U.S. GRAINS COUNCIL

2019/2020 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 Steve Hofing, Lee Singleton, Lisa Eckel and Alex Harvey of Centrec Consulting Group, LLC (Centrec) for their oversight and coordination in developing this report. A team of experts provided analysis and writing support. External team members include Drs. Lowell Hill, Marvin Paulsen and Tom Whitaker. In addition, the Council is indebted to the Illinois Crop Improvement Association's Identity Preserved Grain Laboratory (IPG Lab) for providing the corn quality testing services.

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.

The U.S. Grains Council (USGC) is pleased to present findings from its ninth annual corn quality survey in this *2019/2020 Corn Export Cargo Quality Report*.

The Council is dedicated to the furtherance of global food security and mutual economic benefit and offers this report to promote continuous trade expansion. By providing this reliable and timely report on the quality of U.S. corn destined for export, buyers can make well-informed decisions and have confidence in the capacity and reliability of the U.S. corn market.

The *Corn Export Cargo Quality Report* is the second of two reports released annually by the Council detailing the quality of the 2019 corn crop. The report is based on samples taken at the point of loading for international shipment early in the 2019/2020 marketing year. This report and its sister report, the *2019/2020 Corn Harvest Quality Report*, provide an early look at the grade factors established by the U.S. Department of Agriculture as well as moisture content, chemical composition and other quality characteristics not reported elsewhere. This series of quality reports use a consistent and transparent methodology to allow for insightful comparisons across time.

The Council's mission is one of developing markets, enabling trade and improving lives. To help *Make Something Happen* for U.S. grains and fulfill this mission, the Council is pleased to offer this report as a service to our partners. We hope it continues to provide valuable information about the quality of the U.S. corn crop to our valued trade partners.

Sincerely,

Darren Armstrong
Chairman, U.S. Grains Council
April 2020

The quality of the corn assembled for export early in the 2019/2020 marketing year was impacted by the late planting, delayed maturation and late harvest of the 2019 crop. While the average aggregate quality of the samples tested for the *2019/2020 U.S. Grains Council Corn Harvest Quality Report (Harvest Report)* was better than the grade factor requirements for U.S. No. 1 grade corn, the challenging 2019 growing season forced many U.S. producers to harvest corn at high moisture levels as reflected by the highest average moisture observed in the nine-year history of the *Harvest Report*. The elevated moisture of the corn at harvest necessitated more heated-air drying to reduce moisture content to levels safe for storage compared to previous crops. This likely contributed to aggregate average broken corn and foreign material (BCFM) and stress cracks being slightly higher and whole kernels being lower than the 2018/2019 export samples, respectively.

Despite the challenges faced at harvest, the U.S. marketing channel successfully assembled corn for export with averages that exceeded the test weight and total damage requirements for U.S. No. 1 grade corn. In addition, all but one of the test results for aflatoxin and all of the test results for deoxynivalenol (DON) or vomitoxin were below the U.S. Food and Drug Administration (FDA) action and advisory levels, respectively. Notable U.S. Aggregate results from the *2019/2020 U.S. Grains Council Corn Export Cargo Quality Report* (2019/2020 *Export Cargo Report*) include:

Grade Factors and Moisture

- Lower average **test weight** (56.8 pounds per bushel (lb/bu) or 73.1 kilograms per hectoliter (kg/hl)) than 2018/2019 and the 5YA[1], still indicated overall good quality, with 73.1% of the samples at or above the limit for U.S. No. 1 grade.
- Higher average **BCFM** (3.1%) than 2018/2019, the 5YA and the maximum limit for U.S. No. 2 grade. BCFM predictably increased from 1.0 to 3.1%, as the crop moved from harvest through the marketing channel to export.
- Higher average **total damage** at export (2.9%) than 2018/2019 and the 5YA. Most (90.7%) of the samples were at or below the limit for U.S. No. 2 grade.
- Average **heat damage** was 0.0%, the same as 2018/2019 and the 5YA, indicating good management of drying and storage of corn throughout the marketing channel.
- Average **moisture** (14.5%) same as 2018/2019 and slightly higher than the 5YA.

Chemical Composition

- **Protein** concentration (8.3% dry basis) was slightly lower than 2018/2019 and the 5YA.
- **Starch** concentration (72.2% dry basis) was slightly lower than 2018/2019 and the 5YA.
- **Oil** concentration (4.0% dry basis) was the same as 2018/2019 and the 5YA.

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

[1] *5YA represents the simple average of the quality factor's average or standard deviation from the 2015/2016, 2016/2017, 2016/2017, 2017/2018 and 2018/2019 Export Cargo Reports.*

Physical Factors

- Higher average **stress cracks** (11%) than 2018/2019 and the 5YA. The higher stress crack percentages in 2019/2020 may be due, in part, to higher average moisture at the 2019 harvest than in 2018 and the 5YA. However, the majority of the export samples (74.8%) had less than 15% stress cracks.
- Lower average **100-kernel weight** (35.50 grams) than 2018/2019 and the 5YA, indicating lighter kernels in 2019/2020 than last year and the 5YA.
- Same average **kernel volume** of 0.28 cubic centimeters (cm^3) as 2018/2019 and the 5YA.
- Slightly lower average **true density** (1.278 grams per cubic centimeter (g/cm^3)) than 2018/2019 and the 5YA.
- Lower average percent of **whole kernels** (77.4%) than 2018/2019 and the 5YA.
- Average **horneous (hard) endosperm** of 81%, slightly lower than 2018/2019 but same as the 5YA.

Mycotoxins

- All but one of the samples tested below the FDA action level for **aflatoxin** of 20 parts per billion (ppb). A slightly higher proportion of the export samples had levels of aflatoxin below the Federal Grain Inspection Service (FGIS) "Lower Conformance Limit" of 5.0 ppb in 2019/2020 than in 2018/2019
- All of the samples tested below the 5 parts per million (ppm) FDA advisory level for **DON**, the same as 2018/2019. A lower percentage of samples showed levels of DON below the FGIS Lower Conformance Limit of 0.5 ppm in 2019/2020 than in 2018/2019.
- Of the 180 samples tested for **fumonisin**, 168 or 93.3% tested below the FDA's strictest guidance level for fumonisin of 5.0 ppm.

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 *2019/2020 Export Cargo 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 432 yellow commodity corn samples collected from corn export shipments as they underwent the federal inspection and grading processes performed by the 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.

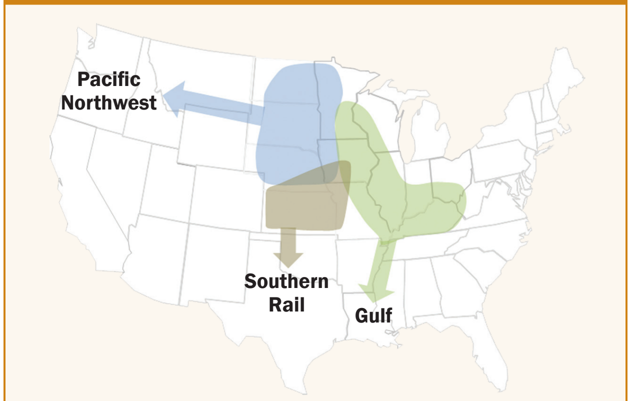
This report provides detailed information on each of the quality factors tested, including average, standard deviation and distribution, for the U.S. Aggregate and for each of the three ECAs. The "Quality Test Results" section summarizes the following quality factors:

- Grade Factors: test weight, BCFM, total damage and heat damage
- Moisture
- Chemical Composition: protein, starch and oil concentrations
- Physical Factors: stress cracks, 100-kernel weight, kernel volume, kernel true density, whole kernels and horneous (hard) endosperm
- Mycotoxins: aflatoxin, DON and fumonisin

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

For the *2019/2020 Export Cargo Report,* FGIS and interior offices collected samples from export shipments loaded from November 2019 through March 2020 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



INTRODUCTION

This *2019/2020 Export Cargo Report* is the ninth 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 nine 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 2019/2020 Corn Harvest Quality Report*, was released in December 2019 and reported on the quality of the corn as it entered the U.S. marketing system. The *2019/2020 Harvest Report* and the *2019/2020 Export Cargo Report* should be studied together so that changes in corn quality occurring between harvest and export can be understood. The "Historical Perspective" section illustrates these changes by displaying the results from this report with all previous *Harvest Reports* and *Export Cargo Reports*.

A. GRADE FACTORS

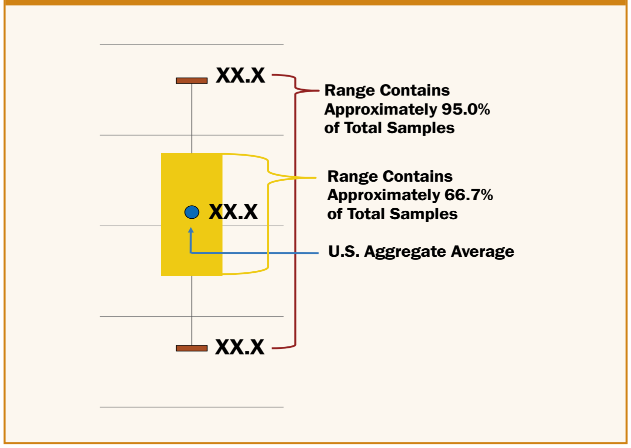
The USDA FGIS has established numerical grades, definitions and standards for measurement of many quality attributes. The attributes that determine the numerical grades for corn are: test weight, BCFM, total damage and heat damage. A table with the numerical requirements for these attributes is in the "U.S. Corn Grades and Conversions" section of this report. Comparisons between contracts loaded as U.S. No. 2 or better and U.S. No. 3 or better could be made only for the Gulf ECA. This year samples from the other two ECA's (with two exceptions) were all one grade.

SUMMARY: GRADE FACTORS AND MOISTURE

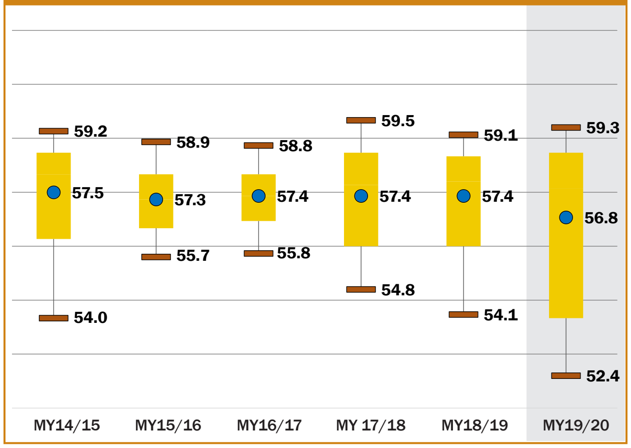
- Average U.S. Aggregate test weight (56.8 lb/bu or 73.1 kg/hl) was lower than 2018/2019, 2017/2018 and the 5YA, but was above the limit for U.S. No. 1 grade (56.0 lb/bu).
- Average U.S. Aggregate BCFM (3.1%) was higher than 2018/2019, 2017/2018 and 5YA (all 2.9%) and only 0.1 percentage point above the U.S. No. 2 grade limit (3.0%). A total of 55.7% of the export samples contained levels at or below the maximum allowed for U.S. No. 2 grade (3.0%), and 83.1% were at or below the limit for U.S. No. 3 grade (4.0%). This is lower than previous years.
- Average BCFM in the Southern Rail ECA (2.2%) was lower than either the Gulf (3.1%) or Pacific Northwest (3.8%) ECAs. Average BCFM for the Southern Rail ECA has been lowest among the ECAs for the previous three years and the 5YA; and average BCFM for the Pacific Northwest ECA has been highest among the ECAs for the previous three years and the 5YA.Average U.S. Aggregate total damage (2.9%) was higher than 2018/2019, 2017/2018 and the 5YA, but below the limit for U.S. No. 1 grade (3.0%). Of the export samples, 59.8% had 3.0% or less damaged kernels, meeting the requirement for U.S. No. 1 grade. In addition, 90.7% 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 the 5YA.
- Average U.S. Aggregate heat damage was 0.0% for 2019/2020, the same as the previous three years and the 5YA.
- Average U.S. Aggregate moisture content (14.5%) was same as 2018/2019, but slightly higher than 2017/2018 and 5YA (both 14.4%).
- A total of 46.9% of the samples had moisture contents above 14.5% which is higher than the previous two years, indicating care should be taken in checking moistures and monitoring storage conditions.

GRADE FACTORS
AGGREGATE SIX-YEAR COMPARISON

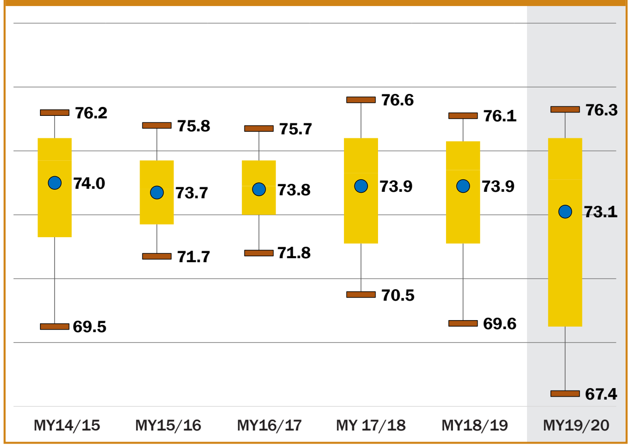
HOW TO READ THE CHARTS



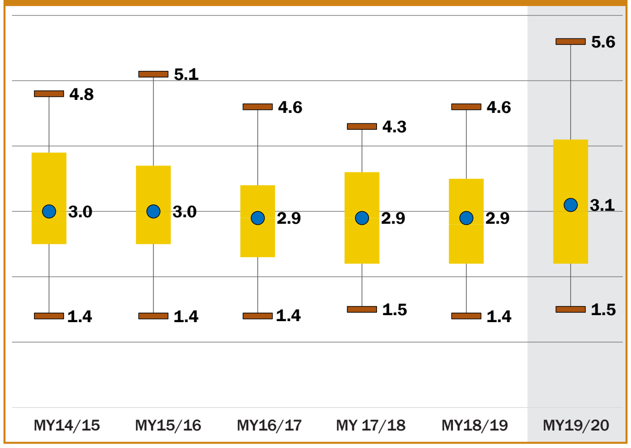
TEST WEIGHT (lb/bu)



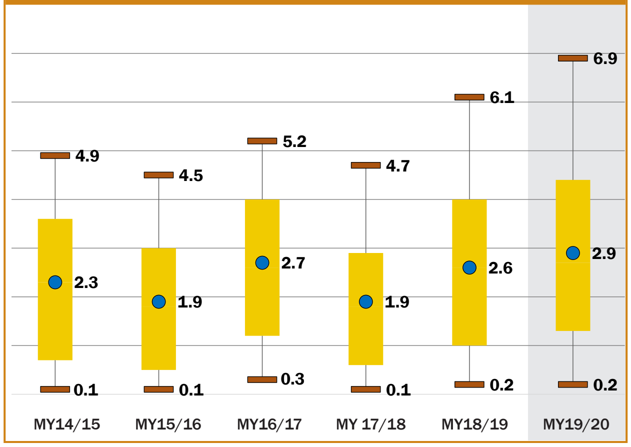
TEST WEIGHT (kg/hl)



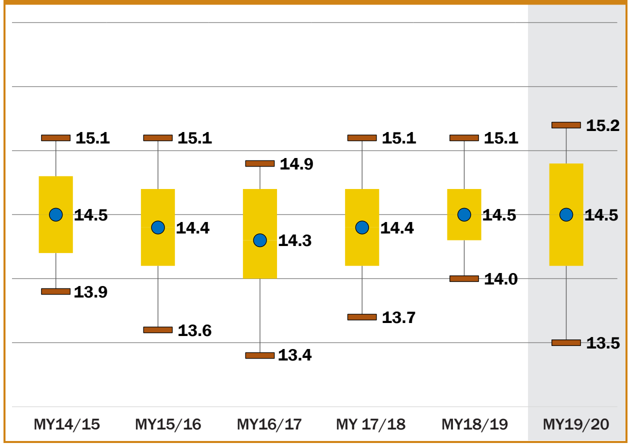
BROKEN CORN AND FOREIGN MATERIAL (%)



TOTAL DAMAGE (%)



MOISTURE (%)



Test Weight

Test weight (weight per volume) is a measure of bulk density. It 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.

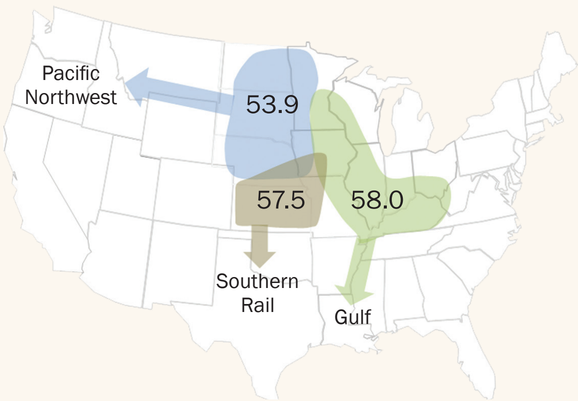
Results

- Average U.S. Aggregate test weight (56.8 lb/bu or 73.1 kg/hl), well above the limit for U.S. No. 1 grade (56.0 lb/bu), was lower than 2018/2019, 2017/2018 and 5YA (all 57.4 lb/bu or 73.9 kg/hl). The 2019/2020 export samples had a standard deviation (1.00 lb/bu), higher than 2018/2019 (0.82 lb/bu), 2017/2018 (0.85 lb/bu) and the 5YA (0.79 lb/bu). The range in values in 2019/2020 was 9.7 lb/bu higher than 2018/2019 (7.6 lb/bu) and to 2017/2018 (6.9 lb/bu).
- Average U.S. Aggregate test weight for 73.1% of the 2019/2020 samples was at or above the minimum for U.S. No. 1 grade (56.0 lb/bu), and 84.0% 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 (56.8 lb/bu or 73.1 kg/hl) was lower than 2019 harvest (57.3 lb/bu or 73.8 kg/hl). The 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 (58.2 lb/bu or 74.9 kg/hl).
- The variability of the 2019/2020 export samples as measured by the standard deviation (1.00 lb/bu) was less than that of the 2019 harvest samples (1.41 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 0.79 lb/bu, compared with the harvest 5YA standard deviation of 1.21 lb/bu.
- The average test weight was lower for the Pacific Northwest (53.9 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 Gulf ECA contracts loaded as U.S. No. 2 or better (58.0 lb/bu) was similar to Gulf ECA contracts loaded as U.S. No. 3 or better (58.1 lb/bu). Comparisons for the other two ECAs could not be made.

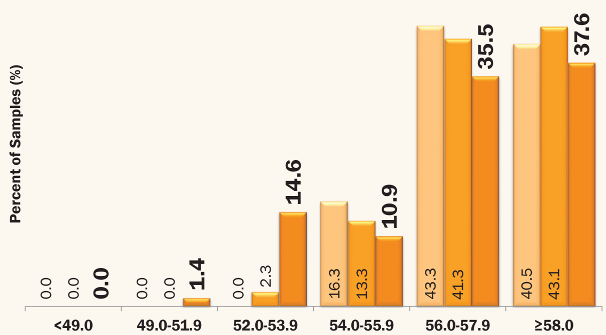
U.S. Grade Minimum Test Weight
No. 1: 56.0 lb
No. 2: 54.0 lb
No. 3: 52.0 lb
No. 4: 49.0 lb
No. 5: 46.0 lb
Sample: <46.0 lb

TEST WEIGHT (lb/bu)

EXPORT CATCHMENT AREA AVERAGE



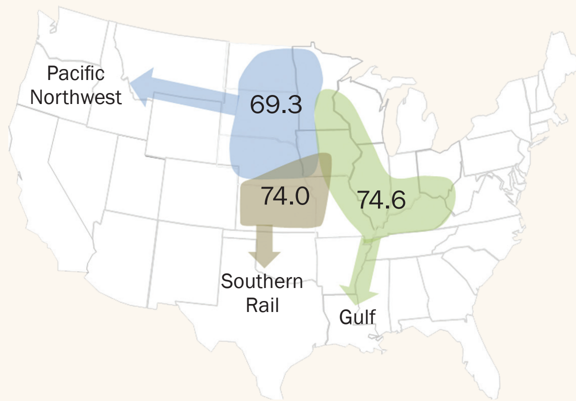
U.S. AGGREGATE



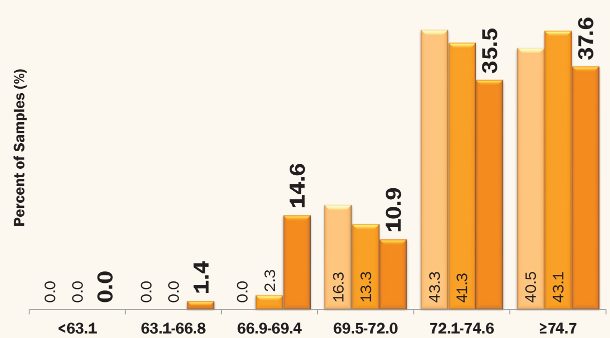
	Avg	Std Dev
MY17/18	57.4	0.85
MY18/19	57.4	0.82
MY19/20	56.8	1.00

TEST WEIGHT (kg/hl)

EXPORT CATCHMENT AREA AVERAGE



U.S. AGGREGATE



	Avg	Std Dev
MY17/18	73.9	1.10
MY18/19	73.9	1.05
MY19/20	73.1	1.29

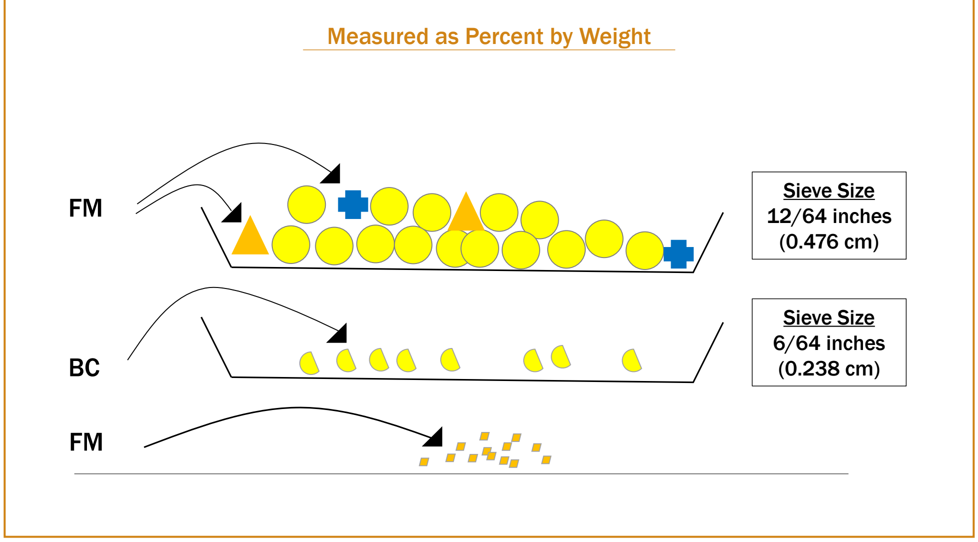
Broken Corn and Foreign Material

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 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



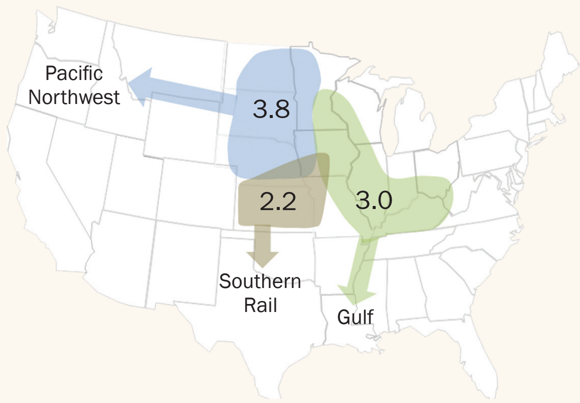
U.S. Grade Broken Corn and Foreign Material Maximum Limits	
No. 1:	2.0%
No. 2:	3.0%
No. 3:	4.0%
No. 4:	5.0%
No. 5:	7.0%
Sample:	>7%

Results

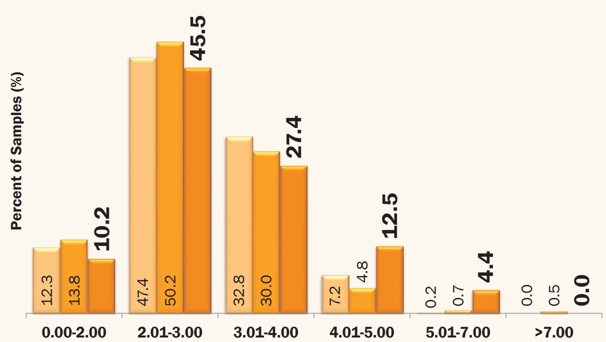
- Average U.S. Aggregate BCFM in export samples (3.1%) was higher than 2018/2019, 2017/2018 and 5YA (all 2.9%) and just above the U.S. No. 2 grade limit (3.0%).
- The variability of the 2019/2020 export samples (with a standard deviation of 0.79%) was higher than 2018/2019 (0.67%), 2017/2018 (0.59%), and the 5YA (0.66%). The range in values (5.9%) was narrower than 2018/2019 (8.4%) but higher than 2017/2018 (4.9%).
- BCFM in the 2018/2019 export samples was distributed with 55.7% of the samples at or below the limit for U.S. No. 2 grade (3.0%), and 83.1% at or below the limit for U.S. No. 3 grade (4.0%). In 2018/2019, 64.0 and 94.0% of the samples were at or below the limit for U.S. No. 2 grade and U.S. No. 3 grade, respectively.
- Average U.S. Aggregate BCFM at export (3.1%) was 2.1 percentage points higher than at harvest (1.0%). This difference also occurred for the 5YA; the harvest 5YA was 0.8% compared to the export 5YA of 2.9%. 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 (2.2%) was lower than either the Gulf (3.1%) or Pacific Northwest (3.8%) 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 for the Pacific Northwest ECA has been highest among the ECAs for the previous three years and the 5YA.
- For the Gulf ECA, contracts loaded as U.S. No. 2 or better had average BCFM of 2.9% compared to the average BCFM of 3.6% contracts loaded as U.S. No. 3 or better.

BROKEN CORN AND FOREIGN MATERIAL (%)

EXPORT CATCHMENT AREA AVERAGE



U.S. AGGREGATE



	Avg	Std Dev
MY17/18	2.9	0.59
MY18/19	2.9	0.67
MY19/20	3.1	0.79

Total Damage

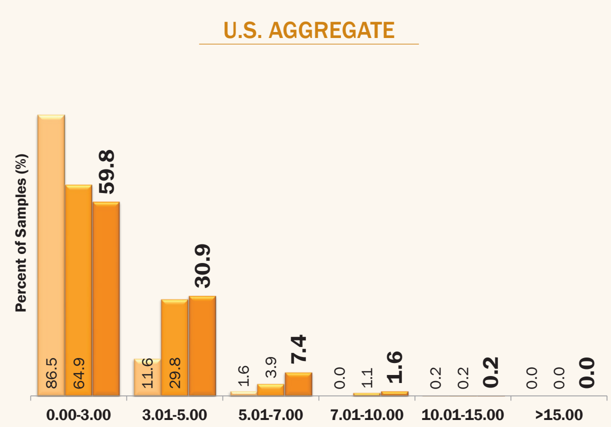
Total damage is the percent of kernels and pieces of kernels that are visually damaged in some way, including damage from heat, frost, insects, sprouting, disease, weather, ground, germ and mold. Most of these types of damage result in some sort of discoloration or change in kernel texture. Damage does 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 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 (2.9%) was higher than 2018/2019 (2.6%), 2017/2018 (1.9%) and the 5YA (2.3%) but was below the limit for U.S. No. 1 grade (3.0%).
- Variability in the 2019/2020 samples, as indicated by the standard deviation (1.37%), was higher than 2018/2019 (1.10%) and 2017/2018 (1.02%) and the 5YA (1.00%). The 2019/2020 sample range (0.1 to 10.8%) was similar to 2018/2019 sample range (0.0 to 10.5%) was similar to the 2017/2018 range (0.0 to 10.4%).
- Of the export samples, 59.8% had 3.0% or less damaged kernels, meeting the requirement for U.S. No. 1 grade. In addition, 90.7% 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 (2.9%) was higher than at harvest (2.7%). The export 5YA (2.3%) was 0.6 percentage points higher than the harvest 5YA (1.7%). Total damage can increase during storage, especially if there are spoutlines and pockets of high moisture in the storage bins or transport containers.

TOTAL DAMAGE (%)



	Avg	Std Dev
MY17/18	1.9	1.02
MY18/19	2.6	1.10
MY19/20	2.9	1.37

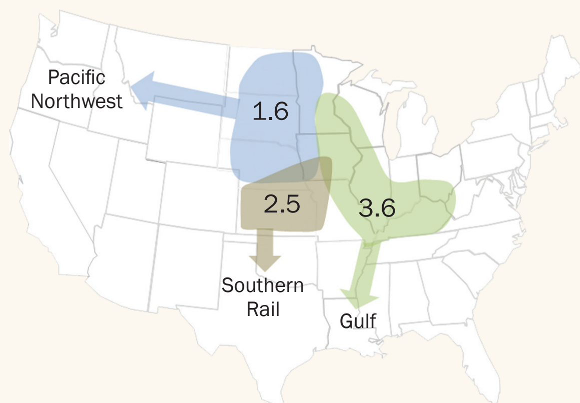
- The Pacific Northwest ECA had lower average total damage (1.6%) than the Gulf (3.6%) and the Southern Rail (2.5%) ECAs. The Pacific Northwest ECA also had the lowest average total damage among the ECAs for each of the last three years and the 5YA.

- Average total damage was 3.6% for Gulf ECA contracts being loaded as U.S. No. 2 or better compared to those loaded as U.S. No. 3 or better (3.7%).

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 (%)

EXPORT CATCHMENT AREA AVERAGE



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 2018/2019, 2017/2018 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 5 samples in the entire 2019/2020 export cargo sample set (total of 431 samples) showed any heat damage (Of the five samples, three were 0.1% and two were 0.2%).

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]

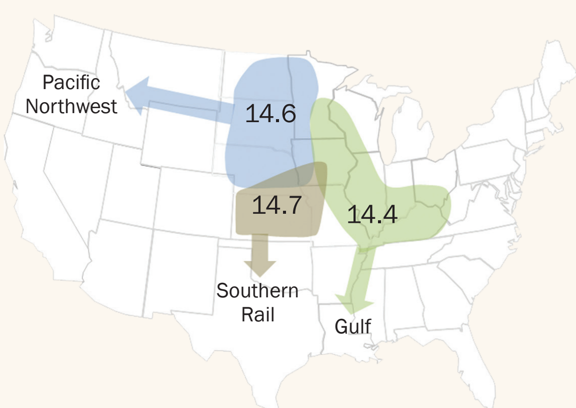
[1] *WWPS-13. 2017. Grain drying, handling and storage handbook. Midwest Plan Service No. 13 third edition. Iowa State University, Ames, IA 50011.*

Results

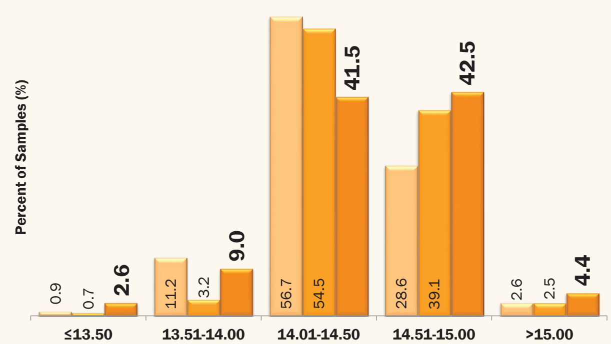
- Average U.S. Aggregate moisture content (14.5%) was the same as 2018/2019, but slightly higher than 2017/2018 and the 5YA (both 14.4%).
- Moisture content standard deviation for the 2019/2020 samples (0.39%) was slightly higher than 2018/2019 (0.28%), 2017/2018 (0.29%) and the 5YA (0.31%).
- The moisture content of the samples ranged from 12.4 to 15.6%, or 3.2 percentage points. This range is greater than 2018/2019 (2.4 percentage points) and 2017/2018 (2.2 percentage points).
- Average moisture content decreased between harvest (17.5%) and export (14.5%) and uniformity among samples increased, as indicated by the lower standard deviation at export (0.39%) compared with harvest (2.35%). 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 2019/2020 samples, 46.9% had a moisture content above 14.5%, which was higher than the 41.6% in 2018/2019 and 31.2% in 2017/2018. The 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.
- Average moisture content in the Pacific Northwest ECA (14.6%) was similar to the Gulf (14.4%) and Southern Rail (14.6%) ECAs.
- Average moisture was slightly lower for Gulf ECA contracts loaded as U.S. No. 2 or better (14.3%) than for Gulf ECA contracts loaded as U.S. No. 3 or better (14.5%). The moisture standard deviation for Gulf ECA contracts loaded as U.S. No. 2 or better (0.42%) was similar to that for contracts loaded as U.S. No. 3 or better (0.41).

MOISTURE (%)

EXPORT CATCHMENT AREA AVERAGE



U.S. AGGREGATE



	Avg	Std Dev
MY17/18	14.4	0.29
MY18/19	14.5	0.28
MY19/20	14.5	0.39

SUMMARY: GRADE FACTORS AND MOISTURE

	2019/2020 Export Cargo					2018/2019 Export Cargo			2017/2018 Export Cargo			5 Year Avg. (2014-2018)	
	No. of Samples	Avg.	Std. Dev.	Min.	Max.	No. of Samples	Avg.	Std. Dev.	No. of Samples	Avg.	Std. Dev.	Avg.	Std. Dev.
U.S. Aggregate													
Test Weight (lb/bu)	431	56.8	1.00	50.4	60.1	436	57.4*	0.82	430	57.4*	0.85	57.4	0.79
Test Weight (kg/hl)	431	73.1	1.29	64.9	77.4	436	73.9*	1.05	430	73.9*	1.10	73.9	1.02
BCFM (%)	431	3.1	0.79	0.9	7.0	436	2.9*	0.67	430	2.9*	0.59	2.9	0.66
Total Damage (%)	430	2.9	1.37	0.1	10.8	436	2.6*	1.10	430	1.9*	1.02	2.3	1.00
Heat Damage (%)	431	0.0	0.01	0.0	0.2	436	0.0	0.01	430	0.0	0.01	0.0	0.01
Moisture (%)	431	14.5	0.39	12.4	15.6	435	14.5	0.28	430	14.4*	0.29	14.4	0.31
Gulf													
Test Weight (lb/bu)	242	58.0	0.76	55.1	59.9	275	58.0	0.66	276	57.8*	0.9	57.8	0.76
Test Weight (kg/hl)	242	74.6	0.97	70.9	77.1	275	74.7	0.85	276	74.4*	1.2	74.4	0.97
BCFM (%)	242	3.0	0.69	1.2	5.6	275	2.9*	0.53	276	2.9*	0.6	2.9	0.58
Total Damage (%)	241	3.6	1.50	0.6	10.8	275	3.3*	1.37	276	2.2*	1.2	2.7	1.14
Heat Damage (%)	242	0.0	0.02	0.0	0.2	275	0.0	0.02	276	0.0	0.0	0.0	0.01
Moisture (%)	242	14.4	0.43	12.7	15.6	274	14.5*	0.23	276	14.5*	0.3	14.4	0.30
Pacific Northwest													
Test Weight (lb/bu)	117	53.9	1.37	50.4	60.1	96	55.5*	1.23	87	55.6*	0.7	56.0	0.92
Test Weight (kg/hl)	117	69.3	1.76	64.9	77.4	96	71.4*	1.58	87	71.6*	0.9	72.1	1.19
BCFM (%)	117	3.8	1.17	1.7	7.0	96	3.5*	1.17	87	3.6	0.7	3.6	0.96
Total Damage (%)[1]	117	1.6	1.47	0.1	7.7	96	0.7*	0.61	87	0.6*	0.5	0.7	0.61
Heat Damage (%)	117	0.0	0.02	0.0	0.2	96	0.0	0.01	87	0.0	0.0	0.0	0.01
Moisture (%)	117	14.6	0.28	14.0	15.4	96	14.4*	0.28	87	14.2*	0.3	14.3	0.26
Southern Rail													
Test Weight (lb/bu)	72	57.5	1.24	54.2	59.4	65	57.5	0.86	67	58.2*	0.7	57.6	0.75
Test Weight (kg/hl)	72	74.0	1.60	69.8	76.5	65	74.0	1.11	67	74.9*	0.9	74.2	0.96
BCFM (%)	72	2.2	0.53	0.9	3.8	65	1.9*	0.53	67	2.1	0.5	2.0	0.57
Total Damage (%)	72	2.5	0.78	1.0	4.9	65	2.4	0.75	67	2.4	0.8	2.5	0.98
Heat Damage (%)	72	0.0	0.00	0.0	0.0	65	0.0	0.00	67	0.0	0.0	0.0	0.00
Moisture (%)	72	14.7	0.47	12.4	15.3	65	14.6	0.45	67	14.3*	0.3	14.5	0.40

**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.*

[1]The relative margin of error for predicting population average exceeded 10%.

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					2019 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						**U.S. Aggregate**					**U.S. Aggregate**				
Test Weight (lb/bu)	241	57.9	0.82	54.2	59.9	178	55.3	1.24	50.4	60.1	623	57.3**	1.41	42.6	61.9
Test Weight (kg/hl)	241	74.5	1.06	69.8	77.1	178	71.2	1.59	64.9	77.4	623	73.8**	1.81	54.8	79.7
BCFM (%)	241	2.7	0.48	1.1	4.7	178	3.8	1.07	1.2	7.0	623	1.0**	0.67	0.0	8.2
Total Damage (%)	240	3.3	1.17	0.6	7.4	178	2.3	1.65	0.1	10.8	623	2.7	2.43	0.0	50.5
Heat Damage (%)	241	0.0	0.01	0.0	0.2	178	0.0	0.02	0.0	0.2	623	0.0	0.00	0.0	0.0
Moisture (%)	241	14.4	0.43	12.4	15.3	178	14.6	0.32	13.2	15.6	613	17.5**	2.35	11.0	30.0
Gulf						**Gulf**					**Gulf**				
Test Weight (lb/bu)	182	58.0	0.67	56.2	59.9	59	58.1	0.98	55.1	59.8	594	57.8**	1.27	48.0	61.9
Test Weight (kg/hl)	182	74.6	0.86	72.3	77.1	59	74.7	1.26	70.9	77.0	594	74.4**	1.64	61.8	79.7
BCFM (%)	182	2.9	0.49	1.4	4.7	59	3.6	0.87	1.2	5.6	594	0.9**	0.61	0.0	5.1
Total Damage (%)	181	3.6	1.29	0.6	7.4	59	3.7	2.02	1.0	10.8	594	3.0**	2.50	0.0	50.5
Heat Damage (%)	182	0.0	0.01	0.0	0.2	59	0.0	0.02	0.0	0.1	594	0.0	0.00	0.0	0.0
Moisture (%)	182	14.3	0.42	12.7	15.3	59	14.5	0.41	13.2	15.6	594	17.6**	2.32	11.0	30.0
Pacific Northwest						**Pacific Northwest**					**Pacific Northwest**				
Test Weight (lb/bu)	0	-	-	-	-	117	53.9	1.37	50.4	60.1	318	55.7**	1.80	42.6	61.9
Test Weight (kg/hl)	0	-	-	-	-	117	69.3	1.76	64.9	77.4	318	71.7**	2.31	54.8	79.7
BCFM (%)	0	-	-	-	-	117	3.8	1.17	1.7	7.0	318	1.2**	0.88	0.0	8.2
Total Damage (%)	0	-	-	-	-	117	1.6	1.47	0.1	7.7	318	2.6**	3.02	0.0	50.5
Heat Damage (%)	0	-	-	-	-	117	0.0	0.02	0.0	0.2	318	0.0	0.00	0.0	0.0
Moisture (%)	0	-	-	-	-	117	14.6	0.28	14.0	15.4	318	18.3**	2.96	11.5	29.6
Southern Rail						**Southern Rail**					**Southern Rail**				
Test Weight (lb/bu)	59	57.6	1.30	54.2	59.4	2	57.2	1.23	56.4	58.1	324	58.6**	1.18	51.9	61.9
Test Weight (kg/hl)	59	74.1	1.68	69.8	76.4	2	73.7	1.58	72.6	74.8	324	75.4**	1.52	66.8	79.7
BCFM (%)	59	2.2	0.45	1.1	3.0	2	3.2	0.80	2.7	3.8	324	0.8**	0.47	0.0	3.8
Total Damage (%)	59	2.5	0.82	1.2	4.9	2	2.4	1.04	1.6	3.1	324	2.3	1.27	0.0	27.9
Heat Damage (%)	59	0.0	0.00	0.0	0.0	2	0.0	0.00	0.0	0.0	324	0.0	0.00	0.0	0.0
Moisture (%)	59	14.7	0.48	12.4	15.3	2	14.3	0.73	13.8	14.8	324	16.0**	1.42	11.0	27.2

***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.*

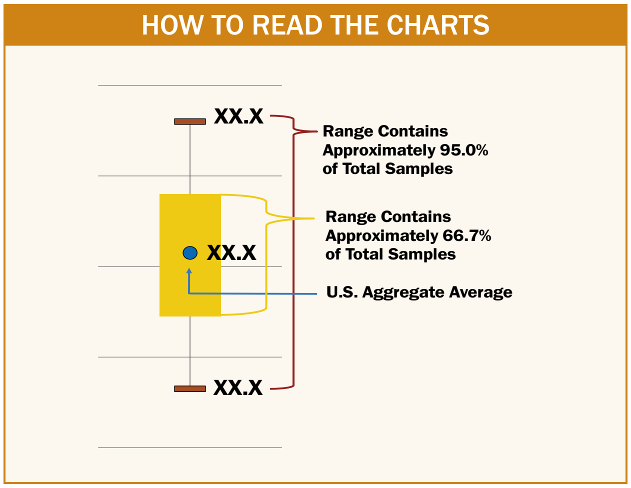
C. CHEMICAL COMPOSITION

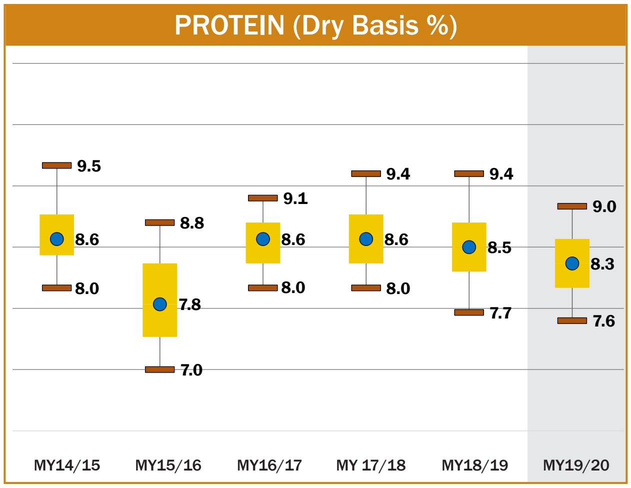
The chemical composition of corn consists primarily of protein, starch, and oil. While these attributes are not grade factors, they are of significant interest to end-users. Chemical composition values provide additional information related to nutritional value for livestock and poultry feeding, for 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. Comparisons between contracts loaded as U.S. No. 2 or better and U.S. No. 3 or better could be made only for the Gulf ECA. The other two ECA's (with two exceptions) had all of their samples in only one grade grouping.

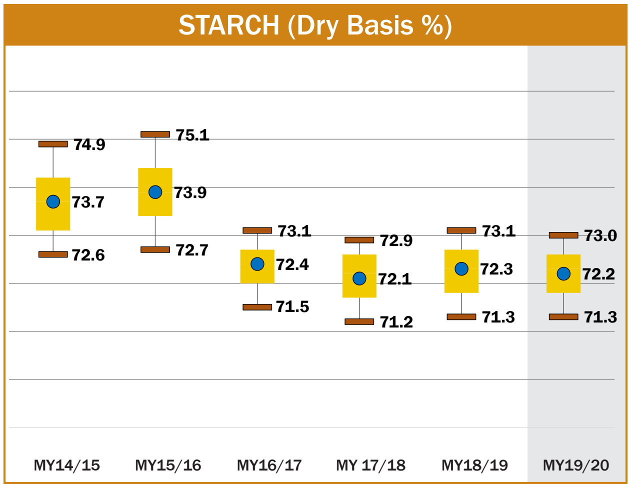
SUMMARY: CHEMICAL COMPOSITION

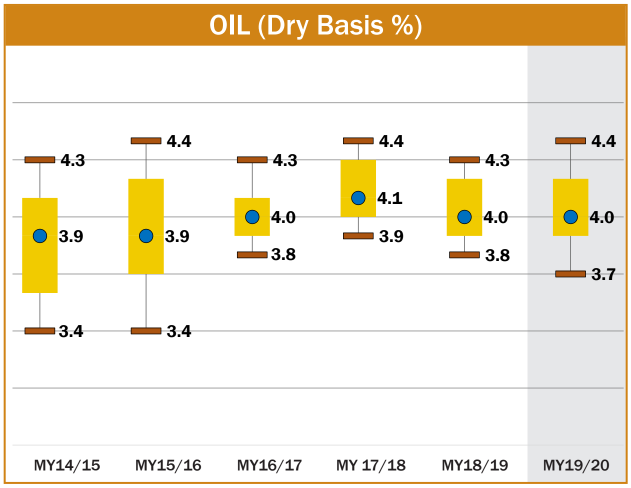
- Average U.S. Aggregate protein concentration at export (8.3%) was lower than 2018/2019, and 2017/2018 and the 5YA and the 2019 harvest average.
- Average U.S. Aggregate starch concentration (72.2%) was the lower than 2018/2019, slightly higher than 2017/2018, but lower than the 5YA and the 2019 harvest average.
- Average U.S. Aggregate oil concentration (4.0%) was the same as 2018/2019, lower than 2017/2018, but the same as 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.

CHEMICAL COMPOSITION
AGGREGATE SIX-YEAR COMPARISON









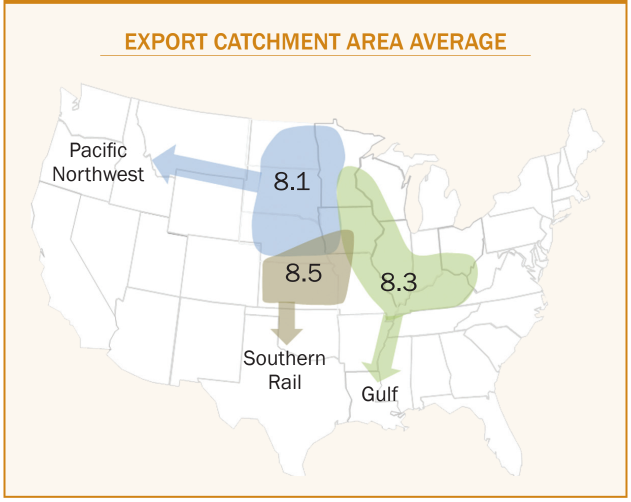
Protein

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

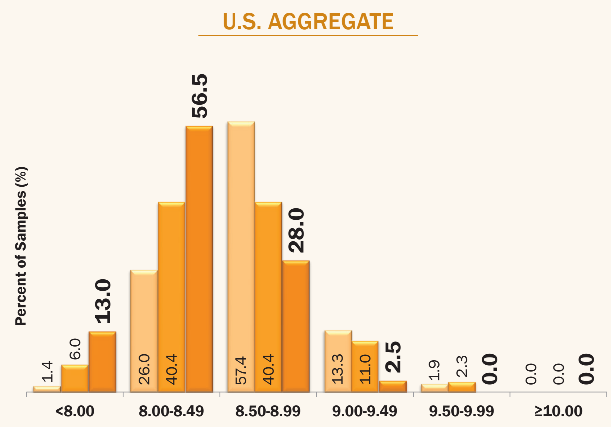
- Average U.S. Aggregate protein concentration (8.3%) was lower than 2018/2019 (8.5%), 2017/2018 (8.6%) and the 5YA (8.4%) but the same as the average U.S. Aggregate protein concentration for the 2019 harvest.
- The 2019/2020 export samples (standard deviation of 0.29%) were more uniform than the 2019 harvest samples (standard deviation of 0.54%). In addition, the range of protein concentrations at export (7.1 to 9.3%) was narrower than at harvest (6.2 to 10.4%). The uniformity is due, in part, to grains becoming more homogenous as they are aggregated from numerous harvest-level sources.

PROTEIN (Dry Basis %)



- The 2019/2020 export samples were distributed with 30.5% of protein concentrations at or above 8.5%, compared with 53.7% of the 2018/2019 samples, 72.6% of the 2017/2018 samples.
- The Gulf ECA (8.3%) had a lower average protein concentration than the Southern Rail ECA (8.5%) but higher than the Pacific Northwest ECA (8.1%).
- Average protein concentration for Gulf ECA contracts loaded as U.S. No. 2 or better (8.3%) was the same as that for Gulf ECA contracts loaded as U.S. No. 3 or better (8.3%). Comparisons for the other two ECAs could not be made.

PROTEIN (Dry Basis %)



	Avg	Std Dev
MY17/18	8.6	0.29
MY18/19	8.5	0.37
MY19/20	8.3	0.29

Starch

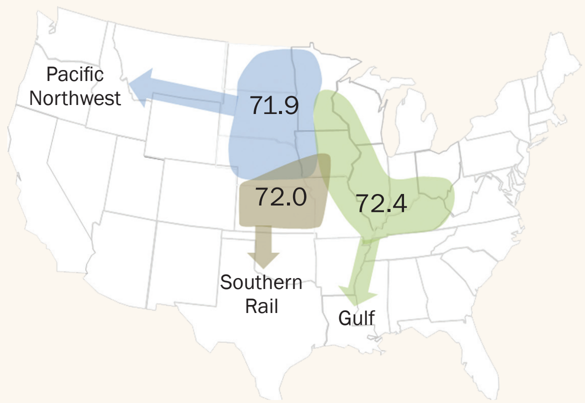
Starch is an important factor for corn used by wet millers and dry-grind ethanol manufacturers. High starch concentration is often indicative of good kernel growing/filling conditions and reasonably moderate kernel densities. Starch is usually inversely related to protein concentration on a single sample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

Results

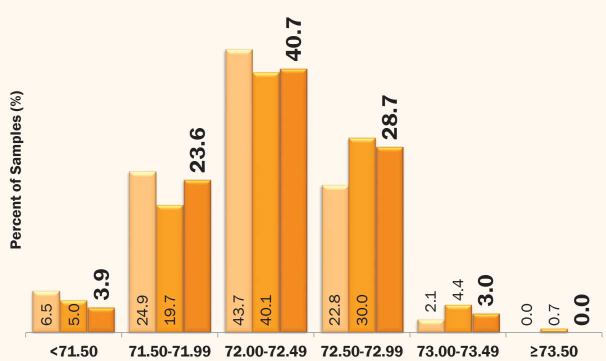
- Average U.S. Aggregate starch concentration (72.2%) was lower than 2018/2019 (72.3%), slightly higher than 2017/2018 (72.1%) but lower than the 5YA (72.9%) and the average U.S. Aggregate concentration for the 2019 harvest (72.3%).
- The standard deviation for starch concentration of the 2019/2020 export samples (0.38%) was lower than the standard deviation of the 2019 harvest samples (0.58%).
- Starch concentrations were distributed with 72.4% at or above 72.0%, compared with 75.2% in 2018/2019 and 68.6% in 2017/2018.
- The Gulf ECA had the highest average starch concentration (72.4%), in comparison to the Pacific Northwest (71.9%) and Southern Rail (72.0%) ECAs. Average starch concentrations were also the highest for the Gulf ECA in 2018/2019, 2017/2018, and the 5YA.
- Average starch concentration for Gulf ECA contracts loaded as U.S. No. 2 or better (72.4%) was slightly higher than that for contracts loaded as U.S. No. 3 or better (72.3%).

STARCH (Dry Basis %)

EXPORT CATCHMENT AREA AVERAGE



U.S. AGGREGATE



	Avg	Std Dev
MY17/18	72.1	0.39
MY18/19	72.3	0.43
MY19/20	72.2	0.38

U.S. GRAINS COUNCIL

Oil

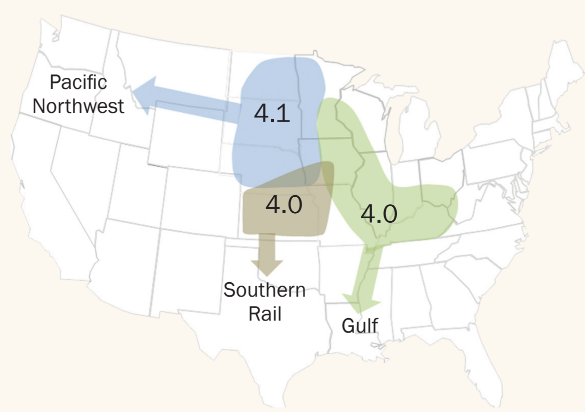
Oil is an essential component of poultry and livestock rations. It serves as an energy source, enables fat-soluble vitamins to be utilized and provides certain essential fatty acids. Oil is also an important co-product of corn wet and dry milling. Results are reported on a dry basis.

Results

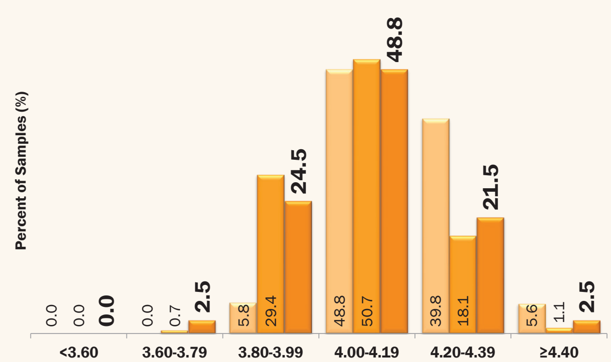
- Average U.S. Aggregate oil concentration (4.0%) was the same as 2018/2019, lower than 2017/2018 (4.1%), and same as the 5YA (4.0%).
- Average oil concentration for the 2019/2020 export samples was lower than the 2019 harvest samples (4.1%), while the standard deviation at export (0.15%) was lower than at harvest (0.23%).
- The 2019/2020 samples showed a higher percentage of samples at or above 4.0% oil (72.8%) than the previous year (69.9%), but below the 2017/2018 samples (94.2%).
- Average oil concentration for the Gulf ECA (4.0%) was the same as the Southern Rail ECA but below the Pacific Northwest ECA (4.1%).
- Average Gulf ECA oil concentrations for contracts loaded as U.S. No. 2 or better (4.0%) were lower than that for contracts loaded as U.S. No. 3 or better (4.1%).

OIL (Dry Basis %)

EXPORT CATCHMENT AREA AVERAGE



U.S. AGGREGATE



	Avg	Std Dev
MY17/18	4.1	0.12
MY18/19	4.0	0.14
MY19/20	4.0	0.15

SUMMARY: CHEMICAL COMPOSITION

	2019/2020 Export Cargo					2018/2019 Export Cargo			2017/2018 Export Cargo			5 Year Avg. (2014-2018)	
	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 %)	432	8.3	0.29	7.1	9.3	436	8.5*	0.37	430	8.6*	0.29	8.4	0.30
Starch (Dry Basis %)	432	72.2	0.38	70.2	73.4	436	72.3	0.43	430	72.1*	0.39	72.9	0.46
Oil (Dry Basis %)	432	4.0	0.15	3.6	4.6	436	4.0	0.14	430	4.1*	0.12	4.0	0.16
Gulf													
Protein (Dry Basis %)	242	8.3	0.22	7.7	9.0	275	8.5*	0.26	276	8.5*	0.27	8.4	0.27
Starch (Dry Basis %)	242	72.4	0.34	71.3	73.4	275	72.4	0.34	276	72.3*	0.37	73.0	0.42
Oil (Dry Basis %)	242	4.0	0.13	3.6	4.4	275	4.0	0.13	276	4.2*	0.13	4.0	0.16
Pacific Northwest													
Protein (Dry Basis %)	117	8.1	0.38	7.1	9.3	96	8.4*	0.55	87	8.9*	0.37	8.7	0.39
Starch (Dry Basis %)	117	71.9	0.44	70.2	73.0	96	72.1*	0.64	87	71.7*	0.46	72.6	0.53
Oil (Dry Basis %)	117	4.1	0.18	3.7	4.6	96	4.1*	0.14	87	4.1	0.11	3.9	0.17
Southern Rail													
Protein (Dry Basis %)	73	8.5	0.37	7.7	9.3	65	8.7	0.53	67	8.7*	0.30	8.5	0.34
Starch (Dry Basis %)	73	72.0	0.41	71.2	72.9	65	72.1	0.51	67	72.1	0.37	72.7	0.49
Oil (Dry Basis %)	73	4.0	0.15	3.7	4.3	65	4.0	0.14	67	4.1*	0.11	4.0	0.16

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

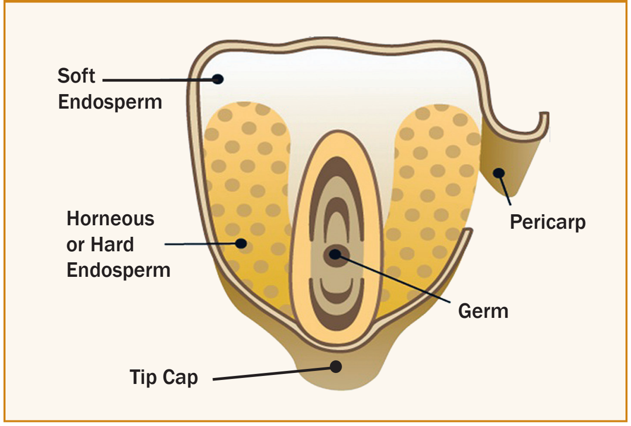
	Export Cargo Samples for Contract Loaded as U.S. No. 2 or Better					Export Cargo Samples forContract Loaded as U.S. No. 3 or Better					2019 Harvest				
	No. of Samples	Avg.	Std. Dev.	Min.	Max.	No. of Samples	Avg.	Std. Dev.	Min.	Max.	No. of Samples	Avg.	Std. Dev.	Min.	Max.
U.S. Aggregate															
Protein (Dry Basis %)	241	8.4	0.26	7.7	9.3	178	8.1	0.33	7.1	9.3	623	8.3	0.54	6.2	10.4
Starch (Dry Basis %)	241	72.3	0.35	71.2	73.4	178	72.1	0.40	70.2	73.1	623	72.3**	0.58	69.8	74.4
Oil (Dry Basis %)	241	4.0	0.14	3.6	4.4	178	4.1	0.16	3.7	4.6	623	4.1	0.23	3.2	5.0
Gulf															
Protein (Dry Basis %)	182	8.3	0.22	7.7	9.0	59	8.3	0.22	7.7	8.8	594	8.2**	0.54	6.2	10.4
Starch (Dry Basis %)	182	72.4	0.34	71.5	73.4	59	72.3	0.33	71.3	73.1	594	72.4	0.58	69.8	74.4
Oil (Dry Basis %)	182	4.0	0.13	3.6	4.4	59	4.1	0.13	3.8	4.4	594	4.0	0.24	3.2	5.0
Pacific Northwest															
Protein (Dry Basis %)	0	-	-	-	-	117	8.1	0.38	7.1	9.3	318	8.2**	0.54	6.6	10.1
Starch (Dry Basis %)	0	-	-	-	-	117	71.9	0.44	70.2	73.0	318	72.2**	0.58	69.8	73.8
Oil (Dry Basis %)	0	-	-	-	-	117	4.1	0.18	3.7	4.6	318	4.1	0.25	3.5	5.0
Southern Rail															
Protein (Dry Basis %)	59	8.5	0.39	7.7	9.3	2	8.8	0.35	8.5	9.0	324	8.6	0.54	6.2	10.4
Starch (Dry Basis %)	59	72.1	0.39	71.2	72.9	2	71.6	0.21	71.4	71.7	324	72.2**	0.56	69.8	74.2
Oil (Dry Basis %)	59	4.0	0.16	3.7	4.3	2	4.0	0.14	3.9	4.1	324	4.0**	0.21	3.3	4.8

**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. It 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. Comparisons between contracts loaded as U.S. No. 2 or better and U.S. No. 3 or better could be made only for the Gulf ECA. The other two ECA's (with two exceptions) had all samples in only one grade grouping.

CORN KERNEL



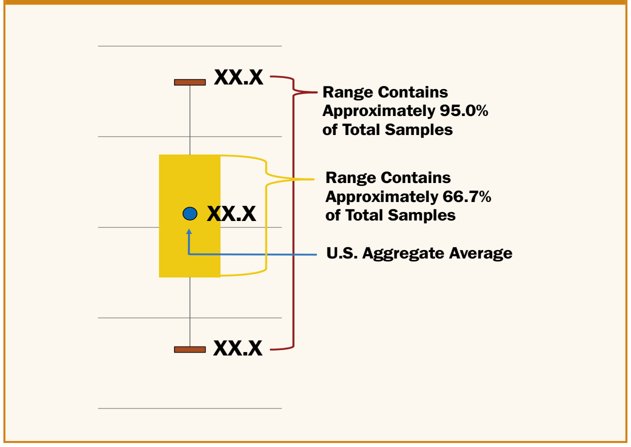
Source: Adapted from Corn Refiners Association, 2011

SUMMARY: PHYSICAL FACTORS

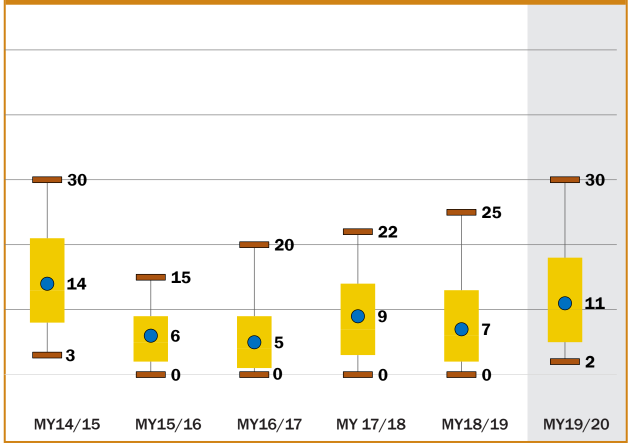
- Average U.S. Aggregate stress cracks (11%) in 2019/2018 was higher than the two previous years and the 5YA.
- Of the 2019/2020 export samples, 25.3% had 15% or higher stress cracks, compared with 11.5% in 2018/2019 and 16.0% in 2017/2018.
- Average U.S. Aggregate 100-kernel weight (35.50 g) was lower than 2018/2019, 2017/2018, and the 5YA.
- Average 100-kernel weight for the Pacific Northwest ECA (32.39 g) was lower than the Gulf ECA (36.79 g) and the Southern Rail ECA (36.20 g).
- In 2019/2020, 38.2% of the samples had a 100-kernel weight of 36.5 g or higher, compared with 53.9, and 58.1% in the two previous years; thus, 2019/2020 samples had a lower percentage of large kernels than those in 2018/2019 and 2017/2018.
- Average U.S. Aggregate kernel volume (0.28 cm^3) was the same as 2018/2019, 2017/2018 and the 5YA. Average kernel volume at export was the same as that for the 2019 harvest.
- Average kernel volume for the Pacific Northwest ECA (0.26 cm^3) was lower than for the Gulf (0.29 cm^3) and Southern Rail ECAs (0.28 cm^3) in 2019/2020. The Pacific Northwest ECA had the lowest average kernel volume and 100-k weight 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 (1.278 g/cm^3) was lower than 2018/2019 (1.288 g/cm^3), 2017/2018 (1.287 g/cm^3) and the 5YA (1.286 g/cm^3).
- For the 2018/2019 export samples, 67.6% had kernel true densities equal to or above 1.275 g/cm^3, compared with 85.3% in 2018/2019 and 83.0% in 2017/2018. Average kernel true density for the 2019/2020 export samples was higher than for the 2019 harvest samples (1.247 g/cm^3). The export 5YA true density (1.286 g/cm^3) was also higher than the harvest 5YA true density (1.259 g/cm^3). Average true densities have been 0.021 to 0.036 g/cm^3 higher at export than at harvest over the past nine years.
- The average percent of whole kernels at export (77.4%) was lower than 2018/2019 (85.2%), 2017/2018 (84.4%) and the 5YA (87.1%).
- The percentage of 2019/2020 export samples with whole kernels greater than or equal to 90.0% was 6.5%, compared to 15.8% in 2018/2019 and 14.7% in 2017/2018, indicating a much lower percentage of whole kernels in 2019/2010 samples than in the two previous years.
- Average U.S. Aggregate horneous endosperm (81%) was lower than 2018/2019 (82%) and the same as 2017/2018 and the 5YA. Of the 2019/2020 export samples, 74.7% had at least 80% horneous endosperm lower than that in 2018/2019 but similar to 2017/2018.

PHYSICAL FACTORS
AGGREGATE SIX-YEAR COMPARISON

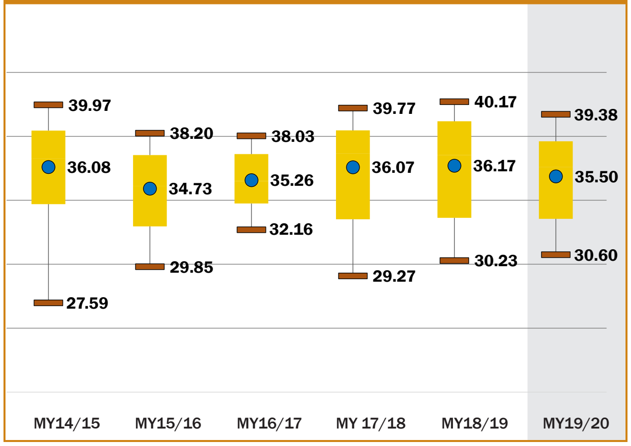
HOW TO READ THE CHARTS



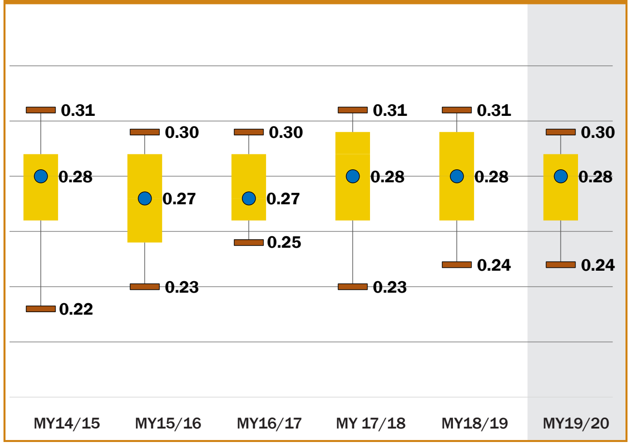
STRESS CRACKS (%)



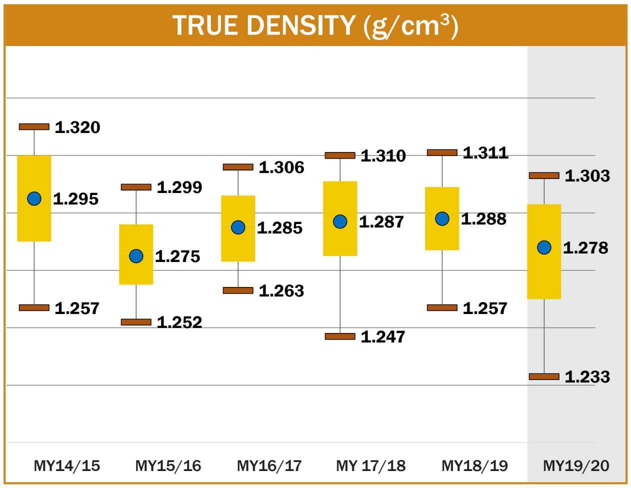
100-KERNEL WEIGHT (g)

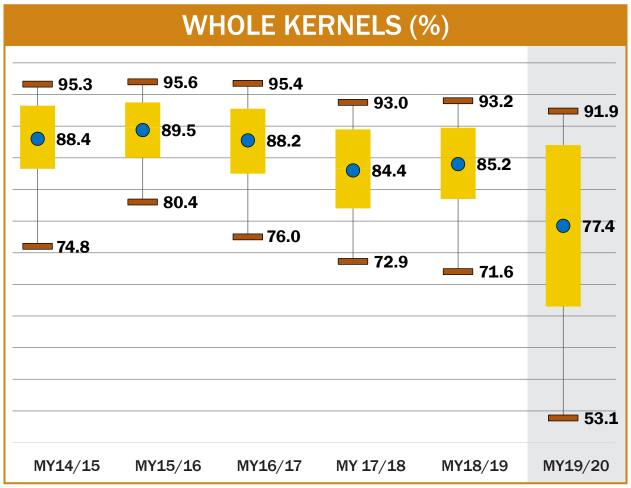


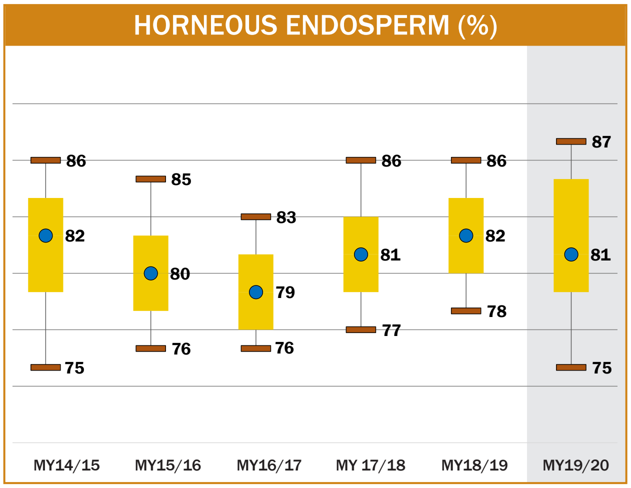
KERNEL VOLUME (cm^3)



PHYSICAL FACTORS
AGGREGATE SIX-YEAR COMPARISON







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 or value or both.
- 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.

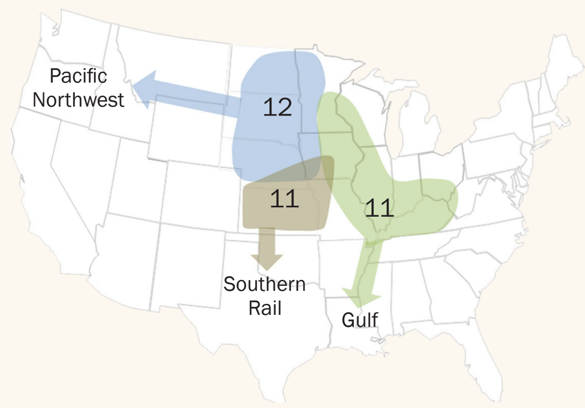
Growing conditions will affect crop maturity, timeliness of harvest and the need for artificial drying, which will influence the degree of stress cracking found from region to region. For example, late maturity or late harvest caused by weather-related factors, such as rain-delayed planting or cool temperatures,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

Results: Stress Cracks

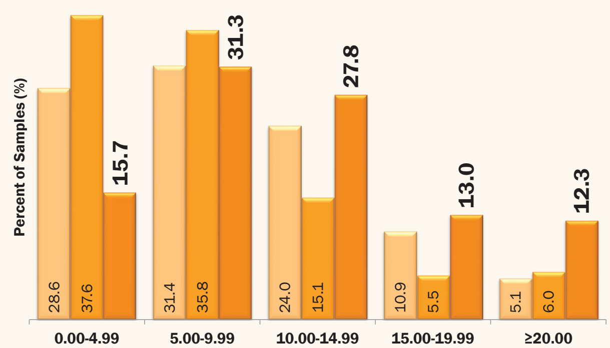
- Average U.S. Aggregate stress cracks (11%) was higher than 2018/2019 (7%), 2017/2018 (9%) and the 5YA (8%).
- Average U.S. Aggregate stress cracks (11%) was higher than the 2019 harvest samples (9%). Average U.S. Aggregate stress cracks has increased from 1 to 4 percentage points between harvest and export for each of the last four years and for the 5YA.
- The range of stress cracks in the export samples (0 to 47%) was narrower than that of the 2019 harvest samples (range of 0 to 95%). However, the standard deviation of 7% was the same at export and harvest).
- Of the 2019/2020 export samples, 25.3% had 15% or higher stress cracks, compared with 11.5% in 2018/2019 and 16.0% in 2017/2018.
- Stress cracks averages were 11%, 12% and 11% for the Gulf, Pacific Northwest and Southern Rail ECAs, respectively. The standard deviation of stress cracks was 6% for the Gulf and Pacific Northwest ECAs, and 11% for the Southern Rail ECA.
- Stress crack percentages for Gulf ECA contracts loaded as U.S. No. 2 or better (10%) was lower than that for contracts loaded as U.S. No. 3 or better (13%). The higher stress cracks found for contracts loaded as U.S. No. 3 or better is consistent with the higher BCFM (3.6%) for those contracts, compared to BCFM (2.9%) for contracts loaded as U.S. No. 2 or better. Comparisons for the other two ECAs could not be made.

STRESS CRACKS (%)

EXPORT CATCHMENT AREA AVERAGE



U.S. AGGREGATE



	Avg	Std Dev
MY17/18	9	5
MY18/19	7	5
MY19/20	11	7

100-Kernel Weight

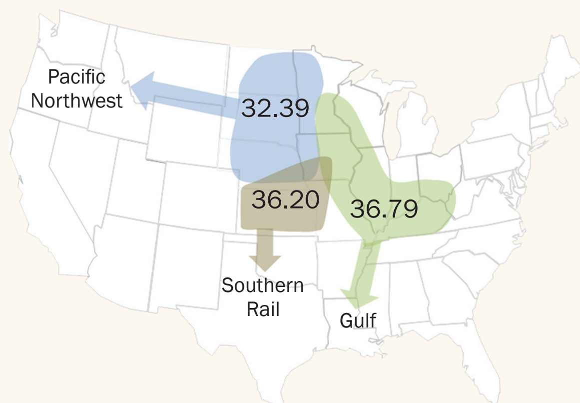
Increasing 100-kernel weight (reported in grams) indicates a larger kernel size. Kernel size affects drying rates. As kernel size increases, the volume-to-surface area ratio becomes higher, and as the ratio gets higher, drying becomes slower. In addition, large, uniform-sized kernels often enable higher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

Results

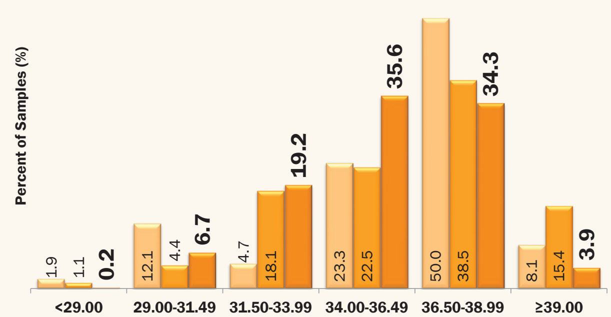
- Average U.S. Aggregate 100-kernel weight (35.47 g) was lower than 2018/2019 (36.17 g), 2017/2018 (36.07 g), and the 5YA (35.66 g).
- Average 100-kernel weight for export (35.50 g) was higher than at harvest (34.60 g). From 2011/2012 through 2019/2020, average 100-kernel weights ranged from 0.00 to 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 (1.37 g) than the 2019 harvest samples (2.48 g). The 100-kernel weight standard deviation was also lower at export than at harvest for 2018/2019, 2017/2018, and the 5YA, indicating greater uniformity at export than at harvest.
- Average 100-kernel weight for the Gulf ECA (36.79 g) was higher than the Pacific Northwest (32.39 g) and the Southern Rail (36.20 g) ECAs. Among ECAs, the Pacific Northwest consistently had the lowest 100-k weight in the last three years and 5YA.
- In 2019/2020, 38.2% of the samples had a 100-kernel weight of 36.5 g or higher, compared with 53.9 in 2018/2019, and 58.1% in 2017/2018. Thus, 2019/2020 samples had a had a lower percentage of large kernels than in 2018/2019 and 2017/2018.

100-KERNEL WEIGHT (g)

EXPORT CATCHMENT AREA AVERAGE



U.S. AGGREGATE



	Avg	Std Dev
MY17/18	36.07	1.43
MY18/19	36.17	1.84
MY19/20	35.50	1.37

Kernel Volume

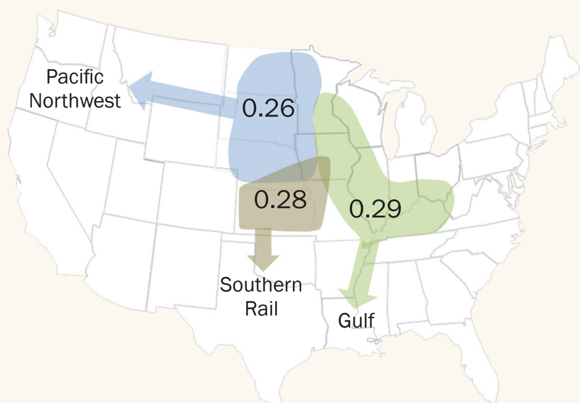
Kernel volume, measured in cubic centimeters (cm³), is often indicative of growing conditions. If conditions are dry, kernels may be smaller than average. If a drought hits later in the season, kernels may have lower fill. Small or round kernels are more difficult to degerm. Additionally, small kernels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

Results

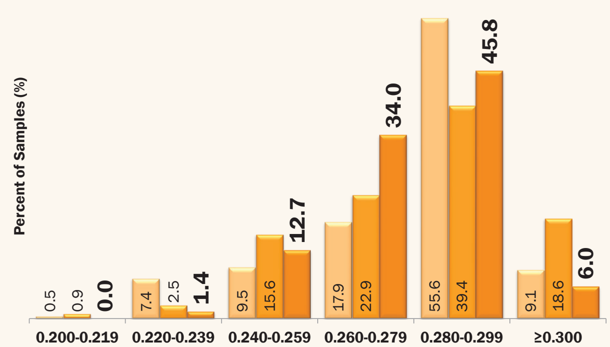
- Average U.S. Aggregate kernel volume (0.28 cm³) was the same as 2018/2019, 2017/2018 and the 5YA.
- Kernel volume range (0.23 to 0.32 cm³) was similar to 2018/2019 (0.20 to 0.32 cm³), 2017/2018 (0.22 to 0.32 cm³).
- The kernel volume standard deviation (0.01 cm³) was the same as 2018/2019, 2017/2018 and the 5YA.
- Average U.S. Aggregate kernel volume at export (0.28 cm³) was the same as the 2019 harvest.
- Average kernel volume was smaller for the Pacific Northwest ECA (0.26 cm³) than for the Gulf (0.29 cm³) and Southern Rail ECAs (0.28 cm³) in 2019/2020. The Pacific Northwest ECA also had the lowest average kernel volume for 2018/2019, 2017/2018 and the 5YA.
- Of the 2019/2020 export samples, 51.8% had kernel volumes equal to or greater than 0.28 cm³, compared with 58.0% in 2018/2019 and 64.7% in 2017/2018.

KERNEL VOLUME (cm³)

EXPORT CATCHMENT AREA AVERAGE



U.S. AGGREGATE

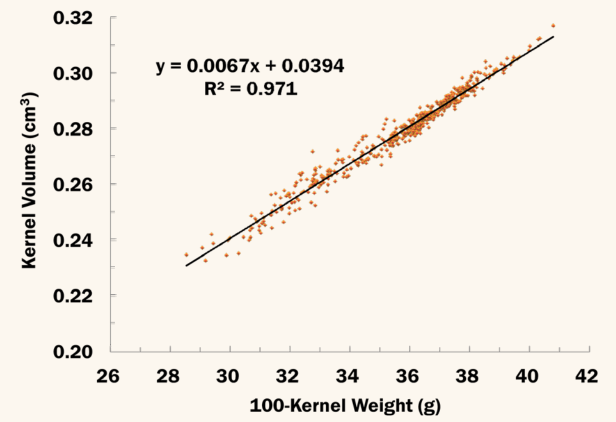


	Avg	Std Dev
MY17/18	0.28	0.01
MY18/19	0.28	0.01
MY19/20	0.28	0.01

- There is a positive relationship between kernel volume and 100-kernel weight in the 2019/2020 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 Gulf ECA contracts loaded as U.S. No. 2 or better (0.29 cm^3) was same as that for contracts loaded as U.S. No. 3 or better (0.29 cm^3).

KERNEL VOLUME vs 100-KERNEL WEIGHT



Kernel True Density

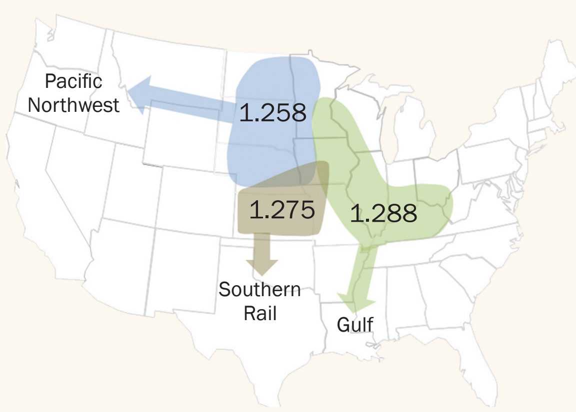
Kernel true density is calculated as the weight of a 100-kernel sample divided by the volume, or displacement, of those 100 kernels and is reported as grams per cubic centimeter (g/cm^3). True density is a relative indicator of kernel hardness, which is useful for alkaline processors and dry millers. True density may be affected by the genetics of the corn hybrid and the growing environment. Corn with a 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/cm^3 indicate very hard corn, which is typically desirable for dry milling and alkaline processing. True densities near the 1.275 g/cm^3 level and below tend to be softer, but process well for wet milling and feed use.

Results

- Average U.S. Aggregate kernel true density (1.278 g/cm^3) was lower than 2018/2019 (1.288 g/cm^3), 2017/2018 (1.287 g/cm^3) and the 5YA (1.286 g/cm^3).
- Average kernel true density for the 2019/2020 export samples was higher than for the 2019 harvest samples (1.247 g/cm^3). The export 5YA true density (1.286 g/cm^3) was also higher than the harvest 5YA true density (1.259 g/cm^3). Average true densities have been 0.021 to 0.036 g/cm^3 higher at export than at harvest over the past nine years.
- The 2019/2020 export samples had a range of 1.205 to 1.314 g/cm^3 (with a standard deviation of 0.012 g/cm^3), while the 2019 harvest samples had a wider range (1.116 to 1.322 g/cm^3) and a larger standard deviation (0.021 g/cm^3).

KERNEL TRUE DENSITY (g/cm^3)

EXPORT CATCHMENT AREA AVERAGE

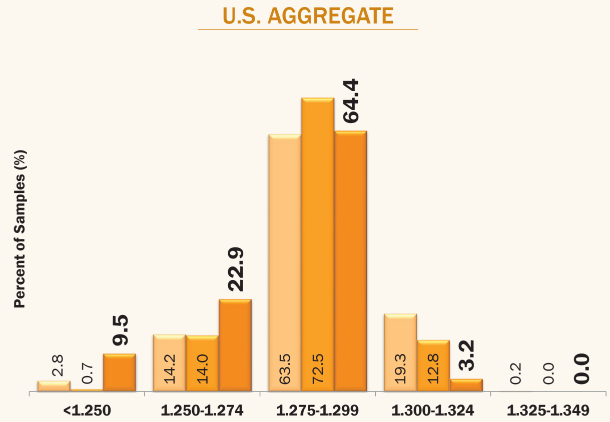


- For the 2019/2020 export samples, 67.6% had kernel true densities equal to or above 1.275 g/cm³, compared 85.3% in 2018/2019 and 83.0% in 2017/2018. This indicates that the distribution of true densities found in the 2019/2020 samples were lower in true density than in the previous two years. Interestingly, average bulk density or test weight (56.8 lb/bu) in 2019/2020 was also lower than the previous two years and the 5YA (all 57.4 lb/bu).

- Average kernel true densities for the Gulf, Pacific Northwest and Southern Rail ECAs were 1.288 g/cm³, 1.258 g/cm³ and 1.275 g/cm³, respectively.

- Average kernel true density for Gulf ECA contracts loaded as U.S. No. 2 or better (1.288 g/cm³) was slightly higher than that for contracts loaded as U.S. No. 3 or better (1.287 g/cm³).

KERNEL TRUE DENSITY (g/cm³)



	Avg	Std Dev
MY17/18	1.287	0.012
MY18/19	1.288	0.011
MY19/20	1.278	0.012

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 or products that do not meet specifications or both. 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 or a kernel's velocity at impact increases or both.[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.

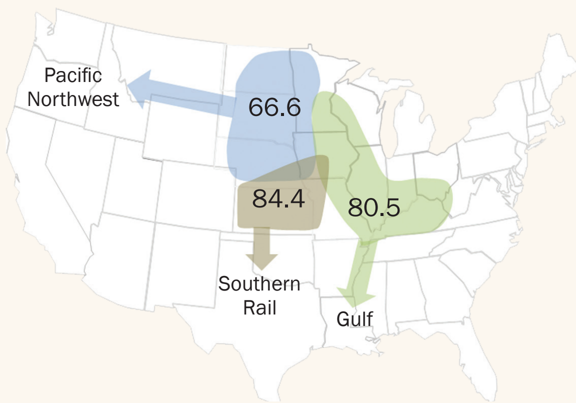
[2] *Foster, G.H. and L.E. Holman. 1973. Grain Breakage Caused by Commercial Handling Methods. USDA. ARS Marketing Research Report Number 968.*

Results

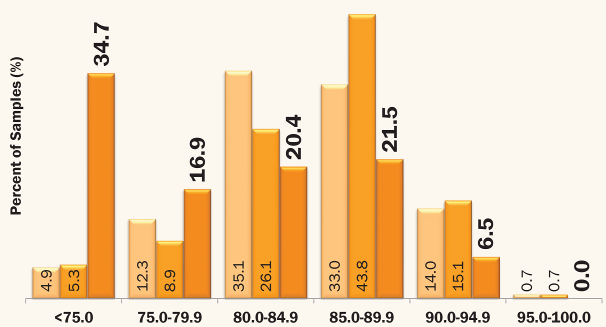
- Average U.S. Aggregate whole kernels (77.4%) was much lower than 2018/2019 (85.2%), 2017/2018 (84.4%), and the 5YA (87.1%).
- The average percentage of whole kernels at export in 2019/2020 was lower than at harvest (90.8%). Whole kernels for the export 5YA (84.1%) was also lower than for the harvest 5YA (93.3%). Over the past three years and the 5YA, the percentages of whole kernels have been 5.5 to 13.4 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 2019/2020 export samples had a wide range of 32.2 to 93.8% whole kernels and high standard deviation of 8.0%). The 2019 harvest samples also had a wide range (25.4 to 99.6%) and a standard deviation of 4.2%.
- The Pacific Northwest ECA (66.6%) had the lowest average whole kernels compared to the Gulf (80.5%) and Southern Rail (84.4%) ECAs.
- The percentage of 2019/2020 export samples with whole kernels greater than or equal to 90.0% was 6.5%, compared with 15.8% in 2018/2019 and 14.7% in 2017/2018, indicating a much lower percentage of whole kernels in the last year than in the previous two years.
- Average whole kernels for Gulf ECA contracts loaded as U.S. No. 2 or better was 81.1%, compared with 78.7% for contracts loaded as U.S. No. 3 or better.

WHOLE KERNELS (%)

EXPORT CATCHMENT AREA AVERAGE



U.S. AGGREGATE



	Avg	Std Dev
MY17/18	84.4	5.0
MY18/19	85.2	4.9
MY19/20	77.4	8.0

U.S. GRAINS COUNCIL

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.

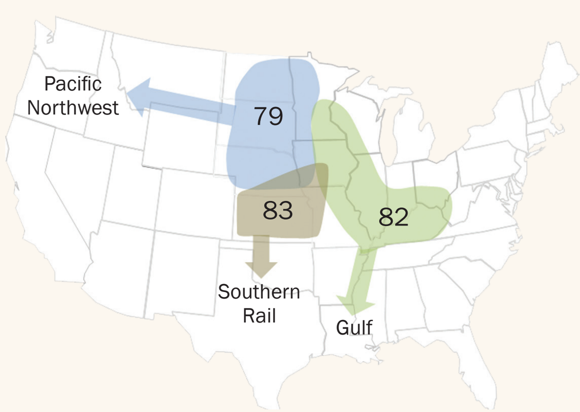
Hardness has been correlated to breakage susceptibility, feed utilization/efficiency and starch digestibility. As a test of overall hardness, there is no good or bad value for horneous endosperm; there is only a preference by different end-users for particular ranges. Many dry millers and alkaline cookers 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 (81%) was lower than 2018/2019 (82%) and the same as 2017/2018 (81%) and the 5YA (81%).
- Average horneous endosperm for 2019/2020, the previous two years and the 5YA were within ±1 percentage point of the average horneous endosperm at harvest for 2019, the previous two years and the 5YA at harvest, respectively.
- The 2019/2020 export samples had more uniform percentages of horneous endosperm compared to the 2019 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 (74 to 87%) compared to the harvest samples (71 to 96%). This same pattern of increased uniformity for the export samples compared with the harvest samples also occurred in 2018/2019, 2017/2018 and the 5YA.

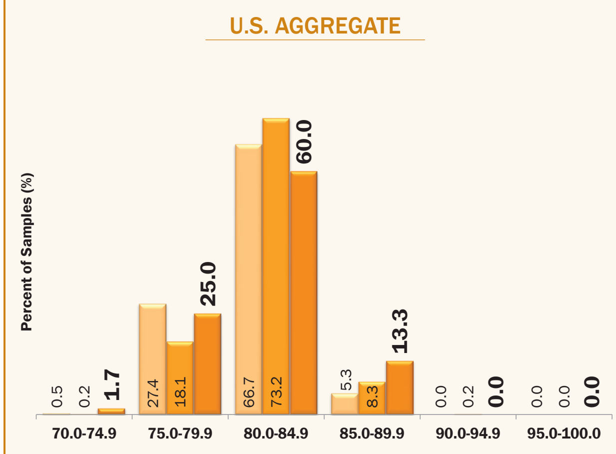
HORNEOUS ENDOSPERM (%)

EXPORT CATCHMENT AREA AVERAGE



- Average horneous endosperm for the Gulf, Pacific Northwest and Southern Rail ECAs was 82, 79, and 83%, respectively.
- Of the 2019/2020 export samples, 74.7% had at least 80% horneous endosperm, lower than 81.7% in 2018/2019 and similar to 72.0% in 2017/2018.
- Average horneous endosperm for Gulf ECA contracts loaded as U.S. No. 2 or better was the same as that for contracts loaded as U.S. No. 3 or better (both 82%).

HORNEOUS ENDOSPERM (%)



	Avg	Std Dev
MY17/18	81	2
MY18/19	82	2
MY19/20	81	2

SUMMARY: PHYSICAL FACTORS

	2019/2020 Export Cargo					2018/2019 Export Cargo			2017/2018 Export Cargo			5 Year Avg. (2014-2018)	
	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 (%)	432	11	7	0	47	436	7*	5	430	9*	5	8	5
100-Kernel Weight (g)	432	35.50	1.37	28.54	40.79	436	36.17*	1.84	430	36.07*	1.43	35.66	1.64
Kernel Volume (cm^3)	432	0.28	0.01	0.23	0.32	436	0.28*	0.01	430	0.28*	0.01	0.28	0.01
True Density (g/cm^3)	432	1.278	0.012	1.205	1.314	436	1.288*	0.011	430	1.287*	0.012	1.286	0.011
Whole Kernels (%)	432	77.4	8.0	32.2	93.8	436	85.2*	4.9	430	84.4*	5.0	87.1	4.4
Horneous Endosperm (%)	180	81	2	74	87	436	82*	2	430	81	2	81	2
Gulf						**Gulf**			**Gulf**			**Gulf**	
Stress Cracks (%)	242	11	6	0	35	275	6*	4	276	9*	6	8	5
100-Kernel Weight (g)	242	36.79	1.28	32.84	40.79	275	37.49*	1.85	276	37.45*	1.31	36.58	1.56
Kernel Volume (cm^3)	242	0.29	0.01	0.25	0.32	275	0.29*	0.01	276	0.29*	0.01	0.28	0.01
True Density (g/cm^3)	242	1.288	0.009	1.244	1.314	275	1.293*	0.009	276	1.293*	0.011	1.290	0.011
Whole Kernels (%)	242	80.5	7.5	48.0	93.8	275	86.0*	3.9	276	83.6*	5.4	87.4	4.3
Horneous Endosperm (%)	102	82	2	77	87	275	82	2	276	81*	2	81	2
Pacific Northwest						**Pacific Northwest**			**Pacific Northwest**			**Pacific Northwest**	
Stress Cracks (%)[1]	117	12	6	2	28	96	14	8	87	12	6	11	6
100-Kernel Weight (g)	117	32.39	1.39	28.54	35.17	96	32.21	1.81	87	31.12*	1.93	32.40	1.92
Kernel Volume (cm^3)	117	0.26	0.01	0.23	0.28	96	0.25*	0.01	87	0.25*	0.01	0.25	0.01
True Density (g/cm^3)	117	1.258	0.018	1.205	1.290	96	1.278*	0.016	87	1.268*	0.017	1.277	0.014
Whole Kernels (%)	117	66.6	9.6	32.2	85.8	96	82.2*	7.7	87	86.8*	3.6	85.5	4.8
Horneous Endosperm (%)	47	79	3	74	85	96	81*	3	87	80*	2	80	2
Southern Rail						**Southern Rail**			**Southern Rail**			**Southern Rail**	
Stress Cracks (%)[1]	73	11	11	0	47	65	5*	4	67	4*	3	6	5
100-Kernel Weight (g)	73	36.20	1.66	32.46	39.99	65	36.52	1.87	67	36.80*	1.29	36.25	1.61
Kernel Volume (cm^3)	73	0.28	0.01	0.26	0.31	65	0.28	0.02	67	0.29	0.01	0.28	0.01
True Density (g/cm^3)	73	1.275	0.012	1.242	1.297	65	1.284*	0.013	67	1.290*	0.008	1.284	0.010
Whole Kernels (%)	73	84.4	7.1	63.2	93.8	65	86.2	4.5	67	84.7	4.9	88.5	3.9
Horneous Endosperm (%)	31	83	3	78	87	65	82	2	67	81*	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

	No. of Samples	Avg.	Std. Dev.	Min.	Max.
U.S. Aggregate					
Stress Cracks (%)	241	11	8	0	47
100-Kernel Weight (g)	241	36.61	1.38	32.46	40.79
Kernel Volume (cm^3)	241	0.28	0.01	0.26	0.32
True Density (g/cm^3)	241	1.285	0.009	1.242	1.314
Whole Kernels (%)	241	81.7	7.1	54.8	93.8
Horneous Endosperm (%)	101	82	2	77	87
Gulf					
Stress Cracks (%)	182	10	6	0	35
100-Kernel Weight (g)	182	36.75	1.27	33.88	40.79
Kernel Volume (cm^3)	182	0.29	0.01	0.26	0.32
True Density (g/cm^3)	182	1.288	0.008	1.271	1.314
Whole Kernels (%)	182	81.1	7.0	54.8	93.8
Horneous Endosperm (%)	77	82	2	77	87
Pacific Northwest					
Stress Cracks (%)[1]	0	-	-	-	-
100-Kernel Weight (g)	0	-	-	-	-
Kernel Volume (cm^3)	0	-	-	-	-
True Density (g/cm^3)	0	-	-	-	-
Whole Kernels (%)	0	-	-	-	-
Horneous Endosperm (%)	0	-	-	-	-
Southern Rail					
Stress Cracks (%)[1]	59	13	12	0	47
100-Kernel Weight (g)	59	36.20	1.75	32.46	39.99
Kernel Volume (cm^3)	59	0.28	0.01	0.26	0.31
True Density (g/cm^3)	59	1.275	0.013	1.242	1.297
Whole Kernels (%)	59	83.6	7.4	63.2	93.8
Horneous Endosperm (%)	24	83	3	79	87

Export Cargo Samples for Contract Loaded as U.S. No. 3 or Better

	No. of Samples	Avg.	Std. Dev.	Min.	Max.
U.S. Aggregate					
Stress Cracks (%)	178	12.19	6	2	28
100-Kernel Weight (g)	178	33.91	1.36	28.54	39.46
Kernel Volume (cm^3)	178	0.27	0.01	0.23	0.31
True Density (g/cm^3)	178	1.27	0.015	1.205	1.306
Whole Kernels (%)	178	70.78	9.4	32.2	92.6
Horneous Endosperm (%)	72	79.45	3	0	87
Gulf					
Stress Cracks (%)	59	12.63	6	2	26
100-Kernel Weight (g)	59	36.92	1.31	32.84	39.46
Kernel Volume (cm^3)	59	0.29	0.01	0.25	0.31
True Density (g/cm^3)	59	1.29	0.010	1.244	1.306
Whole Kernels (%)	59	78.77	9.0	48.0	92.6
Horneous Endosperm (%)	25	82.22	2	79	87
Pacific Northwest					
Stress Cracks (%)[1]	117	12.05	6	2	28
100-Kernel Weight (g)	117	32.39	1.39	28.54	35.17
Kernel Volume (cm^3)	117	0.26	0.01	0.23	0.28
True Density (g/cm^3)	117	1.26	0.018	1.205	1.290
Whole Kernels (%)	117	66.65	9.6	32.2	85.8
Horneous Endosperm (%)	47	78.73	3	74	85
Southern Rail					
Stress Cracks (%)[1]	2	4	2	2	5
100-Kernel Weight (g)	2	34.70	1.61	33.56	35.84
Kernel Volume (cm^3)	2	0.27	0.01	0.26	0.28
True Density (g/cm^3)	2	1.272	0.002	1.271	1.273
Whole Kernels (%)	2	83.4	8.5	77.4	89.4
Horneous Endosperm (%)	0	-	-	-	-

2019 Harvest

	No. of Samples	Avg.	Std. Dev.	Min.	Max.
U.S. Aggregate					
Stress Cracks (%)	623	9**	7	0	95
100-Kernel Weight (g)	623	34.6**	2.48	25.11	43.93
Kernel Volume (cm^3)	623	0.28	0.02	0.22	0.34
True Density (g/cm^3)	623	1.247**	0.021	1.116	1.322
Whole Kernels (%)	623	90.8**	4.2	25.4	99.6
Horneous Endosperm (%)	180	81	3	71	96
Gulf					
Stress Cracks (%)	594	10**	9	0	95
100-Kernel Weight (g)	594	35.39**	2.60	26.61	43.93
Kernel Volume (cm^3)	594	0.28**	0.02	0.22	0.34
True Density (g/cm^3)	594	1.252**	0.019	1.116	1.322
Whole Kernels (%)	594	91.5**	3.8	58.0	99.6
Horneous Endosperm (%)	170	81**	3	71	96
Pacific Northwest					
Stress Cracks (%)[1]	318	9**	7	0	58
100-Kernel Weight (g)	318	32.73	2.19	25.11	42.33
Kernel Volume (cm^3)	318	0.27**	0.02	0.22	0.34
True Density (g/cm^3)	318	1.229**	0.025	1.116	1.316
Whole Kernels (%)	318	88.9**	5.2	25.4	99.0
Horneous Endosperm (%)	95	80**	3	73	90
Southern Rail					
Stress Cracks (%)[1]	324	6**	5	0	95
100-Kernel Weight (g)	324	35.16**	2.54	27.21	42.74
Kernel Volume (cm^3)	324	0.28**	0.02	0.22	0.34
True Density (g/cm^3)	324	1.262**	0.018	1.182	1.322
Whole Kernels (%)	324	91.7**	3.8	58.0	99.6
Horneous Endosperm (%)	91	82	3	73	96

***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, DON and fumonisin are considered to be three 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*, export samples were tested for aflatoxin and DON. In the *2019/2020 Export Cargo Report*, fumonisin was added to the list of mycotoxins tested. The *2019/2020 Export Cargo Report* now includes three mycotoxins: aflatoxin, DON and fumonisin.

The accumulation of nine years of the *Export Cargo Reports* allows for the evaluation of year-to-year patterns of mycotoxin presence in corn at export points. A summary of aflatoxin and DON presence in samples from the past three *Export Cargo Reports* is provided in the section below, and a year-to-year comparison of these mycotoxins' presence across all nine years of the *Harvest* and *Export Cargo Reports* is contained in the "Historical Perspective" section.

Given that the *2019/2020 Export Cargo Report* was the first year in which fumonisin was tested, the presence of fumonisin in the 2019/2020 export samples is summarized in the section below. Comparison of this mycotoxin's presence in samples from the *2019/2020 Harvest Report* and this *Export Cargo Report* is included in the "Historical Perspective" section.

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 and fumonisin 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 https://drive.google.com/file/d/1tqeS5_eOtsRmxZ5RrTnYu7NClr896KGX/view.

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 shown below.

DON Advisory Level	Criteria
5.0 parts per million	Swine, not to exceed 20% of their diet
5.0 parts per million	All other animals not otherwise listed, not to exceed 40% of their diet
10.0 parts per million	Chickens, not to exceed 50% of their diet
10.0 parts per million	Ruminating beef and dairy cattle older than four months

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.

Background: Fumonisin

Fumonisin is a naturally occurring mycotoxin found mostly in cereal grains, mainly corn. Fumonisin is a more recent discovery compared to aflatoxin and DON. Fumonisin is produced by several fungi of the *Fusarium* genus. The fumonisin family consists of fumonisin B1, fumonisin B2 and fumonisin B3. Fumonisin B1 is the most abundant, accounting for about 70 to 80% of the sum of the three fumonisins. The main concern with fumonisin is feed contamination that can have detrimental effects, particularly to horses and pigs. Fungal and fumonisin formation occurs mainly before harvest. Insects play an important role in fumonisin contamination since they act as a wounding agent. Temperature and rainfall conditions are related to fungal growth and fumonisin contamination. In general, fumonisin contamination is related to plant stress, insect damage, drought, and soil moisture. In 2001 FDA issued guidance levels for the sum of the three fumonisins in corn-based foods and feed to reduce human and animal exposure. FDA advisory levels are shown below.

Fumonisin Advisory Level	Criteria
5.0 parts per million	Equids (i.e., horses) and rabbits, not to exceed 20% of diet
20.0 parts per million	Swine and catfish, not to exceed 50% of diet
30.0 parts per million	Breeding ruminants, breeding poultry and breeding mink, not to exceed 50% of diet
60.0 parts per million	Ruminants older than three months raised for slaughter and mink raised for pelt production, not to exceed 50% of diet
100.0 parts per million	Poultry raised for slaughter, not to exceed 50% of diet
10.0 parts per million	All other animals not otherwise listed, not to exceed 50% of their diet

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

To assess the effect of these conditions on aflatoxin, DON and fumonisin development, this report summarizes the results from official USDA FGIS aflatoxin tests and from independent DON and fumonisin tests for the export samples collected as part of this survey. A total of 431 samples collected for this report were tested for aflatoxin while approximately 40% of the 430 samples or 180 samples were tested for DON and fumonisin.

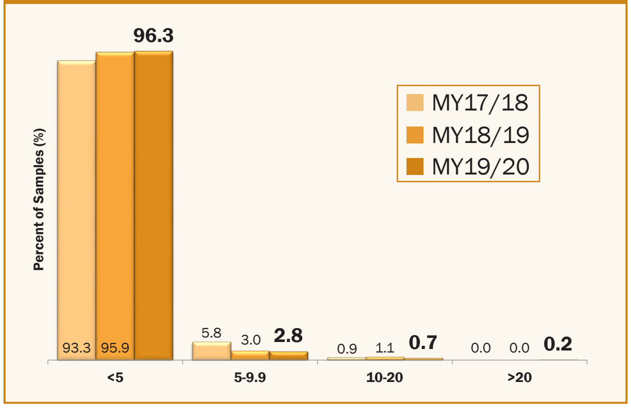
Results: Aflatoxins

A total of 431 export samples were tested for aflatoxin for the *2019/2020 Export Cargo Report* by USDA FGIS. A threshold established by USDA FGIS as the "Lower Conformance Level" was used to determine whether or not a detectable level of the aflatoxin appeared in the sample. The Lower Conformance Level for aflatoxin of the FGIS-approved analytical kits used for this 2019/2020 report were 5.0 ppb. Results of the 2019/2020 survey testing are as follows:

- Of the 431 samples, 415 samples, or 96.3%, had no detectable levels of aflatoxins (below the FGIS LCL of 5.0 ppb). This 96.3% is slightly higher than 2018/2019 (95.9%) and 2017/2018 (93.3%).
- Aflatoxin levels greater than or equal to 5.0 ppb, but less than 10.0 ppb, were found in 12 samples, or 2.8% of the 431 samples tested in 2019/2020. This percentage is slightly lower than 2018/2019 (3.0%) and significantly less than 2017/2018 (5.8%).
- Only three samples, or 0.7% of the 431 samples tested, in 2019/2020 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 0.7% is about is slightly less than 2018/2019 (1.1%) and 2017/2018 (0.9%).
- One (1) of the samples tested in 2019/2020 was above the FDA action level of 20.0 ppb, which is slightly higher than in the 2018/2019 and 2017/2018 *Export Cargo Reports*.

The percentage of sample test results below the Lower Conformance Level in 2019/2020 (96.3%) was slightly higher than in 2018/2019 (95.9%) and 2017/2018 (93.3%). These results suggest that aflatoxin contamination level among lots in the export market was minimal and possibly the lowest in recent marketing years, which is indicative of the weather conditions during the 2019 growing season that were not conducive for mold growth and aflatoxin formation. The one sample exceeding the FDA action level of 20.0 ppb tested below 20.0 ppb on the initial test conducted by FGIS. The sample tested slightly above the FDA action level of 20.0 ppb on this second test. Two different aflatoxin test results on the same sample is likely due to the large random variability associated with mycotoxin concentrations within a sample.

AFLATOXINS TESTING RESULTS (ppb)



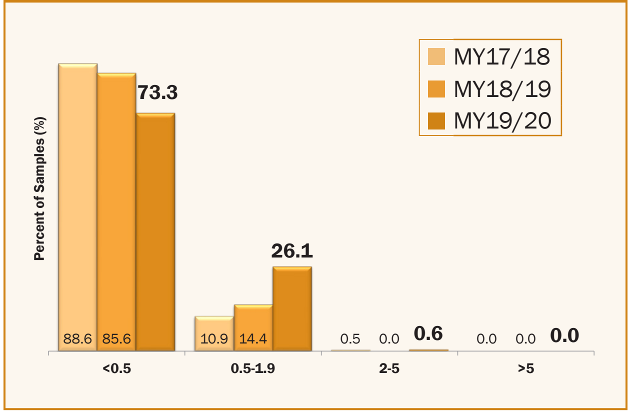
Results: Deoxynivalenol (DON or Vomitoxin)

A total of 180 export samples were tested for DON for the 2019/2020 *Export Cargo Report*. The Lower Conformance Level for DON of the FGIS-approved analytical kits used for this 2019/2020 report were 0.5 ppm. Results of the testing are shown below:

- DON levels less than 0.5 ppm (the FGIS Lower Conformance Level for DON) were found in 132 samples, or 73.3% of the 180 samples tested. This 73.3% is less than 2018/2019 (85.6%) and 2017/2018 (88.6%).
- Forty-seven (47) samples, or 26.1% of the 180 samples tested in 2019/2020 had DON levels greater than or equal to 0.5 ppm, but less than 2.0 ppm. This 26.1% is greater than 2018/2019 (14.4%) and 2017/2018 (10.9%).
- One (1) sample, or 0.6% of the 180 samples tested in 2019/2020 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 0.6% for 2019/2020 is higher than 2018/2019 (0.0%) and similar to 2017/2018 (0.5%).
- None (0) of the 180 samples tested in 2019/2020 were above the FDA advisory level of 5.0 ppm, which is the same as that reported in the 2018/2019 and *2017/2018 Export Reports*.

The 2019/2020 survey results had a lower percentage of samples (73.3%) below the FGIS LCL limit of 0.5 ppm than 2018/2019 (85.6%) and 2017/1918 (88.6%). All export survey samples were below or equal to the FDA advisory level of 5.0 ppm for all three marketing years.

DON TESTING RESULTS (ppm)

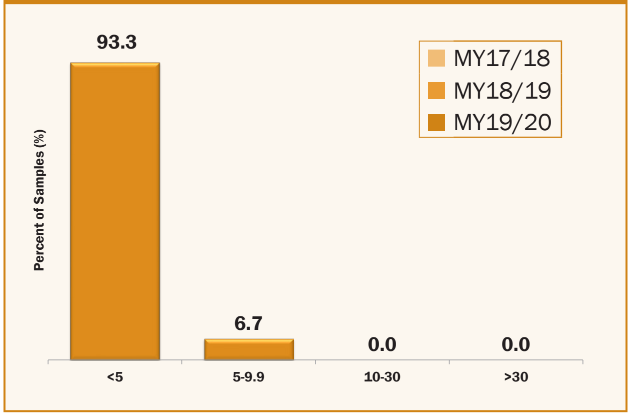


Results: Fumonisin

A total of 180 samples were analyzed collectively for fumonisin in 2019/2020 report. This is the first year that survey samples have been tested for fumonisin. As a result, there are no comparisons to fumonisin results from previous years. Results of the 2019/2020 survey are as follows:

- One hundred sixty-eight (168) or 93.3% of the 180 samples tested below 5.0 ppm, the lowest advisory level for animals (equids and rabbits)
- Twelve (12) or 6.7% of the 180 samples test greater than or equal to 5.0 ppm, but less than 10.0 ppm.
- None (0) or 0.0% of the 180 samples tested greater than or equal to 10.0 ppm, but not greater than 30.0 ppm.
- None (0) or 0.0% of the 180 samples tested greater than 30.0 ppm, which is the advisory level for breeding ruminants, poultry and mink.
- The 2019/2020 survey results had a high percentage of samples (93.3%) that tested below the lowest advisory level for animals (5.0 ppm) which is likely indicative of the weather conditions during the 2019 growing season that were not conducive for mold growth and fumonisin formation.

FUMONISIN TESTING RESULTS (ppm)



This *2019/2020 Export Cargo 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 which means that 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.

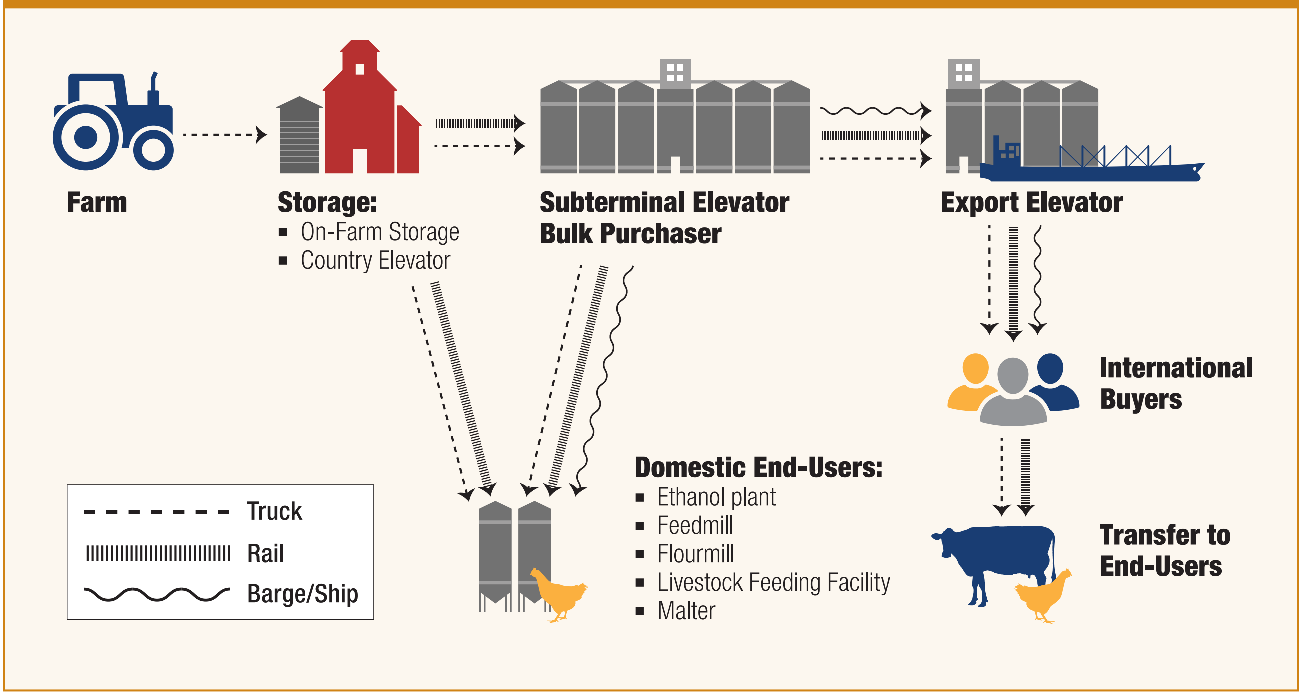
The intrinsic quality characteristics are impacted significantly by genetics and growing season conditions and typically do not change at the aggregate level as corn moves through the marketing system. If the measured values of the intrinsic characteristics differ between harvest and export at the aggregate level, the differences can be due partially 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 FGIS 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, most 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 into 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 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 the 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, the 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 a 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. 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 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.

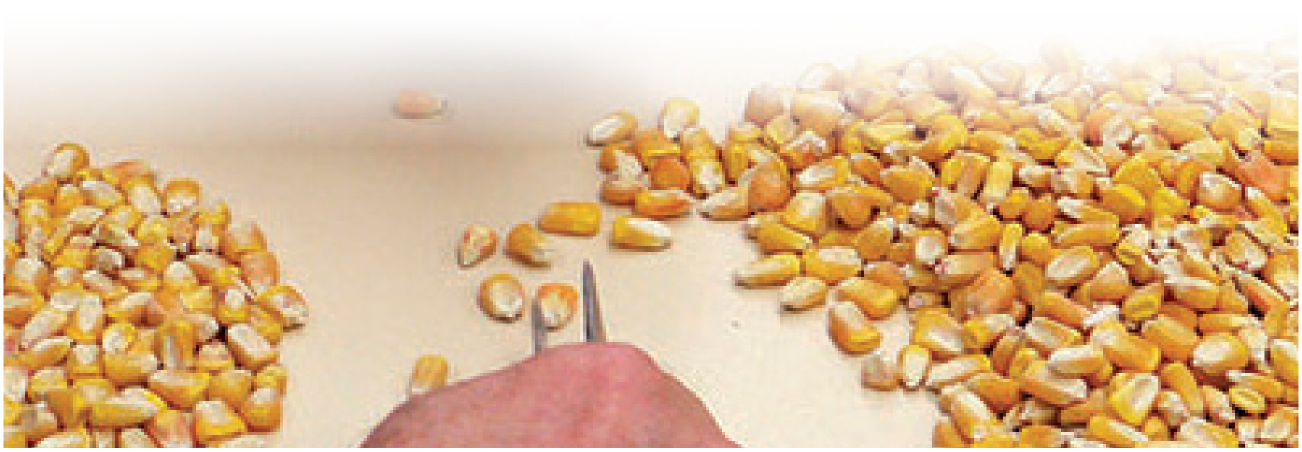
Shipments or "lots" of corn are divided into "sublots." Representative samples for grading are obtained from these sublots using a diverter sampling device approved by FGIS. This device takes a primary portion approximately every 200 to 500 bushels (about 5.1 to 12.7 metric tons) from the

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 Summary Information" section 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, 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.

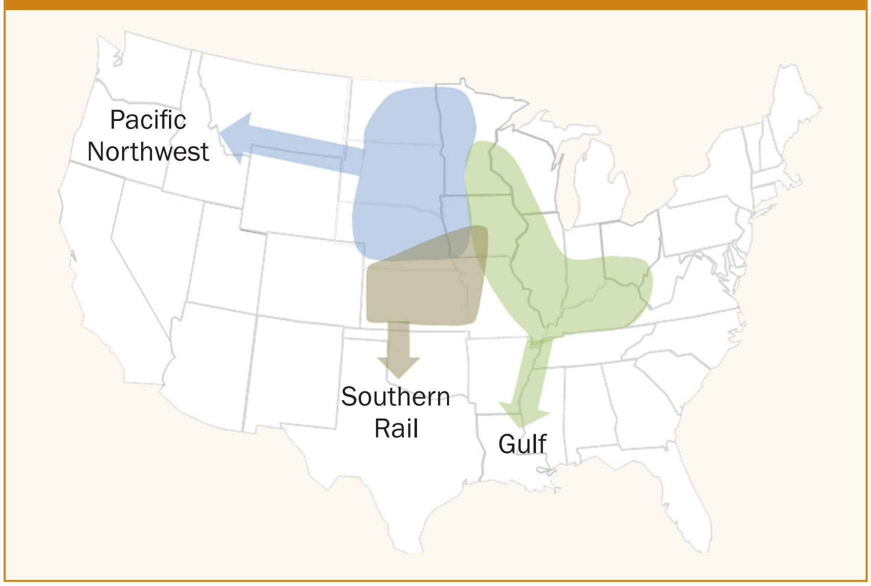


A. OVERVIEW

The key points for the survey design and sampling and statistical analysis for this *2019/2020 Export Cargo Report* are as follows:

- Following the methodology developed for the previous eight *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 430 samples, to be collected from the ECAs as follows: 242 from the Gulf, 117 from the Pacific Northwest and 71 from the Southern Rail.
- A total of 432 samples were ultimately tested for this survey. 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 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 in the Pacific Northwest ECA (17%) and stress cracks in the Southern Rail ECA (23%).
- Two-tailed t-tests at the 95% confidence level were calculated to measure statistical differences between the 2019/2020 and 2018/2019 and the 2019/2020 and 2017/2018 quality factor averages.

EXPORT CATCHMENT AREAS



B. SURVEY DESIGN AND SAMPLING

Survey Design

For the *2019/2020 Export Cargo Report*, the target population was yellow commodity corn from the 12 key U.S. corn-producing states representing over 90% of the estimated 2019/2020 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 USDA, each ECA's proportion of the total expected annual yellow corn exports for the 2019/2020 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 at right.

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 that are 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 14 quality factors evaluated for this year's corn exports were not known, the variance estimates from previous editions of the *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 then calculated using these data.

Percent of Samples per ECA			
Gulf	Pacific Northwest	Southern Rail	Total
56.2%	27.3%	16.5%	100.0%

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).

Number of Samples per ECA			
Gulf	Pacific Northwest	Southern Rail	Total
242	117	71	430

Beginning with the *2019/2020 Export Cargo Report*, a minimum of 180 samples were targeted to be tested for DON and horneous endosperm instead of the full 430 samples. Additionally, the same 180 samples tested for DON and horneous endosperm will also be tested for fumonisin. The *2019/2020 Export Cargo Report* was the first *Export Cargo Report* in which this mycotoxin was tested. In terms of DON, testing at least 180 samples would provide a 95.0% confidence level that the percent of tested samples with DON results below the FDA advisory level of 5.0 ppm would have a relative margin of error of ±10.0%. There was no targeted level of precision for fumonisin for this year's report, as past data on the mycotoxin's variance were not available. In terms of horneous endosperm, the relative margin of error for this quality factor never exceeded 0.3% (well below the targeted level of precision of ±10.0%) in the samples tested from the eight previous reports. Thus, reducing the number of samples tested for horneous endosperm would likely keep the precision of this quality factor's estimates well below the targeted level of ±10.0%.

Sampling

The sampling was administered by FGIS and participating official service providers as part of their inspection services. FGIS sent instruction letters to the Gulf and Pacific Northwest field offices and to the domestic inspection offices. The sampling period began in November 2019. 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.

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 were sampled. This was the same sampling frequency for the Pacific Northwest and Gulf ECAs as last year's 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 IPG Lab, the three file samples were composited into a single sample to undergo the chemical composition, physical factor, and DON and fumonisin 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 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 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 or be better than U.S. No. 3 factor limits.

Within this *2019/2020 Export Cargo Report* is a simple average of the quality factors' averages and standard deviations of the previous five *Export Cargo Reports (2014/2015, 2015/2016, 2016/2017, 2017/2018 and 2018/2019)*. 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. However, it exceeded ±10% for total damage in the Pacific Northwest ECA (17%) and stress cracks in the Southern Rail ECA (23%). While the level of precision for these two estimates are 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%.

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*.

FGIS or FGIS-designated official service providers supplied official grading and aflatoxin results from their normal inspection and testing procedures for each sublot corn sample collected. The *2019/2020 Export Cargo 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, DON and fumonisin testing. Next, the samples were split into two subsamples using a Boerner divider, while keeping the attributes of the grain sample distributed evenly between the two subsamples. One subsample was analyzed for DON and fumonisin. 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 17025:2017 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 the stress crack damage in each kernel can be evaluated. Kernels are sorted into two categories: (1) no cracks; (2) one or more cracks. Stress cracks, expressed as a percent, are all kernels containing one or more 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. Some end-users will specify by contract the acceptable level of cracks based on the intended use.

In previous *Export Cargo Reports*, the stress crack index was reported in addition to the percent stress cracks to provide an indication of the severity of stress cracking. The stress crack index is determined using the following calculation:

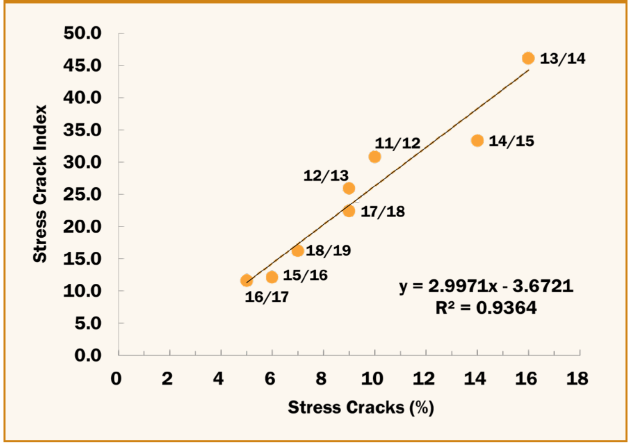
[SSC x 1] + [DSC x 3] + [MSC x 5]

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 U.S. Aggregate percent stress cracks and stress crack index from the first eight export cargo reports are displayed in the scatter chart below. Given its strong correlation (r = 0.97) to percent stress cracks, it was determined that the stress crack index provided limited additional value and was discontinued following the *2018/2019 Export Cargo Report*.

STRESS CRACK INDEX vs STRESS CRACK (%)



Whole Kernels

In the whole kernels test, 50 grams of cleaned (BCFM-free) corn are inspected kernel by kernel. Cracked, broken or chipped grain as well as 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.

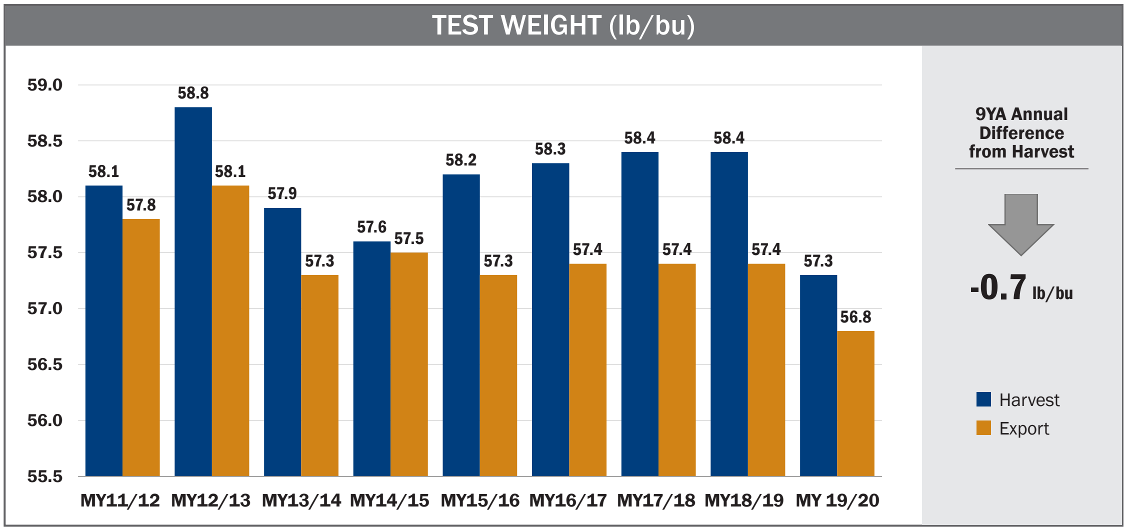
E. MYCOTOXINS

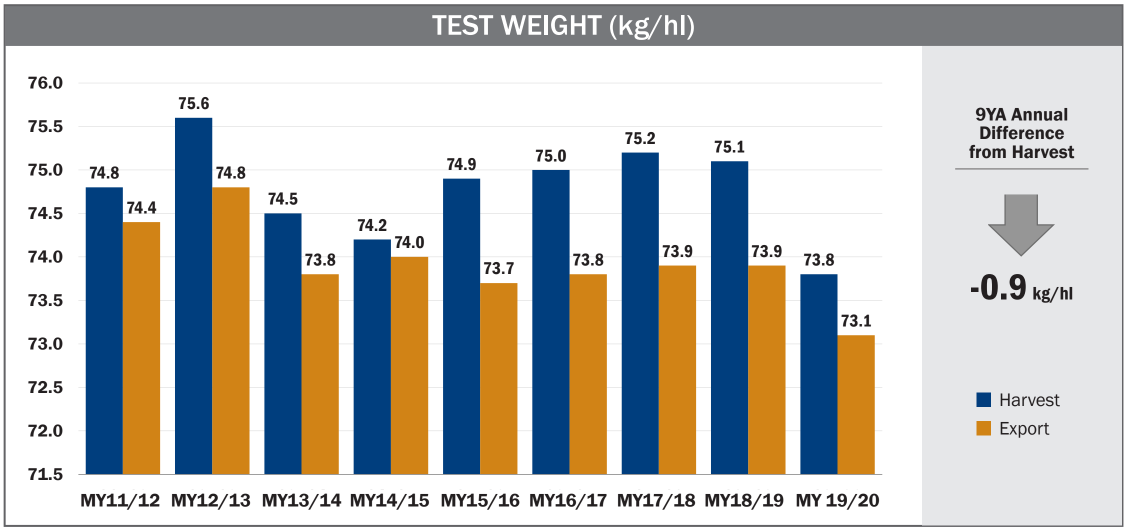
Official aflatoxin results are provided by FGIS for this *2019/2020 Export Cargo Report*. For the aflatoxin testing, a sample of at least 10 pounds of shelled corn is used according to FGIS official procedures. The 10-pound sample is ground using a FGIS-approved grinder. Following the grinding stage, 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; Hygiena LLC Mycotox Total Aflatoxin ELISA; 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; PerkinElmer Inc. AuroFlow AQ Afla Strip Test; or VICAM AflaTest™ or Afla-V AQUA.

For the DON and fumonisin testing, the FGIS-approved EnviroLogix QuickTox™/QuickScan method is used by IPG Lab. 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. DON and fumonisin are extracted from the 50-gram test portions with distilled water (5:1). The extract is tested for DON and fumonisin using the EnviroLogix AQ 304 BG and EnviroLogix AQ 311 BG test kits, respectively. The DON and fumonisin are then quantified by the QuickScan system. A letter of performance has been issued by FGIS for the quantification of DON and fumonisin using the Envirologix AQ 304 BG and AQ 311 BG kits, respectively.

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

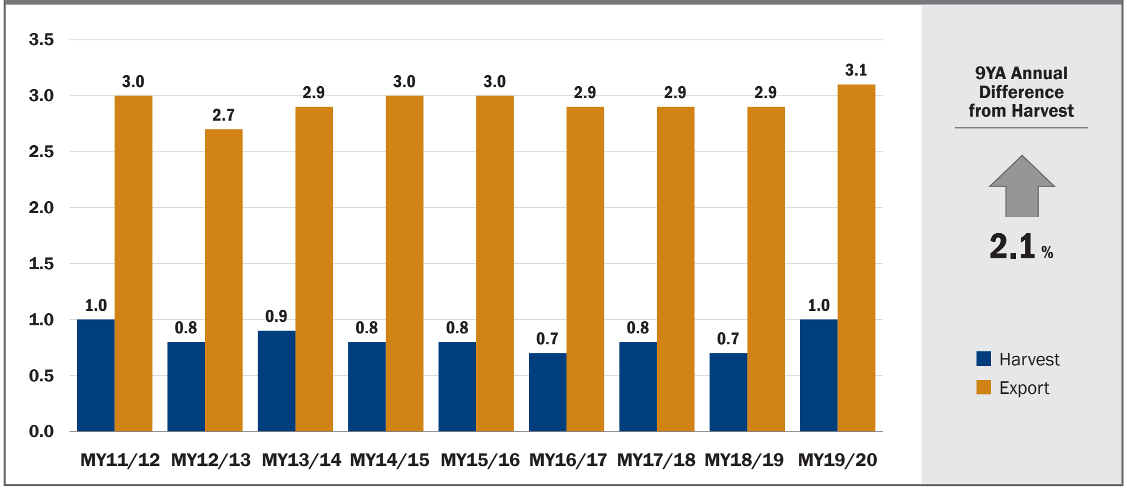
Since 2011, the U.S. Grains Council's Corn Export Cargo Reports have provided clear, concise and consistent information about the quality of each U.S. crop entering international merchandising channels. This series of quality reports has used consistent and transparent methodology to allow for insightful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



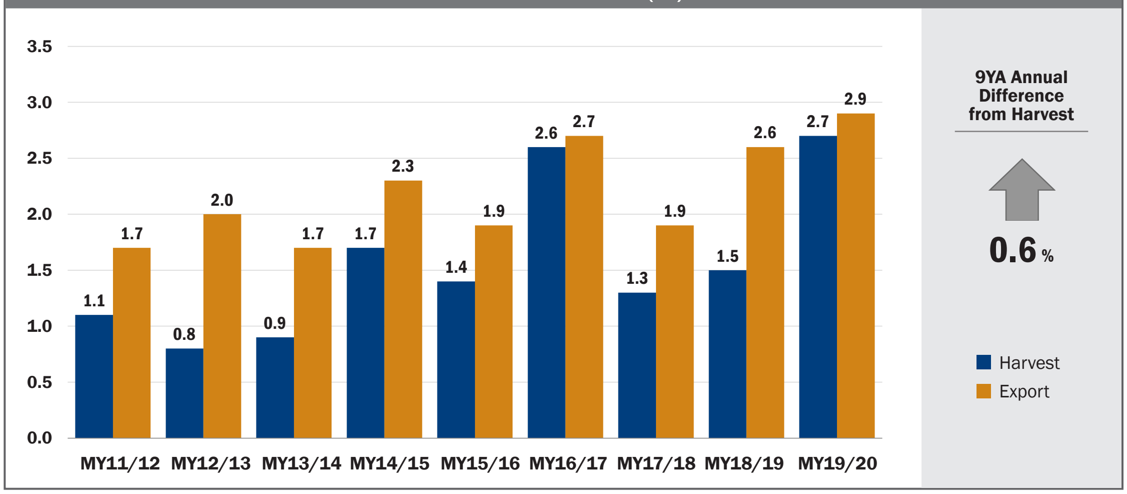


GRADE FACTORS AND MOISTURE
AGGREGATE NINE-YEAR HARVEST AND EXPORT CARGO COMPARISON

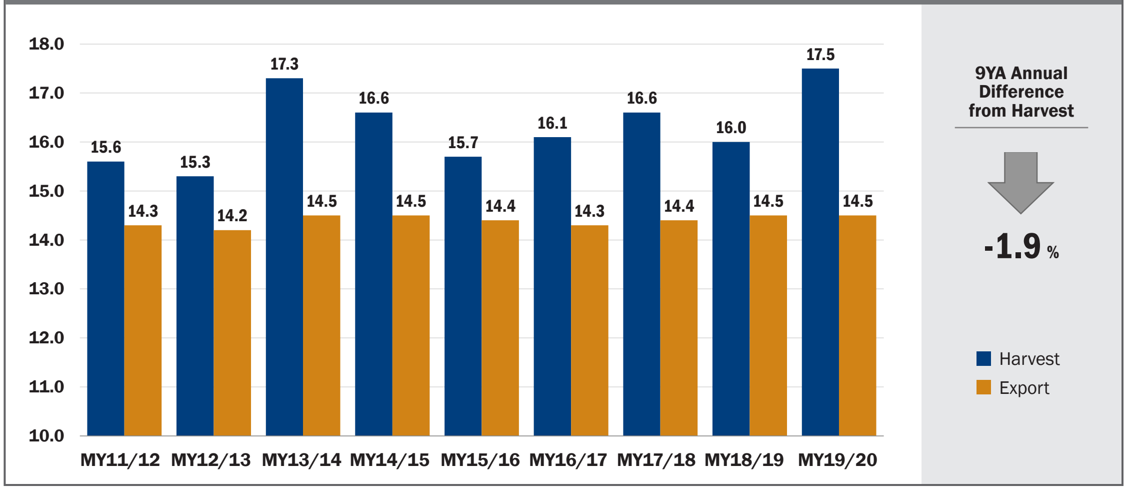
BROKEN CORN AND FOREIGN MATERIAL (%)



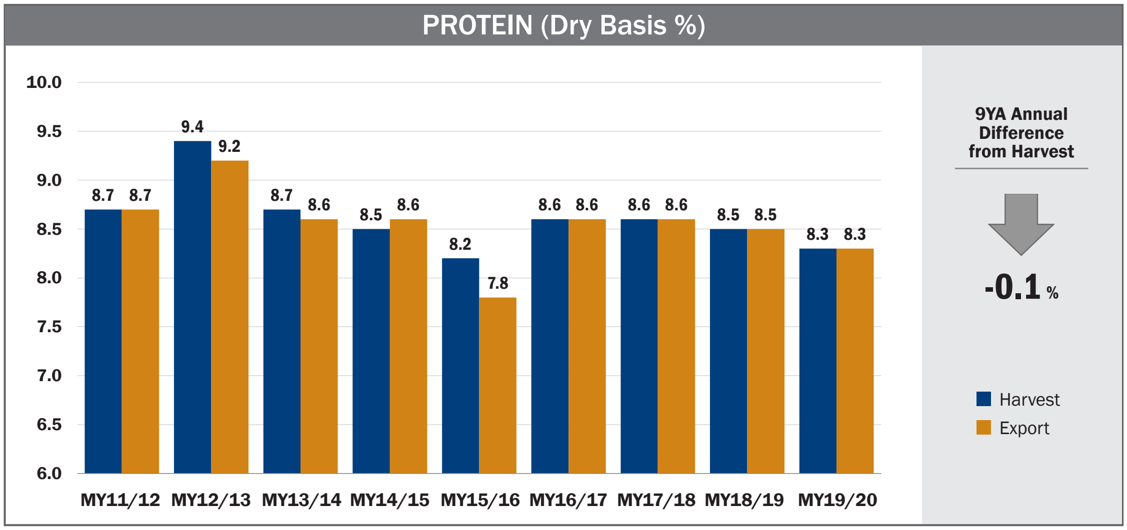
TOTAL DAMAGE (%)

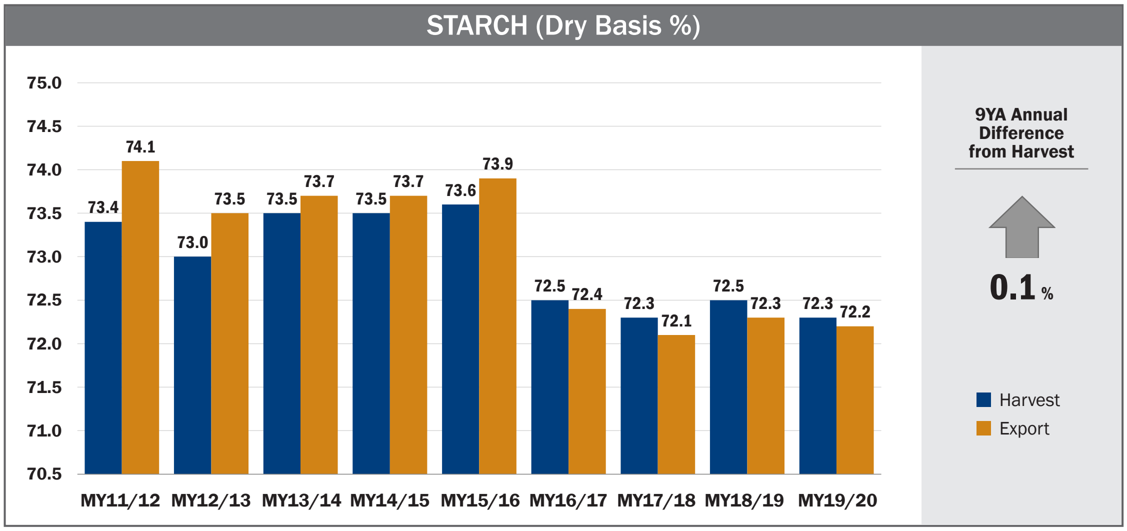


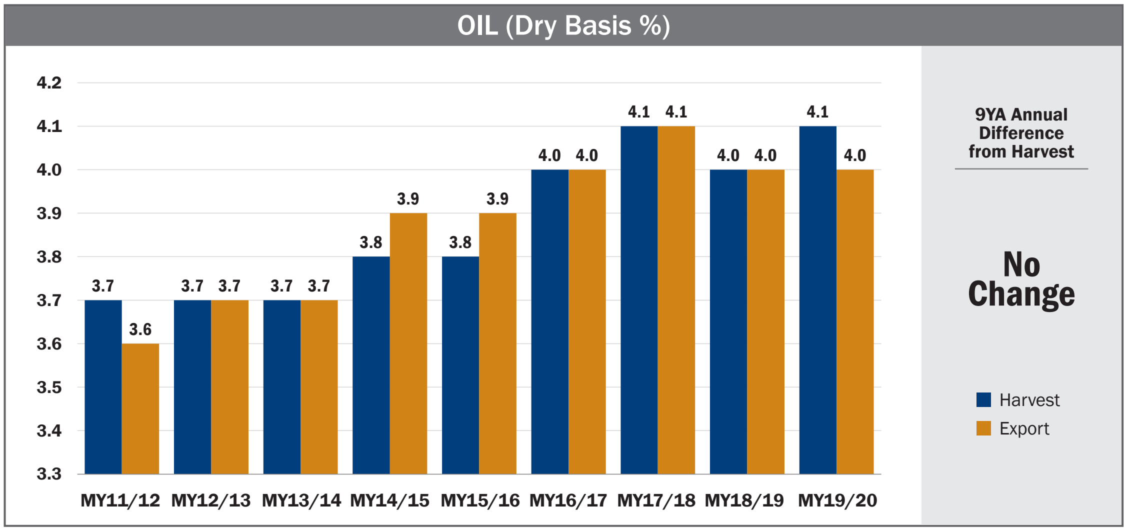
MOISTURE (%)



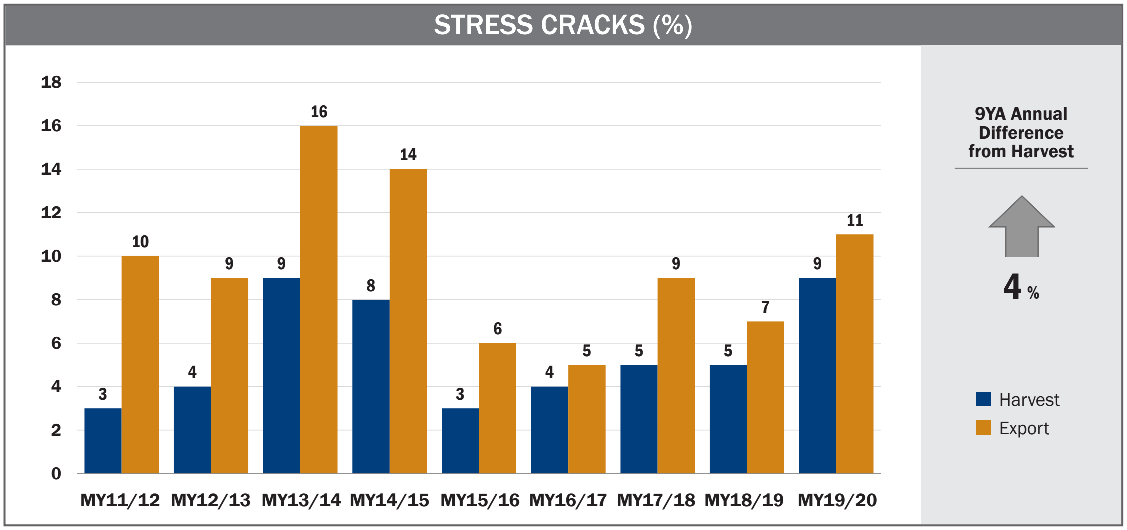
CHEMICAL COMPOSITION
AGGREGATE NINE-YEAR HARVEST AND EXPORT CARGO COMPARISON

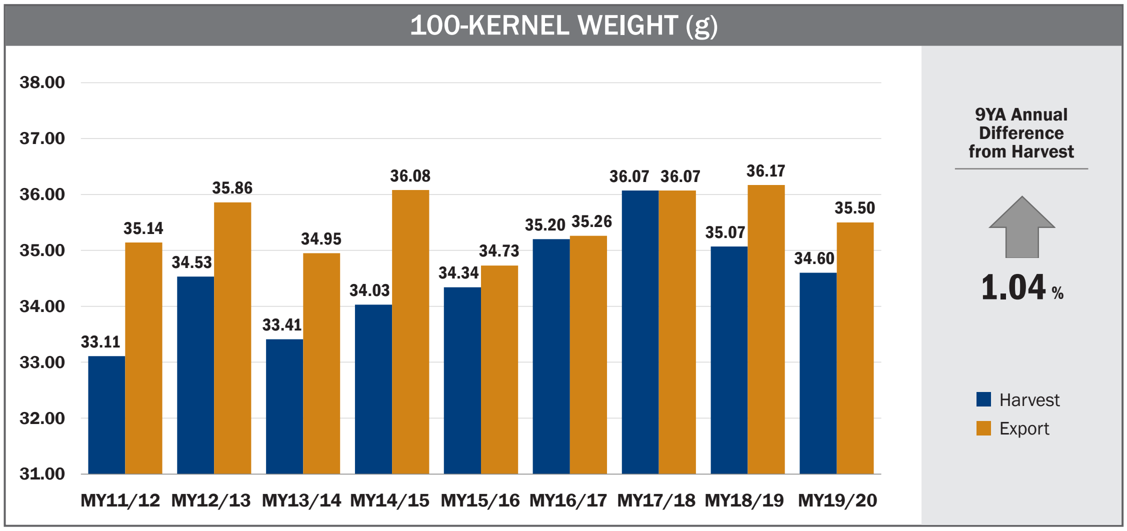


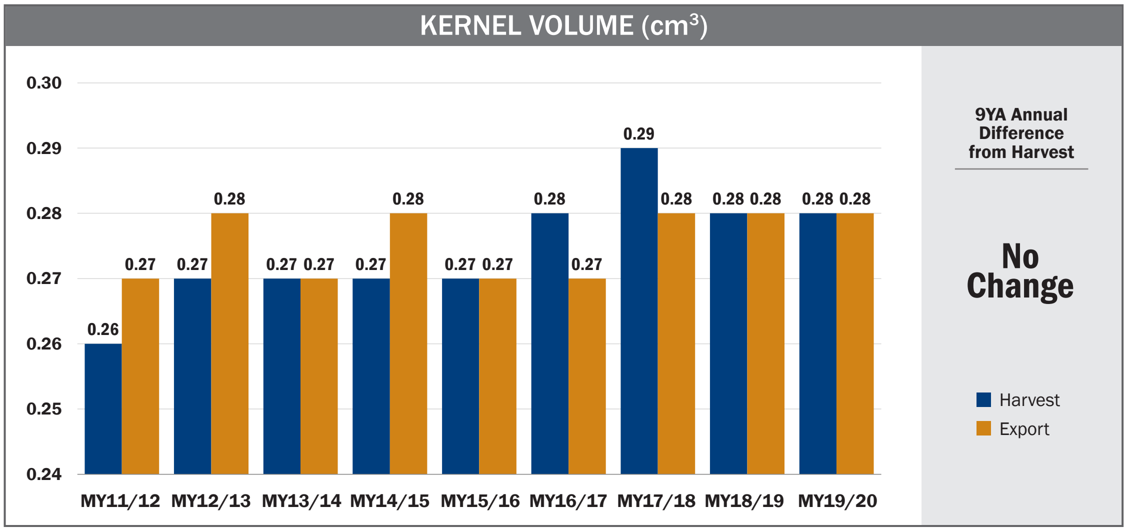




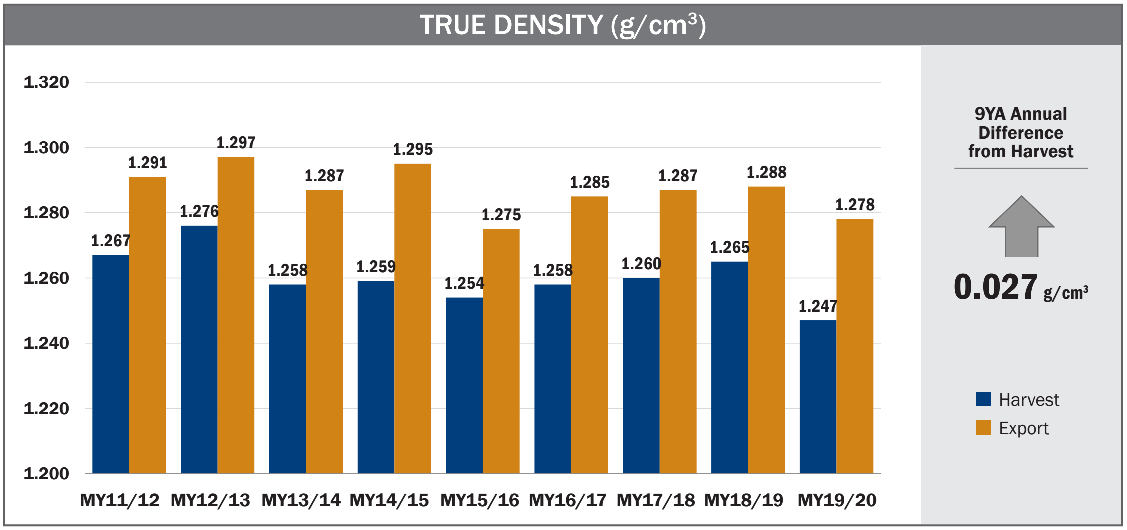
PHYSICAL FACTORS
AGGREGATE NINE-YEAR HARVEST AND EXPORT CARGO COMPARISON

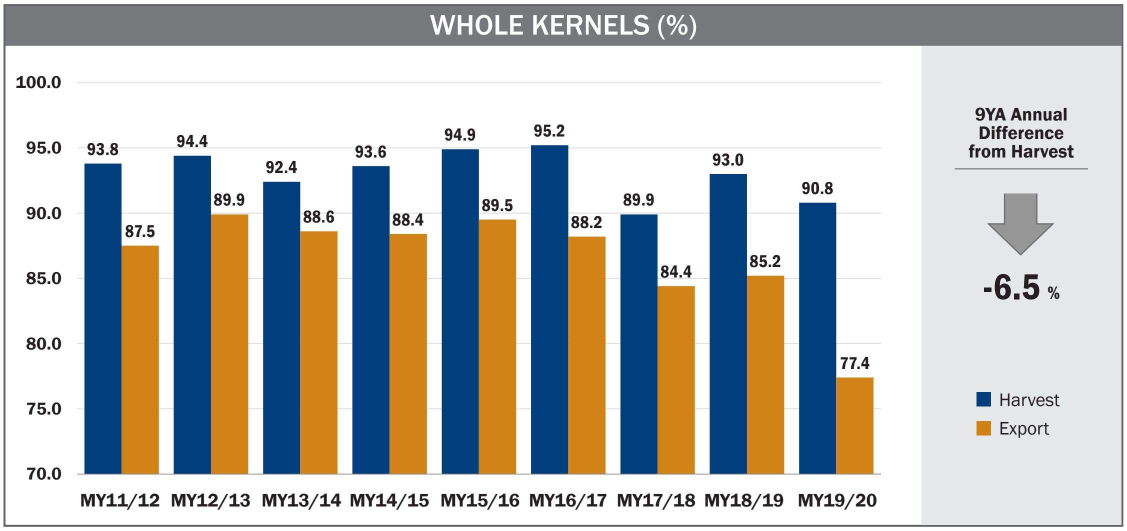


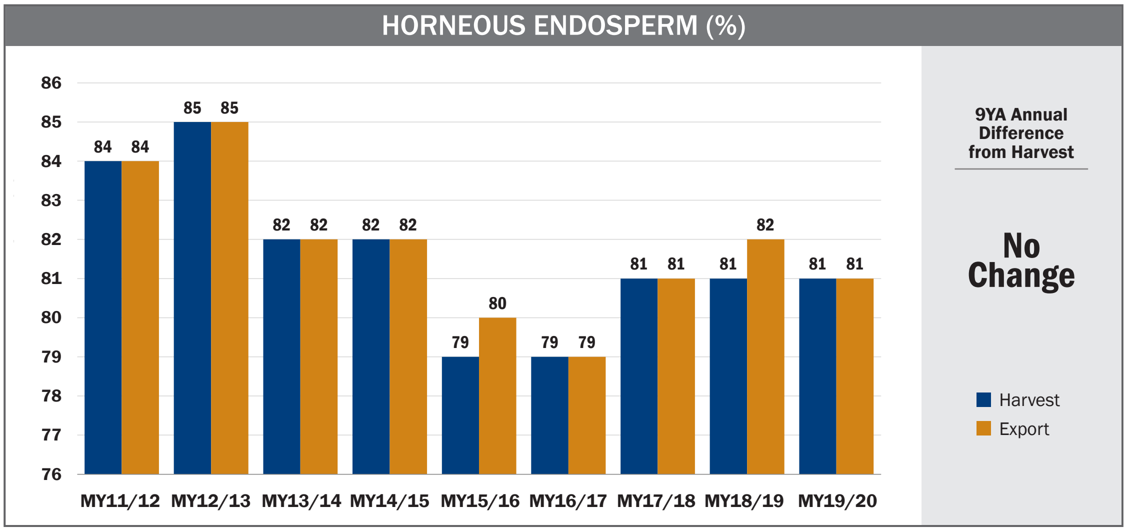




PHYSICAL FACTORS
AGGREGATE NINE-YEAR HARVEST AND EXPORT CARGO COMPARISON



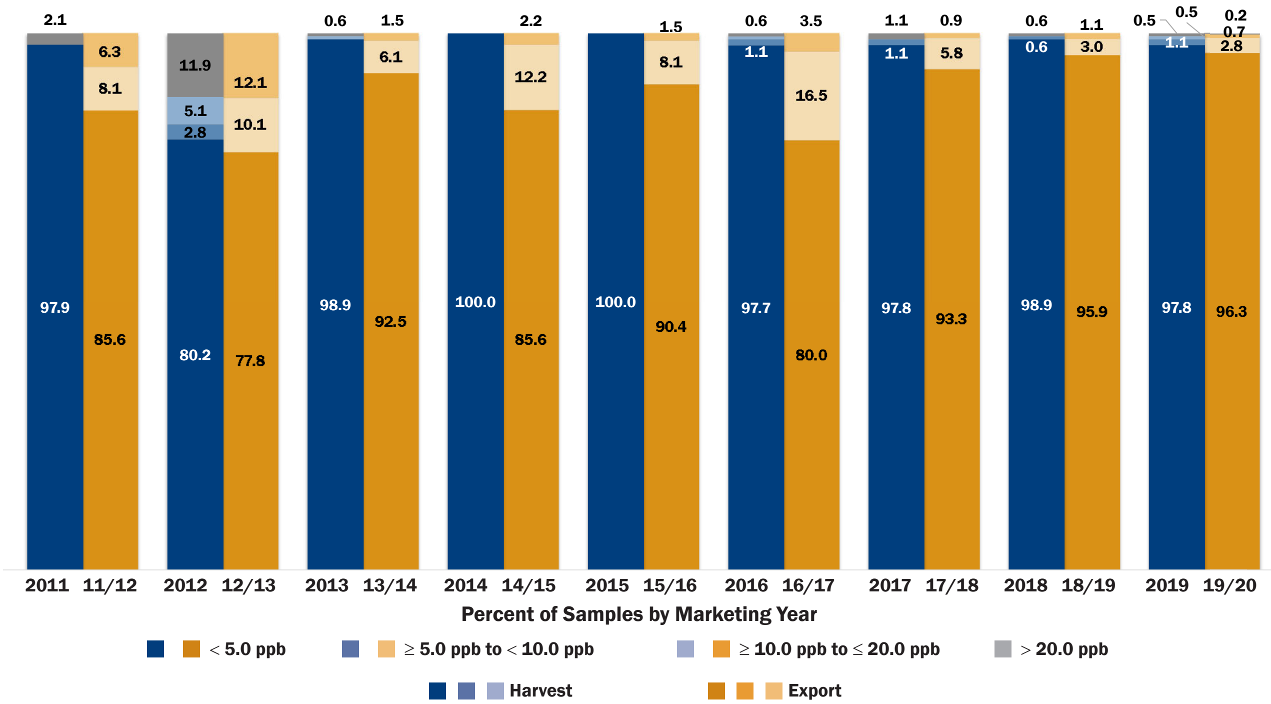




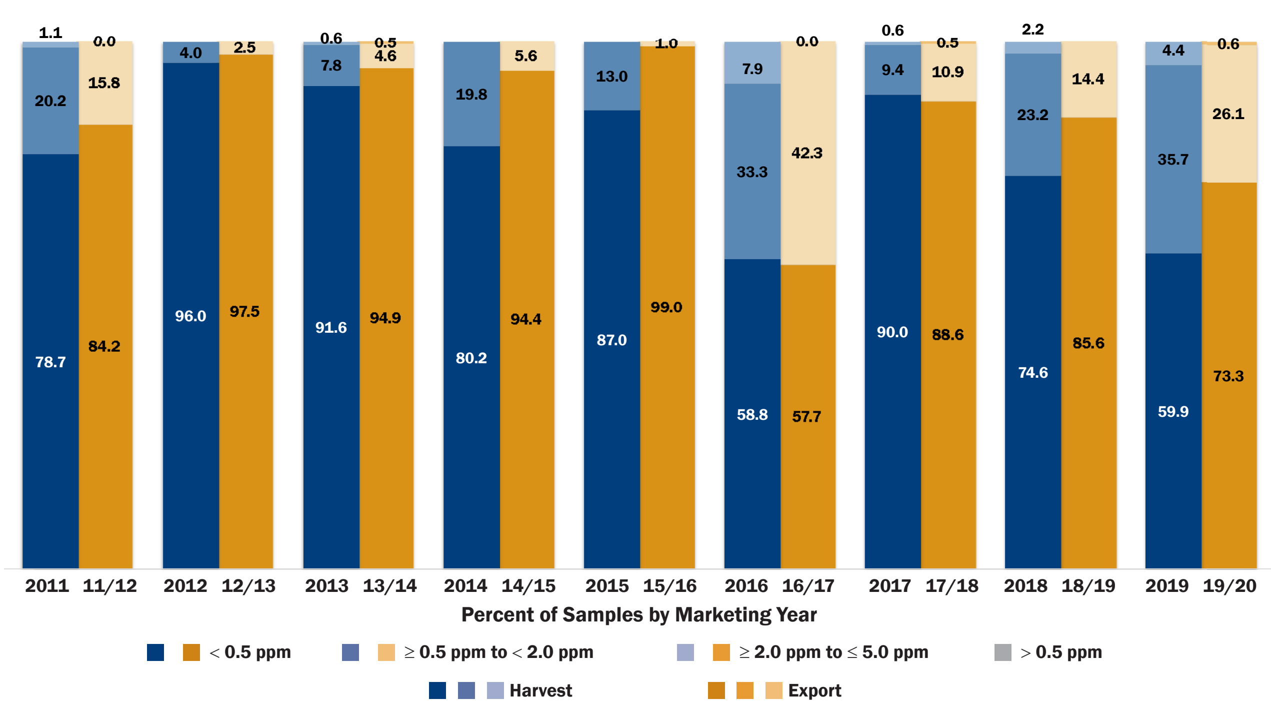
U.S. GRAINS COUNCIL

MYCOTOXINS
NINE-YEAR HARVEST AND EXPORT CARGO COMPARISON

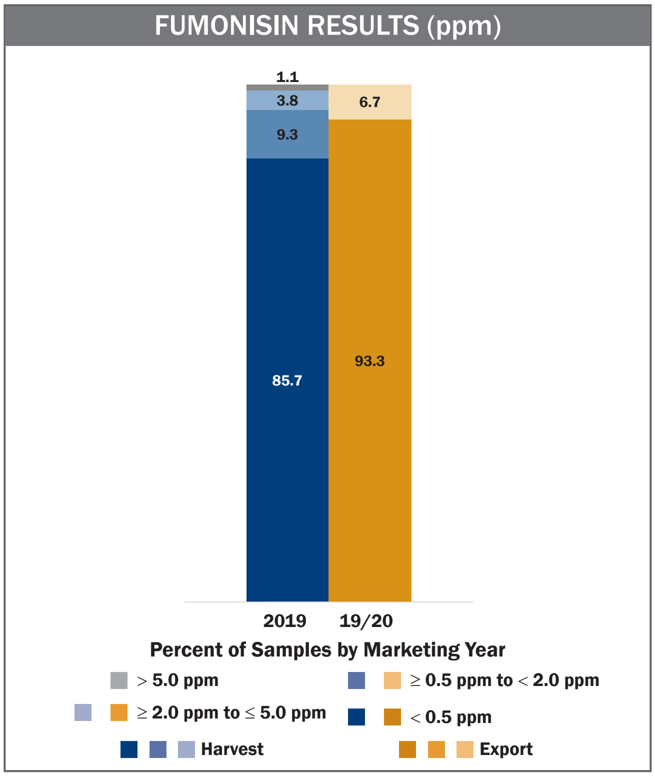
AFLATOXIN RESULTS (ppb)



DEOXYNIVALENOL (DON OR VOMITOXIN) RESULTS (ppm)



MYCOTOXINS
NINE-YEAR HARVEST AND EXPORT CARGO COMPARISON



U.S. CORN GRADES AND GRADE REQUIREMENTS

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

U.S. Sample Grade is corn that: (a) Does not meet the requirements for the grades U.S. Nos. 1, 2, 3, 4, or 5; or (b) Contains stones with an aggregate weight in excess of 0.1% 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 cockleburs (*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. AND METRIC CONVERSIONS

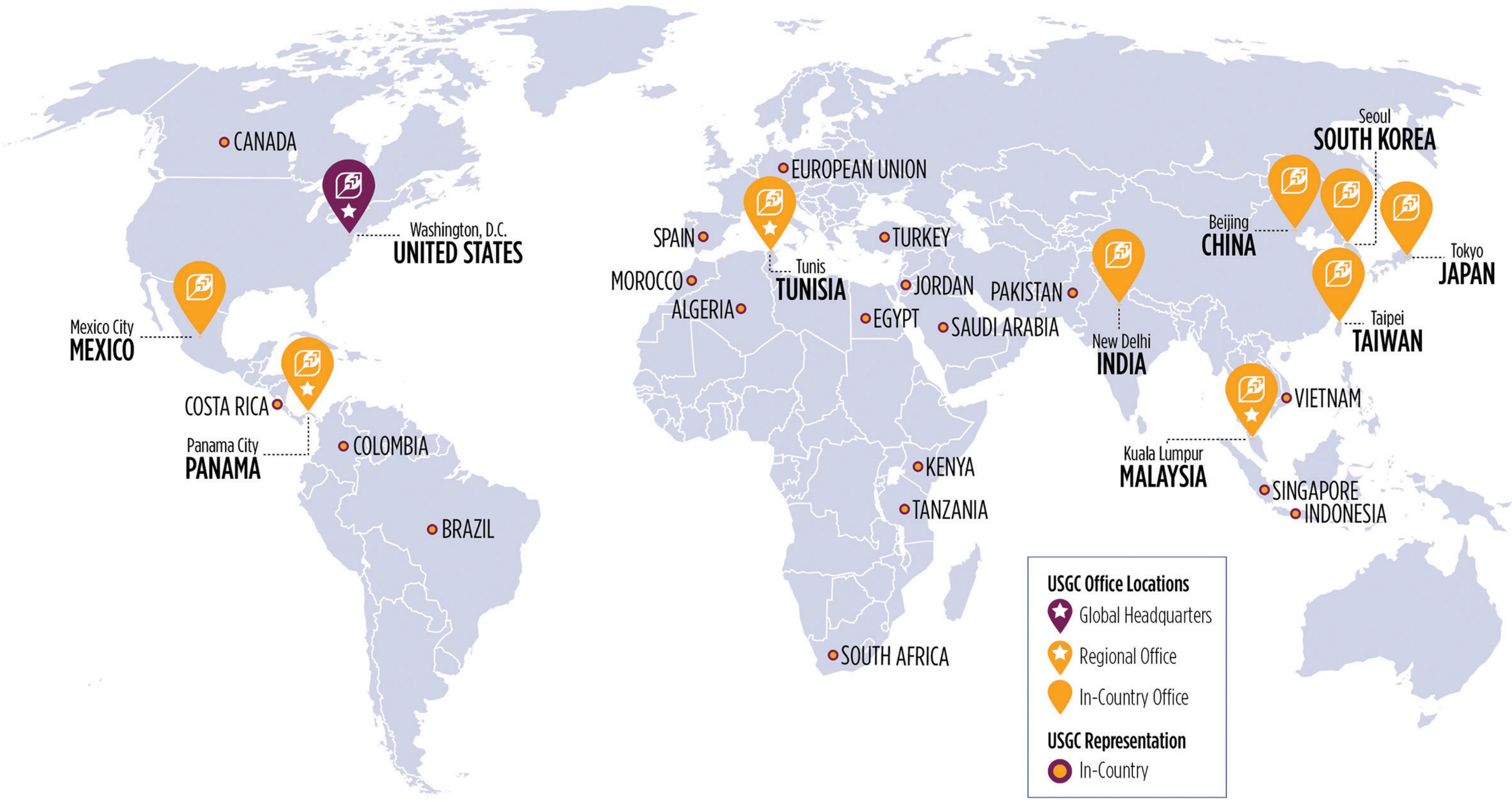
Corn Equivalents		Metric Equivalents	
1 bushel =	56 pounds (25.40 kilograms)	1 pound =	0.4536 kg
39.368 bushels =	1 metric ton	1 hundredweight =	100 pounds or 45.36 kg
15.93 bushels/acre =	1 metric ton/hectare	1 metric ton =	2204.6 lb
1 bushel/acre =	62.77 kilograms/hectare	1 metric ton =	1000 kg
1 bushel/acre =	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
ppb =	parts per billion
ppm =	parts per million

U.S. GRAINS COUNCIL

A **GLOBAL NETWORK** of **professionals BUILDING** worldwide **DEMAND** and **developing markets** for **U.S. GRAINS AND ETHANOL**.



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