unless the contract specifically waives this requirement. Qualified state and private inspection agencies are permitted to be designated by FGIS as official agents to inspect and weigh corn at specified interior locations. In addition, certain state inspection agencies can be delegated by FGIS to inspect and weigh grain officially at certain export facilities. Supervision of these agencies' operations and methodologies is performed by FGIS's field office personnel.

2. Inspection and Sampling

The loading export elevator provides FGIS or the delegated state inspection agency a load order specifying the quality of the corn to be loaded as designated in the export contract. The load order specifies the U.S. grade and all other requirements which have been agreed upon in the contract between the foreign buyer and the U.S. supplier, plus any special requirements requested by the buyer such as minimum protein concentration, maximum moisture content, or other special requirements. The official inspection personnel determine and certify that the corn loaded in the vessel or railcar actually meets the requirements of the load order. Independent laboratories can be used to test for quality factors not mandated to be performed by FGIS, or for which FGIS does not have the local ability to test.

Shipments or "lots" of corn are divided into "sublots." Representative samples for grading are obtained from these sublots using a diverter sampling device approved by FGIS. This device takes an incremental portion every 500 bushels (about 12.7 metric tons) from the moving grain stream just after the final elevation before loading into the vessel or railcar. The incremental portions are combined by sublot and inspected by licensed inspectors. The results are entered into a log, and typically a statistical loading plan is applied to assure not only that the average result for each factor meets the contract specifications, but also to assure the lot is reasonably uniform in quality. Any sublot that does not meet uniformity criteria on any factor must be returned to the elevator or certified separately. The average of all sublot results for each factor is reported on the final official certificate. The FGIS sampling method provides a truly representative sample, while other commonly used methods may yield non-representative samples of a lot due to the uneven distribution of corn in a truck, railcar, or in the hold of a vessel.

3. Grading

Yellow corn is divided into five U.S. numerical grades and U.S. Sample Grade. Each grade has limits for test weight, broken corn and foreign material (BCFM), total damaged kernels and heat-damaged kernels as a subset of total damage. The limits for each grade are summarized in the table shown in the "U.S. Corn Grades and Conversions" section on page 51. In addition, FGIS provides certification of moisture content, and other attributes, if requested, such as stress cracks, protein, oil, and mycotoxins. Export contracts for corn specify many conditions related to the cargo, in addition to the contract grade. In some cases, independent labs are used to conduct tests not required by FGIS.

Since the limits on all official grade factors (such as test weight and total damage) cannot always be met simultaneously, some grade factors may be better than the limit for a specified grade, but they cannot be worse. For that reason, most contracts are written as "U.S. No. 2 or better" or "U.S. No. 3 or better." This permits some grade factor results to be at or near the limit for that grade, while other factor results are "better than" that grade.

V. SURVEY AND STATISTICAL ANALYSIS METHODS

A. Overview

The key points for the survey design and sampling and statistical analysis for this *2015/2016 Export Cargo Report* are as follows:

- Following the process developed for the previous *Export Cargo Reports*, samples were stratified according to Export Catchment Areas (ECAs) – the Gulf, Pacific Northwest and Southern Rail.
- To achieve no more than a ± 10% relative margin of error (Relative ME) for the U.S. Aggregate level and to ensure proportional sampling from each ECA, the targeted number of total samples was 430 samples, to be collected from the ECAs as follows: 272 from the Gulf, 92 from the Pacific Northwest, and 66 from the Southern Rail.
- Southern Rail ECA samples were provided by any of several official agencies designated by USDA's Federal Grain Inspection Service (FGIS) that inspect and grade rail shipments of corn destined for export to Mexico. Gulf and Pacific Northwest samples were collected by FGIS field offices at ports in the respective ECAs.
- Export inspections of shipments from the Southern Rail ECA (interior) did not generate the targeted number of samples for this report within the sampling timeframe required to publish the report in a timely manner. As a result, 44 samples were collected for the Southern Rail ECA. Nonetheless, the U.S. Aggregate averages for the quality factors were weighted according to the targeted proportion by ECA.
- To evaluate the statistical validity of the number of samples surveyed, the Relative ME was calculated for each of the quality attributes at the U.S. Aggregate and the three ECA levels. The Relative MEs for the quality factor results were less than ± 10% except for three attributes from the Pacific Northwest and Southern Rail ECAs – total damage, stress cracks, and stress crack index.

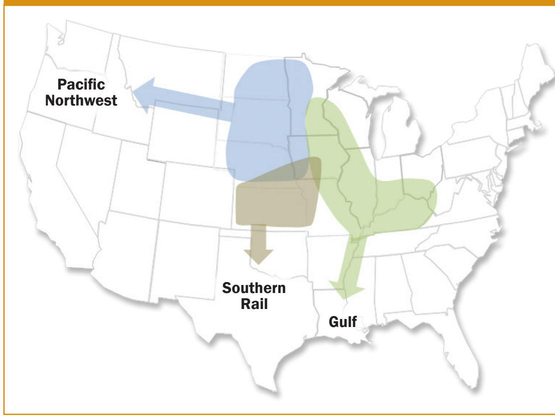
B. Survey Design and Sampling

1. Survey Design

For this *Export Cargo Report*, the target population was yellow commodity corn from the 12 key U.S. corn-producing states representing about 99% of U.S. corn exports. A ***proportionate stratified sampling*** technique was used to ensure a sound statistical sampling of U.S. yellow corn exports. Two key characteristics define the sampling technique for this report: the ***stratification*** of the population to be sampled and the ***sampling proportion*** per subpopulation or stratum.

Stratification involves dividing the survey population of interest into subpopulations called strata. For the *Export Cargo Reports*, the key corn-exporting areas in the United States are divided into three geographical groupings which we refer to as Export Catchment Areas (ECAs). These three ECAs are identified by the three major pathways to export markets:

Export Catchment Areas



1. The Gulf ECA consists of areas that typically export corn through U.S. Gulf ports;
2. The Pacific Northwest ECA includes areas that usually export corn through Pacific Northwest and California ports; and
3. The Southern Rail ECA comprises areas generally exporting corn by rail to Mexico.

Using data from the FGIS Export Grain Information System (EGIS), each ECA's proportion of the total annual yellow corn exports for the 2007/2008 through the 2014/2015 corn marketing years was calculated and averaged over the eight marketing years. This average share of exports was used to determine the ***sampling proportion*** (the percent of total samples per ECA) and, ultimately, the number of yellow corn samples to be collected from each ECA. The specified sampling proportions for the three ECAs are as shown in the table at the right.

Percent of Samples per ECA			
Gulf	Pacific Northwest	Southern Rail	Total
63.2%	21.5%	15.3%	100.0%

The ***number of samples*** collected within each ECA was established so the Council could estimate the true averages of the various quality factors with a certain level of precision. The level of precision chosen for the *Export Cargo Report* was a Relative ME of no greater than ± 10%. A Relative ME of ± 10% is a reasonable target for biological data such as these corn quality factors.

To determine the number of samples for the targeted Relative ME, ideally the population variance (i.e., variability of the quality factor in the corn exports) for each of the quality factors should be used. The more variation among the levels or values of a quality factor, the more samples needed to estimate the true mean with a given confidence limit. In addition, the variances of the quality factors typically differ from one another. As a result, different sample sizes for each of the quality factors would be needed for the same level of precision.

Since the population variances for the 15 quality factors evaluated for this year's corn exports were not known, the variance estimates from last year's *Export Cargo Report* were used as estimates of the population variance. The variances and ultimately the estimated number of samples needed for the Relative ME of ± 10% for 12 quality factors were calculated using the 2014/2015 results of 411 samples. Heat damage, 100-k weight, and kernel

V. SURVEY AND STATISTICAL ANALYSIS METHODS (continued)

volume were not examined. Based on these data, a total sample size of 430 would allow the Council to estimate the true averages of the quality characteristics with the desired level of precision for the U.S. Aggregate. Applying the sampling proportions previously defined to the total of 430 samples resulted in the following number of targeted samples from each ECA (shown in table).

Number of Samples per ECA			
Gulf	Pacific Northwest	Southern Rail	Total
272	92	66	430

2. Sampling

The sampling was administered by FGIS and participating official service providers as part of their inspection services. Based on feedback from the FGIS field offices indicating that 2015 corn was reaching export points by October 2015, it was decided to start the sampling period in November 2015. FGIS sent instruction letters to the Gulf and Pacific Northwest field offices and to the domestic inspections office, and the sampling period began in November 2015 for the three ECAs. The FGIS field offices in the respective ECAs responsible for overseeing the sample collection within their region were as follows: Gulf – New Orleans, Louisiana; Pacific Northwest – Olympia, Washington (Washington State Department of Agriculture); and Southern Rail – FGIS Domestic Inspection Operations Office in Kansas City, Missouri.

Representative sublot samples from the ports in the Gulf and Pacific Northwest ECAs were collected as ships were loaded, and only lots for which quantitative aflatoxin testing was being performed were to be sampled. Samples for grading are obtained by a diverter sampling device approved by FGIS. The diverter sampler "cuts" (or diverts) a representative portion at periodic intervals from a moving stream of corn. A cut occurs every few seconds, or about every 500 bushels (about 12.7 metric tons) as the grain is being assembled for export. The frequency is regulated by an electric timer controlled by official inspection personnel, who periodically determine that the mechanical sampler is functioning properly.

While the sampling process is continuous throughout loading, a shipment or "lot" of corn is divided into "sublots" for the purpose of determining uniformity of quality. Sublot size is based on the hourly loading rate of the elevator and the capacity of the vessel being loaded. Sublot sizes range from 60,000 to 100,000 bushels. All sublot samples are inspected to ensure the entire shipment is uniform in quality.

The same sampling frequency for the Pacific Northwest and Gulf ECAs as last year's export cargo survey was used for this year's survey. Therefore, sublots ending in 0, 3, 5 and 7 from each lot during the survey period were sampled.

For the Southern Rail samples, a representative sample was taken at domestic interior elevators using a diverter sampler to ensure uniform sampling. A cut is taken about every 500 bushels. A composite sample was made from unit trains of yellow corn inspected for export to Mexico and for which quantitative aflatoxin testing was being performed.

For each sample, a minimum of 2700 grams was collected by the FGIS field staff, the Southern Rail ECA official service providers, and the Washington State Department of Agriculture. The samples were congregated at the field offices, and mailed to Illinois Crop Improvement Association's Identity Preserved Grain Laboratory (IPG Lab). Refer to the "Testing Analysis Methods" section for the description of the testing methods employed for the study.

The sampling period ended January 27, 2016 for the Pacific Northwest ECA and February 8, 2016 for the Gulf ECA when the targeted number of samples per ECA was reached. As of March 15, 2016, no additional shipments from which samples could be collected were expected for the Southern Rail in the near future. Therefore, in order to publish the *Export Cargo Report* in a timely manner, the sampling period for the Southern Rail ECA concluded on March 15, 2016.

C. Statistical Analysis

The sample test results for the grade factors, moisture, chemical composition, and physical factors were summarized as the U.S. Aggregate and also by the three ECAs (Gulf, Pacific Northwest, and Southern Rail) and two "contract grade" categories. Contract grades are described in the "Corn Export System" section on page 41. The two contract grade categories in the *Export Cargo Report* are:

- "U.S. No. 2" or "U.S. No. 2 or better" contracts specify that the corn must at least meet U.S. No. 2 factor limits or be better than U.S. No. 2 factor limits. This category is designated as U.S. No. 2 o/b.
- "U.S. No. 3" or "U.S. No. 3 or better" contracts specify that the corn must at least meet U.S. No. 3 factor limits or be better than U.S. No. 3 factor limits. This category is designated as U.S. No. 3 o/b.

The sampling process resulted in less than the targeted number of samples in the Southern Rail ECA. However, the U.S. Aggregate averages and standard deviations were weighted by ECA using the original sampling proportions.

New to this *2015/2016 Export Cargo Report* is a simple average of the quality factors' averages and standard deviations of the previous four *Export Cargo Reports (2011/2012, 2012/2013, 2013/2014,* and *2014/2015).* These simple averages are calculated for the U.S. Aggregate and each of the three ECAs and are referred to as "4YA" in the text and summary tables of the report.

The Relative ME was calculated for each of the quality factors tested for this study at the U.S. Aggregate level and for each of the ECAs. The Relative ME was less than ± 10% for all the quality attributes at the U.S. Aggregate level and for the Gulf ECA. The Relative ME exceeded ± 10% for some quality factors (see table) in the Pacific Northwest and Southern Rail ECAs.

	Relative Margin of Error (ME)		
	Total Damage	Stress Cracks	SCI
Pacific Northwest ECA	19%	12%	15%
Southern Rail ECA	16%	30%	37%

While the level of precision for these quality factors in the two ECAs is less than desired, the levels of Relative ME do not invalidate the estimates. The averages for the quality factors are the best possible unbiased estimates of the true population means. However, they are estimated with greater uncertainty than the quality factors with a Relative ME of less than ± 10%. Footnotes in the summary tables for "Grade Factors and Moisture" and "Physical Factors" indicate the attributes for which the Relative ME exceeds ± 10%. This allows the reader to keep in mind the greater degree of uncertainty of the sample average representing the true population mean.

References in the "Quality Test Results" section to statistical differences were validated by 2-tailed t-tests at the 95% confidence level. The t-tests were calculated:

- Between factors in the *2015/2016 Harvest Report* and *2015/2016 Export Cargo Report*;
- Between factors in the *2015/2016 Export Cargo Report* and *2014/2015 Export Cargo Report,* and the *2015/2016 Export Cargo Report* and *2013/2014 Export Cargo Report;*
- Among factors in the *2015/2016 Export Cargo Report* ECAs (Gulf, Pacific Northwest, Southern Rail); and
- Between chemical and physical factors in the *2015/2016 Export Cargo Report* contract grades (U.S. No. 2 o/b, U.S. No. 3 o/b).

VI. TESTING ANALYSIS METHODS

USDA's Federal Grain Inspection Service (FGIS) or FGIS-designated official service providers provided official grading and aflatoxin results from their normal inspection and testing procedures for each sublot corn sample collected. Approximately 6 pounds (2700 grams) of the corn samples were sent directly from the FGIS field offices and the official service providers to the Illinois Crop Improvement Association's Identity Preserved Grain Laboratory (IPG Lab) in Champaign, Illinois, for the chemical composition, physical factors and DON testing. Upon arrival at IPG Lab, the samples were split into two subsamples using a Boerner divider, while keeping the attributes of the grain sample evenly distributed between the two subsamples. One subsample was analyzed for DON. The other subsample was analyzed for chemical composition and other physical factors following either industry norms or well-established procedures. IPG Lab has received accreditation under the ISO/IEC 17025:2005 International Standard for many of the tests. The full scope of accreditation is available at *http://www.ilcrop.com/index.php/perry-johnson-laboratory-accreditation.html*.

A. Corn Grading Factors

1. Test Weight

Test weight is the weight of the volume of grain that is required to fill a Winchester bushel (2,150.42 cubic inches) to capacity. Test weight is a part of the FGIS Official United States Standards for Grain grading criteria.

The test involves filling a test cup of known volume through a funnel held at a specific height above the test cup to the point where grain begins to pour over the sides of the test cup. A strike-off stick is used to level the grain in the test cup, and the grain remaining in the cup is weighed. The weight is then converted to and reported in the traditional U.S. unit, pounds per bushel (lb/bu).

2. Broken Corn and Foreign Material (BCFM)

Broken corn and foreign material (BCFM) is part of the FGIS Official United States Standards for Grain grading criteria.

The BCFM test determines the amount of all matter that passes through a 12/64th inch round-hole sieve and all matter other than corn that remains on the top of the sieve. The sample for the BCFM measurement is separated into broken corn and foreign material. Broken corn is defined as all material passing through a 12/64th inch round-hole sieve and retained on a 6/64th inch round-hole sieve and typically accounts for the majority of total BCFM. Foreign material is defined as all material passing through a 6/64th inch round-hole sieve and the coarse non-corn material retained on the 12/64th inch round-hole sieve. While FGIS can report broken corn and foreign material separately if requested, BCFM is the default measurement and thus is provided for the *Export Cargo Report*. BCFM is reported as a percentage of the initial sample by weight.

3. Total Damage/Heat Damage

Total damage is part of the FGIS Official United States Standards for Grain grading criteria.

A representative working sample of 250 grams of BCFM-free corn is visually examined by a trained and licensed inspector for content of damaged kernels. Types of damage include blue-eye mold, cob rot, dryer-damaged kernels (different from heat-damaged kernels), germ-damaged kernels, heat-damaged kernels, insect-bored kernels, mold-damaged kernels, mold-like substance, silk-cut kernels, surface mold (blight), surface mold, mold (pink *Epicoccum*) and sprout-damaged kernels. Total damage is reported as the weight percentage of the working sample that is total damaged grain.

Heat damage is a subset of total damage and consists of kernels and pieces of corn kernels that are materially discolored and damaged by heat. Heat-damaged kernels are determined by a trained and licensed inspector visually inspecting a 250-gram sample of BCFM-free corn. Heat damage, if found, is reported separately from total damage.

B. Moisture

Moisture content is determined using an approved moisture meter at the time of inspection and is reported on the certificate. These electronic moisture meters sense an electrical property of grains, called the dielectric constant, that varies with moisture. The dielectric constant rises as moisture content rises. Moisture is reported as a percent of total wet weight.

C. Chemical Composition

The chemical composition (protein, oil and starch concentration) of corn is measured using near-infrared transmittance (NIRT) spectroscopy. NIRT uses unique interactions of specific wavelengths of light with each sample. It is calibrated to traditional chemistry methods, in order to predict the concentrations of oil, protein and starch in the sample. This procedure is nondestructive to the corn. Chemical composition tests for protein, oil and starch is conducted using a 400- to 450-gram (g) sample in a whole-kernel Foss Infratec 1229 NIRT instrument. Results are reported on a dry basis percentage (percent of non-water material).

D. Physical Factors

1. 100-Kernel Weight, Kernel Volume and Kernel True Density

The 100-kernel weight is determined from the average weight of two 100-kernel replicates using an analytical balance that measures to the nearest 0.1 mg. The averaged 100-kernel weight is reported in grams.

The kernel volume for each 100-kernel replicate is calculated using a helium pycnometer and is expressed in cubic centimeters (cm^3) per kernel. Kernel volumes usually range from 0.18 to 0.30 cm^3 per kernel for small and large kernels, respectively.

True density of each 100-kernel sample is calculated by dividing the mass (or weight) of the 100 externally sound kernels by the volume (displacement) of the same 100 kernels. The two replicate results are averaged. True density is reported in grams per cubic centimeter (g/cm^3). True densities typically range from 1.16 to 1.35 g/cm^3 at “as is” moistures of about 12 to 15%.

2. Stress Crack Analysis

Stress cracks are evaluated by using a backlit viewing board to accentuate the cracks. A sample of 100 intact kernels with no external damage is examined kernel by kernel. The light passes through the horneous or hard endosperm so that the severity of the stress crack damage in each kernel can be evaluated. Kernels are sorted into four categories: (1) no cracks; (2) one crack; (3) two cracks; and (4) more than two cracks. Stress cracks, expressed as a percentage, are all kernels containing one, two or more than two cracks divided by 100 kernels. Lower levels of stress cracks are always better, since higher levels of stress cracks lead to more breakage in handling. If stress cracks are present, singles are better than doubles or multiples. Some corn end users will specify by contract the acceptable level of cracks based on the intended use.

Stress crack index (SCI) is a weighted average of the stress cracks. This measurement indicates the severity of stress cracking. SCI is calculated as

$$SCI = [SSC \times 1] + [DSC \times 3] + [MSC \times 5];$$

Where

SSC is the percentage of kernels with only one crack;

DSC is the percentage of kernels with exactly two cracks; and

MSC is the percentage of kernels with more than two cracks.

The SCI can range from 0 to 500, with a high number indicating numerous multiple stress cracks in a sample, which is undesirable for most uses.

3. Whole Kernels

In the whole kernels test, 50 grams of cleaned (BCFM-free) corn are inspected kernel by kernel. Cracked, broken, or chipped grain, along with any kernels showing significant pericarp damage, are removed, the whole kernels are weighed, and the result is reported as a percentage of the original 50-gram sample. Some companies perform the same test, but report the “cracked & broken” percentage. A whole kernels score of 97% equates to a cracked & broken rating of 3%.

4. Horneous (Hard) Endosperm

The horneous (or hard) endosperm test is performed by visually rating 20 externally sound kernels, placed germ facing up, on a light table. Each kernel is rated for the estimated portion of the kernel’s total endosperm that is horneous endosperm. Soft endosperm is opaque and will block light, while horneous endosperm is translucent. The rating is made from standard guidelines based on the degree to which the soft endosperm at the crown of the kernel extends down toward the germ. The average of horneous endosperm ratings for the 20 externally sound kernels is reported. Ratings of horneous endosperm are made on a scale of 70 to 100%, though most individual kernels fall in the 70 to 95% range.

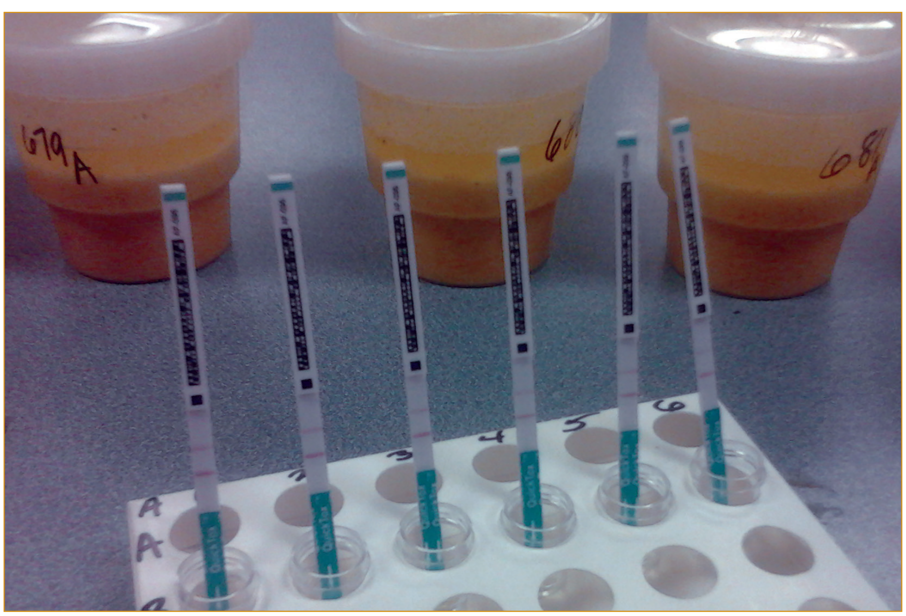
E. Mycotoxin Testing

Official aflatoxin results are provided by FGIS for the *Export Cargo Report 2014/2015*. For the aflatoxin testing, a sample of at least 10 pounds of shelled corn is used according to FGIS official procedures. The 10-pound sample is ground using a FGIS-approved grinder. Following the grinding stage, two 500-gram ground portions are removed from the 10-pound comminuted sample using a riffle divider. From one of the 500-gram ground portions, a 50-gram test portion is randomly selected for testing. After adding the proper extraction solvent to the 50-gram test portion, aflatoxin is quantified. The following FGIS-approved quantitative test kits may have been used: VICAM AflaTest™ or Afla-V, Beacon Aflatoxin Plate Kit, Romer Labs FluoroQuant Afla, FluoroQuant Afla IAC or AgraStrip Total Aflatoxin Quantitative Test WATEX, Envirologix QuickTox™ for QuickScan Aflatoxin (AQ 109 BG and AQ 209 BG), Neogen Reveal Q+ for Aflatoxin, Reveal Q+ for Aflatoxin Green (AccuScan Gold or AccuScan Pro), or Veratox® Aflatoxin Quantitative Test, Charm Sciences ROSA® FAST and WET-S5 Aflatoxin Quantitative Tests, or R-Biopharm RIDASCREEN® FAST Aflatoxin SC or RIDA QUICK Aflatoxin RQS.

For the DON testing, the FGIS-approved Envirologix QuickTox™/QuickScan method is used. A 1350-gram sample of shelled corn (obtained by dividing the original sample) is ground to a particle size which would pass through a number 20 wire mesh sieve and divided down to a 50-gram test portion using a Romer Model 2A sampling mill. The 50-gram test portion is then processed as the FGIS *DON (Vomitoxin) Handbook* requires. DON is extracted with distilled water (5:1), and the extract is tested using the Envirologix AQ 254 BG test kits. The DON is quantified by the QuickScan system.

The EnviroLogix quantitative test kits report specific concentration levels of the mycotoxin if the concentration level exceeds a specific level called a "Limit of Detection" (LOD). The LOD is defined as the lowest concentration level that can be measured with an analytical method that is statistically different from measuring an analytical blank (absence of a mycotoxin). The LOD will vary among different types of mycotoxins, test kits and commodity combinations. The LOD for the EnviroLogix AQ 254 BG is 0.3 parts per million (ppm) for DON.

A letter of performance has been issued by FGIS for the quantification of DON using the Envirologix AQ 254 BG kit.



VII. U.S. CORN GRADES AND CONVERSIONS

U.S. CORN GRADES AND GRADE REQUIREMENTS

Grade	Minimum Test Weight per Bushel (Pounds)	Maximum Limits of Damaged Kernels: Heat Damaged (Percent)	Maximum Limits of Damaged Kernels: Total (Percent)	Maximum Limits of Broken Corn and Foreign Material (Percent)
U.S. No. 1	56.0	0.1	3.0	2.0
U.S. No. 2	54.0	0.2	5.0	3.0
U.S. No. 3	52.0	0.5	7.0	4.0
U.S. No. 4	49.0	1.0	10.0	5.0
U.S. No. 5	46.0	3.0	15.0	7.0

U.S. Sample Grade is corn that: (a) Does not meet the requirements for the grades U.S. Nos. 1, 2, 3, 4 or 5; or (b) Contains stones with an aggregate weight in excess of 0.1 percent of the sample weight, two or more pieces of glass, three or more crotalaria seeds (*Crotalaria spp.*), two or more castor beans (*Ricinus communis L.*), four or more particles of an unknown foreign substance(s) or a commonly recognized harmful or toxic substance(s), eight or more cocklebural (*Xanthium spp.*), or similar seeds singly or in combination, or animal filth in excess of 0.20 percent in 1,000 grams; or (c) Has a musty, sour or commercially objectionable foreign odor; or (d) Is heating or otherwise of distinctly low quality.

Source: *Code of Federal Regulations, Title 7, Part 810, Subpart D, United States Standards for Corn*

U.S. AND METRIC CONVERSIONS

Corn Equivalents		Metric Equivalents	
1 bushel =	56 pounds (25.40 kilograms)	1 pound =	0.4536 kg
39.368 bushels =	1 metric ton	1 hundredweight =	100 pounds or 45.36 kg
15.93 bushels/acre =	1 metric ton/hectare	1 metric ton =	2204.6 lbs
1 bushel/acre =	62.77 kilograms/hectare	1 metric ton =	1000 kg
1 bushel/acre =	0.6277 quintals/hectare	1 metric ton =	10 quintals
56 lbs/bushel =	72.08 kg/hectoliter	1 quintal =	100 kg
		1 hectare =	2.47 acres

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Developing Markets ◼ Enabling Trade ◼ Improving Lives