Wheat

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Contents:

Photo 1: Golden Wheat
Source: Dudua 2006

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1) General Information

A. Scientific Classification

Table 1: Scientific Classification of Wheat

Kingdom	Plantae	Plants
Subkingdom	Tracheobionta	Vascular Plants
Superdivision	Spermatophyta	Seed Plants
Division	Magnoliophyta	Flowering Plants
Class	Liliopsida	Monocotyledons
Subclass	Commelinidae	
Order	Cyperales	
Family	Poaceae	Grass Family
Genus	*Triticum*	Wheat
Species	*Triticum aestivum*	Common Wheat

Source: USDA National Resources Conservation Service 1996

Table 2: Classification of Wheat Varieties

Common wheat	*Triticum aestivum*

Einkorn wheat	*Triticum monococcum*
Emmer and Durum wheat	*Triticum turgidum*
Bread wheats	*Triticum aestivum*

Source: International Starch Institute 2001

Wild einkorn wheat is the primary ancestor for every variety of wheat found today as well as most other varieties of barley and rye (Smith 603). Wild einkorn, a very distinct species of wheat, contains 14 chromosomes (Katz 527). This allows for a great range of evolutionary adaptations, all of which are very similar in genetic makeup. Therefore, botanists mostly rely on morphological characteristics to identity different wheats (Kipel and Kriemhild 165). Today, with over 30,000 varieties of wheat world wide, physical classification has become complicated due to their extremely close similarities (Kipel and Kriemhild 1878).

B. Etymology

The word "wheat" is derived from many different locations, specifically from English, German and Welsh languages. Middle English *whete* evolved from Old English term *hwæte*. Similarly, the old German term *weizzi*, wheat, evolved from *hwīz* and *wīz*, meaning white (Merrian-Webster). The Welsh term *gwenith*, wheat, is very closely related to *gwenn*, meaning white. Wheat is most commonly defined by all cultures as "that which is white" due to its physical characteristics of light colored crops (Harper).

C. Botanical Description

Wheat is a tall, annual plant with a height ranging from two to six feet in early varieties. The plant is made up of leaves surrounding a slender stalk that terminates in spikes, or ears, of grain at the top of wheat (International Starch Institute). Each spike, ear, of grain is made up of spikelets, which encloses the wheat grain in between the lemma and the palea. The wheat grain is in the shape of an oval and is what gives wheat its nutritional value. The grain may also vary in its length of brush hairs, either long or short. Cultivated wheat is most commonly grown with physical characteristics of fusiform spikes, are awned (bearded) and are easily threshed (McKevith 114). Domestic wheats are also bread for strong seed heads which will not shatter during processing (Katz 527).

Photo 2: Head of a Moscow Wheat Stalk
Source: Megan Pru, 2006

Each of the three major categories of wheats, hard, soft and durum, have slight variations in their botanical descriptions. Hard wheats contain hard, small wheat kernels while soft wheats contain larger, softer kernels. Durum wheats are completely different than both hard and soft wheats. Its kernels are much larger and is has a unique shape than the other wheat varieties (Eborn).

D. Early American Wheat Varietals

The varietals that were most significant in American cultivation were, in order of appearance, Red May, Mediterranean, Fultz, Fife, Marquis, and Turkey Red. Red May, or the "American King of Wheats," was believed to be introduced by Columbus on his 1493 voyage (Colwell 67). It was an unspecialized wheat, neither spring nor winter, and has evolved to what is currently known as a soft red winter wheat (Colwell 68). Mediterranean was a foreign wheat that was introduced in 1819. This variety was specifically important for its resistant to the Hessian fly, which had begun to destroy red wheat amongst New England farms (Colwell 69). Flutz was the first descendant of Mediterranean and first originated in Pennsylvania around 1862.It grew free of barbed awnes and made heavier yields with stronger stalks. It quickly became the most commonly grown soft read wheat variety across America; however, was eventually replaced by later descendants (Colwell 70). Fife and Marquis were two "miracle" wheat varieties. The Fife variety was introduced to North America in 1860 from Canada. David Fife, a Scotland native, developed the variety to withstand the harsh weather conditions of Canadian winters. This variety became extremely popular in America, and was its major spring wheat variety until early in the twentieth century. Canadian farmers also introduced Marquis in 1913, which matured earlier and yielded more bushels than Red Fife (Colwell 71-72). Lastly, Turkey Red is known as the most famous wheat of all. It was believed to be introduced around 1870 by German immigrants to Kansas. Famous for growing in almost all conditions, "despite great obstacles" (Colwell 74), its popularity continued until Kanred, its first competitor which was slightly superior, was introduced in 1906.

2) Nutritional Aspects

The nutritional value of wheat is addressed through its macronutrient and micronutrient components. These groups consist of carbohydrate, proteins and lipids, for macronutrients, and vitamins, minerals and phytochemicals for micronutrients.

First to macronutrients, grains consist of approximately 75% carbohydrate (McKevith 124), and therefore many believe that the importance of carbohydrate and fiber within wheat takes precedence over their concentrations of vitamins, minerals, and phytochemicals (Basey 79). Carbohydrates are categorized into "good carbs" and "bad carbs," the difference between them being rates of fiber digestion. "Good carbs" are unrefined complex carbohydrates, such as whole grains, and have a very slow rate of fiber digestion, delivering a slow, steady rate of glucose to the blood, creating a feeling of full-ness. Refined complex carbohydrates, such as white flour and white pasta, are known as "bad carbs." These have a very fast rate of fiber digestion, which leads to a feeling of hunger soon after a meal. This is where the idea of "low-carb" diets originated, believing that eating no carbs would help to eliminate the amount of "bad carbs" being consumed (Basey 81).

The second major macronutrient within wheat is protein, the most concentrated being gliadins and glutenins. However, these proteins are still in relatively low amounts and therefore, essential amino acids must be supplied from another source of the diet (McKevith 124). Lastly, lipids are a very minor component, only consisting of about 1-3% within wheat (McKevith 125).

Unlike macronutrients, micronutrients are not as concentrated within wheat and therefore cannot be compared within their percentages. They do, however, serve an extremely important purpose to the human body, specifically in their roles of promoting health and preventing disease (Basey 79). The most significant vitamins found within wheat are B, specifically thiamin, riboflavin and niacin, and E (McKevith 125). The dominant mineral found in all wheat is potassium, however, in whole grain wheat, iron, magnesium, manganese and zinc are also found in high concentrations (*Wheat Germ* 8). Lastly, the most interesting micronutrient found within wheat are phytochemicals or plant bioactive substances. Research has shown that these substances many have many health promoting effects, similar to antioxidants, which are extremely beneficial to disease prevention (McKevith 126-127).

Although all wheat contains the majority of these nutrients, wheat germ is believed to be the most nutritional part of the wheat plant. Wheat germ is what makes up whole-wheat products, consisting of only whole-wheat flour (Bliss 16). The reason why "whole-wheat" products are greatly valued is due to the processing of the wheat. Refined wheat products, white bread and white pasta, have the germ and bran removed from the flour giving it a lighter or "whiter" coloring. Since wheat germ is the "small inner part of the wheat kernel that is a concentrated source of nutrients" (Bliss 16), removing the germ and bran is essentially removing the core or "heart" of wheat's nutrients (*Wheat Germ* 8). Research has also shown that wheat germ may help to decrease the body's absorption of dietary cholesterol and may also inhibit the growth of some cancers (*Wheat Germ* 8).

Nutritional Value of Refined Wheat: Compared to Whole Wheat

- -Calorie content increases 10%
- -66% of Vitamin B has been removed
- -70% of all minerals have been removed
- -79% of fiber has been removed
- -19% of protein has been removed

These numbers come from the flour refinement process in which most nutrients, other than carbohydrates, are removed. Therefore, white flour is very nutrient poor and resembles nothing of the original born wheat (Durtschi).

The three major categories of wheats, hard, soft and durum, have a great variety in their nutritional aspects, specifically in their protein levels. Hard wheat typically has high protein and gluten levels which make it particularly useful for bread making. Bread making requires a 12% protein level and specific varieties of hard wheat can contain up to a 16% protein level. Soft wheats contain a 9-11% protein level, making them ideal for making pastries and cakes. Durum, although containing high levels of protein, does not contain the type of protein needed to form a strong gluten and therefore, is used to make pasta and is commonly referred to as "macaroni wheat" (Eborn).



Photos 3, 4, and 5: Wheat Bread (Hard), Cupcakes (Soft), and Macaroni (Durum)
Source: double.reed 2007 Source: QuintanaRoo 2006 Source:Ciokkolata 2007

Another important factor within wheat is their level of gluten. Bread wheat, primarily hard wheat, has the highest level of glutenin and gliadin which, when moistened and kneaded, combine to create gluten. Gluten provides a network of fibers that traps carbon dioxide and steam, allowing for a light, porous break by creating small pockets during baking (Smith 603). Although it is a major component of all wheat, gluten can lead to a very serious food allergy known as celiac disease (Kipel and Kriemhild 1013).

3) Cultivation

A. Climate Requirements

Wheat, like most grains, thrive in cool climates and tends to do poorly in warm, humid climates, which often ruins the crop through disease. Although wheat prefers cool climates, they do not grow as far north as heavier grains, such as rye and oat (Kipel and Kriemhild 1878). The growing period of wheat lasts approximately 90 days and requires little attention other than a period of dry, sunny weather (Katz 530). Wheat also ideally requires land free of competition, which could draw its water supply and potentially block sunlight; however, it is known for readily growing in the presence of weeds (Kipel and Kriemhild 168).

B. Soil Requirements

Domesticated wheats require nitrogen-rich soils, infused with inorganic materials, such as potassium, lime, and phosphoric acid (Katz 531). In contrast, wild wheats, such as einkorn and emmer, are poor competitors in nitrogen-rich soils, and prefer clay soils (Kipel and Kriemhild168). Wheats are easily cultivated due to their ability to grow in regions of sparse rainfall, for their roots have the ability to take up nutrients from dry upper soil as long as they have access to moist lower soil (Bowden, Ma, and Rengel 308). Another function of their roots, which makes wheat particularly adaptable to drought and nutrient deficiency, is the ability to extend their roots into deep soil to gain access to nutrient-rich patches which would be normally unreachable (Bowden, Ma, and Rengel 307). Wheat, including other grains, can also tolerate high levels of copper and zinc, making them very stable crops (Gupta and Kalra 2510).

3. Global Wheat Harvest

Wheat has the ability to be produced at any time of the year, making it a perennial plant. This is due to wheat's unique capability to be seeded anywhere from sea level to elevations of 10,000 ft, and can grow in any temperate climate world wide (Katz 530).

Table 3: Perennial World Wheat Harvest

Month	*Country/Countries*
January	Argentina, Chile, Australia, New Zealand
February	Egypt, India
March	N/A
April	Egypt, Asia Minor, Mexico
May	Algeria, Central Asia, China, United States
June	Turkey, Spain, France, United States, Italy
July	Romania, Czech Republic, Slovakia, Austria, Russia, Germany, Switzerland, France, England, Denmark, Poland, US, Canada, Italy
August	Holland, Belgium, England, Denmark, Poland, US, Canada
September	Scotland, Sweden, Norway, Russia
October	Scotland, Sweden, Norway, Russia
November	Peru, South Africa
December	India, Argentina

Source: Katz 531

4) Origin and Geographic Distribution

A. History of Cultivation and Distribution

The development of agriculture arose 10,000 years ago, as a shift from the hunter-gather mode to a more domesticated system which allowed for the growth and development of permanent civilizations. Through selective gathering or deliberate cultivation, humans were able to domesticate common varieties of wild wheats, most likely wild emmer or einkorn. With time, the process of preparing soil, sowing seeds, and eliminating competing plants helped fuel the great success of wheat production, shown today though the ability to process, store, cultivate and trade grain world-wide (Kipel and Kriemhild 160, Katz 527).

The debate over wheat's origin has never been fully resolved, and although the region of greatest development seems to lie in the eastern region (Mediterranean to Asia), it cannot be determined whether wheat stemmed from the Far or Near East. Two scientists in particular have aided to this debate, and through research, have helped to discover the origin of this grain. Nikolai Vavilov, a Russian botanist, studied the diversity of wild wheats in South East Asia. From his research on gene pool of wild wheats and barley, he concluded that this region is the ancestral homeland of wheat, for where diversity is greatest so must be the point of crop origin, fixing mutations and inbreeding. In contradiction, Robert Braidwood, an archaeologist from the University of Chicago, claimed the Near East of the Mediterranean must have been the birthplace of wheat. His studies focused mostly on the modern ecological range of wild wheats, reasoning that the first wheat farmers chose to "settle in" to these regions due to the great variety of wild wheat that allowed them to successfully adapt both culturally and ecologically (Kipel and Kriemhild 160). The conclusion of this study resulted in the determination of wheat origin within a geographic range known as the Fertile Crescent, whose core is within central Asia and extends to northern Africa through the Mediterranean (Katz 527).

The development of agriculture and cultivation of wheat occurred approximately 9,000 to 10,000 years ago (Katz 527). Wild einkorn, the most common variety of wheat prior to the Neolithic revolution, led to the evolution of wild emmer by crossing with wild goat weed. Emmer is the oldest cultivated variety of wheat, grown as early as 8700 B.C.E. in ancient Turkey, and quickly spreading to Mesopotamia, Egypt, Rome and Greece (Kipel and Kriemhild 159). During these prehistoric times, the cultivation of wheat increased rapidly, extending to North Africa, and the Indus valley of northern India by 4000 B.C.E. northern China by 3000 B.C.E. and western Europe by 2000 B.C.E. Wheat was introduced the New World by the Spanish, and eventually reached America by the early 17th century though English settlers in the North American Colonies (Smith 603). Currently wheat is globally produced and traded amongst all nations. Refer below to tables 4 and 5.

Table 4: Top Importers of Wheat from 1995-1997

Country	*Amount Imported (millions of tons)*
China	9.0
Belarus	6.9
Brazil	6.8
Thailand	5.8
Indonesia	4.3
Mexico	1.5

Source: www.CIMMYT.org, May 2002

Table 5: Top Exporters of Wheat in 2000

Country	*Wheat Production*	*Exports (millions of tons)*
United States	69.4	31.9
Canada	29.0	19.2
Australia	21.6	17.6
European Union	104.2	16.5
Argentina	12.3	12.5

Source: U.S. Wheat Associates, 2000

B. Medical

The major medical disease affiliated with wheat is celiac disease, which is an allergic response to gluten, a major compound found within most grains (Katz 117). Also known as celiac syndrome or gluten-sensitive enteropathy, major symptoms include diarrhea, gastrointestinal distress, feelings of wasting for adults and a failure to grow in children. Research by Dutch physician W.K. Dicke at the end of the 1940s showed that the ingestion of wheat resulted in the damage of the intestinal mucosa and absorptive cells, or enterocytes, which line the interior surface of the intestine. This led to the gastrointestinal symptoms as well as long term effects of malabsorption because the damaged enterocytes are responsible for absorption of all major nutrients.

The origin of disease has yet to be fully understood, however, it is believed to be due to a number of interrelated factors, including, human evolution, evolution of wheat, evolution of protein structures unique to wheat, and evolution of culture. These evolutions combined with the development of agriculture and cultivation of wheat may have caused the negative response to gluten (Kipel and Kriemhild 1008). This allergy is prevalent world-wide, even more so in countries that have just recently been introduced to wheat (Katz 177). Specifically in the United States 1 in 5,000 Americans have or will develop the disease. Currently the only known cure is

the elimination of wheat, barley, rye, and other grains from the diet, all of which have high levels of gluten.

C. Culinary

Historically

Women were primarily responsible for the preparation and cooking of wheat, being careful to select the heads of wheat with the largest grains for those were easiest to separate from their hulls (Katz 527). During this time, prior to the Neolithic revolution, the primary variety of wheat, which grew wild, was einkorn.

As cultivation continued to expand, so did the culinary use of wheat. The Ancient world developed many ways to extend wheat to both food and drink. This included porridge, noodles, breads and ales. Specifically, the production of bread is thought to be the creation of ancient Egyptians, who discovered that gluten in wheat allows bread to rise. At the same time, people in Ancient Mesopotamia were creating an entirely new use of wheat by patting them into flat disks, wrapping them in leaves, and burying them in hot ashes. This discovery was the first development of the "flat bread" (Smith 603).

Table 6: Regional Uses of Wheat (Historically)

Region	*Use*
Mediterranean	Flatbread Pita
India	Chapati
Asia	Noodles
Africa	Couscous

Source: Smith 603

Today

Wheat is the most widely produced and consumed cereal grain in the world (Katz 527). Its popularity arises from its large range of uses, extending from breads, pastas, cereals, pastries, cakes, and beers. This large range of uses comes from the high gluten level within wheat, which traps air as the product is cooked. This unique ability is often adopted by rye and oats, which do not develop significant levels of gluten, by combining wheat flour with their flours (Smith 116). The first cold cereals, or "modern convenience foods", used whole-wheat flour in and was produced in 1863 (Smith 199). Wheat beer is primarily produced in Bavaria, Belgium, and Northern Germany, and is made from a mixture of malt and crushed grain (Smith 116).

Table 7: Classification of Hard, Soft and Durum Wheat

Hard Red Winter	**Hard Red Spring**	**Soft Red Winter**	**Durum**	**Hard White**	**Soft White**
High in protein, strong in gluten. Used for yeast breads, hard rolls.	High in protein for use in yeast breads and hard rolls.	Used for flat breads, cereal, cakes, pastries and crackers.	Used for macaroni and other pasta.	Used for yeast breads, hard rolls and noodles.	Used for flat breads, cakes, pastries, cereal, crackers and noodles.

Source: The Wheat Food Council 1996

D. <u>Wheat and the Development of Social Hierarchy</u>

Another interesting effect that wheat has had on cultures is its use within social hierarchies. At the beginning of its cultivation and production, the value of wheat was defined by its color, white (refined) or dark (unrefined), its consistency, fine or crass, and its availability within society. White, fine wheat was originally considered a very prestigious food and was eaten only by higher classes within society, including British Isles, Dutch Republic, southern Europe and Scotland (Kipel and Kriemhild 1220). However, with time, the consumption of wheat changed and both types, white and dark, became available to all groups of society. Specifically, within Scotland, wheat became a symbol of successful farming for it was eaten by lower classes on special occasions, such as harvesting (Kipel and Kriemhild 251). In southern Europe, only the whitest wheat flour was used for nobility while bran was crass and only eaten by laborers, for white wheat was considered the most prestigious and the healthiest form of wheat. However today, it is known that bran is actually the healthiest and now all classes consume the same variety of wheat products (Kipel and Kriemhild1208).

5) History in Early 19th Century America

American wheat cultivation and production went through a complete transformation in the early 19th century. Specifically, the inventions of industrial tools increased crop yield while lowering the cost of production. Prior to these inventions, wheat was originally cultivated by hoe and harvested by sickle/sythe both of which were very time consuming and extremely labor intensive. The cultivated wheat was then stored in woven baskets and delivered to market by wagon (Boehm and Sayler). However, creations of the reaper, steel plow and thresher quickly eliminated the old time-consuming processes through their new innovative technologies.

Photo 6: Some Old Sickles
Source: net_efekt 2006

Beginning in 1834 with Cyrus McCormick's invention of the reaper, the industrialization of wheat was not only extremely beneficial to farmers, but also prompted the increase of Midwestern wheat production (Smith 604). McCormick's reaper replaced the existing system of

hand cutting wheat with sickles and scythes, allowing for a much faster collection of wheat. John Deere followed three years later in 1837 with the invention of the steel plow, replacing the iron plow. Steel is much lighter than iron, and therefore allowed for easier and faster plowing. Deere's plows became so popular, that in 1846 he opened the first industrial plow factory, which also aided in the increase of Midwestern wheat production. The third invention that played a major role in 19th century wheat farming was the thresher. Developed by A.H. Pitt in the 1830s, the thresher could produce about twenty-five bushels of wheat per hour, allowing for quick and easy processing (Smith 604).

Photo 7: A modern day reaping machine located in Shorthampton, Oxfordshire
Source: Robert Silversmith, 2007

In addition to the influence of industrialized inventions, another contributor in the increase of wheat production was due to the construction of transportation across the United States. Specifically, the development of canals and westward railroads allowed easier access for wheat farmers to grow and sell their products (Smith 605). Two other factors which attributed to wheat growth were the Homestead Act of 1862 and the push of wheat out of New England and into the Midwest. This push was compensated by the increased production of dairy, vegetables and tobacco throughout the east coast (Boehm and Sayler). The Homestead Act encouraged this shift by allowing all American citizens the opportunity to file for 160 acres of free land, west of the thirteen colonies, for a very small fee (Kramer). Throughout the reminder of the 19th century, the "chief wheat states" underwent a number of changes, slowly moving from the Northeast into the prairie land of the Midwest (Boehm and Sayler). Overall, the states who have contributed the most to wheat production are Ohio, Indiana, Illinois, Wisconsin and Iowa, which contributed 25% of America's wheat in 1839 and 50% of America's wheat in 1859 (Smith 605). Today, America's wheat belt reaches north from Texas through Oklahoma and east from Washington to central Montana (Smith 607).

Table 8: US Wheat Movement

Date	Movement
1840	New York, Pennsylvania, Virginia and Ohio are primary

	wheat states
1844-1855	Commercial wheat and corn belts begin to develop
1860-1865	Wisconsin, Indiana and Illinois are primary wheat states
1870-1885	Wheat belt moves across Mississippi river, influenced by increase in corn production
1910-1921	Wheat production has reached all areas of the Plains

Source: Boehm and Sayler

Lastly, to end the 19th century of wheat industrialization, the United States Department of Agriculture began testing the quality of wheat being produced. However, without any defined legislation the classification of wheat became very subjective, using very ambiguous scales to measure its value, such as wet or dry, clean or dirty, and good or bad. Therefore, in 1916, the U.S. Grain Standards Act was passed, which created precise terms to describe wheat quality and classification (Boehm and Sayler).

New York State

Specifically, in New York State, wheat was the chief product of the early colonies. Its cultivation began on Long island, but quickly moved onto river flats of the Hudson once the soil became exhausted. From here, wheat traveled through the Mohawk and central New York, until its final site at the Genesee Valley. For the following decade the Valley adopted the nick-name "Granary of the Country" due to the high amount of wheat production. (Hedrick 332). New York State primarily grew winter wheat varieties until the mid 1830's, when an infestation from the midge and Hessian fly forced farmers to grow spring wheats (Kelsey 5). From this point on winter and spring wheat were grown in equal ratios. The high yield of wheats placed New York, along with Pennsylvania, as the leading state for wheat cultivation for the first half of the nineteenth century. However, this changed once railroads and the Erie Canal were created, for they transported cheaper wheat from the mid-west and therefore became the primary site of wheat production (Hedrick 332).

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