

**2019**

**U.S. DURUM WHEAT**

*Regional Quality*

*Report*



## OVERVIEW

**THE 2019** durum crop produced in North Dakota and Montana is smaller in production compared to 2018, and is skewed lower in overall quality due to historic rains during the month of September and a significantly delayed harvest. Regional production is estimated at 52 million bushels (1.4 MMT), down 20 percent from 2018, as planted area fell by 35 percent. Excellent mid-season moisture propelled the crop to well above average yields in many areas, offsetting part of the acreage decline. Final production may fall further from current estimates however, as roughly 20 percent of the crop in the region remained unharvested as of mid-October. Due to the unusual harvest conditions this year, the entire crop is not represented in this crop quality report. Only 77% of the expected durum samples were collected and analyzed for this report, and a higher than normal percentage of the crop will be moved directly into feed channels.

**THE SURVEYED CROP** averages a No. 2 Amber Durum (AD). Thirty-seven percent of the crop grades a #1 or #2 Hard Amber Durum (HAD), down from 86 percent a year ago. The average test weight is 61.1 lbs/bu (79.6 kg/hl), similar to a year ago, and above the 5-yr average. Test weight distributions show nearly 70 percent of the crop above 60 lbs/bu (78.1 kg/hl). Total kernel defects average 3 percent, higher than 1 percent last year and 1.3 percent for a 5-yr average. All of the increase is in damaged kernels, up from 0.3 percent in 2018 to 2.3 percent this year. The higher level of damaged kernels is due to elevated disease pressures during the growing season in some areas, and damage from the prolonged harvest period.

**VITREOUS KERNEL** levels average just 64 percent, down sharply from 90 percent in 2018 and 87 percent for a 5-yr average. The overly wet harvest conditions are the primary contributing factor for the lower vitreous levels, but in some areas with well above average yields, lower protein levels impacted vitreous kernels. Still, distribution data shows that nearly one-fourth of the crop is above 90 percent vitreous kernels, and thirty-eight percent above 75 percent vitreous. The crop average protein is 13.9 percent (12% basis), equal to the 5-yr average, but down from 14.5 percent in 2018. Distribution data shows a narrower range in protein in 2019 compared to 2018 with nearly 80 percent of the crop between 12.0 and 14.9%, compared to just 62. In 2019 a small share is above 15% protein.

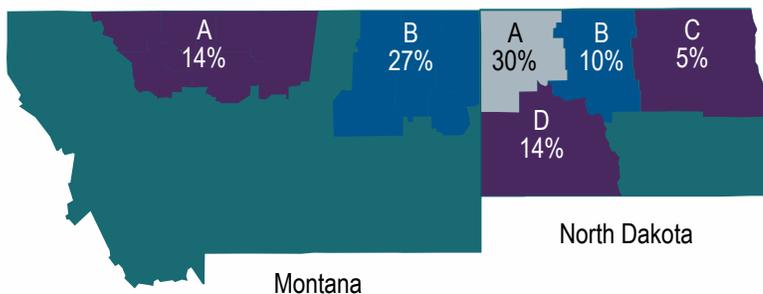
**EXCELLENT CONDITIONS** during kernel development boosted average thousand kernel weight to 44 grams, up from 41 last year, and notably higher than the 5-yr average. The 2019 crop is also showing a higher percent of large kernels. Falling number analysis on the 2019 crop reveals the impact of the wet harvest period for much of the region, with a crop average falling number of 345 seconds, compared to 425 in 2018. Positively, 75 percent of the crop remains above 300 seconds, although the level above 400 seconds is only 26 percent. Disease pressures were higher in 2019 compared to recent years, with some areas impacted by Fusarium to a greater degree than others. The crop average DON is 0.6 ppm, up from 0.2 last year, but slightly below the 5-yr average. DON levels by area range from non-detectable to 2.4 ppm.

**MILLING** for the 2019 survey was performed on a Quadrumat Junior mill, limiting direct comparisons to the Buhler laboratory mill used in previous years. Semolina extraction is 57.5 percent, down sharply from 2019, likely attributed to the notable decline in vitreous kernels, but also to the shift in milling equipment. The milled product is showing a marked decline in ash levels, 0.6%, with just a slight increase in speck counts compared to 2019. Gluten index values are higher, at 67 percent, compared to 57 percent in 2018.

| PRODUCTION DATA           |             |             |                 |
|---------------------------|-------------|-------------|-----------------|
|                           | 2019        | 2018        | 2014-18 AVERAGE |
| <b>MILLION BUSHELS</b>    |             |             |                 |
| Montana                   | 22.5        | 23.3        | 19.9            |
| North Dakota              | 29.2        | 42.5        | 40.0            |
| <b>U.S. Total</b>         | <b>57.7</b> | <b>78.0</b> | <b>73.8</b>     |
| <b>MILLION METRIC TON</b> |             |             |                 |
| Montana                   | 0.53        | 0.63        | 0.54            |
| North Dakota              | 0.78        | 1.16        | 1.09            |
| <b>U.S. Total</b>         | <b>1.57</b> | <b>2.12</b> | <b>2.01</b>     |

Source: USDA 2019 Small Grains Summary

### APPROXIMATE SHARE OF REGIONAL PRODUCTION



# U.S. DURUM WHEAT

MONTANA | NORTH DAKOTA

**SEMOLINA** and cooked spaghetti evaluations show lower values, compared to last year and the 5-yr average. Semolina color values are lower for both color and brightness, and the cooked pasta score is 7.8, compared to 8.3 in 2018 and 8.7 for the 5-yr average. Mixing properties are revealing a stronger crop with an average mixogram of 6.4, on a scale of 1 to 8, compared to 5.3 last year. Cooked pasta evaluations show higher cooked weight compared to the 5-yr average, but higher cooking loss and less cooked firmness.

**BUYERS** will need to be extra vigilant in 2019 in exploring the best value and quality of durum that meets their needs. The smaller than typical percent of the crop which meets all of the criteria for the traditional milling quality specifications will command sharp market premiums. Buyers may need to explore contract specification adjustments due to the adverse harvest impacts on the 2019 crop, but also recognize the impact that may have on final product quality. Ample carryover supplies from the excellent quality 2018 crop will be helpful in meeting traditional quality needs of buyers, but some parameters may still prove challenging.

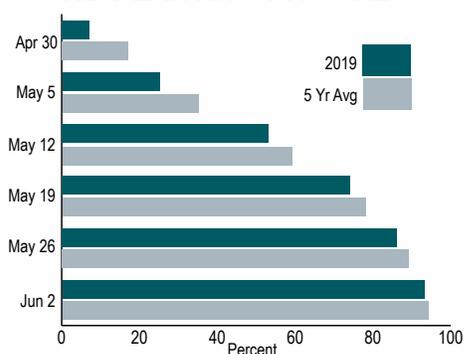
## SEASONAL CONDITIONS

**PLANTING** started in early May, slower than average, as cool soil conditions delayed planting at the beginning of the month. The pace picked up as conditions turned warmer and drier the second half of May, and most of the planting was finished by the first week of June, close to average.

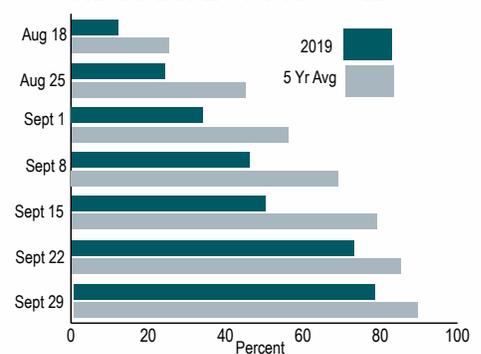
**EMERGENCE** was slower than normal due to the return of cooler temperatures. Initially, growing conditions were favorable for yield potential with adequate moisture, and crop condition ratings were high. However, lack of precipitation throughout June stressed crops in some areas. Crop development remained behind normal. The end of July brought humid, wetter conditions which brought about increased disease pressure and quality concerns.

**HARVEST** of the Northern durum crop proved more challenging than normal due to overly wet conditions. Harvest began in mid-August, well behind last year and the average pace. The first portion of the harvest came off under good weather conditions. However, the beginning of September brought rains that continued throughout the remainder of harvest, severely delaying progress and compromising quality. By mid-September, less than half of the crop had been harvested and adverse weather continued into October. In the second week of October, only 80 percent of the North Dakota crop and 64 percent of the Montana crop had been harvested. Many of those acres will likely not be harvested.

### ND PLANTING PROGRESS



### ND HARVEST PROGRESS



## WHEAT CHARACTERISTICS

### WHEAT GRADES

as defined by the Federal Grain Inspection Service (FGIS) of the USDA Grain Inspection, Packers and Stockyards Administration (GIPSA), reflect the general quality and condition of a representative sample. U.S. grades are based on test weight and include limits on damaged kernels, foreign material, shrunken and broken kernels, and wheat of contrasting classes. Each determination is made on the basis of the grain when free from dockage and shrunken and broken kernels.

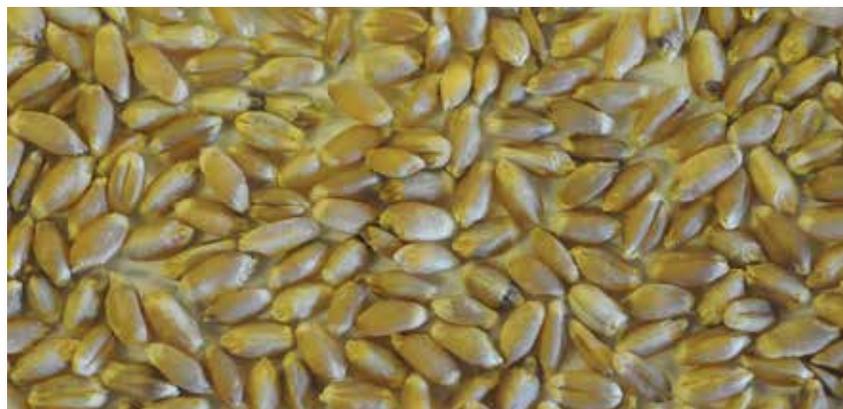
**SUBCLASS** is as separate marketing factor based on the weight percentage of kernels with a complete, hard and vitreous endosperm, the portion that makes semolina. For durum wheat, the subclasses are:

- Hard Amber Durum (HAD) – at least 75 percent more hard, vitreous kernels;
- Amber Durum (AD) –between 60 and 74 percent hard, vitreous kernels;
- Durum (D) –less than 60 percent hard, vitreous kernels.

| GRADING FACTORS                     | U.S. GRADES |      |      |      |      |
|-------------------------------------|-------------|------|------|------|------|
|                                     | 1           | 2    | 3    | 4    | 5    |
| <b>DURUM – MINIMUM TEST WEIGHTS</b> |             |      |      |      |      |
| Pounds per bushel                   | 60.0        | 58.0 | 56.0 | 54.1 | 51.0 |
| Kilograms per hectoliter            | 78.2        | 75.6 | 73.0 | 70.4 | 66.5 |
| <b>MAXIMUM PERCENT LIMITS OF:</b>   |             |      |      |      |      |
| Damaged kernels                     |             |      |      |      |      |
| Heat (part of total)                | 0.2         | 0.2  | 0.   | 1.0  | 3.0  |
| Total                               | 2.0         | 4.0  | 7.0  | 10.0 | 15.0 |
| Foreign material                    | 0.4         | 0.7  | 1.3  | 3.0  | 5.0  |
| Shrunken/broken kernels             | 3.0         | 5.0  | 8.0  | 12.0 | 20.0 |
| Total <sup>1</sup>                  | 3.0         | 5.0  | 8.0  | 12.0 | 20.0 |
| Wheat of other class <sup>2</sup>   |             |      |      |      |      |
| Contrasting classes                 | 1.0         | 2.0  | 3.0  | 10.0 | 10.0 |
| Total <sup>3</sup>                  | 3.0         | 5.0  | 10.0 | 10.0 | 10.0 |
| Stones                              | 0.1         | 0.1  | 0.1  | 0.1  | 0.1  |
| <b>MAXIMUM COUNT LIMITS OF:</b>     |             |      |      |      |      |
| Other material                      |             |      |      |      |      |
| Animal filth                        | 1           | 1    | 1    | 1    | 1    |
| Castor beans                        | 1           | 1    | 1    | 1    | 1    |
| Crotalaria seeds                    | 2           | 2    | 2    | 2    | 2    |
| Glass                               | 0           | 0    | 0    | 0    | 0    |
| Stones                              | 3           | 3    | 3    | 3    | 3    |
| Unknown foreign material            | 3           | 3    | 3    | 3    | 3    |
| Total <sup>4</sup>                  | 4           | 4    | 4    | 4    | 4    |
| Insect-damaged kernels              | 31          | 31   | 31   | 31   | 31   |

U.S. sample grade is wheat that:

- a. Does not meet the requirements for U.S. Nos. 1, 2, 3, 4 or 5; or
- b. Has a musty, sour or commercially objectionable foreign odor (except smut or garlic odor); or
- c. Is heating or of distinctly low quality.
  1. Includes damaged kernels (total, foreign material and shrunken and broken kernels).
  2. Unclassed wheat of any grade may contain not more than 10.0 percent of wheat of other classes.
  3. Includes contrasting classes.
  4. Includes any combination of animal filth, castor beans, crotalaria seeds, glass, stones or unknown foreign substance.



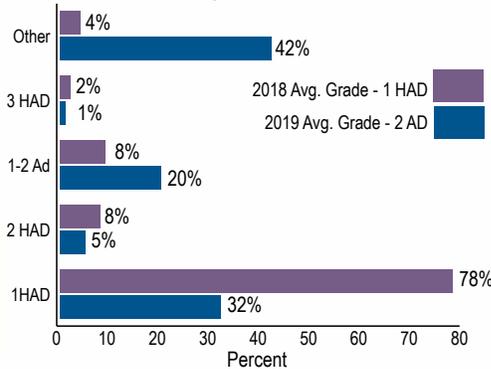
# U.S. DURUM WHEAT

MONTANA | NORTH DAKOTA

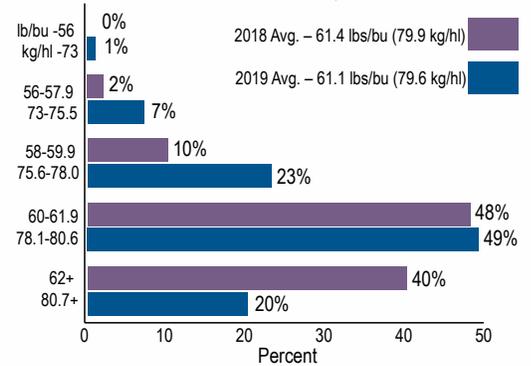
## WHEAT GRADING DATA

| STATE AND CROP REPORTING AREA | TEST WEIGHT LBS/BU | TEST WEIGHT KG/HL | DAMAGE % | SHRUNKEN/BROKEN KERNELS % | TOTAL DEFECTS % | CONTRASTING CLASSES % | U.S. GRADE | VITREOUS KERNELS % |
|-------------------------------|--------------------|-------------------|----------|---------------------------|-----------------|-----------------------|------------|--------------------|
| <b>MONTANA</b>                |                    |                   |          |                           |                 |                       |            |                    |
| Area A                        | 59.8               | 77.9              | 0.3      | 0.7                       | 1.0             | 0.0                   | 2 HAD      | 88                 |
| Area B                        | 61.3               | 79.8              | 0.8      | 0.7                       | 1.5             | 0.0                   | 1 AD       | 60                 |
| State Avg 2019                | 60.8               | 79.2              | 0.6      | 0.7                       | 1.3             | 0.0                   | 1 AD       | 70                 |
| State Avg 2018                | 61.1               | 79.5              | 0.2      | 0.8                       | 1.0             | 0.4                   | 1 HAD      | 95                 |
| <b>NORTH DAKOTA</b>           |                    |                   |          |                           |                 |                       |            |                    |
| Area A                        | 61.9               | 80.6              | 2.3      | 0.6                       | 2.9             | 0.0                   | 1 AD       | 64                 |
| Area B                        | 60.8               | 79.2              | 3.9      | 0.6                       | 4.5             | 0.0                   | 2 D        | 55                 |
| Area C                        | 62.4               | 81.3              | 0.9      | 0.4                       | 1.3             | 0.0                   | 1 AD       | 73                 |
| Area D                        | 60.3               | 78.5              | 7.0      | 0.8                       | 8.0             | 0.0                   | 3 D        | 45                 |
| State Avg 2019                | 61.4               | 80.0              | 3.4      | 0.6                       | 4.1             | 0.0                   | 2 D        | 59                 |
| State Avg 2018                | 61.5               | 80.1              | 0.3      | 0.7                       | 1.1             | 0.4                   | 1 HAD      | 88                 |
| <b>TWO-STATE AVERAGE</b>      |                    |                   |          |                           |                 |                       |            |                    |
| Avg 2019                      | 61.1               | 79.6              | 2.3      | 0.7                       | 3.0             | 0.0                   | 2 AD       | 64                 |
| Avg 2018                      | 61.4               | 79.9              | 0.3      | 0.7                       | 1.0             | 0.4                   | 1 HAD      | 90                 |
| Five-Year Avg                 | 60.5               | 78.8              | 0.4      | 1.0                       | 1.3             | 0.3                   | 1 HAD      | 87                 |

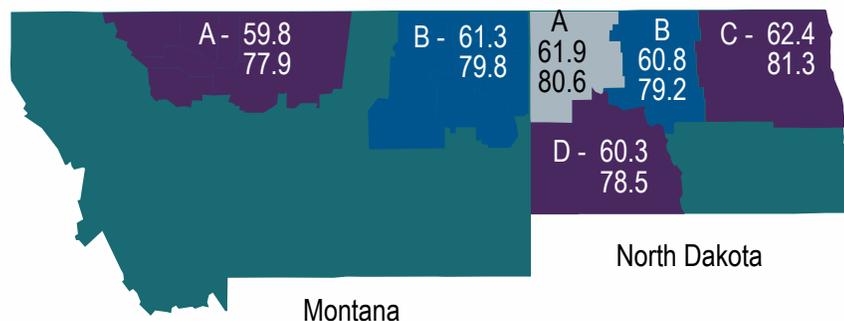
**GRADE – Regional Distribution**



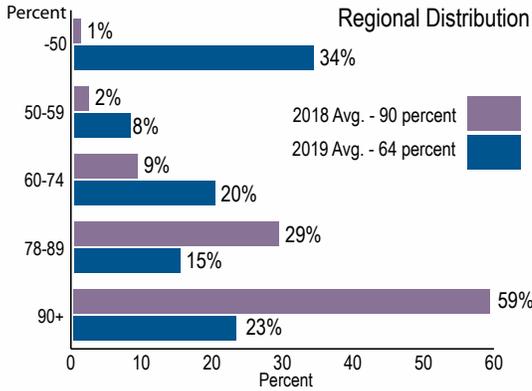
**TEST WEIGHT – Regional Distribution**



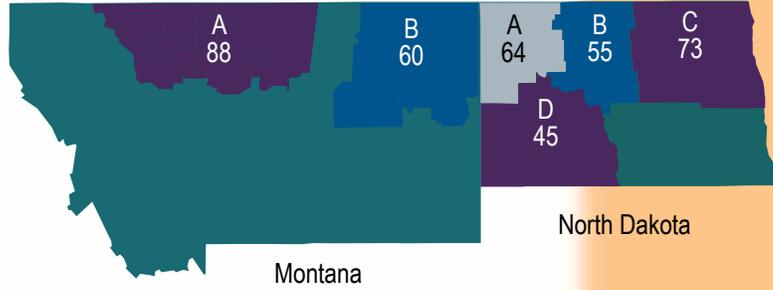
## AVERAGE TEST WEIGHT BY AREA



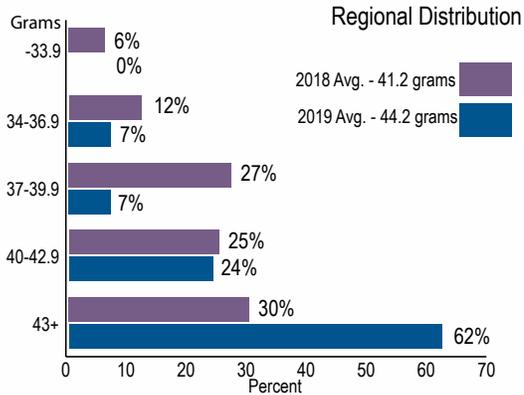
## VITREOUS KERNEL



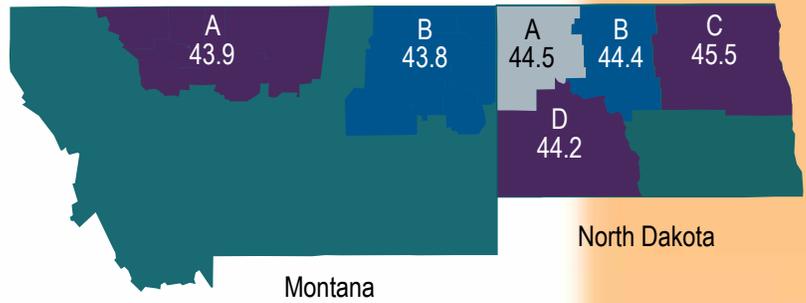
## AVERAGE VITREOUS KERNEL BY AREA (Percent)



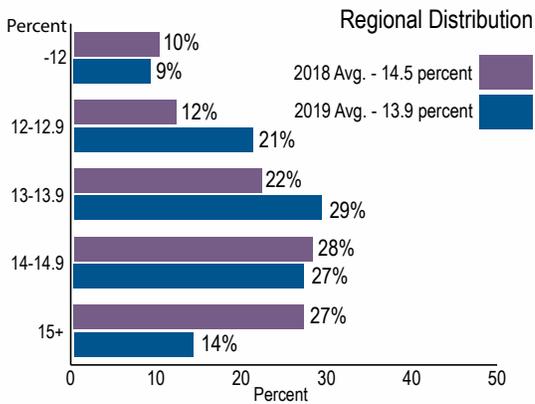
## 1000 KERNEL WEIGHT



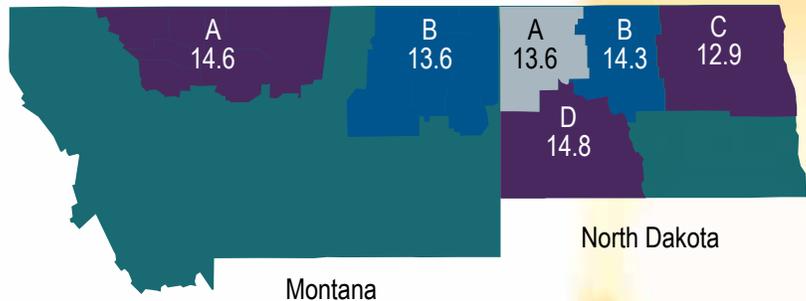
## AVERAGE 1000 KERNEL WEIGHT BY AREA (Grams)



## PROTEIN - 12% MOISTURE



## AVERAGE PROTEIN BY AREA 12% Moisture Basis - Percent



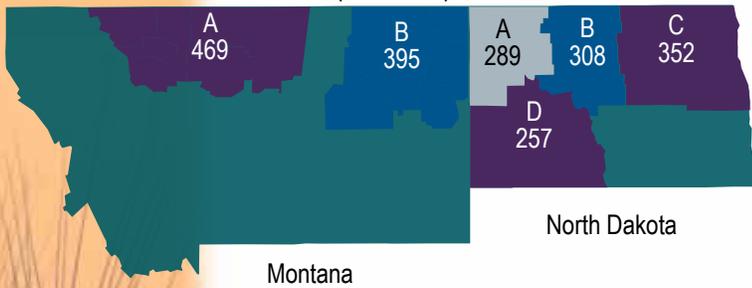
# U.S. DURUM WHEAT

MONTANA | NORTH DAKOTA

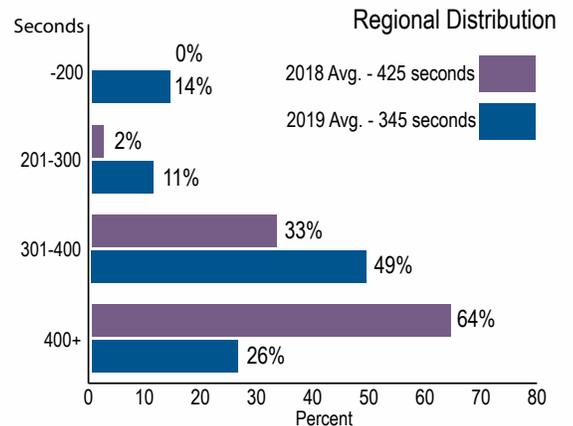
## OTHER KERNEL QUALITY DATA

| STATE AND CROP REPORTING AREA | DOCKAGE % | MOISTURE % | 1000 KERNEL WEIGHT G | KERNEL DIST. MED/LGE % | PROTEIN 12%/0% MOISTURE BASIS % | DON (PPM) | WHEAT ASH % | FALLING NUMBER (SEC) | MICRO SED (CC) |
|-------------------------------|-----------|------------|----------------------|------------------------|---------------------------------|-----------|-------------|----------------------|----------------|
| <b>MONTANA</b>                |           |            |                      |                        |                                 |           |             |                      |                |
| Area A                        | 2.0       | 11.3       | 43.9                 | 43/54                  | 14.6/16.6                       | 0.0       | 1.50        | 469                  | 74             |
| Area B                        | 1.1       | 11.7       | 43.8                 | 42/55                  | 13.6/15.5                       | 0.2       | 1.51        | 395                  | 58             |
| State Avg 2019                | 1.4       | 11.6       | 43.8                 | 42/55                  | 14.0/15.9                       | 0.1       | 1.50        | 421                  | 64             |
| State Avg 2018                | 0.5       | 10.3       | 40.1                 | 47/49                  | 15.3/17.4                       | <0.5      | 1.55        | 468                  | 62             |
| <b>NORTH DAKOTA</b>           |           |            |                      |                        |                                 |           |             |                      |                |
| Area A                        | 1.3       | 12.6       | 44.5                 | 34/64                  | 13.6/15.4                       | 0.3       | 1.50        | 289                  | 57             |
| Area B                        | 1.1       | 12.7       | 44.4                 | 37/61                  | 14.3/16.3                       | 1.3       | 1.49        | 308                  | 63             |
| Area C                        | 0.8       | 12.4       | 45.5                 | 30/69                  | 12.9/14.7                       | 1.3       | 1.43        | 352                  | 62             |
| Area D                        | 1.3       | 12.4       | 44.2                 | 39/58                  | 14.8/16.8                       | 2.4       | 1.59        | 257                  | 61             |
| State Avg 2019                | 1.2       | 12.6       | 44.5                 | 35/63                  | 13.9/15.8                       | 1.0       | 1.51        | 293                  | 60             |
| State Avg 2018                | 0.8       | 11.8       | 41.8                 | 41/57                  | 14.0/15.9                       | <0.5      | 1.54        | 401                  | 61             |
| <b>TWO-STATE AVERAGE</b>      |           |            |                      |                        |                                 |           |             |                      |                |
| State Avg 2019                | 1.3       | 12.2       | 44.2                 | 38/59                  | 13.9/15.8                       | 0.6       | 1.51        | 345                  | 61             |
| State Avg 2018                | 0.7       | 11.2       | 41.2                 | 43/54                  | 14.5/16.4                       | 0.2       | 1.54        | 425                  | 61             |
| Five-State Avg                | 0.7       | 11.5       | 39.2                 | 48/49                  | 13.9/15.8                       | 0.8       | 1.57        | 384                  | 65             |

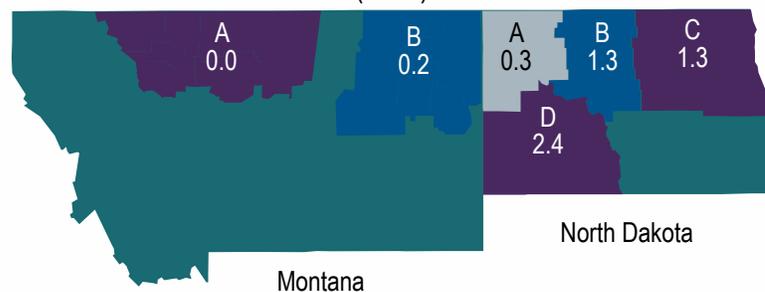
### AVERAGE FALLING NUMBER BY AREA (Seconds)



### FALLING NUMBER



### AVERAGE DON BY AREA (PPM)



## MILLING CHARACTERISTICS

**TOTAL EXTRACTION** represents the portion of the kernel that can be milled into flour and semolina.

**SEMOLINA** extraction is the portion milled into semolina only.

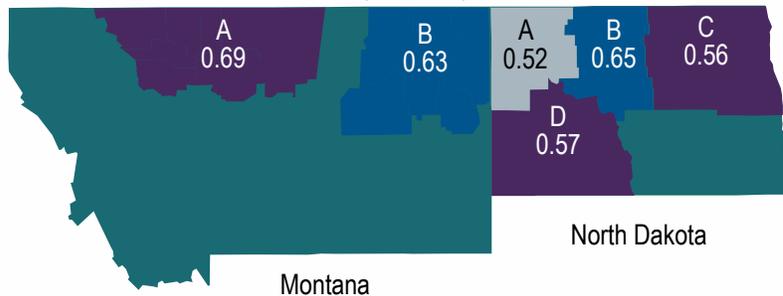
**ASH CONTENT** in the endosperm of durum is inherently higher than in the endosperm of other hard wheats, but can still be used as a relative measure of bran or mineral content in the flour and semolina.

**SPECKS** appear in semolina when small particles of bran or other material escape the cleaning and purifying process. Millers can control speck count by selecting durum that is free of disease and foreign material, thoroughly cleaning the durum, properly tempering and conditioning the wheat before milling, and by using purifiers to remove small bran particles from the semolina.

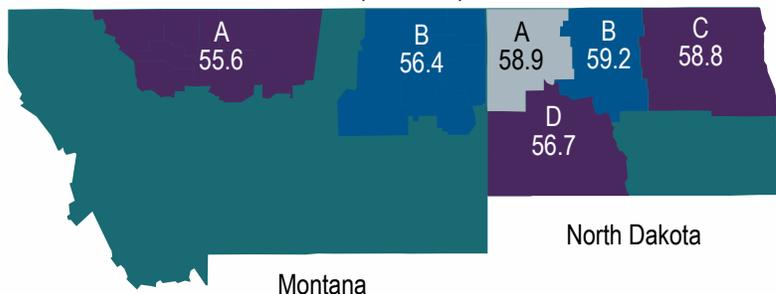
**PROTEIN CONTENT** in semolina has a high correlation with gluten content and, in turn, mechanical strength and cooking quality. Wet gluten is a quantitative measure of the gluten forming proteins in semolina that are primarily responsible for its mechanical strength and pasta quality.

**MIXOGRAM** curves reveal important information about the dough quality of semolina and ultimately about the potential cooked firmness of pasta. Mixograms are rated on a scale of 1 to 8, with the higher values indicating stronger mixing characteristics.

### AVERAGE ASH CONTENT BY AREA (Percent)



### AVERAGE SEMOLINA EXTRACTION BY AREA (Percent)



# U.S. DURUM WHEAT

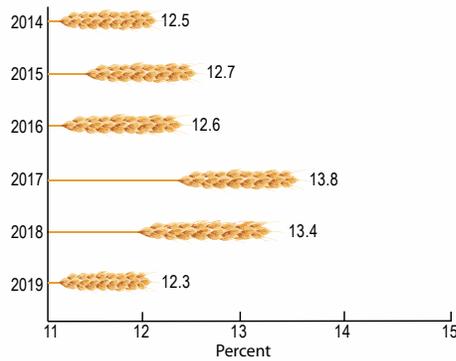
MONTANA | NORTH DAKOTA

## SEMOLINA QUALITY DATA

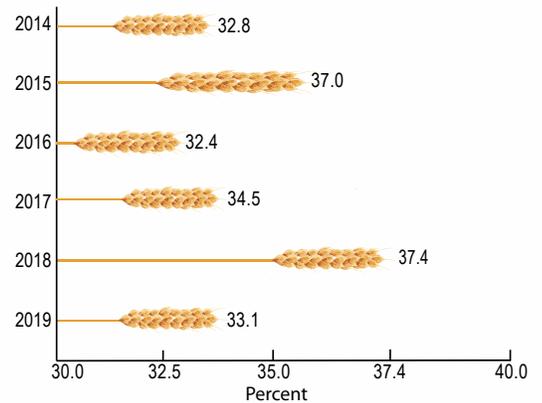
1. The 2019 samples were milled on a Quad Junior Mill, awaiting the installation of a new Buhler Lab Mill. As a result, no total extraction data is available, and year-to-year comparison for semolina extraction and ash values is limited.

| STATE AND CROP REPORTING AREA | TOTAL EXTRACTION <sup>1</sup><br>% | SEMOLINA EXTRACTION <sup>1</sup><br>% | ASH <sup>1</sup><br>% | SPECKS NO/10 SQ IN <sup>1</sup><br>% | PROTEIN (14% MOISTURE)<br>% | WET GLUTEN<br>% | GLUTEN INDEX<br>% | MIXOGRAM CLASSIFICATION SCALE 1-8 |
|-------------------------------|------------------------------------|---------------------------------------|-----------------------|--------------------------------------|-----------------------------|-----------------|-------------------|-----------------------------------|
| <b>MONTANA</b>                |                                    |                                       |                       |                                      |                             |                 |                   |                                   |
| Area A                        | n/a                                | 55.6                                  | 0.69                  | 20                                   | 12.9                        | 32.8            | 95                | 8.0                               |
| Area B                        | n/a                                | 56.4                                  | 0.63                  | 27                                   | 12.0                        | 32.5            | 65                | 6.5                               |
| State Avg 2019                | n/a                                | 56.1                                  | 0.65                  | 25                                   | 12.3                        | 32.6            | 76                | 7.0                               |
| State Avg 2018                | 73.5                               | 69.0                                  | 0.75                  | 28                                   | 14.3                        | 40.3            | 63                | 5.5                               |
| <b>NORTH DAKOTA</b>           |                                    |                                       |                       |                                      |                             |                 |                   |                                   |
| Area A                        | n/a                                | 58.9                                  | 0.52                  | 35                                   | 11.9                        | 32.9            | 59                | 6.0                               |
| Area B                        | n/a                                | 59.2                                  | 0.65                  | 32                                   | 12.7                        | 34.0            | 74                | 6.5                               |
| Area C                        | n/a                                | 58.8                                  | 0.56                  | 35                                   | 11.3                        | 30.8            | 65                | 6.0                               |
| Area D                        | n/a                                | 56.7                                  | 0.57                  | 42                                   | 13.0                        | 36.0            | 54                | 5.0                               |
| State Avg 2019                | n/a                                | 58.5                                  | 0.56                  | 36                                   | 12.2                        | 33.5            | 61                | 5.9                               |
| State Avg 2018                | 74.2                               | 69.4                                  | 0.72                  | 29                                   | 12.9                        | 35.9            | 54                | 5.2                               |
| <b>TWO-STATE AVERAGE</b>      |                                    |                                       |                       |                                      |                             |                 |                   |                                   |
| State Avg 2019                | n/a                                | 57.5                                  | 0.60                  | 31                                   | 12.3                        | 33.1            | 67                | 6.4                               |
| State Avg 2018                | 74.0                               | 69.3                                  | 0.73                  | 29                                   | 13.4                        | 37.4            | 57                | 5.3                               |
| Five-Year Avg                 | 72.2                               | 67.1                                  | 0.70                  | 27                                   | 13.0                        | 34.3            | 60                | 5.3                               |

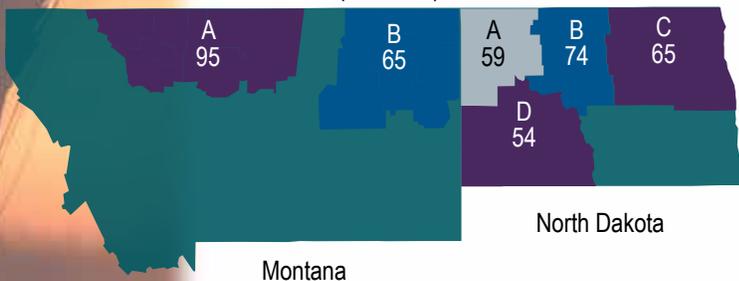
**SEMOLINA PROTEIN – Regional Average**



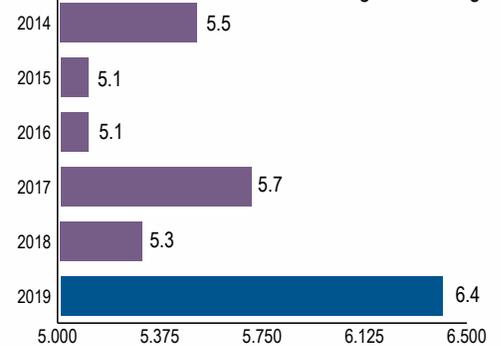
**WET GLUTEN – Regional Average**



**AVERAGE GLUTEN INDEX BY AREA (Percent)**



**MIXOGRAM CLASSIFICATION (Scale of 1-8) Regional Average**



## SEMOLINA & SPAGHETTI DATA

| STATE AND CROP REPORTING AREA | SEMOLINA COLOR L (BLACK-WHITE) | SEMOLINA COLOR A (GREEN-RED) | SEMOLINA COLOR B (BLUE-YELLOW) | SPAGHETTI COLOR SCORE (1-12) | SPAGHETTI COOKED WEIGHT G | SPAGHETTI COOKING LOSS % | SPAGHETTI COOKED FIRMNESS G CM |
|-------------------------------|--------------------------------|------------------------------|--------------------------------|------------------------------|---------------------------|--------------------------|--------------------------------|
| <b>MONTANA</b>                |                                |                              |                                |                              |                           |                          |                                |
| Area A                        | 82.9                           | -2.3                         | 31.0                           | 8.5                          | 31.7                      | 6.7                      | 4.5                            |
| Area B                        | 83.1                           | -2.4                         | 29.7                           | 8.0                          | 32.0                      | 6.7                      | 3.9                            |
| State Avg 2019                | 83.0                           | -2.4                         | 30.2                           | 8.2                          | 31.9                      | 6.7                      | 4.1                            |
| State Avg 2018                | 83.7                           | -2.5                         | 29.8                           | 8.5                          | 30.3                      | 5.9                      | 4.8                            |
| <b>NORTH DAKOTA</b>           |                                |                              |                                |                              |                           |                          |                                |
| Area A                        | 83.2                           | -2.6                         | 29.0                           | 7.5                          | 32.3                      | 7.2                      | 3.7                            |
| Area B                        | 82.7                           | -2.4                         | 28.3                           | 7.5                          | 32.5                      | 7.2                      | 3.5                            |
| Area C                        | 83.2                           | -2.6                         | 28.6                           | 7.5                          | 32.6                      | 7.4                      | 3.6                            |
| Area D                        | 81.5                           | -2.1                         | 28.6                           | 7.5                          | 32.9                      | 8.0                      | 3.9                            |
| State Avg 2019                | 82.8                           | -2.4                         | 28.7                           | 7.5                          | 32.5                      | 7.4                      | 3.7                            |
| State Avg 2018                | 83.5                           | -2.5                         | 29.9                           | 8.2                          | 30.7                      | 5.5                      | 4.4                            |
| <b>TWO-STATE AVERAGE</b>      |                                |                              |                                |                              |                           |                          |                                |
| State Avg 2019                | 82.9                           | -2.4                         | 29.3                           | 7.8                          | 32.2                      | 7.1                      | 3.8                            |
| State Avg 2018                | 83.6                           | -2.5                         | 29.9                           | 8.3                          | 30.5                      | 5.7                      | 4.5                            |
| Five-Year Avg                 | 84.0                           | -2.9                         | 29.5                           | 8.7                          | 31.1                      | 6.1                      | 4.4                            |

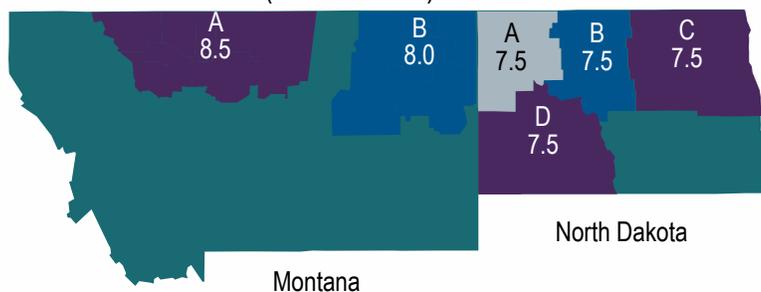
## PASTA CHARACTERISTICS

**DRY PASTA PROCESSORS** want a finished product that is visually appealing, elastic and strong enough to resist breakage during cutting, packaging, handling and shipping, able to withstand the rigors of cooking, and satisfying to the consumer palate.

Yellow color in semolina and pasta is a traditional, rather than functional, mark of quality. In the early days of the pasta industry, before sophisticated testing evolved, consumers assumed that a yellow pasta was made from durum wheat, which is known to make pasta with superior cooking quality compared to that made from other hard wheats.

Most consumers prefer pasta that is “al dente,” meaning it has some firmness to the bite. Good quality pasta that is cooked according to package directions should not be sticky or mushy when eaten.

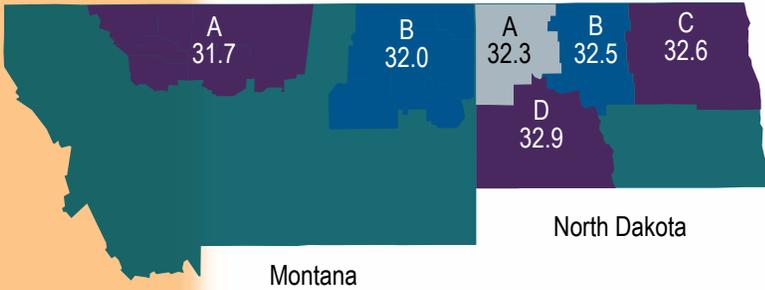
**AVERAGE COLOR SCORE BY AREA**  
(Scale of 1-12)



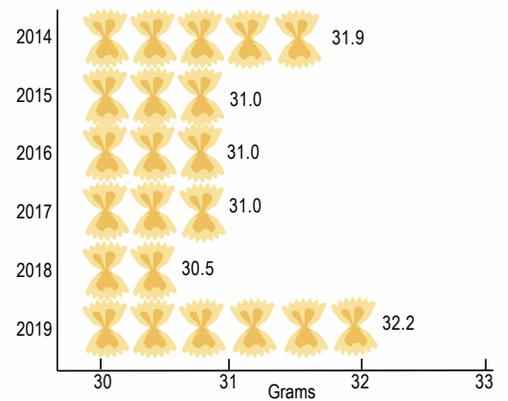
# U.S. DURUM WHEAT

MONTANA | NORTH DAKOTA

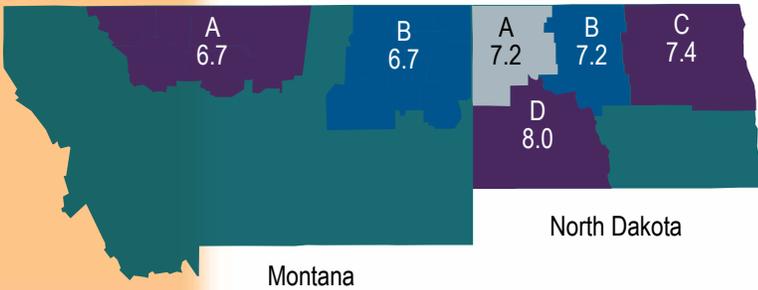
### AVERAGE COOKED WEIGHT BY AREA (Grams)



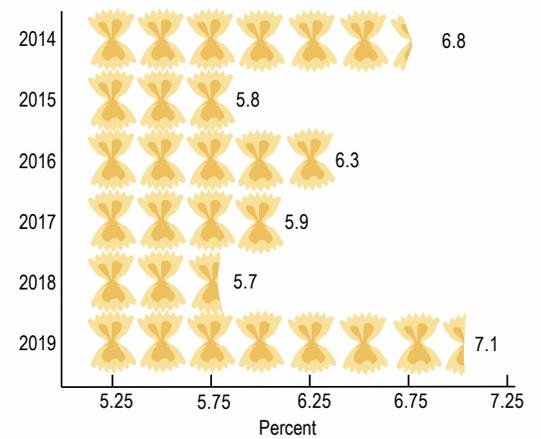
### COOKED WEIGHT – Regional Average



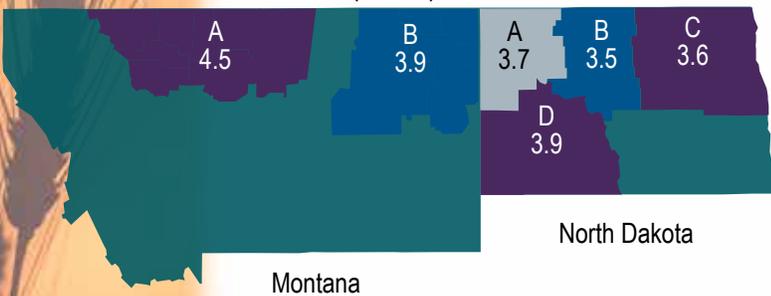
### AVERAGE COOKING LOSS BY AREA (Percent)



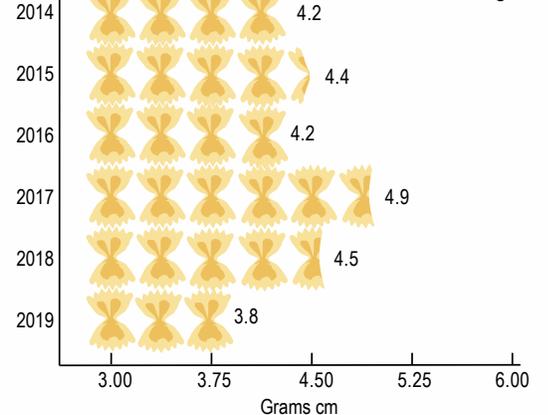
### COOKING LOSS – Regional Average



### AVERAGE COOKED FIRMNESS BY AREA (G CM)



### COOKED FIRMNESS – Regional Average



## RECENT QUALITY TRENDS

|                                  | 2019 | 2018  | 2017  | 2016  | 2015  | 2014 | FIVE-YEAR<br>AVERAGE |
|----------------------------------|------|-------|-------|-------|-------|------|----------------------|
| <b>GRADING AND WHEAT DATA</b>    |      |       |       |       |       |      |                      |
| Test Weight (lbs/bu)             | 61.1 | 61.4  | 60.9  | 61.2  | 60.6  | 59.0 | 60.5                 |
| Test Weight (kg/hl)              | 79.6 | 79.9  | 79.4  | 79.7  | 78.9  | 76.8 | 78.8                 |
| Total Defects (%)                | 3.0  | 1.0   | 1.2   | 1.2   | 1.3   | 1.6  | 1.0                  |
| Vitreous Kernels (%)             | 64   | 90    | 88    | 90    | 91    | 74   | 87                   |
| Grades                           | 2 AD | 1 HAD | 1 HAD | 1 HAD | 1 HAD | 2 AD | 1 HAD                |
| <b>OTHER WHEAT DATA</b>          |      |       |       |       |       |      |                      |
| Dockage (%)                      | 1.3  | 0.7   | 1.1   | 0.2   | 0.9   | 0.7  | 0.7                  |
| Protein: 12% moisture            | 13.9 | 14.5  | 14.5  | 13.4  | 13.9  | 13.2 | 13.9                 |
| 1000 Kernel Weight (gm)          | 44.2 | 41.2  | 38.4  | 40.0  | 38.5  | 38.0 | 39.2                 |
| Moisture (%)                     | 12.2 | 11.2  | 11.3  | 11.4  | 11.2  | 12.4 | 11.5                 |
| DON                              | 0.6  | 0.2   | <0.5  | 1.0   | 0.8   | 2.1  | 0.8                  |
| Ash (%)                          | 1.51 | 1.54  | 1.46  | 1.61  | 1.57  | 1.64 | 1.57                 |
| Falling Number (sec)             | 345  | 425   | 380   | 423   | 414   | 276  | 384                  |
| Sedimentation (cc)               | 61   | 61    | 87    | 54    | 62    | 60   | 65                   |
| <b>SEMOLINA DATA</b>             |      |       |       |       |       |      |                      |
| Total Extraction (%)             | n/a  | 74.0  | 72.2  | 73.6  | 70.6  | 70.4 | 72.2                 |
| Semolina Extraction (%)          | 57.5 | 69.3  | 68.5  | 67.9  | 65.1  | 64.5 | 67.1                 |
| Ash (%)                          | 0.60 | 0.73  | 0.69  | 0.71  | 0.64  | 0.74 | 0.70                 |
| Wet Gluten (%)                   | 33.1 | 37.4  | 34.5  | 32.4  | 37.0  | 32.8 | 34.3                 |
| Specks (no/10 sq in)             | 31   | 29    | 26    | 30    | 24    | 26   | 27                   |
| Protein (%)                      | 12.3 | 13.4  | 13.8  | 12.6  | 12.7  | 12.5 | 13.0                 |
| Gluten Index (%)                 | 67   | 57    | 86    | 61    | 50    | 45   | 60                   |
| Mixograph Classification         | 6.4  | 5.3   | 5.7   | 5.1   | 5.1   | 5.5  | 5.3                  |
| *Color: L (black-white)          | 82.9 | 83.6  | 83.3  | 84.3  | 84.4  | 84.9 | 84.0                 |
| *a (green-red)                   | -2.4 | -2.5  | -2.3  | -2.8  | -3.1  | -4.0 | -2.9                 |
| *b (blue-yellow)                 | 29.3 | 29.9  | 29.4  | 30.3  | 30.1  | 27.9 | 29.5                 |
| <b>SPAGHETTI PROCESSING DATA</b> |      |       |       |       |       |      |                      |
| Color Score (scale of 1-12)      | 7.8  | 8.3   | 9.0   | 8.5   | 8.9   | 8.8  | 8.7                  |
| *L (black-white)                 | 51.8 | 52.8  | 54.4  | 53.5  | 54.5  | 53.5 | 53.7                 |
| *b (blue-yellow)                 | 24.2 | 25.6  | 27.1  | 26.4  | 27.3  | 26.6 | 26.6                 |
| Cooked Weight (gm)               | 32.2 | 30.5  | 31.0  | 31.0  | 31.0  | 31.9 | 31.1                 |
| Cooking Loss (%)                 | 7.1  | 5.7   | 5.9   | 6.3   | 5.8   | 6.8  | 6.1                  |
| Cooked Firmness (g cm)           | 3.8  | 4.5   | 4.9   | 4.2   | 4.4   | 4.2  | 4.4                  |

\* Semolina color performed on CIE color scale. Granulation size is approximately 40 percent above 425 microns and 12 percent below 180 microns. Spaghetti color is performed on Hunter color scale.

# U.S. DURUM WHEAT

MONTANA | NORTH DAKOTA

## HANDLING & TRANSPORTATION

The durum wheat growing region in the Northern Plains has a vast network of country elevators to facilitate efficient and precise movement to domestic and export markets. On average, nearly 80 percent of the region's wheat moves to markets by rail.

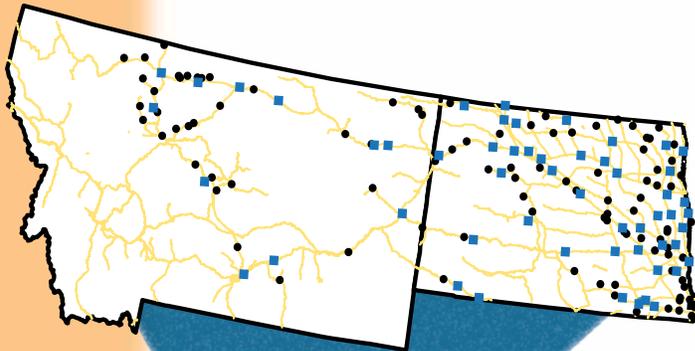
Duluth is the only export market easily serviced by trucks. Shipments to the Pacific Northwest and Gulf export markets are almost entirely by rail, with some barge movement to the Gulf. The dominant railroad is the Burlington Northern Santa Fe, followed by the Canadian Pacific.

A growing number of elevators in the region are investing to ship 100-110 car units in "shuttle" trains. Each rail car holds approximately 3,500 bushels

(95 metric tons) of wheat. Shuttle-equipped facilities receive the lowest rates, sharing volume and transaction efficiencies with the railroad.

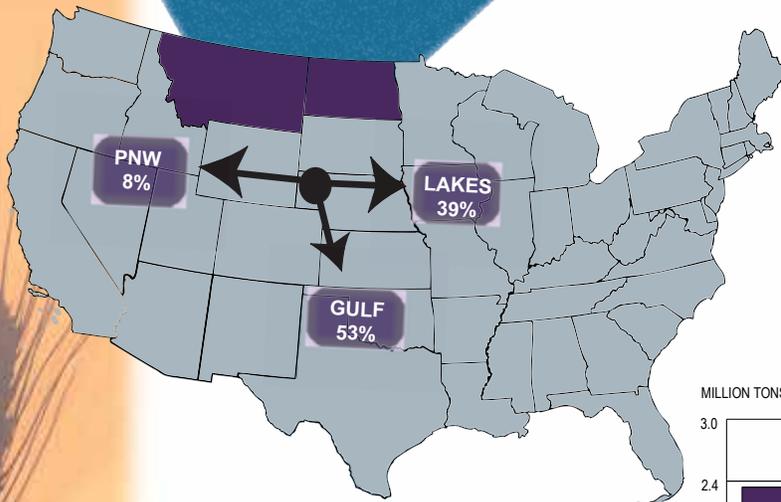
The diverse rail shipping capacities and widespread network of elevators are strengths buyers can capitalize on, especially as their demand heightens for more precise quality specifications and consistency between shipments. Buyers are encouraged to explore origin-specific shipments to optimize quality and value.

The rail and elevator network in the U.S. northern grown durum region is well suited for meeting the increasing quality demands of both domestic and international customers.



- Track for 50 to 99 rail cars
- Track for 100 or more cars

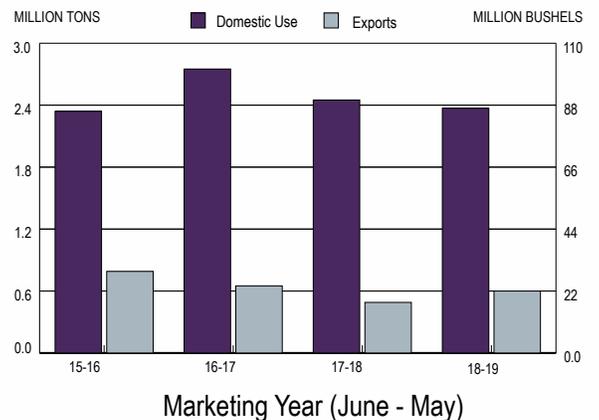
Source: Upper Great Plains Transportation Institute



AVERAGE SHARE OF U.S. DURUM EXPORTS BY PORT (2015-2018)

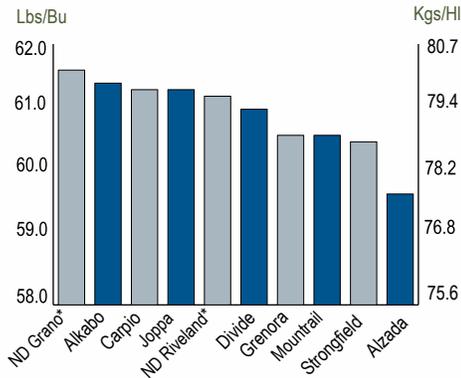
### Grain Handling and Transportation Facilities in the Two-State Region

### 2015-18 U.S. DURUM DOMESTIC USE AND EXPORTS

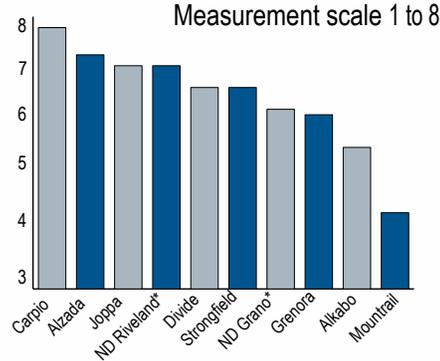


## VARIETAL INFORMATION

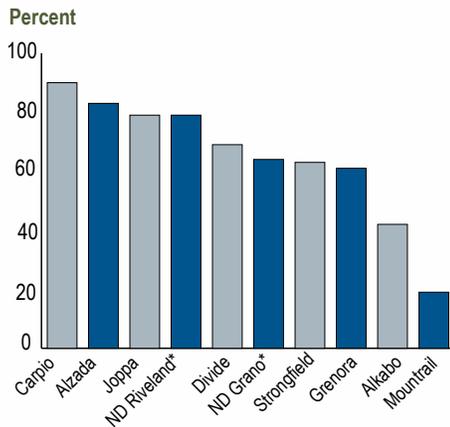
### TEST WEIGHT



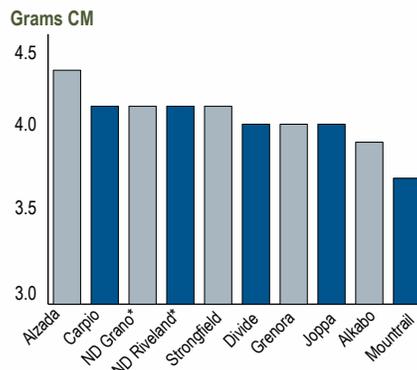
### MIXOGRAPH



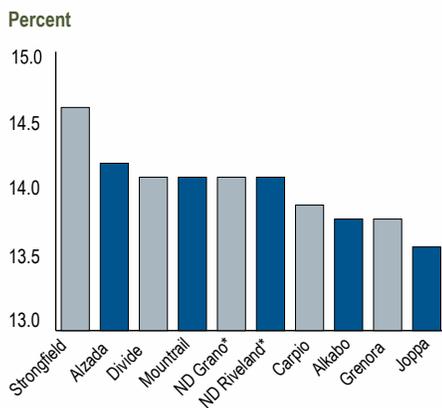
### GLUTEN INDEX



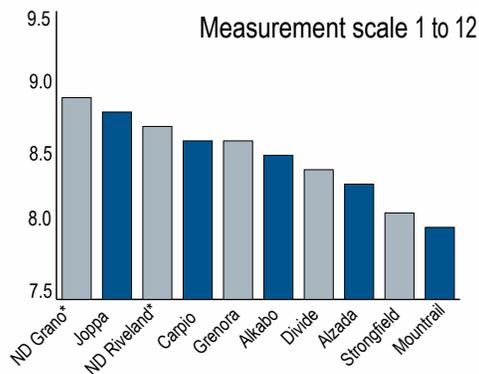
### COOKED FIRMNESS



### KERNEL PROTEIN



### PASTA COLOR



**THESE TABLES** illustrate the quality evaluation of some of the most popular varieties (cultivars), for key kernel and end-use parameters during the 2014-2018 growing seasons. A commitment to extensive end-use quality testing of new cultivars during the development stages is a major priority for producers in the region. The goal is to develop and release cultivars that excel in numerous kernel, milling and end-product parameters, across a broad environment.

\* Low Cadmium Varieties



# U.S. DURUM WHEAT

MONTANA | NORTH DAKOTA

## MAJOR VARIETIES PRODUCED IN REGION • AGRONOMIC FACTORS

| VARIETY      | AGRONOMIC DESCRIPTION        |               |                      |                     |                                   | AVERAGE YIELD <sup>3</sup> |                |
|--------------|------------------------------|---------------|----------------------|---------------------|-----------------------------------|----------------------------|----------------|
|              | AGENT or ORIGIN <sup>1</sup> | YEAR RELEASED | STRAW STRENGTH (1-9) | PLANT HEIGHT INCHES | FOLIAR DISEASE <sup>2</sup> (1-9) | BU/PER ACRE                | MT/PER HECTARE |
| Alkabo       | ND                           | 2005          | 2                    | 33                  | 5                                 | 58.9                       | 3.96           |
| Alzada       | WB                           | 2004          | 6                    | 28                  | 8                                 | 47.3                       | 3.18           |
| Carpio       | ND                           | 2012          | 5                    | 34                  | 5                                 | 59.5                       | 4.00           |
| Divide       | ND                           | 2005          | 5                    | 34                  | 5                                 | 59.4                       | 3.99           |
| Grenora      | ND                           | 2005          | 5                    | 31                  | 5                                 | 58.1                       | 3.91           |
| Joppa        | ND                           | 2013          | 5                    | 34                  | 5                                 | 61.5                       | 4.13           |
| Mountrail    | ND                           | 1998          | 5                    | 33                  | 5                                 | 60.5                       | 4.07           |
| ND Grano*    | ND                           | 2017          | 5                    | 33                  | n/a                               | 61.4                       | 4.13           |
| ND Riveland* | ND                           | 2017          | 4                    | 35                  | n/a                               | 61.7                       | 4.15           |
| Strongfield  | CAN                          | 2004          | 6                    | 33                  | 6                                 | 54.3                       | 3.65           |

## GROWN AND TESTED ACROSS NORTH DAKOTA • QUALITY & END-USE FACTORS

| VARIETY      | QUALITY FACTORS <sup>4</sup> |                   |                 |                         |                            |                          |                |                      |   |  |
|--------------|------------------------------|-------------------|-----------------|-------------------------|----------------------------|--------------------------|----------------|----------------------|---|--|
|              | TEST WEIGHT LB/BU            | TEST WEIGHT KG/HL | WHEAT PROTEIN % | WHEAT FALLING # SECONDS | MIXOGRAM SCORE (SCALE 1-8) | PASTA COLOR (SCALE 1-12) | GLUTEN INDEX % | COOKED FIRMNESS G CM | OVERALL PASTA QUALITY RATING <sup>5</sup> |  |
| Alkabo       | 61.4                         | 80.0              | 13.8            | 414                     | 5.6                        | 8.5                      | 42             | 3.9                  | good                                      |  |
| Alzada       | 59.7                         | 77.8              | 14.2            | 486                     | 7.3                        | 8.3                      | 83             | 4.3                  | excellent                                 |  |
| Carpio       | 61.3                         | 79.8              | 13.9            | 458                     | 7.8                        | 8.6                      | 90             | 4.1                  | excellent                                 |  |
| Divide       | 61.0                         | 79.4              | 14.1            | 454                     | 6.7                        | 8.4                      | 69             | 4.0                  | good                                      |  |
| Grenora      | 60.6                         | 79.0              | 13.8            | 395                     | 6.2                        | 8.6                      | 61             | 4.0                  | good                                      |  |
| Joppa        | 61.3                         | 79.9              | 13.6            | 437                     | 7.1                        | 8.8                      | 79             | 4.0                  | good                                      |  |
| Mountrail    | 60.6                         | 78.9              | 14.1            | 443                     | 4.4                        | 8.0                      | 19             | 3.7                  | average                                   |  |
| ND Grano*    | 61.6                         | 80.3              | 14.1            | 479                     | 6.3                        | 8.9                      | 64             | 4.1                  | good                                      |  |
| ND Riveland* | 61.2                         | 79.7              | 14.1            | 455                     | 7.1                        | 8.7                      | 79             | 4.1                  | excellent                                 |  |
| Strongfield  | 60.5                         | 78.8              | 14.6            | 444                     | 6.7                        | 8.1                      | 63             | 4.1                  | good                                      |  |

\* Low Cadmium

Source: 2019 North Dakota Durum Wheat Variety Performance Descriptions

1. ND – North Dakota State University, CAN – Canada and WB – Westbred.
2. Foliar Disease includes tan spot and septoria: 1 to 9 scale, with 1 = resistant and 9 very susceptible.
3. Yield trials 2014-18 crop years grown at Carrington, Dickinson, Langdon, Minot and Williston, North Dakota.
4. Based on NDSU Durum Quality Lab testing of 2014-18 samples grown at Carrington, Dickinson, Langdon, Minot and Williston, North Dakota.
5. Based on kernel attributes, milling and semolina processing, pasta color and spaghetti cooking performance. Ratings can be excellent, good, average, fair and poor.

## NORTH DAKOTA AND MONTANA

**THE TOP** four durum varieties grown in North Dakota in 2019 are Joppa, Divide, Mountrail and Divide, accounting for nearly two-thirds of the acres. These four have been the top four since 2017. In Montana, the top four varieties in 2019 are Alzada, Joppa, Mountrail and Divide, accounting for nearly eighty percent of the acres.

**JOPPA** has been the leading variety in North Dakota for three straight years, accounting for 30 percent of the acres in 2019. In Montana, it ranks second with 20 percent of the acres. Released from NDSU in 2013, Joppa is popular with producers for its high-end yield potential and positive agronomic characteristics. It is noted for very good end-use quality traits with especially high pasta color scores.

**DIVIDE** remains in second place in North Dakota with a 21 percent share, and is fourth in Montana with nearly 17 percent of the acres. It was the leading variety in North Dakota from 2009-2016. Divide was released in 2005 from NDSU, and remains popular with producers for its high yield potential and higher ratings for disease tolerance. It is rated good for end-use quality.

**ALKABO** holds third position in North Dakota with 8 percent of the acres but is down from its peak of 21 percent in 2015. A 2005 release from NDSU, it remains popular for its stronger straw properties. Alkabo possesses good end-use quality traits, especially for color.

**CARPIO** accounts for 6 percent of the acreage in North Dakota, down from 12 percent in 2018. Carpio was released from NDSU in 2012, and is rated excellent for end-use quality with strong gluten properties, and high scores for color and cooked firmness.

| MONTANA VARIETY SHARE OF PLANTED ACRES <sup>3</sup> |                    |                    |
|---|--------------------|--------------------|
| VARIETY   | 2019% <sup>1</sup> | 2018% <sup>1</sup> |
| Alzada  | 22.8               | 20.2               |
| Joppa   | 20.5               | 37.6               |
| Mountrail   | 19.4               | 5.3                |
| Divide  | 16.7               | 11.8               |
| Tioga   | 4.8                | 13.5               |
| Carpio  | 1.0                | 2.7                |
| Kyle  | 0.8                | 1.1                |
| Other <sup>2</sup>                                  | 13.9               | 8.0                |

1. Percentage may not add to 100 due to rounding.  
 2. Includes varieties with less than 1% of acreage in 2019 and unknown varieties.  
 3. 1,000 acres (1 acre = 0.405 hectares)  
 2019 – 550,000 acres  
 2018 – 840,000 acres

**ALZADA** is the leading variety in Montana with nearly 23 percent of the acres in 2019. It is the dominant variety produced in the North Central region where it is primarily grown under contracted production. Alzada is a 2004 release from Westbred. It has good yield and agronomic traits with uniquely strong gluten properties and excellent cooking quality, but has very low disease resistance.

**MOUNTRAIL** is the third most popular variety in Montana with a 19 percent acreage share, rebounding from 2018 levels of just 5 percent. Mountrail was released in 1998 from NDSU, and remains popular with producers for its stability in agronomic traits and high-end yield potential. It is rated as average for end-use quality traits.

| NORTH DAKOTA VARIETY SHARE OF 2019 PLANTED ACRES BY CROP DISTRICT |            |              |            |                                 |                  |
|---|------------|--------------|------------|---------------------------------|------------------|
| VARIETY   | NORTH WEST | WEST CENTRAL | SOUTH WEST | COMBINED DISTRICTS <sup>1</sup> | TOTAL STATE      |
| PERCENTAGE (%) <sup>2</sup>                                       |            |              |            |                                 |                  |
| Joppa   | 14.8       | 34.8         | 51.0       | 46.9                            | 30.2             |
| Divide  | 19.9       | 32.3         | 3.5        | 28.7                            | 21.2             |
| Alkabo  | 11.6       | 0.0          | 14.7       | 0.0                             | 7.8              |
| Carpio  | 6.8        | 6.8          | 10.4       | 1.7                             | 6.1              |
| VT Peak   | 6.9        | 0.0          | 12.5       | 3.3                             | 6.0              |
| Mountrail   | 11.0       | 0.0          | 0.0        | 0.0                             | 5.4              |
| ND Riveland   | 3.9        | 2.3          | 0.8        | 0.2                             | 2.4              |
| ND Grano  | 3.3        | 0.0          | 0.0        | 0.0                             | 1.6              |
| Pierce  | 1.3        | 0.0          | 4.9        | 0.2                             | 1.4              |
| Tioga   | 1.8        | 4.4          | 0.0        | 0.0                             | 1.4              |
| Other <sup>3</sup>  | 18.7       | 19.4         | 2.4        | 18.9                            | 16.5             |
| 1,000 ACRES (1 ACRE = 0.4 HECTARES)                               |            |              |            |                                 |                  |
| Total Acres <sup>3</sup>  | 343.0      | 87.0         | 101.0      | 169.0                           | 700 <sup>4</sup> |

1. Data from North Central, Northeast, Central, East Central, South Central and Southeast districts are combined to avoid disclosure of individual operations.  
 2. Percentages may not add to 100 due to rounding.  
 3. Includes varieties with less than 1% acreage in 2019 and unknown varieties.  
 4. September 30, 2019 small grain estimate was 720,000 acres.

| NORTH DAKOTA VARIETY SHARE OF PLANTED ACRES <sup>3</sup> |                    |                    |
|--|--------------------|--------------------|
| VARIETY  | 2019% <sup>1</sup> | 2018% <sup>1</sup> |
| Joppa  | 30.2               | 24.1               |
| Divide   | 21.2               | 18.3               |
| Alkabo   | 7.8                | 9.2                |
| Carpio   | 6.1                | 11.6               |
| VT Peak  | 6.0                | 6.3                |
| Mountrail  | 5.4                | 5.1                |
| ND Riveland  | 2.4                | 0.6                |
| ND Grano   | 1.6                | 0.5                |
| Pierce   | 1.4                | 0.1                |
| Tioga  | 1.4                | 2.4                |
| Other <sup>2</sup>                                       | 16.5               | 21.8               |

1. Percentage may not add to 100 due to rounding.  
 2. Includes varieties with less than 1% of acreage in 2019 and unknown varieties.  
 3. 1,000 acres (1 acre = 0.405 hectares)  
 2019 – 720,000 acres  
 2018 – 1,100,000 acres

# U.S. DURUM WHEAT

MONTANA | NORTH DAKOTA

## LABORATORY ANALYSIS

All quality data contained in this report is the result of testing and analysis conducted by or under the supervision of Dr. Frank Manthey, professor, James Perleberg, chemist, and Yu Liu, food technologist of the Durum Wheat Quality and Pasta Processing Laboratory in the Department of Plant Science at North Dakota State University, Fargo, North Dakota, USA.

**COLLECTION** • The North Dakota and Montana state offices of the National Agricultural Statistics Service obtained durum wheat samples during harvest directly from growers, farm bins and local elevators. These samples reflect the condition of the grain at the point of origin. Collection began in mid August and continued through early October, but collections fell short of goal due to adverse harvest conditions. A total of 166 samples were collected from Montana (62) and North Dakota (104). The goal for collection was 220 total samples.

**ANALYSIS** • Half of the total wheat samples collected were analyzed for grade and other physical kernel characteristics. The data obtained from the analyses was used to generate frequency distributions as a percentage of the harvested crop. Distribution results may differ from data presented in the various tables, because the latter are derived from production adjusted averages, rather than simple averages.

All samples received in the laboratory were sub-sampled to obtain one composite sample for each of the four areas in North Dakota and one composite each of two areas for Montana. These were analyzed for grade and physical characteristics as well as milling performance and spaghetti processing qualities. Again, all state and regional averages have been adjusted to reflect production as opposed to simple averaging.

## METHODS, TERMS, SYMBOLS

### WHEAT

**SAMPLE COLLECTION** • Each sample contained approximately 2 to 3 pounds of wheat, stored in securely closed, moisture proof plastic bags.

**MOISTURE** • Official USDA procedure using Motomco Moisture Meter.

**GRADE** • Official United States Standards for Grain, as determined by a licensed grain inspector. North Dakota Grain Inspection Service, Fargo, ND, provided grades for composite wheat samples representing each crop reporting area.

**VITREOUS KERNELS** • Approximate percentage of kernels having vitreous endosperm, based on weights.

**DOCKAGE** • Official USDA procedure. All matter other than wheat which can be removed readily from a test portion of the original sample by use of an approved device (Carter Dockage Tester). Dockage may also include underdeveloped, shriveled and small pieces of wheat kernels removed in properly separating the material other than wheat and which cannot be recovered by properly rescreening or recleaning.

**TEST WEIGHT** • American Association of Cereal Chemists Method 55-10.01 approved April 1961, re-

vised October 1999. Measured as pounds per bushel (lb/bu), kilograms per hectoliter (kg/hl) = (lbs/bu X 1.292) + 0.630. Approved Methods of the American Association of Cereal Chemists, Cereal Laboratory Methods (10th Edition), St. Paul, MN (2000).

**THOUSAND KERNEL WEIGHT** • Based on 10 gram sample of cleaned wheat (free of foreign material and broken kernels) counted by electronic seed counter.

**KERNEL SIZE DISTRIBUTION** • Determinations made according to the procedure described in Cereal Science Today 5:(3), 71 (1960). Kernels remaining over a Tyler No. 7 (2.92 mm opening) are classified as "large;" kernels passing through the top sieve but remaining on a Tyler No. 9 (2.24 mm opening) are classified as "medium" size kernels. Kernels passing through the second sieve are classed as "small." Size is reported as percentage of large, medium, and small kernels.

**PROTEIN** • American Association of Cereal Chemists (AACC) Method: 46-30.01 (Combustion Method), expressed on dry basis and 12 percent moisture basis.

**ASH** • American Association of Cereal Chemists Method 08-01.01, approved April 1961, revised October 1999; expressed on a 14 percent moisture basis.

**DON** • Analysis was done on ground wheat using a gas chromatograph with an electron capture detector as described in J. Assoc. Official Anal. Chem 79,472 (1996)

**FALLING NUMBER** • American Association of Cereal Chemists Method 56-81.03, approved November 1972, revised September 1999; units of seconds (14 percent moisture basis).

**MICRO SEDIMENTATION** • Determined as described by Dick, J.W. and Quick, J.S. Cereal Chem. 60(4):315-318, 1983.

**WET GLUTEN** • American Association of Cereal Chemists Method 38-12.01, approved October 1999; expressed on a 14 percent moisture basis determined with the glutomatic instrument.

**GLUTEN INDEX** • American Association of Cereal Chemists Method 38-12.02, approved October 1999; determined with the glutomatic instrument as an indication of gluten strength.

## SEMOLINA

**EXTRACTION** • Durum tempered to 15.5% moisture and milled on a Brabender Quadrumat Jr mill configured to mill semolina.

**ASH** • AACC Method 08-01.01, approved April 1961, revised October 1999; expressed on a 14 percent moisture basis.

**PROTEIN** • AACC Method 46-30.01 (combustion method), approved September 1995, revised October 1999, N x 5.7, expressed on a 14 percent moisture basis.

**SPECKS** • The number of specks in semolina was determined on a flat surface under a constant light source, and counting the visible specks (brown and black particles) in three different one-inch square areas. The average of the three readings was converted to the number of specks per 10 square inches.

**MIXOGRAPH** • Mixograph evaluation of semolina was performed according to the AACC Method 54-40.02 with some modifications: Ten grams of semolina (weighed on 14 percent moisture basis)

were mixed for 8 min at constant water absorption of 5.8 ml, using a spring setting of 8. The mixograms were scored by comparing them to reference mixograms. A scale of 1 to 8 is employed, higher values indicate strong mixing characteristics (see reference mixogram chart).

## SPAGHETTI

**PROCESSING** • Pasta was made using the laboratory procedure described by Walsh, Ebeling, and Dick, Cereal Sci. Today: 16(11) 385, 1971. A 1-Kg semolina was mixed with the appropriate amount of water that gave a dough consistency of 32 percent total water absorption. The other processing conditions used were: Water temperature, 40 C, extruder shaft speed, 25 rpm and vacuum, 18 in. Hg; the dough was pressed through an 84-strand teflon-coated spaghetti die with 0.157 cm openings. The extruded spaghetti samples were dried at high temperature for 12 hrs, using maximum temperature and relative humidity of 73 C and 83 percent, respectively.

**COLOR** • Color scores were determined by light reflectance (AACC Method 14-22.01, 1983), using a Minolta Color Difference Meter (Model CR 410, Minolta Camera Co., Japan). The scores were generated according to the new color map designed by Debbouz (Pasta J. vol 6, No 6, 1994). A spaghetti sample with a score of 8.0 or higher is considered to have good color.

**COOKED WEIGHT** • 10 g of dry spaghetti were placed in 300 ml boiling distilled water and cooked for 12 min. The cooked and drained spaghetti sample was weighed and the results were reported in grams.

**COOKING LOSS** • AACC Method 66-50.01. Solids lost to the cooking water. After drying the residue was weighed and reported as percentage of the original dry sample.

**FIRMNESS** • AACC Method 66-50.01 with a Plexiglas tooth attached to a Texture Analyzer (Model TA-XT2, Texture Technology Corp., Scarsdale, New York).



**2019**

**U.S. DURUM WHEAT**

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