U.S. GRAINS COUNCIL

2018/2019 CORN EXPORT CARGO QUALITY REPORT

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 Lee Singleton, Chris Schroeder, Lisa Eckel and Alex Harvey of Centrec Consulting Group 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 analyses of the chemical composition, physical factors and the vomitoxin or deoxynivalenol (DON) content 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 its 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.

U.S. GRAINS COUNCIL

GREETINGS FROM THE COUNCIL

The U.S. Grains Council is pleased to offer this *2018/2019 Corn Export Cargo Quality Report*, detailing our annual quality survey of U.S. yellow commodity corn destined for export. The Council is committed to furthering global food security and mutual economic benefit through trade. To promote continuous trade expansion, this report should assist buyers in making well-informed decisions by providing reliable and timely information about U.S. corn quality.

The *Export Cargo Report*, the second of two reports released by the Council detailing the quality of the 2018 corn crop, is based on samples taken at the point of loading for international shipment early in the 2018/2019 marketing year. The *Export Cargo Report* and its sister report, the *2018/2019 Corn Harvest Quality Report*, provide reliable information on U.S. corn quality from the farm to the customer based on a transparent and consistent methodology. These reports provide an early look at the grade factors established by the U.S. Department of Agriculture, moisture content and additional quality characteristics not reported elsewhere.

The *2018/2019 Corn Harvest Quality Report* and the *2018/2019 Corn Export Cargo Quality Report* are the eighth editions of the annual series produced by the Council. This series has consistently created value for all stakeholders due to the familiarity of the information and the ability to evaluate year-to-year changes in the U.S. corn crop. The Council's mission is one of developing markets, enabling trade and improving lives. To help fulfill this mission, the Council is pleased to offer this report as a service to our partners. We hope it continues in its role of providing information about the quality of the U.S. corn crop to our valued trade partners.

Sincerely,

Jim Stitzlein
Chairman, U.S. Grains Council
March 2019

WHEN TRADE WORKS, THE WORLD WINS

The average aggregate quality of the corn assembled for export early in the 2018/2019 marketing year was better than or equal to U.S. No. 2 on all grade factors, and average moisture content was slightly higher than 2017/2018. Chemical composition attributes indicated slightly higher starch and slightly lower protein and oil concentrations than 2017/2018. The early 2018/2019 corn exports had lower stress cracks and higher whole kernels than 2017/2018. In addition, all of the samples' test results for aflatoxin and deoxynivalenol (DON) or vomitoxin were below the U.S. Food and Drug Administration (FDA) action and advisory levels, respectively. Notable U.S. Aggregate quality attributes of the 2018/2019 export samples include:

Grade Factors and Moisture

- Same average **test weight** of 57.4 pounds per bushel (lb/bu) (73.9 kilograms per hectoliter (kg/hl)) as 2017/2018, indicating overall good quality, with 84.4% of the samples at or above the limit for U.S. No. 1 grade.
- Same average broken corn and foreign material (**BCFM**) (2.9%) as 2017/2018 and slightly lower than the 5YA[1] and the maximum limit for U.S. No. 2 grade. BCFM predictably increased from 0.7 to 2.9%, as the crop moved from harvest through the marketing channel to export.
- Higher average **total damage** at export (2.6%) than 2017/2018 and the 5YA. Most (94.7%) of the samples were below the limit for U.S. No. 2 grade.
- Average **heat damage** was 0.0%, the same as 2017/2018 and the 5YA, indicating good management of drying and storage of corn throughout the marketing channel.
- Slightly higher average **moisture** (14.5%) than 2017/2018 and the 5YA.

Chemical Composition

- Slightly lower average **protein** concentration (8.5% dry basis) than 2017/2018 but same as the 5YA.
- Slightly higher average **starch** concentration (72.3% dry basis) than 2017/2018 but lower than the 5YA.
- Slightly lower average **oil** concentration (4.0% dry basis) than 2017/2018 but slightly higher than the 5YA.

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

[1] *5YA represents the simple average of the quality factor's average or standard deviation from the 2013/2014, 2014/2015, 2015/2016, 2016/2017 and 2017/2018 Export Cargo Reports.*

Physical Factors

- Lower average **stress cracks** (7%) than 2017/2018 and the 5YA. The majority of the export samples (88.5%) had less than 15% stress cracks, which should result in relatively low rates of breakage during handling.
- Lower average **stress crack index** (16.2) than 2017/2018 and the 5YA. The lower stress crack index and stress crack percentages in 2018/2019 than in 2017/2018 may be due, in part, to lower average moisture at the 2018 harvest than at the 2017 harvest.
- Higher average **100-kernel weight** (36.17 grams) than 2017/2018 and the 5YA, indicating heavier kernels in 2018/2019 than last year and the 5YA.
- Same average **kernel volume** (0.28 cubic centimeters (cm^3)) as 2017/2018 and the 5YA.
- Slightly higher average **true density** (1.288 grams per cubic centimeter (g/cm^3) than 2017/2018 and the 5YA.
- Higher average percent of **whole kernels** (85.2%) than 2017/2018 but lower than the 5YA.
- Average **horneous (hard) endosperm** of 82%, slightly higher than 2017/2018 and the 5YA, indicating slightly harder corn.

Mycotoxins

- All of the export samples tested below the U.S. FDA action level of 20 parts per billion (ppb) for **aflatoxins**. A higher proportion of the export samples had no detectable levels of aflatoxins than in 2017/2018.
- 100% of the corn export samples tested below the 5 parts per million (ppm) FDA advisory level for **DON** (same as 2017/2018). There were slightly fewer samples showing levels of DON below the Federal Grain Inspection Service (FGIS) "Lower Conformance Level" of 0.5 ppm in 2018/2019 than in 2017/2018.

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's (Council's) *2018/2019 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 processes for U.S. corn waterborne and rail export shipments.

This *Export Cargo Report* is based on 436 yellow commodity corn samples collected from corn export shipments as they underwent the federal inspection and grading processes performed by the U.S. Department of Agriculture (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 typically exporting corn through U.S. Gulf ports;
2. The Pacific Northwest ECA includes areas exporting corn through Pacific Northwest ports; and
3. The Southern Rail ECA comprises areas generally exporting corn to Mexico by rail from inland subterminals.

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.

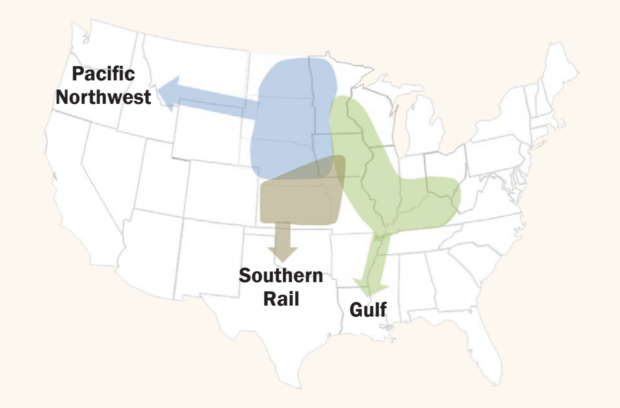
This report provides detailed information on each of the quality factors tested, including average, standard deviation and distribution, for the U.S. Aggregate and for each of the three ECAs. The "Quality Test Results" section summarizes the following quality factors:

- Grade Factors: test weight, BCFM, total damage and heat damage
- Moisture
- Chemical Composition: protein, starch and oil concentrations
- 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.

For the *2018/2019 Export Cargo Report,* FGIS and interior offices collected samples from export shipments loaded from mid-November 2018 through February 2019 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) of not more than ±10% for the U.S. Aggregate level. Details of the statistical sampling and analysis methods are presented in the "Survey and Statistical Analysis Methods" section.

EXPORT CATCHMENT AREAS



This *2018/2019 Export Cargo Report* is the eighth in a series of annual surveys of the quality of 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 are providing increased value to stakeholders. The eight years of data enable export buyers and other stakeholders to make year-to-year comparisons and assess 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 participants 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. Many factors, including weather, genetics, commingling and grain drying and handling, affect quality changes 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 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.

The companion report, the *U.S. Grains Council 2018/2019 Corn Harvest Quality Report*, was released in December 2018 and reported on the quality of the corn as it entered the U.S. marketing system. The *2018/2019 Harvest Report* and the *2018/2019 Export Cargo Report* should be studied together so that changes in corn quality occurring between harvest and export can be understood. To illustrate these changes, a new "Historical Perspective" section has been added to this report on page 65 to display the results from all previous Harvest and Export Cargo Quality Reports.

A. GRADE FACTORS

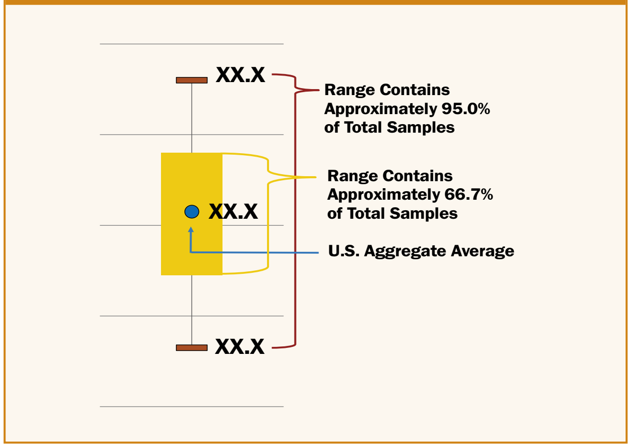
The USDA FGIS has established numerical grades, definitions and standards for measurement of many quality attributes. The attributes that determine the numerical grades for corn are: test weight, BCFM, total damage and heat damage. A table displaying the numerical requirements for these attributes is included in the "U.S. Corn Grades and Requirements" section on page 72 of this report.

SUMMARY: GRADE FACTORS AND MOISTURE

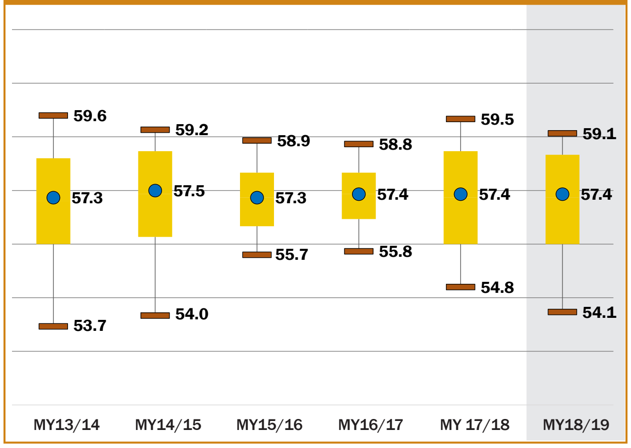
- Average U.S. Aggregate test weight (57.4 lb/bu or 73.9 kg/hl) was the same as 2017/2018, 2016/2017 and the 5YA, and all were well above the limit for U.S. No. 1 grade (56.0 lb/bu).
- Average U.S. Aggregate BCFM (2.9%) was the same as 2017/2018 and 2016/2017. All were slightly lower than the 5YA (3.0%). A total of 64.0% of the export samples contained levels at or below the maximum allowed for U.S. No. 2 grade (3.0%), and 94.0% were at or below the limit for U.S. No. 3 grade (4.0%).
- Average U.S. Aggregate total damage (2.6%) was higher than 2017/2018 and the 5YA, similar to 2016/2017 and well below the limit for U.S. No. 1 grade (3.0%). Of the export samples, 64.9% had 3.0% or less damaged kernels, meeting the requirement for U.S. No. 1 grade. In addition, 94.7% were at or below the limit for U.S. No. 2 grade (5.0%).
- Export samples from the Pacific Northwest ECA had the lowest average total damage among the three ECAs for each of the last three years and for the 5YA.
- Average U.S. Aggregate heat damage was 0.0% for 2018/2019, the same as the previous three years and the 5YA.
- Test weight, total damage and heat damage averages for contracts loaded as U.S. No. 2 or better and for contracts loaded as U.S. No. 3 or better were at or better than U.S. No. 1 grade limits.
- Average BCFM for contracts loaded as U.S. No. 2 or better was below the limit for U.S. No. 2. Average BCFM for contracts loaded as U.S. No. 3 or better was well below the limit for U.S. No. 3.
- Average U.S. Aggregate moisture content (14.5%) was slightly higher than 2017/2018, 2016/2017 and the 5YA.
- A total of 41.6% of the samples had moisture contents above 14.5%, which was higher than in the previous two years, indicating care should be taken in monitoring moistures and checking storage conditions.
- The Pacific Northwest ECA average moisture (14.4%) was lower than the Gulf (14.5%) and Southern Rail (14.6%) ECAs. The Pacific Northwest ECA had the lowest average moisture content among ECAs for each of the last three years and for the 5YA.

GRADE FACTORS
AGGREGATE SIX-YEAR COMPARISON

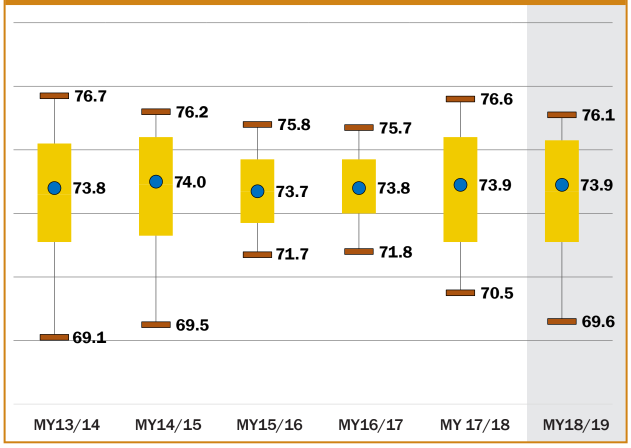
HOW TO READ THE CHARTS



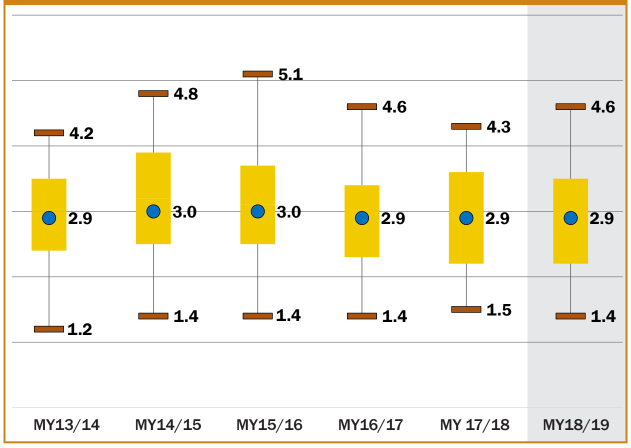
TEST WEIGHT (lb/bu)



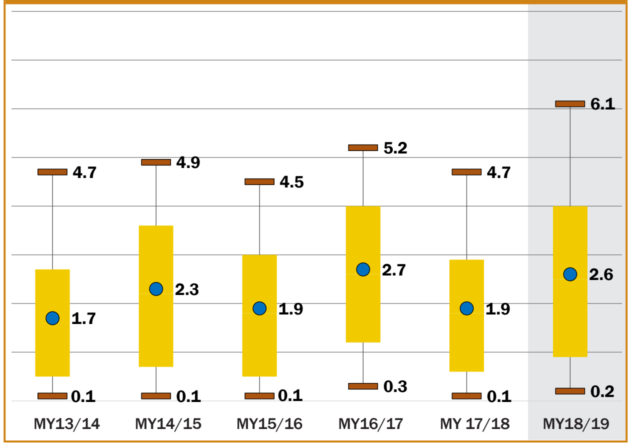
TEST WEIGHT (kg/hl)



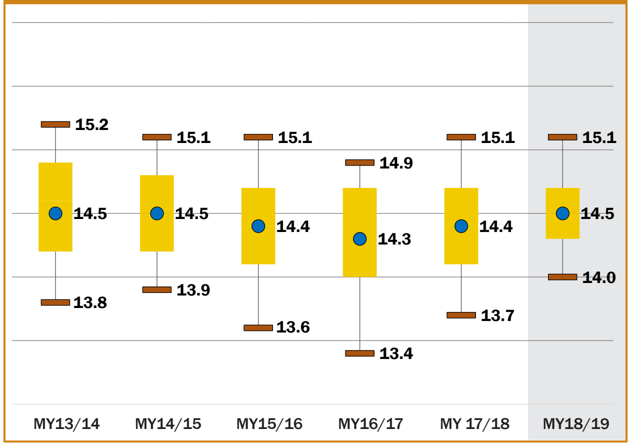
BROKEN CORN AND FOREIGN MATERIAL (%)



TOTAL DAMAGE (%)



MOISTURE (%)



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 for alkaline cookers and dry millers. High test weight corn takes up less storage space than the same weight of corn with lower test weight. Test weight is initially impacted by genetic differences in the structure of the kernel. However, it is also affected by moisture content, the 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, kernel maturity, kernel hardness and microbiological damage. When sampled and measured at the point of delivery from the farm at a given moisture content, high test weight generally indicates high quality, a high percent of horneous (or hard) endosperm and sound, clean corn. Test weight is positively correlated with true density and reflects kernel hardness and good maturation conditions.

Results

- Average U.S. Aggregate test weight (57.4 lb/bu or 73.9 kg/hl), well above the limit for U.S. No. 1 grade (56.0 lb/bu), was the same as 2017/2018, 2016/2017 and the 5YA. The 2018/2019 export samples had a standard deviation (0.82 lb/bu), below 2017/2018 (0.85 lb/bu), above 2016/2017 (0.61 lb/bu) and similar to the 5YA (0.80 lb/bu). The range in values in 2018/2019 was 7.6 lb/bu, similar to 2017/2018 (6.9 lb/bu) and wider than 2016/2017 (4.5 lb/bu).

- Average U.S. Aggregate test weight for 84.4% of the 2018/2019 samples was at or above the minimum for U.S. No. 1 grade (56.0 lb/bu), and 97.7% of the samples were at or above the limit for U.S. No. 2 grade (54.0 lb/bu).

- Average U.S. Aggregate test weight at export (57.4 lb/bu or 73.9 kg/hl) was lower than at 2017 harvest (58.4 lb/bu or 75.1 kg/hl). Average test weight at export has been consistently lower than at harvest, as indicated by the export 5YA (57.4 lb/bu or 73.9 kg/hl) and the harvest 5YA (58.1 lb/bu or 74.8 kg/hl).

- The variability of the 2018/2019 export samples as measured by the standard deviation (0.82 lb/bu) was less than the 2018 harvest samples with a standard deviation of 1.20 lb/bu. As corn is commingled moving through the marketing channel, test weight becomes more uniform, with a lower standard deviation and a narrower range between maximum and minimum values than at harvest. The 5YA standard deviation at export was 0.80 lb/bu, compared with the harvest 5YA standard deviation of 1.27 lb/bu.

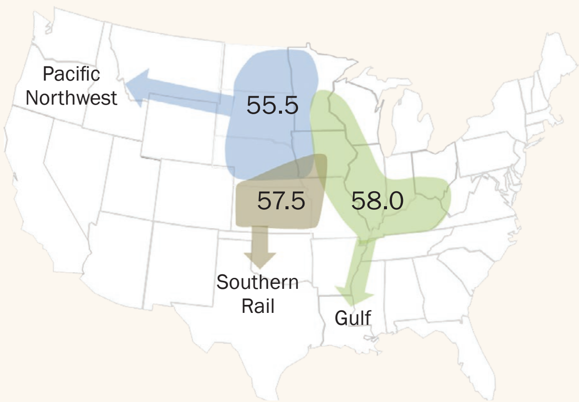
- Average test weight was lower for the Pacific Northwest (55.5 lb/bu) than for the Southern Rail (57.5 lb/bu) and the Gulf (58.0 lb/bu) ECAs.

- Average test weight of corn for contracts loaded as U.S. No. 2 or better (57.5 lb/bu) was higher than for contracts loaded as U.S. No. 3 or better (57.4 lb/bu). Averages for both contracts were above the limit for U.S. No. 1 grade.

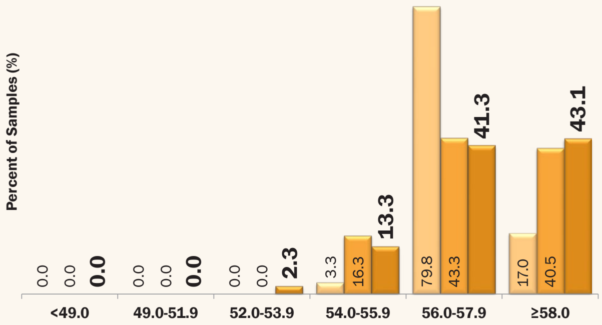
U.S. Grade Minimum Test Weight
No. 1: 56.0 lb
No. 2: 54.0 lb
No. 3: 52.0 lb
No. 4: 49.0 lb
No. 5: 46.0 lb
Sample: <46.0 lb

TEST WEIGHT (lb/bu)

EXPORT CATCHMENT AREA AVERAGE



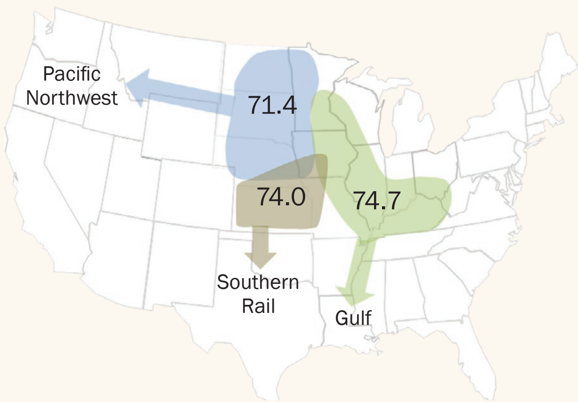
U.S. AGGREGATE



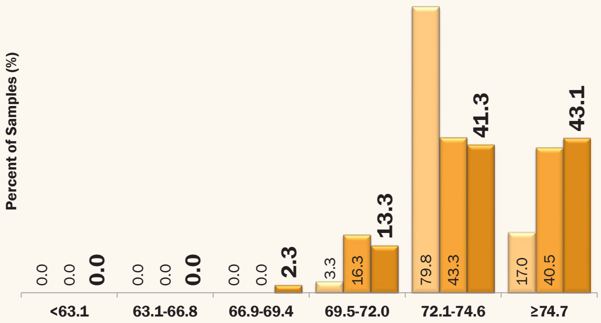
	Avg	Std Dev
MY16/17	57.4	0.61
MY17/18	57.4	0.85
MY18/19	57.4	0.82

TEST WEIGHT (kg/hl)

EXPORT CATCHMENT AREA AVERAGE



U.S. AGGREGATE



	Avg	Std Dev
MY16/17	73.8	0.78
MY17/18	73.9	1.10
MY18/19	73.9	1.05

Broken Corn and Foreign Material

BCFM is an indicator of the amount of clean, sound corn available for feeding and processing. The lower the percentage of BCFM, the less foreign material and/or fewer broken kernels are in the sample. As corn moves from farm deliveries through the marketing 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 from the farm to the local elevator.

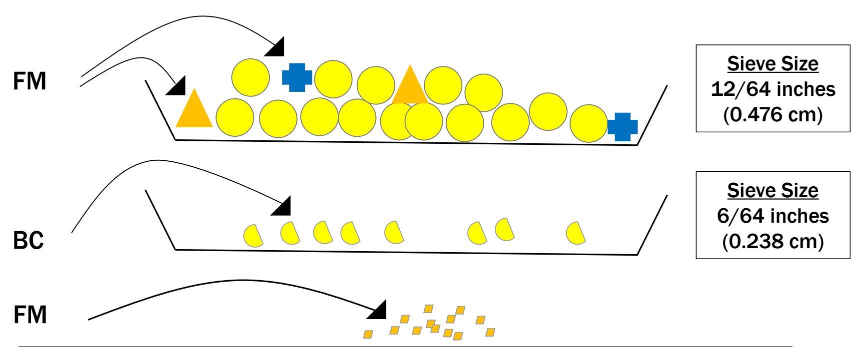
Broken corn (BC) is defined as corn and any other material (such as weed seeds) small enough to pass through a 12/64th-inch round-hole sieve, but too large to pass through a 6/64th-inch round-hole sieve.

Foreign material (FM) is defined as any non-corn material 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 below illustrates the measurement of broken corn and foreign material for the U.S. corn grades.

BROKEN CORN AND FOREIGN MATERIAL

Measured as Percent by Weight



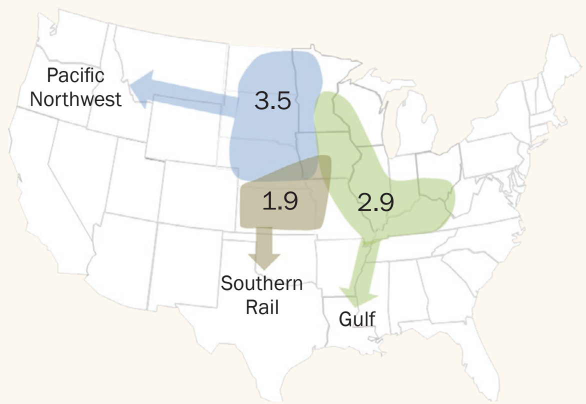
U.S. Grade Broken Corn and Foreign Material Maximum Limits
No. 1: 2.0%
No. 2: 3.0%
No. 3: 4.0%
No. 4: 5.0%
No. 5: 7.0%
Sample: >7%

Results

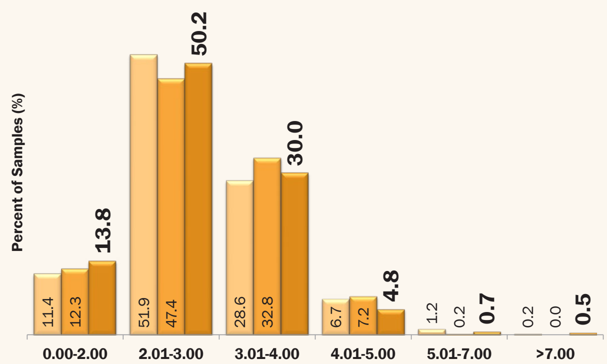
- Average U.S. Aggregate BCFM in export samples (2.9%) was the same as 2017/2018, 2016/2017, but slightly lower than the 5YA and the U.S. No. 2 grade limit (3.0%). Average BCFM at export between years has been within ±0.1 percentage point for the past three years and the 5YA, indicating the ability of exporters to consistently manage cargo to meet importers' specifications.
- The variability of the 2018/2019 export samples (with a standard deviation of 0.67%) was similar to 2017/2018 (0.59%), 2016/2017 (0.68%) and the 5YA (0.66%). The range in values (8.4%) was wider than 2017/2018 (4.9%) and 2016/2017 (6.0%).
- BCFM in the 2018/2019 export samples was distributed with 64.0% of the samples at or below the limit for U.S. No. 2 grade (3.0%), and 94.0% at or below the limit for U.S. No. 3 grade (4.0%).
- Average U.S. Aggregate BCFM at export (2.9%) was 2.2 percentage points higher than at harvest (0.7%). This increase is the same as the 5YA. The harvest 5YA was 0.8% compared to the export 5YA of 3.0%. This increase is likely a result of artificial drying and increased breakage that occurs with additional impacts caused by conveying, dropping and handling as the corn moves through the marketing channel.
- Average BCFM in the Southern Rail ECA (1.9%) was lower than either the Gulf (2.9%) or Pacific Northwest (3.5%) ECAs. Average BCFM for the Southern Rail ECA has also been lowest among the ECAs for the previous three years and the 5YA.
- Average BCFM was 2.7% for contracts loaded as U.S. No. 2 or better compared to the average BCFM of 3.0% for contracts loaded as U.S. No. 3 or better. Corn arriving at the export point is normally commingled from many origins and may be cleaned to meet the limits for the contracted grade.

BROKEN CORN AND FOREIGN MATERIAL (%)

EXPORT CATCHMENT AREA AVERAGE



U.S. AGGREGATE



	Avg	Std Dev
MY16/17	2.9	0.68
MY17/18	2.9	0.59
MY18/19	2.9	0.67

Total Damage

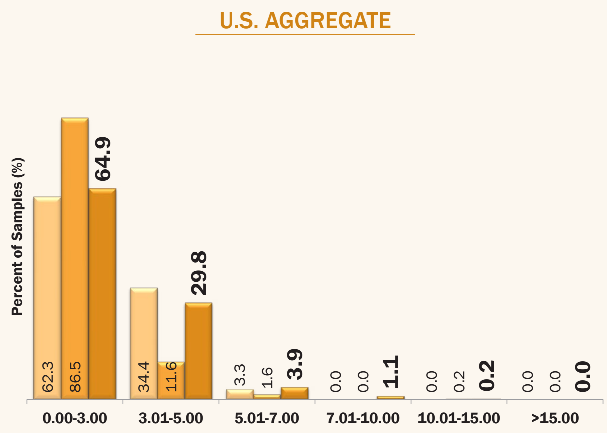
Total damage is the percent of kernels and pieces of kernels that are visually damaged in some way, including damage from heat, frost, insects, sprouting, disease, weather, ground, germ and mold. Most of these types of damage result in some sort of discoloration or change in kernel texture. Damage does 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 high moisture content and warm temperatures during the growing season and/or during storage. There are several field molds, such as Diplodia, Aspergillus, Fusarium and Gibberella, that can lead to mold-damaged kernels during the growing season if the weather conditions are conducive to their development. While some fungi that produce mold damage can also produce mycotoxins, not all fungi produce mycotoxins. Chances of mold decrease as corn is dried and cooled to lower temperatures.

Results

- Average U.S. Aggregate total damage (2.6%) was higher than 2017/2018 (1.9%) and the 5YA (2.1%) but was similar to 2016/2017 (2.7%); it was well below the limit for U.S. No. 1 grade (3.0%).
- Variability in the 2018/2019 samples, as indicated by the standard deviation (1.10%), was similar to 2017/2018 (1.02%), 2016/2017 (1.09%) and the 5YA (1.00%). The 2018/2019 sample range (0.0 to 10.5%) was similar to the 2017/2018 range (0.0 to 10.4%) but wider than the 2016/2017 range (0.1 to 6.8%).
- Of the export samples, 64.9% had 3.0% or less damaged kernels, meeting the requirement for U.S. No. 1 grade. In addition, 94.7% were at or below the limit for U.S. No. 2 grade (5.0%).
- The average level of total damage in the marketing channel at export (2.6%) was higher than at harvest (1.5%). The increase in total damage from the 2018 harvest to the 2018/2019 exports is higher than the changes seen in previous years. The export 5YA (2.1%) was 0.5 percentage points higher than the harvest 5YA (1.6%). Total damage can increase during storage, especially if there are spout lines and pockets of high moisture in the storage bins or transport containers.

TOTAL DAMAGE (%)

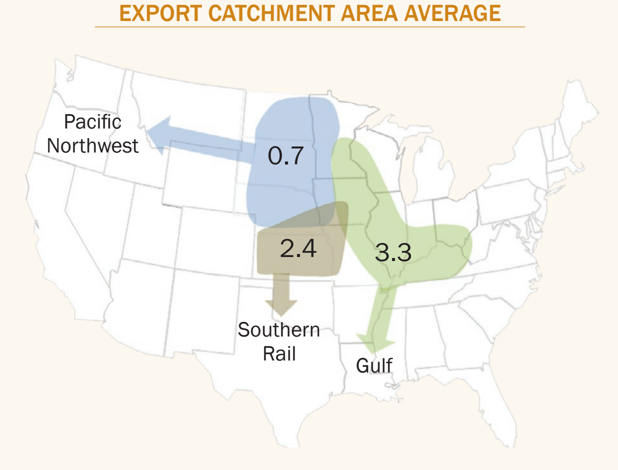


	Avg	Std Dev
MY16/17	2.7	1.09
MY17/18	1.9	1.02
MY18/19	2.6	1.10

- The Pacific Northwest ECA had lower average total damage (0.7%) than the Gulf (3.3%) and the Southern Rail (2.4%) ECAs. The Pacific Northwest ECA also had the lowest average total damage among the ECAs for each of the last three years and the 5YA.
- Average total damage for contracts being loaded as U.S. No. 2 or better (2.5%) and as U.S. No. 3 or better (2.8%) were below the limit for U.S. No. 1 grade (3.0%).

U.S. Grade Total Damage Maximum Limits
No. 1: 3.0%
No. 2: 5.0%
No. 3: 7.0%
No. 4: 10.0%
No. 5: 15.0%
Sample: >15%

TOTAL DAMAGE (%)



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 dried and stored at moisture contents and temperatures that prevent damage in the marketing channel.

Results

- Average U.S. Aggregate heat damage was 0.0%, the same as 2017/2018, 2016/2017 and the 5YA. These averages have been below the limit for U.S. No. 1 grade (0.1%), indicating good management of drying and storage of the corn throughout the marketing channel.
- Only eight samples in the entire 2018/2019 export cargo sample set (total of 436 samples) showed any heat damage (each was 0.1%).

U.S. Grade Heat Damage Maximum Limits
No. 1: 0.1%
No. 2: 0.2%
No. 3: 0.5%
No. 4: 1.0%
No. 5: 3.0%
Sample: >3%

B. MOISTURE

Moisture content is reported on official grade certificates, and maximum moisture content is usually specified in the contract. However, moisture is not a grade factor; therefore, it does not determine which numerical grade will be assigned to the sample. Moisture content is important because it affects the amount of dry matter being sold and purchased. Moisture content is also an indicator of whether a need exists for drying, has potential implications for storability and affects test weight. Higher moisture content at harvest increases the chance of kernel damage during harvesting and drying. Moisture content and the amount of drying required will also affect stress cracks, breakage and germination. Extremely wet grain may be a precursor to high mold damage later in storage or transport. While the weather during the growing season affects yield, grain composition and the development of the grain kernels, grain harvest moisture is influenced largely by crop maturation, the timing of harvest and harvest weather conditions. General moisture guidelines for storing shelled corn suggest that 15.0% is the maximum moisture content for storage up to six months under winter conditions, and 13.0% or lower moisture content is recommended for storage of six months to more than one year for quality, clean corn in aerated storage under typical U.S. Corn Belt conditions.[1]

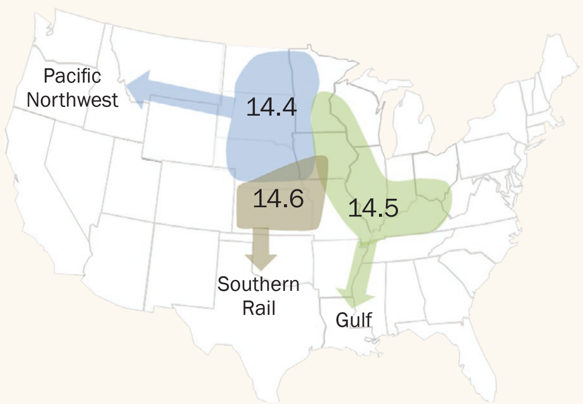
[1] *WWPS-13. 2017. Grain drying, handling and storage handbook. Midwest Plan Service No. 13 third edition. Iowa State University, Ames, IA 50011.*

Results

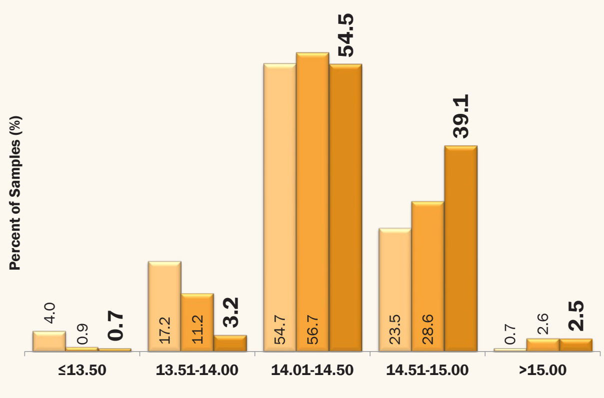
- Average U.S. Aggregate moisture content (14.5%) was slightly higher than 2017/2018 (14.4%), 2016/2017 (14.3%) and the 5YA (14.4%).
- Moisture content standard deviation from the 2018/2019 samples (0.28%) was slightly lower than 2017/2018 (0.29%), 2016/2017 (0.34%) and the 5YA (0.32%).
- The moisture content of the samples ranged from 13.2 to 15.6%, or 2.4 percentage points. This range is similar to 2017/2018 and 2016/2017 (both 2.2 percentage points).
- Average moisture content decreased between harvest (16.0%) and export (14.5%) and uniformity among samples increased, as indicated by the lower standard deviation at export (0.28%) compared with harvest (1.58%). Drying at the local elevator lowers harvest moisture content to levels safe for storage and transport. Uniformity in moisture content increases between harvest and export as the corn from various sources is commingled and conditioned to bring it to the desired moisture content.
- Of the 2018/2019 samples, 41.6% had a moisture content above 14.5%, which was higher than the 31.2% in 2017/2018 and 24.2% in 2016/2017. The increased number of samples above 14.5% moisture in this year's crop indicates that care should be taken in monitoring moisture and checking storage conditions.
- The average moisture content in the Pacific Northwest ECA (14.4%) was lower than the Gulf (14.5%) and Southern Rail (14.6%) ECAs. The Pacific Northwest ECA also reported the lowest average moisture content among the three ECAs for 2017/2018, 2016/2017, and the 5YA.
- Average moisture was slightly lower for contracts loaded as U.S. No. 2 or better (14.4%) than for contracts loaded as U.S. No. 3 or better (14.6%). The moisture standard deviation for contracts loaded as U.S. No. 2 or better (0.28%) was the same as that for contracts loaded as U.S. No. 3 or better.

MOISTURE (%)

EXPORT CATCHMENT AREA AVERAGE



U.S. AGGREGATE



	Avg	Std Dev
MY16/17	14.3	0.34
MY17/18	14.4	0.29
MY18/19	14.5	0.28

SUMMARY: GRADE FACTORS AND MOISTURE

	2018/2019 Export Cargo					2017/2018 Export Cargo			2016/2017 Export Cargo			5 Year Avg. (2013-2017)	
	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						**U.S. Aggregate**			**U.S. Aggregate**			**U.S. Aggregate**	
Test Weight (lb/bu)	436	57.4	0.82	52.0	59.6	430	57.4	0.85	430	57.4	0.61	57.4	0.80
Test Weight (kg/hl)	436	73.9	1.05	66.9	76.7	430	73.9	1.10	430	73.8	0.78	73.9	1.03
BCFM (%)	436	2.9	0.67	0.4	8.8	430	2.9	0.59	430	2.9	0.68	3.0	0.66
Total Damage (%)	436	2.6	1.10	0.0	10.5	430	1.9*	1.02	430	2.7	1.09	2.1	1.00
Heat Damage (%)	436	0.0	0.01	0.0	0.1	430	0.0	0.01	430	0.0*	0.00	0.0	0.01
Moisture (%)	435	14.5	0.28	13.2	15.6	430	14.4*	0.29	430	14.3*	0.34	14.4	0.32
Gulf						**Gulf**			**Gulf**			**Gulf**	
Test Weight (lb/bu)	275	58.0	0.66	55.5	59.4	276	57.8*	0.9	278	57.6*	0.59	57.8	0.77
Test Weight (kg/hl)	275	74.7	0.85	71.4	76.5	276	74.4*	1.2	278	74.1*	0.76	74.3	0.99
BCFM (%)	275	2.9	0.53	1.3	4.9	276	2.9	0.6	278	2.9	0.58	3.0	0.62
Total Damage (%)	275	3.3	1.37	0.8	10.5	276	2.2*	1.2	278	3.0*	1.05	2.4	1.08
Heat Damage (%)	275	0.0	0.02	0.0	0.1	276	0.0	0.0	278	0.0*	0.00	0.0	0.01
Moisture (%)	274	14.5	0.23	13.8	15.2	276	14.5	0.3	278	14.3*	0.39	14.4	0.32
Pacific Northwest						**Pacific Northwest**			**Pacific Northwest**			**Pacific Northwest**	
Test Weight (lb/bu)	96	55.5	1.23	52.0	58.4	87	55.6	0.7	91	56.8*	0.71	55.9	0.95
Test Weight (kg/hl)	96	71.4	1.58	66.9	75.2	87	71.6	0.9	91	73.1*	0.92	72.0	1.22
BCFM (%)	96	3.5	1.17	1.5	8.8	87	3.6	0.7	91	3.4	1.06	3.5	0.84
Total Damage (%)[1]	96	0.7	0.61	0.0	2.8	87	0.6	0.5	91	1.3*	1.21	0.7	0.80
Heat Damage (%)	96	0.0	0.01	0.0	0.1	87	0.0	0.0	91	0.0	0.01	0.0	0.01
Moisture (%)	96	14.4	0.28	13.2	15.1	87	14.2*	0.3	91	14.2*	0.24	14.3	0.26
Southern Rail						**Southern Rail**			**Southern Rail**			**Southern Rail**	
Test Weight (lb/bu)	65	57.5	0.86	55.9	59.6	67	58.2*	0.7	61	57.3	0.52	57.7	0.75
Test Weight (kg/hl)	65	74.0	1.11	72.0	76.7	67	74.9*	0.9	61	73.8	0.67	74.3	0.97
BCFM (%)	65	1.9	0.53	0.4	3.0	67	2.1	0.5	61	2.1	0.60	2.2	0.55
Total Damage (%)	65	2.4	0.75	1.0	4.3	67	2.4	0.8	61	3.3*	1.10	2.4	0.93
Heat Damage (%)	65	0.0	0.00	0.0	0.0	67	0.0	0.0	61	0.0	0.00	0.0	0.00
Moisture (%)	65	14.6	0.45	13.5	15.6	67	14.3*	0.3	61	14.5	0.25	14.6	0.37

**Indicates average was significantly different from current year's Export Cargo, based on a 2-tailed t-test at the 95.0% level of significance.*

SUMMARY: GRADE FACTORS AND MOISTURE

	Export Cargo Samples for Contract Loaded as U.S. No. 2 or Better					Export Cargo Samples for Contract Loaded as U.S. No. 3 or Better					2018 Harvest				
	No. of Samples	Avg.	Std. Dev.	Min.	Max.	No. of Samples	Avg.	Std. Dev.	Min.	Max.	No. of Samples	Avg.	Std. Dev.	Min.	Max.
U.S. Aggregate															
Test Weight (lb/bu)	313	57.5	0.77	54.3	59.6	114	57.4	0.83	52.0	59.4	618	58.4**	1.20	52.3	62.1
Test Weight (kg/hl)	313	74.0	1.00	69.9	76.7	114	73.9	1.07	66.9	76.5	618	75.1**	1.54	67.3	79.9
BCFM (%)	313	2.7	0.47	0.4	4.6	114	3.0*	0.88	1.5	8.8	618	0.7**	0.51	0.0	7.5
Total Damage (%)	313	2.5	0.95	0.2	8.3	114	2.8	1.73	0.0	10.5	618	1.5**	1.25	0.0	19.3
Heat Damage (%)	313	0.0	0.01	0.0	0.1	114	0.0	0.02	0.0	0.1	618	0.0**	0.00	0.0	0.0
Moisture (%)	313	14.4	0.28	13.2	15.6	113	14.6*	0.28	14.0	15.2	618	16.0**	1.58	10.1	25.0
Gulf															
Test Weight (lb/bu)	237	58.0	0.66	55.5	59.3	38	58.1	0.68	56.7	59.4	587	58.6**	1.13	52.3	62.1
Test Weight (kg/hl)	237	74.7	0.85	71.4	76.3	38	74.8	0.87	73.0	76.5	587	75.4**	1.46	67.3	79.9
BCFM (%)	237	2.9	0.48	1.3	4.6	38	2.8	0.77	1.5	4.9	587	0.7**	0.50	0.0	7.5
Total Damage (%)	237	3.3	1.21	0.8	8.3	38	3.5	2.11	1.0	10.5	587	1.8**	1.41	0.0	19.3
Heat Damage (%)	237	0.0	0.01	0.0	0.1	38	0.0	0.02	0.0	0.1	587	0.0**	0.00	0.0	0.0
Moisture (%)	237	14.5	0.21	13.8	15.0	37	14.6*	0.30	14.0	15.2	587	16.1**	1.58	10.1	25.0
Pacific Northwest															
Test Weight (lb/bu)	20	55.9	1.02	54.3	57.7	76	55.4*	1.26	52.0	58.4	288	57.5**	1.37	52.3	62.1
Test Weight (kg/hl)	20	72.0	1.32	69.9	74.3	76	71.3*	1.62	66.9	75.2	288	74.0**	1.77	67.3	79.9
BCFM (%)	20	2.6	0.41	1.8	3.3	76	3.7*	1.18	1.5	8.8	288	0.8**	0.58	0.1	5.4
Total Damage (%)	20	0.6	0.37	0.2	1.5	76	0.8*	0.65	0.0	2.8	288	0.9	0.83	0.0	11.2
Heat Damage (%)	20	0.0	0.00	0.0	0.0	76	0.0	0.01	0.0	0.1	288	0.0	0.00	0.0	0.0
Moisture (%)	20	14.2	0.36	13.2	14.8	76	14.5*	0.23	14.0	15.1	288	16.1**	1.75	10.1	25.0
Southern Rail															
Test Weight (lb/bu)	56	57.5	0.88	55.9	59.6	0	-	-	-	-	355	58.9**	1.19	53.6	61.9
Test Weight (kg/hl)	56	74.0	1.14	72.0	76.7	0	-	-	-	-	355	75.8**	1.53	69.0	79.7
BCFM (%)	56	1.9	0.53	0.4	3.0	0	-	-	-	-	355	0.7**	0.44	0.0	7.5
Total Damage (%)	56	2.4	0.75	1.0	4.3	0	-	-	-	-	355	1.8**	1.23	0.0	15.3
Heat Damage (%)	56	0.0	0.00	0.0	0.0	0	-	-	-	-	355	0.0	0.00	0.0	0.0
Moisture (%)	56	14.6	0.43	13.6	15.6	0	-	-	-	-	355	15.5**	1.35	10.1	22.0

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

***Indicates current year's Export Cargo average was significantly different from this year's Harvest, based on a 2-tailed t-test at the 95% level of confidence.*

C. CHEMICAL COMPOSITION

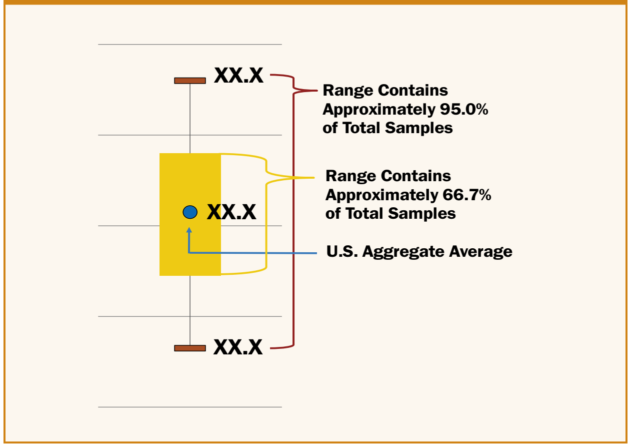
The chemical composition of corn consists primarily of protein, starch and oil. While these attributes are not grade factors, they are of significant interest to end-users. Chemical composition values provide additional information related to nutritional value for livestock and poultry feeding, for wet milling uses and 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

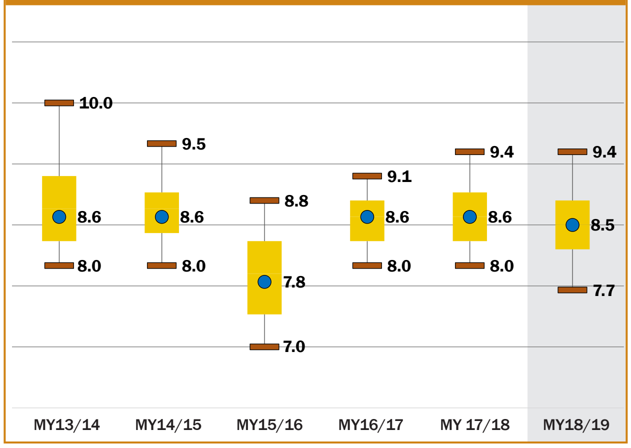
- Average U.S. Aggregate protein concentration at export (8.5%) was lower than 2017/2018 and 2016/2017, but the same as the 5YA and the 2018 harvest average.
- Average U.S. Aggregate starch concentration (72.3%) was slightly higher than 2017/2018, but was lower than 2016/2017, the 5YA and the 2018 harvest average.
- Average U.S. Aggregate oil concentration (4.0%) was lower than 2017/2018, the same as 2016/2017 and higher than the 5YA.
- The standard deviations for protein, starch and oil concentrations were lower and ranges were narrower for the export samples than for the harvest samples.
- Average protein, starch and oil concentrations were the same for contracts loaded as U.S. No. 2 or better and U.S. No. 3 or better.

CHEMICAL COMPOSITION
AGGREGATE SIX-YEAR COMPARISON

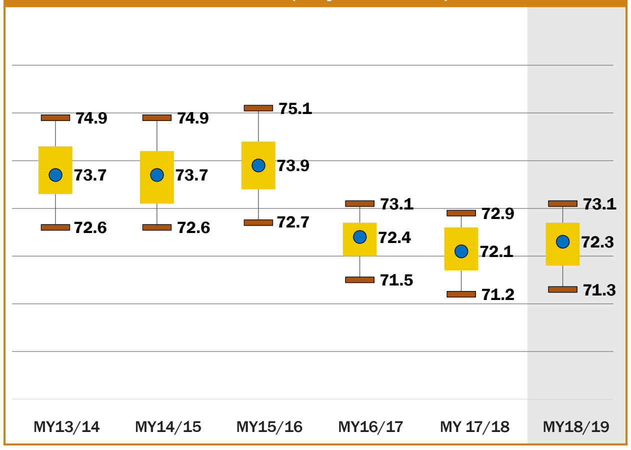
HOW TO READ THE CHARTS



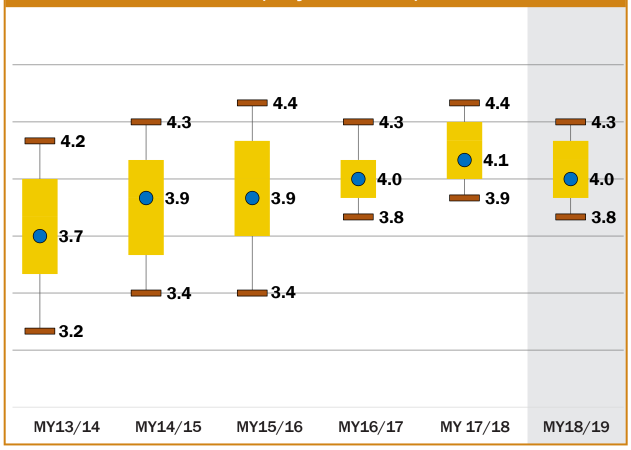
PROTEIN (Dry Basis %)



STARCH (Dry Basis %)



OIL (Dry Basis %)



Protein

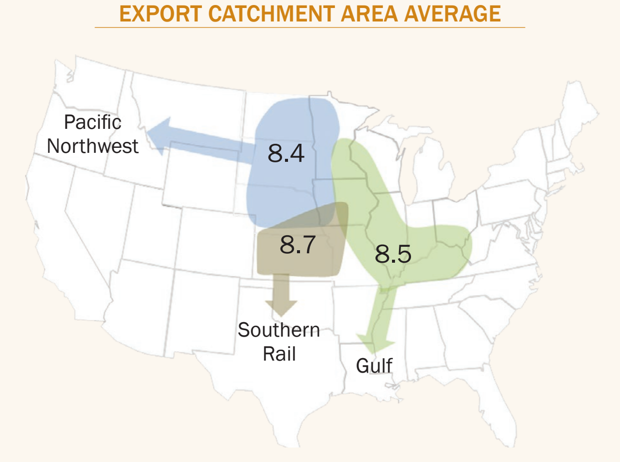
Protein is very important for poultry and livestock feeding because it supplies essential sulfur-containing amino acids and helps to improve feed conversion efficiency. Protein concentration tends to decrease with decreased available soil nitrogen and in years with high yields. On a single sample basis, protein is usually inversely related to starch concentration. Results are reported on a dry basis.

Results

- Average U.S. Aggregate protein concentration (8.5%) was lower than 2017/2018 and 2016/2017 (both 8.6%) but same as the 5YA and the average U.S. Aggregate protein concentration for the 2018 harvest.

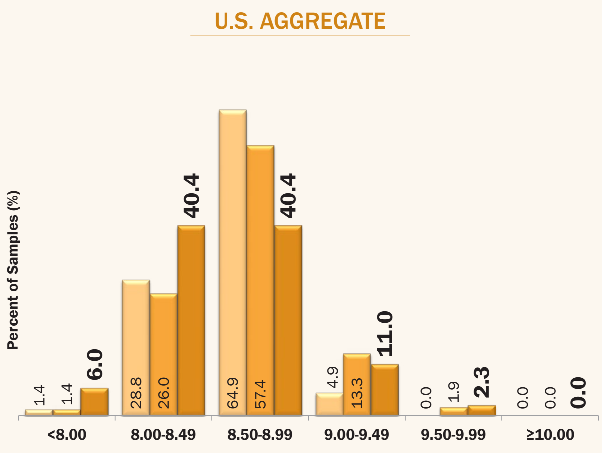
- The 2018/2019 export samples (standard deviation of 0.37%) were more uniform than the 2018 harvest samples (standard deviation of 0.53%). In addition, the range of protein concentrations at export (7.1 to 9.8%) was narrower than at harvest (6.6 to 11.9%). The uniformity is due, in part, to grains becoming more homogenous as they are aggregated from numerous harvest-level sources.

PROTEIN (Dry Basis %)



- The 2018/2019 export samples were distributed with 53.7% of protein concentrations at or above 8.5%, compared with 72.6% of the 2017/2018 samples and 69.8% of the 2016/2017 samples.
- The Gulf ECA (8.5%) had a lower average protein concentration than the Southern Rail ECA (8.7%) but similar to the Pacific Northwest ECA (8.4%).
- Average protein concentration for contracts loaded as U.S. No. 2 or better (8.5%) was the same as that for contracts loaded as U.S. No. 3 or better.

PROTEIN (Dry Basis %)



	Avg	Std Dev
MY16/17	8.6	0.26
MY17/18	8.6	0.29
MY18/19	8.5	0.37

Starch

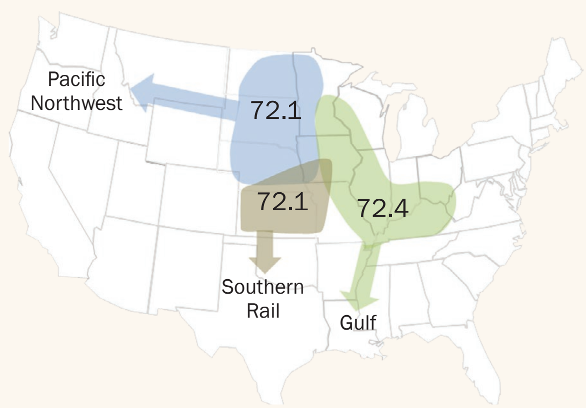
Starch is an important factor for corn used by wet millers and dry-grind ethanol manufacturers. High starch concentration is often indicative of good kernel growing/filling conditions and reasonably moderate kernel densities. Starch is usually inversely related to protein concentration on a single sample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

Results

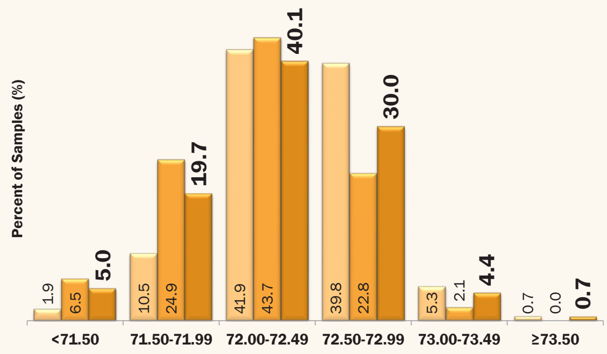
- Average U.S. Aggregate starch concentration (72.3%) was slightly higher than 2017/2018 (72.1%) and lower than 2016/2017 (72.4%), the 5YA (73.2%) and the average U.S. Aggregate concentration for the 2018 harvest (72.5%).
- The standard deviation for starch concentration of the 2018/2019 export samples (0.43%) was lower than the standard deviation of the 2018 harvest samples (0.62%).
- Starch concentrations were distributed with 75.2% at or above 72.0%, compared with 68.6% in 2017/2018 and 87.7% in 2016/2017.
- The Gulf ECA had the highest average starch concentration (72.4%), in comparison to the Pacific Northwest and Southern Rail (both 72.1%) ECAs. Average starch concentrations were also the highest for the Gulf ECA in 2017/2018, 2016/2017 and the 5YA.
- Average starch concentration for contracts loaded as U.S. No. 2 or better (72.3%) was the same as that for contracts loaded as U.S. No. 3 or better.

STARCH (Dry Basis %)

EXPORT CATCHMENT AREA AVERAGE



U.S. AGGREGATE



	Avg	Std Dev
MY16/17	72.4	0.35
MY17/18	72.1	0.39
MY18/19	72.3	0.43

Oil

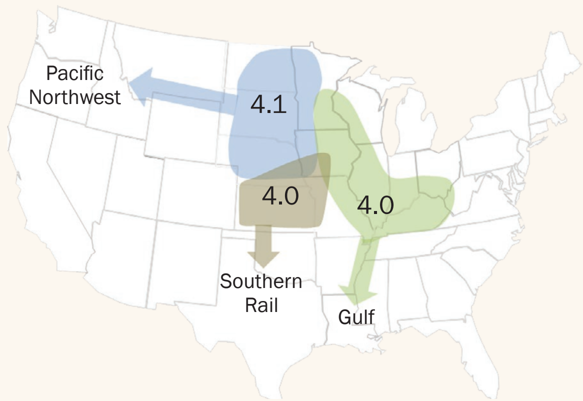
Oil is an essential component of poultry and livestock rations. It serves as an energy source, enables fat-soluble vitamins to be utilized and provides certain essential fatty acids. Oil is also an important co-product of corn wet and dry milling. Results are reported on a dry basis.

Results

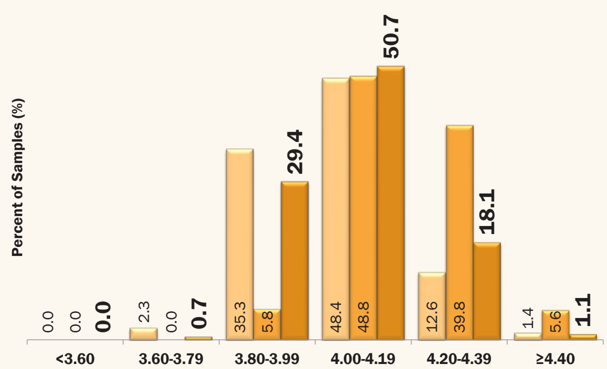
- Average U.S. Aggregate oil concentration (4.0%) was lower than 2017/2018 (4.1%), the same as 2016/2017 (4.0%) and higher than the 5YA (3.9%).
- The average oil concentration for the 2018/2019 export samples was the same as the 2018 harvest samples, while the standard deviation at export (0.14%) was lower than at harvest (0.22%).
- The 2018/2019 samples showed a lower percentage of samples above 4.0% oil than the previous year. A total of 69.9% of the 2018/2019 samples contained at least 4.0% oil, in contrast to 94.2% in 2017/2018 and 62.4% in 2016/2017.
- Average oil concentration for the Gulf ECA (4.0%) was slightly lower than the Pacific Northwest ECA (4.1%) but same as the Southern Rail ECA.
- Average U.S. Aggregate and Gulf ECA oil concentrations for contracts loaded as U.S. No. 2 or better (4.0%) were the same as for contracts loaded as U.S. No. 3 or better.

OIL (Dry Basis %)

EXPORT CATCHMENT AREA AVERAGE



U.S. AGGREGATE



	Avg	Std Dev
MY16/17	4.0	0.13
MY17/18	4.1	0.12
MY18/19	4.0	0.14

SUMMARY: CHEMICAL COMPOSITION

	2018/2019 Export Cargo					2017/2018 Export Cargo			2016/2017 Export Cargo			5 Year Avg. (2013-2017)	
	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 %)	436	8.5	0.37	7.1	9.8	430	8.6*	0.29	430	8.6*	0.26	8.5	0.29
Starch (Dry Basis %)	436	72.3	0.43	70.4	73.9	430	72.1*	0.39	430	72.4*	0.35	73.2	0.47
Oil (Dry Basis %)	436	4.0	0.14	3.7	4.5	430	4.1*	0.12	430	4.0*	0.13	3.9	0.18
Gulf													
Protein (Dry Basis %)	275	8.5	0.26	7.4	9.2	276	8.5	0.27	278	8.5	0.24	8.4	0.26
Starch (Dry Basis %)	275	72.4	0.34	71.3	73.1	276	72.3*	0.37	278	72.5*	0.31	73.3	0.46
Oil (Dry Basis %)	275	4.0	0.13	3.7	4.5	276	4.2*	0.13	278	4.0*	0.12	4.0	0.18
Pacific Northwest													
Protein (Dry Basis %)	96	8.4	0.55	7.1	9.8	87	8.9*	0.37	91	8.6*	0.27	8.8	0.37
Starch (Dry Basis %)	96	72.1	0.64	70.4	73.9	87	71.7*	0.46	91	72.2	0.42	72.9	0.49
Oil (Dry Basis %)	96	4.1	0.14	3.7	4.5	87	4.1*	0.11	91	4.1*	0.14	3.8	0.20
Southern Rail													
Protein (Dry Basis %)	65	8.7	0.53	7.6	9.8	67	8.7	0.30	61	8.6	0.31	8.4	0.32
Starch (Dry Basis %)	65	72.1	0.51	71.1	73.3	67	72.1	0.37	61	72.2	0.43	73.1	0.49
Oil (Dry Basis %)	65	4.0	0.14	3.7	4.3	67	4.1*	0.11	61	4.0	0.12	4.0	0.17

**Indicates average was significantly different from current year's Export Cargo, based on a 2-tailed t-test at the 95.0% level of significance.*

SUMMARY: CHEMICAL COMPOSITION

	Export Cargo Samples for Contract Loaded as U.S. No. 2 or Better					Export Cargo Samples forContract Loaded as U.S. No. 3 or Better					2018 Harvest				
	No. of Samples	Avg.	Std. Dev.	Min.	Max.	No. of Samples	Avg.	Std. Dev.	Min.	Max.	No. of Samples	Avg.	Std. Dev.	Min.	Max.
U.S. Aggregate															
Protein (Dry Basis %)	313	8.5	0.38	7.1	9.8	114	8.5	0.30	7.6	9.8	618	8.5	0.53	6.6	11.9
Starch (Dry Basis %)	313	72.3	0.44	71.1	73.9	114	72.3	0.46	70.4	73.5	618	72.5**	0.62	68.9	74.6
Oil (Dry Basis %)	313	4.0	0.14	3.7	4.5	114	4.0	0.15	3.7	4.5	618	4.0	0.22	3.3	5.2
Gulf															
Protein (Dry Basis %)	237	8.5	0.27	7.4	9.2	38	8.4	0.22	8.1	9.1	587	8.3**	0.50	6.6	11.9
Starch (Dry Basis %)	237	72.4	0.33	71.3	73.1	38	72.4	0.40	71.4	73.1	587	72.7**	0.61	68.9	74.6
Oil (Dry Basis %)	237	4.0	0.13	3.7	4.5	38	4.0	0.15	3.8	4.3	587	4.0	0.23	3.3	5.2
Pacific Northwest															
Protein (Dry Basis %)	20	8.2	0.58	7.1	9.2	76	8.5	0.53	7.6	9.8	288	8.6**	0.60	6.6	11.9
Starch (Dry Basis %)	20	72.5	0.68	71.5	73.9	76	72.0*	0.60	70.4	73.5	288	72.4**	0.64	69.0	74.4
Oil (Dry Basis %)	20	4.0	0.15	3.8	4.4	76	4.1	0.14	3.7	4.5	288	4.0**	0.21	3.3	4.7
Southern Rail															
Protein (Dry Basis %)	56	8.7	0.54	7.6	9.8	0	-	-	-	-	355	8.8	0.55	6.7	11.9
Starch (Dry Basis %)	56	72.1	0.51	71.1	73.3	0	-	-	-	-	355	72.3**	0.63	70.2	74.6
Oil (Dry Basis %)	56	4.0	0.14	3.7	4.3	0	-	-	-	-	355	4.0	0.21	3.3	4.7

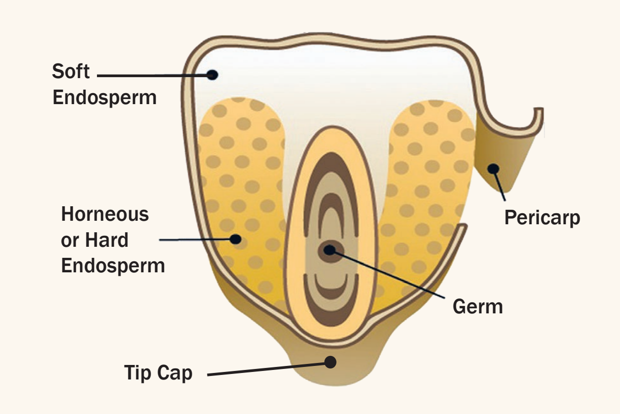
**Indicates the averages for samples with Grade 3 or better were significantly different from the averages for the samples with Grade 2 or better, based on a 2-tailed t-test at the 95% level of significance.*

***Indicates current year's Export Cargo average was significantly different from this year's Harvest, based on a 2-tailed t-test at the 95% level of confidence.*

D. PHYSICAL FACTORS

Physical factors are other quality attributes that are neither grade factors nor chemical composition. Physical factors include stress cracks, kernel weight, kernel volume, true 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 and 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 protein, and the pericarp and tip cap are mostly fiber.

CORN KERNEL



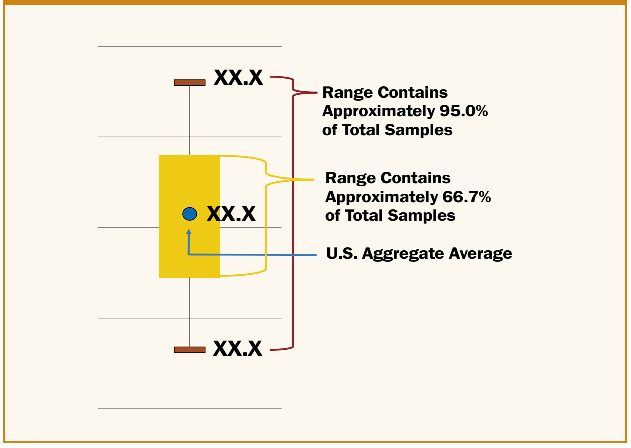
Source: Adapted from Corn Refiners Association, 2011

SUMMARY: PHYSICAL FACTORS

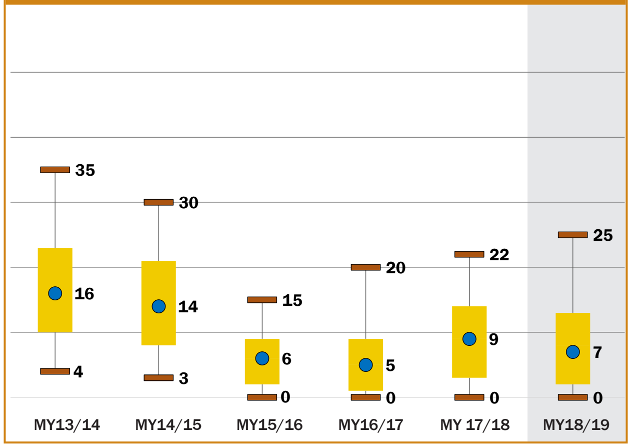
- Average U.S. Aggregate stress cracks (7%) in 2018/2019 was lower than 2017/2018 and the 5YA, but higher than 2016/2017.
- Of the 2018/2019 export samples, 11.5% had 15% or higher stress cracks, compared with 16.0% in 2017/2018 and 5.6% in 2016/2017.
- Average U.S. Aggregate stress crack index (16.2) was lower than 2017/2018 (22.4) and the 5YA (25.1), but higher than 2016/2017 (11.6).
- In 2018/2019, 29.8% of the samples had a stress crack index of 20 or higher, compared with 48.7% in 2017/2018 and 19.7% in 2016/2017. This indicates that the percentage of samples with double or multiple stress cracks was lower than in 2017/2018, but higher than in 2016/2017.
- Average U.S. Aggregate 100-kernel weight (36.17 g) was slightly higher than 2017/2018 but much higher than 2016/2017.
- Average 100-kernel weight for the Pacific Northwest ECA (32.21 g) was lower than the Gulf ECA (37.49 g) and the Southern Rail ECA (36.52 g).
- Average U.S. Aggregate kernel volume (0.28 cm^3) was the same as 2017/2018 and the 5YA, but higher than 2016/2017. Average kernel volume at export was the same as that for 2018 harvest.
- Average kernel volume for the Pacific Northwest ECA (0.25 cm^3) was lower than for the Gulf (0.29 cm^3) and Southern Rail ECAs (0.28 cm^3) in 2018/2019. The Pacific Northwest ECA had either the lowest or tied for the lowest average kernel volume for the previous three years and the 5YA, indicating Pacific Northwest usually has had smaller kernels than the Gulf and Southern Rail ECAs.
- Average U.S. Aggregate kernel true density (1.288 g/cm^3) was slightly higher than 2017/2018, 2016/2017 and the 5YA. For the 2018/2019 export samples, 85.3% had kernel true densities equal to or above 1.275 g/cm^3, compared with 83.0% in 2017/2018 and 80.7% in 2016/2017.
- The average percent of whole kernels at export (85.2%) was higher than 2017/2018, but lower than 2016/2017 and the 5YA.
- The percentage of 2018/2019 export samples with whole kernels greater than or equal to 90.0% was 15.8%, compared to 14.7% in 2017/2018 and 39.3% in 2016/2017, indicating a much lower percentage of whole kernels in the last two years than in 2016/2017.
- Average U.S. Aggregate horneous endosperm (82%) was higher than 2017/2018, 2016/2017 and the 5YA. Of the 2018/2019 export samples, 81.7% had at least 80% horneous endosperm, in contrast to 72.0% in 2017/2018 and 25.3% in 2016/2017. Thus, in the last two years, a higher percentage of the samples contained high amounts of horneous endosperm than in 2016/2017.

PHYSICAL FACTORS
AGGREGATE SIX-YEAR COMPARISON

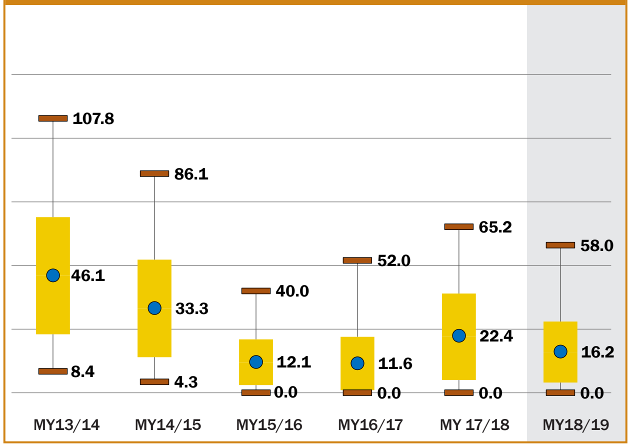
HOW TO READ THE CHARTS



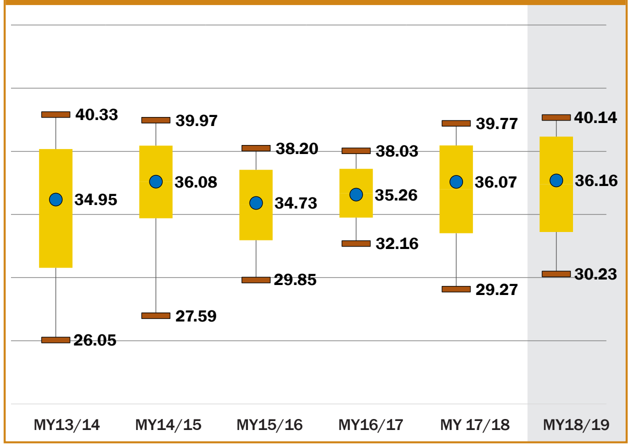
STRESS CRACKS (%)



STRESS CRACK INDEX



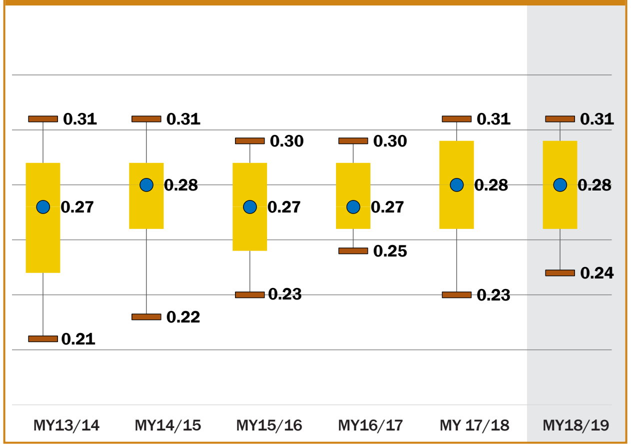
100-KERNEL WEIGHT (g)



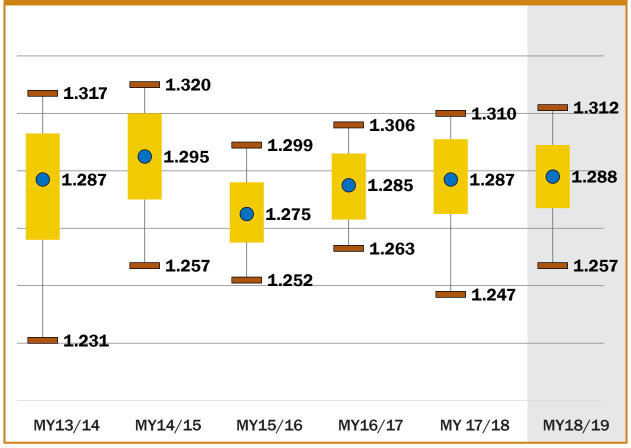
U.S. GRAINS COUNCIL

PHYSICAL FACTORS
AGGREGATE SIX-YEAR COMPARISON

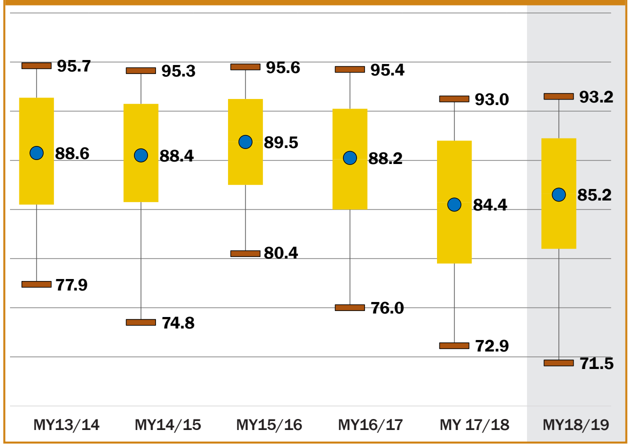
KERNEL VOLUME (cm^3)



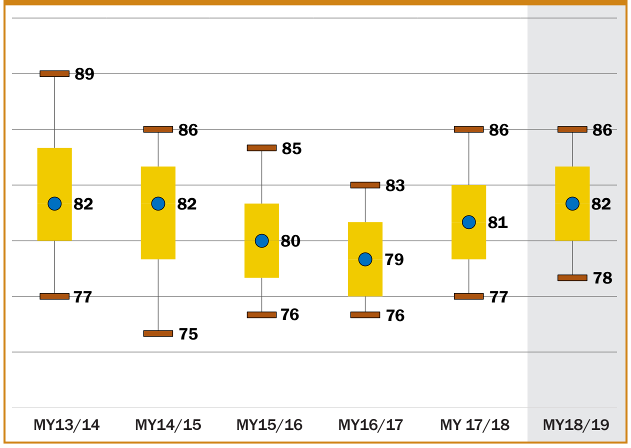
TRUE DENSITY (g/cm^3)



WHOLE KERNELS (%)



HORNEOUS ENDOSPERM (%)



Stress Cracks

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.

Stress crack measurements include "stress cracks" (the percentage of kernels with at least one crack) and stress crack index, which is the weighted average of single, double and multiple stress cracks. Both measurements use the same sample of 100 intact kernels with no external damage. "Stress cracks" measures only the number of kernels with stress cracks; whereas, the stress crack index shows the severity of cracking. For example, if half of the kernels have only a single stress crack, "stress cracks" is 50% and the stress crack index is 50 (50 × 1). However, if half of the kernels have multiple stress cracks (more than two cracks), indicating a higher potential for handling breakage, "stress cracks" remains at 50%, but the stress crack index becomes 250 (50 × 5). Lower values for "stress cracks" and the stress crack index are always more desirable. In years with high levels of stress cracks, the stress crack index provides valuable information, because high stress crack index numbers (perhaps 300 to 500) indicate the sample had a very high percentage of multiple stress cracks. Multiple stress cracks are generally more detrimental to quality changes than single stress cracks.

The cause of stress cracks is pressure buildup due to moisture and temperature gradients 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 hard, horneous endosperm; therefore, corn with a higher percentage 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 most common cause of stress cracks is high-temperature drying that rapidly removes moisture. The impact of high levels of stress cracks on various uses includes:

- General: Increased susceptibility to breakage during handling. This may lead to processors needing to remove more broken corn during cleaning operations and a possible reduction in grade and/or value.
- Wet Milling: Lower starch yields due to the increased difficulty in separating starch and protein. Stress cracks may also alter steeping requirements.
- Dry Milling: The 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.

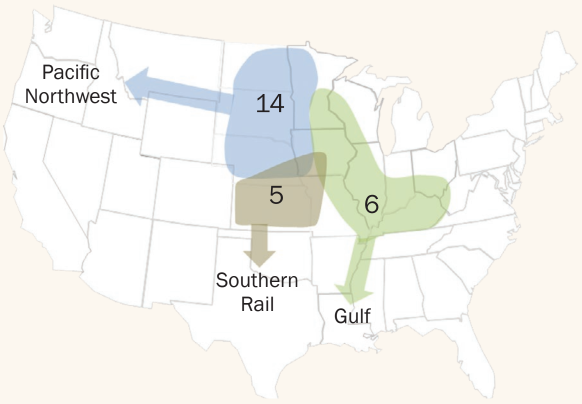
Growing conditions will affect crop maturity, timeliness of harvest and the need for artificial drying, which will influence the degree of stress cracking found from region to region. For example, late maturity or late harvest caused by weather-related factors, such as rain-delayed planting or cool temperatures, may increase the need for artificial drying, thus potentially increasing the occurrence of stress cracks.

Results: Stress Cracks

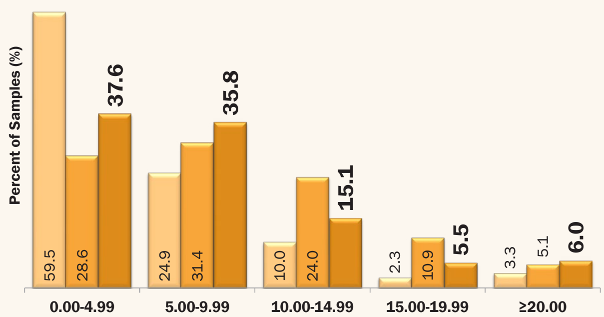
- Average U.S. Aggregate stress cracks (7%) was lower than 2017/2018 (9%) and the 5YA (10%), but higher than 2016/2017 (5%). The lower harvest moisture in 2018 (16.0%) versus 2017 (16.6%) may have, in part, contributed to lower stress cracks found this year.
- Average U.S. Aggregate stress cracks (7%) was slightly higher than the 2018 harvest samples (5%). Average U.S. Aggregate stress cracks has increased from 1 to 4 percentage points between harvest and export for each of the last four years and for the 5YA.
- Stress cracks in the export samples (with a range of 0 to 36% and a standard deviation of 5%) were more uniform than in the 2018 harvest samples (with a range of 0 to 88% and a standard deviation of 6%).
- Of the 2018/2019 export samples, 11.5% had 15% or higher stress cracks, compared with 16.0% in 2017/2018 and 5.6% in 2016/2017.
- Stress cracks averages were 6%, 14% and 5% for the Gulf, Pacific Northwest and Southern Rail ECAs, respectively. The standard deviation of stress cracks was 4% for the Gulf ECA, 8% for the Pacific Northwest ECA and 4% for the Southern Rail ECA.
- Stress crack percentages for contracts loaded as U.S. No. 2 or better (8%) was the same as that for contracts loaded as U.S. No. 3 or better.

STRESS CRACKS (%)

EXPORT CATCHMENT AREA AVERAGE



U.S. AGGREGATE



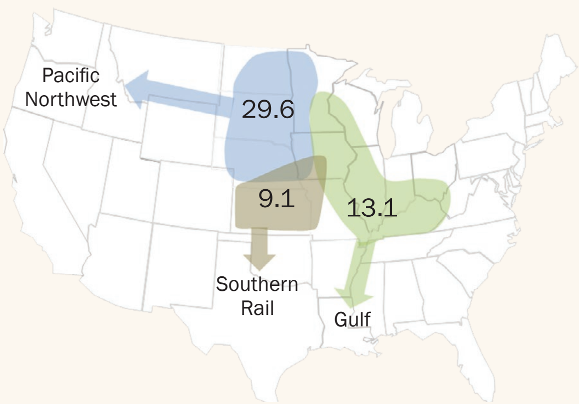
	Avg	Std Dev
MY16/17	5	4
MY17/18	9	5
MY18/19	7	5

Results: Stress Crack Index

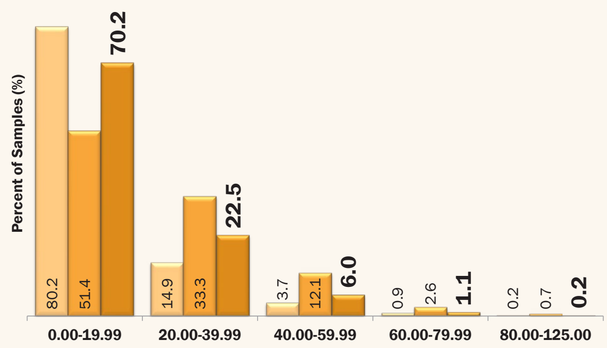
- Average U.S. Aggregate stress crack index (16.2) was lower than 2017/2018 (22.4) and the 5YA (25.1), but higher than 2016/2017 (11.6).
- Stress crack index in the export samples (with a range of 0 to 94 and a standard deviation of 11.8) had less variability than 2017/2018 (with a range of 0 to 120 and a standard deviation of 15.6). The 2018/2019 samples had a standard deviation that was slightly higher than that of the 2016/2017 samples (10.9).
- Average U.S. Aggregate stress crack index at export (16.2) was higher than the average U.S. Aggregate stress crack index found at harvest (11.5).
- Average stress crack index was lowest for the Southern Rail ECA (9.1) and highest for the Pacific Northwest ECA (29.6). Average stress crack index for the Gulf ECA was 13.1.
- Stress crack index standard deviations across ECAs were 9.5, 19.0 and 10.5 for the Gulf, Pacific Northwest and Southern Rail ECAs, respectively.
- In 2018/2019, 29.8% of the samples had a stress crack index of 20 or higher, compared with 48.7% in 2017/2018, and 19.7% in 2016/2017. This indicates that the percentage of samples with double or multiple stress cracks was lower than in 2017/2018, but higher than in 2016/2017.
- Stress crack index for contracts loaded as U.S. No. 2 or better (17.7) was higher than contracts loaded as U.S. No. 3 or better (17.1).

STRESS CRACK INDEX

EXPORT CATCHMENT AREA AVERAGE



U.S. AGGREGATE



	Avg	Std Dev
MY16/17	11.6	10.9
MY17/18	22.4	15.6
MY18/19	16.2	11.8

100-Kernel Weight

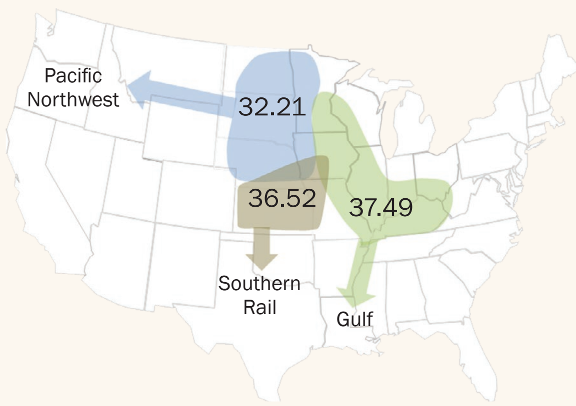
Increasing 100-kernel weight (reported in grams) indicates larger kernel size. Kernel size affects drying rates. As kernel size increases, the volume-to-surface area ratio becomes higher, and as the ratio gets higher, drying becomes slower. In addition, large, uniform-sized kernels often enable higher flaking grit yields in dry milling.

Results

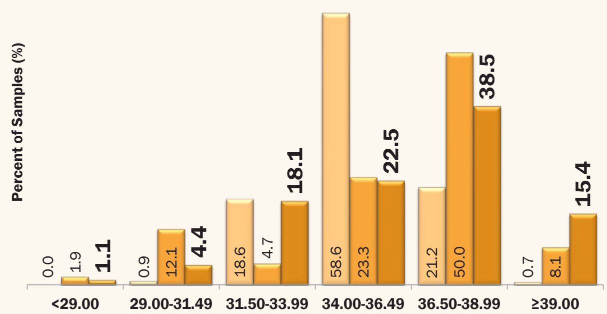
- Average U.S. Aggregate 100-kernel weight (36.17 g) was higher than 2017/2018 (36.07 g), 2016/2017 (35.26 g) and the 5YA (35.42 g).
- Average 100-kernel weight for export (36.17 g) was higher than at harvest (35.07 g). From 2011/2012 through 2017/2018, average 100-kernel weights ranged from 0.00 to 2.05 g higher at export than at harvest. Since 100-kernel weight is based on 100 fully intact kernels, any breakage or reduction in whole kernels occurring in transit may have self-selected out small kernels with low 100-kernel weights that might have been more prone to breakage.
- The export samples had a lower standard deviation (1.84 g) than the 2018 harvest samples (2.84 g). The 100-kernel weight standard deviation was also lower at export than at harvest for 2017/2018, 2016/2017 and the 5YA, indicating greater uniformity at export than at harvest.
- The average 100-kernel weight for the Gulf ECA (37.49 g) was higher than the Pacific Northwest (32.21 g) and the Southern Rail (36.52 g) ECAs.
- In 2018/2019, 53.9% of the samples had a 100-kernel weight of 36.5 g or higher, compared with 58.1% in 2017/2018 and 21.9% in 2016/2017. Thus, 2018/2019 and 2017/2018 had a higher percentage of large kernels than in 2016/2017.
- 100-kernel weight for contracts loaded as U.S. No. 2 or better (36.03 g) was lower than for contracts loaded as U.S. No. 3 or better (36.82 g).

100-KERNEL WEIGHT (g)

EXPORT CATCHMENT AREA AVERAGE



U.S. AGGREGATE



	Avg	Std Dev
MY16/17	35.26	1.45
MY17/18	36.07	1.43
MY18/19	36.17	1.84

Kernel Volume

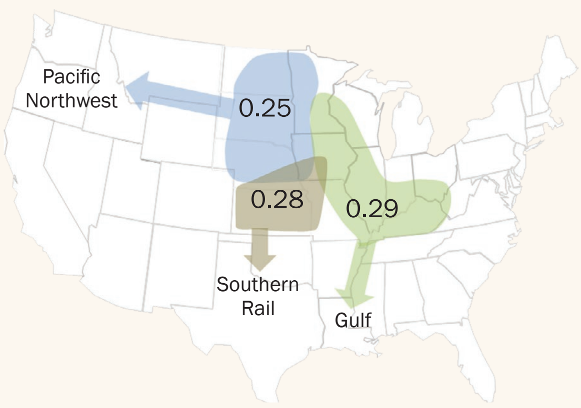
Kernel volume, measured in cubic centimeters (cm³), is often indicative of growing conditions. If conditions are dry, kernels may be smaller than average. If drought hits later in the season, kernels may have lower fill. Small or round kernels are more difficult to degerm. Additionally, small kernels may lead to increased cleanout losses for processors and higher yields of fiber.

Results

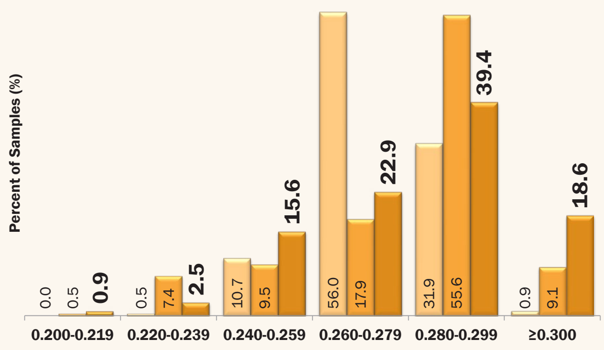
- Average U.S. Aggregate kernel volume (0.28 cm³) was higher than 2016/2017 (0.27 cm³), but same as 2017/2018 and the 5YA.
- Kernel volume range (0.20 to 0.32 cm³) was similar to 2017/2018 (0.22 to 0.32 cm³) and 2016/2017 (0.24 to 0.31 cm³).
- The kernel volume standard deviation (0.01 cm³) was the same as 2017/2018, 2016/2017 and the 5YA.
- Average U.S. Aggregate kernel volume at export (0.28 cm³) was the same as the 2018 harvest.
- Average kernel volume was smaller for the Pacific Northwest ECA (0.25 cm³) than for the Gulf (0.29 cm³) and Southern Rail ECAs (0.28 cm³) in 2018/2019. The Pacific Northwest ECA also had the lowest or tied for the lowest average kernel volume for 2017/2018, 2016/2017 and the 5YA.
- Of the 2018/2019 export samples, 58.0% had kernel volumes equal to or greater than 0.28 cm³, compared with 64.7% in 2017/2018 and 32.8% in 2016/2017.

KERNEL VOLUME (cm³)

EXPORT CATCHMENT AREA AVERAGE



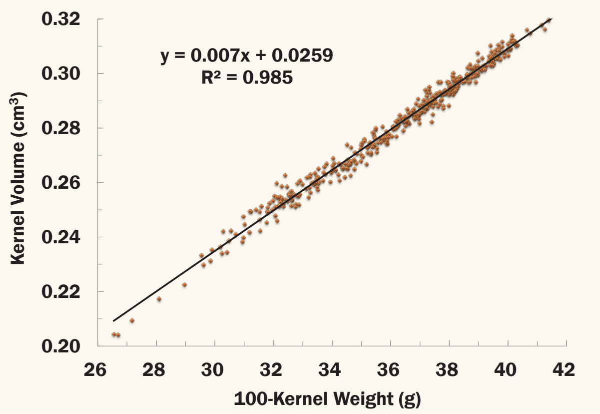
U.S. AGGREGATE



	Avg	Std Dev
MY16/17	0.27	0.01
MY17/18	0.28	0.01
MY18/19	0.28	0.01

- There is a positive relationship between kernel volume and 100-kernel weight in the 2018/2019 export samples, as shown in the adjacent figure (the correlation coefficient is 0.99). This indicates that the higher the weight of 100 kernels of corn, the greater the kernel volume.
- Average kernel volume for contracts loaded as U.S. No. 2 or better (0.28 cm^3) was lower than for contracts loaded as U.S. No. 3 or better (0.29 cm^3).

KERNEL VOLUME vs 100-KERNAL WEIGHT



Kernel True Density

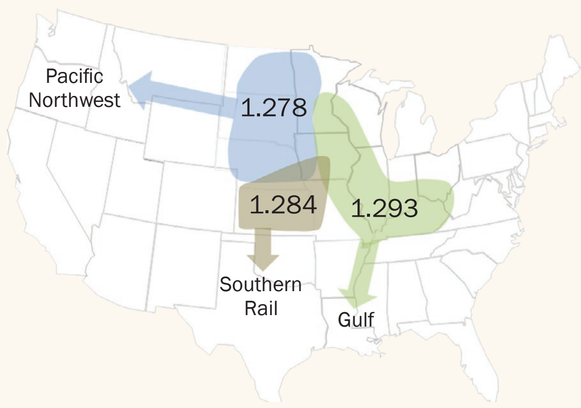
Kernel true density is calculated as the weight of a 100-kernel sample divided by the volume, or displacement, of those 100 kernels and is reported as grams per cubic centimeter (g/cm³). True density is a relative indicator of kernel hardness, which is useful for alkaline processors and dry millers. 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 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 (1.288 g/cm³) was slightly higher than 2017/2018 (1.287 g/cm³), 2016/2017 (1.285 g/m³) and the 5YA (1.286 g/cm³).
- Average kernel true density for the 2018/2019 export samples was higher than for the 2018 harvest samples (1.265 g/cm³). The export 5YA true density (1.286 g/cm³) was also higher than the harvest 5YA true density (1.258 g/cm³). Average true densities have been 0.021 to 0.036 g/cm³ higher at export than at harvest over the past eight years.
- The 2018/2019 export samples had a range of 1.235 to 1.325 g/cm³ (with a standard deviation of 0.011 g/cm³), while the 2018 harvest samples had a wider range (1.167 to 1.374 g/cm³) and a larger standard deviation (0.018 g/cm³).

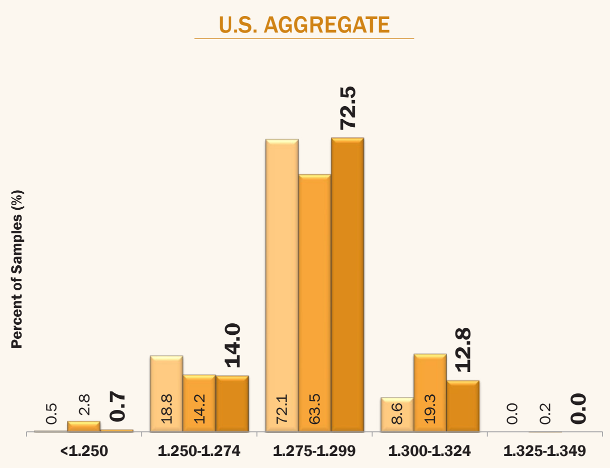
KERNEL TRUE DENSITY (g/cm³)

EXPORT CATCHMENT AREA AVERAGE



- For the 2018/2019 export samples, 85.3% had kernel true densities equal to or above 1.275 g/cm^3, compared with 83.0% in 2017/2018 and 80.7% in 2016/2017. This indicates that the distribution of true densities found in the 2018/2019 samples was similar to the distributions from the past three years. Interestingly, average bulk density or test weight also remained constant at 57.4 lb/bu over the past three years and the 5YA.
- Average kernel true densities for the Gulf, Pacific Northwest and Southern Rail ECAs were 1.293 g/cm^3, 1.278 g/cm^3 and 1.284 g/cm^3, respectively. No consistent pattern in true densities among ECAs has been observed across the years.
- Average kernel true density for contracts loaded as U.S. No. 2 or better (1.287 g/cm^3) was the same as for contracts loaded as U.S. No. 3 or better.

KERNEL TRUE DENSITY (g/cm^3)



	Avg	Std Dev
MY16/17	1.285	0.011
MY17/18	1.287	0.012
MY18/19	1.288	0.011

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 the size of the material. 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 intact or whole kernels. Too much water uptake during cooking can result in loss of soluble, non-uniform cooking, expensive shutdown time and/or products that do not meet specifications. Some companies pay contracted premiums for corn delivered above a specified level of whole kernels.

Second, intact whole kernels are less susceptible to storage molds and breakage in handling. While hard endosperm lends itself to the preservation of more whole kernels than soft corn, the primary factor in delivering whole kernels is harvesting and handling. This begins with proper combine adjustment, followed by minimizing the severity of kernel impacts due to conveyors and the number of handlings required from the farm field to the end-user. Each subsequent handling will generate additional breakage. Actual amounts of breakage increase exponentially as moisture decreases, drop heights increase and/or a kernel's velocity at impact increases.[2] In addition, harvesting at higher moisture contents (e.g., greater than 25%) will usually lead to soft pericarps and more pericarp damage to corn than when harvesting at lower moisture levels.

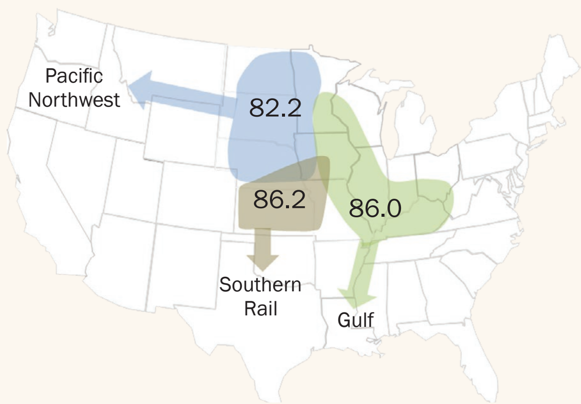
[2]*Foster, G.H. and L.E. Holman. 1973. Grain Breakage Caused by Commercial Handling Methods. USDA. ARS Marketing Research Report Number 968.*

Results

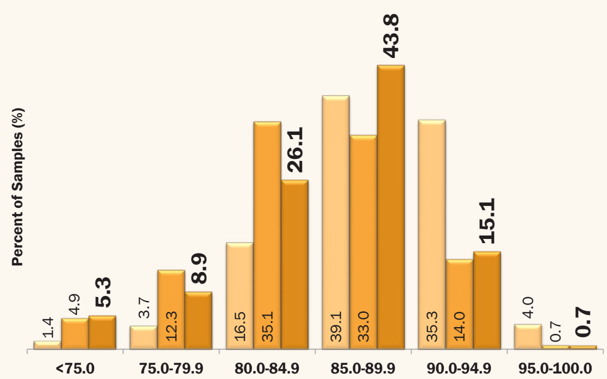
- Average U.S. Aggregate whole kernels (85.2%) was higher than 2017/2018 (84.4%), but lower than 2016/2017 (88.2%) and the 5YA (87.8%).
- The average percentage of whole kernels at export in 2018/2019 was lower than at harvest (93.0%). Whole kernels for the export 5YA (87.8%) was also lower than for the harvest 5YA (93.2%). Over the past three years and the 5YA, the percentages of whole kernels have been 5.4 to 7.8 percentage points lower at export than at harvest. This reduction in whole kernels from harvest to export is likely caused by the additional handling required to reach export loading locations.
- The 2018/2019 export samples had a range of 61.4 to 96.2% whole kernels (with a standard deviation of 4.9%), while the 2018 harvest samples had a similar range (66.0 to 98.6%) and standard deviation (3.0%).
- The Pacific Northwest ECA (82.2%) had the lowest average whole kernels compared to the Gulf (86.0%) and Southern Rail (86.2%) ECAs.
- The percentage of 2018/2019 export samples with whole kernels greater than or equal to 90.0% was 15.8%, compared with 14.7% in 2017/2018 and 39.3% in 2016/2017, indicating a much lower percentage of whole kernels in the last two years than in 2016/2017.
- Average whole kernels for contracts loaded as U.S. No. 2 or better was 85.0%, compared with 86.4% for contracts loaded as U.S. No. 3 or better.

WHOLE KERNELS (%)

EXPORT CATCHMENT AREA AVERAGE



U.S. AGGREGATE



	Avg	Std Dev
MY16/17	88.2	3.9
MY17/18	84.4	5.0
MY18/19	85.2	4.9

Horneous (Hard) Endosperm

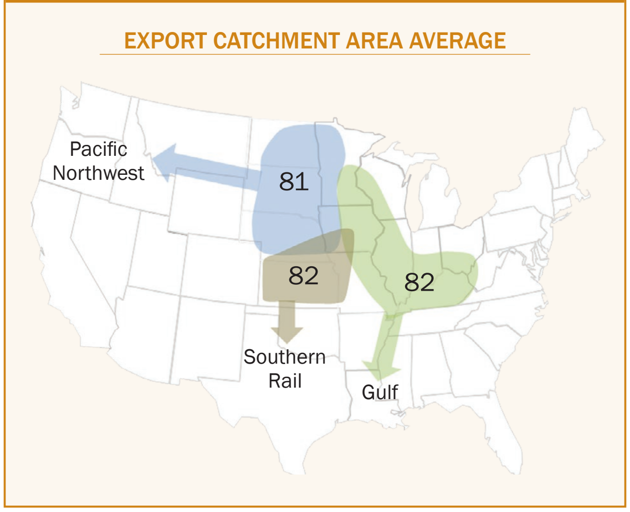
The horneous (hard) endosperm test measures the percent of horneous or hard endosperm out of the total endosperm in a kernel, with a potential value from 70 to 100%. The greater the amount of horneous endosperm relative to soft endosperm, the harder the corn kernel is said to be. The degree of hardness is important depending on the type of processing. A hard kernel is needed to produce high yields of large-flaking grits in dry milling. Hard to medium hardness is desired for alkaline cooking. Medium 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 85% horneous endosperm, while wet millers and feeders would typically like values between 70% and 85%. However, there are certainly exceptions in user preference.

Results

- Average U.S. Aggregate horneous endosperm (82%) was higher than 2017/2018 (81%), 2016/2017 (79%) and the 5YA (81%).
- Average horneous endosperm for 2018/2019, 2017/2018, 2016/2017 and the 5YA were within ±1 percentage point of the average horneous endosperm for 2018, 2017, 2016 and the 5YA at harvest, respectively.
- The 2018/2019 export samples had more uniform percentages of horneous endosperm compared to the 2018 harvest samples as indicated by the lower standard deviation at export (2%) compared to that at harvest (3%). The export samples also had a narrower range (75 to 91%) compared to the harvest samples (72 to 92%). This same pattern of increased uniformity for the export samples compared with the harvest samples also occurred in 2017/2018, 2016/2017 and the 5YA.

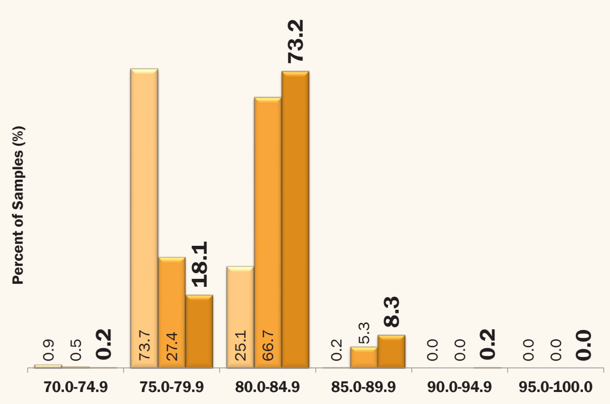
HORNEOUS ENDOSPERM (%)



- Average horneous endosperm among all ECAs was within 1 percentage point of each other for 2018/2019, 2017/2018, 2016/2017 and the 5YA, respectively. No ECA consistently has had higher or lower average horneous endosperm relative to the others across years.
- Of the 2018/2019 export samples, 81.7% had at least 80% horneous endosperm, in contrast to 72.0% in 2017/2018 and 25.3% in 2016/2017. This indicates a higher percentage of the samples in the last two years contained high amounts of horneous endosperm compared to 2016/2017.
- Average horneous endosperm for contracts loaded as U.S. No. 2 or better (82%) was the same as that for contracts loaded as U.S. No. 3 or better.

HORNEOUS ENDOSPERM (%)

U.S. AGGREGATE



	Avg	Std Dev
MY16/17	79	2
MY17/18	81	2
MY18/19	82	2

SUMMARY: PHYSICAL FACTORS

	2018/2019 Export Cargo					2017/2018 Export Cargo			2016/2017 Export Cargo			5 Year Avg. (2013-2017)	
	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						**U.S. Aggregate**			**U.S. Aggregate**			**U.S. Aggregate**	
Stress Cracks (%)	436	7	5	0	36	430	9*	5	430	5*	4	10	6
Stress Crack Index	436	16.2	11.8	0	94	430	22.4*	15.6	430	11.6*	10.9	25.1	16.5
100-Kernel Weight (g)	436	36.17	1.84	26.55	42.05	430	36.07	1.43	430	35.26*	1.45	35.42	1.73
Kernel Volume (cm^3)	436	0.28	0.01	0.20	0.32	430	0.28	0.01	430	0.27*	0.01	0.28	0.01
True Density (g/cm^3)	436	1.288	0.011	1.235	1.325	430	1.287	0.012	430	1.285*	0.011	1.286	0.012
Whole Kernels (%)	436	85.2	4.9	61.4	96.2	430	84.4*	5.0	430	88.2*	3.9	87.8	4.3
Horneous Endosperm (%)	436	82	2	75	91	430	81*	2	430	79*	2	81	2
Gulf						**Gulf**			**Gulf**			**Gulf**	
Stress Cracks (%)	275	6	4	0	23	276	9*	6	278	4*	3	10	5
Stress Crack Index	275	13.1	9.5	0	53	276	23.8*	17.2	278	8.5*	9.3	25.7	16.8
100-Kernel Weight (g)	275	37.49	1.85	31.80	42.05	276	37.45	1.31	278	35.65*	1.39	36.33	1.61
Kernel Volume (cm^3)	275	0.29	0.01	0.25	0.32	276	0.29	0.01	278	0.28*	0.01	0.28	0.01
True Density (g/cm^3)	275	1.293	0.009	1.262	1.325	276	1.293	0.011	278	1.284*	0.012	1.290	0.011
Whole Kernels (%)	275	86.0	3.9	73.6	95.8	276	83.6*	5.4	278	89.2*	3.5	87.9	4.5
Horneous Endosperm (%)	275	82	2	75	87	276	81*	2	278	79*	2	81	2
Pacific Northwest						**Pacific Northwest**			**Pacific Northwest**			**Pacific Northwest**	
Stress Cracks (%)[1]	96	14	8	1	36	87	12	6	91	11*	6	12	6
Stress Crack Index[1]	96	29.6	19.0	3	94	87	29.5	15.5	91	25.0	16.2	27.8	16.1
100-Kernel Weight (g)	96	32.21	1.81	26.55	36.85	87	31.12*	1.93	91	34.67*	1.34	31.74	2.12
Kernel Volume (cm^3)	96	0.25	0.01	0.20	0.29	87	0.25*	0.01	91	0.27*	0.01	0.25	0.02
True Density (g/cm^3)	96	1.278	0.016	1.235	1.308	87	1.268*	0.017	91	1.290*	0.013	1.272	0.014
Whole Kernels (%)	96	82.2	7.7	61.4	96.2	87	86.8*	3.6	91	83.5	5.5	87.0	4.1
Horneous Endosperm (%)	96	81	3	76	91	87	80*	2	91	79*	2	80	2
Southern Rail						**Southern Rail**			**Southern Rail**			**Southern Rail**	
Stress Cracks (%)[1]	65	5	4	0	18	67	4	3	61	3*	4	8	5
Stress Crack Index[1]	65	9.1	10.5	0	40	67	7.5	9.3	61	5.8	10.3	17.9	15.2
100-Kernel Weight (g)	65	36.52	1.87	33.40	41.39	67	36.80	1.29	61	34.35*	1.89	36.33	1.72
Kernel Volume (cm^3)	65	0.28	0.02	0.26	0.32	67	0.29	0.01	61	0.27*	0.01	0.28	0.01
True Density (g/cm^3)	65	1.284	0.013	1.260	1.318	67	1.290*	0.008	61	1.283	0.009	1.284	0.010
Whole Kernels (%)	65	86.2	4.5	73.2	95.0	67	84.7*	4.9	61	90.3*	3.3	88.8	4.0
Horneous Endosperm (%)	65	82	2	77	87	67	81*	2	61	78*	2	81	2

Indicates average was significantly different from current year's Export Cargo, based on a 2-tailed t-test at the 95.0% level of significance.

SUMMARY: PHYSICAL FACTORS

	Export Cargo Samples for Contract Loaded as U.S. No. 2 or Better					Export Cargo Samples for Contract Loaded as U.S. No. 3 or Better					2018 Harvest				
	No. of Samples	Avg.	Std. Dev.	Min.	Max.	No. of Samples	Avg.	Std. Dev.	Min.	Max.	No. of Samples	Avg.	Std. Dev.	Min.	Max.
U.S. Aggregate															
Stress Cracks (%)	313	8	5	0	30	114	8	5	0	36	618	5**	6	0	88
Stress Crack Index	313	17.7	12.7	0	68	114	17.1	11.5	0	94	618	11.5**	16.8	0	304
100-Kernel Weight (g)	313	36.03	1.67	29.90	41.39	114	36.82*	1.90	26.55	42.05	618	35.07**	2.84	23.86	45.88
Kernel Volume (cm^3)	313	0.28	0.01	0.23	0.32	114	0.29*	0.01	0.20	0.32	618	0.28**	0.02	0.19	0.36
True Density (g/cm^3)	313	1.287	0.011	1.248	1.325	114	1.287	0.010	1.235	1.308	618	1.265**	0.018	1.167	1.374
Whole Kernels (%)	313	85.0	4.7	70.0	95.0	114	86.4*	4.7	61.4	96.2	618	93.0**	3.0	66.0	98.6
Horneous Endosperm (%)	313	82	2	75	87	114	82	2	76	91	618	81**	3	72	92
Gulf															
Stress Cracks (%)	237	6	4	0	23	38	6	4	0	14	587	4**	5	0	88
Stress Crack Index	237	13.1	9.5	0	53	38	13.4	9.3	0	33	587	10.2**	15.2	0	304
100-Kernel Weight (g)	237	37.34	1.80	31.80	41.14	38	38.43*	1.89	32.33	42.05	587	35.74**	2.86	23.86	45.88
Kernel Volume (cm^3)	237	0.29	0.01	0.25	0.32	38	0.3*	0.01	0.25	0.32	587	0.28**	0.02	0.19	0.36
True Density (g/cm^3)	237	1.293	0.009	1.262	1.325	38	1.289*	0.008	1.274	1.305	587	1.266**	0.017	1.167	1.374
Whole Kernels (%)	237	85.6	3.9	73.6	94.6	38	87.9*	3.6	76.4	95.8	587	93.1**	3.0	66.0	98.6
Horneous Endosperm (%)	237	82	2	75	87	38	82	2	78	87	587	81**	3	72	92
Pacific Northwest															
Stress Cracks (%)[1]	20	17	10	1	30	76	13	7	1	36	288	7**	8	0	88
Stress Crack Index[1]	20	36.6	22.8	3	68	76	27.7	17.6	3	94	288	18.0**	24.5	0	289
100-Kernel Weight (g)	20	31.95	1.15	29.90	34.82	76	32.28	1.94	26.55	36.85	288	32.97**	2.67	23.86	45.42
Kernel Volume (cm^3)	20	0.25	0.01	0.23	0.27	76	0.25	0.02	0.20	0.29	288	0.26**	0.02	0.19	0.35
True Density (g/cm^3)	20	1.271	0.017	1.248	1.304	76	1.28*	0.015	1.235	1.308	288	1.257**	0.018	1.167	1.374
Whole Kernels (%)	20	82.3	7.2	70.0	91.4	76	82.2	7.8	61.4	96.2	288	92.9**	3.1	73.6	98.6
Horneous Endosperm (%)	20	81	2	78	84	76	82	3	76	91	288	81	3	72	91
Southern Rail															
Stress Cracks (%)[1]	56	5	4	0	18	0	-	-	-	-	355	3**	4	0	84
Stress Crack Index[1]	56	9.4	10.6	0	40	0	-	-	-	-	355	6.6	11.9	0	304
100-Kernel Weight (g)	56	36.60	1.86	33.40	41.39	0	-	-	-	-	355	35.59**	2.98	23.86	45.88
Kernel Volume (cm^3)	56	0.29	0.01	0.26	0.32	0	-	-	-	-	355	0.28**	0.02	0.19	0.36
True Density (g/cm^3)	56	1.283	0.013	1.260	1.318	0	-	-	-	-	355	1.274**	0.019	1.198	1.374
Whole Kernels (%)	56	86.1	4.6	73.2	95.0	0	-	-	-	-	355	92.8**	2.7	82.6	98.6
Horneous Endosperm (%)	56	82	2	77	87	0	-	-	-	-	355	82	3	72	92

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

***Indicates current year's Export Cargo average was significantly different from this year's Harvest, based on a 2-tailed t-test at the 95% level of confidence.*

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, aflatoxin and DON 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 contamination 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.

As in the previous *Export Cargo Reports*, the 2018/2019 export samples were tested for aflatoxin and DON for this year's report. The accumulation of eight years of the *Export Cargo Reports* allows for the evaluation of year-to-year patterns of mycotoxin presence in corn at export points. A comparison of the mycotoxin presence is described below for the past three marketing years for aflatoxin and DON. In addition, a year-to-year comparison of the mycotoxin presence across all eight years of the *Harvest* and *Export Cargo Reports* is contained in the "Historical Perspective" section on page 65.

Background: Mycotoxins 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. In some years, the growing conditions across the corn-producing regions might not produce elevated levels of any mycotoxins. In other years, the environmental conditions in a particular area might be conducive to the production of a particular mycotoxin to levels that impact the corn's use for human and livestock consumption. Humans and livestock are sensitive to mycotoxins at varying levels. As a result, the FDA has issued action levels for aflatoxin 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 the 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 imports 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 the 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 the 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-FDARegulatoryGuidancefor-Mycotoxins8-2011.pdf*.

Background: Aflatoxin

The most important type of mycotoxin associated with corn grain is aflatoxin. There are several types of aflatoxin produced by different species of *Aspergillus*, with the most prominent species being *A. flavus*. The 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 aflatoxin naturally found in foods – aflatoxins B1, B2, G1 and G2. These four aflatoxins are commonly referred to as "aflatoxin" or "total aflatoxin." Aflatoxin B1 is the most commonly found aflatoxin in food and feed and is also the most toxic. Research has shown that B1 is a potent, naturally-occurring carcinogen in animals, with a strong link to human cancer incidence. Additionally, dairy cattle will metabolize aflatoxin to a different form of aflatoxin called aflatoxin M1, which may accumulate in milk.

Aflatoxin expresses 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 aflatoxin, possibly resulting in death in poultry, the most sensitive of the animal species. Livestock may experience reduced feed efficiency or reproduction, and both human and animal 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 aflatoxin in human food, grain and livestock feed in parts per billion (ppb) (see table below).

The FDA has established additional policies and legal provisions concerning the blending of corn with levels of aflatoxin exceeding these threshold levels. In general, the FDA currently does not permit the blending of corn blended to reduce the aflatoxin content to be sold in general commerce.

Corn exported from the United States must be tested for aflatoxin according to federal law. Unless the contract exempts this requirement, testing must be conducted by FGIS. Corn above the FDA action level of 20.0 ppb cannot be exported unless other strict conditions are met. This results in relatively low levels of aflatoxin in exported grain.

Aflatoxins Action Level	Criteria
0.5 ppb (Aflatoxin M1)	Milk intended for human consumption
20.0 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
20.0 ppb	For animal feeds, other than corn or cottonseed meal
100.0 ppb	For corn and other grains intended for breeding beef cattle, breeding swine, or mature poultry
200.0 ppb	For corn and other grains intended for finishing swine of 100 pounds or greater
300.0 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

Background: Deoxynivalenol (DON or Vomitoxin)

DON is another mycotoxin of concern to some importers of corn grain. It is produced by a certain species of *Fusarium*, the most important of which is *Fusarium graminearum* (*Gibberellazeae*), 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, 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:

- 5.0 ppm in grains and grain co-products for swine, not to exceed 20% of their diet;
- 10.0 ppm in grains and grain co-products for chickens and cattle, not to exceed 50% of their diet; and
- 5.0 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 will perform either a qualitative or quantitative test for DON at the buyer’s request.

Assessing the Presence of Aflatoxin and Deoxynivalenol (DON or Vomitoxin)

To assess the effect of these conditions on aflatoxin and DON development, this report summarizes the results from official USDA FGIS aflatoxin tests and from independent DON tests for all the export samples collected as part of this survey. All (100%) of the samples (436) collected for this report were tested for aflatoxin and DON development.

A threshold established by USDA FGIS as the "Lower Conformance Level" (LCL) was used to determine whether or not a detectable level of the mycotoxin appeared in the sample. The LCLs for the FGIS-approved analytical kits used for this 2018/2019 report were 5.0 ppb for aflatoxin and 0.5 ppm for DON. The FGIS LCL was no higher than the lower Limit of Detection (LOD) of 5.0 ppb and higher than the lower LOD of 0.1 ppm specified for the aflatoxin and DON kits, respectively, used for testing the export samples collected for this survey. Details on the testing methodology employed in this study for the mycotoxins are in the "Testing Analysis Methods" section.

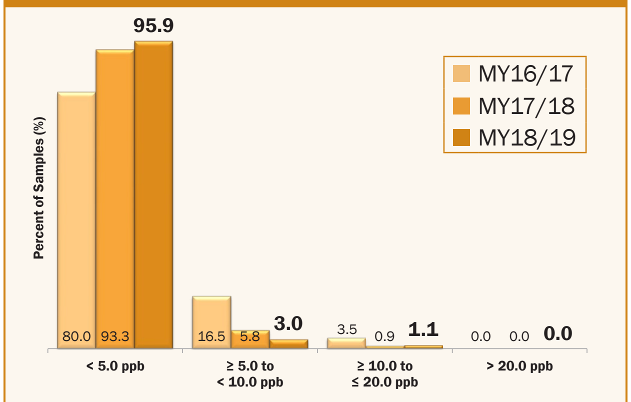
Results: Aflatoxins

A total of 436 export samples were tested for aflatoxin for the *2018/2019 Export Cargo Report*. Results of the 2018/2019 survey testing are as follows:

- Of the 436 samples, 418 samples, or 95.9%, had no detectable levels of aflatoxins (below the FGIS LCL of 5.0 ppb). This 95.9% is greater than 2017/2018 (93.3%) and 2016/2017 (80.0%).
- Aflatoxin levels greater than or equal to 5.0 ppb, but less than 10.0 ppb, were found in 13 samples, or 3.0% of the 436 samples tested in 2018/2019. This percentage is slightly less than 2017/2018 (5.8%) and significantly less than 2016/2017 (16.5%).
- Only five samples, or 1.1% of the 436 samples tested, in 2018/2019 had aflatoxin levels greater than or equal to 10.0 ppb, but below or equal to the FDA action level of 20.0 ppb. This 1.1% is about the same as 2017/2018 (0.9%) and less than 2016/2017 (3.5%).
- None (0) of the samples tested in 2018/2019 were above the FDA action level of 20.0 ppb, which is the same as that reported in the 2017/2018 and *2016/2017 Export Cargo Reports*.

Similar to 2017/2018 and 2016/2017, 100% of the 2018/2019 export survey sample test results were below the FDA action level of 20.0 ppb. In addition, the percentage of sample test results below the LCL was greater in 2018/2019 (95.9%) than in 2017/2018 (93.3%) and significantly greater than in 2016/2017 (80.0%). As a result, there were fewer positive incidences (4.1%) in 2018/2019 of sample test results greater than or equal to 5.0 ppb than in either 2017/2018 (6.7%) or 2016/2017 (20.0%). These results suggest that aflatoxin contamination level among lots in the export market was minimal and possibly the lowest in recent crop years. The high percentage of samples that tested below the LCL is probably indicative of the weather conditions during the 2018 growing season that were not conducive for mold growth and aflatoxin formation.

AFLATOXINS TESTING RESULTS



AFLATOXINS

	Percent of Total Samples				
	< 5.0 ppb	≥ 5.0 to < 10.0 ppb	≥ 10.0 to ≤ 20.0 ppb	> 20.0 ppb	Total
U.S. Aggregate	95.9%	3.0%	1.1%	0.0%	100.0%
By ECA					
Gulf	93.5%	4.7%	1.8%	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%

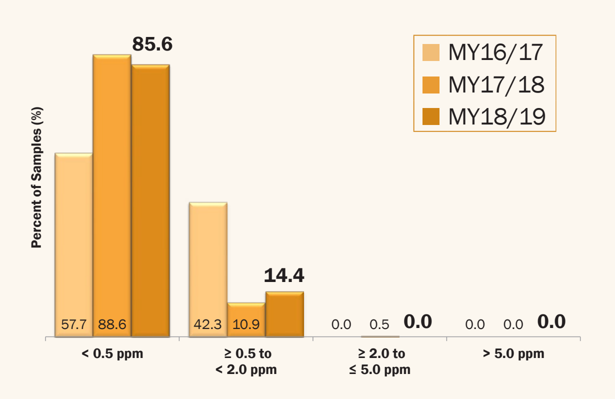
Results: Deoxynivalenol (DON or Vomitoxin)

A total of 436 export samples were tested for DON for the *2018/2019 Export Cargo Report*. Results of the testing are shown below:

- DON levels less than 0.5 ppm (the FGIS LCL for DON) were found in 373 samples, or 85.6% of the 436 samples tested. This 85.6% is about the same as 2017/2018 (88.6%), but significantly greater than 2016/2017 (57.7%).
- Sixty-three (63) samples, or 14.4% of the 436 samples tested in 2018/2019 had DON levels greater than or equal to 0.5 ppm, but less than 2.0 ppm. This 14.4% is slightly greater than 2017/2018 (10.9%), but significantly less than 2016/2017 (42.3%).
- No (0) samples, or 0.0% of the 436 samples tested in 2018/2019 had DON levels greater than or equal to 2.0 ppm, but less than or equal to the FDA advisory level of 5.0 ppm. This 0.0% for 2018/2019 is similar to 2017/2018 (0.5%) and 2016/2017 (0.0%).
- None (0) of the 436 samples tested in 2018/2019 were above the FDA advisory level of 5.0 ppm, which is the same as that reported in the 2017/2018 and *2016/2017 Export Reports*.

The 2018/2019 survey results were very similar to the 2017/2018 survey results showing a high percentage of the sample below the FGIS LCL limit of 0.5 ppm. The 2018/19 survey results showed significantly fewer incidences of DON than the 2016/2017 survey results. All export survey samples were below or equal to the FDA advisory level of 5.0 ppm for all three marketing years. The large percentage of sample test results below the LCL in 2018/2019 is indicative of weather conditions that were not conducive for mold growth and DON formation.

DON TESTING RESULTS



DON	Percent of Total Samples				
	< 0.5 ppm	≥ 0.5 to < 2.0 ppm	≥ 2.0 to ≤ 5.0 ppm	> 5.0 ppm	Total
U.S. Aggregate	85.6%	14.4%	0.0%	0.0%	100.0%
By ECA					
Gulf	90.2%	9.8%	0.0%	0.0%	100.0%
Pacific Northwest	99.0%	1.0%	0.0%	0.0%	100.0%
Southern Rail	46.2%	53.8%	0.0%	0.0%	100.0%

This *U.S. Grains Council 2018/2019 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 concentrations, and kernel 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 non-visual, they can only be determined by analytical tests.
- Physical quality characteristics – These attributes are associated with the outward visible appearance of the kernel or measurement of the kernel characteristics. Characteristics include kernel size, shape and color; moisture content; 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.

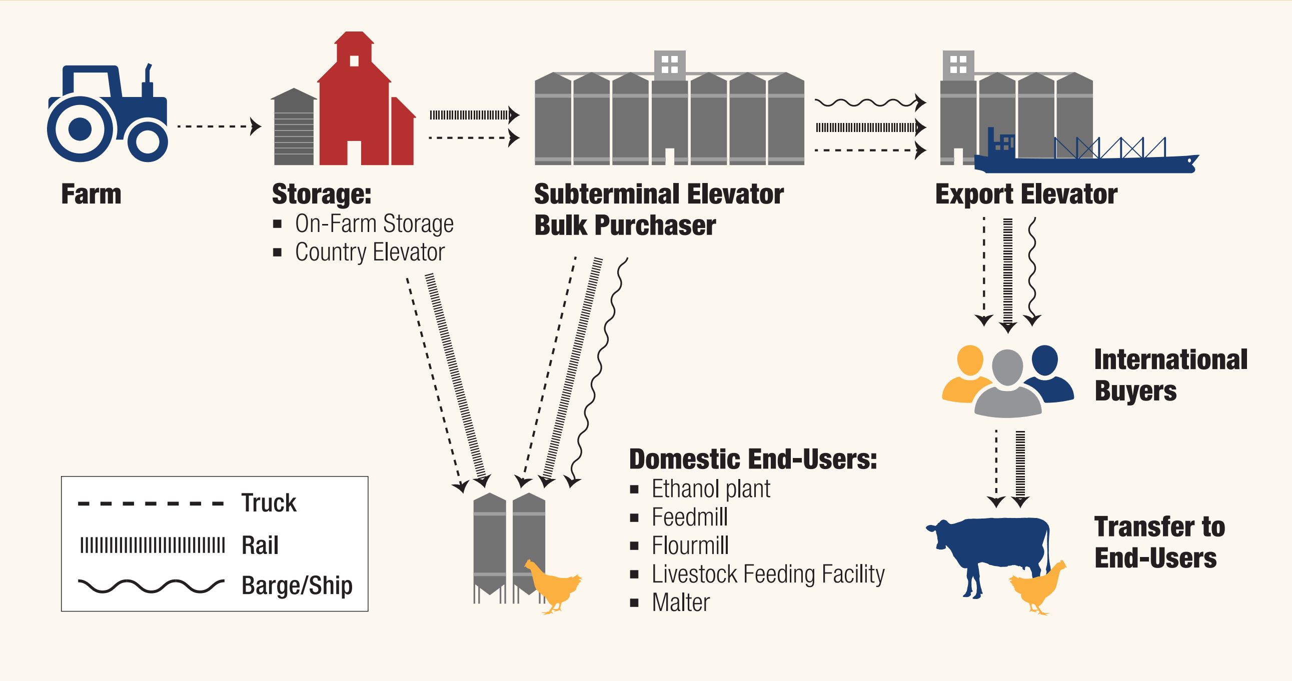
The intrinsic quality characteristics are impacted significantly by genetics and growing season conditions and typically do not change at the aggregate level as corn moves through the marketing system. If the measured values of the intrinsic characteristics differ between harvest and export at the aggregate 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 marketing channel. The parties involved in corn marketing and distribution use operating practices (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 to 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 subsequent practices, including cleaning, drying, handling, blending, storing and transporting of the crop up to the point where it is being loaded for export. To provide the backdrop for this assessment, the following sections describe the marketing channel from farm to export, the practices applied to corn as it moves through the marketing channel and the implications of these practices on corn quality. Lastly, the inspection and grading services provided by USDA GIPSA or an official service provider 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 subterminals, river elevators and port elevators. Local grain elevators typically receive most of their grain directly from farmers. Inland subterminals or river elevators collect grain in quantities suitable for loading on unit trains and barges for further transport. These elevators may receive more than half of their corn from other elevators and are often located where the transport of bulk grain can be easily accommodated by unit trains or barges. Local grain, inland subterminals 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 below conveys the flow of United States corn destined for export markets.

U.S. CORN EXPORT FLOW



B. IMPACT OF THE CORN MARKETING 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.

Drying and Conditioning

Farmers often harvest corn at moisture contents 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 content to become safe for storage and transport. Conditioning is the use of aeration fans to control temperatures and moisture content, 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. 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.

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, as they allow aeration with uniform airflow throughout 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, 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.

Cleaning

Cleaning corn involves scalping or removing large non-corn material and sieving to remove small, shriveled kernels, broken pieces of kernels and fine material. This process reduces the amount of BCFM 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 marketing channel where cleaning equipment is available.

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 commercial grain facilities 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.

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 humidity and air temperature, 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 the final destination.

Implications on Quality

The intrinsic quality attributes, such as oil, protein and starch concentrations, remain essentially unchanged in a corn kernel between harvest and export, assuming negligible kernel respiration or mold damage. However, as corn moves through the U.S. corn marketing channel, corn from multiple sources is mixed together. As a result, the average for a given intrinsic quality characteristic is determined by the quality levels of the corn from multiple sources. Other changes occur in the physical and sanitary quality characteristics. These include test weight, damaged kernels, broken kernels, stress crack levels, moisture content and variability, foreign material and mycotoxin levels.

C. U.S. GOVERNMENT INSPECTION AND GRADING

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 the quality of grain at the time of loading for transport to the buyer; 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 for foreign commerce must be officially inspected and weighed by 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 field office personnel.

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, moisture content 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 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 a primary portion approximately every 200 to 500 bushels (about 5.1 to 12.7 metric tons) from the moving grain stream just after the final elevation before loading into the vessel, shipping bin or railcar. The primary portions are usually further

reduced by a secondary sampler, and 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 ensure not only that the average result for each factor meets the contract specifications, but also to ensure 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.

Grading

Yellow corn is divided into five U.S. numerical grades and U.S. Sample Grade. Each grade has limits for test weight, 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 Requirements" section found on page 72 of this report. In addition, FGIS provides certification of moisture content and aflatoxin results. Export contracts for corn can also specify other conditions or attributes related to the cargo, if requested, such as stress cracks, protein or oil concentrations and other mycotoxin results. 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.

A. OVERVIEW

The key points for the survey design and sampling and statistical analysis for this *2018/2019 Export Cargo Report* are as follows:

- Following the methodology developed for the previous seven *Export Cargo Reports*, samples were proportionately stratified according to ECAs – the Gulf, Pacific Northwest and Southern Rail.

- To achieve no more than a ±10% Relative ME for the U.S. Aggregate level and to ensure proportionate sampling from each ECA, the targeted number of total samples was 431 samples, to be collected from the ECAs as follows: 270 from the Gulf, 96 from the Pacific Northwest and 65 from the Southern Rail.

- A total of 436 samples were ultimately tested for this survey as 275 samples from the Gulf were received. Since additional samples from the Gulf were included in the survey, the weight of each Gulf sample was adjusted so that the Gulf's overall weight in the survey remained unchanged relative to the other two ECAs.

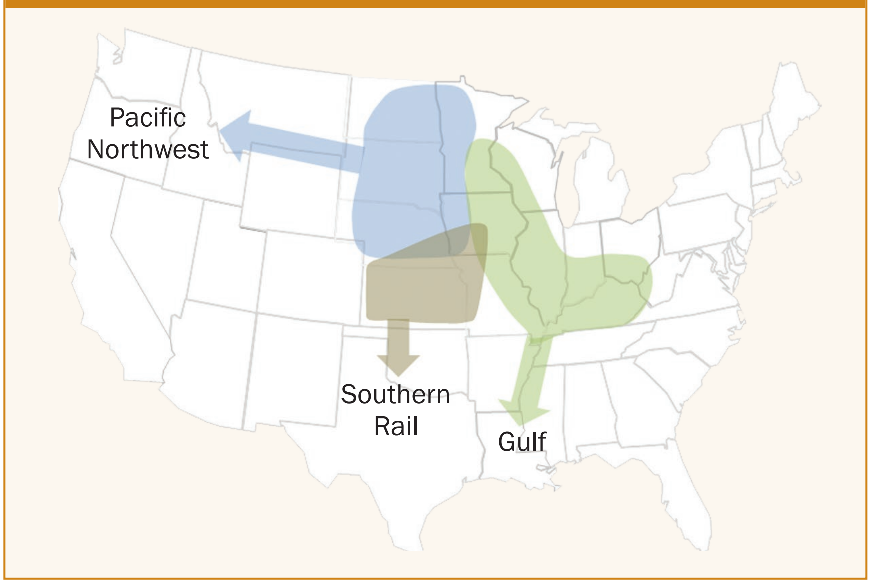
- Weighted averages and standard deviations following standard statistical techniques for proportionate stratified sampling were calculated for the U.S. Aggregate and the three ECAs.

- Southern Rail ECA samples were provided by official agencies designated by the 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.

- To evaluate the statistical validity of the results, the Relative ME was calculated for each quality attribute at the U.S. Aggregate and the three ECA levels. The Relative ME for each of the quality factor results was not more than ±10% at the U.S. Aggregate level. The Relative ME exceeded ±10% for total damage, stress cracks and stress crack index in the Pacific Northwest ECA; and stress cracks and stress crack index in the Southern Rail ECA (see table on page 59).

- Two-tailed t-tests at the 95% confidence level were calculated to measure statistical differences between the 2018/2019 and 2017/2019 and the 2018/2019 and 2016/2017 quality factor averages.

EXPORT CATCHMENT AREAS



B. SURVEY DESIGN AND SAMPLING

Survey Design

For the *2018/2019 Export Cargo Report*, the target population was yellow commodity corn from the 12 key U.S. corn-producing states representing approximately 95% of the estimated 2018/2019 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 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 ports; and
3. The Southern Rail ECA comprises areas that generally export corn by rail to Mexico.

Using data from the USDA, each ECA's proportion of the total expected annual yellow corn exports for the 2018/2019 corn marketing year was calculated. 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 shown below.

Percent of Samples per ECA			
Gulf	Pacific Northwest	Southern Rail	Total
62.7%	22.2%	15.1%	100.0%

The ***number of samples*** collected within each ECA was established so the Council could estimate the true U.S. Aggregate average for 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 not more 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., the 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 targeted number of samples for the desired level of precision for all quality factors were calculated using results from previous editions of this survey. Based on these historical data, 430 samples 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). The total samples targeted became 431 due to rounding.

Number of Samples per ECA			
Gulf	Pacific Northwest	Southern Rail	Total
270	96	65	431

Sampling

The sampling was administered by FGIS and participating official service providers as part of their inspection services. The FGIS field offices indicated that 2018 corn was reaching export points in October 2018. Therefore, FGIS sent instruction letters to the Gulf and Pacific Northwest field offices and to the domestic inspection offices, and the sampling period began in November 2018, 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.

While the sampling process is continuous throughout the loading of an ocean-bound vessel, a shipment or "lot" of corn is divided into "sublots" for the purpose of determining the 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 30,000 to 120,000 bushels. All sublot samples are inspected to ensure the entire shipment is uniform in quality.

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 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 200 to 500 bushels (about 5.1 to 12.7 metric tons), as the grain is being assembled for export. The frequency is regulated by an electronic timer controlled by official inspection personnel, who periodically determine that the mechanical sampler is functioning properly.

Sublots ending in zero, three, five and seven from each lot during the survey period were sampled. This was the same sampling frequency for the Pacific Northwest and Gulf ECAs as last year's export cargo survey. For each sample, a minimum of 2,700 grams was collected by the FGIS field staff and the Washington State Department of Agriculture.

For the Southern Rail ECA, representative samples were taken at domestic interior elevators using a diverter sampler to ensure uniform sampling. A cut is taken about every 200 bushels (about 5.1 metric tons). Only trains of yellow corn inspected for export to Mexico were sampled. Unlike the samples collected from the Gulf and Pacific Northwest ECAs, which collected additional samples at the time of loading specifically for this report, the Southern Rail ECA official service providers submitted file samples. These samples were collected and tested for grade factors and aflatoxin at the time of sampling and then kept on file at the official service providers to be retested in the case of disputes. Each file sample weighed approximately 1,000 grams and represented a composite of five railcars. For each train sampled, three file samples were mailed to the Illinois Crop Improvement Association's Identity Preserved Grain Laboratory (IPG Lab) when their retention dates were reached, which were generally 30 days after loading. Upon arrival at the lab, the three file samples were composited into a single sample to undergo the chemical composition, physical factor and DON tests. The grade factor results from the three file samples were averaged to represent a single sample. Aflatoxin results were used only if all three file samples were lower than 5 ppb. If one or more of the three file samples tested greater than 5 ppb, then the composited sample was tested at IPG Lab for aflatoxin using the EnviroLogix AQ 309 BG test kits.

Refer to the "Testing Analysis Methods" section for the description of the testing methods employed for the study.

C. STATISTICAL ANALYSIS

The sample test results for the grade factors, moisture content, chemical composition and physical factors were summarized for the U.S. Aggregate and also by the three ECAs (Gulf, Pacific Northwest and Southern Rail) and the following two contract grade categories:

- "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.
- "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.

Within this *2018/2019 Export Cargo Report* is a simple average of the quality factors' averages and standard deviations of the previous five *Export Cargo Reports (2013/2014, 2014/2015, 2015/2016, 2016/2017 and 2017/2018)*. These simple averages are calculated for the U.S. Aggregate and each of the three ECAs and are referred to as the "5YA" 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 not more than ±10% for all the quality attributes at the U.S. Aggregate level. The table shown below displays all Relative MEs exceeding ±10.0% by quality factor and composite grouping.

	Relative Margin of Error (ME)		
	Total Damage	Stress Cracks	Stress Crack Index
Pacific Northwest ECA	17%	11%	13%
Southern Rail ECA		23%	28%

While the level of precision for these quality factors in the three 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. These tests were calculated to determine statistical differences between quality factor averages from this *Export Cargo Report* and the following:

- This year's *Harvest Report* and
- Each of the previous two *Export Cargo Reports*.

In addition, tests were conducted to determine statistical differences between the quality factor averages from shipments loaded as contract grade U.S. No. 2 or better and those loaded as contract grade U.S. No. 3 or better in this year's *Export Cargo Report.*

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. The 2018/2019 Corn Export Cargo Quality Report samples (approximately six pounds or 2,700 grams) were sent directly from the FGIS field offices and official service providers to the IPG Lab in Champaign, Illinois, for chemical composition, physical factors and DON testing. Next, 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/labservices.

A. GRADE FACTORS

Test Weight

Test weight is a measure of the volume of grain that is required to fill a Winchester bushel (2,150.42 cubic inches) to capacity. Test weight is part of the FGIS Official U.S. Standards for Corn 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).

Broken Corn and Foreign Material

BCFM is part of the FGIS Official U.S. Standards for Corn 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. BCFM measurement can be 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. Foreign material is defined as all material passing through the 6/64th-inch round-hole sieve and the coarse non-corn material retained on top of 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.

Total Damage and Heat Damage

Total damage is part of the FGIS Official U.S. 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 identified as 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. Electronic moisture meters sense an electrical property of grains called the dielectric constant that varies with moisture. The dielectric constant rises as moisture content increases. Moisture is reported as a percent of total wet weight.

C. CHEMICAL COMPOSITION

The chemical composition (protein, oil, and starch concentrations) of corn is measured using near-infrared (NIR) transmittance spectroscopy. The technology uses unique interactions of specific wavelengths of light with each sample. It is calibrated to traditional chemistry methods to predict the concentrations of protein, oil and starch in the sample. This procedure is nondestructive to the corn.

Chemical composition tests for protein, oil and starch concentrations were conducted using a 550 to 600-gram sample in a whole-kernel Foss Infratec 1241 NIR instrument. The NIR was calibrated to chemical tests, and the standard error of predictions for protein, oil and starch concentrations were about 0.27%, 0.26% and 0.65%, respectively. Comparisons of the Foss Infratec 1229 used in *Export Cargo Reports* prior to 2016/2017 to the Foss Infratec 1241 on 21 laboratory check samples showed the instruments averaged within 0.25%, 0.26% and 0.25% of each other for protein, oil and starch, respectively. Results are reported on a dry basis percentage (percent of non-water material).

D. PHYSICAL FACTORS

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 0.14 to 0.36 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 1.20 to 1.30 g/cm^3 at "as is" moisture contents of about 12 to 15%.

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 percent, 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 end-users will specify by contract the acceptable level of cracks based on the intended use.

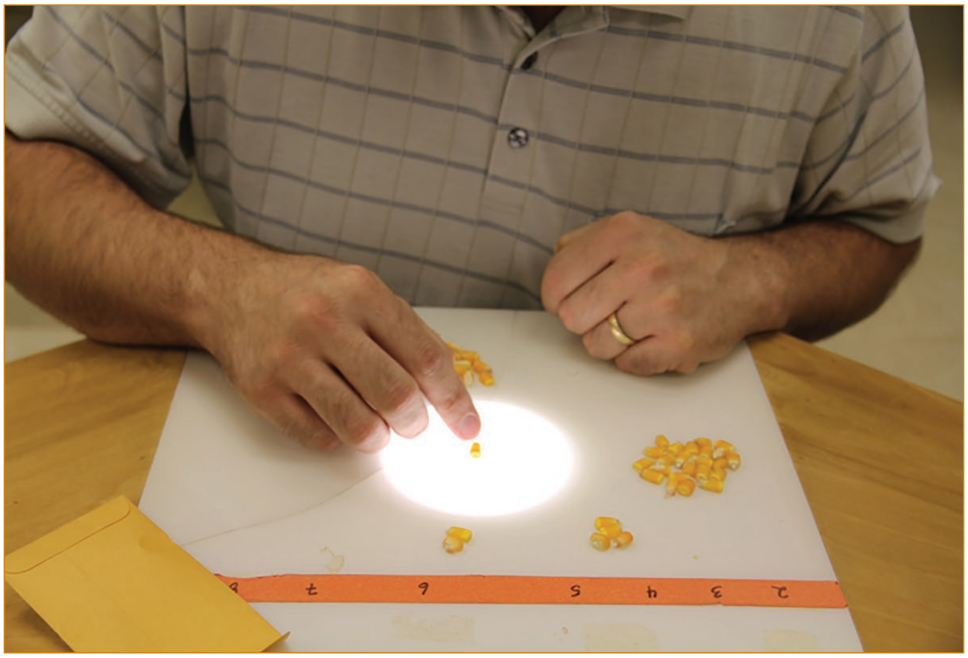
Stress crack index is a weighted average of the stress cracks. This measurement indicates the severity of stress cracking. Stress crack index is calculated as

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

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



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 then 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 97.0% equates to a cracked & broken rating of 3.0%.

Horneous (Hard) Endosperm

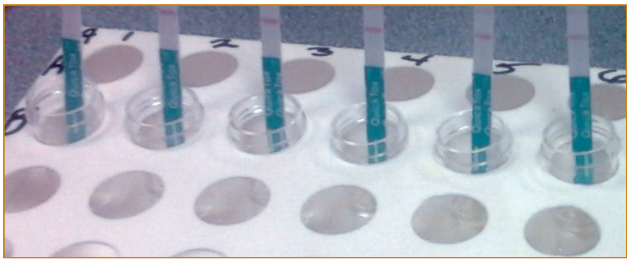
The horneous (or hard) endosperm test is performed by visually rating 20 externally sound kernels, placed germ facing up, on a backlit viewing board. Each kernel is rated for the estimated portion of the kernel's total endosperm that is horneous endosperm. Soft endosperm is opaque and will block light, 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. MYCOTOXINS

Official aflatoxin results are provided by FGIS for this 2018/2019 Export Cargo Report. 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, aflatoxins are quantified. The following FGIS-approved quantitative test kits may have been used: Charm Sciences, Inc. ROSA® FAST, WET-S3 or WET-S5 Aflatoxin Quantitative Tests; EnviroLogix, Inc. QuickTox™ Kit for QuickScan Aflatoxin Flex AQ 309 BG; Neogen Corporation Reveal Q+ MAX for Aflatoxin, Reveal Q+ for Aflatoxin, or Veratox® Aflatoxin Quantitative Test (8030 or 8035); R-Biopharm, Inc. RIDASCREEN® FAST Aflatoxin ECO; Romer Labs, Inc. FluoroQuant Afla or AgraStrip Total Aflatoxin Quantitative Test WATEX; or VICAM AflaTest™ or Afla-V AQUA.

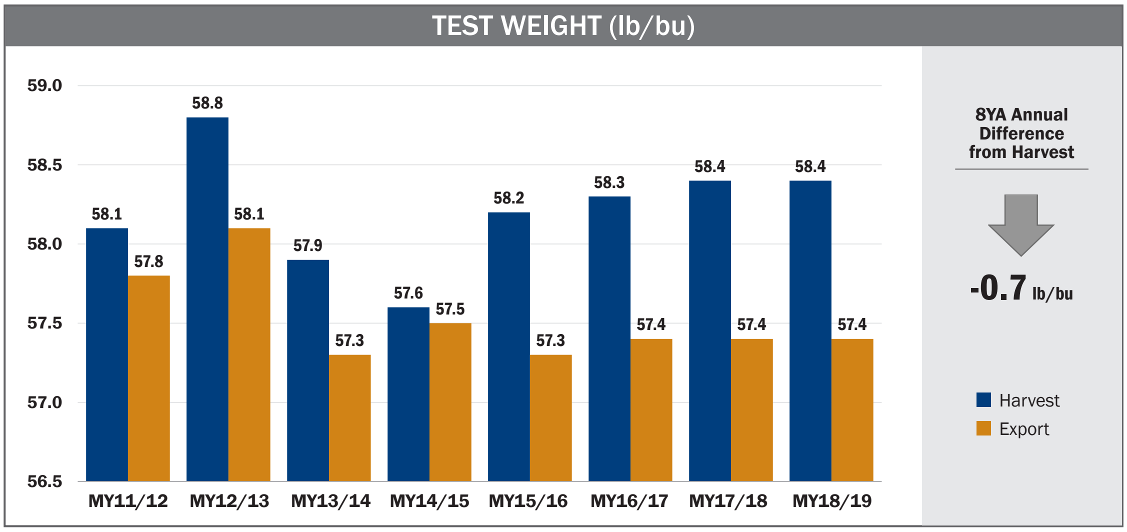
For the DON testing, the FGIS-approved EnviroLogix QuickTox™/QuickScan method is used. A minimum of a 1,000-gram sample of shelled corn (obtained by dividing the original sample) is ground to a particle size which would pass through a No. 20 wire mesh sieve and divided down to a 50-gram test portion using a Romer Model 2A sampling mill. The 50-gram test portion is then processed as the FGIS DON Handbook requires. DON is extracted with distilled water (5:1), and the extract is tested using the EnviroLogix AQ 304 BG test kits. The DON is quantified by the QuickScan system.

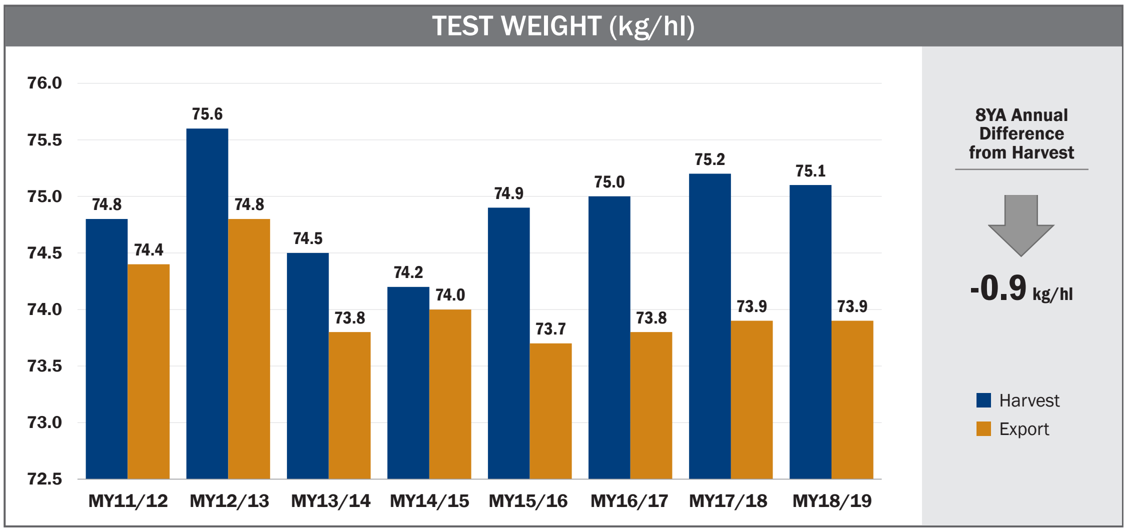
A letter of performance has been issued by FGIS for the quantification of DON using the EnviroLogix AQ 304 BG kit.



GRADE FACTORS AND MOISTURE
AGGREGATE EIGHT-YEAR HARVEST AND EXPORT CARGO COMPARISON

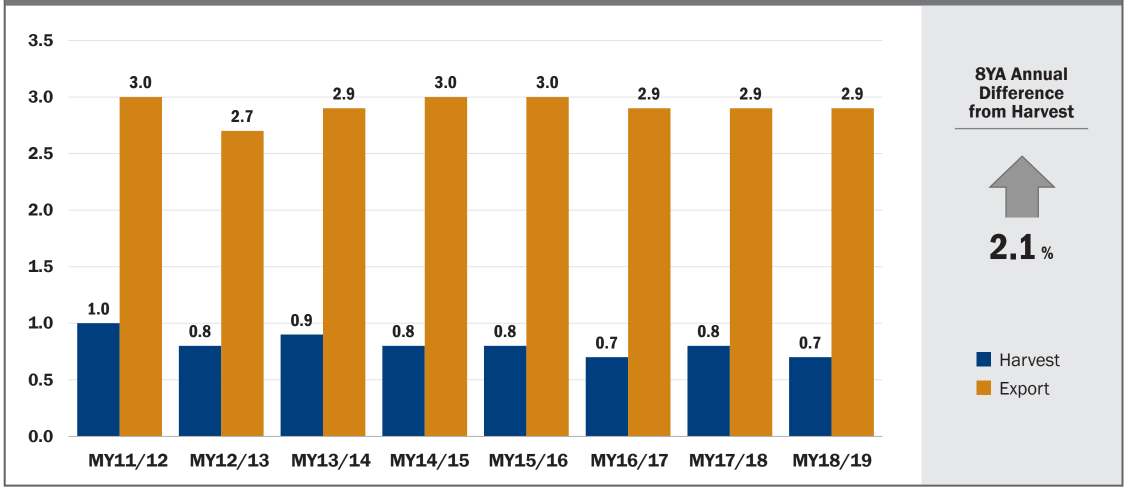
Since 2011, the U.S. Grains Council's Corn Export Cargo Reports have provided clear, concise and consistent information about the quality of each U.S. crop entering international merchandising channels. This series of quality reports has used consistent and transparent methodology to allow for insightful comparisons across time. The following charts display the average U.S. Aggregate from all eight reports for each quality factor tested to provide historical context to this year's results.



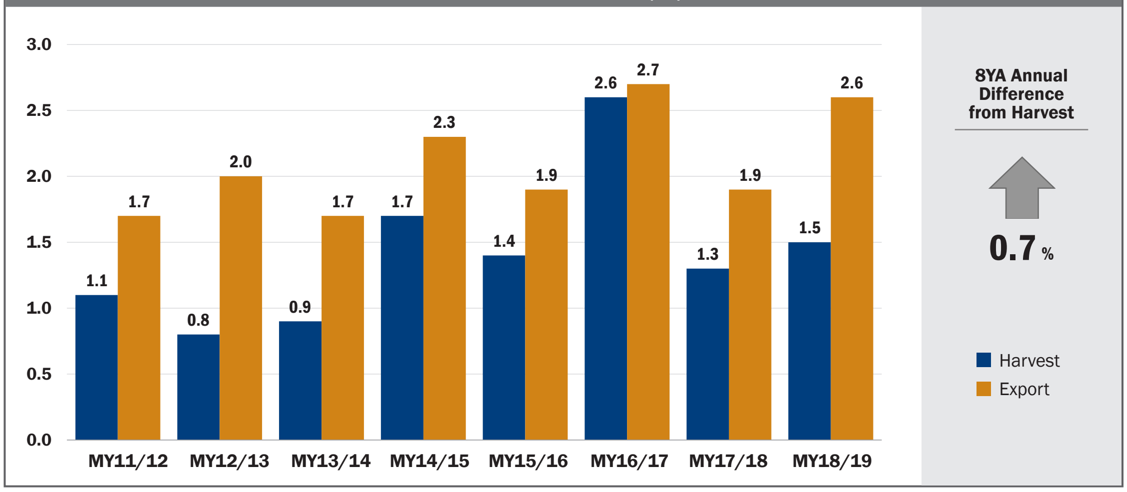


GRADE FACTORS AND MOISTURE
AGGREGATE EIGHT-YEAR HARVEST AND EXPORT CARGO COMPARISON

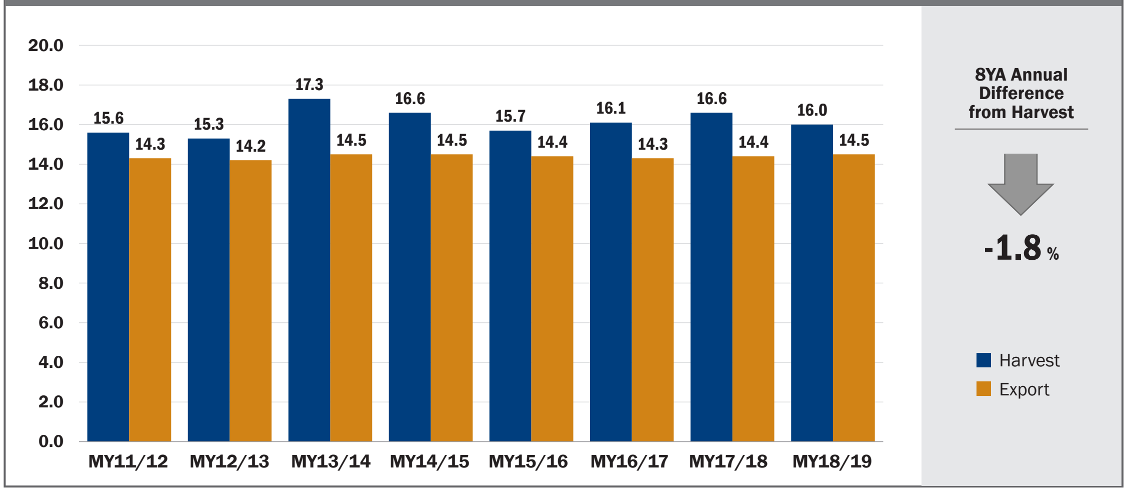
BROKEN CORN AND FOREIGN MATERIAL (%)



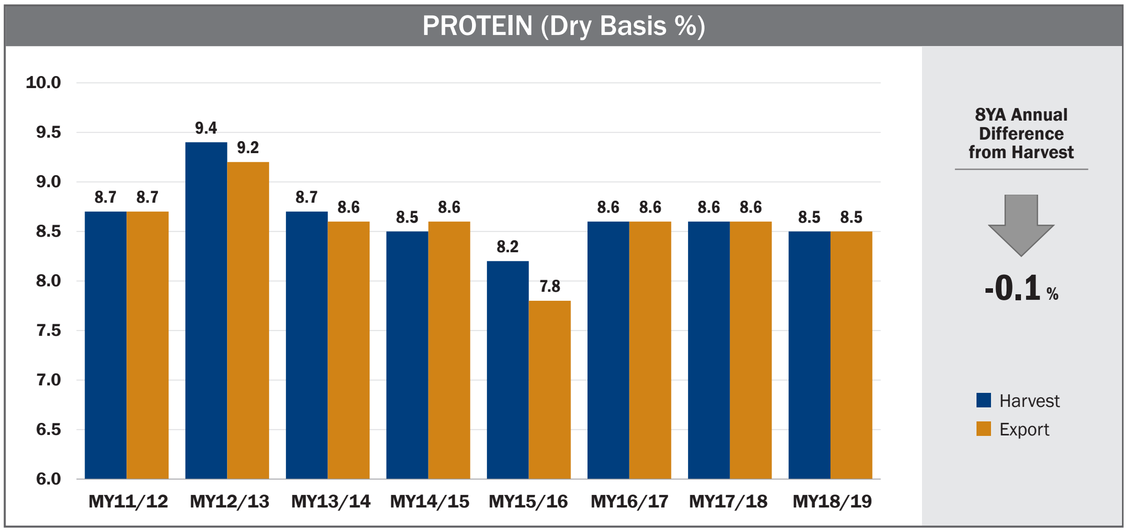
TOTAL DAMAGE (%)

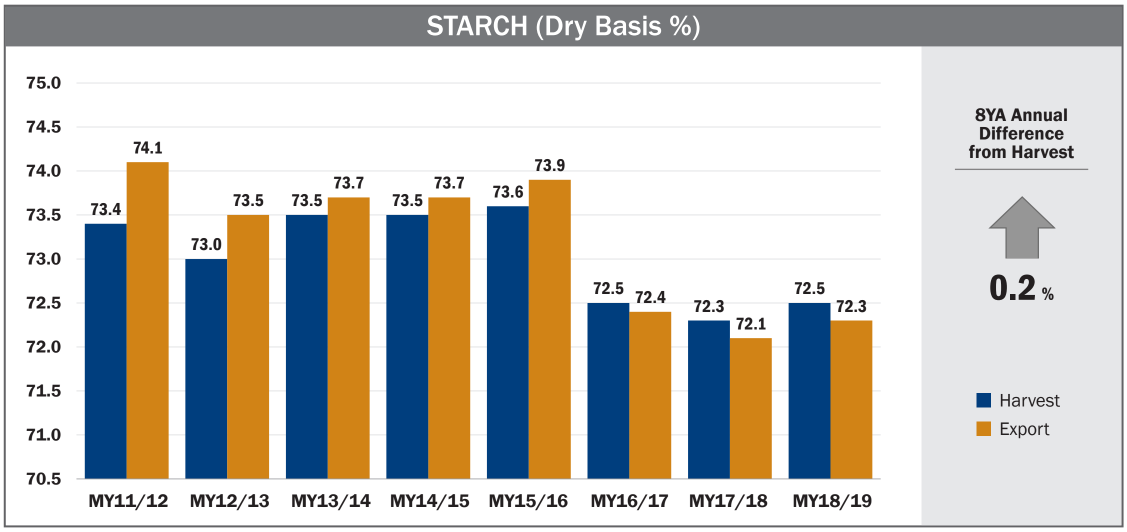


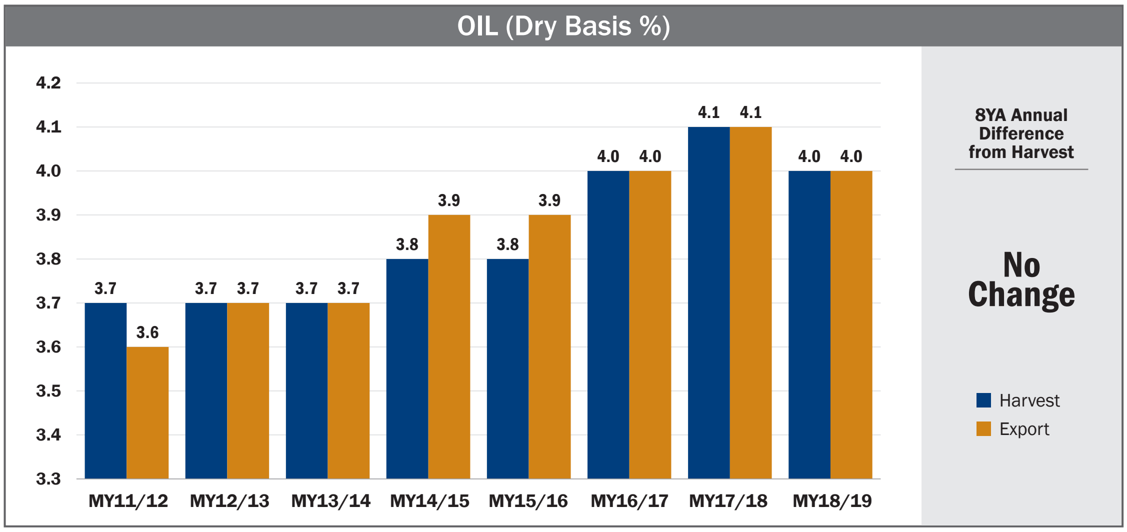
MOISTURE (%)



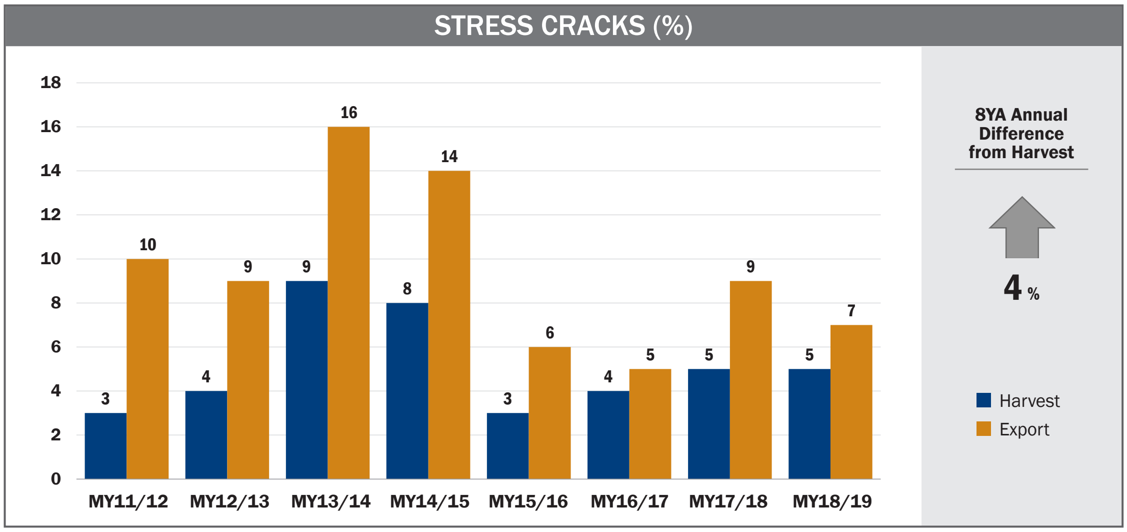
CHEMICAL COMPOSITION
AGGREGATE EIGHT-YEAR HARVEST AND EXPORT CARGO COMPARISON

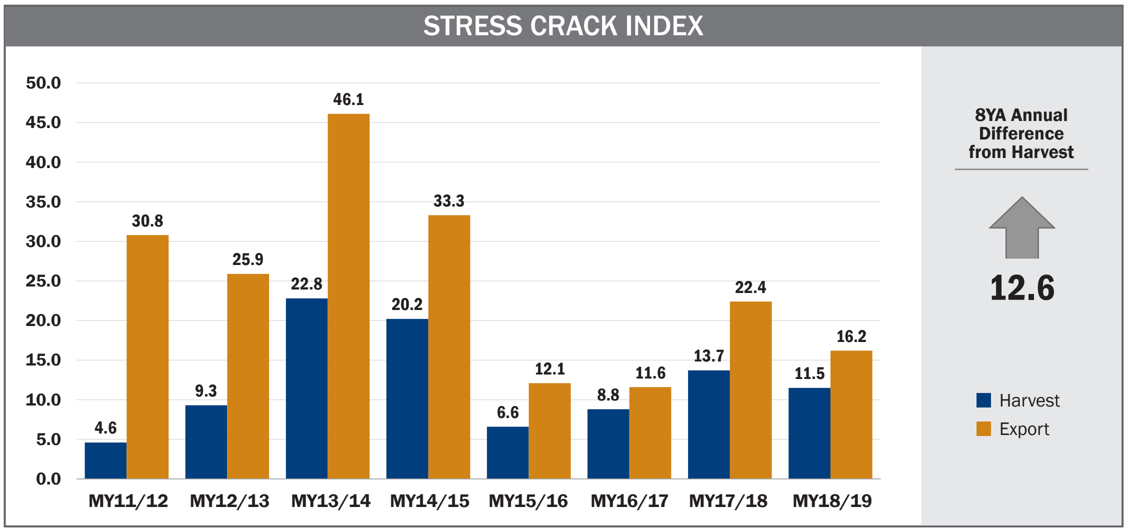


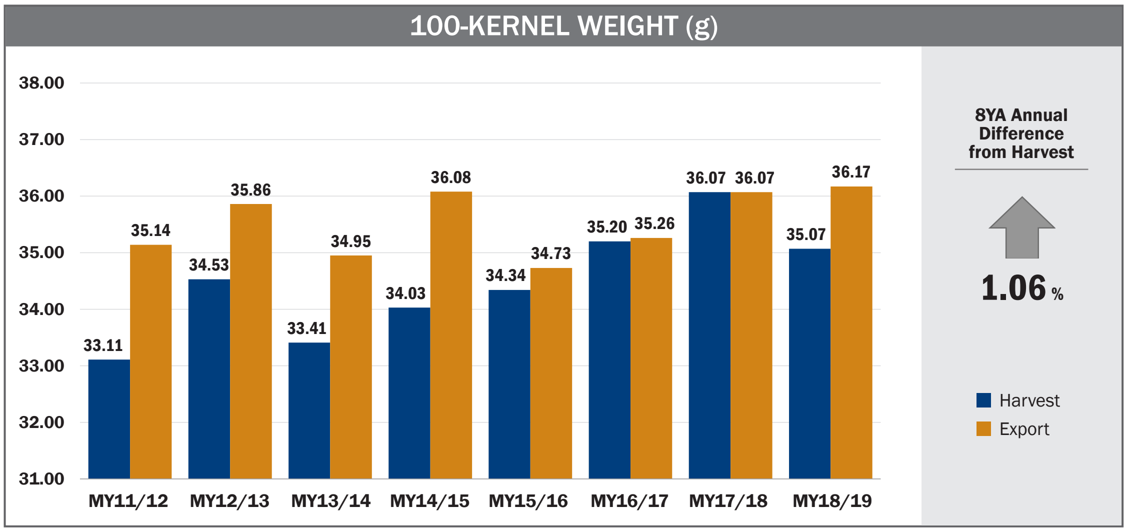




PHYSICAL FACTORS
AGGREGATE EIGHT-YEAR HARVEST AND EXPORT CARGO COMPARISON

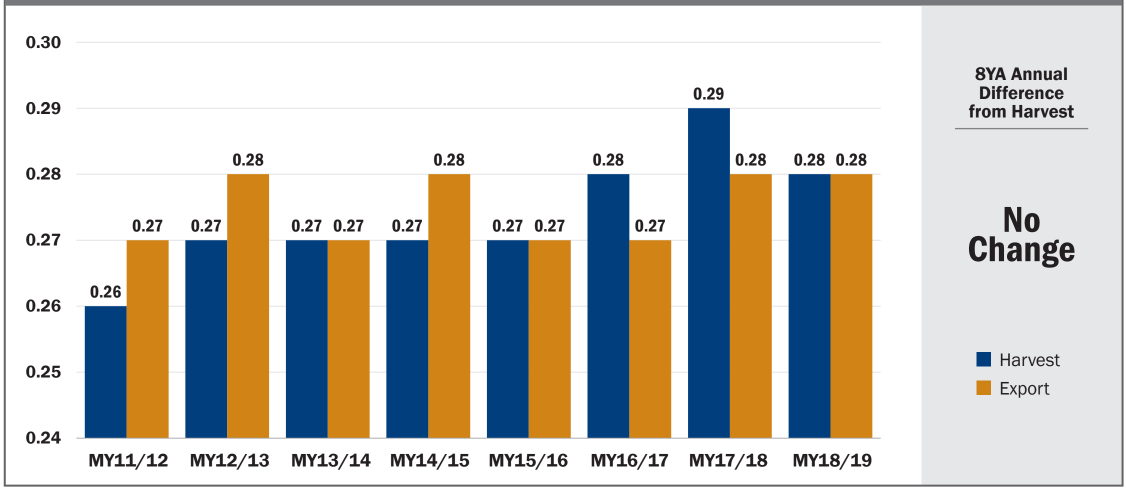




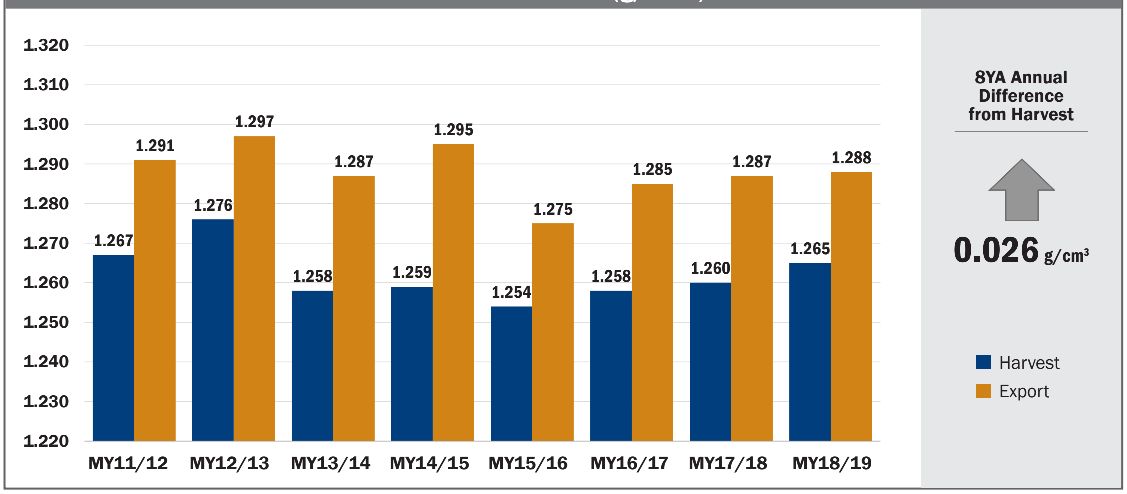


PHYSICAL FACTORS
AGGREGATE EIGHT-YEAR HARVEST AND EXPORT CARGO COMPARISON

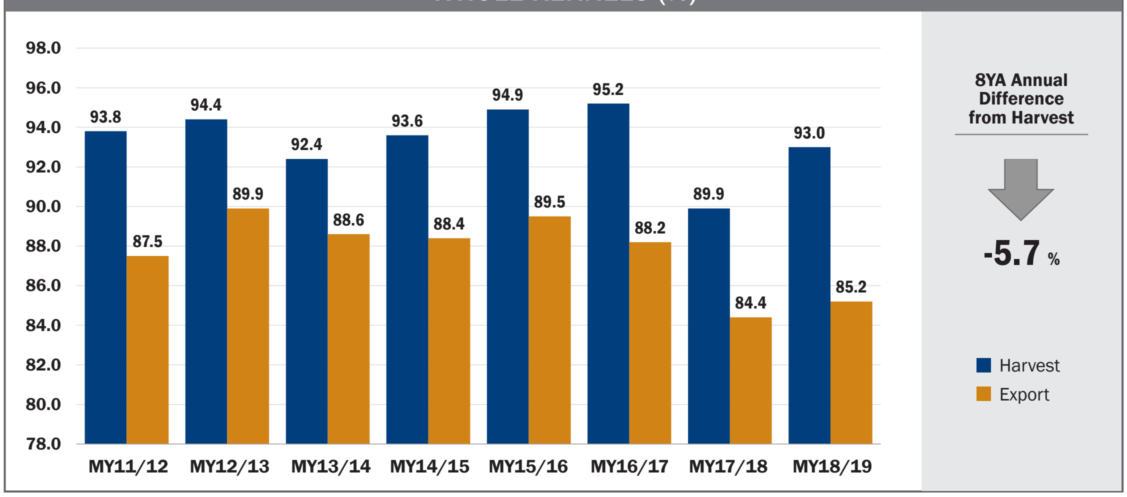
KERNEL VOLUME (cm^3)



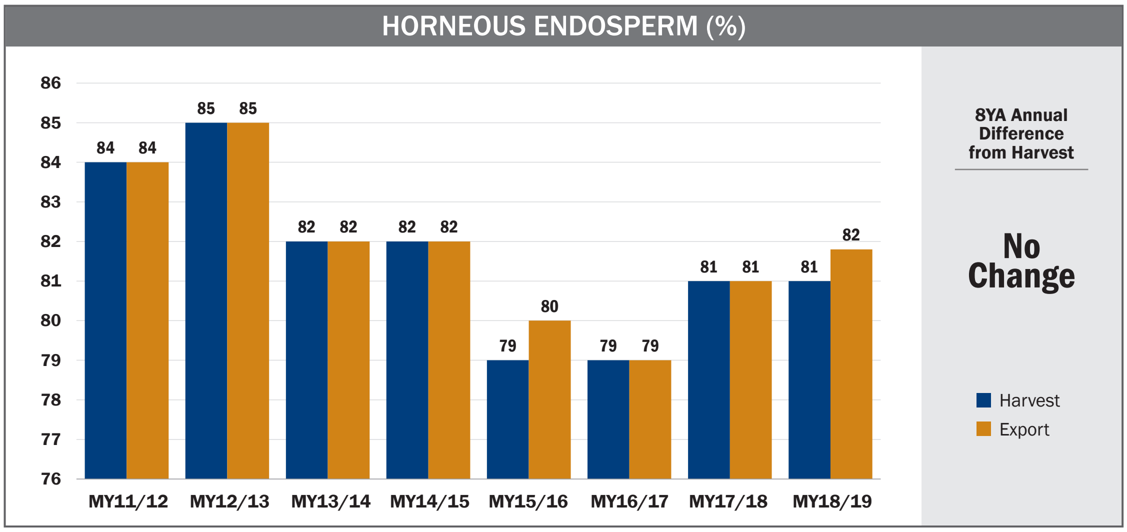
TRUE DENSITY (g/cm^3)



WHOLE KERNELS (%)

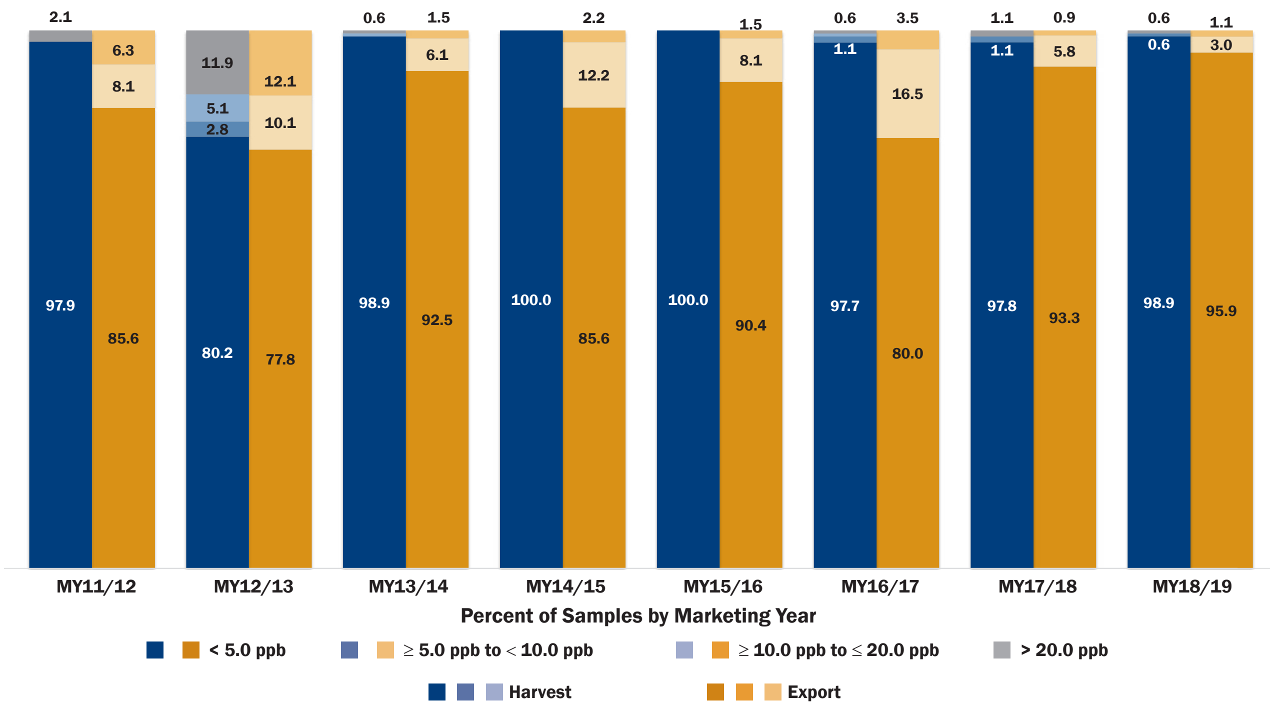


PHYSICAL FACTORS
AGGREGATE EIGHT-YEAR HARVEST AND EXPORT CARGO COMPARISON

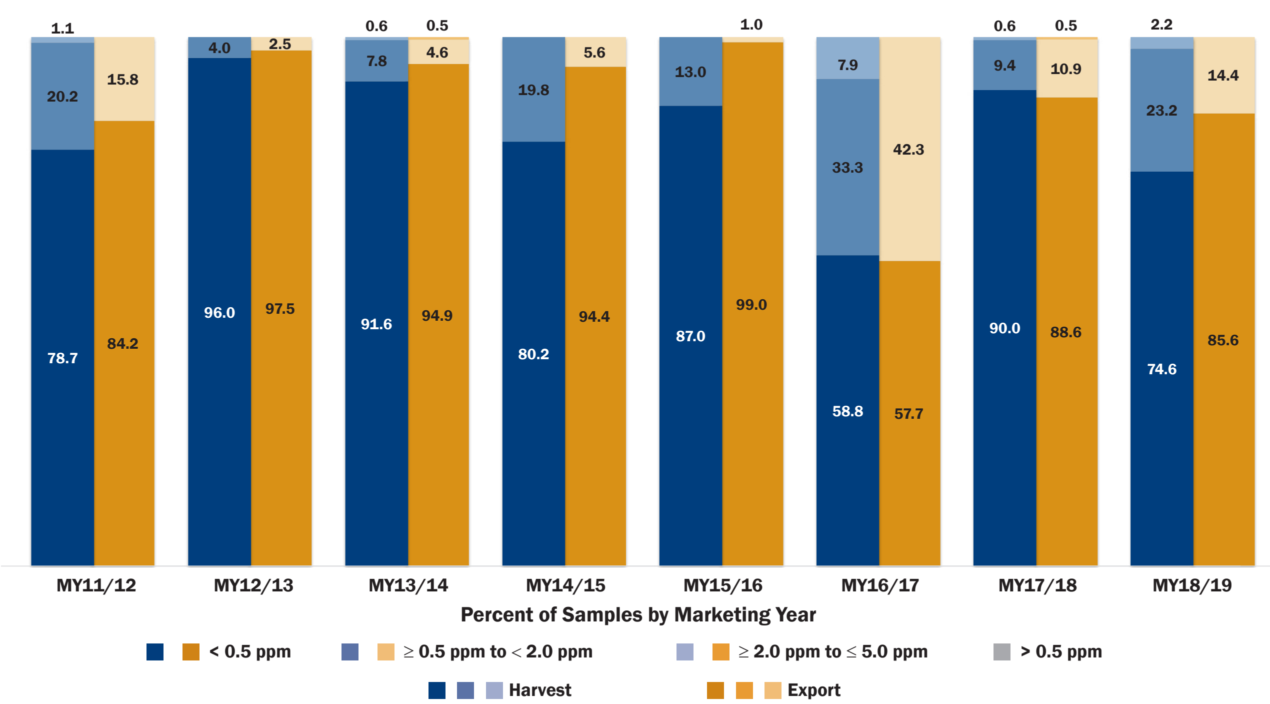


MYCOTOXINS
EIGHT-YEAR HARVEST AND EXPORT CARGO COMPARISON

AFLATOXIN RESULTS (ppb)



DEOXYNIVALENOL (DON OR VOMITOXIN) RESULTS (ppm)



U.S. CORN GRADES AND GRADE REQUIREMENTS

Grade	Minimum Test Weight per Bushel (Pounds)	Maximum Limits of — Damaged Kernels — Heat Damaged (Percent)	Damaged Kernels — Total (Percent)	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% 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 cockleburss (*Xanthium spp.*), or similar seeds singly or in combination, or animal filth in excess of 0.20% in 1,000 g 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. GRAINS COUNCIL

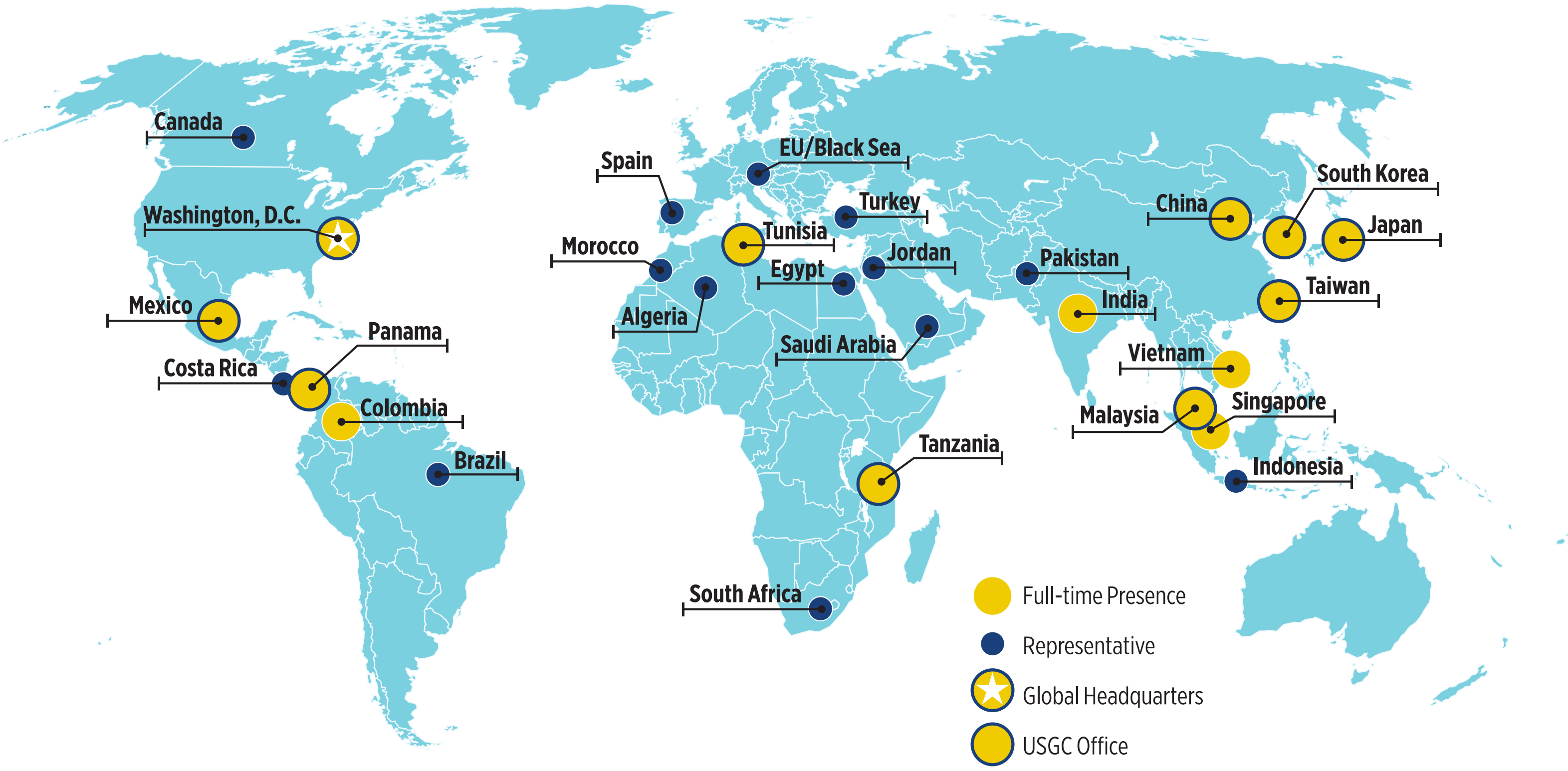
U.S. AND METRIC CONVERSIONS

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 lb
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

ABBREVIATIONS

cm^3 =	cubic centimeters
g =	grams
g/cm^3 =	grams per cubic centimeter
kg/hl =	kilograms per hetoliter
lb/bu =	pounds per bushel
LCL =	lower conformance level
LOD =	limit of detection
ppb =	parts per billion
ppm =	parts per million

U.S. GRAINS COUNCIL



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