Joe Trummer- Research and Development Director
December 6, 2018

A study of wheat flour for use in the tortilla industry

PURE TORTILLA JOY

Wheat Flour and it's role in Tortillas

Since wheat flour is typically the largest component of tortillas (50%+ formula weight), the study of wheat is a worthwhile topic to explore.

Wheat is the number 1 cereal crop in the world in terms of acres planted, but more corn is produced, and rice leads in human consumption.

Wheat production in the US is third behind corn and soybeans. Despite it's third place ranking, approximately 20% of daily calories consumed come from wheat and other cereal products.

Wheats early ancestors were among the first plants cultivated by humans.

Wheat's Uniqueness

Wheat is a member of the grass family and grows relatively easily in soil and climatic conditions that exist over wide temperature regions of the earth. It's high yielding and easy to cultivate. With modern milling, extraction is nearly 100%.

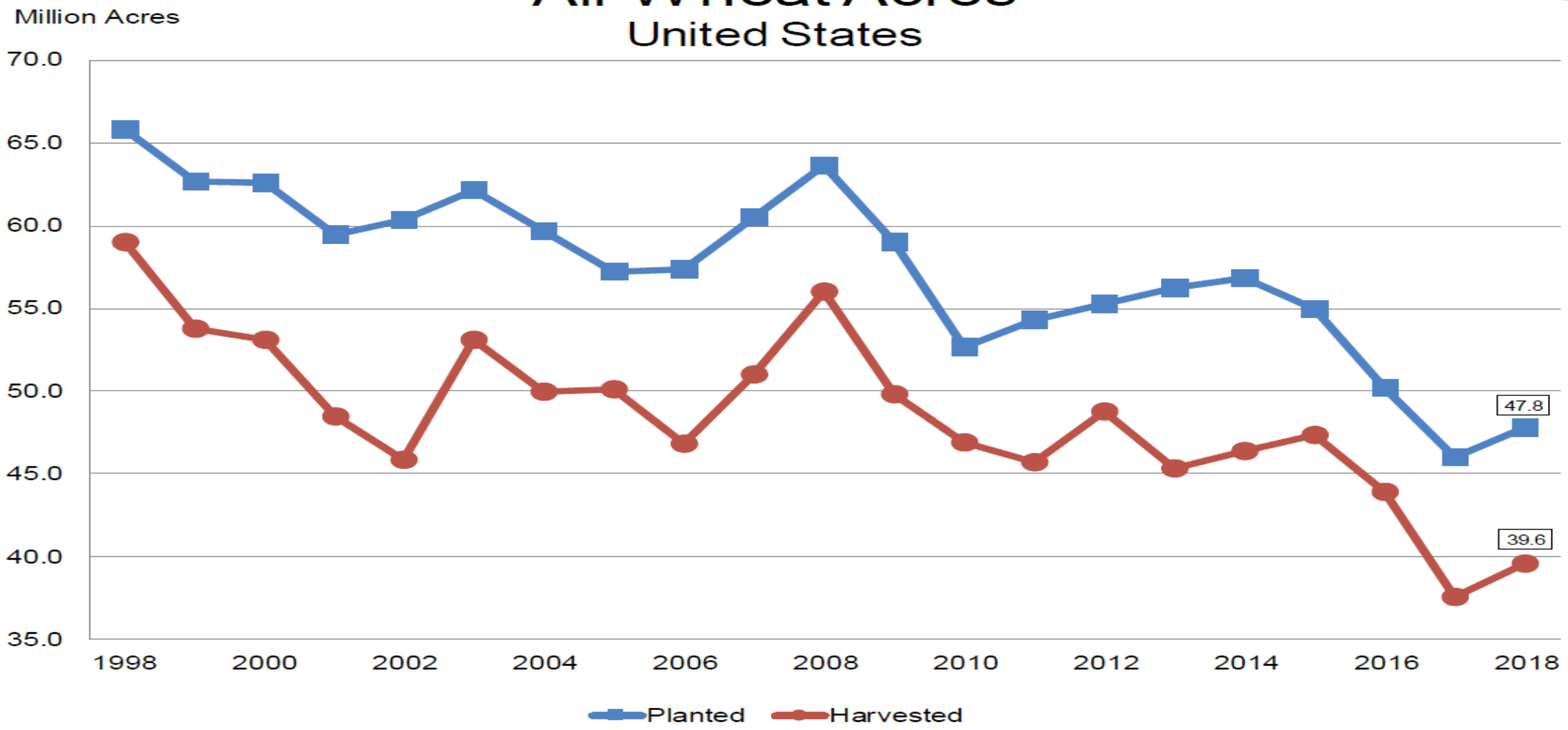
Whole Wheat contains antioxidant amounts at or near those of other fruits and vegetables.

2017/2018 USDA data for millions of acres of planted:

Corn	89.1 million acres
Soybean	89.6 million acres
Wheat	47.8 million acres

Source: USDA ERS Data

All Wheat Acres
United States



USDA-NASS
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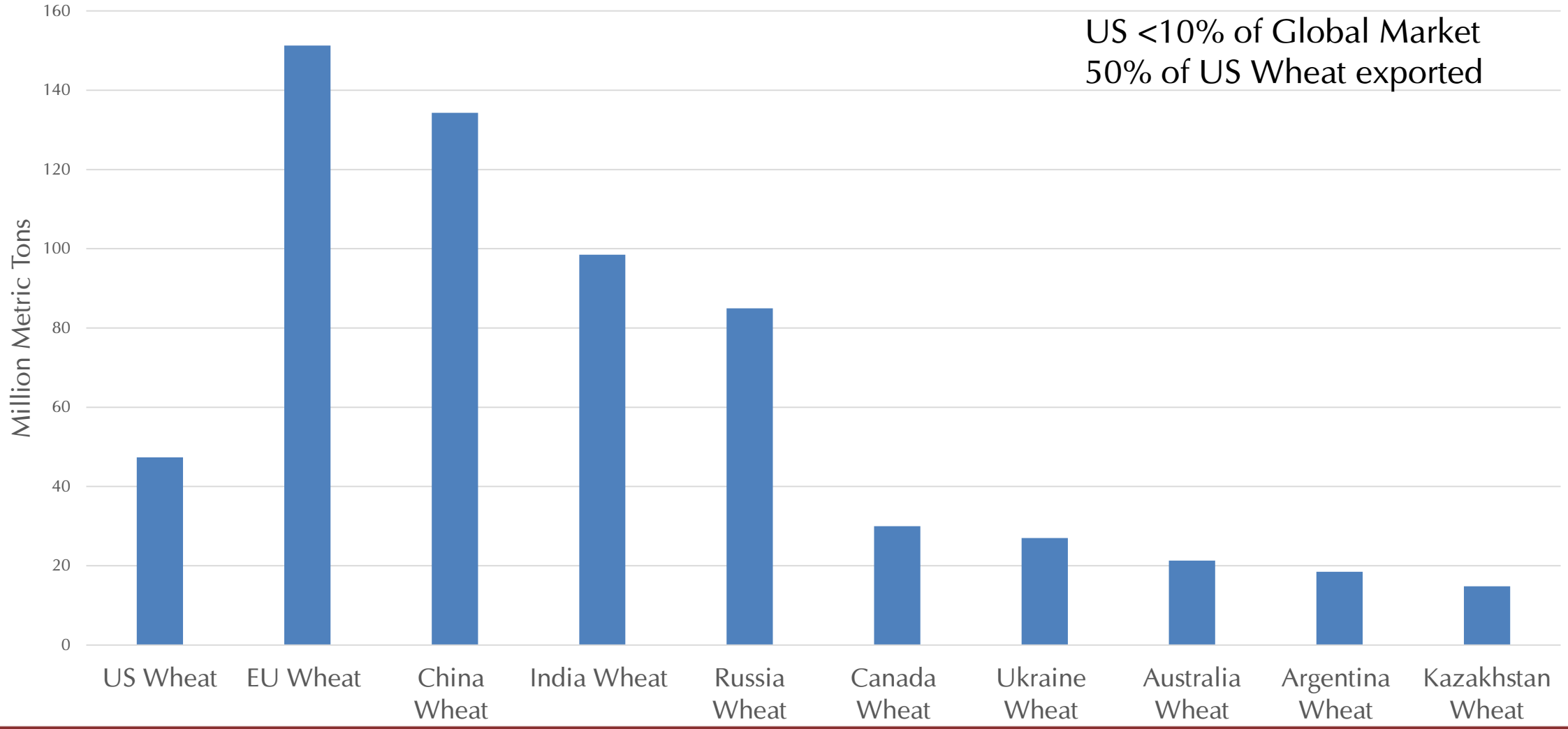
Global Wheat Producers 2017/2018 USDA ERS Data



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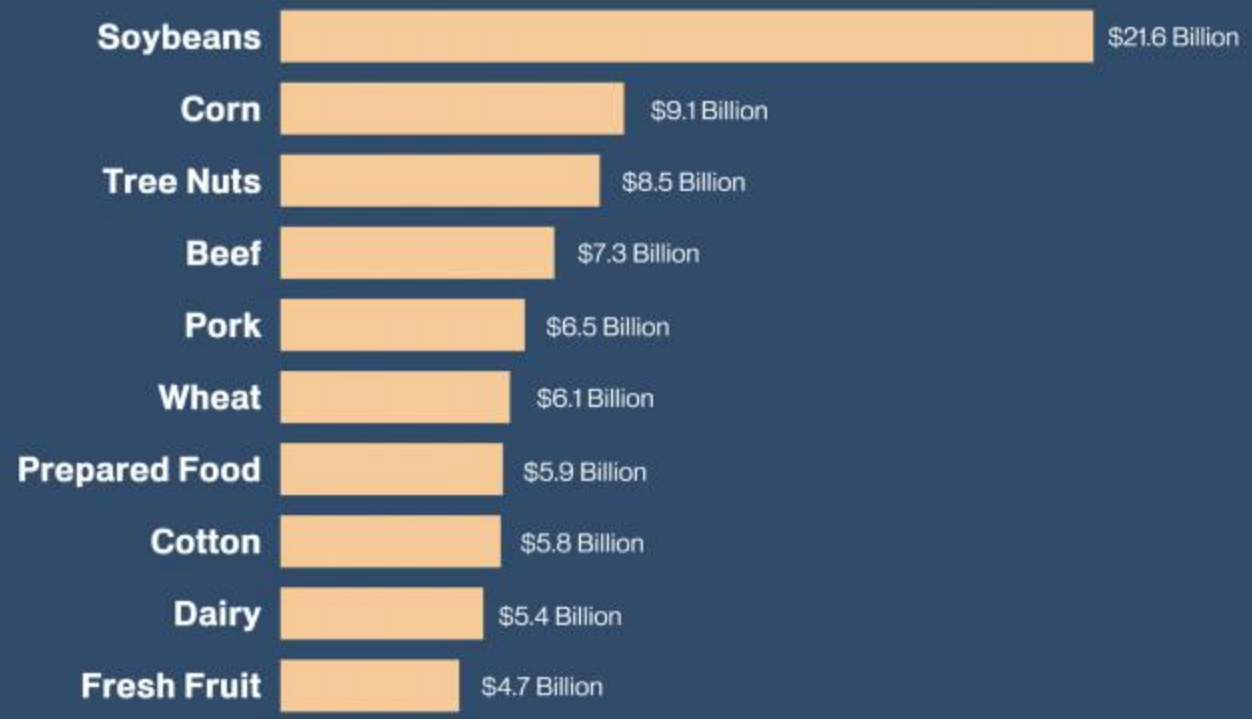
Top U.S. Agricultural Exports in 2017



Website: **www.fas.usda.gov**
Twitter: **@USDAForeignAg**

USDA
United States Department of Agriculture
Foreign Agricultural Service

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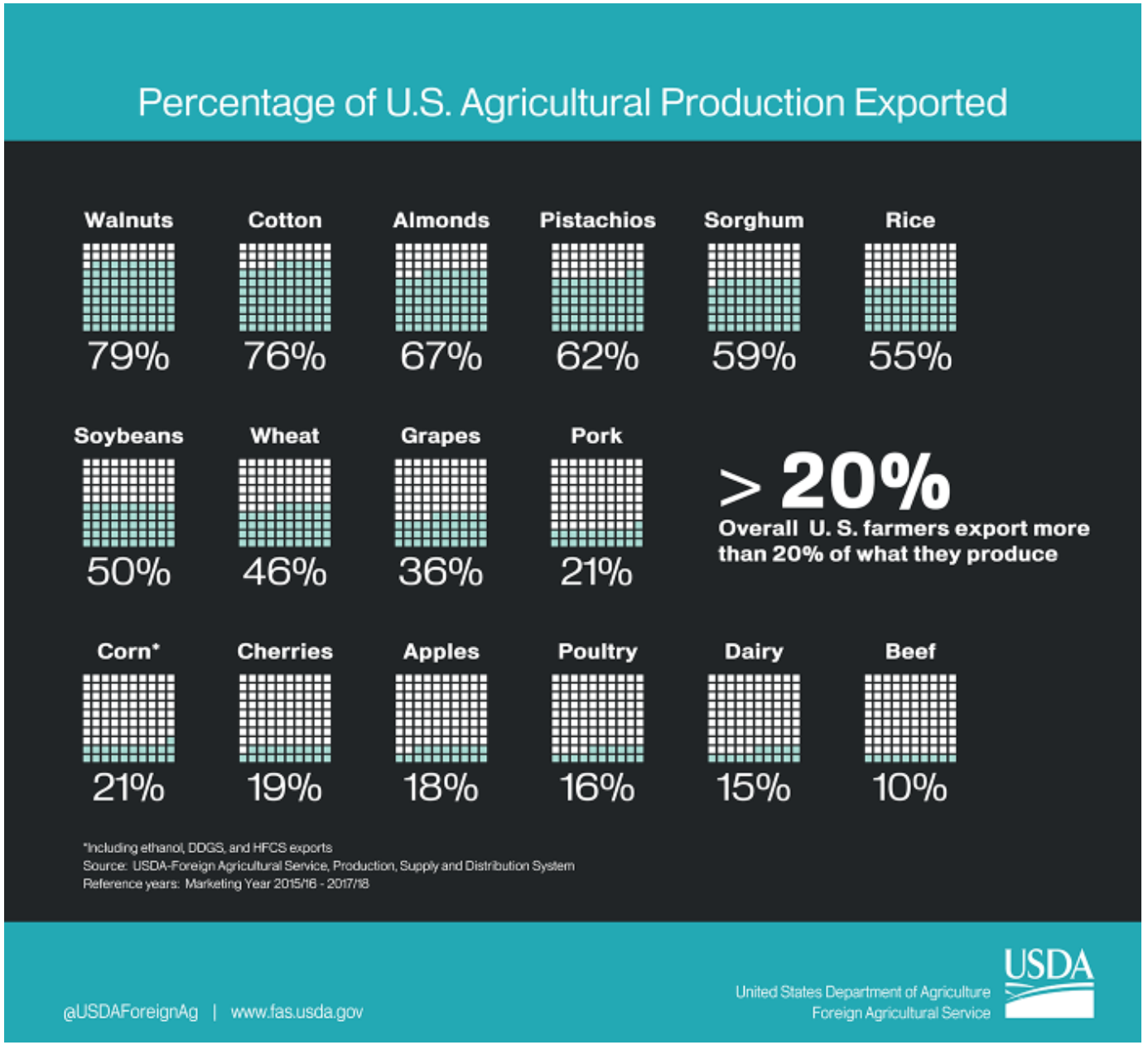


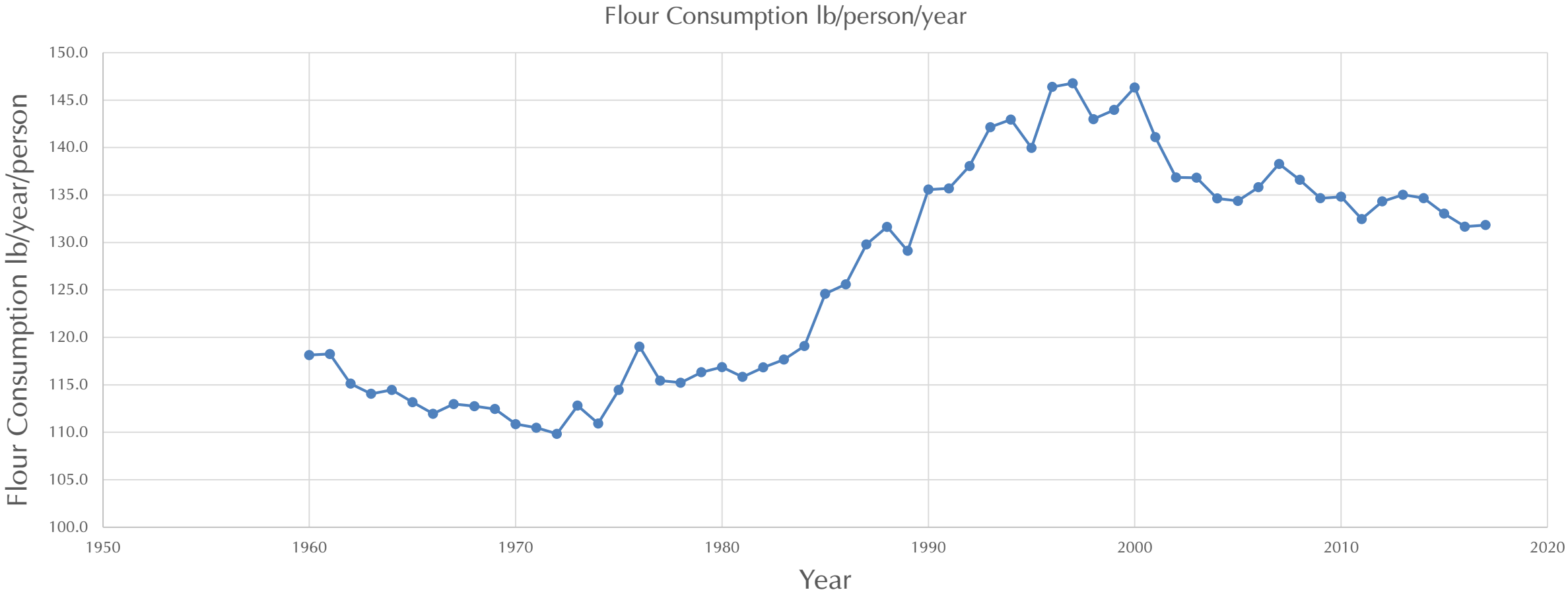
Wheat Consumption and Production Trends

Wheat consumption in the US has been declining in the US since the late 90's. According to the USDA, wheat consumption has fallen from 146.3 pounds per person in 2000 to 132.5 pounds in 2011.

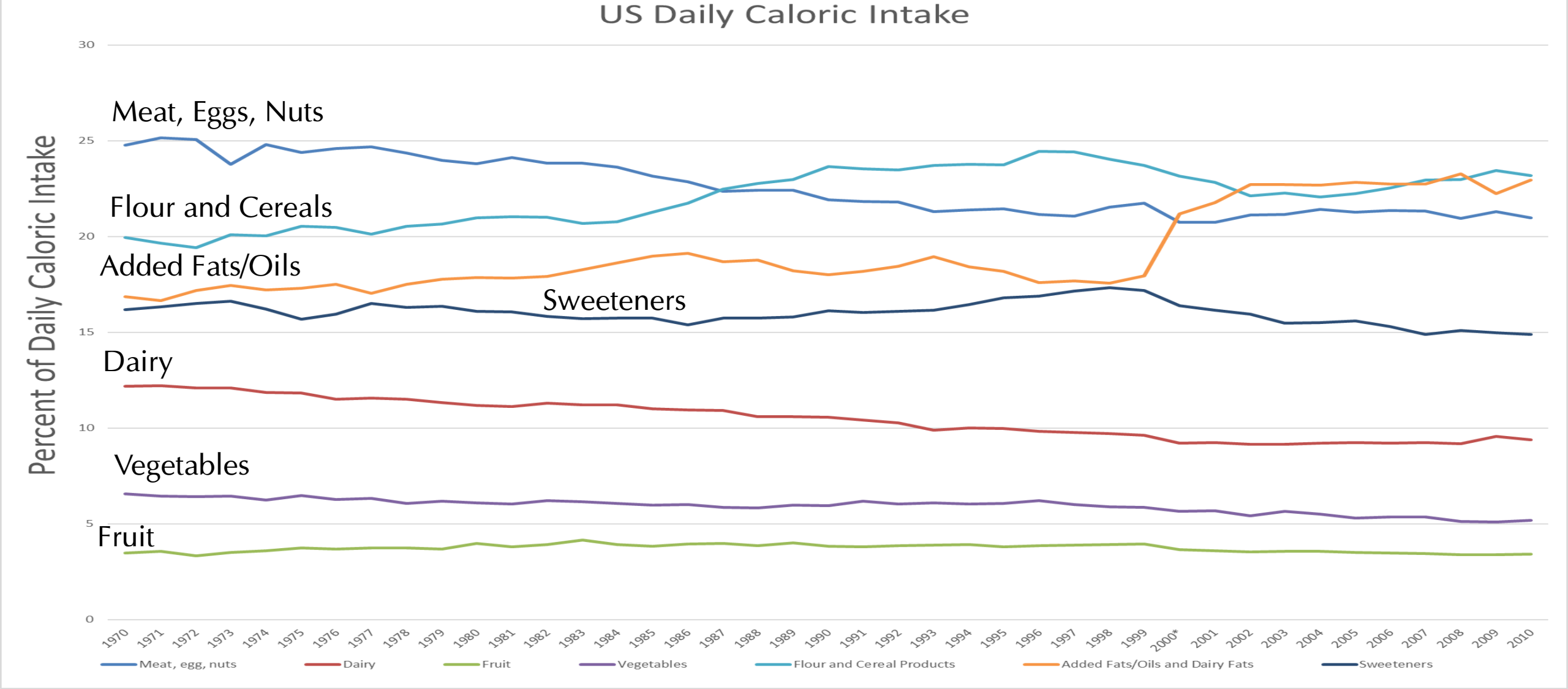
The decline in wheat consumption can be attributed to changes in health and diet habits beginning in early 2000. Ironically, an increase in wheat consumption began in the 1970's due to health and diet trends with a move from meat-based diets to more grain-based ones. This then changed beginning in early 2000 as people moved to more gluten free and carbohydrate free diets.

As a results wheat production in the US is on the decline due to these trends and more competition form FSU countries (Russia, Kazakhstan and Ukraine) as well as China.

US Wheat Flour Consumption thru 2017



Source: ERS/USDA based on data from various sources (see https://www.ers.usda.gov/data-products/food-availability-per-capita-data-system/food-availability-documentation/). Data last updated Feb. 1, 2018



Source: ERS/USDA Calculated by ERS/USDA based on data from various sources (see https://www.ers.usda.gov/data-products/food-availability-per-capita-data-system/loss-adjusted-food-availability-documentation/). Data last updated June 1, 2018.

Wheat and Farming

6 Classes of Wheat

Hard Red Winter	Versatile bread and tortilla wheat with high protein 10-13%, medium hard endosperm, red bran, medium gluten content and mellow gluten.
Hard Red Spring	An important bread wheat high in protein (12-15%), hard endosperm, red bran, strong gluten and high, water absorption. This is a value-added improver wheat.
Soft Red Winter	High yielding, low protein (8.5-10.5%) soft endosperm, red bran and weak gluten. It's used in pastries, cakes, cookies, crackers and flatbreads.
Soft White	Grown primarily in the Pacific Northwest has a low protein (8.5-10.5%), and low moisture. Use for cakes, pastries and Middle Eastern Flatbreads.
Hard White	Newest class of wheat it has hard endosperm, white bran and a medium to high protein (10-14%). Good for Asian noodles, pan breads, tortillas and flat breads.
Durum	Hardest of all wheat classes it has high protein (12-15%), yellow endosperm and white bran. Its mainly used for pasta, couscous and some breads.

2018 Production of US Wheat in Millions of Bushels:

Hard Red Winter	394 or 36.5% of production
Hard Red Spring	288 or 26.7% of production
Soft Red Winter	216 or 20.0% of production
White Wheat	90 or 8.4% of production
Durum Wheat	90 or 8.4% of production

Source: USDA ERS Data

2017/2018 US Millions of acres of wheat planted:

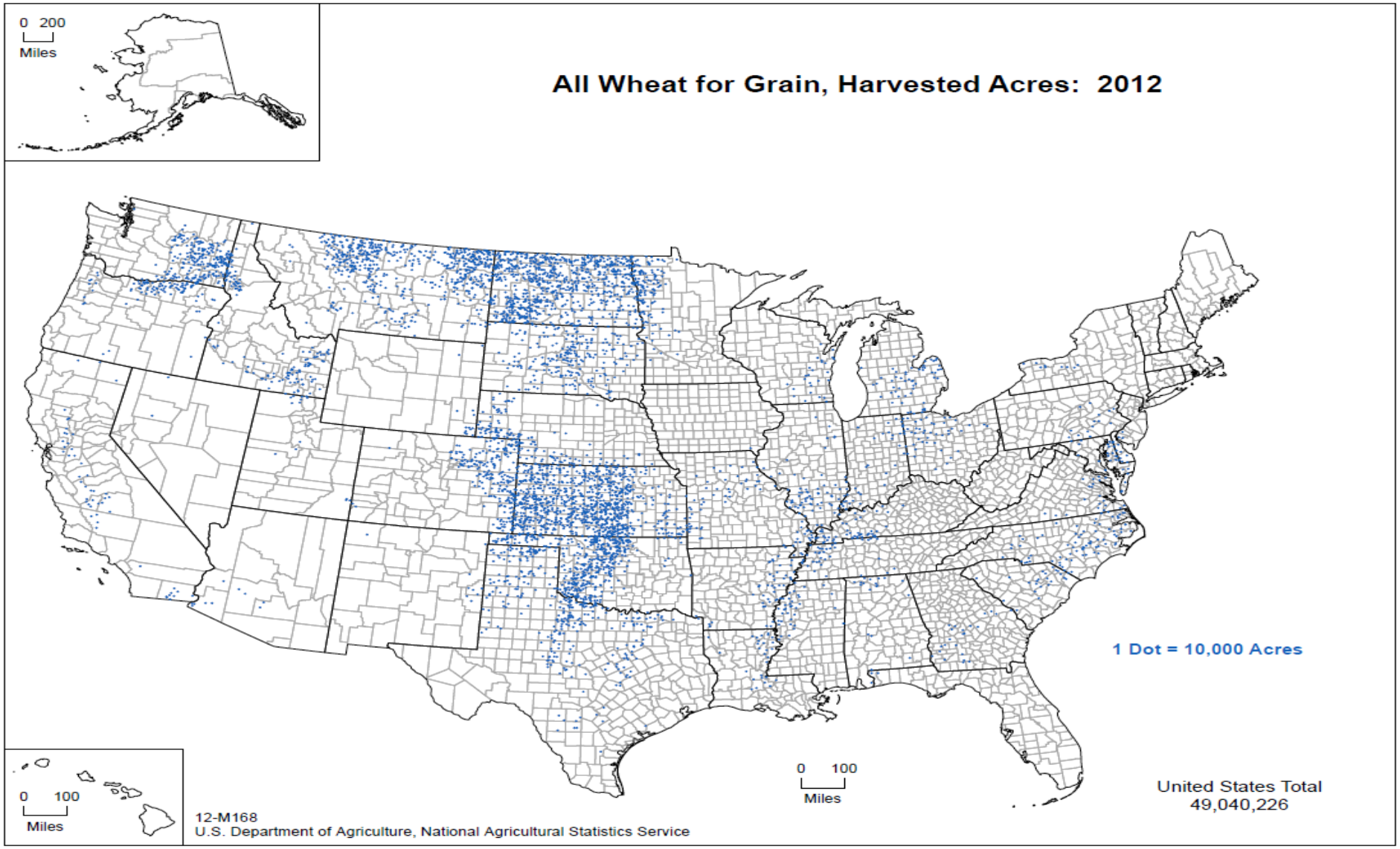
Winter Wheat – 32.7 million acres.

23.2 million acres is HRW
5.82 million acres is SRW
3.62 million acres is White Wheat

Spring Wheat – 13.2 million acres.

12.7 million acres is HRS

Source: USDA ERS Data



Major Wheat producing states include:

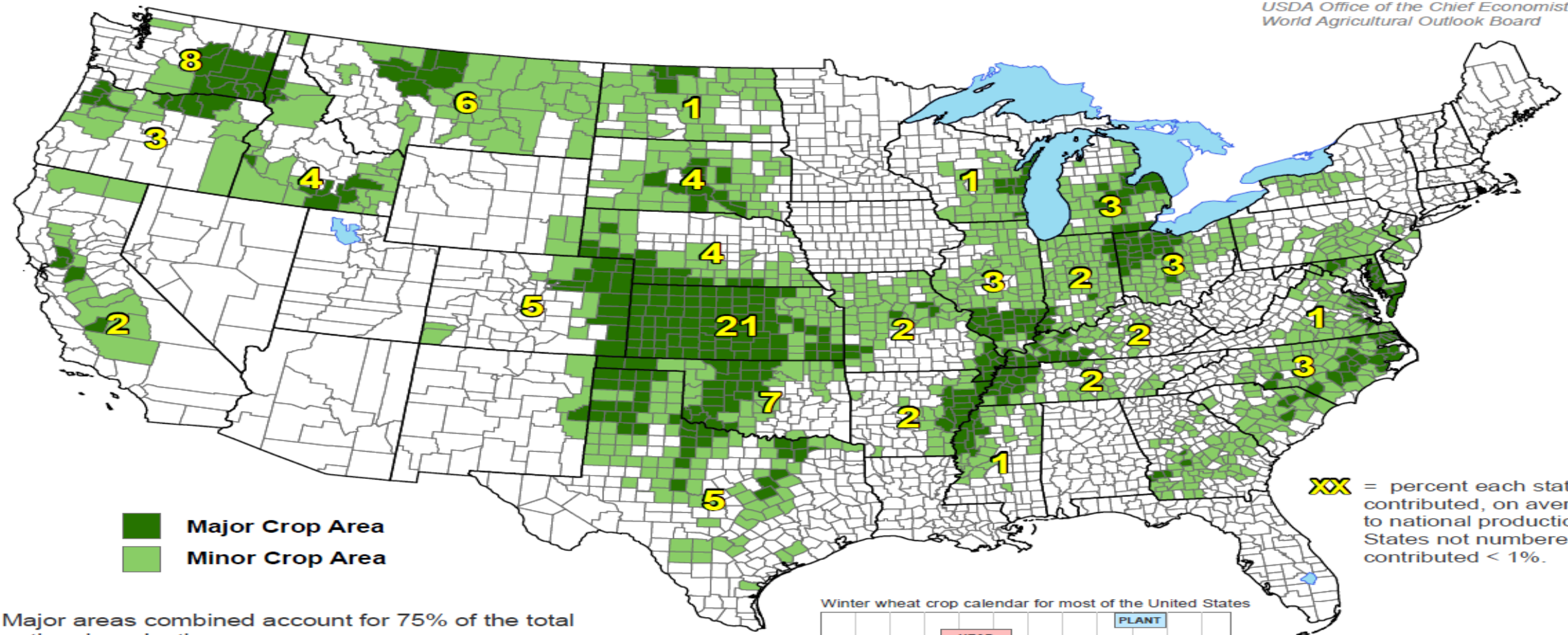
Texas
Oklahoma
Kansas
Colorado
Nebraska
North Dakota
South Dakota
Montana
Idaho
Washington
Oregon
California

Source: USDA ERS Data

United States: Winter Wheat

USDA United States Department of Agriculture

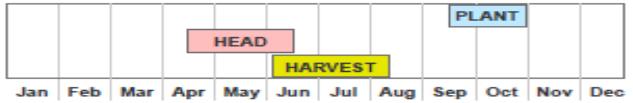
This product was prepared by the USDA Office of the Chief Economist World Agricultural Outlook Board



XX = percent each state contributed, on average, to national production. States not numbered contributed < 1%.

- Major areas combined account for 75% of the total national production.
- Major and minor areas combined account for 99% of the total national production.
- Major and minor areas and state production percentages are derived from NASS survey data from 2010 to 2014.

Winter wheat crop calendar for most of the United States

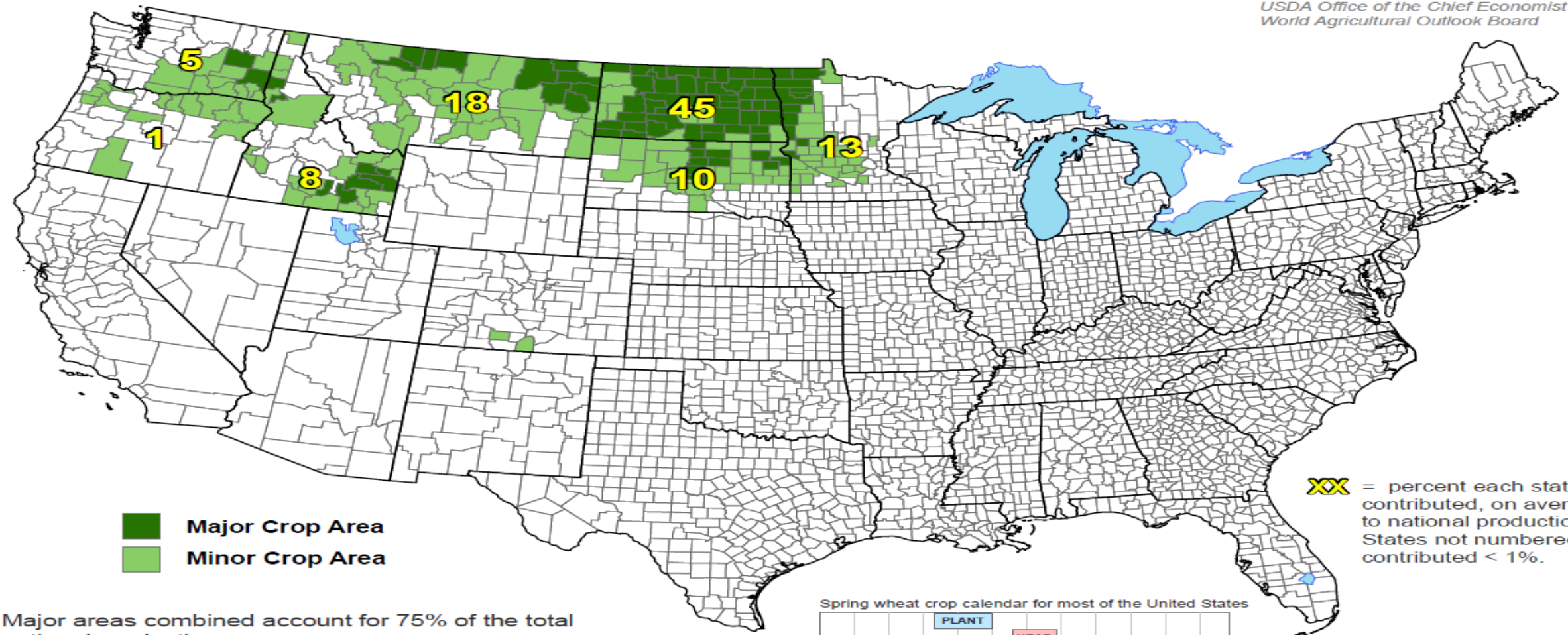


The crop calendar was developed using NASS crop progress data from 2010-2014. This calendar illustrates, on average, the dates when national progress advanced from 10 to 90 percent.

United States: Spring Wheat

United States Department of Agriculture

This product was prepared by the USDA Office of the Chief Economist World Agricultural Outlook Board



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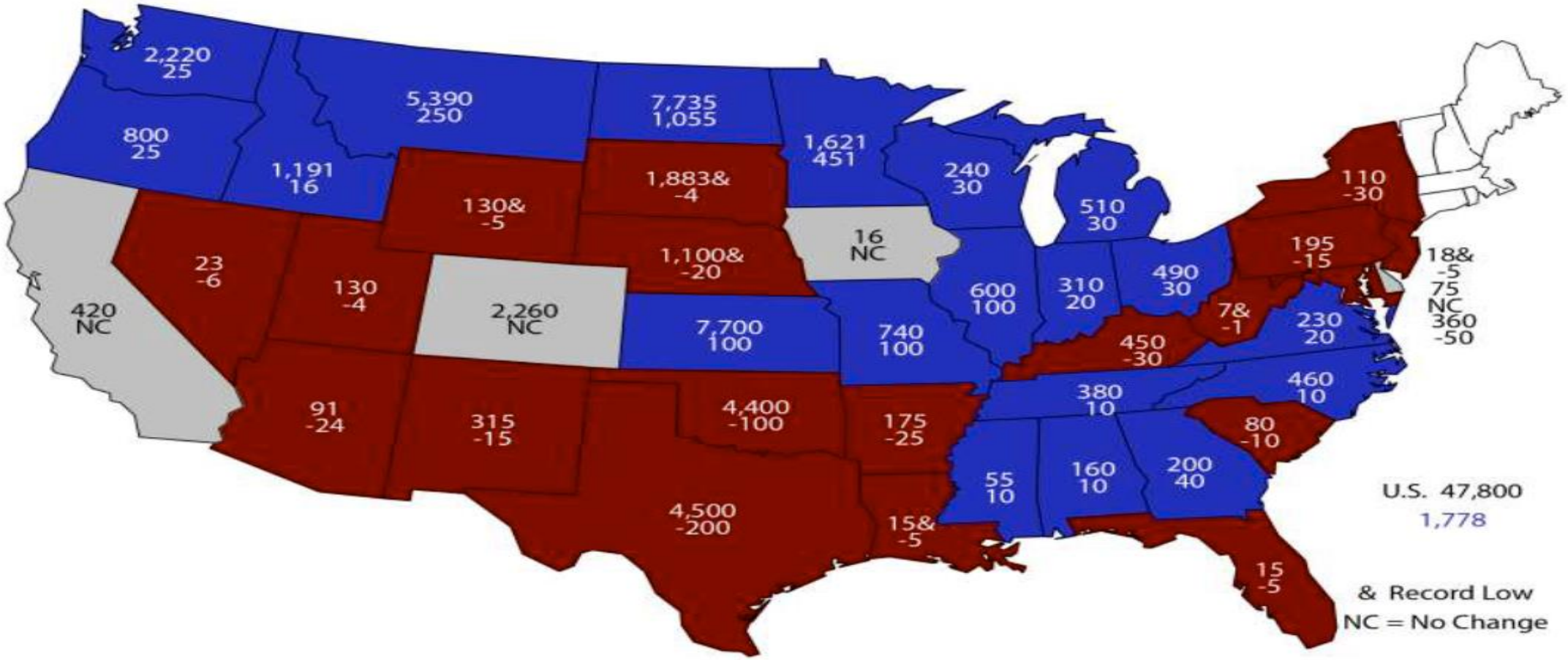
2018 All Wheat Planted Area

(000) Acres and Change From Previous Year



Source: USDA ERS Data

USDA-NASS
9-28-18

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Wheat Milling, Flour Production, Flour Science & End Use Testing

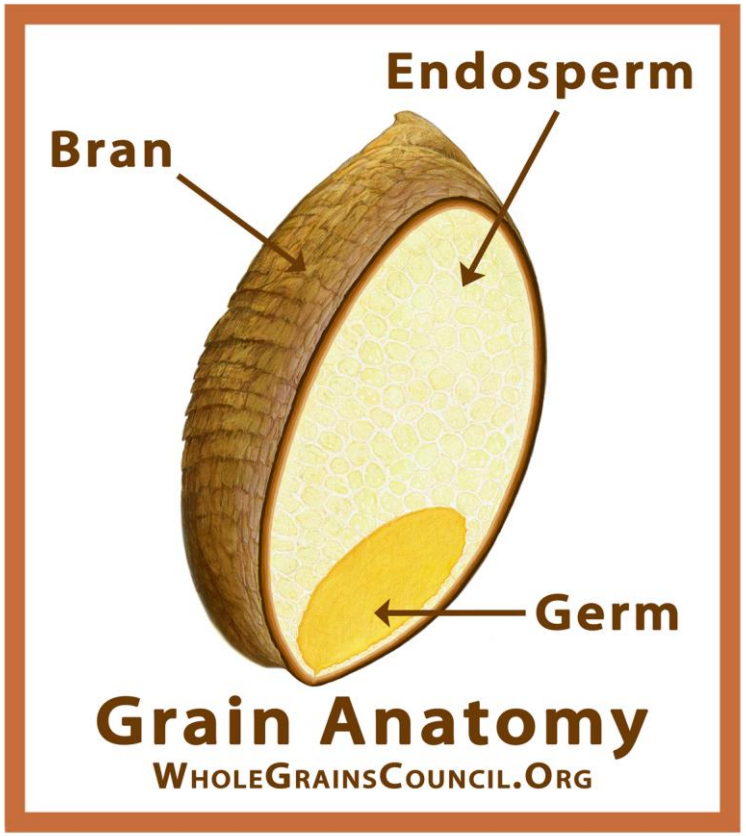
Wheat Kernel

Wheat consists of three distinct components. The outer bran layer, the endosperm and the germ.

Bran is the outer layer and contains antioxidants, vitamins, fiber and constitutes 3-17% of the kernel.

Endosperm is the largest part of the seed and stores the energy from which a new plant will draw from. This is where the starch and protein are stored and is 80-85% of the kernel.

Germ contains many B-vitamins, minerals healthy fats, some protein and contains the embryo in which a new plant will sprout and comprises 2-3% of the kernel.



Scource: Whole Grains Council

Milling

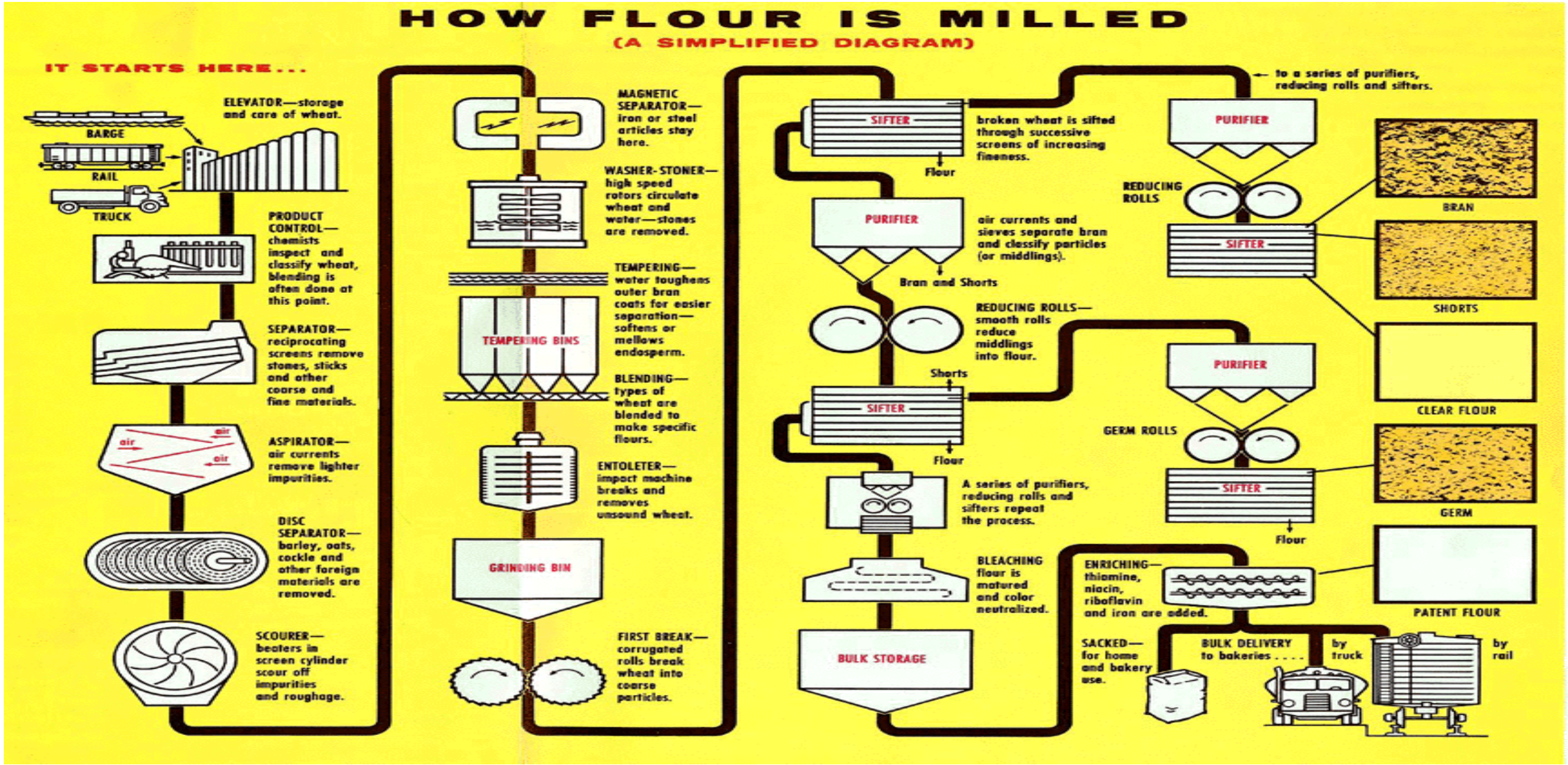
Flour is milled to remove foreign matter and separate the flour into its distinct components.

White flour is milled to remove the bran and germ.

Whole wheat flour is milled to include all three components of the wheat kernel.

Each miller follows their own specification for grinding the wheat kernel into flour that is suitable for tortilla manufacturing.

Starch damage happens during milling and causes tortillas to be less stretchable with increased firmness. In general the harder the wheat variety the greater the starch damage during milling.



Source: Wheat Foods Council

Flour Whitening

The natural color of flour tends to be creamy yellow to off white. Oxidation of the yellow pigment is the process by which the flour is whitened.

Flour bleaching should not impact maturation of the flour.

Benzoyl Peroxide is a non-maturing type bleaching agent.

Chlorine and Chlorine dioxide have some maturing and whitening action.

Flour Enrichment

During milling, flour loses as much as 60-80% of B Vitamins and iron. Enrichment is the process that adds them back.

Flour enrichment began in 1941. During the 1930's, national surveys determined a lack of vitamins and nutrients being consumed in the American diet. With impending involvement in WWII, the US wanted to make sure citizens were nutritionally ready. Therefore, enrichment of bread became mandatory during the war but reverted to being voluntary after it was over. Most bread manufactures continued enrichment and many individual states mandate enrichment.

Flour Enrichment

In 1971, the FDA set current standards for enriching bread.

Niacin – necessary for healthy cells and tissues aka vitamin B3
Riboflavin – necessary for growth aka vitamin B2
Thiamine – necessary for growth aka vitamin B1
Folic Acid – helps manufacture red blood cells aka vitamin B9
Iron – necessary for growth

Tortilla Dough Production:

Flour
Water
Fat/Oil
Minor
Ingredients

+ Mechanical Mixing

= Tortilla Dough (85% water + starch + protein. Remainder: 15%)

Wheat Protein

Wheat is unique in that it contains two different types of gluten protein molecules, glutenin and gliadin, that act to provide elasticity and extensibility of the dough. This unique protein combination gives wheat dough it's viscoelastic ability.

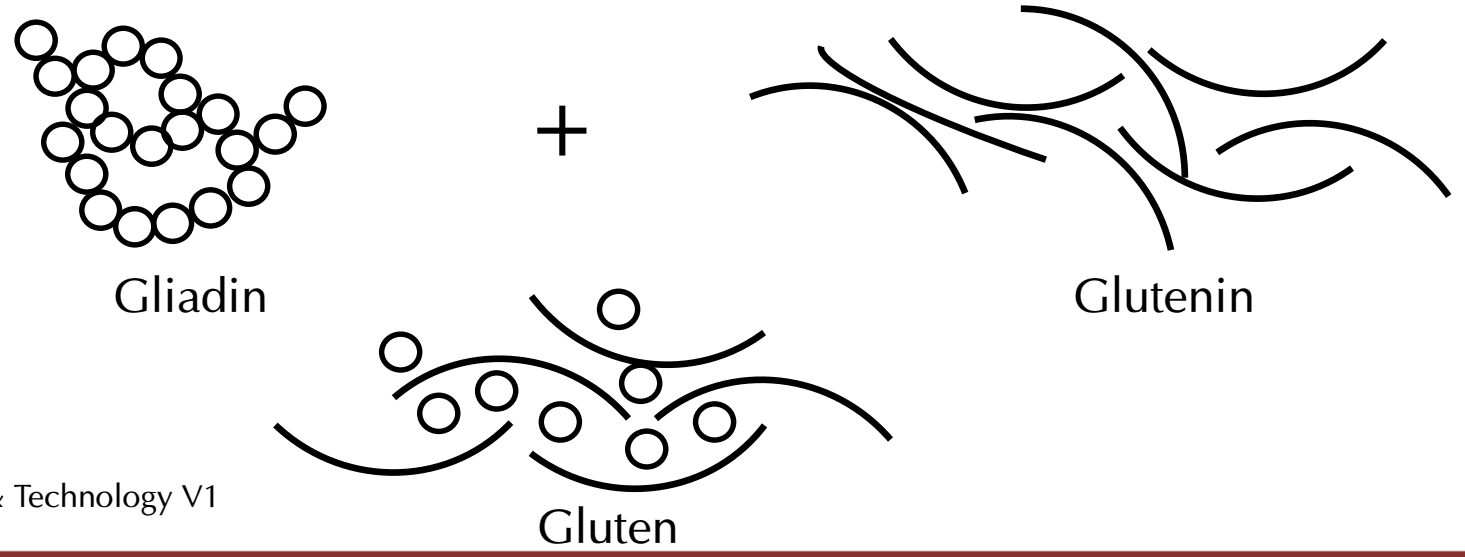
Glutenin comprise about 35-45% of total wheat proteins. Gliadin is 55-65% of total wheat protein.

When water and flour are mixed, the proteins in the flour form gluten which when baked denature and support the starch component to produce edible baked goods such as tortillas.

It has been shown that protein quantity is environmentally influenced, while protein quality is genetically determined. Both are important to determining a viable tortilla flour.

Gluten formation and changes during baking:

Gluten provides the strong film that is needed to retain gasses during baking. It also forms a matrix containing starches. Gluten denatures (coagulates) during baking (at 185F) adding structural support to the baked product. Gluten gives the extensible and elastic properties necessary for successful tortilla manufacturing. Proteins are twisted chains of amino acids.



Source: Baking Science & Technology V1

Wheat Starch

Two types of starches exist in Wheat Starch: amylose and amylopectin and exist in roughly 1:3 ratio. Starches are long chain polysaccharides.

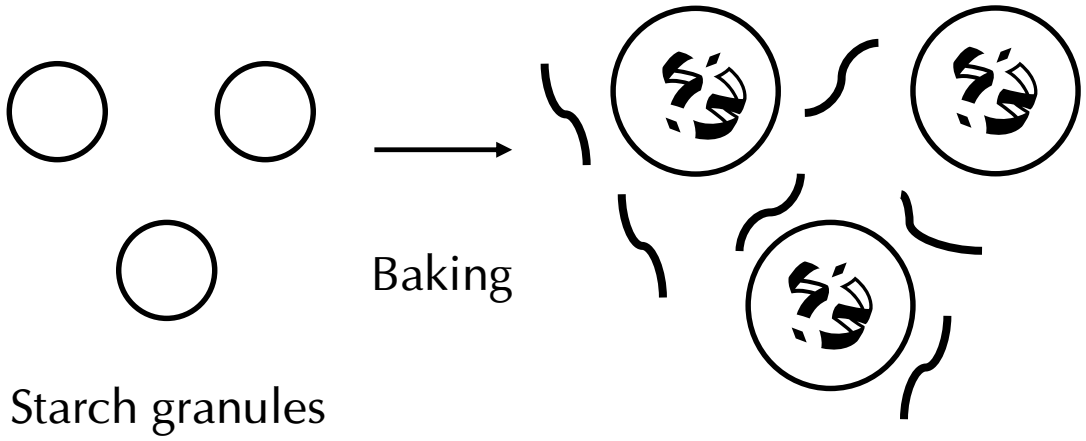
The role of starch in baking: dilutes gluten, provides sugar via amylase action, provides a surface suitable for strong union with gluten, becomes flexible during gelatinization.

All starches are insoluble in cold water. However, when heated to 140-158F in the presence of water, the granules begin to swell and absorb water; they become thicker, larger and more viscous.

During shelf life, the solubility of the starch decreases and begin to crystallize or retrograde. This is also known as staling and firming of the crumb of the tortilla.

Gelatinization of wheat starch molecules:

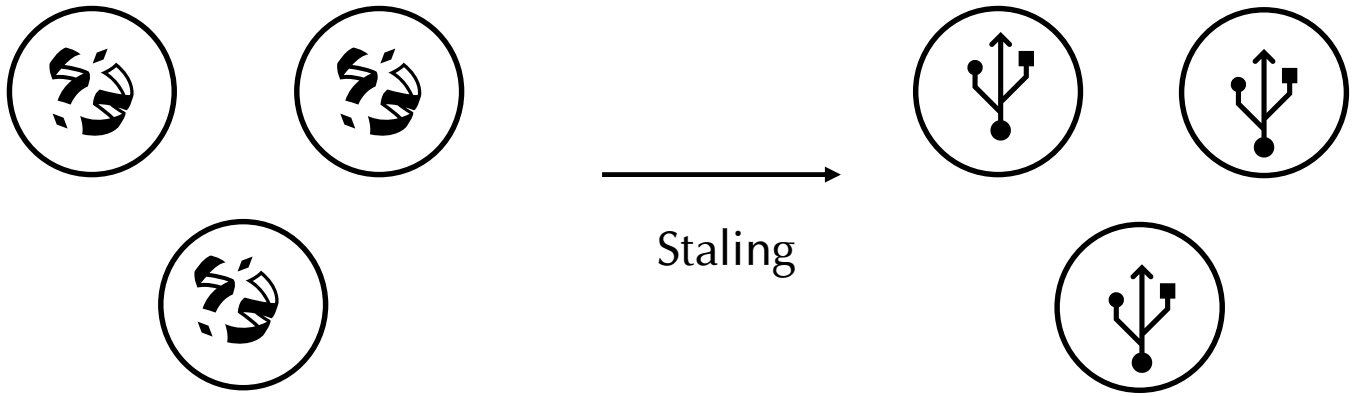
Starch granules unfold with absorption of water. During gelatinization, granules swell and allow water in and some chains starch out. Starches are branched chains of linked saccharide units. Starches are responsible for the tender eating quality of baked goods. Most of wheat flour is starch (70%) bound by hydrogen atoms and interspersed with protein molecules.



Source: Baking Science & Technology V1

Starch Retrogradation during shelf life:

During shelf life, tortillas undergo staling whereby the starch retrogrades and pushes out water. Longer chain molecules will retrograde more rapidly. Swollen starch molecules release water which is absorbed by other components in the substrate or released to the atmosphere.



Source: Baking Science & Technology V1

Enzymes and emulsifiers can act to reduce the amount of staling that occurs during shelf life. Enzymes cleave long starch chain starches producing short chains molecules which retrograde more slowly. The shorter chains open up and allow more water in the molecule retaining moisture. Emulsifiers complex with outer starch molecules and interfere with the retrograding process.

Reducing and Oxidizing Agents Act on Flour

Since wheat is a natural product, variability in protein amount, native enzyme and other starch quality can vary from crop year to crop year. Enhancement to flour performance is sometimes necessary to assure uniformity of end product. Oxidation and Reduction agents are examples of performance enhancers.

Oxidants are used to artificially age flour for improved strength. Oxidizing agents act on the gluten to enhance extensibility. Examples of this are azodicarbonamide, ascorbic acid and potassium bromate.

Reducing agents act to lower extensibility to cut mixing time and improve size. They act by cleaving gluten molecules during mixing but are reformed after they are all used up. Examples of reducing agents are L-cysteine and sodium metabisulfite.

Enzymes can also be used to alter wheat starch, protein and gluten molecules for improved dough and finished tortilla performance.

Flour Quality Tests

Farinogram

Alveograph

Mixograph

Color L*a*b

Falling Number

Gluten Number

Gluten Index

Texture Analysis

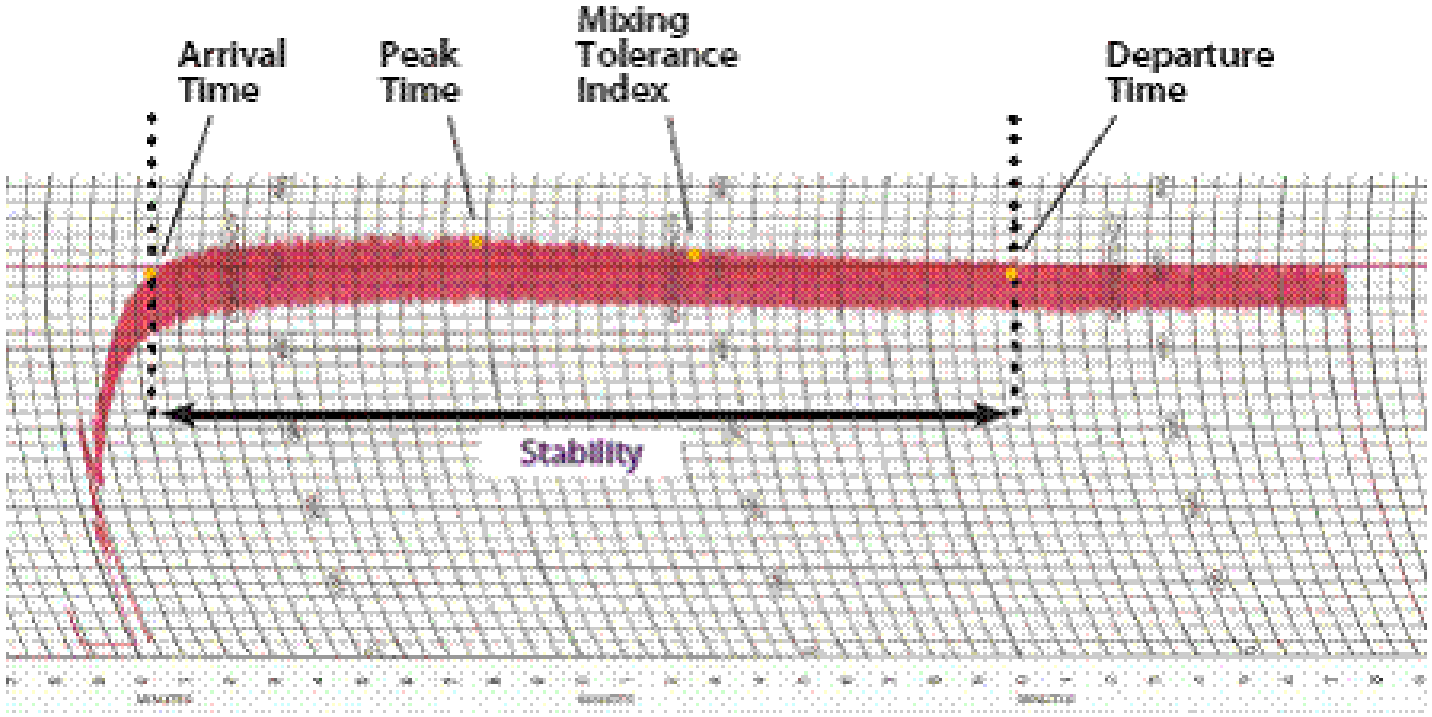
Farinogram

Farinograph – laboratory mixer designed to measure flour quality by documenting amount of power required to move mixer paddles through a mixture of flour and water.

Useful for measuring:

1. Dough development time (time to max resistance)
2. Dough stability (measures tolerance to mixing)
3. Dough mix tolerance (resistance to breakdown)
4. Water absorption

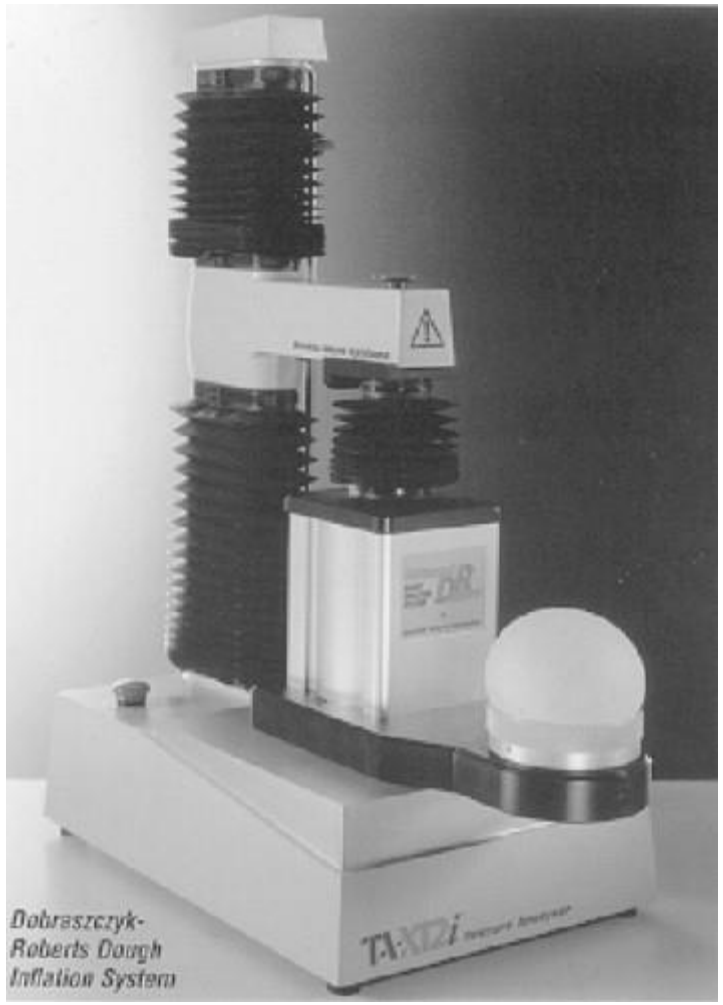
Brabender GmbH & Co. KG



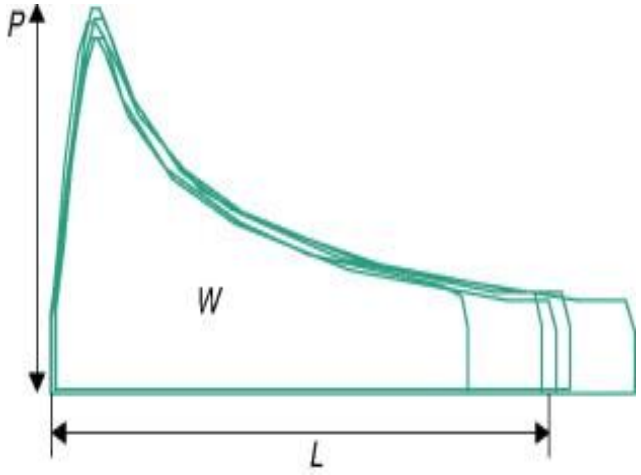
Strong Gluten Flour

North Dakota State University Wheat Quality and Carbohydrate Research

Alveograph



Chopin Technologies

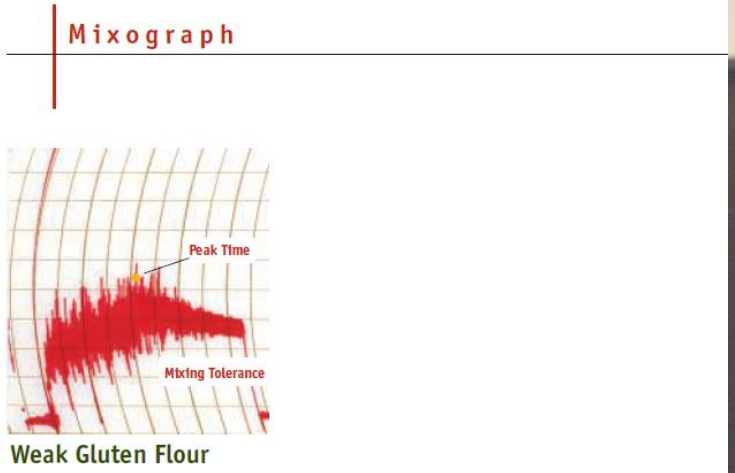


Chopin Technologies

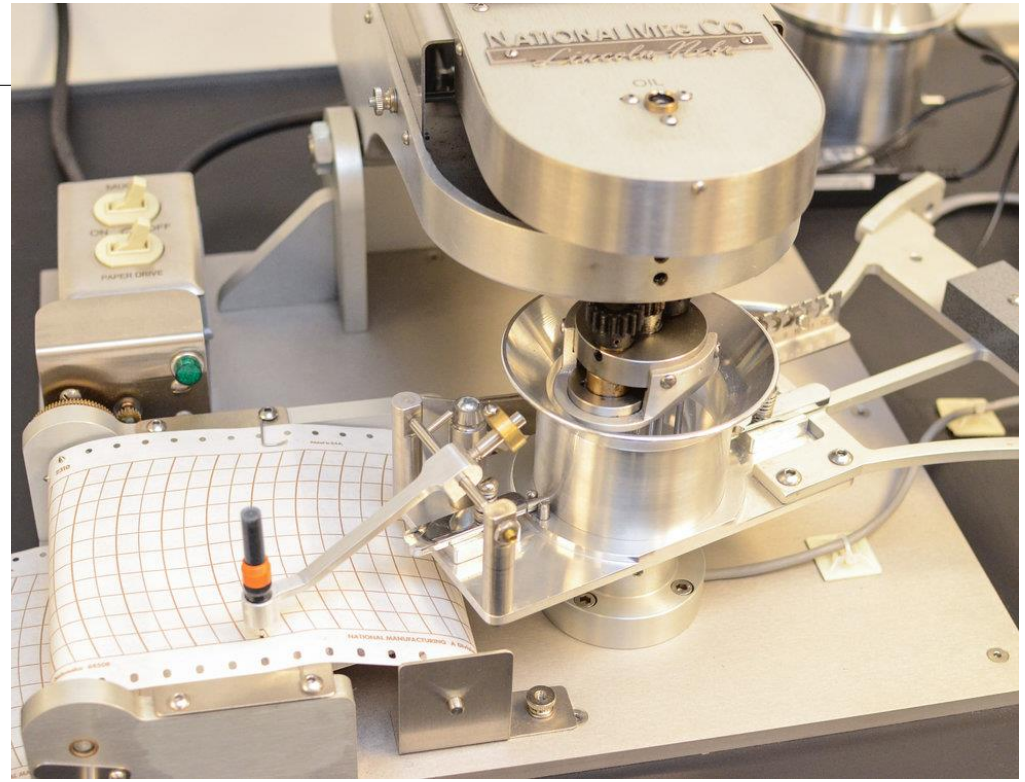
Alveograph measures:

1. P Value – Measures strength of dough. Bigger number for stronger dough.
2. L Value – measures extensibility of dough.
3. W Value – baking strength area under curve.
4. P/L – ratio of strength/extensibility.

Mixograph



The Wheat Marketing Center



The National Manufacturing Company

The mixograph is a device used to measure water absorption, mix time and mix tolerance. It is mostly used by wheat breeders to determine gluten strength as it measures dough resistance over time. It has been shown to show strong correlation between gluten strength and tortilla diameter (Barros et al 2010)

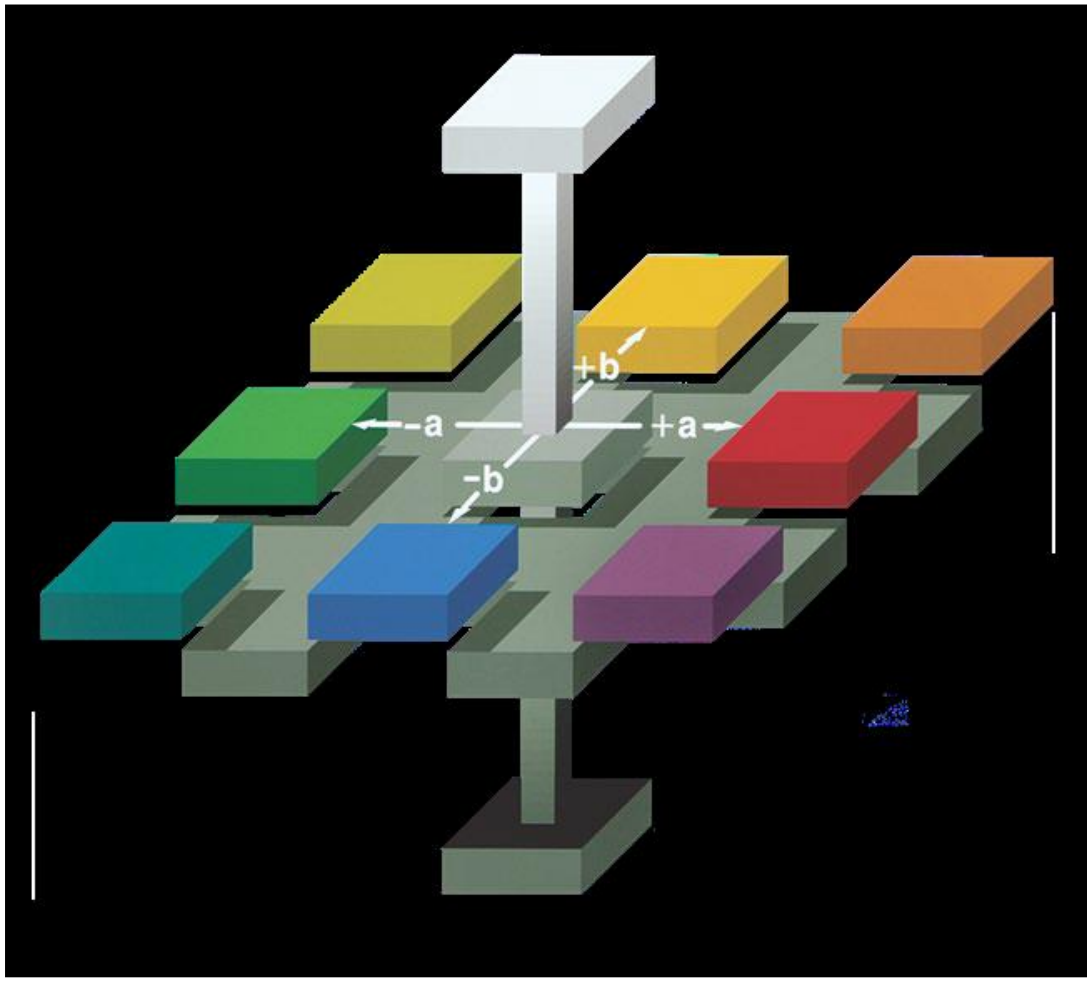
Color Measuring Techniques

Hunter Color Difference Meter:

L scale which measures degree of whiteness scale 0-100. A low number is dark and high number means light.

***a** scale which measures red and green with red as a positive number and green as a negative number.

***b** scale measures yellow versus blue with blue as a negative number and yellow as positive.



Source: Hunter Laboratory Website

Falling Number

Test which measures the alpha amylase enzyme activity of flour which is an indicatory of kernel germination.

The more amylase activity the more starch cleavage and the lower the falling number.

Not enough enzyme activity and the number will be high.

For tortilla flour, the Falling number should be greater than 250.

Gluten Index and Gluten number

Gluten number measures the quantity of gluten in a flour sample.

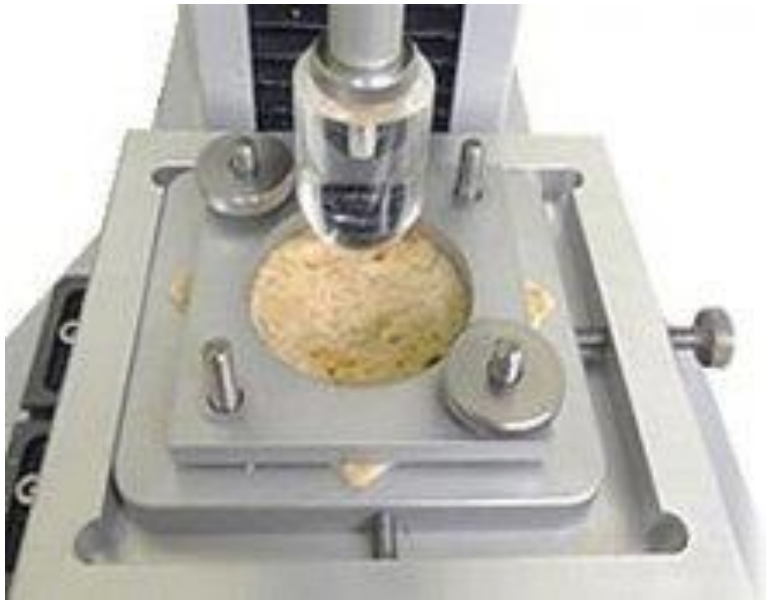
Gluten index measures the quality of the gluten on scale of 0-100%.

Weak Gluten quality: <30%

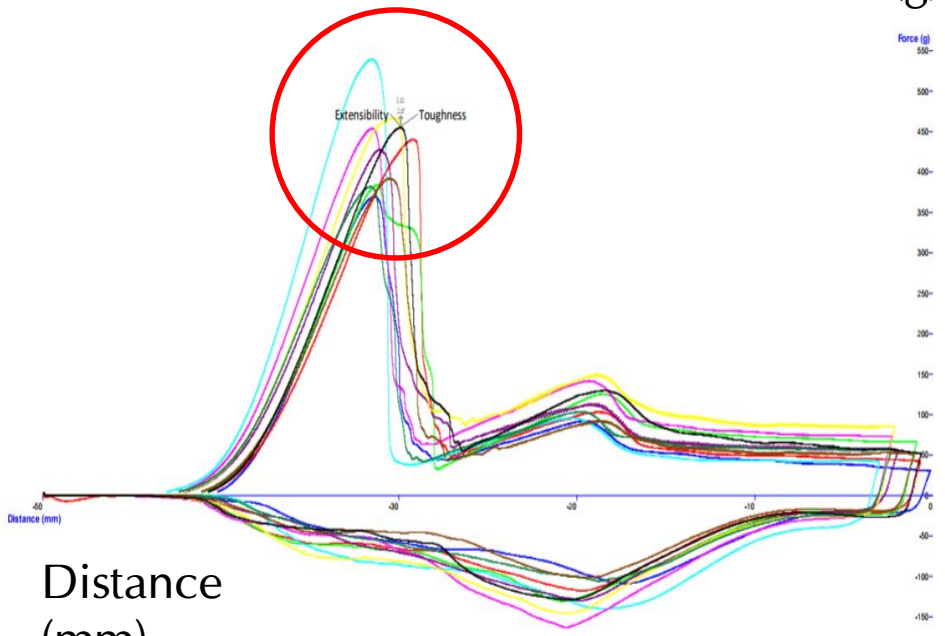
Normal Gluten quality: 30-80%

Strong Gluten quality: >80%

Texture Analysis



Force (g)



Distance (mm)

Source:
http://www.foodtechcorp.com/bakery

Predictors of a good quality flour for tortilla making:

1. High water absorption 60-63%
2. Relatively short mix time 4-6 minutes
3. Medium mix stability 10-20 minutes
4. Medium elasticity
5. Good extensibility during hot press.
6. Flexible during shelf life
7. Strong puncture resistance and good rollability
8. Best predictor is……..

Best Flour Test of All……..

Bake with it!

Resources for Information and Testing Services

California Wheat Commission (provides bakery lab services): www.californiawheat.org

Plains Grain Inc (Plains HRW marketing non for profit): www.plainsgrains.org

Washington Grains Commission (state agency): www.wagrains.org

Tortillas Wheat Flour and Corn Products by Rooney, L.W. and Serna-Saldivar, S.O., AACC International Press, 2015

Baking Science and Technology Volume 1, by Pyler, E.J. and Gorton, L.A., Sosland Publishing, 2008

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