U.S. GRAINS COUNCIL

2020/2021 CORN EXPORT CARGO QUALITY REPORT

ACKNOWLEDGMENTS

Developing a report of this scope and breadth in a timely manner requires participation by several 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) and Champaign-Danville Grain Inspection (CDGI) 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. 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.

GREETINGS FROM THE COUNCIL

The U.S. Grains Council (USGC) is pleased to present findings from its tenth annual corn quality survey in this *2020/2021 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 2020 corn crop. The report is based on samples taken at the point of loading for international shipment early in the 2020/2021 marketing year. This report and its sister report, the *2020/2021 Corn Harvest Quality Report*, provide an early look at the grade factors established by the U.S. Department of Agriculture as well as 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 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,

Jim Raben
Chairman, U.S. Grains Council
May 2021

BUILDING RELATIONSHIPS BUILDING TRADE

Favorable growing season conditions experienced by the 2020 U.S. crop likely benefitted the quality of the corn assembled for export early in the 2020/2021 marketing year. Reflecting this impact, the average aggregate quality of the corn samples tested for the *2020/2021 U.S. Grains Council Corn Export Cargo Quality Report* (*2020/2021 Export Cargo Report*) was better than or equal to U.S. No. 2 on all grade factors, with higher test weight and lower total damage and broken corn and foreign material (BCFM) than the 2019/2020 export samples. In addition, only one sample's test result was above the U.S. Food and Drug Administration (FDA) action level for aflatoxin, and all samples tested below the FDA's advisory level for deoxynivalenol (DON) or vomitoxin. Notable U.S. Aggregate quality attributes of the 2020/2021 export samples include:

GRADE FACTORS

- Higher average **test weight** (57.9 pounds per bushel (lb/bu) or 74.5 kilograms per hectoliter (kg/hl)) than 2019/2020 and the 5YA[1], indicating overall good quality. Most (92.7%) of the samples tested at or above the limit for U.S. No. 1 grade compared to 73.1% of the samples in 2019/2020.
- Lower average **BCFM** (2.8%) than 2019/2020, the 5YA and the maximum limit for U.S. No. 2 grade. BCFM predictably increased from 0.8 to 2.8%, as the crop moved from harvest through the marketing channel to export.
- Lower average **total damage** at export (2.3%) than 2019/2020 but similar to the 5YA. Nearly all (96.6%) of the samples were at or below the limit for U.S. No. 2 grade.
- Average **heat damage** was 0.0%, the same as 2019/2020 and the 5YA, indicating good management of drying and storage of corn throughout the marketing channel.

CHEMICAL COMPOSITION

- **Protein** concentration (8.4% dry basis) was slightly higher than 2019/2020 and the same as the 5YA.
- **Starch** concentration (72.1% dry basis) was slightly lower than 2019/2020 and the 5YA.
- **Oil** concentration (3.8% dry basis) was lower than 2019/2020 and the 5YA.

[1] *The 5YA represents the simple average of the quality factors' average or standard deviation from the 2015/2016, 2016/2017, 2017/2018, 2018/2019 and 2019/2020 Export Cargo Reports.*

PHYSICAL FACTORS

- Same average **stress cracks** (11%) as 2019/2020 but higher than the 5YA. However, the majority of the export samples (78.0%) had less than 15% stress cracks.
- Average **100-kernel weight** (37.01 grams) was higher than 2019/2020 and the 5YA, indicating heavier kernels in 2020/2021 than last year and the 5YA.
- Higher average **kernel volume** of 0.29 cubic centimeters (cm^3) than 2019/2020 and the 5YA.
- Similar average **true density** (1.277 grams per cubic centimeter (g/cm^3)) compared to 2019/2020 but lower than the 5YA.
- Average percent of **whole kernels** (83.2%) was higher than 2019/2020 but lower than the 5YA.
- Average **horneous (hard) endosperm** of 80%, slightly lower than 2019/2020 and similar to the 5YA.

MYCOTOXINS

- All but one of the samples tested below the FDA action level for **aflatoxin** of 20.0 parts per billion (ppb). A total of 98.3% of the export samples had levels of aflatoxin below the Federal Grain Inspection Service (FGIS) “Lower Conformance Limit” of 5.0 ppb in 2020/2021, a slightly higher proportion than in 2019/2020 (96.3%).
- All of the samples tested below the 5.0 parts per million (ppm) FDA advisory level for **DON**, the same as 2019/2020. Of the 180 samples tested for DON in 2020/2021, 95.6% showed levels of DON below 1.5 ppm, a lower proportion than in 2019/2020 (98.3%).
- Of the 180 samples tested for **fumonisin**, 179 or 99.4% 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 *2020/2021 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.

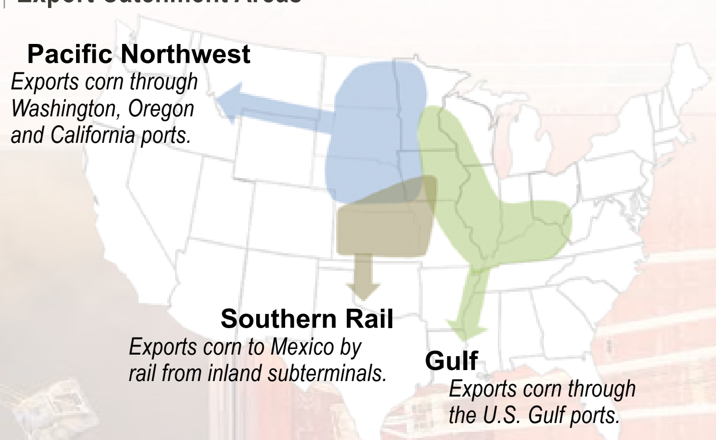
This *Export Cargo Report* is based on 440 yellow commodity corn samples collected from corn export shipments as they underwent the federal inspection and grading processes performed by FGIS or licensed inspectors at interior offices. The sample test results are reported at the U.S. aggregate level (U.S. Aggregate) and by export points associated with three general regions, which are labeled Export Catchment Areas (ECAs). These three ECAs are identified by the three major pathways to export markets:

- The Gulf ECA includes areas typically exporting corn through U.S. Gulf ports;
- The Pacific Northwest ECA includes areas exporting corn through Pacific Northwest ports;
- The Southern Rail ECA includes areas generally exporting corn to Mexico by rail from inland subterminals.

The sample test results are also summarized by grade categories “U.S. No. 2” and “U.S. No. 3” to illustrate the practical quality differences between these two specifications. Samples are classified into grade categories based on their actual grade factor test results rather than the loading contract specified by the trading partners.

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:

Export Catchment Areas



- Grade Factors: test weight, BCFM, total damage and heat damage
- 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 *2020/2021 Export Cargo Report*, FGIS and interior offices collected samples from export shipments loaded from February through April 2021 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.

This *2020/2021 Export Cargo Report* is the tenth 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 ten 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. It is important for all participants in the value chain to understand their own contract needs and obligations. In addition to grade, many of the quality attributes 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 2020/2021 Corn Harvest Quality Report*, was released in November 2020 and reported on the quality of the corn as it entered the U.S. marketing system. The *2020/2021 Harvest Report* and the *2020/2021 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

USDA FGIS has established numerical grades, definitions and standards for the 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 Supporting Information" section of this report.

SUMMARY: GRADE FACTORS

- Average U.S. Aggregate test weight (57.9 lb/bu or 74.5 kg/hl) was higher than 2019/2020, 2018/2019, the 5YA and the 10YA, and was well above the limit for U.S. No. 1 grade (56.0 lb/bu).
- Average U.S. Aggregate BCFM (2.8%) was lower than 2019/2020 (3.1%), 2018/2019 (2.9%), the 5YA (3.0%) and the 10YA (2.9%), and also well below the U.S. No. 2 grade limit (3.0%).
- A total of 71.2% of the export samples were at or below the maximum BCFM allowed for U.S. No. 2 grade (3.0%) and 91.7% were at or below the BCFM limit for U.S. No. 3 grade (4.0%).
- Average BCFM in the Southern Rail ECA (2.2%) was lower than the Gulf (2.6%) and Pacific Northwest (3.3%) ECAs. Average BCFM for the Southern Rail ECA has been lowest among the ECAs for the previous two years, the 5YA and the 10YA. Average BCFM for the Pacific Northwest ECA has been highest among the ECAs for the previous two years, the 5YA and the 10YA.
- Average U.S. Aggregate total damage (2.3%) was lower than 2019/2020 (2.9%), 2018/2019 (2.6%) and the 5YA (2.4%), higher than the 10YA (2.2%), but well below the limit for U.S. No. 1 grade (3.0%).
- Of the export samples, 75.7% had 3.0% or less damaged kernels, meeting the U.S. No. 1 grade. In addition, 96.6% were at or below the limit for U.S. No. 2 grade (5.0%).
- Average U.S. Aggregate heat damage was 0.0% for 2020/2021, the same as the previous two years, the 5YA and 10YA.

- Average BCFM of U.S. No. 2 corn from the Gulf ECA (2.5%) was lower than U.S. No. 3 corn (3.3%). This was also the case in the Pacific Northwest ECA, where BCFM in U.S. No. 2 corn was 2.5% compared to 3.5% in U.S. No. 3 corn. For the Gulf and Pacific Northwest ECAs, BCFM was the only grade factor in which the difference between U.S. No. 2 corn and U.S. No. 3 corn was statistically significant.
- In the Southern Rail ECA, total damage was the only grade factor in which the difference between U.S. No. 2 corn (2.3%) and U.S. No. 3 corn (4.9%) was statistically significant.

U.S. Corn Grades and Grade Requirements

		Maximum Limits of		
		Damaged Kernels		
Grade	Minimum Test Weight per Bushel (Pounds)	Heat Damaged (Percent)	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

TEST WEIGHT

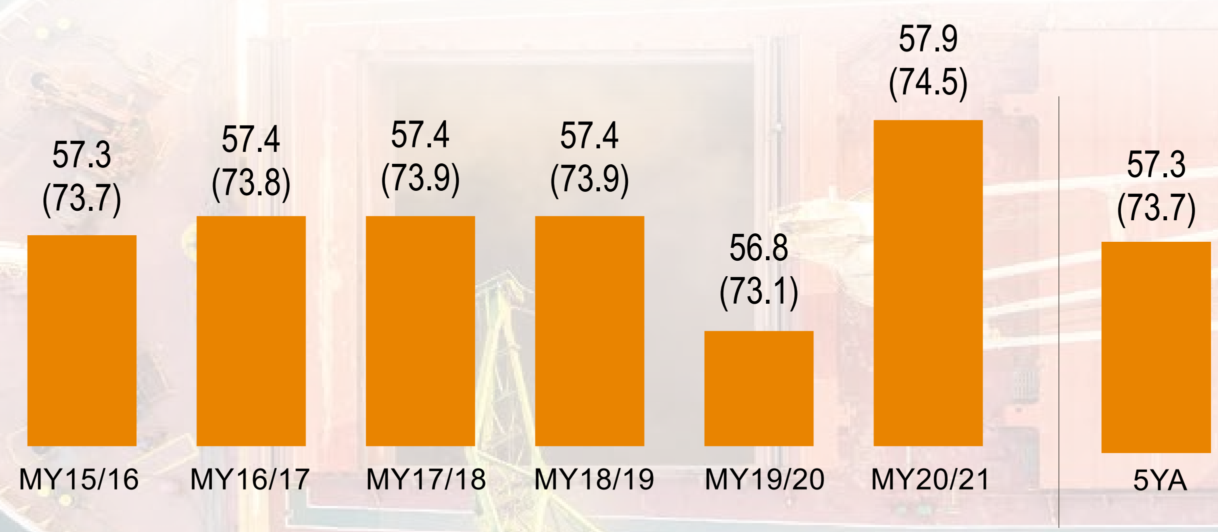
Test weight (weight per volume) is a measure of bulk density. It is often used as a general indicator of overall quality and as a gauge of endosperm hardness for alkaline cookers and dry millers. High test weight corn takes up less storage space than the same weight of corn with lower test weight. Test weight is initially impacted by genetic differences in the structure of the kernel. However, it is also affected by moisture content, drying speed, physical damage to the kernel (broken or scuffed kernel surfaces), foreign material in the sample, kernel size and hardness, kernel maturity 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 has a positive correlation with true density and reflects kernel hardness and good maturation conditions.

RESULTS

- Average U.S. Aggregate test weight (57.9 lb/bu or 74.5 kg/hl) was well above the limit for U.S. No. 1 grade (56.0 lb/bu) and was higher than 2019/2020 (56.8 lb/bu), 2018/2019 (57.4 lb/bu), the 5YA (57.3 lb/bu) and the 10YA (57.5 lb/bu).
- The 2020/2021 export samples had a standard deviation (0.63 lb/bu), lower than 2019/2020 (1.0 lb/bu) 2018/2019 (0.82 lb/bu), the 5YA (0.81 lb/bu) and the 10YA (0.78 lb/bu). The range in values in 2020/2021 was 6.4 lb/bu, less than 2019/2020 (9.7 lb/bu) and 2018/2019 (7.6 lb/bu).

TEST WEIGHT (lb/bu & kg/hl)

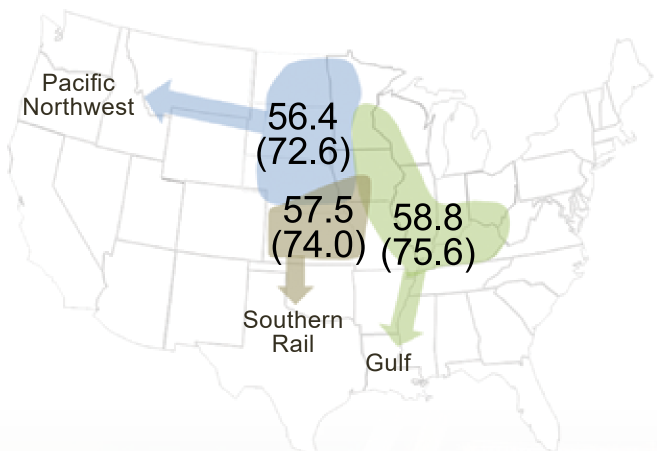
U.S. Aggregate Results Summary



- Average U.S. Aggregate test weight for 92.7% of the 2020/2021 samples was at or above the minimum for U.S. No. 1 grade (56.0 lb/bu), and 100.0% 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 (57.9 lb/bu) was lower than the 2020 harvest (58.7 lb/bu or 75.5 kg/hl). The average test weight at export has been consistently lower than at harvest, as indicated by the export 5YA (57.3 lb/bu) and 10YA (57.5 lb/bu) compared to the harvest 5YA (58.1 lb/bu) and 10YA (58.2 lb/bu).
- The variability of the 2020/2021 export samples as measured by the standard deviation (0.63 lb/bu) was less than that of the 2020 harvest samples (1.22 lb/bu). As corn is commingled moving in the marketing channel, test weight becomes more uniform, with a lower standard deviation and a range between maximum and minimum values that is less than at harvest. The 5YA standard deviation at export was 0.81 lb/bu, compared with the harvest 5YA standard deviation of 1.22 lb/bu.
- The average test weight was lower for the Pacific Northwest (56.4 lb/bu) than for the Southern Rail (57.5 lb/bu) and the Gulf (58.8 lb/bu) ECAs.

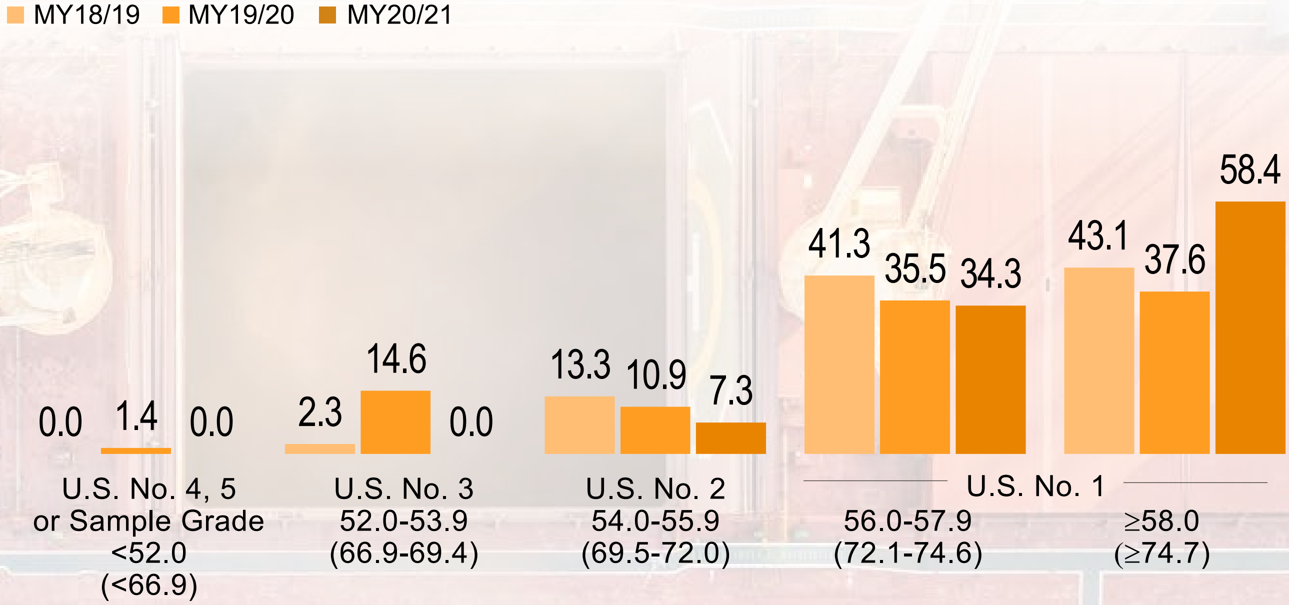
TEST WEIGHT (lb/bu & kg/hl)

2020/2021 Average by Export Catchment Area



TEST WEIGHT (lb/bu & kg/hl)

Percent of Samples by Marketing Year



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.

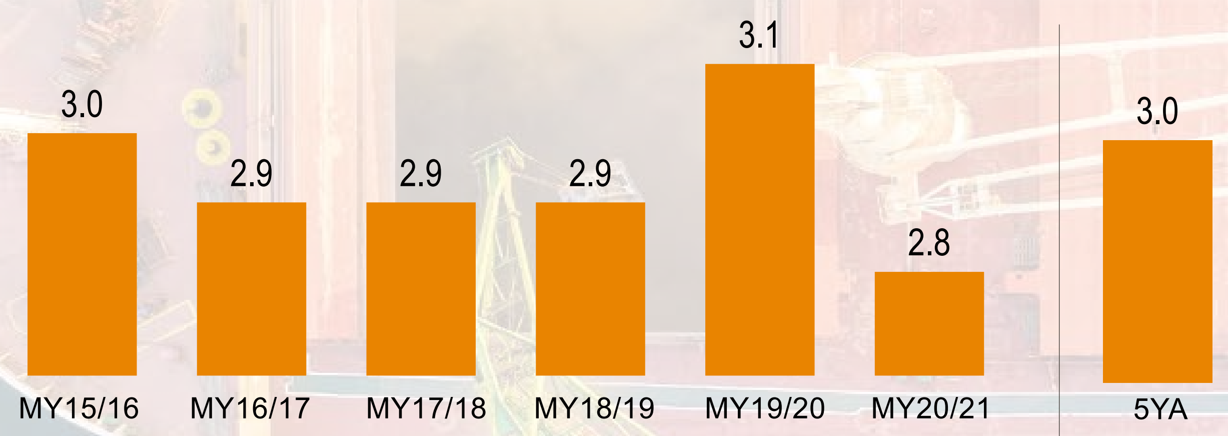
Broken corn (BC) is defined as corn and any other material (such as weed seeds) small enough to pass through a 12/64th-inch round-hole sieve but too large to pass through a 6/64th-inch round-hole sieve. Foreign material (FM) is defined as any non-corn material too large to pass through a 12/64th-inch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

RESULTS

- Average U.S. Aggregate BCFM in export samples (2.8%) was lower than 2019/2020 (3.1%), 2018/2019 (2.9%), the 5YA (3.0%) and the 10YA (2.9%), and also below the U.S. No. 2 grade limit (3.0%).
- The variability of the 2020/2021 export samples (with a standard deviation of 0.80%) was similar to 2019/2020 (0.79%), 2018/2019 (0.67%) and the 5YA and 10YA (both 0.69%). The range in values (8.2%) was greater than 2019/2020 (6.1%) but similar to 2018/2019 (8.4%).
- BCFM in the 2020/2021 export samples was distributed with 71.2% of the samples at or below the limit for U.S. No. 2 grade (3.0%), and 91.7% at or below the limit for U.S. No. 3 grade (4.0%).

BCFM (%)

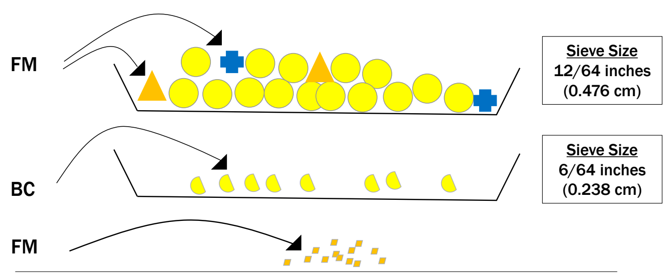
U.S. Aggregate Results Summary



- Average U.S. Aggregate BCFM at export (2.8%) was 2.0 percentage points higher than at harvest (0.8%). A similar difference also occurred for the harvest 5YA and 10YA (both 0.8%) compared to the export 5YA (3.0%) and 10YA (2.9%). This increase is likely higher broken corn as a result of artificial drying and additional impacts caused by conveying and handling as the corn moves through the market channel.
- Average BCFM in the Southern Rail ECA (2.2%) was lower than the Gulf (2.6%) and Pacific Northwest (3.3%) ECAs. Average BCFM for the Southern Rail has also been lowest among the ECAs for the previous two years, the 5YA and the 10YA. Average BCFM for the Pacific Northwest ECA has been highest among the ECAs for the previous two years, the 5YA and the 10YA.

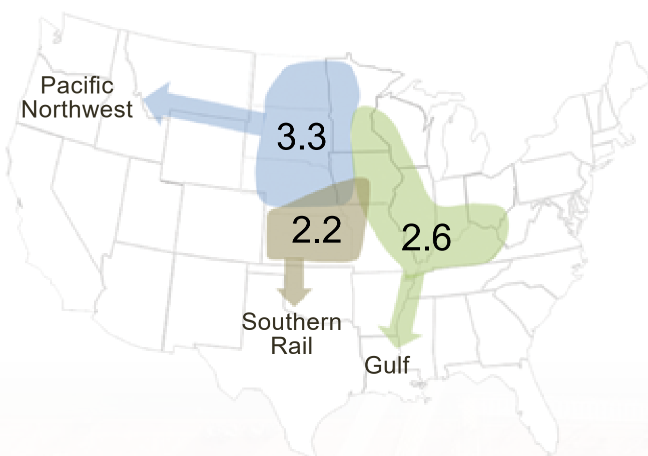
BCFM (%)

Broken Corn and Foreign Material Measured as Percent by Weight



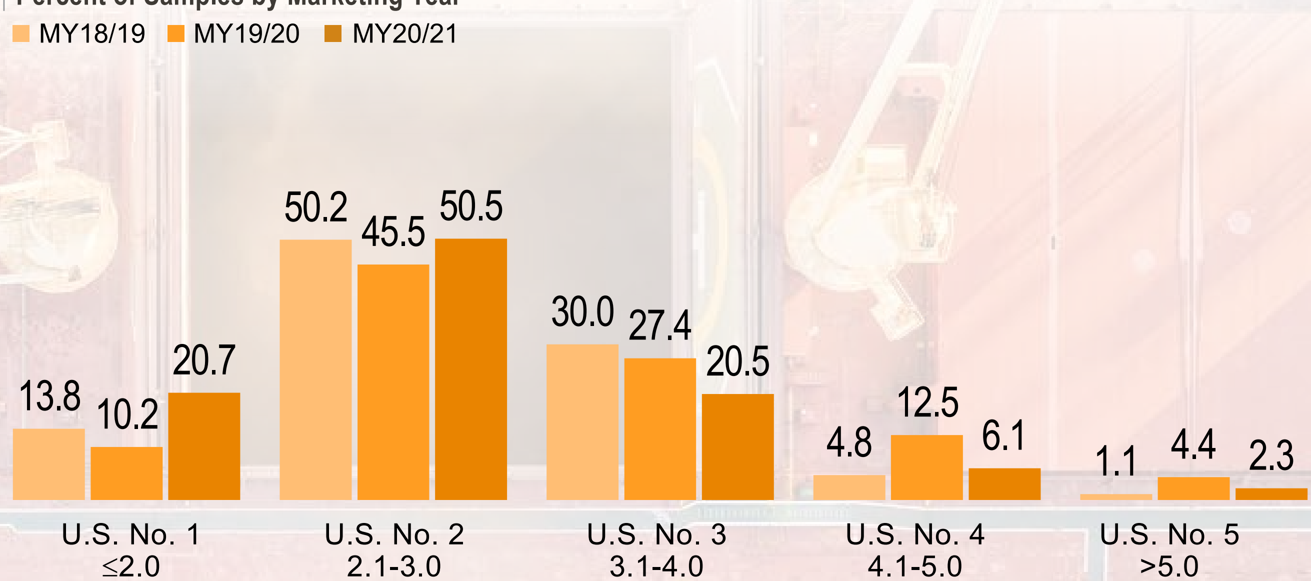
BCFM (%)

2020/2021 Average by Export Catchment Area



BCFM (%)

Percent of Samples by Marketing Year



TOTAL DAMAGE

Total damage is the percent of kernels and pieces of kernels that are visually damaged in some way, including damage from mold, frost, insects, sprouting, disease, weather, ground, germ and heat. Most of these types of damage result in some discoloration or change in kernel texture. However, damage does not include broken pieces of grain that are otherwise normal in appearance.

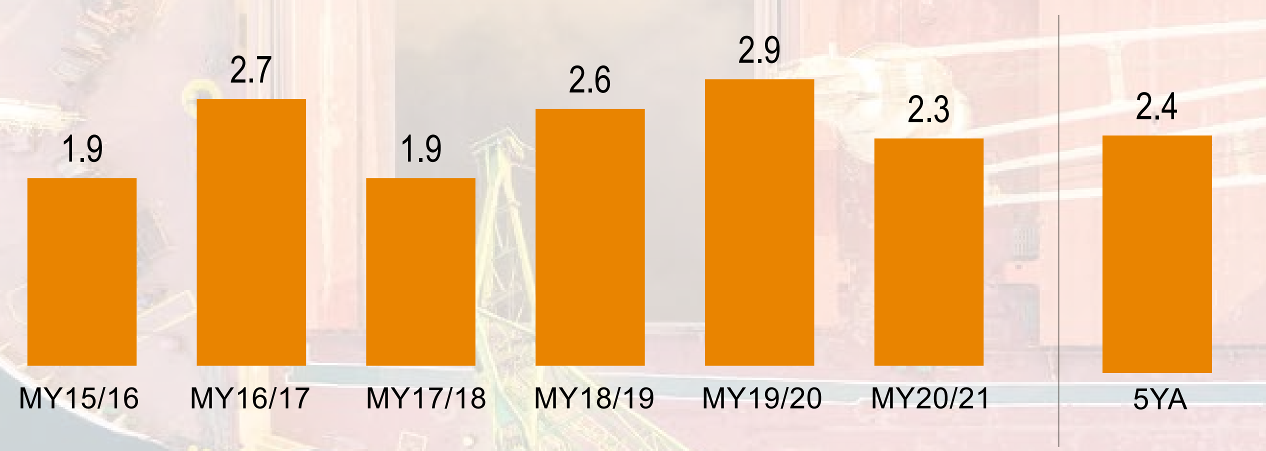
Mold damage is usually associated with higher moisture content and warm temperatures during the growing season or during storage. Several field molds, such as Diplodia, Aspergillus, Fusarium and Gibberella, can lead to mold-damaged kernels during the growing season if the weather conditions are conducive to their development. While some fungi that produce mold damage can also produce mycotoxins, not all fungi produce mycotoxins. The chance of mold decreases as corn is dried and cooled to lower temperatures.

RESULTS

- Average U.S. Aggregate total damage (2.3%) was well below the limit for U.S. No. 1 grade (3.0%) and lower than 2019/2020 (2.9%) and 2018/2019 (2.6%) but above the 10YA (2.2%). While the 5YA for total damage was 2.4%, this difference from the 2020/2021 average was not statistically significant.
- Variability in the 2020/2021 samples, as indicated by the standard deviation (1.26%), was lower than 2019/2020 (1.37%), but similar to 2018/2019 (1.10%), the 5YA and 10YA (both 1.09%). The 2020/2021 sample range (0.1 to 8.6%) was lower than the range for 2019/2020 (0.1 to 10.8%) and 2018/2019 (0.0 to 10.5%).

TOTAL DAMAGE (%)

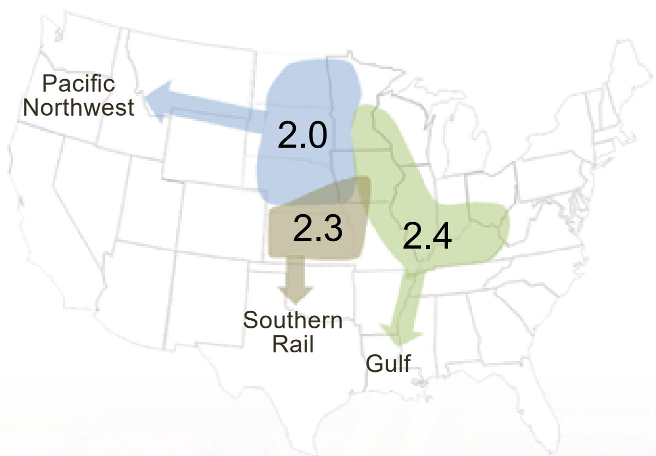
U.S. Aggregate Results Summary



- Of the export samples, 75.7% had 3.0% or less damaged kernels, meeting the U.S. No. 1 grade. In addition, 96.6% 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 (2.3%) was higher than at harvest (1.1%). The export 5YA (2.4%) was 0.5 percentage points higher than the harvest 5YA (1.9%). The export 10YA (2.2%) was 0.7 percentage points higher than the harvest 10YA (1.5%). Total damage can increase during storage, especially if there are spout-lines and pockets of high moisture corn in the storage bins or transport containers.
- Average U.S. Aggregate total damage for ECAs were Gulf (2.4%), Pacific Northwest (2.0%) and Southern (2.3%). Average total damage for the Pacific Northwest ECA has been lowest among the ECAs for the previous two years, the 5YA and the 10YA.

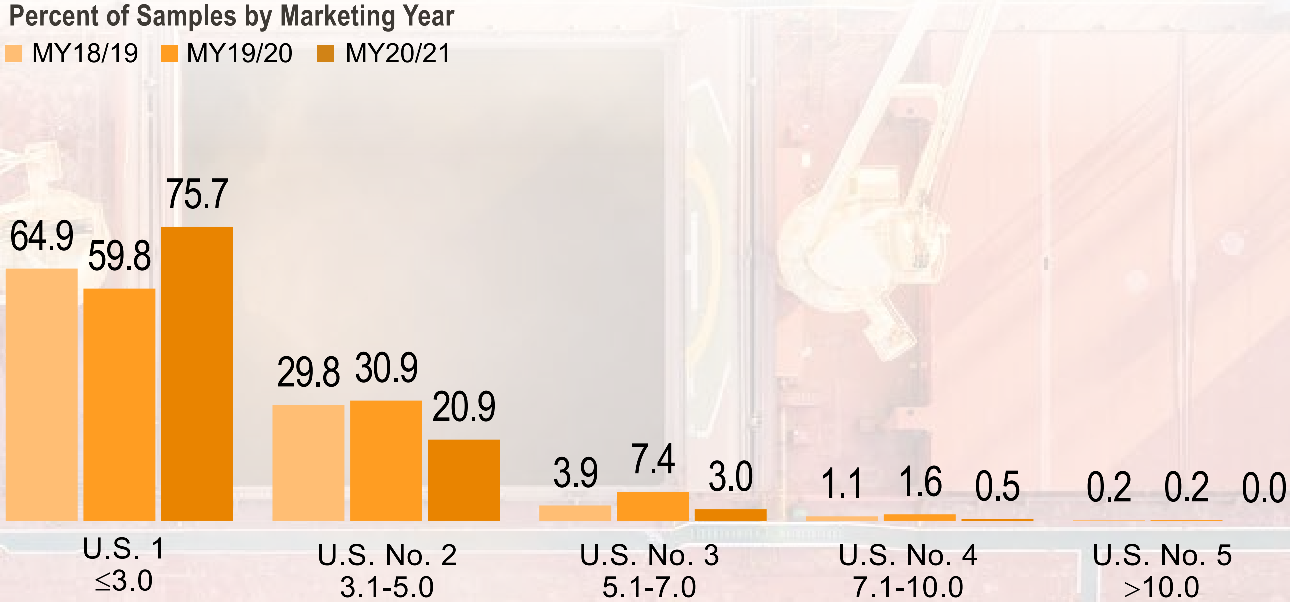
TOTAL DAMAGE (%)

2020/2021 Average by Export Catchment Area



TOTAL DAMAGE (%)

Percent of Samples by Marketing Year



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 for 2020/2021 was 0.0%, the same as 2019/2020, 2018/2019, the 5YA and 10YA. 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 one sample in the entire 2020/2021 export cargo sample set (a total of 440 samples) showed any heat damage. This sample had 0.2% heat damage.

SUMMARY: GRADE FACTORS

	2020/2021 Export Cargo					2019/2020 Export Cargo					2018/2019 Export Cargo				
	No. of Samples	Avg.	Std. Dev.	Min.	Max.	No. of Samples	Avg.	Std. Dev.	Min.	Max.	No. of Samples	Avg.	Std. Dev.	Min.	Max.
U.S. Aggregate															
Test Weight (lb/bu)	440	57.9	0.63	54.0	60.4	431	56.8*	1.00	50.4	60.1	436	57.4*	0.82	52.0	59.6
Test Weight (kg/hl)	440	74.5	0.81	69.5	77.7	431	73.1*	1.29	64.9	77.4	436	73.9*	1.05	66.9	76.7
BCFM (%)	440	2.8	0.80	0.9	9.1	431	3.1*	0.79	0.9	7.0	436	2.9*	0.67	0.4	8.8
Total Damage (%)	440	2.3	1.26	0.1	8.6	430	2.9*	1.37	0.1	10.8	436	2.6*	1.10	0.0	10.5
Heat Damage (%)	440	0.0	0.01	0.0	0.2	431	0.0	0.01	0.0	0.2	436	0.0*	0.01	0.0	0.1
Gulf															
Test Weight (lb/bu)	244	58.8	0.51	57.3	60.4	242	58.0*	0.76	55.1	59.9	275	58.0*	0.66	55.5	59.4
Test Weight (kg/hl)	244	75.6	0.66	73.8	77.7	242	74.6*	0.97	70.9	77.1	275	74.7*	0.85	71.4	76.5
BCFM (%)	244	2.6	0.66	1.1	4.9	242	3.0*	0.69	1.2	5.6	275	2.9*	0.53	1.3	4.9
Total Damage (%)	244	2.4	0.98	0.2	6.5	241	3.6*	1.50	0.6	10.8	275	3.3*	1.37	0.8	10.5
Heat Damage (%)	244	0.0	0.01	0.0	0.2	242	0.0	0.02	0.0	0.2	275	0.0	0.02	0.0	0.1
Pacific Northwest															
Test Weight (lb/bu)	120	56.4	0.73	54.0	58.4	117	53.9*	1.37	50.4	60.1	96	55.5*	1.23	52.0	58.4
Test Weight (kg/hl)	120	72.6	0.94	69.5	75.2	117	69.3*	1.76	64.9	77.4	96	71.4*	1.58	66.9	75.2
BCFM (%)	120	3.3	1.25	1.1	9.1	117	3.8*	1.17	1.7	7.0	96	3.5	1.17	1.5	8.8
Total Damage (%)[1]	120	2.0	1.53	0.1	7.1	117	1.6*	1.47	0.1	7.7	96	0.7*	0.61	0.0	2.8
Heat Damage (%)	120	0.0	0.00	0.0	0.0	117	0.0	0.02	0.0	0.2	96	0.0	0.01	0.0	0.1
Southern Rail															
Test Weight (lb/bu)	76	57.5	0.83	56.3	59.9	72	57.5	1.24	54.2	59.4	65	57.5	0.86	55.9	59.6
Test Weight (kg/hl)	76	74.0	1.06	72.5	77.1	72	74.0	1.60	69.8	76.5	65	74.0	1.11	72.0	76.7
BCFM (%)	76	2.2	0.54	0.9	4.2	72	2.2	0.53	0.9	3.8	65	1.9*	0.53	0.4	3.0
Total Damage (%)[1]	76	2.3	1.74	0.1	8.6	72	2.5	0.78	1.0	4.9	65	2.4	0.75	1.0	4.3
Heat Damage (%)	76	0.0	0.00	0.0	0.0	72	0.0	0.00	0.0	0.0	65	0.0	0.00	0.0	0.0

**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 the population average exceeded ±10.0%.

SUMMARY: GRADE FACTORS

	Five-Year Average (MY15/16-MY19/20)			Ten-Year Average (MY11/12-MY20/21)		
	No. of Samples	Avg.	Std. Dev.	No. of Samples	Avg.	Std. Dev.
U.S. Aggregate						
Test Weight (lb/bu)	2,135	57.3	0.81	4,174	57.5	0.78
Test Weight (kg/hl)	2,135	73.7	1.04	4,174	74.0	1.01
BCFM (%)	2,135	3.0	0.69	4,174	2.9	0.69
Total Damage (%)	2,134	2.4	1.09	4,173	2.2	1.09
Heat Damage (%)	2,135	0.0	0.01	4,174	0.0	0.01
Gulf						
Test Weight (lb/bu)	1,343	57.8	0.75	2,719	58.0	0.70
Test Weight (kg/hl)	1,343	74.4	0.96	2,719	74.7	0.90
BCFM (%)	1,343	2.9	0.58	2,719	2.9	0.64
Total Damage (%)	1,342	2.9	1.23	2,718	2.6	1.20
Heat Damage (%)	1,343	0.0	0.01	2,719	0.0	0.01
Pacific Northwest						
Test Weight (lb/bu)	483	55.7	0.94	958	55.9	0.97
Test Weight (kg/hl)	483	71.7	1.21	958	72.0	1.25
BCFM (%)	483	3.6	1.06	958	3.4	0.91
Total Damage (%)	483	0.9	0.84	958	0.9	0.86
Heat Damage (%)	483	0.0	0.01	958	0.0	0.01
Southern Rail						
Test Weight (lb/bu)	309	57.5	0.83	497	57.8	0.85
Test Weight (kg/hl)	309	74.1	1.07	497	74.4	1.10
BCFM (%)	309	2.1	0.59	497	2.2	0.51
Total Damage (%)	309	2.5	0.91	497	2.2	0.90
Heat Damage (%)	309	0.0	0.00	497	0.0	0.01

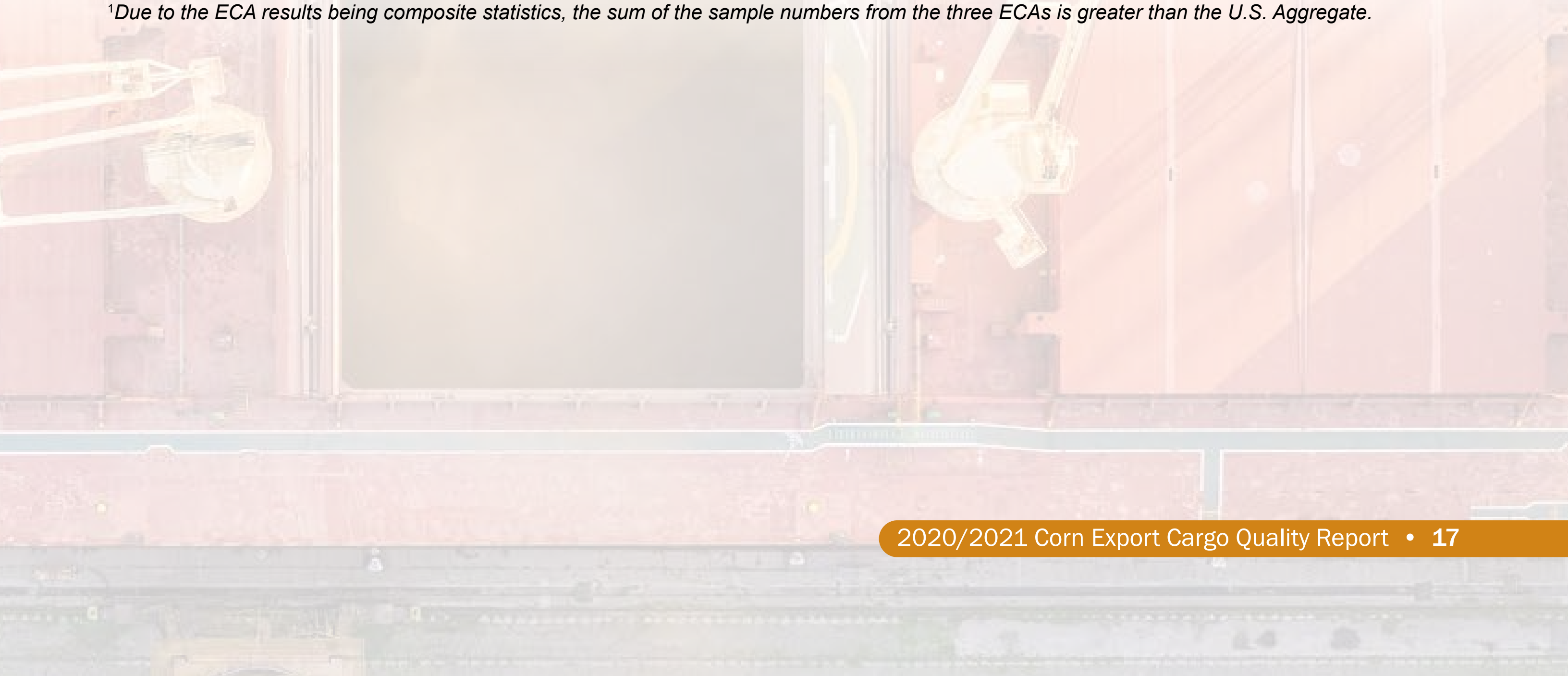
U.S. GRAINS COUNCIL

SUMMARY: GRADE FACTORS

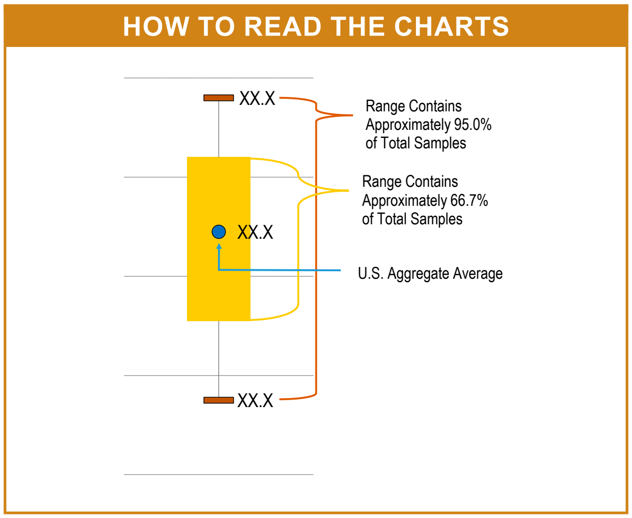
	2020/2021 Export Cargo Samples U.S. No. 2					2020/2021 Export Cargo Samples U.S. No. 3					2020 Harvest				
	No. of Samples	Avg.	Std. Dev.	Min.	Max.	No. of Samples	Avg.	Std. Dev.	Min.	Max.	No. of Samples[1]	Avg.	Std. Dev.	Min.	Max.
U.S. Aggregate															
Test Weight (lb/bu)	236	58.0	0.60	55.4	60.4	103	58.0	0.64	54.0	59.9	601	58.7*	1.22	52.6	62.5
Test Weight (kg/hl)	236	74.7	0.77	71.3	77.7	103	74.7	0.83	69.5	77.1	601	75.5*	1.57	67.7	80.4
BCFM (%)	236	2.5	0.36	1.2	3.0	103	3.3	0.36	2.2	4.2	601	0.8*	0.49	0.1	8.8
Total Damage (%)	236	2.3	1.12	0.1	5.0	103	2.6	1.36	0.2	7.0	601	1.1*	1.06	0.0	18.3
Heat Damage (%)	236	0.0	0.00	0.0	0.0	103	0.0	0.00	0.0	0.0	601	0.0	0.00	0.0	0.1
Gulf															
Test Weight (lb/bu)	145	58.7	0.53	57.3	60.4	62	58.8	0.49	57.9	59.9	549	58.8	1.25	53.4	62.5
Test Weight (kg/hl)	145	75.6	0.68	73.8	77.7	62	75.7	0.64	74.5	77.1	549	75.7	1.61	68.7	80.4
BCFM (%)	145	2.5	0.35	1.2	3.0	62	3.3	0.34	2.2	4.1	549	0.8*	0.53	0.1	8.8
Total Damage (%)	145	2.5	0.99	0.2	5.0	62	2.6	1.04	1.0	6.5	549	1.5*	1.42	0.0	18.3
Heat Damage (%)	145	0.0	0.00	0.0	0.0	62	0.0	0.00	0.0	0.0	549	0.0	0.00	0.0	0.1
Pacific Northwest															
Test Weight (lb/bu)	48	56.4	0.62	55.4	58.1	34	56.6	0.93	54.0	58.4	293	58.3*	1.19	52.6	61.9
Test Weight (kg/hl)	48	72.6	0.80	71.3	74.8	34	72.8	1.20	69.5	75.2	293	75.0*	1.53	67.7	79.7
BCFM (%)	48	2.5	0.39	1.6	3.0	34	3.5	0.41	2.4	4.2	293	0.8*	0.44	0.1	4.1
Total Damage (%)	48	1.7	1.35	0.1	4.8	34	2.2	1.79	0.2	7.0	293	0.5*	0.64	0.0	8.4
Heat Damage (%)	48	0.0	0.00	0.0	0.0	34	0.0	0.00	0.0	0.0	293	0.0	0.00	0.0	0.1
Southern Rail															
Test Weight (lb/bu)	43	57.5	0.81	56.4	59.9	7	57.9	0.56	56.9	58.4	319	58.9*	1.18	53.4	62.5
Test Weight (kg/hl)	43	74.1	1.04	72.6	77.1	7	74.5	0.72	73.2	75.2	319	75.8*	1.51	68.7	80.4
BCFM (%)	43	2.4	0.37	1.6	3.0	7	2.5	0.32	2.2	3.1	319	0.8*	0.44	0.1	8.8
Total Damage (%)	43	2.3	1.29	0.3	4.6	7	4.9	2.07	0.3	6.5	319	0.9*	0.68	0.0	14.1
Heat Damage (%)	43	0.0	0.00	0.0	0.0	7	0.0	0.00	0.0	0.0	319	0.0*	0.00	0.0	0.1

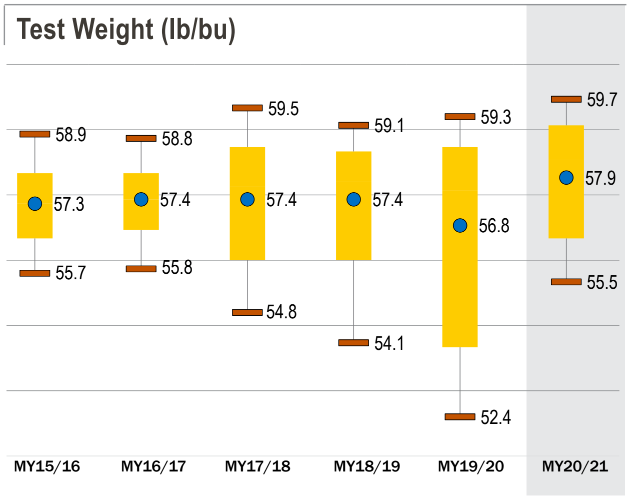
**Indicates current year's Export Cargo average was significantly different from this year's Harvest, based on a 2-tailed t-test at the 95% level of confidence.*

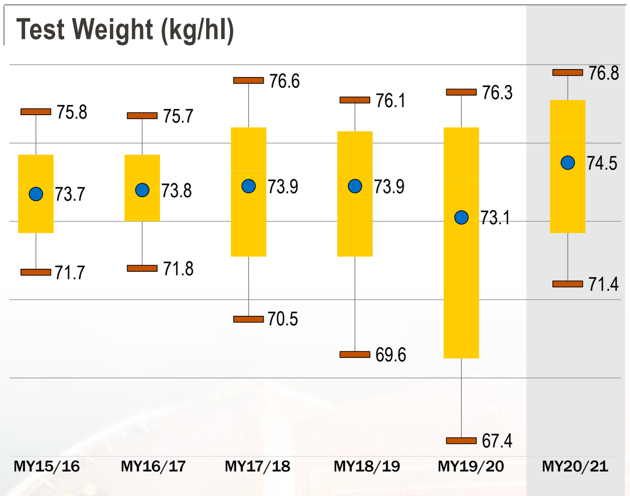
[1]Due to the ECA results being composite statistics, the sum of the sample numbers from the three ECAs is greater than the U.S. Aggregate.

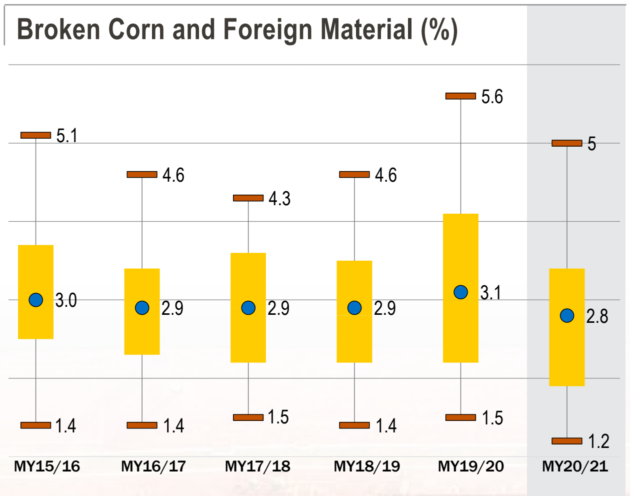


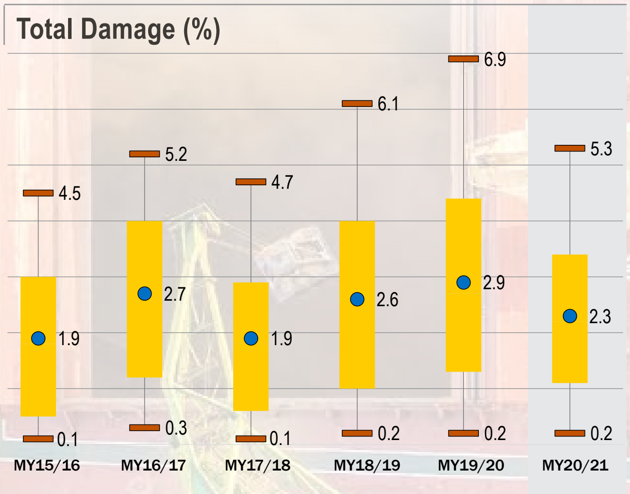
GRADE FACTORS
AGGREGATE SIX-YEAR COMPARISON











B. CHEMICAL COMPOSITION

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

SUMMARY: CHEMICAL COMPOSITION

- Average U.S. Aggregate protein concentration at export (8.4%) was slightly higher than 2019/2020 (8.3%), the same as the 5YA (8.4%), but lower than 2018/2019, 10YA and the 2020 harvest average (all 8.5%).
- Average U.S. Aggregate starch concentration (72.1%) was lower than 2019/2020 (72.2%), 2018/2019 (72.3%), the 5YA (72.6%), the 10YA (73.0%) and the 2020 harvest average (72.2%).
- Average U.S. Aggregate oil concentration (3.8%) was lower than 2019/2020, 2018/2019 and the 5YA (all 4.0%), and the 10YA and 2020 harvest average (both 3.9%).
- The standard deviations for protein, starch and oil concentrations were lower in the export samples than in the harvest samples.
- No statistically significant differences in protein, starch and oil concentrations were observed between U.S. No. 2 corn and U.S. No. 3 corn from each ECA.

PROTEIN

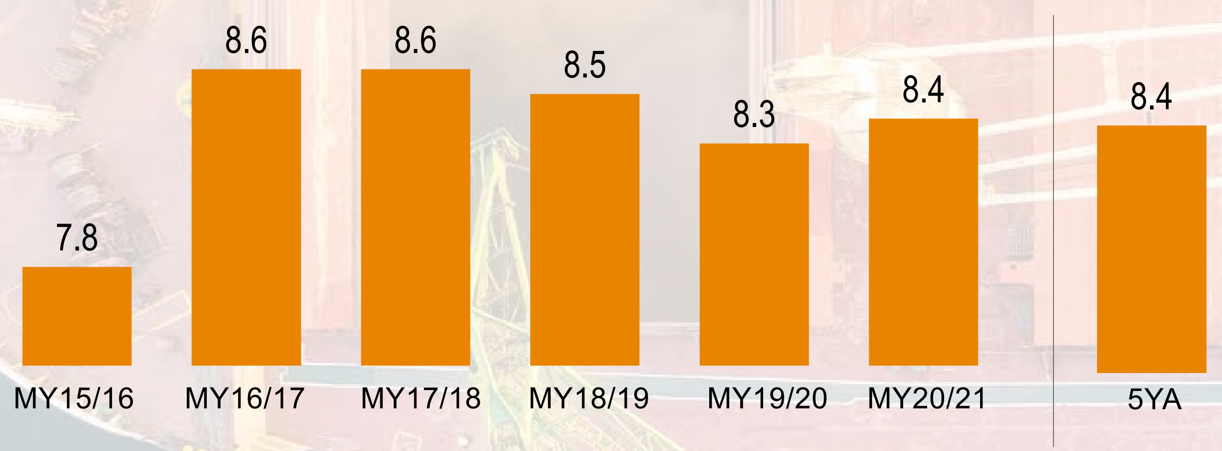
Protein is very important for poultry and livestock feeding because it supplies essential sulfur-containing amino acids and helps to improve feed conversion efficiency. Protein concentration tends to decrease with decreased available soil nitrogen and in years with high yields. On a single sample basis,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

RESULTS

- Average U.S. Aggregate protein concentration (8.4%) was higher than 2019/2020 (8.3%), the same as the 5YA, but lower than 2018/2019, 10YA and the 2020 harvest average (all 8.5%).
- Variability in the 2020/2021 samples, as indicated by the standard deviation (0.31%), was similar to 2019/2020 (0.29%) and the 10YA (0.30%), the same as the 5YA but lower than 2018/2019 (0.37%).
- The average protein concentration of the 2020/2021 export samples (8.4%) was not statistically different than the average of the 2020 harvest samples (8.5%). The average protein concentration generally changes little from harvest to export.

PROTEIN (DRY BASIS %)

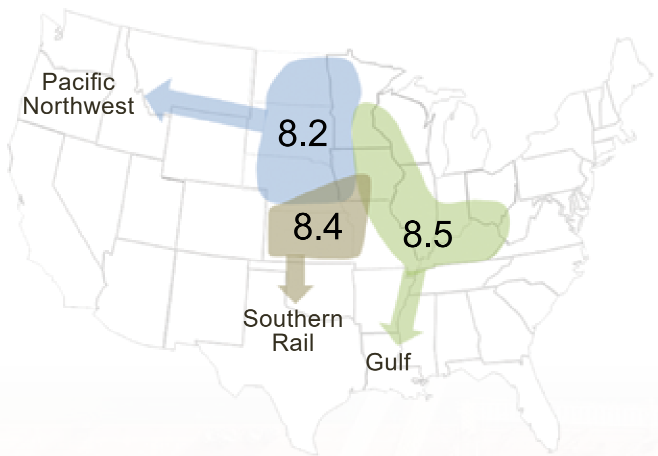
U.S. Aggregate Results Summary



- The 2020/2021 export samples (standard deviation of 0.31%) were more uniform than the 2020 harvest samples (standard deviation of 0.58%). In addition, the range of protein concentrations at export (7.5 to 9.4%) was less than at harvest (6.1 to 10.7%). The uniformity is due, in part, to grains becoming more homogenous as they are aggregated from numerous harvest-level sources.
- The 2020/2021 export samples were distributed with 89.8% of protein concentrations at or above 8.0%, compared with 87.0% of the 2019/2020 samples and 94.0% of the 2018/2019 samples.
- The Gulf ECA had the highest average protein concentration (8.5%), followed by the Southern Rail ECA (8.4%) and the Pacific Northwest ECA (8.2%).
- No statistically significant differences in protein concentration were observed between U.S. No. 2 corn and U.S. No. 3 corn from each of the ECAs.

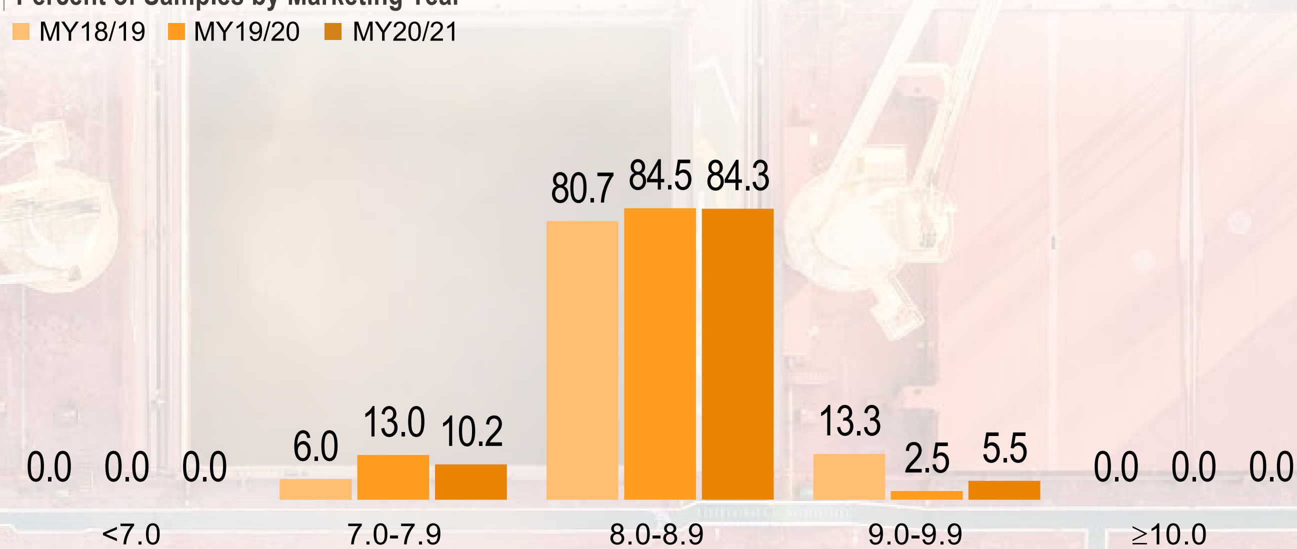
PROTEIN (DRY BASIS %)

2020/2021 Average by Export Catchment Area



PROTEIN (DRY BASIS %)

Percent of Samples by Marketing Year



STARCH

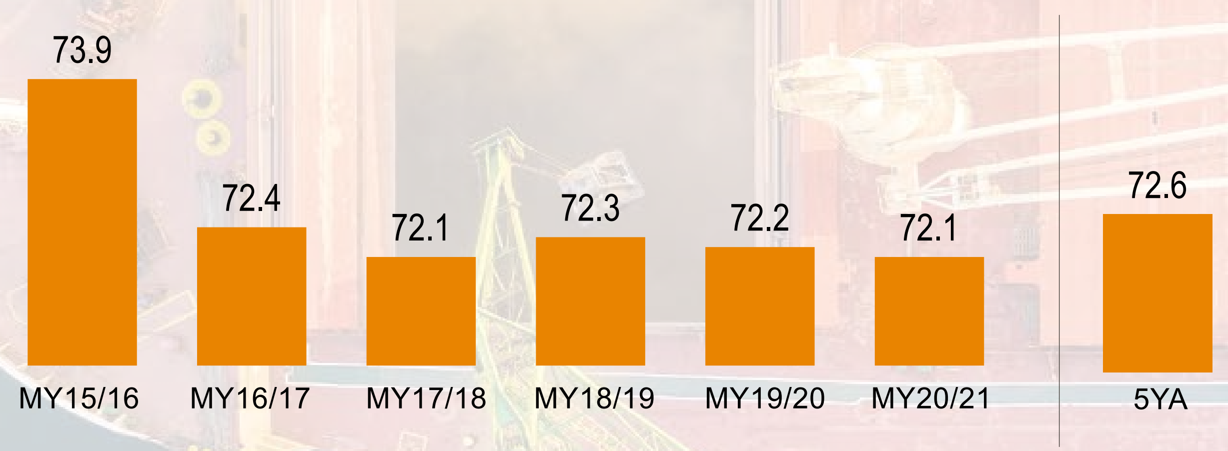
Starch is an important factor for corn used by wet millers and dry-grind ethanol manufacturers. High starch concentration is often indicative of good kernel growing/filling conditions and reasonably moderate kernel densities. Starch is usually inversely related to protein concentration on a single sample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

RESULTS

- Average U.S. Aggregate starch concentration (72.1%) was lower than 2019/2020 (72.2%), 2018/2019 (72.3%), the 5YA (72.6%), the 10YA (73.0%) and the average U.S. Aggregate concentration for the 2020 harvest (72.2%).
- Variability in the 2020/2021 samples, as indicated by the standard deviation (0.35%), was lower than 2019/2020 (0.38%), 2018/2019 (0.43%), the 5YA (0.42%) and the 10YA (0.46%). The 2020/2021 sample range (70.8 to 73.0%) was lower than the range for 2019/2020 (70.2 to 73.4%) and 2018/2019 (70.4 to 73.9%).

STARCH (DRY BASIS %)

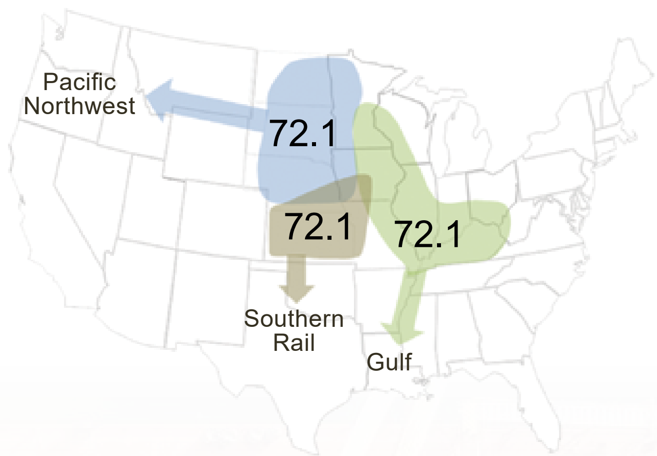
U.S. Aggregate Results Summary



- The standard deviation for starch concentration of the 2020/2021 export samples (0.35%) was lower than the standard deviation of the 2020 harvest samples (0.61%). The average starch concentration of the export samples (72.1%) was also lower than the average of the 2020 harvest samples (72.2%). Average starch concentration generally changes little from harvest to export, while variability in export samples, as indicated by the standard deviation, is typically less at export than at harvest.
- Starch concentrations were distributed with 69.1% at or above 72.0%, compared with 72.4% in 2019/2020 and 75.2% in 2018/2019.
- Average starch concentration for the Gulf ECA (72.1%) was the same as the Southern Rail ECA and the Pacific Northwest ECA.
- No statistically significant differences in starch concentration were observed between U.S. No. 2 corn and U.S. No. 3 corn from each of the ECAs.

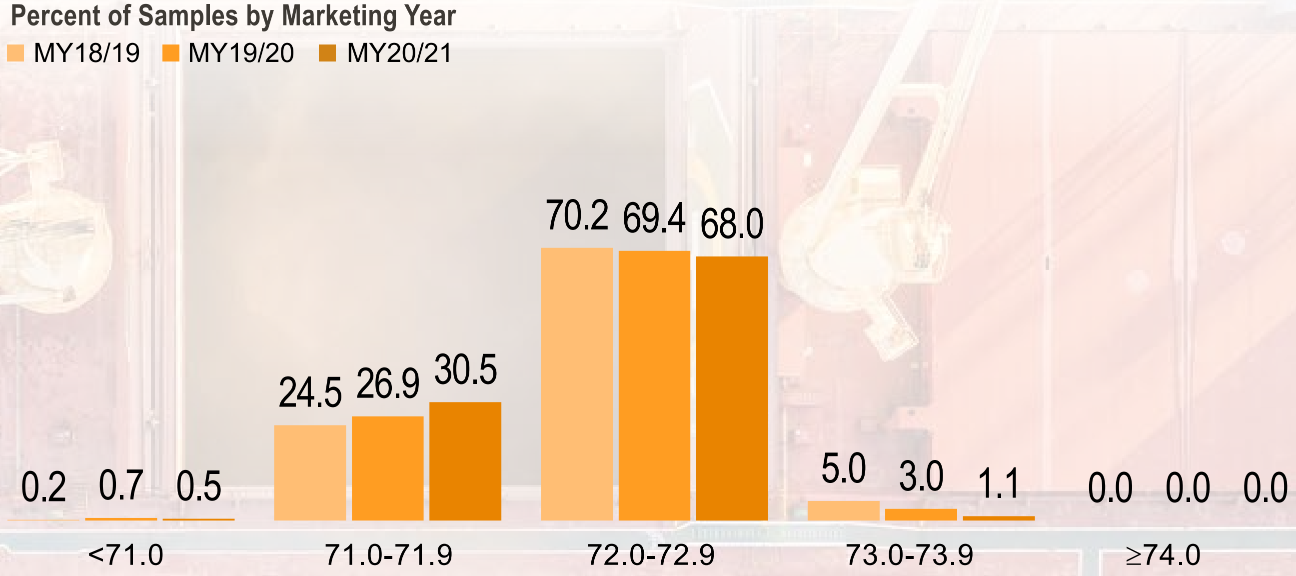
STARCH (DRY BASIS %)

2020/2021 Average by Export Catchment Area



STARCH (DRY BASIS %)

Percent of Samples by Marketing Year



OIL

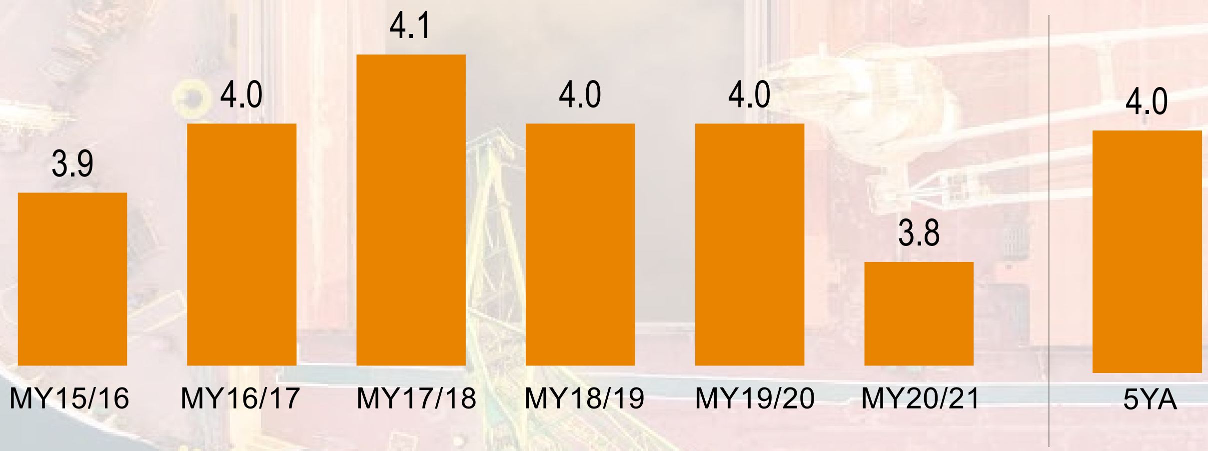
Oil is an essential component of poultry and livestock rations. It serves as an energy source, enables fat-soluble vitamins to be utilized and provides certain essential fatty acids. Oil is also an important co-product of corn wet and dry milling. Results are reported on a dry basis.

RESULTS

- Average U.S. Aggregate oil concentration (3.8%) was lower than 2019/2020, 2018/2019 and the 5YA (all 4.0%) and the 10YA (3.9%).
- The 2020/2021 export samples had a standard deviation (0.13%), similar to 2019/2020 (0.15%), 2018/2019 (0.14%) and the 5YA (0.15%) but lower than the 10YA (0.17%).
- Average oil concentration for the 2020/2021 export samples was lower than the 2020 harvest samples (3.9%). The standard deviation at export (0.13%) was also lower than at harvest (0.22%). Average oil concentration generally changes little from harvest to export while variability in export samples, as indicated by the standard deviation, is typically less at export than at harvest.

OIL (DRY BASIS %)

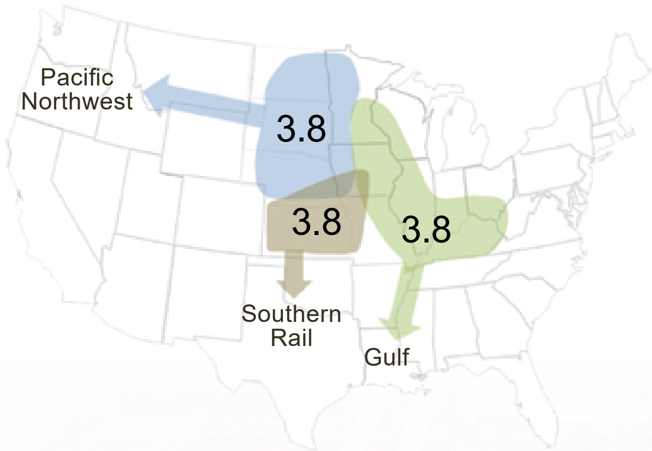
U.S. Aggregate Results Summary



- The 2020/2021 samples showed a much lower percentage of samples at or above 4.0% oil (15.2%) than in 2019/2020 (72.9%), and in 2018/2019 (69.9%).
- Average oil concentration for the Gulf ECA (3.8%) was the same as the Southern Rail ECA and the Pacific Northwest ECA.
- No statistically significant differences in oil concentration were observed between U.S. No. 2 corn and U.S. No. 3 corn from each of the ECAs.

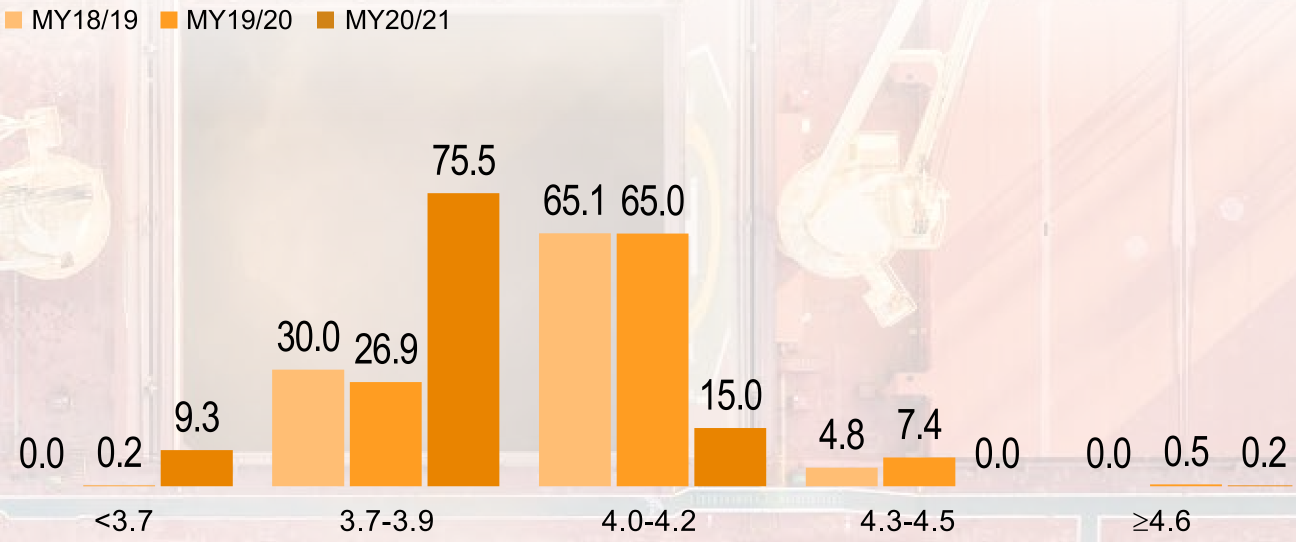
OIL (DRY BASIS %)

2020/2021 Average by Export Catchment Area



OIL (DRY BASIS %)

Percent of Samples by Marketing Year



SUMMARY: CHEMICAL COMPOSITION

2020/2021 Export Cargo	No. of Samples	Avg.	Std. Dev.	Min.	Max.
U.S. Aggregate					
Protein (Dry Basis %)	440	8.4	0.31	7.5	9.4
Starch (Dry Basis %)	440	72.1	0.35	70.8	73.0
Oil (Dry Basis %)	440	3.8	0.13	3.4	4.7
Gulf					
Protein (Dry Basis %)	244	8.5	0.25	7.6	9.4
Starch (Dry Basis %)	244	72.1	0.30	71.2	73.0
Oil (Dry Basis %)	244	3.8	0.12	3.4	4.1
Pacific Northwest					
Protein (Dry Basis %)	120	8.2	0.37	7.5	9.3
Starch (Dry Basis %)	120	72.1	0.41	70.8	73.0
Oil (Dry Basis %)	120	3.8	0.13	3.4	4.1
Southern Rail					
Protein (Dry Basis %)	76	8.4	0.41	7.7	9.2
Starch (Dry Basis %)	76	72.1	0.42	71.0	73.0
Oil (Dry Basis %)	76	3.8	0.17	3.5	4.7

2019/2020 Export Cargo	No. of Samples	Avg.	Std. Dev.	Min.	Max.
U.S. Aggregate					
Protein (Dry Basis %)	432	8.3*	0.29	7.1	9.3
Starch (Dry Basis %)	432	72.2*	0.38	70.2	73.4
Oil (Dry Basis %)	432	4.0*	0.15	3.6	4.6
Gulf					
Protein (Dry Basis %)	242	8.3*	0.22	7.7	9.0
Starch (Dry Basis %)	242	72.4*	0.34	71.3	73.4
Oil (Dry Basis %)	242	4.0*	0.13	3.6	4.4
Pacific Northwest					
Protein (Dry Basis %)	117	8.1*	0.38	7.1	9.3
Starch (Dry Basis %)	117	71.9*	0.44	70.2	73.0
Oil (Dry Basis %)	117	4.1*	0.18	3.7	4.6
Southern Rail					
Protein (Dry Basis %)	73	8.5	0.37	7.7	9.3
Starch (Dry Basis %)	73	72.0	0.41	71.2	72.9
Oil (Dry Basis %)	73	4.0*	0.15	3.7	4.3

2018/2019 Export Cargo	No. of Samples	Avg.	Std. Dev.	Min.	Max.
U.S. Aggregate					
Protein (Dry Basis %)	436	8.5*	0.37	7.1	9.8
Starch (Dry Basis %)	436	72.3*	0.43	70.4	73.9
Oil (Dry Basis %)	436	4.0*	0.14	3.7	4.5
Gulf					
Protein (Dry Basis %)	275	8.5	0.26	7.4	9.2
Starch (Dry Basis %)	275	72.4*	0.34	71.3	73.1
Oil (Dry Basis %)	275	4.0*	0.13	3.7	4.5
Pacific Northwest					
Protein (Dry Basis %)	96	8.4*	0.55	7.1	9.8
Starch (Dry Basis %)	96	72.1	0.64	70.4	73.9
Oil (Dry Basis %)	96	4.1*	0.14	3.7	4.5
Southern Rail					
Protein (Dry Basis %)	65	8.7*	0.53	7.6	9.8
Starch (Dry Basis %)	65	72.1	0.51	71.1	73.3
Oil (Dry Basis %)	65	4.0*	0.14	3.7	4.3

**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.*

U.S. GRAINS COUNCIL

SUMMARY: CHEMICAL COMPOSITION

	Five-Year Average (MY15/16-MY19/20)			Ten-Year Average (MY11/12-MY20/21)		
	No. of Samples	Avg.	Std. Dev.	No. of Samples	Avg.	Std. Dev.
U.S. Aggregate						
Protein (Dry Basis %)	2,136	8.4	0.31	4,175	8.5	0.30
Starch (Dry Basis %)	2,136	72.6	0.42	4,175	73.0	0.46
Oil (Dry Basis %)	2,136	4.0	0.15	4,175	3.9	0.17
Gulf						
Protein (Dry Basis %)	1,343	8.3	0.27	2,719	8.5	0.26
Starch (Dry Basis %)	1,343	72.7	0.38	2,719	73.1	0.44
Oil (Dry Basis %)	1,343	4.0	0.15	2,719	3.9	0.17
Pacific Northwest						
Protein (Dry Basis %)	483	8.5	0.37	958	8.7	0.41
Starch (Dry Basis %)	483	72.3	0.50	958	72.8	0.51
Oil (Dry Basis %)	483	4.0	0.16	958	3.8	0.18
Southern Rail						
Protein (Dry Basis %)	310	8.5	0.36	498	8.6	0.36
Starch (Dry Basis %)	310	72.5	0.47	498	72.9	0.44
Oil (Dry Basis %)	310	4.0	0.16	498	3.9	0.17

SUMMARY: CHEMICAL COMPOSITION

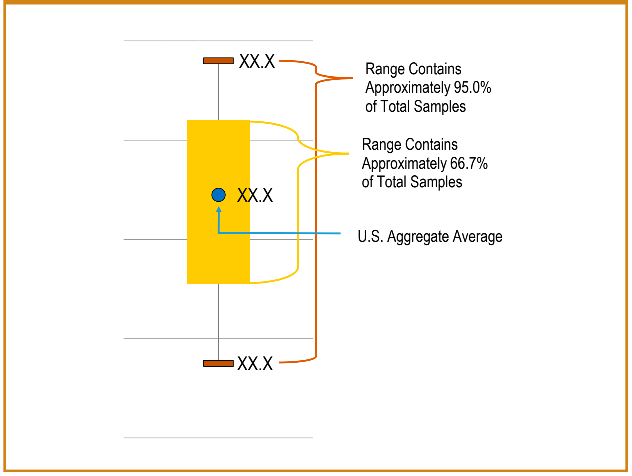
	2020/2021 Export Cargo Samples U.S. No. 2					2020/2021 Export Cargo Samples U.S. No. 3					2020 Harvest				
	No. of Samples	Avg.	Std. Dev.	Min.	Max.	No. of Samples	Avg.	Std. Dev.	Min.	Max.	No. of Samples[1]	Avg.	Std. Dev.	Min.	Max.
U.S. Aggregate															
Protein (Dry Basis %)	236	8.4	0.29	7.5	9.4	103	8.4	0.28	7.6	9.1	601	8.5	0.58	6.1	10.7
Starch (Dry Basis %)	236	72.1	0.32	71.2	73.0	103	72.1	0.33	71.1	73.0	601	72.2*	0.61	69.7	74.5
Oil (Dry Basis %)	236	3.8	0.14	3.4	4.7	103	3.8	0.12	3.4	4.1	601	3.9*	0.22	3.2	4.8
Gulf															
Protein (Dry Basis %)	145	8.5	0.23	8.0	9.4	62	8.5	0.25	7.6	9.0	549	8.4*	0.56	6.1	10.7
Starch (Dry Basis %)	145	72.1	0.30	71.2	72.8	62	72.1	0.32	71.3	73.0	549	72.3*	0.60	70.0	74.5
Oil (Dry Basis %)	145	3.8	0.12	3.4	4.1	62	3.8	0.11	3.5	4.0	549	3.9*	0.23	3.2	4.8
Pacific Northwest															
Protein (Dry Basis %)	48	8.2	0.35	7.5	9.0	34	8.3	0.30	7.7	9.1	293	8.5*	0.63	6.1	10.7
Starch (Dry Basis %)	48	72.3	0.33	71.7	73.0	34	72.1	0.36	71.1	72.7	293	72.2	0.65	69.7	74.5
Oil (Dry Basis %)	48	3.8	0.12	3.5	4.1	34	3.8	0.13	3.4	4.1	293	3.9*	0.21	3.2	4.8
Southern Rail															
Protein (Dry Basis %)	43	8.4	0.41	7.7	9.2	7	8.6	0.42	7.9	9.0	319	8.7*	0.54	6.8	10.7
Starch (Dry Basis %)	43	72.1	0.39	71.2	73.0	7	72.2	0.22	71.8	72.4	319	72.1	0.58	70.0	73.9
Oil (Dry Basis %)	43	3.8	0.20	3.5	4.7	7	3.8	0.12	3.6	3.9	319	3.9	0.21	3.3	4.7

**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.*

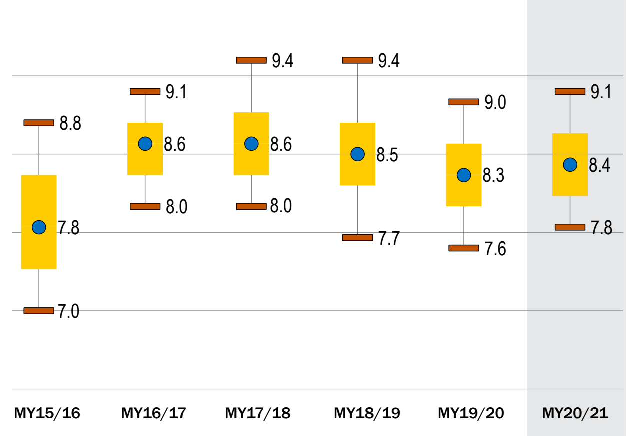
[1]Due to the ECA results being composite statistics, the sum of the sample numbers from the three ECAs is greater than the U.S. Aggregate.

CHEMICAL COMPOSITION
AGGREGATE SIX-YEAR COMPARISON

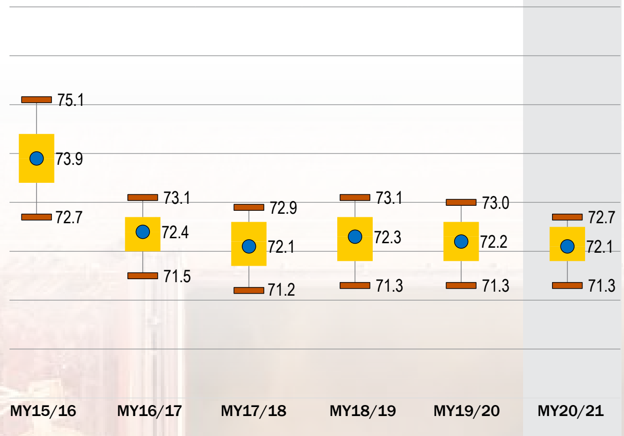
HOW TO READ THE CHARTS



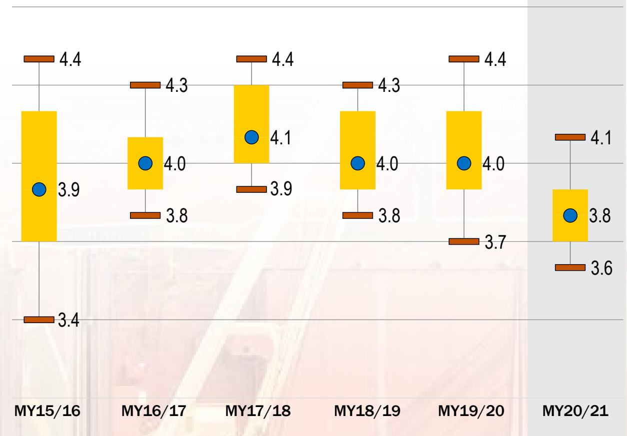
Protein (Dry Basis %)



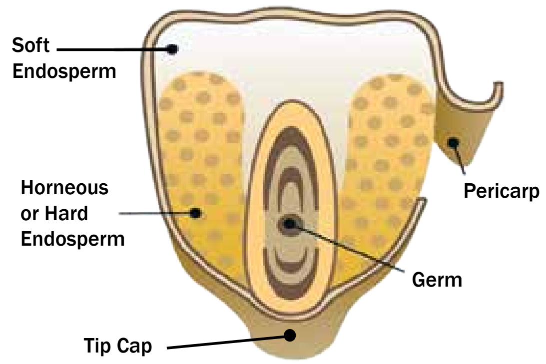
Starch (Dry Basis %)



Oil (Dry Basis %)



C. PHYSICAL FACTORS



Source: Adapted from Corn Refiners Association, 2011

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 and 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.

SUMMARY: PHYSICAL FACTORS

- Average U.S. Aggregate stress cracks (11%) in 2020/2021 was the same as 2019/2020, but higher than 2018/2019 (7%) and the 5YA (8%) and the 10YA (10%).
- Of the 2020/2021 export samples, 22.0% had 15% or higher stress cracks, compared with 25.3% in 2019/2020 and 11.5% in 2018/2019.
- Average U.S. Aggregate 100-kernel weight (37.01 g) was higher than 2019/2020, 2018/2019, the 5YA and 10YA.
- Average 100-kernel weight for the Pacific Northwest ECA (33.86 g) was lower than the Gulf ECA (38.47 g) and the Southern Rail ECA (37.09 g).
- In 2020/2021, 85.0% of the samples had a 100-kernel weight of 34.0 g or higher, compared with 73.8% and 76.4% in the two previous years. Thus, 2020/2021 samples had a higher percentage of large kernels than in the previous two years.

- Average U.S. Aggregate kernel volume (0.29 cm^3) was higher than the two previous years, and the 5YA and 10YA (all 0.28 cm^3). Average kernel volume at export was higher than that for the 2020 harvest (0.27 cm^3).
- Average kernel volume for the Pacific Northwest ECA (0.27 cm^3) was lower than for the Gulf (0.30 cm^3) and Southern Rail ECAs (0.29 cm^3) in 2020/2021. The Pacific Northwest ECA had the lowest average kernel volume and 100-k weight for the previous three years, the 5YA and 10YA, indicating that the Pacific Northwest usually has had smaller kernels than the Gulf and Southern Rail ECAs.
- Aggregate kernel true density (1.277 g/cm^3) was similar to 2019/2020 (1.278 g/cm^3) but lower than 2018/2019 (1.288 g/cm^3), the 5YA (1.283 g/cm^3) and the 10YA (1.286 g/cm^3).
- The Pacific Northwest has consistently had the lowest true densities and lowest test weights among ECAs for the past three years, the 5YA and 10YA.
- For the 2020/2021 export samples, 59.5% had kernel true densities equal to or above 1.275 g/cm^3, compared with 67.6% in 2019/2020 and 85.3% in 2018/2019.
- Average kernel true density for the 2020/2021 export samples (1.277 g/cm^3) was higher than for the 2020 harvest samples (1.255 g/cm^3). The export 5YA true density (1.283 g/cm^3) was also higher than the harvest 5YA true density (1.257 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 ten years.
- The average percent of whole kernels at export (83.2%) was higher than 2019/2020 (77.4%) but lower than 2018/2019 (85.2%), the 5YA (84.9%) and the 10YA (86.2%).
- The percentage of 2020/2021 export samples with whole kernels greater than or equal to 85.0% was 35.7%, compared to 28.0% in 2019/2020 and 59.6% in 2018/2019, indicating a lower percentage of whole kernels in the last two years than in 2018/2019.
- Average U.S. Aggregate horneous endosperm (80%) was similar to 2019/2020 and the 5YA (both 81%), and lower than 2018/2019 and the 10YA (both 82%). Of the 2020/2021 export samples, 61.1% had at least 80% horneous endosperm, lower than 73.3% in 2019/2020 and 81.7% in 2018/2019.

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.

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.

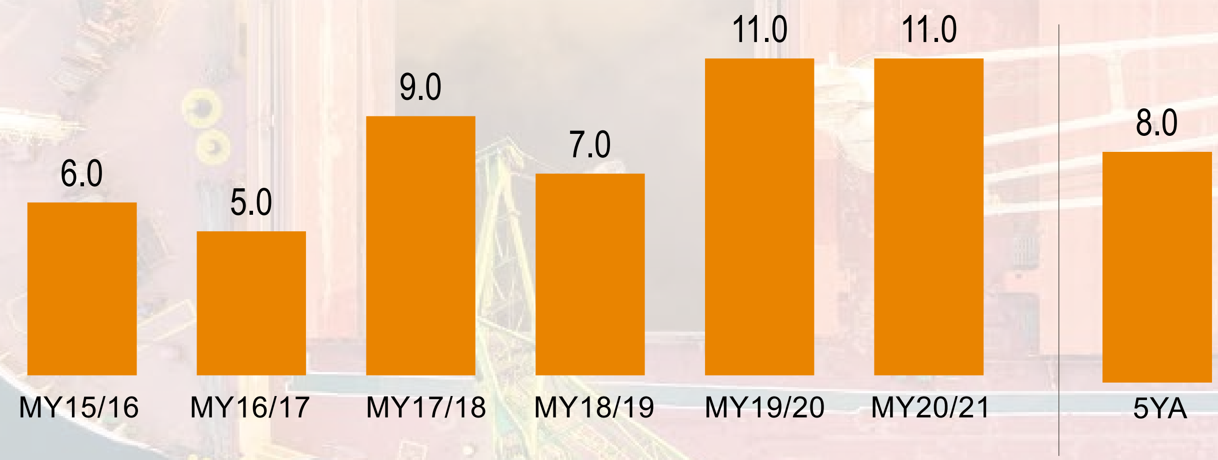
Wet Milling: Lower starch yields due to the increased difficulty in separating starch and protein. Stress cracks may also alter steeping requirements.

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.

STRESS CRACKS (%)

U.S. Aggregate Results Summary



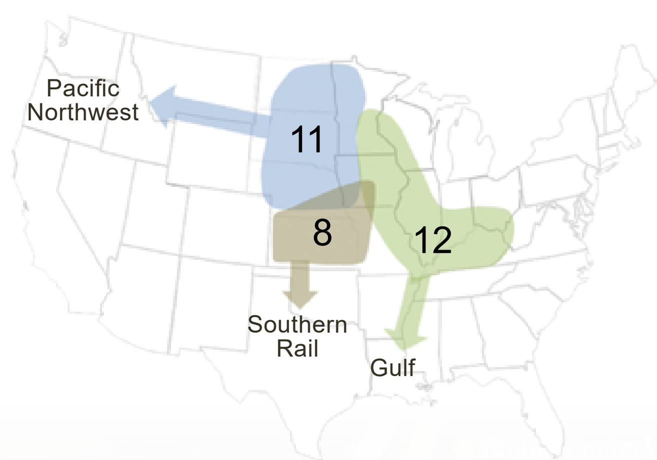
Growing conditions will affect crop maturity, the timing of harvest and the need for artificial drying, which will influence the degree of stress cracking found from region to region. For example, late maturity or late harvest caused by weather-related factors, such as rain-delayed planting or cool temperatures,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

RESULTS: STRESS CRACKS

- Average U.S. Aggregate stress cracks (11%) was the same as 2019/2020, but higher than 2018/2019 (7%), the 5YA (8%) and the 10YA (10%).
- Average U.S. Aggregate stress cracks (11%) was higher than the 2020 harvest samples (6%). Average U.S. Aggregate stress cracks has increased from 1 to 5 percentage points between harvest and export for each of the last five years and for the 5YA.
- Of the 2020/2021 export samples, 22.0% had 15% or higher stress cracks, compared with 25.3% in 2019/2020 and 11.5% in 2018/2019.
- Among ECAs, the Southern Rail has had or tied for the lowest average stress cracks for the last three years and the 5YA and 10YA.

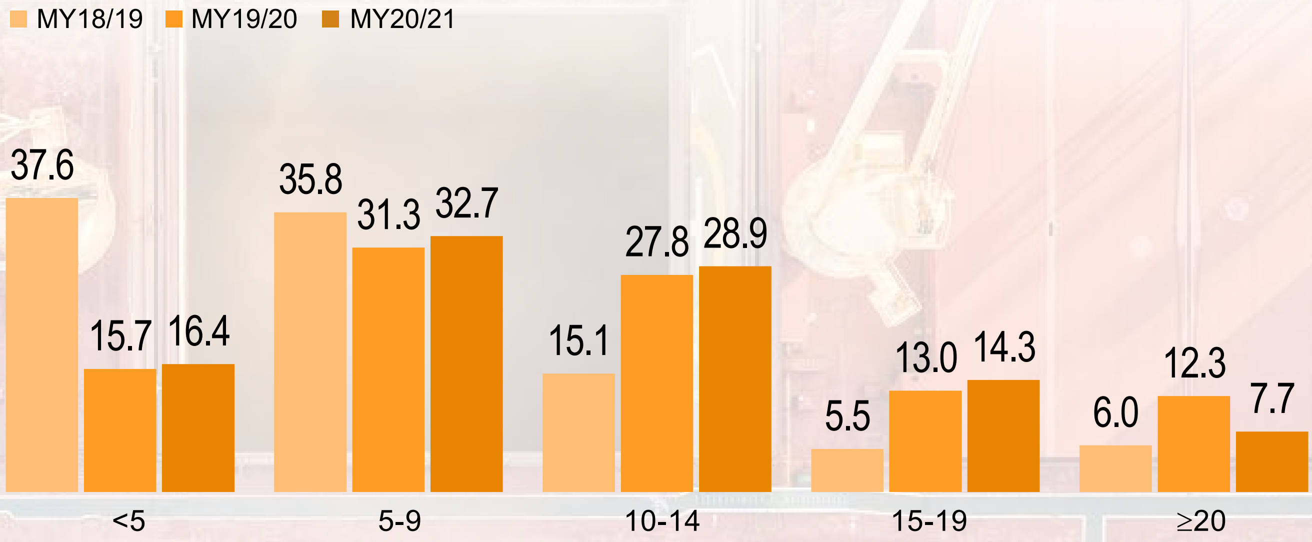
STRESS CRACKS (%)

2020/2021 Average by Export Catchment Area



STRESS CRACKS (%)

Percent of Samples by Marketing Year



100-KERNEL WEIGHT

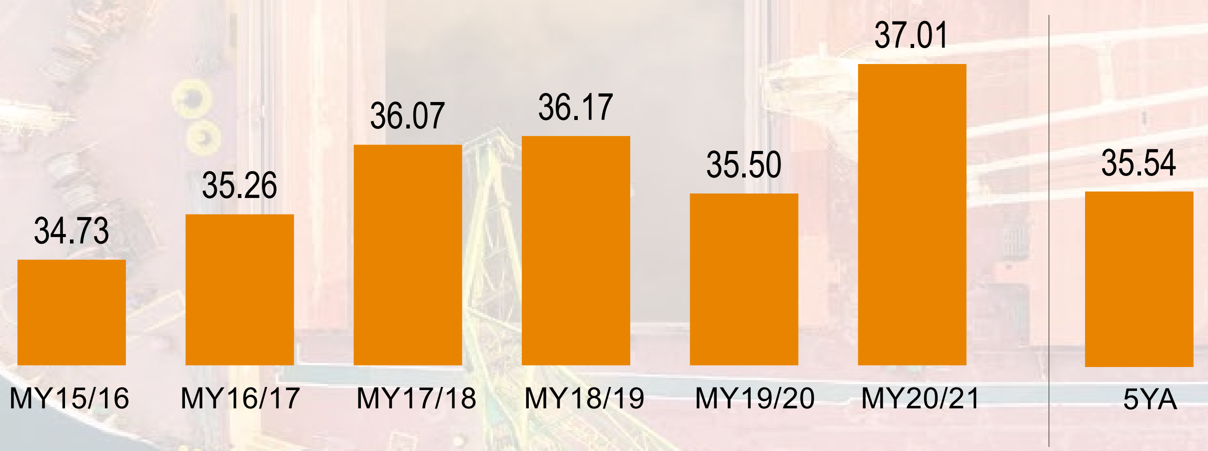
Increased 100-kernel weight (reported in grams) indicates a larger kernel size. Kernel size affects drying rates. As kernel size increases, the volume-to-surface area ratio becomes higher, and as the ratio gets higher, drying becomes slower. In addition, large, uniform-sized kernels often enable higher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

RESULTS

- Average U.S. Aggregate 100-kernel weight (37.01 g) was higher than 2019/2020 (35.50 g), 2018/2019 (36.17 g), the 5YA (35.54 g) and 10YA (35.67 g). Average 100-kernel weight for export was higher than at harvest (34.53 g).
- From 2011/2012 through 2020/2021, average 100-kernel weights ranged from 0.00 to 2.48 g greater 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 (1.16 g) than the 2020 harvest samples (3.64 g). The 100-kernel weight standard deviation was also lower at export than at harvest for the last three years, the 5YA and 10YA, indicating greater uniformity at export than at harvest.

100-KERNEL WEIGHT (g)

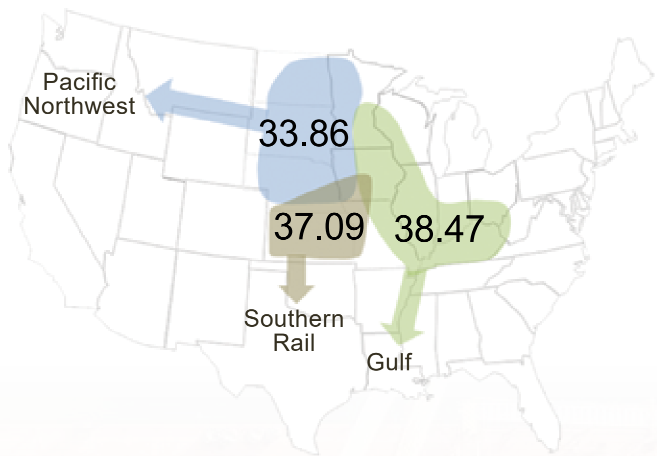
U.S. Aggregate Results Summary



- Average 100-kernel weight for the Gulf ECA (38.47 g) was higher than the Pacific Northwest (33.86 g) and the Southern Rail (37.09 g) ECAs. Among ECAs, the Pacific Northwest consistently had the lowest 100-k weight in the last three years, the 5YA and 10YA.
- In 2020/2021, 85.0% of the samples had a 100-kernel weight of 34.0 g or higher, compared with 73.8% in 2019/2020 and 76.4% in 2018/2019. Thus, 2020/2021 samples had a higher percentage of large kernels than in the two previous years.

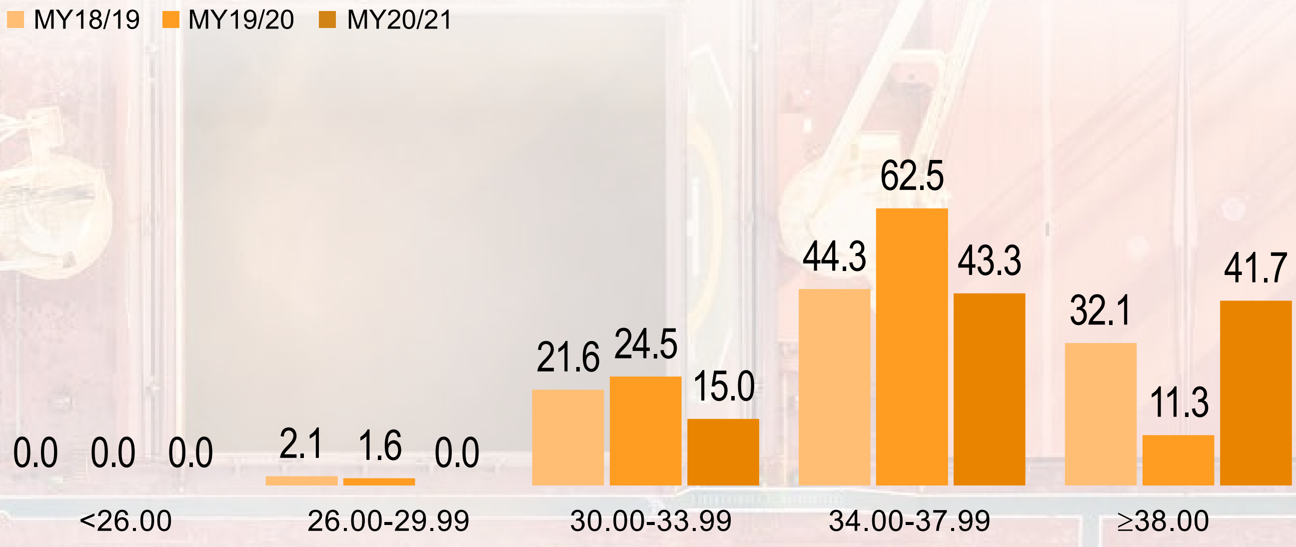
100-KERNEL WEIGHT (g)

2020/2021 Average by Export Catchment Area



100-KERNEL WEIGHT (g)

Percent of Samples by Marketing Year



KERNEL VOLUME

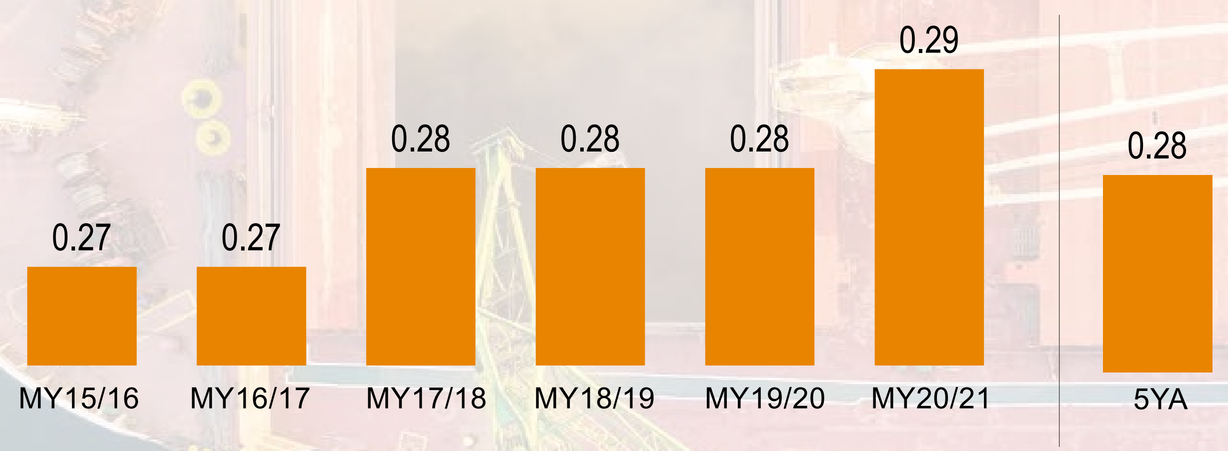
Kernel volume, measured in cubic centimeters (cm^3), is often indicative of growing conditions. If conditions are dry, kernels may be smaller than average. If a drought hits later in the season, kernels may have lower fill. Small or round kernels are more difficult to degerm. Additionally, small kernels may lead to increased cleanout losses for processors and higher yields of fiber.

RESULTS

- Average U.S. Aggregate kernel volume (0.29 cm^3) was higher than 2019/2020, 2018/2019, the 5YA and 10YA (all 0.28 cm^3).
- Kernel volume range (0.24 to 0.32 cm^3) was similar to 2019/2020 (0.23 to 0.32 cm^3) and 2018/2019 (0.20 to 0.32 cm^3).
- The kernel volume standard deviation (0.01 cm^3) was the same as the previous two years, and the 5YA and 10YA.
- Average U.S. Aggregate kernel volume at export (0.29 cm^3) was higher than that for the 2020 harvest (0.27 cm^3).
- There were no differences in average kernel volume between U.S. No. 2 corn and U.S. No. 3 corn from each of the ECAs.

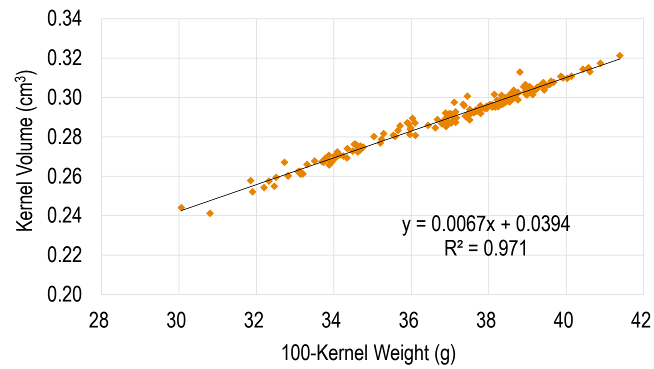
KERNEL VOLUME (cm^3)

U.S. Aggregate Results Summary



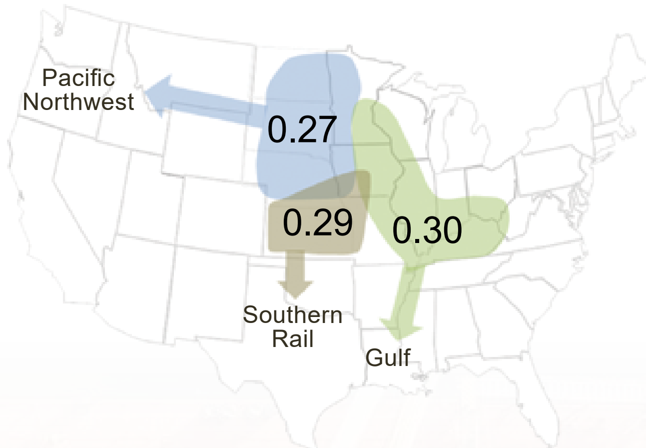
- Average kernel volume was smaller for the Pacific Northwest ECA (0.27 cm^3) than for the Gulf (0.30 cm^3) and Southern Rail ECAs (0.29 cm^3) in 2020/2021. The Pacific Northwest ECA also had the lowest average kernel volume among ECAs for the two previous years, the 5YA and 10YA.
- Of the 2020/2021 export samples, 56.2% had kernel volumes equal to or higher than 0.29 cm^3, compared with 22.7% in 2019/2020 and 40.6% in 2018/2019.
- There is a positive relationship between kernel volume and 100-kernel weight in the 2020/2021 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 or size.

Kernel Volume vs 100-Kernel Weight, U.S. Aggregate 2020/2021



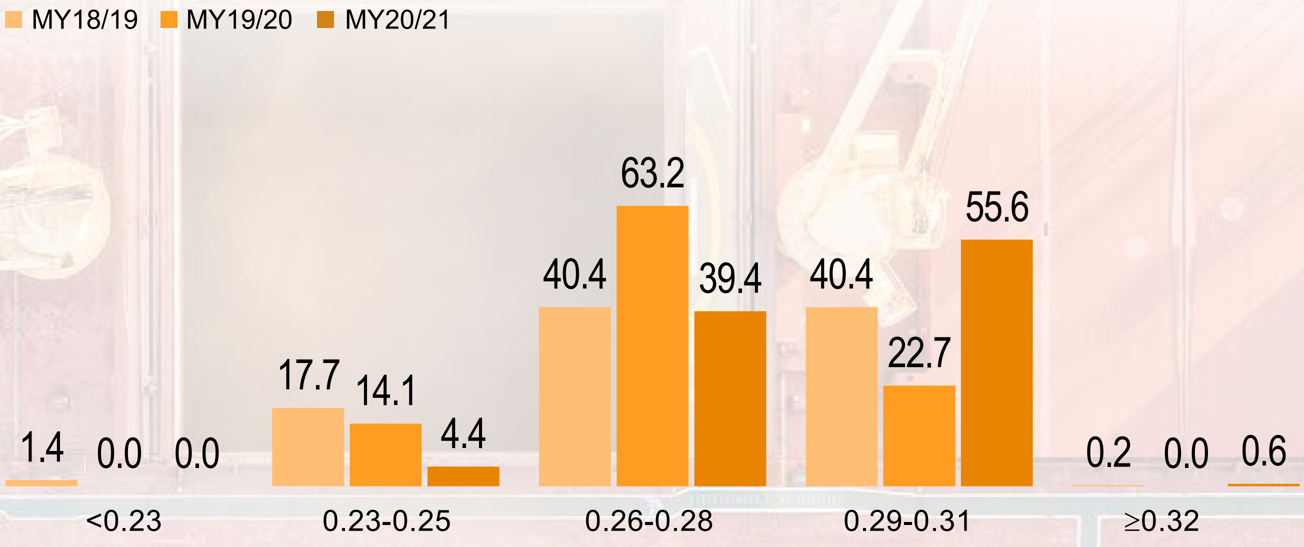
KERNEL VOLUME (cm^3)

2020/2021 Average by Export Catchment Area



KERNEL VOLUME (cm^3)

Percent of Samples by Marketing Year



KERNEL TRUE DENSITY

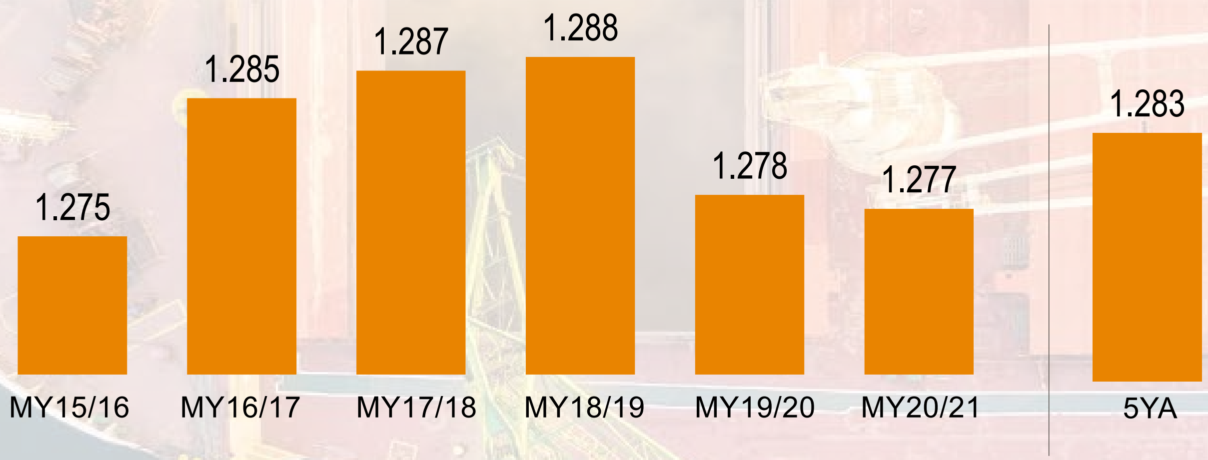
Kernel true density is calculated as the weight of a 100-kernel sample divided by the volume or displacement of those 100 kernels and is reported as grams per cubic centimeter (g/cm^3). True density is a relative indicator of kernel hardness, which is useful for alkaline processors and dry millers. True 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 of developing 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 (1.277 g/cm^3) was similar to 2019/2020 (1.278 g/cm^3) but lower than 2018/2019 (1.288 g/cm^3), the 5YA (1.283 g/cm^3) and the 10YA (1.286 g/cm^3).
- Average kernel true density for the 2020/2021 export samples (1.277 g/cm^3) was higher than for the 2020 harvest samples (1.255 g/cm^3). The export 5YA true density (1.283 g/cm^3) was also higher than the harvest 5YA true density (1.257 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 ten years.

TRUE DENSITY (g/cm^3)

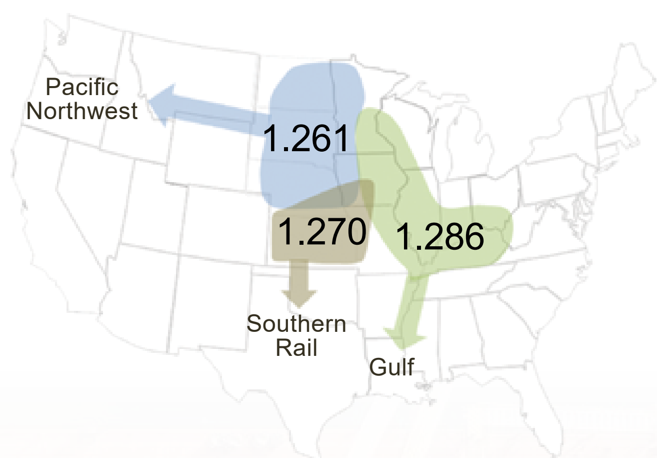
U.S. Aggregate Results Summary



- The 2020/2021 export samples had a range of 1.225 to 1.306 g/cm³ (with a standard deviation of 0.009 g/cm³), while the 2020 harvest samples had a greater range (1.171 to 1.312 g/cm³) and a higher standard deviation (0.023 g/cm³).
- For the 2020/2021 export samples, 59.5% had kernel true densities equal to or above 1.275 g/cm³, compared to 67.6% in 2019/2020 and 85.3% in 2018/2019.
- Average kernel true densities for ECAs were 1.286 g/cm³ for the Gulf, 1.261 g/cm³ for the Pacific Northwest and 1.270 g/cm³ for the Southern Rail. The Pacific Northwest has consistently had the lowest true densities and lowest test weights among ECAs for the past three years, the 5YA and 10YA.
- Average kernel true density for U.S. No. 2 corn from the Gulf ECA (1.286 g/cm³) was slightly lower than U.S. No. 3 corn (1.287 g/cm³).

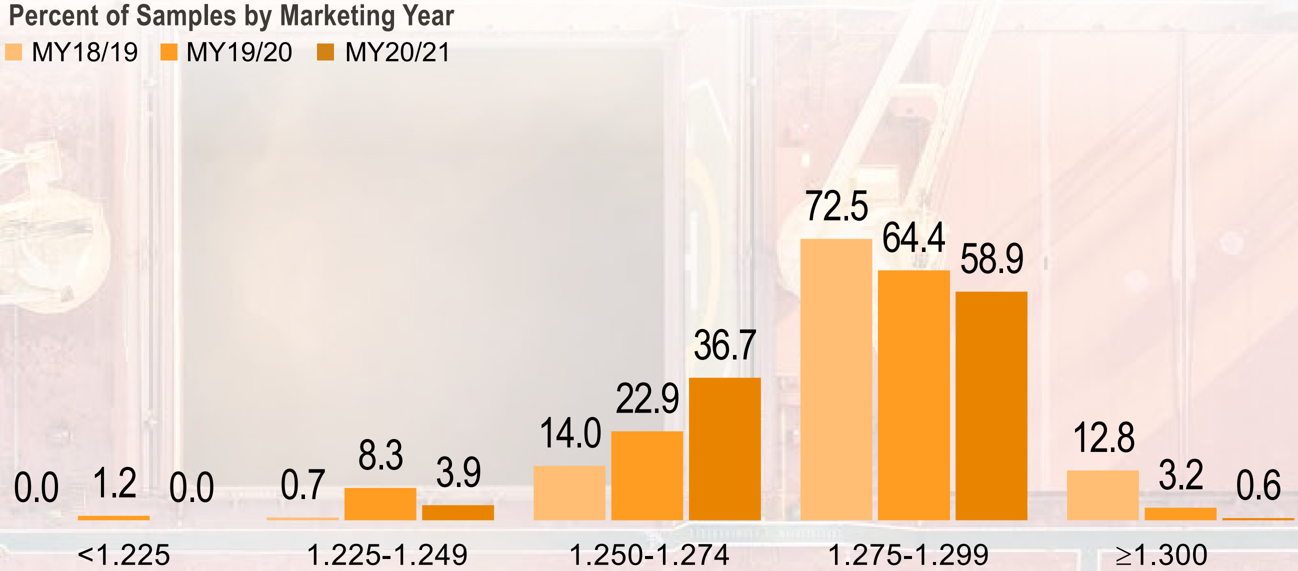
TRUE DENSITY (g/cm³)

2020/2021 Average by Export Catchment Area



TRUE DENSITY (g/cm³)

Percent of Samples by Marketing Year



WHOLE KERNELS

The whole kernels test measures 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 solubles, 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.

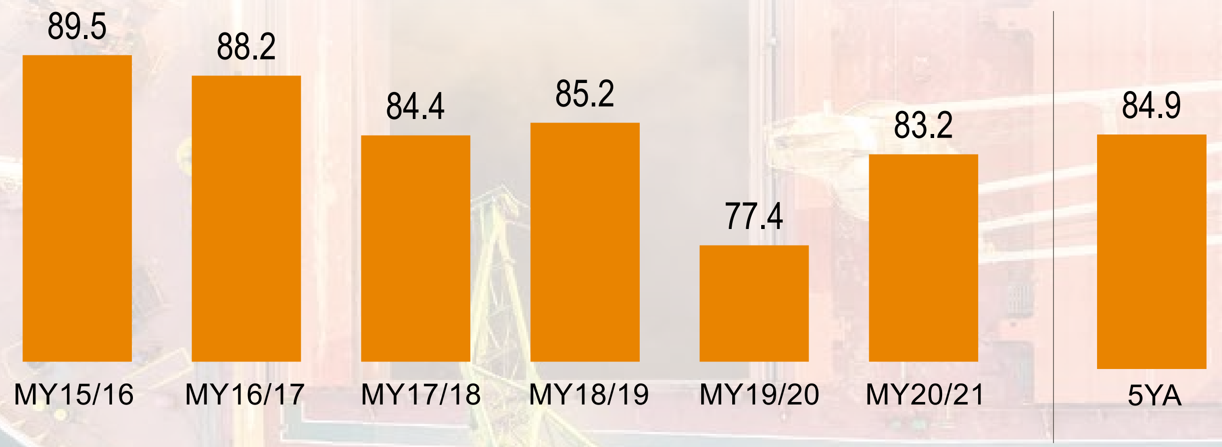
Second, intact whole kernels are less susceptible to storage molds and breakage in handling. While hard endosperm lends itself to the preservation of more whole kernels than soft corn, the primary factor in delivering whole kernels is harvesting and handling. This begins with proper combine adjustment, 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.[1] In addition, harvesting at the higher moisture content (e.g., greater than 25%) will usually lead to soft pericarps and more pericarp damage to corn than when harvesting at lower moisture levels.

RESULTS

- Average U.S. Aggregate whole kernels (83.2%) was higher than 2019/2020 (77.4%) but lower than 2018/2019 (85.2%), the 5YA (84.9%) and the 10YA (86.2%).

WHOLE KERNELS (%)

U.S. Aggregate Results Summary

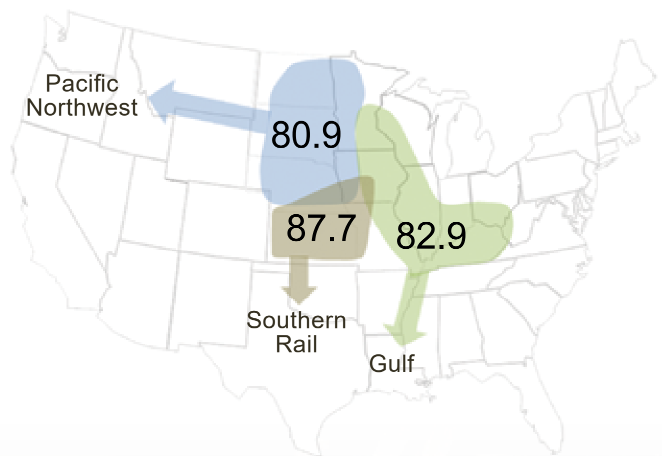


[1] *Foster, G.H. and L.E. Holman. 1973. Grain Breakage Caused by Commercial Handling Methods. Marketing Research Report No. 968. ARS, USDA, Washington, D.C.*

- The average percentage of whole kernels at export in 2020/2021 was lower than at harvest (92.5%). Whole kernels for the export 5YA (84.9%) was also lower than for the harvest 5YA (92.8%). Over the past three years and for the 5YA and 10YA, the percentages of whole kernels at export have been 5.5 to 13.4 percentage points lower than at harvest. This reduction in whole kernels is likely caused by the additional handling required to reach export loading locations.
- The 2020/2021 export samples had a range of 67.6 to 95.8% whole kernels and a standard deviation of 4.6%.
- The Pacific Northwest ECA (80.9%) had the lowest average whole kernels compared to the Gulf (82.9%) and Southern Rail (87.7%) ECAs.
- The percentage of export samples with whole kernels greater than or equal to 85% was 35.7% for 2020/2021, 28.0% for 2019/2020 and 59.6% for 2018/2019.
- Average whole kernels for U.S. No. 2 corn from the Gulf ECA was 82.9%, compared with 82.0% for U.S. No. 3 corn.

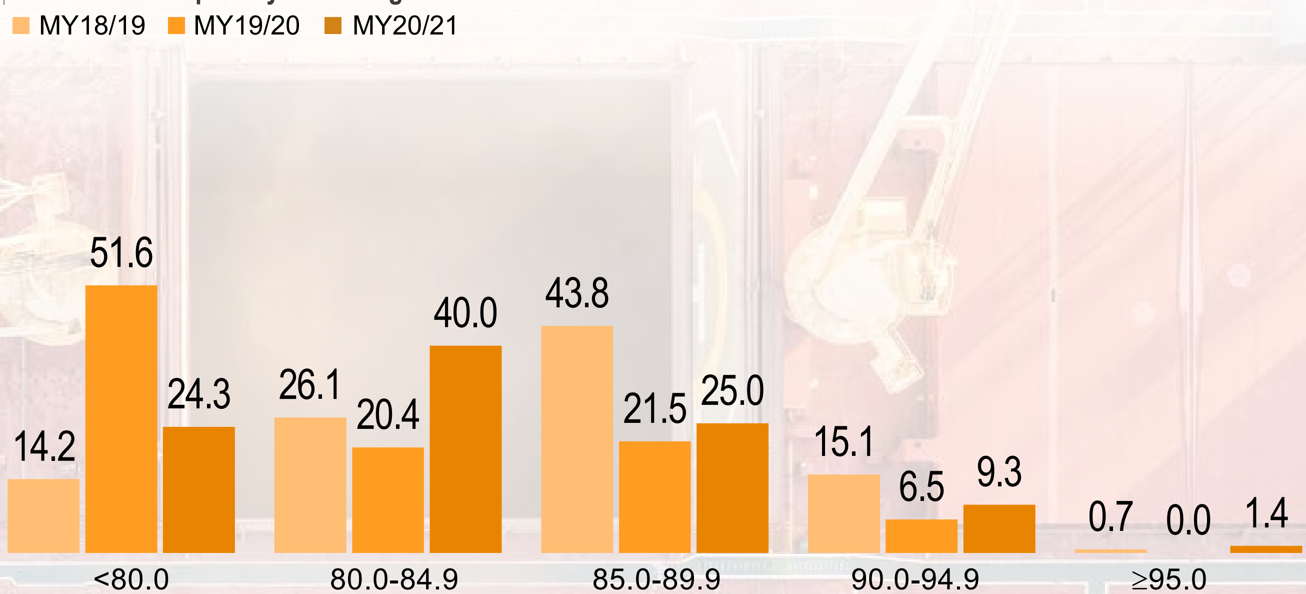
WHOLE KERNELS (%)

2020/2021 Average by Export Catchment Area



WHOLE KERNELS (%)

Percent of Samples by Marketing Year



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.

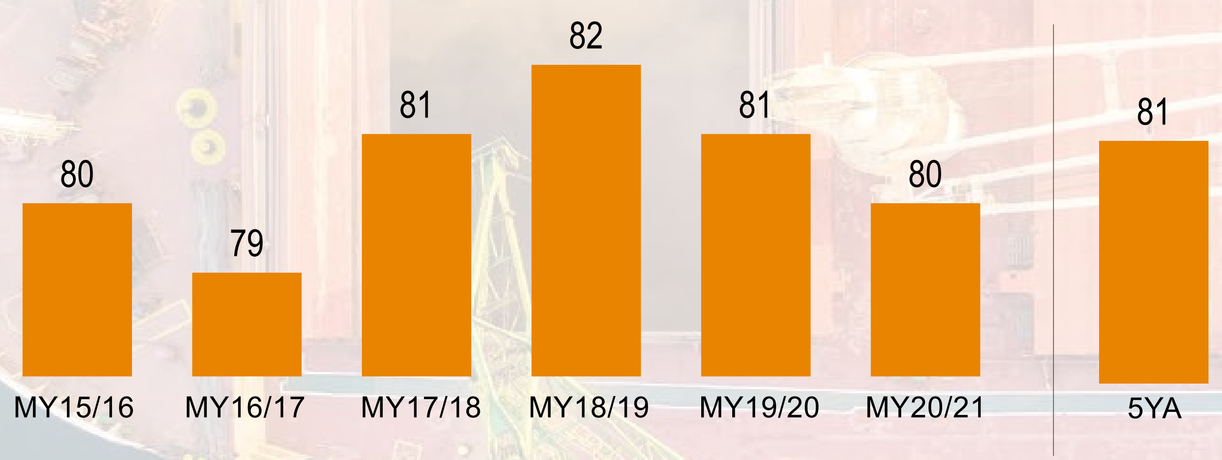
Hardness has been correlated to breakage susceptibility, feed utilization/efficiency and starch digestibility. As a test of overall hardness, there is no good or bad value for horneous endosperm. There is only a preference by different end-users for particular ranges. Many dry millers and alkaline cookers 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 (80%) was similar to 2019/2020 and the 5YA (both 81%), and lower than 2018/2019 and the 10YA (both 82%). While the 5YA for horneous endosperm was 81%, this difference from the 2020/2021 average was not statistically significant.
- Average horneous endosperm at export and at harvest were within ±1 percentage point for 2020/2021, the previous two years, for the 5YA and the 10YA.

HORNEOUS ENDOSPERM (%)

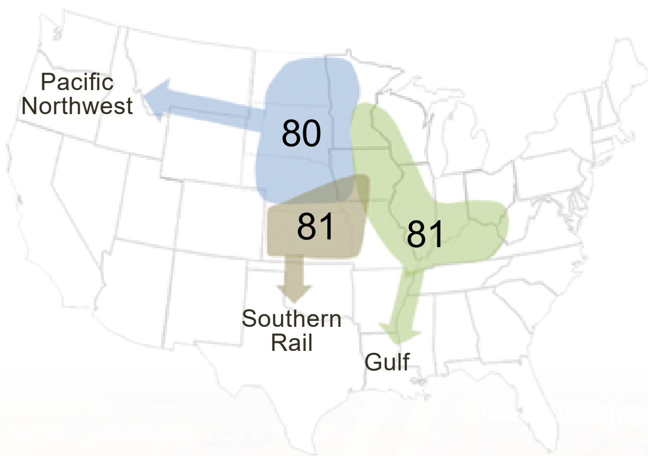
U.S. Aggregate Results Summary



- The 2020/2021 export samples had more uniform percentages of horneous endosperm compared to the 2020 harvest samples, as indicated by the lower standard deviation at export (2%) compared to that at harvest (4%). The export samples also had a range (75 to 86%) which was less than the harvest samples (72 to 92%). This same pattern of increased uniformity for the export samples compared with the harvest samples also occurred in 2019/2020, 2018/2019, the 5YA and 10YA.
- Average horneous endosperm for ECAs were 81% for the Gulf, 80% for the Pacific Northwest and 81% for the Southern Rail.
- Of the 2020/2021 export samples, 61.1% had at least 80% horneous endosperm, lower than 73.3% in 2019/2020 and 81.7% in 2018/2019.
- Average horneous endosperm for U.S. No. 2 grade corn from the Gulf (81%) was higher than that for U.S. No. 3 grade corn (80%). Average horneous endosperm from the Pacific Northwest was the same for both for U.S. No. 2 grade and U.S. No. 3 grade corn (80%).

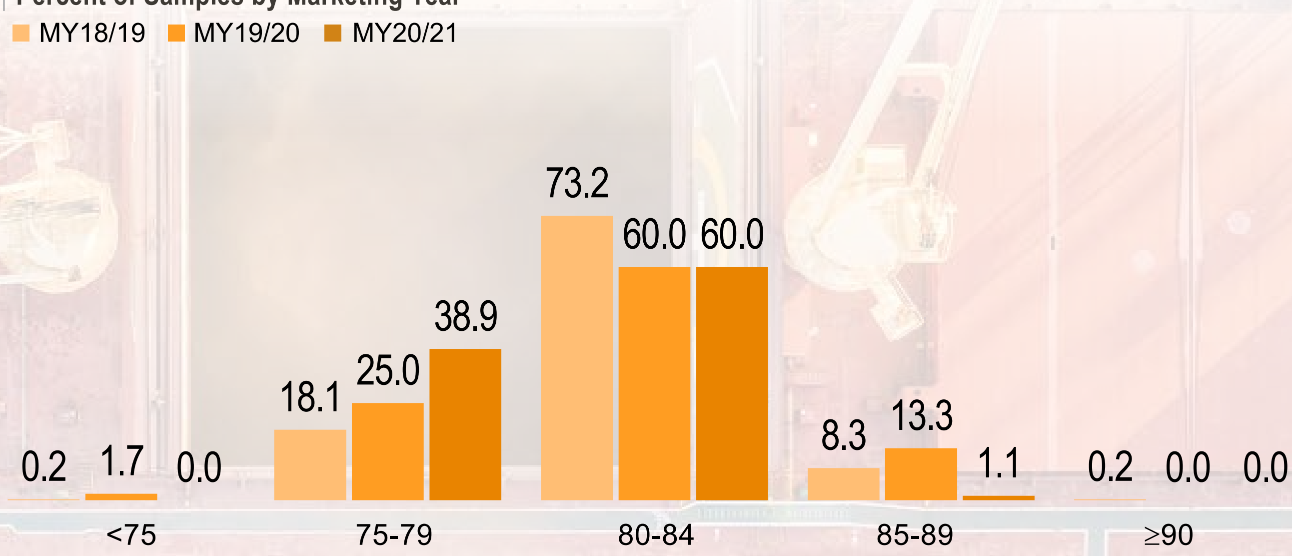
HORNEOUS ENDOSPERM (%)

2020/2021 Average by Export Catchment Area



HORNEOUS ENDOSPERM (%)

Percent of Samples by Marketing Year



SUMMARY: PHYSICAL FACTORS

	2020/2021 Export Cargo					2019/2020 Export Cargo					2018/2019 Export Cargo				
	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**				
Stress Cracks (%)	440	11	6	0	39	432	11	7	0	47	436	7*	5	0	36
100-Kernel Weight (g)	180	37.01	1.16	30.06	41.39	432	35.50*	1.37	28.54	40.79	436	36.17*	1.84	26.55	42.05
Kernel Volume (cm^3)	180	0.29	0.01	0.24	0.32	432	0.28*	0.01	0.23	0.32	436	0.28*	0.01	0.20	0.32
True Density (g/cm^3)	180	1.277	0.009	1.225	1.306	432	1.278	0.012	1.205	1.314	436	1.288*	0.011	1.235	1.325
Whole Kernels (%)	440	83.2	4.6	67.6	95.8	432	77.4*	8.0	32.2	93.8	436	85.2*	4.9	61.4	96.2
Horneous Endosperm (%)	180	80	2	75	86	180	81*	2	74	87	436	82*	2	75	91
Gulf						**Gulf**					**Gulf**				
Stress Cracks (%)	244	12	6	1	32	242	11	6	0	35	275	6*	4	0	23
100-Kernel Weight (g)	96	38.47	1.04	36.11	41.39	242	36.79*	1.28	32.84	40.79	275	37.49*	1.85	31.80	42.05
Kernel Volume (cm^3)	96	0.30	0.01	0.28	0.32	242	0.29*	0.01	0.25	0.32	275	0.29*	0.01	0.25	0.32
True Density (g/cm^3)	96	1.286	0.006	1.270	1.306	242	1.288	0.009	1.244	1.314	275	1.293*	0.009	1.262	1.325
Whole Kernels (%)	244	82.9	4.2	67.6	92.0	242	80.5*	7.5	48.0	93.8	275	86.0*	3.9	73.6	95.8
Horneous Endosperm (%)	96	81	2	75	85	102	82*	2	77	87	275	82*	2	75	87
Pacific Northwest						**Pacific Northwest**					**Pacific Northwest**				
Stress Cracks (%)[1]	120	11	5	0	29	117	12*	6	2	28	96	14*	8	1	36
100-Kernel Weight (g)	52	33.86	1.28	30.06	36.67	117	32.39*	1.39	28.54	35.17	96	32.21*	1.81	26.55	36.85
Kernel Volume (cm^3)	52	0.27	0.01	0.24	0.29	117	0.26*	0.01	0.23	0.28	96	0.25*	0.01	0.20	0.29
True Density (g/cm^3)	52	1.261	0.011	1.225	1.279	117	1.258	0.018	1.205	1.290	96	1.278*	0.016	1.235	1.308
Whole Kernels (%)	120	80.9	5.1	69.8	93.4	117	66.6*	9.6	32.2	85.8	96	82.2	7.7	61.4	96.2
Horneous Endosperm (%)	52	80	2	75	84	47	79*	3	74	85	96	81*	3	76	91
Southern Rail						**Southern Rail**					**Southern Rail**				
Stress Cracks (%)[1]	76	8	6	0	39	73	11*	11	0	47	65	5*	4	0	18
100-Kernel Weight (g)	32	37.09	1.39	34.09	39.61	73	36.20*	1.66	32.46	39.99	65	36.52	1.87	33.40	41.39
Kernel Volume (cm^3)	32	0.29	0.01	0.27	0.31	73	0.28*	0.01	0.26	0.31	65	0.28*	0.02	0.26	0.32
True Density (g/cm^3)	32	1.270	0.015	1.246	1.294	73	1.275	0.012	1.242	1.297	65	1.284*	0.013	1.260	1.318
Whole Kernels (%)	76	87.7	5.2	73.6	95.8	73	84.4*	7.1	63.2	93.8	65	86.2	4.5	73.2	95.0
Horneous Endosperm (%)	32	81	2	77	86	31	83*	3	78	87	65	82*	2	77	87

**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 the population average exceeded ±10.0%.

SUMMARY: PHYSICAL FACTORS

	Five-Year Average (MY15/16-MY19/20)			Ten-Year Average (MY11/12-MY20/21)		
	No. of Samples	Avg.	Std. Dev.	No. of Samples	Avg.	Std. Dev.
U.S. Aggregate						
Stress Cracks (%)	2,136	8	5	4,175	10	6
100-Kernel Weight (g)	2,136	35.54	1.54	3,915	35.67	1.61
Kernel Volume (cm^3)	2,136	0.28	0.01	3,915	0.28	0.01
True Density (g/cm^3)	2,136	1.283	0.012	3,915	1.286	0.011
Whole Kernels (%)	2,136	84.9	5.1	4,175	86.2	4.6
Horneous Endosperm (%)	1,884	81	2	3,663	82	2
Gulf						
Stress Cracks (%)	1,343	7	5	2,719	10	6
100-Kernel Weight (g)	1,343	36.52	1.50	2,571	36.69	1.50
Kernel Volume (cm^3)	1,343	0.28	0.01	2,570	0.28	0.01
True Density (g/cm^3)	1,343	1.287	0.010	2,571	1.291	0.010
Whole Kernels (%)	1,343	85.9	4.8	2,719	86.6	4.5
Horneous Endosperm (%)	1,203	81	2	2,431	82	2
Pacific Northwest						
Stress Cracks (%)	483	11	6	958	11	6
100-Kernel Weight (g)	483	32.48	1.60	890	32.25	1.85
Kernel Volume (cm^3)	483	0.25	0.01	890	0.25	0.01
True Density (g/cm^3)	483	1.274	0.015	890	1.272	0.014
Whole Kernels (%)	483	81.3	6.1	958	84.5	4.9
Horneous Endosperm (%)	413	80	2	820	81	2
Southern Rail						
Stress Cracks (%)	310	6	6	498	7	6
100-Kernel Weight (g)	310	36.05	1.66	454	36.43	1.71
Kernel Volume (cm^3)	310	0.28	0.01	454	0.28	0.01
True Density (g/cm^3)	310	1.281	0.011	454	1.284	0.011
Whole Kernels (%)	310	87.1	4.7	498	87.8	4.4
Horneous Endosperm (%)	268	81	2	412	82	2

SUMMARY: PHYSICAL FACTORS

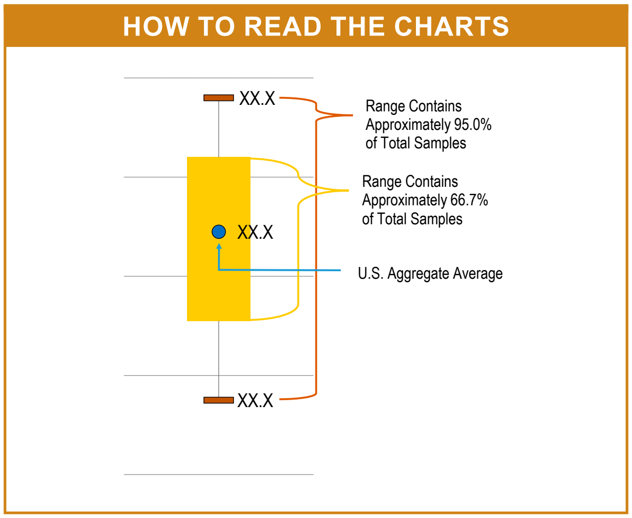
	2020/2021 Export Cargo Samples U.S. No. 2					2020/2021 Export Cargo Samples U.S. No. 3					2020 Harvest				
	No. of Samples	Avg.	Std. Dev.	Min.	Max.	No. of Samples	Avg.	Std. Dev.	Min.	Max.	No. of Samples[1]	Avg.	Std. Dev.	Min.	Max.
U.S. Aggregate						**U.S. Aggregate**					**U.S. Aggregate**				
Stress Cracks (%)	236	11	6	0	39	103	11	7	0	31	601	6*	5	0	80
100-Kernel Weight (g)	101	37.31	1.00	32.33	40.61	43	36.94	1.14	30.06	40.88	180	34.53*	3.64	22.32	43.18
Kernel Volume (cm^3)	101	0.29	0.01	0.26	0.31	43	0.29	0.01	0.24	0.32	180	0.27*	0.03	0.19	0.33
True Density (g/cm^3)	101	1.278	0.009	1.225	1.306	43	1.279	0.008	1.232	1.299	180	1.255*	0.023	1.171	1.312
Whole Kernels (%)	236	83.2	4.2	68.4	93.8	103	82.1	4.4	70.0	95.6	601	92.5*	3.9	35.8	99.6
Horneous Endosperm (%)	101	80	2	75	85	43	80	2	75	85	180	81*	4	72	92
Gulf						**Gulf**					**Gulf**				
Stress Cracks (%)	145	12	6	1	32	62	12	7	2	31	549	7*	6	0	80
100-Kernel Weight (g)	60	38.42	0.90	36.90	40.61	23	38.56	0.94	36.80	40.88	160	35.56*	3.31	23.47	43.18
Kernel Volume (cm^3)	60	0.30	0.01	0.29	0.31	23	0.30	0.01	0.29	0.32	160	0.28*	0.02	0.19	0.33
True Density (g/cm^3)	60	1.286	0.007	1.270	1.306	23	1.287	0.006	1.276	1.299	160	1.259*	0.024	1.171	1.312
Whole Kernels (%)	145	82.9	3.9	68.4	92.0	62	82.0	3.8	70.4	91.0	549	92.2*	4.2	35.8	99.6
Horneous Endosperm (%)	60	81	2	75	85	23	80	2	77	84	160	82*	4	72	92
Pacific Northwest						**Pacific Northwest**					**Pacific Northwest**				
Stress Cracks (%)	48	11	5	3	21	34	11	6	0	29	293	5*	4	0	52
100-Kernel Weight (g)	20	34.00	0.85	32.33	35.29	17	33.91	1.58	30.06	36.67	89	33.01*	3.37	22.32	39.71
Kernel Volume (cm^3)	20	0.27	0.01	0.26	0.28	17	0.27	0.01	0.24	0.29	89	0.26	0.03	0.19	0.32
True Density (g/cm^3)	20	1.258	0.010	1.225	1.271	17	1.264	0.010	1.232	1.279	89	1.247*	0.022	1.171	1.285
Whole Kernels (%)	48	80.5	4.3	70.8	90.8	34	80.9	5.2	70.0	90.4	293	92.9*	3.9	59.0	99.6
Horneous Endosperm (%)	20	80	1	78	82	17	80	2	75	84	89	81*	4	72	89
Southern Rail						**Southern Rail**					**Southern Rail**				
Stress Cracks (%)	43	8	7	0	39	7	8	9	1	27	319	5*	4	0	69
100-Kernel Weight (g)	21	37.28	1.49	34.09	39.61	3	37.30	0.77	36.62	38.14	92	33.95*	3.32	23.47	41.09
Kernel Volume (cm^3)	21	0.29	0.01	0.27	0.31	3	0.29	0.01	0.28	0.30	92	0.27*	0.02	0.19	0.33
True Density (g/cm^3)	21	1.269	0.016	1.246	1.294	3	1.281	0.015	1.265	1.293	92	1.258*	0.021	1.171	1.305
Whole Kernels (%)	43	86.8	4.9	74.2	93.8	7	88.9	6.1	77.8	95.6	319	92.7*	3.5	35.8	98.8
Horneous Endosperm (%)	21	81	2	77	84	3	83	2	81	85	92	82	4	72	88

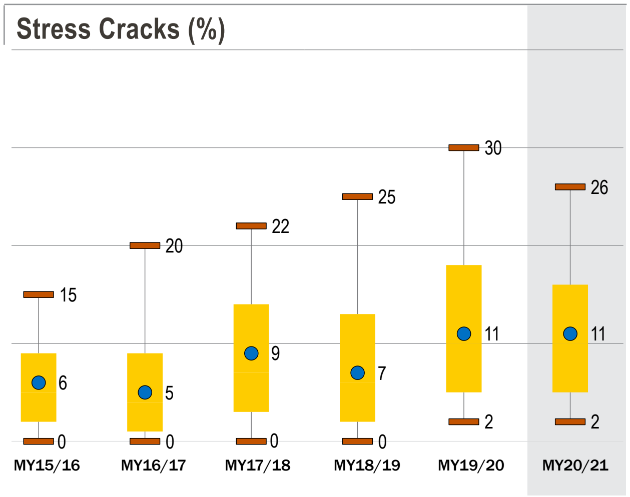
**Indicates current year's Export Cargo average was significantly different from this year's Harvest, based on a 2-tailed t-test at the 95% level of confidence.*

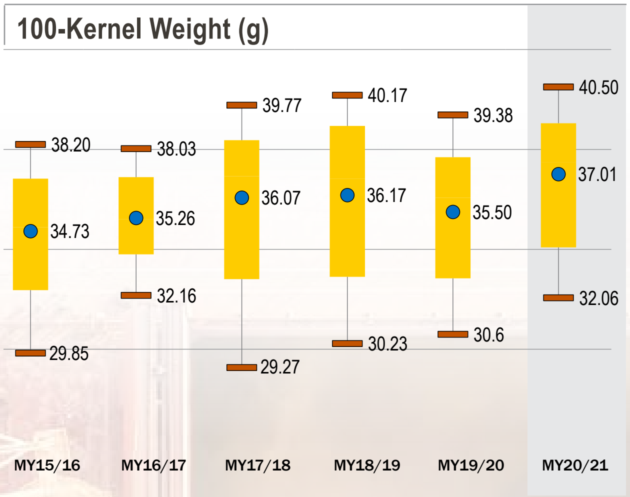
[1]Due to the ECA results being composite statistics, the sum of the sample numbers from the three ECAs is greater than the U.S. Aggregate.

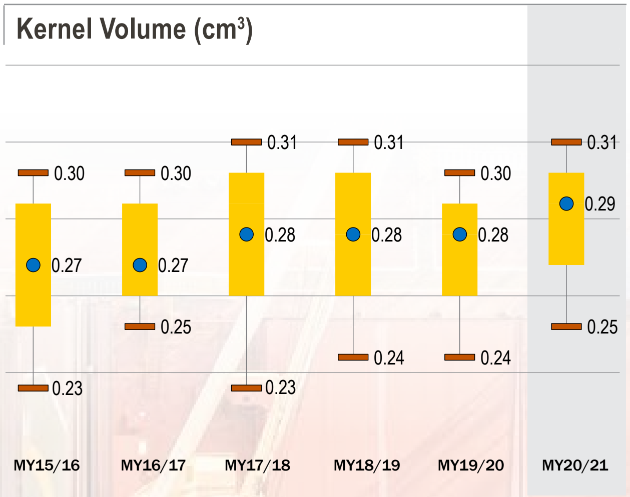
U.S. GRAINS COUNCIL

PHYSICAL FACTORS
AGGREGATE SIX-YEAR COMPARISON

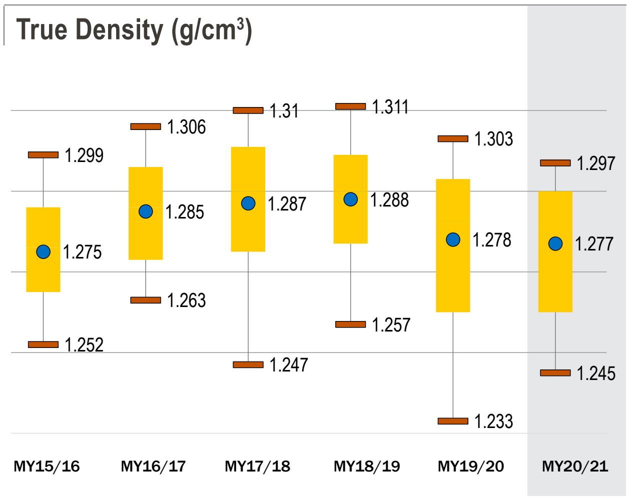


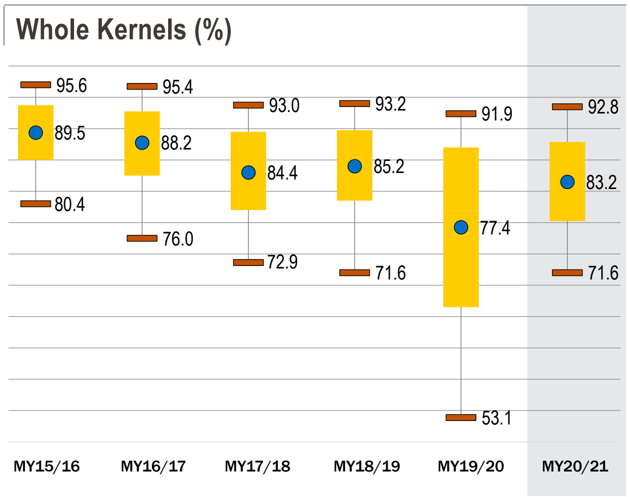


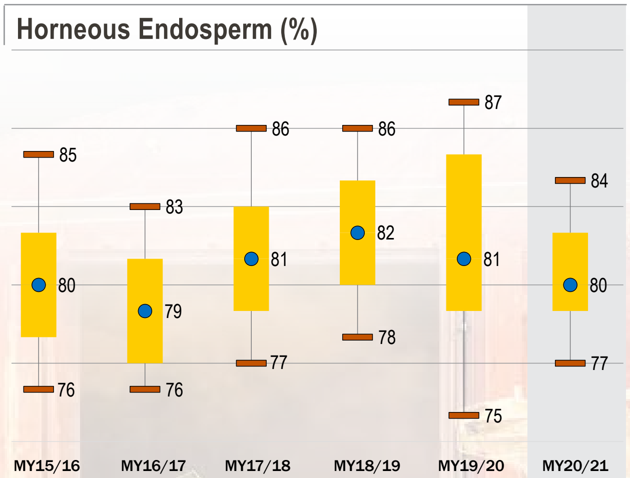




PHYSICAL FACTORS
AGGREGATE SIX-YEAR COMPARISON







D. 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. Several mycotoxins have been found in corn grain. Aflatoxin, DON and fumonisin are considered three of the important mycotoxins.

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. Therefore, the *2020/2021 Export Cargo Report* now includes three mycotoxins: aflatoxin, DON and fumonisin.

Depending on the year, environmental conditions under which the corn is produced and stored may or may not be conducive to developing 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, advisory levels for DON and fumonisin by intended use.

Action levels specify limits of contamination above which the agency is prepared to take regulatory action. Action levels signal that the FDA believes it has data to support regulatory 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 action levels, they are considered adulterated and may be seized and removed from interstate commerce by the FDA.

Advisory levels guide the industry concerning levels of a substance present in food or feed 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 the following link: https://drive.google.com/file/d/1tqeS5_eOtsRmxZ5RrTnYu7NCIr896KGX/view.

A total of 180 samples were tested for aflatoxin, DON and fumonisin for this *2020/2021 Export Cargo Report*. Details on the testing methodology employed in this study for mycotoxins are in the "Testing Analysis Methods" section.

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. 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 aflatoxin.

The FDA has established action levels in parts per billion (ppb) for aflatoxin M1 in milk intended for human consumption and aflatoxin in human food, grain and livestock feed (see table below).

Aflatoxin Action Level	Criteria
20.0 parts per billion	Dairy animals, pets of all ages, immature animals (including immature poultry) and when the animal’s destination is not known
100.0 parts per billion	Breeding beef cattle, breeding swine and mature poultry
200.0 parts per billion	Finishing swine of 100 pounds or greater
300.0 parts per billion	Finishing (i.e., feedlot) beef cattle

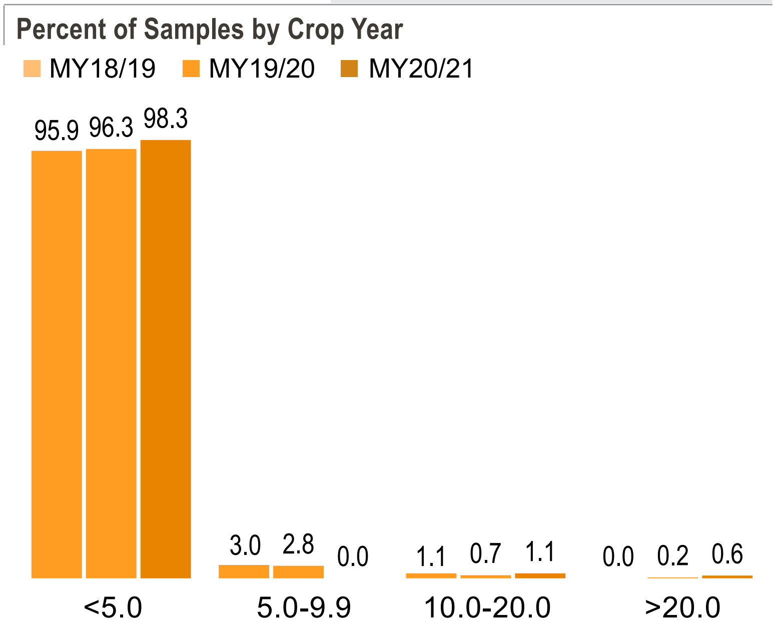
Source: www.ngfa.org
For additional information, see the National Grain and Feed Association’s guidance document titled “FDA Mycotoxin Regulatory Guidance” found at https://drive.google.com/file/d/1tqeS5_eOtsRmxZ5RrTnYu7NCIr896KGX/view.

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.

RESULTS

AFLATOXIN (ppb)



A total of 180 export samples were tested by USDA FGIS for aflatoxin for the *2020/2021 Export Cargo Report*. A threshold established by USDA FGIS as the "Lower Conformance Level" was used to determine whether or not a detectable level of aflatoxin appeared in the sample. The Lower Conformance Level for aflatoxin of the FGIS-approved analytical kits used for this 2020/2021 report were 5.0 ppb. Results of the 2020/2021 survey testing are as follows:

- Of the 180 samples, 177 samples (98.3%) had no detectable levels of aflatoxin (below the FGIS LCL of 5.0 ppb). This 98.3% is higher than 2019/2020 (96.3%) and 2018/2019 (95.9%).
- No samples (0.0%) were found with aflatoxin levels greater than or equal to 5.0 ppb, but less than 10.0 ppb of the 180 samples tested in 2020/2021. This percentage is lower than 2019/2020 (2.8%) and 2018/2019 (3.0%).
- Only two (2) samples (1.1%) of the 180 samples tested in 2020/2021 had aflatoxin levels greater than or equal to 10.0 ppb, but below or equal to the FDA action level of 20.0 ppb. This 1.1% is about is about the same as 2019/2020 (0.7%) and the same as 2018/2019 (1.1%).
- One (1) of the 180 samples (0.6%) tested in 2020/2021 was above the FDA action level of 20.0 ppb, which is slightly higher than in 2019/2020 (0.2%) and 2018/2019 (0.0%).

The percentage of sample test results below the Lower Conformance Level in 2020/2021 (98.3%) was higher than in 2019/2020 (96.3%) and 2018/2019 (95.9%). 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 weather conditions during the 2020 growing season that were not conducive for mold growth and aflatoxin formation.

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. 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. Therefore, 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. In addition, 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 in parts per million (ppm). 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

Source: www.ngfa.org
For additional information, see the National Grain and Feed Association's guidance document titled "FDA Mycotoxin Regulatory Guidance" found at https://drive.google.com/file/d/1tqeS5_eOtsRmxZ5RrTnYu7NCIr896KGX/view.

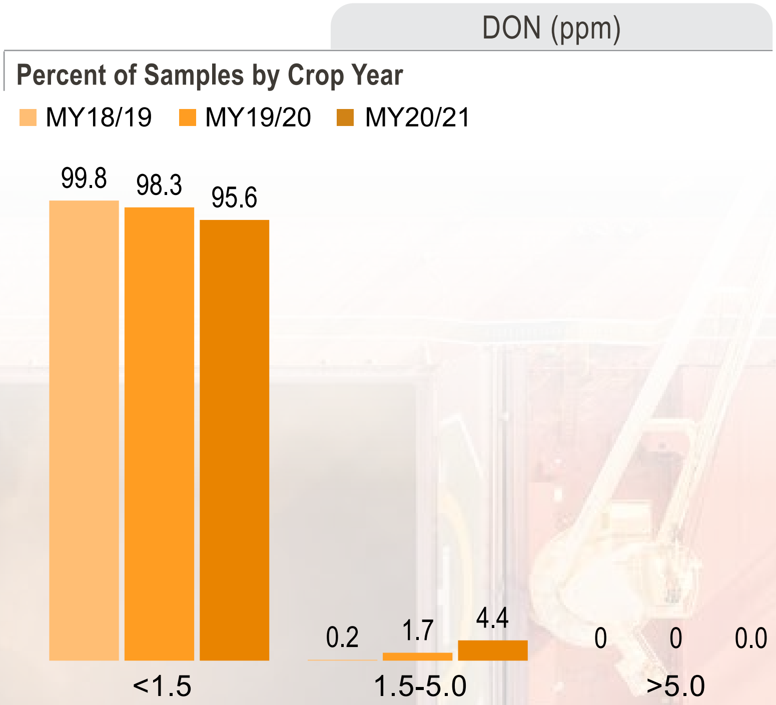
FGIS is not required to test for DON on corn bound for export markets but will perform either a qualitative or quantitative test for DON at the buyer's request.

RESULTS

A total of 180 export samples were tested for DON for the *2020/2021 Export Cargo Report*. Results of the testing are shown below:

- DON levels less than 1.5 ppm were found in 172 samples (95.6%) of the 180 samples tested. This 95.6% is slightly less than 2019/2020 (98.3%) and 2018/2019 (99.8%).
- Eight (8) samples (4.4%) of the 180 samples tested in 2020/2021 had DON levels greater than or equal to 1.5 ppm but less than 5.0 ppm. This 4.8% is greater than 2019/2020 (1.7%) and 2018/2019 (0.2%).
- None (0) of the 180 samples tested in 2020/2021 were above the FDA advisory level of 5.0 ppm, which is the same as 2019/2020 and 2018/2019.

The 2020/2021 survey results had a slightly lower percentage of samples (95.6%) below 1.5 ppm than 2019/2020 (98.3%) and 2018/1919 (99.8%). All export survey samples were below or equal to the FDA advisory level of 5.0 ppm for all three marketing years.



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 on 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

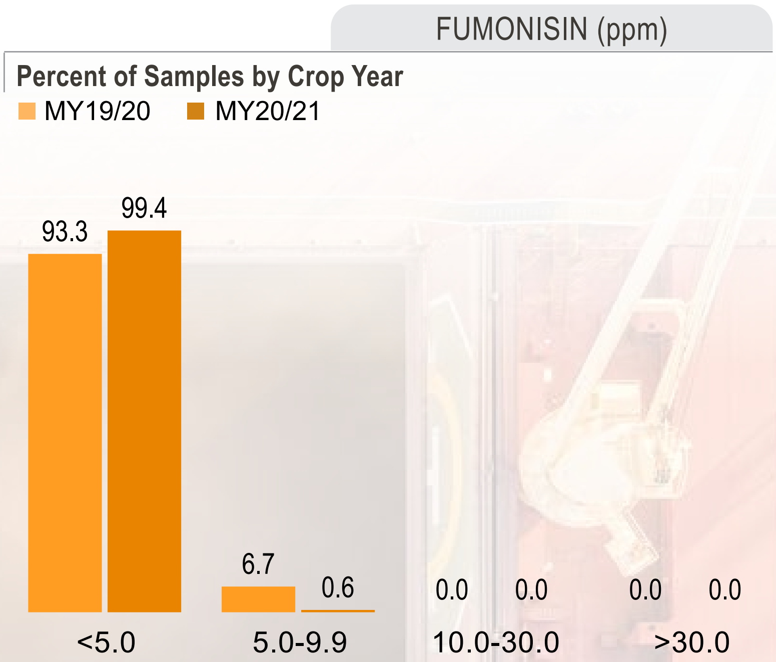
Source: www.ngfa.org
For additional information, see the National Grain and Feed Association's guidance document titled "FDA Mycotoxin Regulatory Guidance" found at https://drive.google.com/file/d/1tqeS5_eOtsRmxZ5RrTnYu7NCIr896KGX/view.

RESULTS

A total of 180 samples were analyzed collectively for fumonisin in the 2020/2021 report. This is the second year that survey samples have been tested for fumonisin. Results of the 2020/2021 survey are as follows:

- One hundred seventy-nine (179) (99.4%) of the 180 samples tested below 5.0 ppm, the lowest advisory level for animals (equids and rabbits), which is higher than 2019/2020 results (93.3%).
- One (1) (0.6%) of the 180 samples test greater than or equal to 5.0 ppm, but less than 10.0 ppm, which is much less than 2019/2020 results (6.7%).
- None (0) (0.0%) of the 180 samples tested greater than or equal to 10.0 ppm, but not greater than 30.0 ppm, which is the same as 2019/2020 results (0.0%).
- None (0) (0.0%) of the 180 samples tested greater than 30.0 ppm, which is the advisory level for breeding ruminants, poultry and mink, and is the same as 2019/2020 results (0.0%).

The 2020/2021 survey results had a high percentage of samples (99.4%) that tested below the lowest advisory level for animals (5.0 ppm). This is likely indicative of the weather conditions during the 2020 growing season, which were not conducive for mold growth and fumonisin formation.



This *2020/2021 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, as well as kernel hardness and density, are 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; 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 foreign material, odor, dust, rodent excreta, insects, residues, fungal infection and non-millable materials.

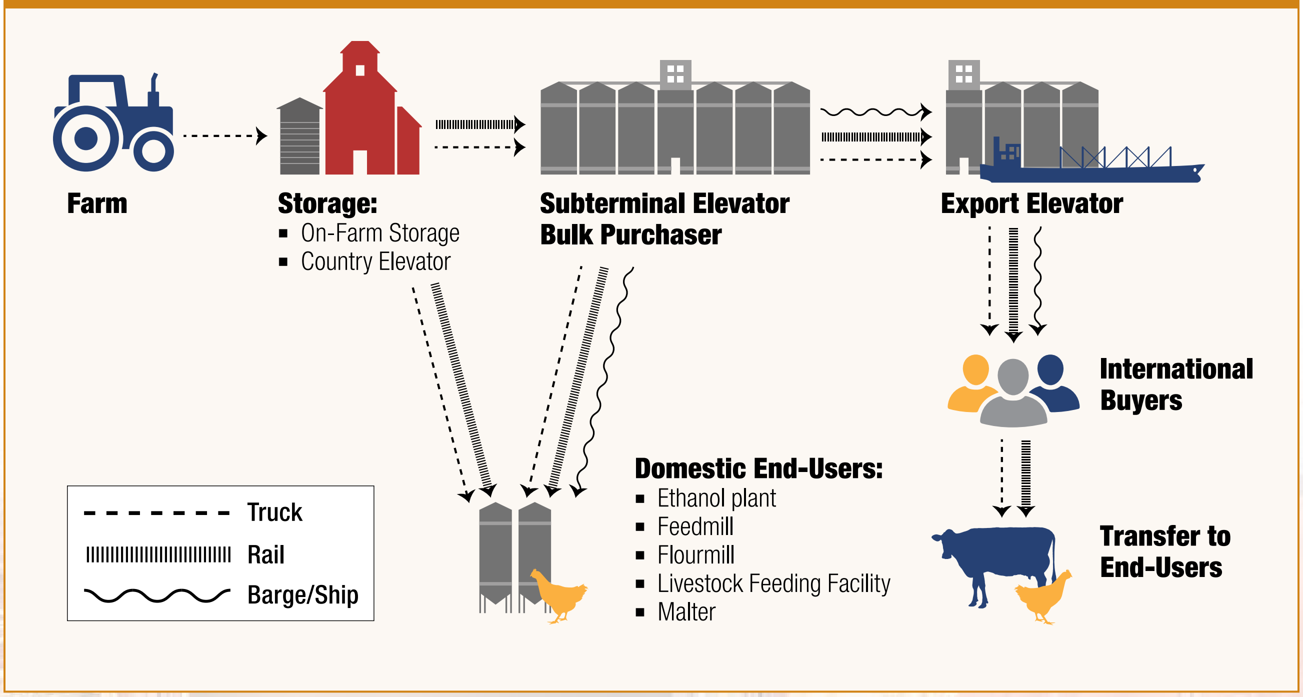
The intrinsic quality characteristics are impacted significantly by genetics and growing season conditions and typically do not change at the aggregate level as corn moves through the marketing system. If the measured values of the intrinsic characteristics differ between harvest and export at the aggregate 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 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 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

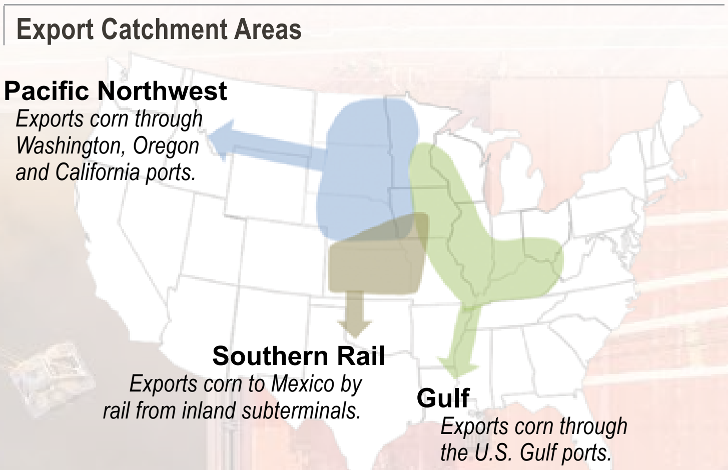
Yellow corn is divided into five U.S. numerical grades and U.S. Sample Grade. Each grade has limits for test weight, BCFM, total damaged kernels and heat-damaged kernels as a subset of total damage. The limits for each grade are summarized in the table shown in the “U.S. Corn Supporting Information” 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 *2020/2021 Export Cargo Report* are as follows:

- Following the methodology developed for the previous nine *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: 240 from the Gulf, 114 from the Pacific Northwest and 76 from the Southern Rail.
- A total of 440 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. In the Pacific Northwest ECA, the Relative ME exceeded ±10% for total damage and stress cracks (both 14%). In the Southern Rail ECA, the Relative ME exceeded ±10% for total damage (17%) and stress cracks (19%).
- Two-tailed t-tests at the 95% confidence level were calculated to measure statistical differences between the 2020/2021 and 2019/2020 and the 2020/2021 and 2018/2019 quality factor averages.



B. SURVEY DESIGN AND SAMPLING

Survey Design

For the *2020/2021 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 2020/2021 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:

- The Gulf ECA consists of areas that typically export corn through U.S. Gulf ports;
- The Pacific Northwest ECA includes areas that usually export corn through Pacific Northwest ports; and
- 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 2020/2021 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 ***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.

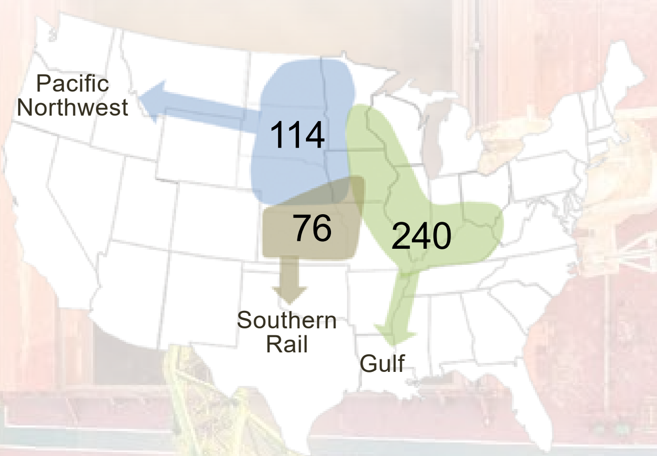
Since the population variances for the 12 quality factors evaluated for this year's corn exports were not known, the variance estimates from previous editions of the *Export Cargo Report* were used as estimates of the population variance. The targeted number of samples for the desired level of precision for all quality factors were then calculated using these data.

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 below).

Beginning with the *2019/2020 Export Cargo Report*, a minimum of 180 samples was 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 were also tested for fumonisin. The *2019/2020 Export Cargo Report* was the first *Export Cargo Report* in which this mycotoxin was tested. In terms of horneous endosperm, the Relative ME for this quality factor never exceeded 0.3% (well below the targeted level of precision of ±10.0%) in the samples tested from the first 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%. In the *2019/2020 Export Cargo Report*, the first *Export Cargo Report* in which only 180 samples were tested for horneous endosperm, the Relative ME for this quality factor was only 0.4% (well below the targeted level of precision of ±10.0%).

Beginning with this *2020/2021 Export Cargo Report*, the target of 180 samples was extended to 100-kernel weight, kernel volume and kernel true density. Given the historical data collected from the first nine *Export Cargo Reports*, reducing the number of samples tested for these three additional quality factors would likely keep the precision of their estimates well below the targeted level of ±10.0%.

Targeted Samples by Export Catchment Area



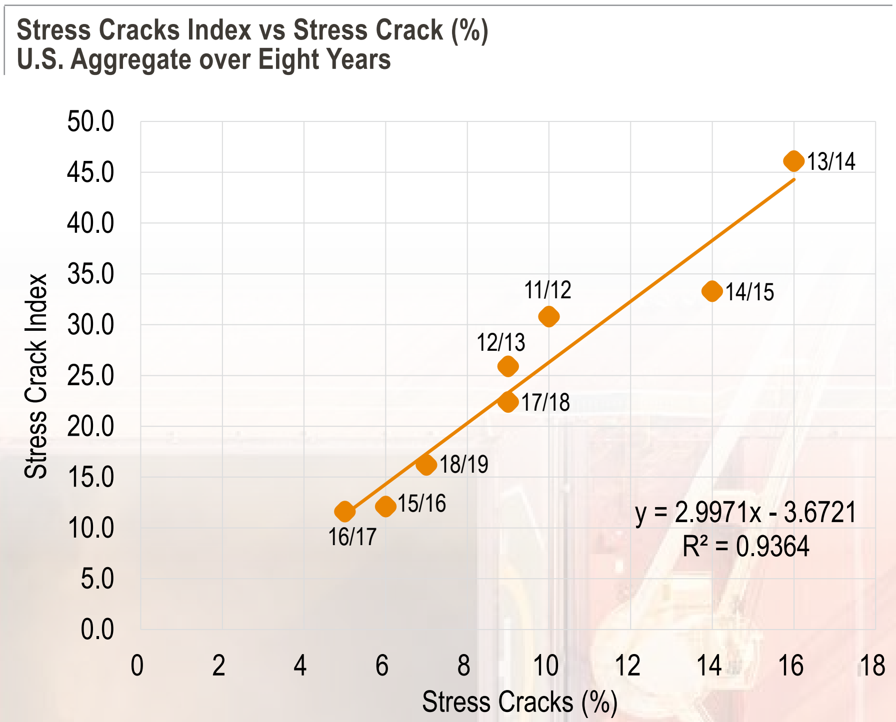
In the first eight years of the *Export Cargo Report*, the stress crack index was reported in addition to the percent stress cracks to indicate the severity of stress cracking. The stress crack index is determined using the following calculation:

[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* is 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*.



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 February 2021. 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. 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. 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.

C. STATISTICAL ANALYSIS

The sample test results for grade factors, 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 grade categories[1]:

- "U.S. No. 2" grade samples meet or are better than U.S. No. 2 grade factor limits.
- "U.S. No. 3" grade samples meet or are better than U.S. No. 3 grade factor limits.

Within this *2020/2021 Export Cargo Report* is a simple average of the quality factors' averages and standard deviations of the previous five *Export Cargo Reports (2015/2016, 2016/2017, 2017/2018, 2018/2019 and 2019/2020)*. 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. References to the "10YA" are also made throughout the report. The 10YA represents the simple average of the quality factors' averages from the *2011/2012 Export Cargo Report* through this *2020/2021 Export Cargo 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 and stress cracks in the Pacific Northwest ECA (both 14%) as well as in the Southern Rail ECA, with a Relative ME of 17% for total damage and 19% for stress cracks. While the level of precision for these estimates is less than desired, the levels of Relative ME do not invalidate the estimates. The averages for the quality factors are the best possible unbiased estimates of the true population means. However, they are estimated with greater uncertainty than the quality factors with a Relative ME of less than ±10%. Footnotes in the summary tables for "Grade Factors and Moisture" and "Physical Factors" indicate the attributes for which the Relative ME exceeds ±10%.

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*.

[1] *All grade factor tests were conducted by Champaign-Danville Grain Inspection in Urbana, Illinois. These test results determined each sample's grade classification. Some samples tested had grades other than U.S. No. 2 or U.S. No. 3. U.S. Aggregate results for grades other than U.S. No. 2 or U.S. No. 3 are not reported due to limited number of samples.*

The *2020/2021 Export Cargo Report* samples were sent directly from the FGIS field offices and official service providers to the IPG Lab in Champaign, Illinois. IPG Lab conducted chemical composition, physical factor and mycotoxin testing. All grade factor tests were conducted by Champaign-Danville Grain Inspection (CDGI) in Urbana, Illinois. CDGI is the official grain inspection service provider for East Central Illinois as designated by USDA FGIS. The grade testing procedures were in accordance with FGIS's *Grain Inspection Handbook* and are described in the following section. 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 required to fill a Winchester bushel (2,150.42 cubic inches). Test weight is a 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 test cup's sides. 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 Grain and 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. The definition of foreign material is 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 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 trained and licensed inspector visually examines a representative working sample of 250 grams of BCFM-free corn for 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), mold (pink Epicoccum) and sprout-damaged kernels. Total damage is reported as the weight percentage of the working sample that is total damaged grain.

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

B. CHEMICAL COMPOSITION

Near-Infrared Transmission Spectroscopy (NIR) Proximate Analysis

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

Chemical composition tests for protein, oil and starch 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 errors of predictions for protein, oil and starch were about 0.22%, 0.26% and 0.65%, respectively. Comparisons of the Foss Infratec 1229 used in *Export Cargo Reports* before 2016 to the Foss Infratec 1241 on 21 laboratory check samples showed the instruments averaged within 0.25%, 0.26% and 0.25% points of each other for protein, oil and starch, respectively. Results are reported on a dry basis percentage (percent of non-water material).

C. 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 milligrams. 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 cubic centimeters to 0.36 cubic centimeters 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 grams per cubic centimeter to 1.30 grams per cubic centimeter 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 each kernel's stress crack damage 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 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.

Whole Kernels

In the whole kernels test, 50 grams of cleaned (BCFM-free) corn are inspected kernel by kernel. Kernels that are cracked, broken, chipped or showed 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 kernel 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. The soft endosperm is opaque and will block light, while the 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 90% range.

D. MYCOTOXINS

To report the frequency of occurrences of aflatoxin, DON and fumonisin for the *2020/2021 Export Cargo Report*, IPG Lab performed the mycotoxin testing using test kits approved by FGIS. For this study, a 1,000-gram laboratory sample was subdivided from the survey sample of shelled kernels for the mycotoxin analysis. The 1,000-gram survey sample was ground in a Romer Model 2A mill so that 60 to 75% would pass through a 20-mesh screen. From this well-mixed ground material, a 50-gram test portion was removed for each mycotoxin tested. EnviroLogix AQ 309 BG, AQ 304 BG and AQ 411 BG quantitative test kits were used for the aflatoxin, DON and fumonisin analysis, respectively. DON and fumonisin were extracted with water (5:1), while the aflatoxin was extracted with buffered water (3:1). The extracts were tested using the EnviroLogix QuickTox lateral flow strips, and the QuickScan system quantified the mycotoxins.

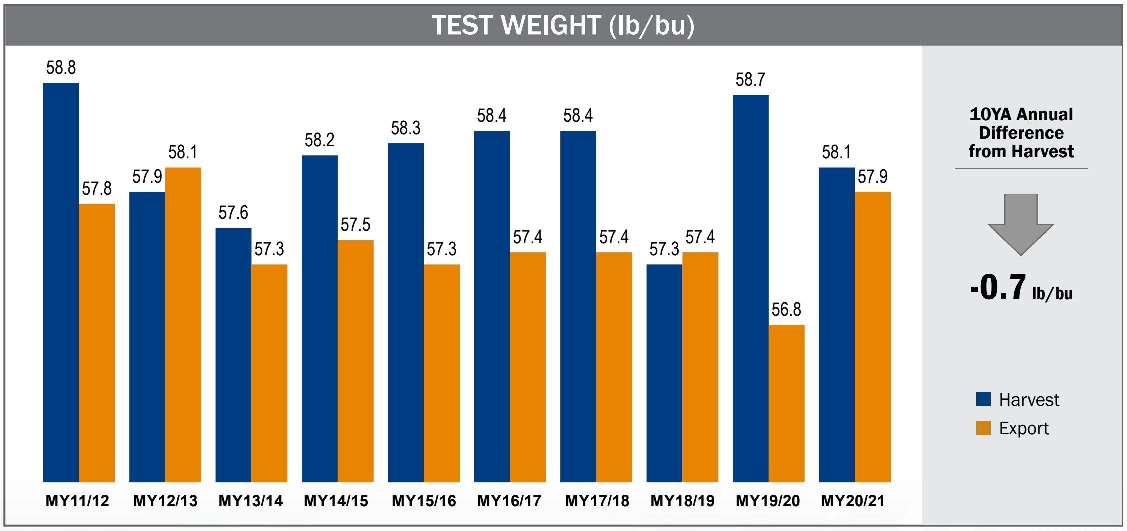
The EnviroLogix quantitative test kits report specific concentration levels of the mycotoxin if the concentration level exceeds a specific level called a "Limit of Detection." The limit of detection is defined as the lowest concentration level that can be measured with an analytical method that is statistically different from measuring an analytical blank (absence of a mycotoxin). The limit of detection will vary among different types of mycotoxins, test kits and commodity combinations. The limit of detection for the EnviroLogix AQ 309 BG is 2.7 parts per billion for aflatoxin. The limit of detection for DON using the EnviroLogix AQ 304 BG is 0.1 parts per million. For the fumonisin tests, the EnviroLogix AQ 411 BG has a limit of detection of 0.1 parts per million. FGIS has issued a letter of performance for the quantification of aflatoxin, DON and fumonisin using the Envirologix AQ 309 BG, AQ 304 BG and AQ 411 BG kits, respectively.

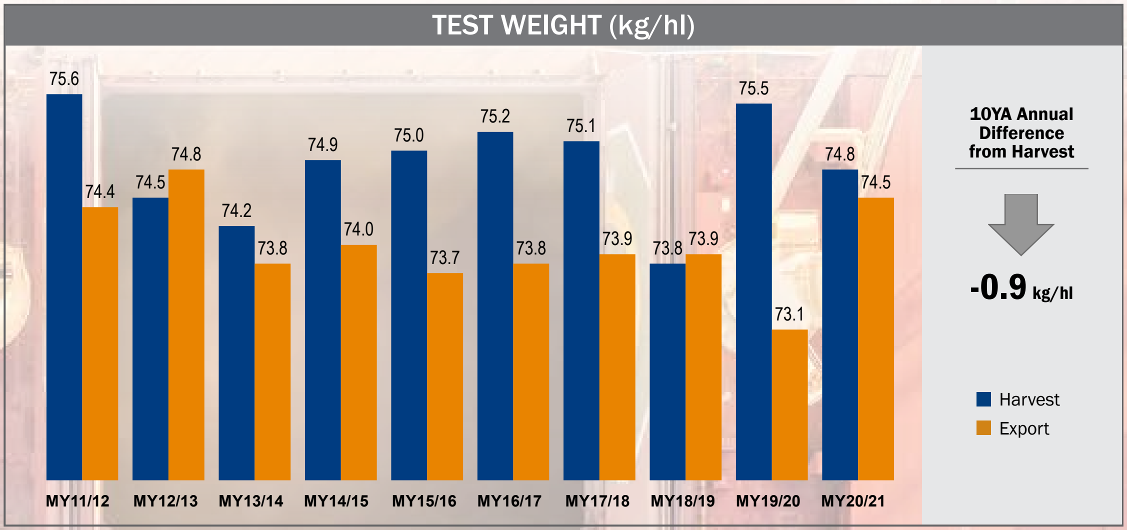
In the first nine *Export Cargo Reports*, FGIS provided aflatoxin results. Official FGIS protocol for aflatoxin testing requires the grinding of at least 10 pounds of shelled corn from vessel sublot and composite inspections. For this *Export Cargo Report*, IPG Lab received a minimum of 1,000 grams for aflatoxin testing. This represents a change in protocol from previous *Export Cargo Reports.*

According to the official FGIS aflatoxin testing protocol utilized in the first nine *Export Cargo Reports*, a 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.

GRADE FACTORS
AGGREGATE HARVEST AND EXPORT CARGO COMPARISON

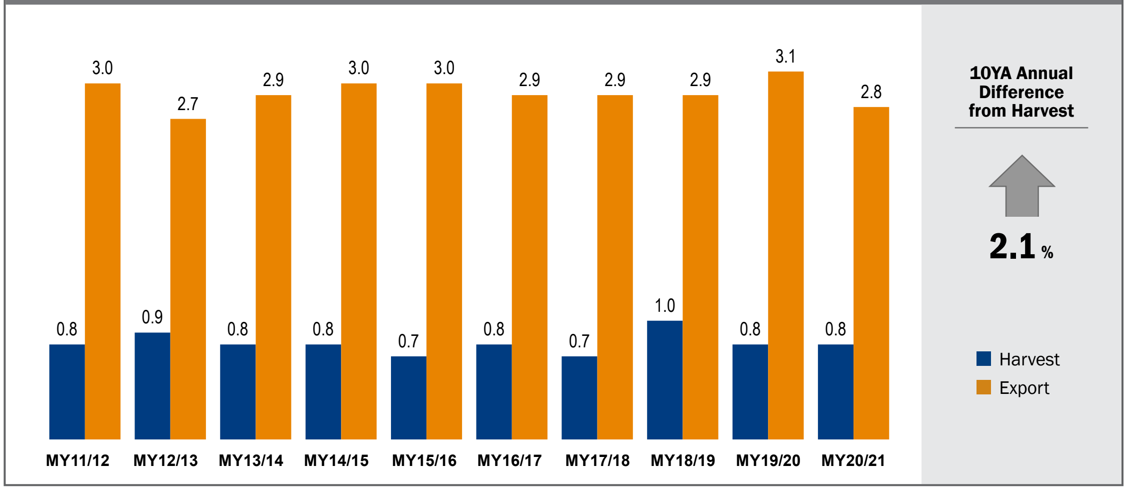
Since 2011, the U.S. Grains Council's *Export Cargo Reports* have provided clear, concise and consistent information about the quality of each U.S. crop entering international merchandising channels. This series of quality reports has used consistent and transparent methodology to allow for insightful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



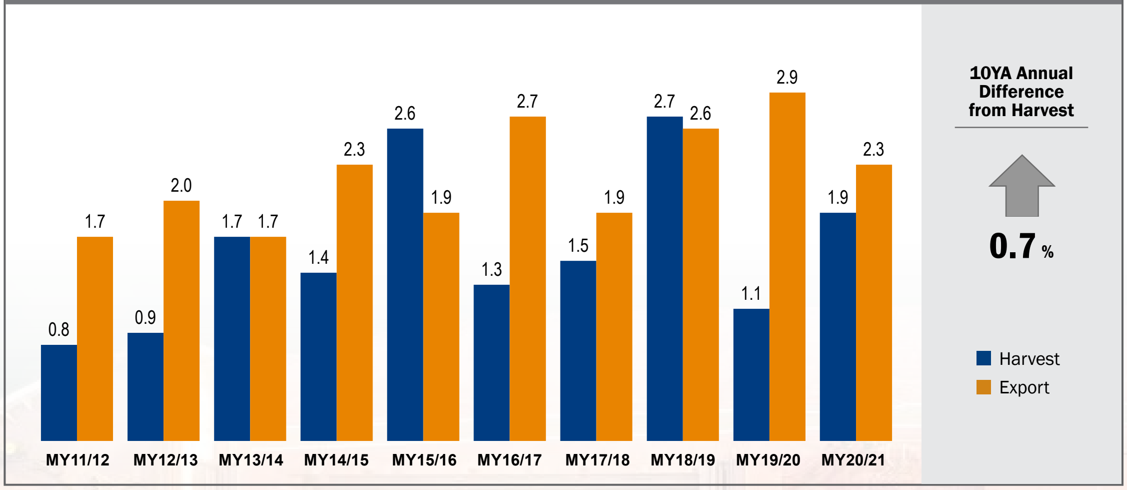


GRADE FACTORS
AGGREGATE HARVEST AND EXPORT CARGO COMPARISON

BROKEN CORN AND FOREIGN MATERIAL (%)

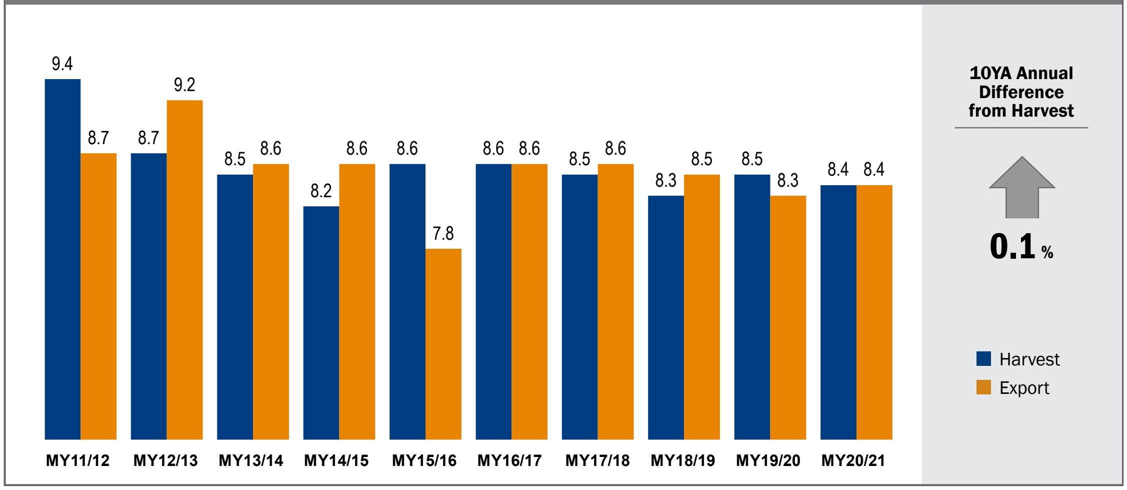


TOTAL DAMAGE (%)

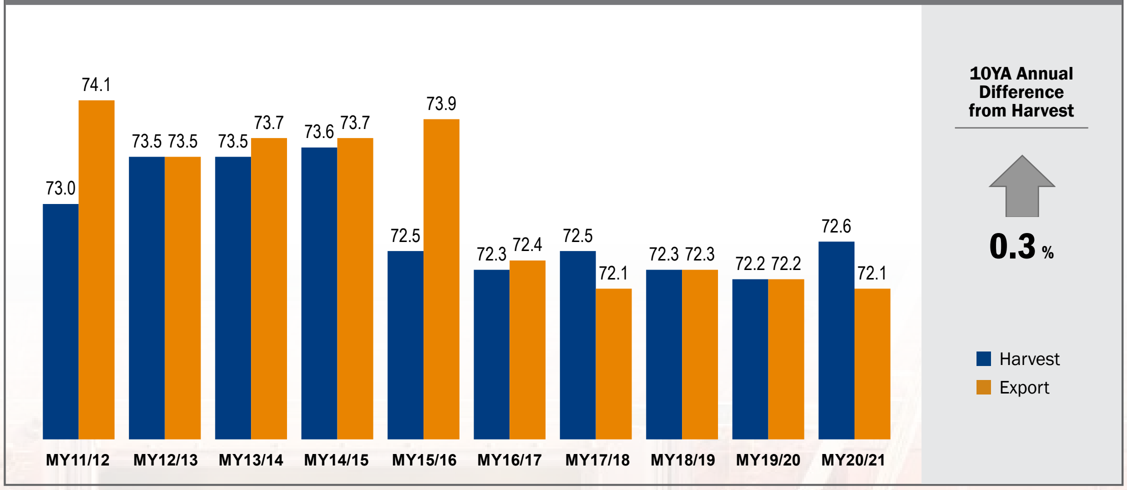


CHEMICAL COMPOSITION
AGGREGATE HARVEST AND EXPORT CARGO COMPARISON

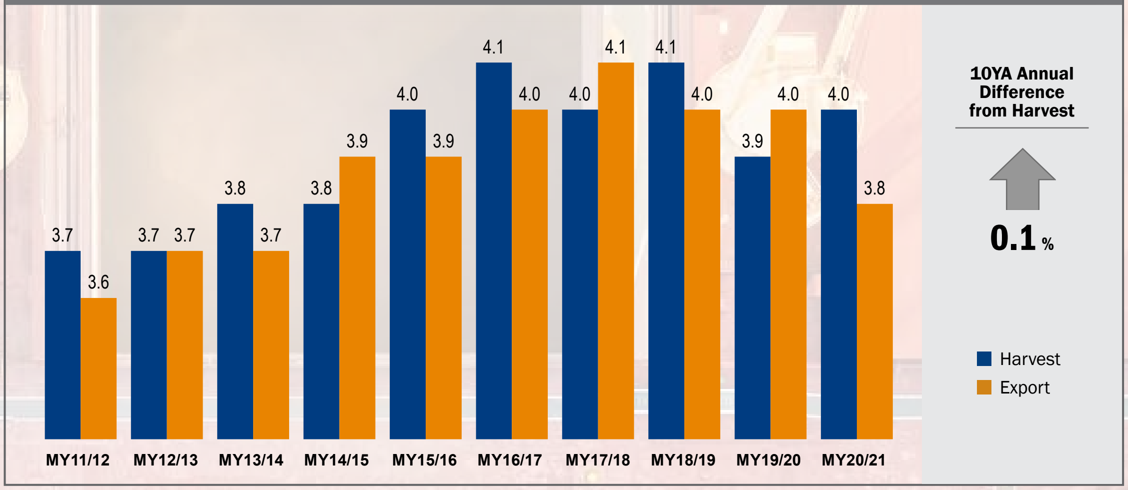
PROTEIN (Dry Basis %)



STARCH (Dry Basis %)

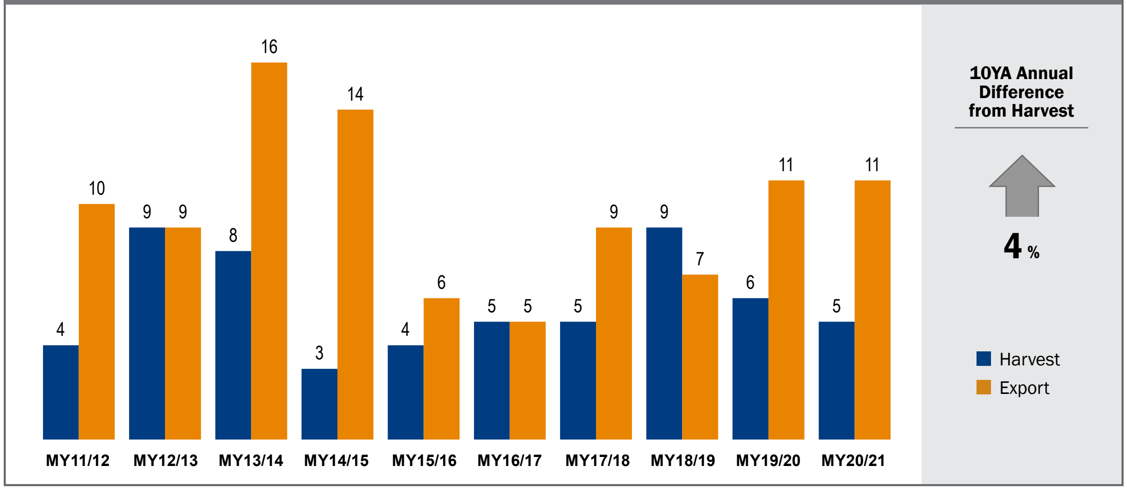


OIL (Dry Basis %)

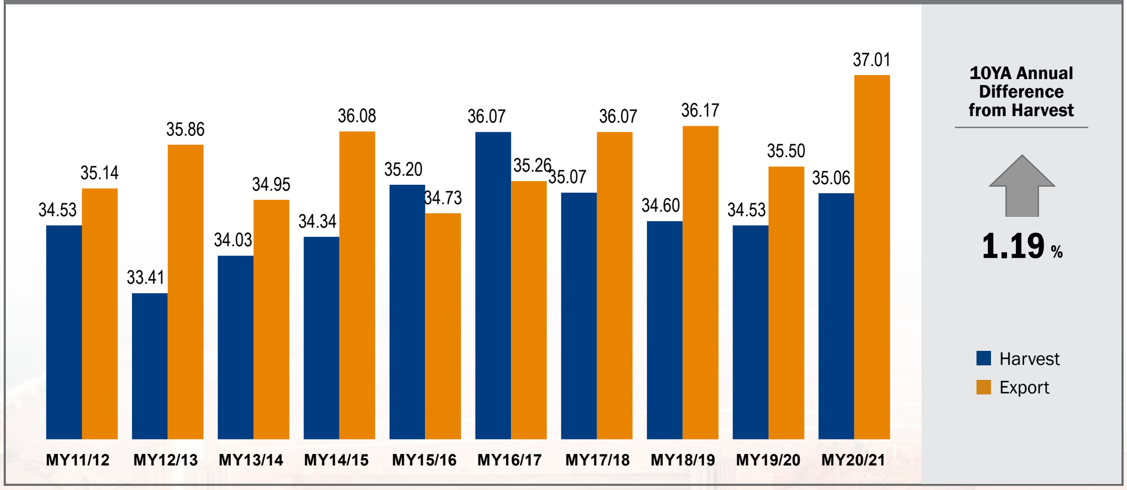


PHYSICAL FACTORS
AGGREGATE HARVEST AND EXPORT CARGO COMPARISON

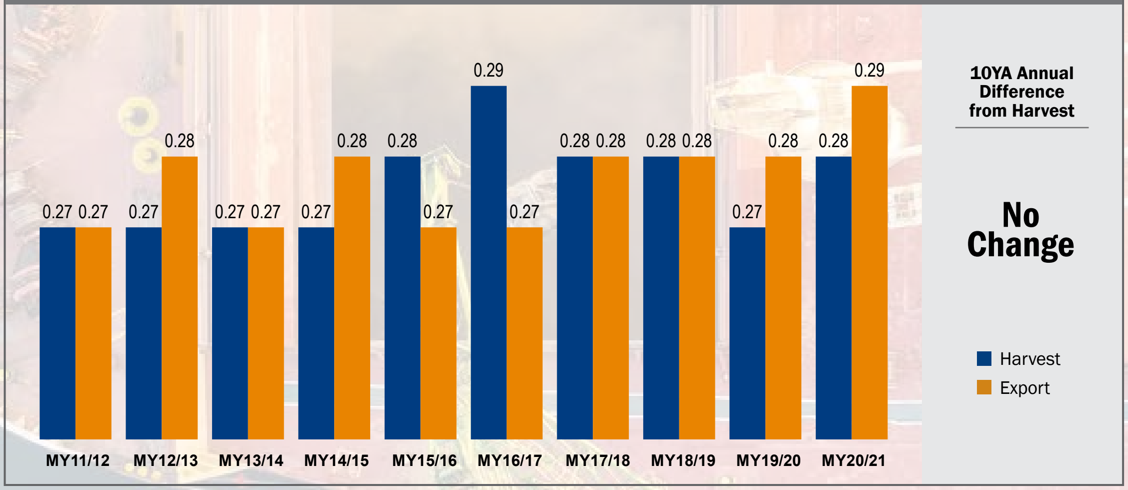
STRESS CRACKS (%)



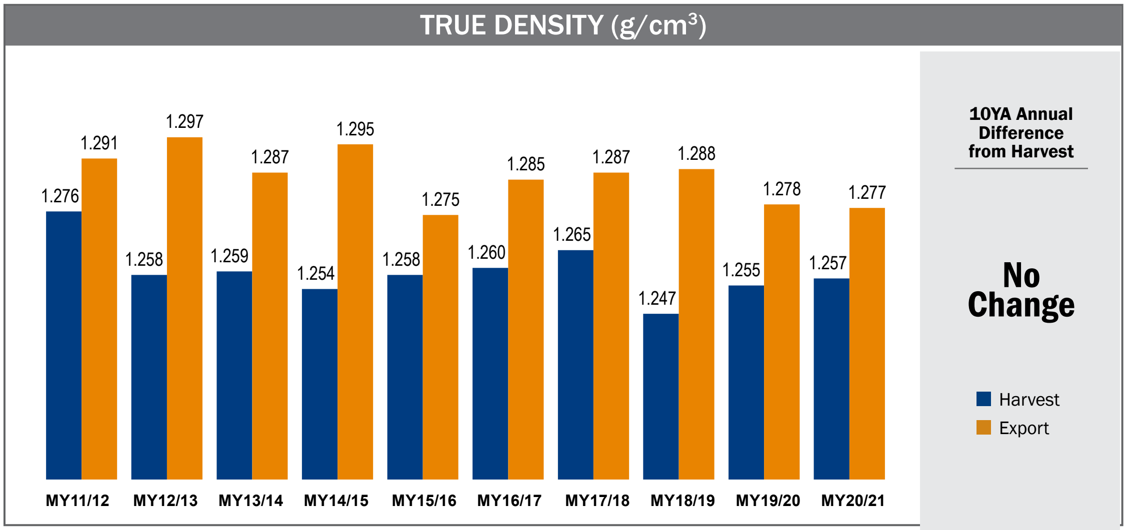
100-KERNEL WEIGHT (g)

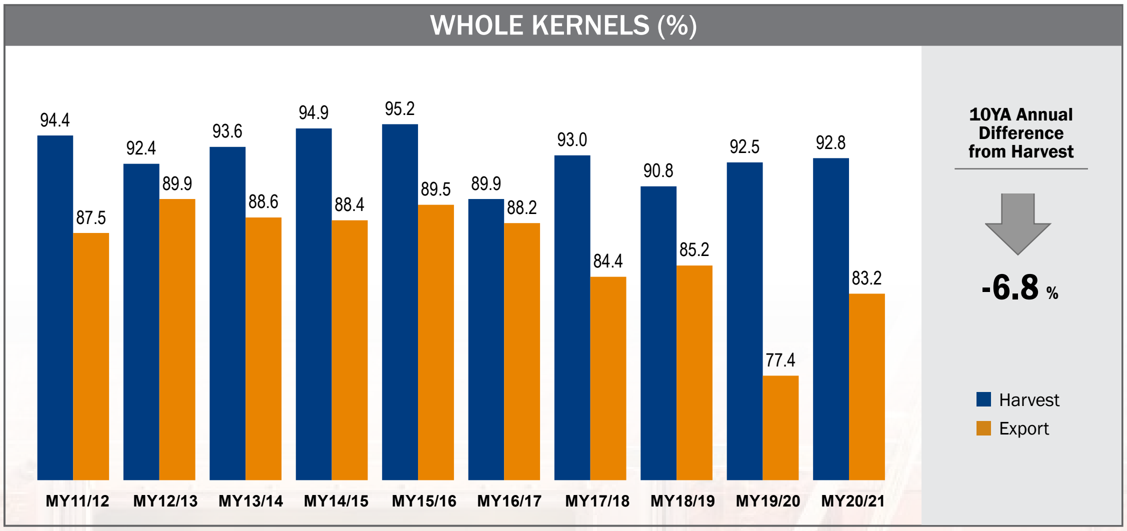


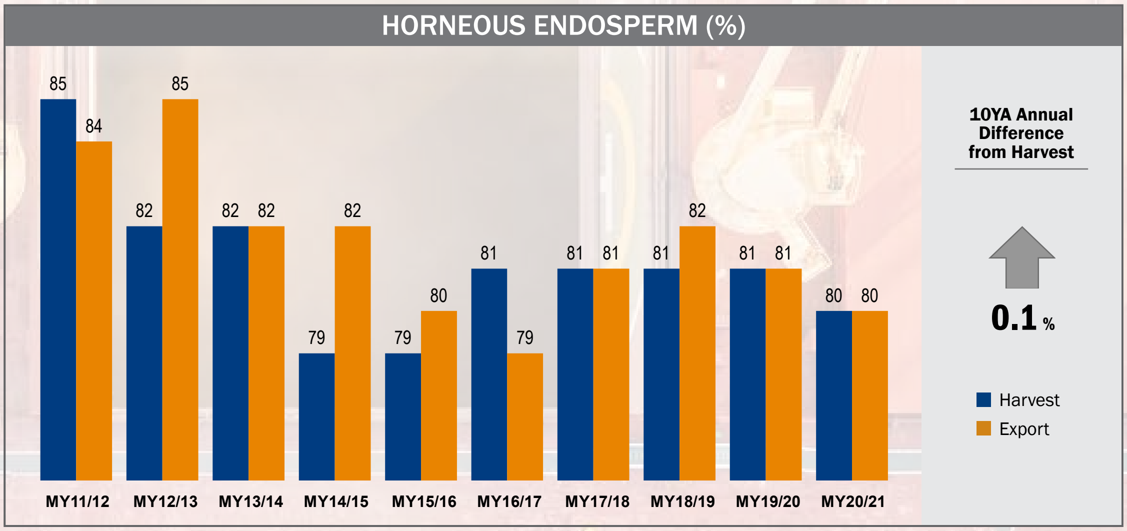
KERNEL VOLUME (cm^3)



PHYSICAL FACTORS
AGGREGATE HARVEST AND EXPORT CARGO COMPARISON

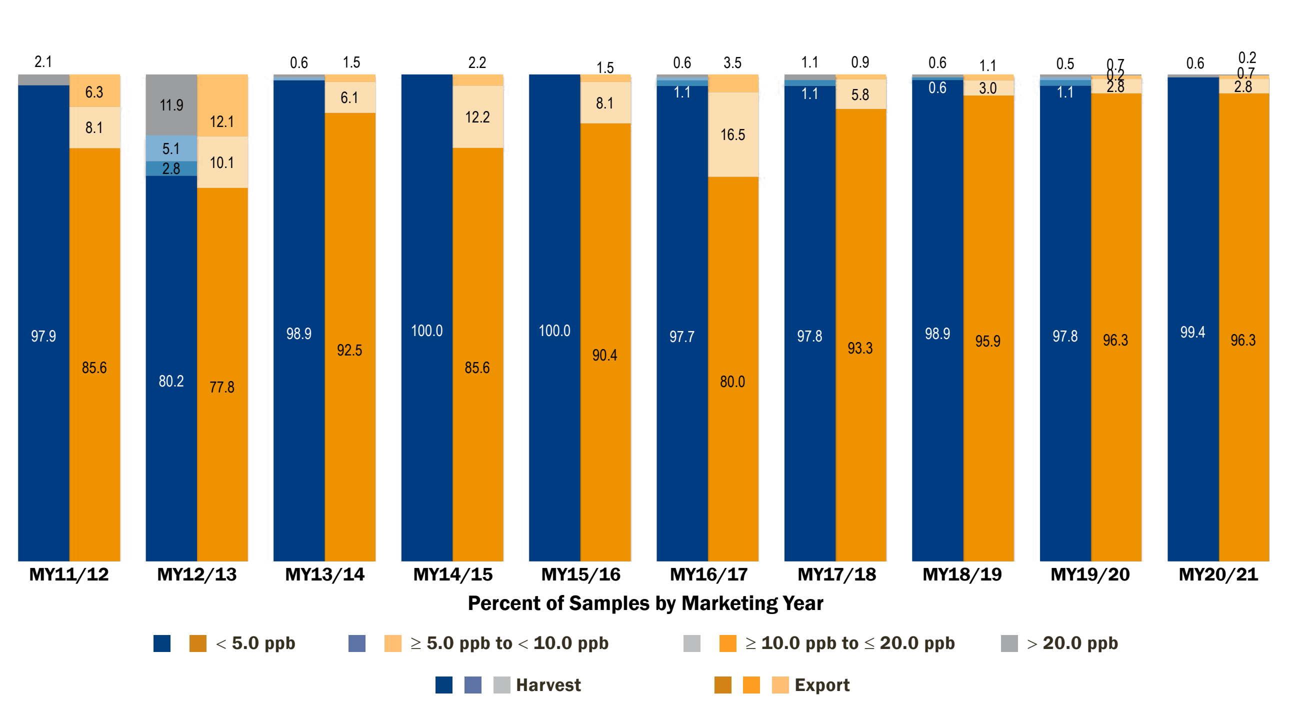




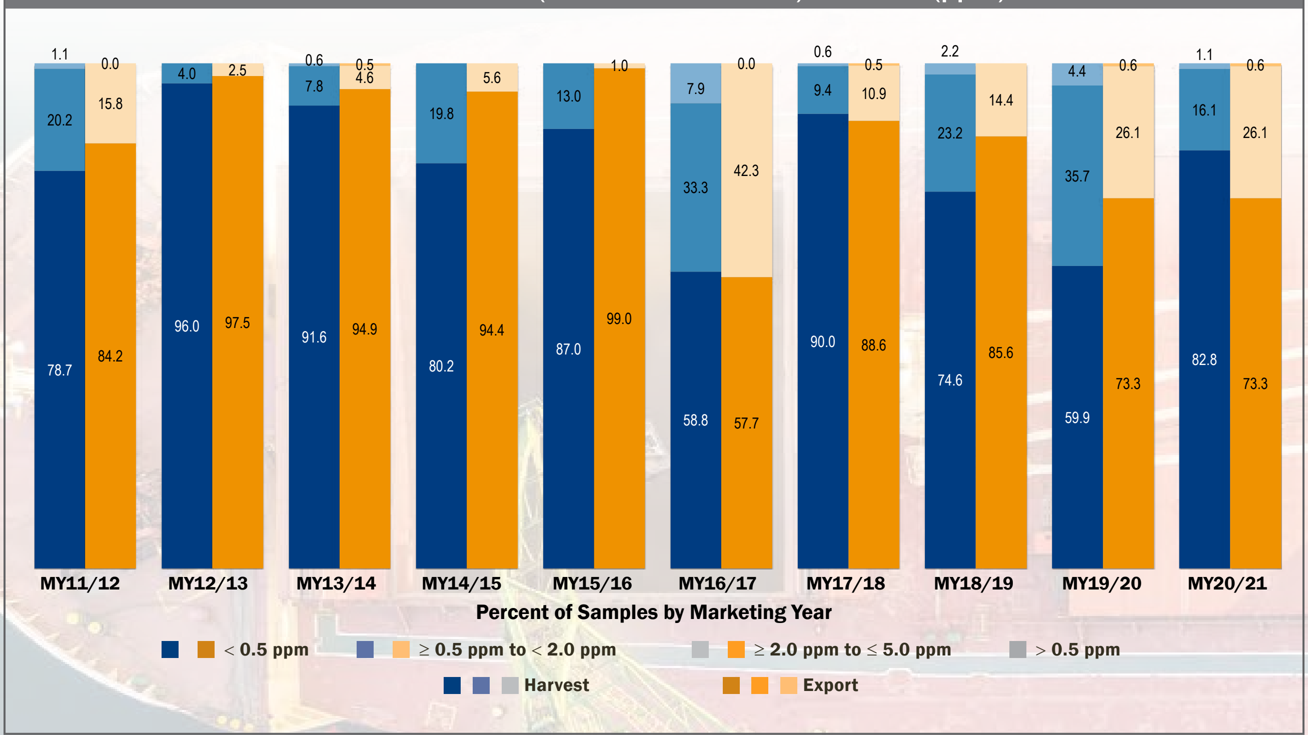


MYCOTOXINS
HARVEST AND EXPORT CARGO COMPARISON

AFLATOXIN RESULTS (ppb)

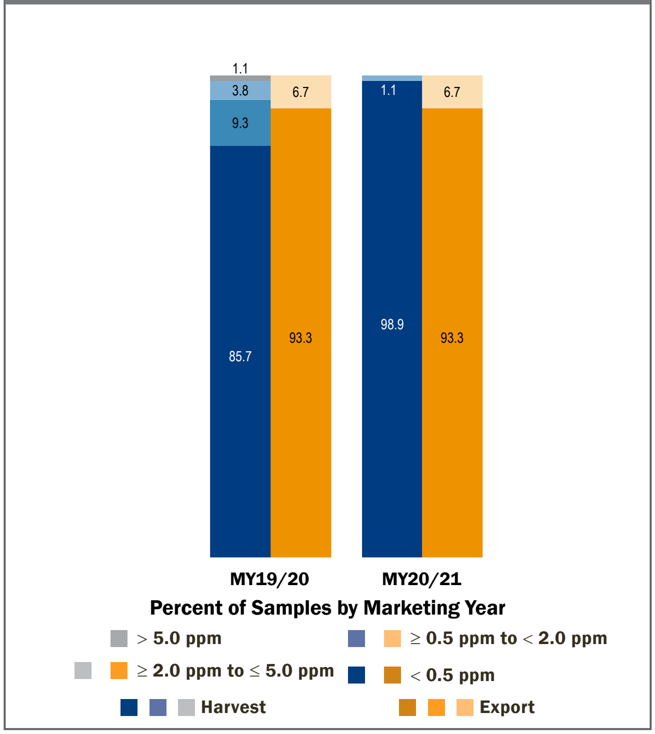


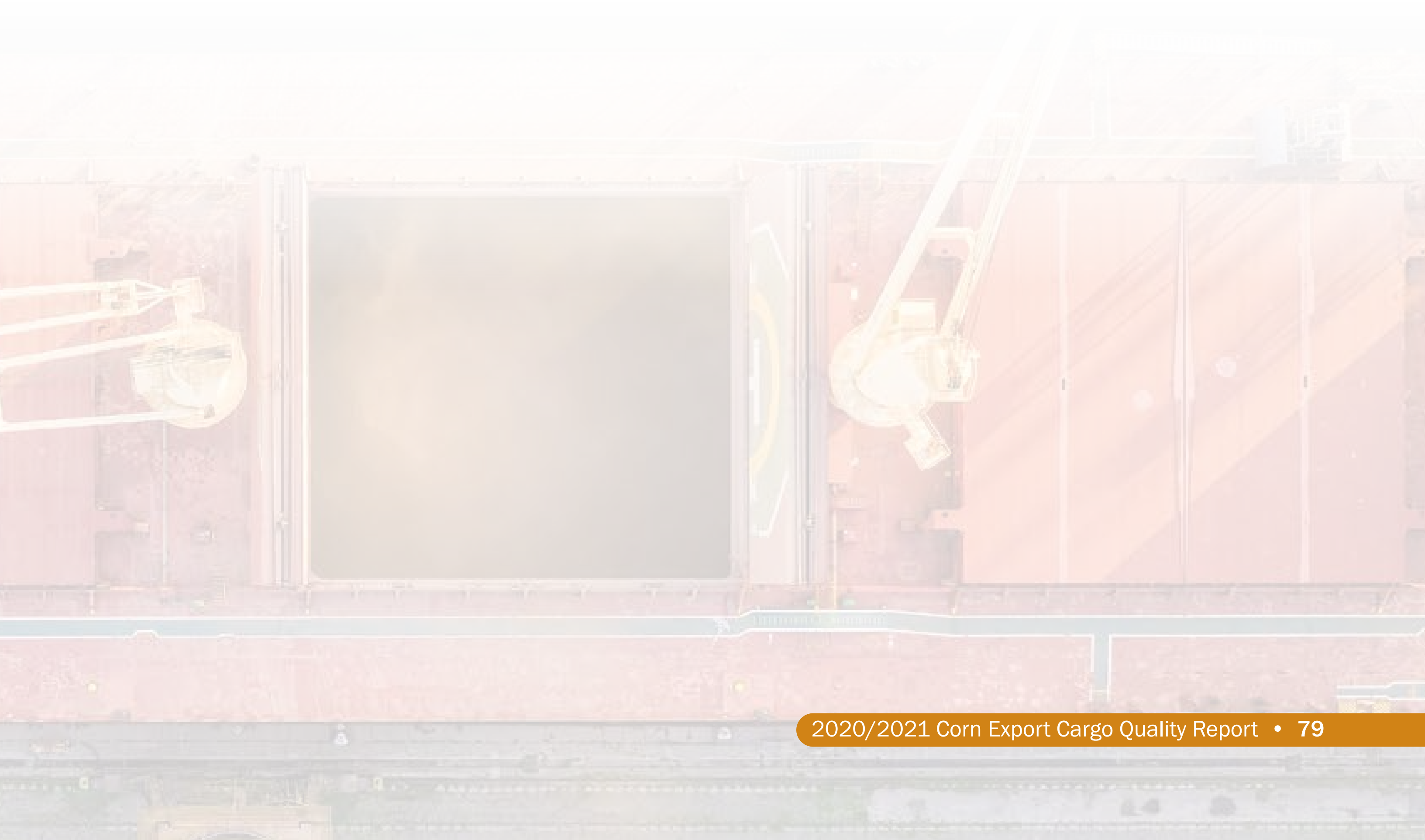
DEOXYNIVALENOL (DON OR VOMITOXIN) RESULTS (ppm)



MYCOTOXINS
HARVEST AND EXPORT CARGO COMPARISON

FUMONISIN RESULTS (ppm)





U.S. CORN GRADES AND GRADE REQUIREMENTS

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

U.S. Sample Grade is corn that: (a) Does not meet the requirements for the grades U.S. Nos. 1, 2, 3, 4, or 5; or (b) Contains stones with an aggregate weight in excess of 0.1% of the sample weight, 2 or more pieces of glass, 3 or more crotalaria seeds (*Crotalaria spp.*), 2 or more castor beans (*Ricinus communis L.*), 4 or more particles of an unknown foreign substance(s) or a commonly recognized harmful or toxic substance(s), 8 or more cockleburs (*Xanthium spp.*), or similar seeds singly or in combination, or animal filth in excess of 0.2% in 1,000 grams; or (c) Has a musty, sour, or commercially objectionable foreign odor; or (d) Is heating or otherwise of distinctly low quality.

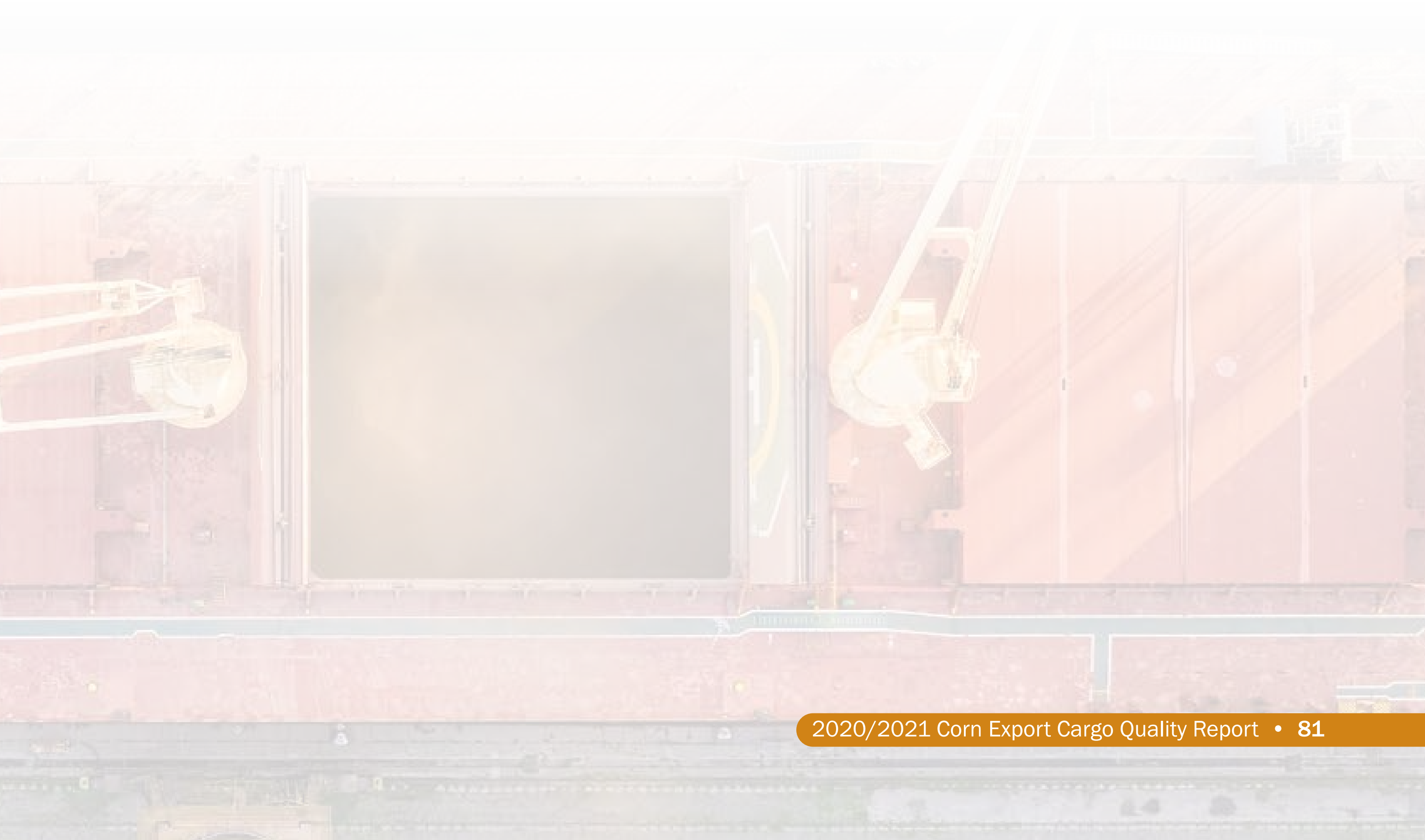
Source: Code of Federal Regulations, Title 7, Part 810, Subpart D, United States Standards for Corn

U.S. AND METRIC CONVERSIONS

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

ABBREVIATIONS

cm^3 =	cubic centimeters
g =	grams
g/cm^3 =	grams per cubic centimeter
kg/hl =	kilograms per hectoliter
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.

HEADQUARTERS:

20 F Street NW, Suite 900 • Washington, DC 20001
Phone: +1-202-789-0789 • Fax: +1-202-898-0522
Email: grains@grains.org • Website: grains.org

PEOPLE'S REPUBLIC OF CHINA: Beijing

Tel1: +86-10-6505-1314 • Tel2: +86-10-6505-2320
Fax: +86-10-6505-0236 • china@grains.org.cn

JAPAN: Tokyo

Tel: +81-3-6206-1041 • Fax: +81-3-6205-4960
japan@grains.org • www.grainsjp.org

KOREA: Seoul

Tel: +82-2-720-1891 • Fax: +82-2-720-9008
seoul@grains.org

MEXICO: Mexico City

Tel1: +52-55-5282-0244 • Tel2: +52-55-5282-0973
Tel3: +52-55-5282-0977 • Fax: +52-55-5282-0974
mexicousg@grains.org

MIDDLE EAST AND AFRICA: Tunis

Tel: +216-71-191-640 • Fax: +216-71-191-650
tunis@grains.org

SOUTH ASIA

adcastillo@grains.org

SOUTH EAST ASIA: Kuala Lumpur

Tel: +603-2093-6826
sea-oceania@grain.org

TAIWAN: Taipei

Tel: +886-2-2523-8801 • Fax: +886-2-2523-0189
taipei@grains.org

WESTERN HEMISPHERE: Panama City

Tel: +507-315-1008
panama@grains.org

Developing Markets ■ Enabling Trade ■ Improving Lives