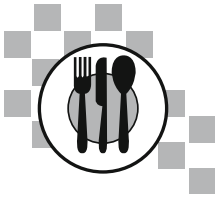
Grains

6



Introduction

Throughout the world, there is a great variety of types and amounts of grain products that are selected to be consumed by individuals. The World Health Organization (WHO) and many countries including the United States stress the *nutritional* importance of grains as a foundation of a good diet.

From a *culinary* point of view, consumers see a great variety of grains included in menu offerings—from soups and salads to desserts. Grain consumption has risen substantially in popularity due in part to a committed number of Americans making more nutritious food selections. Specific grain choices may be based on food intolerances or allergies.

In this chapter the physical and chemical properties of grains are addressed. The variety of cereals, milling, type of flours used in bread making, pasta products, safety, and nutritional value are presented. Further discussion of quick breads, yeast breads, the functions of various added ingredients, and details of gluten appear in the chapter on Baked Products.

Cereals Definition

Cereal is a cultivated *grass*, such as wheat, corn, rice, and oats, which produces an edible *seed* (grain or fruit). By definition, ***cereal*** comprises all the cereal products prepared from grain, not merely cold, sweetened, boxed breakfast cereal! Depending on the composition, the cereal crops may be *processed into various items* such as the following:

- **Bread**, using flour or meal from various grains (Chap. 15)
- **Cereal**, ready-to-eat, or cooked breakfast cereal varieties; such as oatmeal
- **Oil**, from germ processing (Chap. 12)
- **Pasta**, a dried paste of various flours (and perhaps legumes, herbs, and spices)
- **Starch**, from the starchy component of endosperm (Chap. 4)

When stored *properly*, and thus protected from adverse environmental impact, insect, and animal pests, grains are extremely resistant to deterioration during storage, especially when compared to the perishable dairy, eggs, meats, or fruit and vegetable crops. Grains are utilized extensively in developing and *less* affluent countries where animal products are either not available or not used. In *more* affluent countries, many varieties of grains and whole grains, processed ready-to-eat (r-t-e) breakfast cereals, cereal bars, and so forth are routinely consumed along with animal products.

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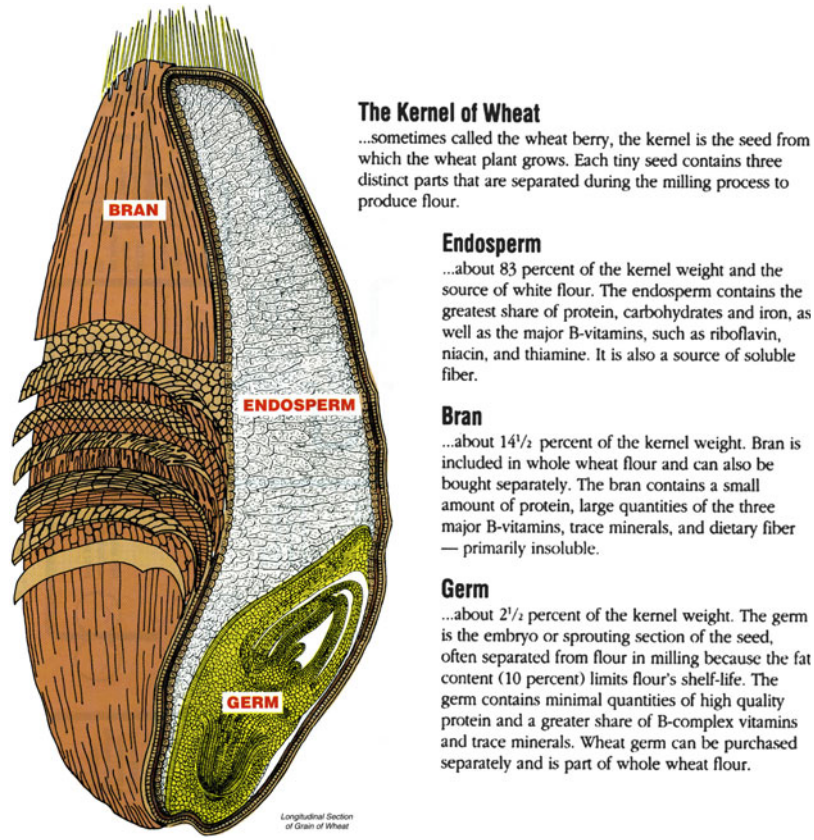


Fig. 6.1 Structure of a wheat kernel (*Source*: Wheat Foods Council)

Structure of Cereal Grains

The structure is similar in all grains. Each kernel of grain is composed of three parts: the *germ*, *endosperm*, and *bran*, and if *all* are present in a grain, it is a *whole grain*, such as whole wheat. When the bran and/or germ of the seed are removed or separated from the kernel in milling, a product is no longer "whole grain," however *refined* (Fig. 6.1). Most likely, these two terms are familiar to the reader. It is recommended by the USDA to "make half your grains whole." That advice also appears on many grain-based food products available to the consumer, such as whole grain crackers and cereals. Actual whole grain content is made available on Nutrition Facts and the Ingredients labels.

The ***germ***, or embryo, is the *inner* portion of the kernel—located on the lower end. It composes approximately 2.5 % of the seed and is where sprouting begins as the new plant grows. The germ is the kernel component with the highest percent lipid, containing 6–10 % lipid. Rancidity may result from either the lipoxidase *enzyme*, or *non-enzymatic* oxidative rancidity.

Due to this possibility of rancidity, a whole grain product may either undergo germ removal or include antioxidants such as BHA or BHT (see Additives, Chap. 18). The germ contains approximately 8 % of the kernel's protein and most of the thiamin.

Another structural part of the kernel is the ***endosperm***. It represents the greatest percentage of the kernel and is primarily starch, held as part of a protein matrix, with an exact composition that differs among grain types and varieties.

Regardless of the grain type, wheat, corn, or another grain, the endosperm is the seed component *lowest* in fat, containing *less* than the *germ*, with up to only 1.5 % of the lipid of the seed. It is also *lower* in fiber than the *bran*. The endosperm makes up approximately 83 % of the seed and has approximately 70–75 % of the protein of the kernel

Specifically regarding wheat—certain varieties or types of wheat may be carefully specified for use in various food products in order to ensure success in baking or cooking. Wheat bakes and functions differently depending on the type of wheat that is utilized. For example, wheat may be a *soft* or *hard* type, with the soft wheat variety containing more starch and less protein than hard wheat. The composition makes a difference as shown later in this chapter.

The *third* major component of a grain in addition to the germ and endosperm is the ***bran***. It is the layered, outer coat of a kernel and consists of an *outside* pericarp layer, offering protection to the seed, and an *inside* layer that includes the seed coat. The bran is often removed by abrasion or polishing in the milling process and may be used in many foods or animal feed. It is approximately 14.5 % of the seed and contains 19 % of the protein, 3–5 % lipid, and minerals such as iron.

Bran provides *cellulose* and *hemicellulose* that are both fiber or "roughage" in the diet. Yet, functionally, the individual bran may differ among grain types and varieties. For example, *wheat bran* includes an *insoluble fiber* that functions chiefly as a stool softener. *Oat bran* is a soluble fiber that functions among other ways, to reduce serum cholesterol.

If wheat is devoid of the bran, and germ, only the endosperm remains, and that is the component used in making white bread.

Composition of Cereal Grains

In *structural* composition, the various grains each contain three parts and thus the grains are similar; however, they vary in their *nutrient* composition, with each grain containing different amounts of carbohydrate, fat, protein, water, vitamins, and minerals (Tables 6.1 and 6.2). The main nutrient component of cereal grains is **carbohydrate**, which makes up 79–83 % of the dry matter of grain. It exists predominantly as starch, with fiber especially cellulose and hemicellulose, composing approximately 6 % of the grain.

Lipid (fats and oil) makes up approximately 1–7 % of a kernel, depending on the grain. For example, wheat, rice, corn, rye, and barley contain 1–2 % lipid; oats contain 4–7 %. The lipid is 72–85 % unsaturated fatty acids—primarily, oleic acid and linoleic acid.

Protein composes 7–14 % of the grain, depending on the grain. Cereals are low in the amino acids tryptophan and methionine, and although potential breeding may produce cereals higher in the amino acid *lysine*, it remains the *limiting* amino acid in cereals.

Grain consumption provides half of the protein consumed worldwide. However, in comparison to animal foods such as milk, meats, or eggs, grains from plants do *not* include all the essential amino acids contained in animal protein. Grains are not complete proteins. In fact, the protein is of *low biological value*, and therefore, less efficient in supporting body needs.

Combining the various food sources of protein is common in cultures throughout the world. For example, the preparation of traditional dishes combines the lower biological value grains with *legumes* or *nuts* and *seeds* to provide the needed amino acids to yield a *complete* dietary protein. In particular, combining beans with rice, or beans with cornbread; combining tofu and vegetables, or tofu and cashews, or eating chickpeas and sesame seed paste (tahini) known as hummus, or peanut butter on whole wheat bread, and so forth are put together (eaten in combinations) creating complete proteins. (Botanically, each of these grains, legumes, nuts, and seeds are *fruits* of a plant.)

CULINARY ALERT! All "flour" used in a recipe is not created equal. High protein or "hard" flour absorbs more water than low protein "soft" flour. Therefore, finished products using assorted "flour" will differ. The recipe

Table 6.1 Typical percent composition of common cereal grains (100 g)

Grain	Carbohydrate	Fat	Protein	Fiber	Water
Wheat flour	71.0	2.0	13.3	2.3	12.0
Rice	80.4	0.4	6.7	0.3	12.0
Corn meal	78.4	1.2	7.9	0.6	12.0
Oats, rolled	68.2	7.4	14.2	1.2	8.3
Rye flour	74.8	1.7	11.4	1.0	11.1
Barley	78.9	Trace	10.4	0.4	10.0
Non-cereal flours					
Buckwheat flour	72.1	2.5	11.8	1.4	12.1
Soybean flour, defatted	38.1	0.9	47.0	2.3	8.0

Source: Wheat Flour Institute

Table 6.2 Vitamin, mineral, and fiber content of wheat flours (100 g)

Flour	Thiamin B_1 (mg)	Riboflavin B_2 (mg)	Niacin B_3 (mg)	Iron (mg)	Fiber (g)
Whole wheat flour (whole grain)	0.66	0.14	5.2	4.3	2.8
Enriched flour (enriched)	0.67	0.43	5.9	3.6	0.3
White flour (refined)	0.07	0.06	1.0	0.9	0.3

Source: Wheat Flour Institute

must specify flour type and users must plan usage accordingly in order to ensure product success.

Significant proteins in some grains such as wheat, rye, and barley are *gliadin, secalin, and hoirdein*, respectively. To the extent that these proteins are present, flour has ***"gluten-forming potential."*** Then, with subsequent and sufficient hydration and manipulation these proteins form a gummy, elastic ***gluten*** structure (Chap. 15). *Wheat* contains both gliadin and glutenin proteins that contribute desirable strength and extensibility to the yeast dough, in bread making. Other flours without these two proteins cannot rise sufficiently, even with the use of yeast because there are no gluten stands to trap the yeasts' air and gasses.

CULINARY ALERT! Knowing that gluten may be an allergen, some individuals must follow a gluten-free diet.

CULINARY ALERT! Gluten-forming flour is high protein. Yeast is a good leaven to slowly fill the gluten structure as it readily stretches. Non-gluten-forming flour contains less protein. Baking powder and baking soda that bubble up immediately are good leavens for non-gluten-forming flour.

An additional protein, the enzyme α-amylase, is naturally present in grains and promotes dextrinization of starch molecules to shorter-chain polymers, as well as the sugars maltose and glucose. The action of α-amylase may thin starch mixtures or be detrimental to the bread-making industry, yet it is often added in the form of malt so that there is sugar to feed yeast.

In this section on proteins in grains, we have seen that worldwide, grain consumption is common, as is one grain used in combination with other grains.

For a number of nations, just *having* grains is an important issue. For other more affluent and mobile nations, a Baker may *have* sufficient grain and have concerns instead about the *baking* properties of the grain. In this latter case, for example, the chef might be concerned, not about shortages, though rather about functionality of the flour. The fact is that wheat flours *high* in protein absorb a lot of water, while *low* protein flours do not absorb much. This can mean a dry or a soupy mixture, and perhaps unsatisfactory finished foods. Armed with a knowledge of flour differences, an experienced

baker knows that recipes that work for them in one region of the country may not work in another, and that all "flour" is not created equal!

Vitamins present in cereals are predominantly the B vitamins—thiamin (B_1), riboflavin (B_2), and niacin (B_3). These vitamins may be lost in the milling process andso are added back through the process of ***enrichment***. Today, there is less prevalence of the once deadly diseases beriberi and pellagra, due to cereal enrichment with thiamin and niacin, respectively (Table 6.2). Whole grain products contain some fat-soluble vitamins in the germ.

Minerals are *naturally* present at higher levels in *whole* grains than in *refined* grains. ***Fortification*** of refined flour with added iron (Table 6.2) is common. Zinc, calcium as well as vitamins may also be added at *levels beyond/not present in the original grain*.

Water is present in cereal grains at levels of 10–14 % of the grain. Of course soaking and cooking add water to cereal grains, and the grain size expands as additional water is absorbed. If a flour is *high* in protein content, it absorbs *a lot* of added water compared to *low* protein flour.

Fiber content is measured by *crude fiber* (CF) and *total dietary fiber* (TDF). These two measurements are *not* correlated. CF is composed of *cellulose* and the non-carbohydrate *lignin*. TDF includes cellulose and lignin, *plus hemicellulose, pectic substances, gums,* and *mucilages*.

Common Cereal Grains and Their Uses

Common cereal grains are noted below. While there is a great variety of cereal grains and their uses throughout the world, the most important and largest cereal grain consumed by man in the United States diet is *wheat*. That will be discussed first. Some wheat is also used for animal feed.

Wheat

Wheat has widespread uses. It may be cracked (bulgur, couscous), made into flour, and breads, cereals, and pasta and is the basis of numerous products that are recognized in diets throughout the world (more later). Some individuals exhibit an intolerance or even an allergy to wheat and its protein (see Gluten Intolerance).

As noted, the wheat kernel (wheat berry) is the most common cereal milled into flour in the United States (see Fig. 6.2). There are over 30,000 varieties of wheat grown in the United States, grouped into the following *major* classifications: hard red winter, hard red spring, soft red winter, hard white wheat, soft white wheat, and durum wheat.

This large number of wheat varieties is named according to several factors—*season planted, texture, and color*.

- Season—wheat is classified as winter wheat or spring wheat. *Winter wheat* is planted in cold seasons such as Fall and Winter and is harvested in June or July. *Spring wheat* is the spring planting and is harvested in late summer or fall seasons.
  (Spring wheat may have a continuous growth cycle with no inactive period. In areas where winters are severe, such as northern North America, wheat is planted in the spring after there is no risk of frost. In areas with very mild winters, such as India or Australia, spring wheat is sown in the autumn and grows through the winter.)
- Texture—wheat is classified as either *hard* or *soft*. *Hard* wheat kernels contain strong protein–starch bonds, the kernel is tightly packed, and there are minimal air spaces. *Hard* wheat flour forms elastic dough due to its *high* gluten-forming protein content and is the best flour to use for bread making. Hard *spring* wheat is 12–18 % protein and hard *winter* wheat is 10–15 % protein.
  Conversely, *soft w*heat is *lower* in protein and is desirable for cakes and pastries.
  Starch-protein bonds in the kernel break down more easily in soft wheat, than hard. (Yet inherent differences in the starch or protein components of hard and soft wheat alone do *not* sufficiently explain the differences in hardness.) Hard and soft wheat may be blended to create all-purpose flour that contains about 10.5 % protein. In the absence

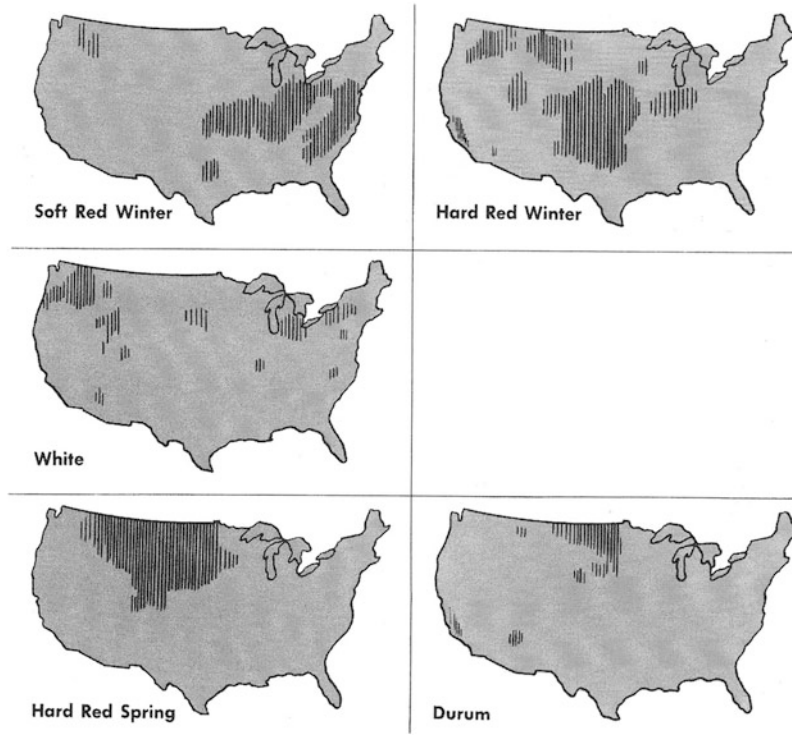


Fig. 6.2 Map showing wheat growth in the United States (*Source*: Wheat Flour Institute)

of pastry flour, "instant" (see below) flour and all-purpose flour may be combined.

- Color—*red, white,* and *amber*. The color of the grain depends on the presence of pigment, such as carotenoid. Durum wheat, for example, is hard wheat and highly pigmented. Its endosperm is milled into ***semolina*** for pasta, and couscous (most spaghetti is made from wheat).

Milling process of wheat. Specific milling tolerances of the ground wheat kernel or 'berry' must meet the Food and Drug Administration (FDA) grades to call the product "flour." When milled, each 100 lb of wheat yields approximately 72 lb of white flour and 28 lb of other product, including animal feed.

The conventional milling process (Fig. 6.3) of wheat first involves washing to remove foreign substances such as dirt or rocks. Conditioning or tempering by adjustment to water level (the addition or removal of water) of the kernel follows in order to obtain the appropriate water content and to facilitate the easy separation of the kernel components. Next, wheat is subject to coarse breaking of the kernels into *middlings*. The breaking process separates most of the kernels' outside (bran) and inside core (germ) from the endosperm. Once the endosperm is separated, it is subsequently ground multiple times in reduction rolls to become finer and finer for flour. As the bran and germ are removed, the refined flour contains streams that contain less vitamins and minerals.

If flour streams of the endosperm are blended during the milling process, various flours are created. *Straight grade* flour is a combination of *all* of the mill streams. Typically, home and bakery operations use ***patent flours*** that are 85 % straight grade flour and the combination of various highly refined mill streams.

Patent flour is the highest grade of flour; hence, the highest in value. *Short-patent* flour, such as cake flour, contains *more starch* in the starch-protein matrix and is produced by combining fewer streams than the *higher-protein*, *long-patent* flour. The remainder of flour, not incorporated into patent flours, is *clear* flour. It is used when color is not of importance, as it is slightly gray.

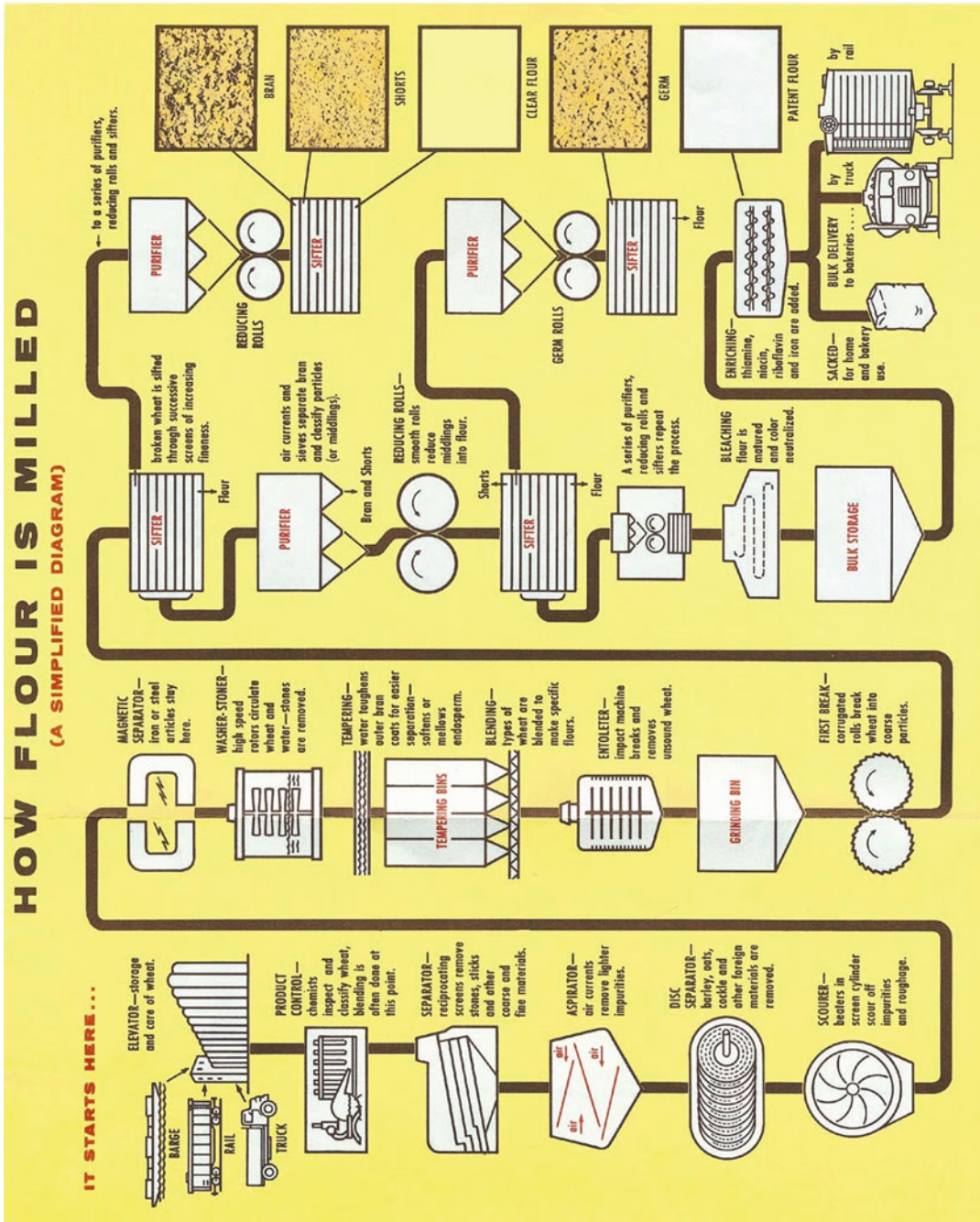


Fig. 6.3 The milling process (*Source:* Wheat Flour Institute)

It is the rule that flours from the *same* mill *vary* in composition from 1 year to the next. Also, the *various* flour production mills may produce slightly *different* flours, depending on such factors as geographic location of the crop, rainfall, soil, and temperature. It follows that this variance of crop year, mill, geographic location, and so forth may produce different baking results. For that reason, food manufacturers (and their Research and Development laboratory) constantly test flour so that variance is minimal or nonexistent. Otherwise flour may produce slightly different finished products. Of course, using *different flours* may produce *disastrous* results!

Additionally, milling produces the less common instant-blending, instantized, or "agglomerated" flour. Instant-blending flour is all-purpose flour that has been hydrated and dried, forming large "agglomerated" or clustered particles, larger than that the FDA approves for commercial white wheat flour. It has a more uniform particle size range than white wheat flour and does *not* readily pack down. Instant-blending flour is easily dispersible in water and is used when dispersibility of flour in liquid is preferred or required. It *mixes* into a formulation or recipe *better than* ordinary flour and is free-flowing, pouring like salt or sugar.

CULINARY ALERT! When a product formulation specifies a particular flour type, and that type is unavailable, the baker may combine various blends of flour to yield the correct flour product and better product results.

Milling (see Fig. 6.3) of various textures of wheat produces some of the following flours.

Hard Wheat: 10–18 % Protein

Bread flour

- It is typically made of hard red spring wheat kernels, with a high protein-to-starch ratio.
- It is capable of holding a lot of water (2 cups flour holds 1 cup water).
- It has a high gluten-forming potential forming a very strong and elastic structure, which can hold the air and gasses of yeast.
- It is not finely milled. Recall that hard spring wheat has a greater protein content than hard winter wheat. ("Gluten flour," milled from spring wheat, may contain 40–45 % protein.)

Hard and Soft Wheat Blend: 10.5 % Protein

All-purpose flour

- Combines the desirable qualities of both hard and soft wheat flour.
- It does not contain bran or germ and is known as white wheat flour, or simply "flour."
- It forms a less strong and elastic dough than bread flour.
- It may be enriched or bleached.

Soft Wheat: 7–9 % Protein

Cake flour

- Contains less protein, and more starch than all-purpose flour, and holds less water (2–3/4 cup holds 1 cup water)
- It is *low* in gluten-forming potential, is highly bleached, and finely milled (7/8 cup all-purpose flour + 2 tablespoons cornstarch = 1 cup cake flour).

Pastry flour

- It maintains intermediate characteristics of all-purpose and cake flour.
  It contains less starch than cake flour, and less protein than all-purpose flour.

Additional flour treatments involve the following:

- **Self-rising flour (phosphated flour)** contains 1–1/2 teaspoons of baking powder and ½ teaspoon of salt per cup of flour (and provides convenience!)
- ***Bleached flour*** is created when the yellowish (mainly xanthophyll) pigment is bleached by oxygen to a white color. Bleaching is achieved (1) naturally by exposure to oxygen in the air (2 or 3 months), or (2) by the chemical addition of either chlorine dioxide gas or benzoyl peroxide, *bleaching agents* which later evaporate. (Yes, even unbleached flour is bleached, naturally!) Bleaching results in finer grain and a higher volume.
- ***Matured flour*** also comes (1) naturally with age or (2) by the addition of *maturing agents*. If matured, gluten elasticity and baking properties of dough are improved because the unwanted effects of excess sulfhydryl groups are controlled. There is less polymerization of gluten protein molecules, and therefore, a less gummy dough (Chap. 20). Not all bleaching agents are maturing agents, yet chlorine dioxide (above) serves as both types of agent.
- ***Organic (chemical-free) flour*** uses grains that are grown without the application of synthetic herbicides and pesticides.

Wheat foods also include bulgur (Fig. 6.4), cracked wheat, and couscous as discussed below.

Bulgur is the whole kernel, i.e., parboiled, dried, and treated to remove a small percentage of the bran. It is then cracked and used as breakfast cereal or pilaf. Bulgur is similar in taste to wild rice.

Cracked wheat is similar to bulgur—the whole kernel broken into small pieces, yet not subject to parboiling. Whole grains should be stored in an airtight container, in a cool, dark place. *Farina* is the pulverized wheat middlings of endosperm used predominantly as a cooked cereal. It is similar in appearance to grits (corn).

Fig. 6.4 Bulgur wheat (*Source*: Wheat Foods Council)

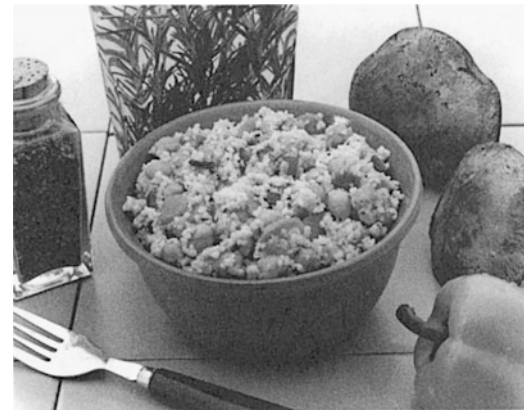


Fig. 6.5 Couscous (*Source*: Wheat Foods Council)

Couscous is a processed form of semolina wheat (Fig. 6.5). It is popular throughout the world, especially in Northern Africa and Latin America. It is often served as a pilaf or as tabouli.

In addition to wheat, other common grains are highlighted in the text that follows.

Rice

Rice is a major cereal grain whose varieties are used as *staple foods* by people throughout the

world. Thus, it may be the *major* aspect of a diet, or as well, incorporated to a *lesser degree* into the main dish, side dish, or dessert. It is commonly used in the preparation of r-t-e breakfast cereals. Rice, and rice flour, is especially important to persons with wheat allergies, or gluten intolerance, and rice is commonly eaten as a 'first food' by infants, as it is food that offers the least cereal allergy.

Rice may be eaten as the *whole grain*, or *polished*, which involves shedding the outer coat of bran. Brown rice contains the bran. Generally, rice is polished during milling in order to remove the brown hull; however, it *al*so removes some of the protein, vitamins, and minerals. When left unpolished, whole rice is *more* subject to rancidity and favors deterioration, as well as insect infestation compared to polished, white rice.

Today, most white rice is enriched with vitamins and minerals, to add back nutrients lost in milling. (Recall, the once-prevalent deadly disease, beriberi resulted from eating polished rice as a staple food. Thiamin removed in the milling process.)

Enrichment (Table 6.3) of rice is common and may be achieved by two primary methods. *One method* is to coat the grain with a powder of thiamin and niacin, waterproof it, dry it, and then coat the grain with iron before it is dried again. *Another method* of enrichment involves parboiling or "converting" rice. This process allows water-soluble bran and germ nutrients to travel to the endosperm by boiling or a pressure steam treatment. As a result nutrients are retained when the outside hull is removed. Following the steaming process, rice is subsequently dried and polished. Optional enrichment may include vitamins such as riboflavin, and vitamin D, and the mineral calcium.

Rice is grown in a variety of sizes. *Long* grain rice (with three times the length as width) is *high in amylose* content. *Medium* and *short* grain rice contain *less* amylose. Rice remains *soft* in hot form; however, leftover rice is hard because the high amylose crystallizes, or hardens as it cools.

It is recommended that rice puddings prepared with leftover rice use *medium or short grain* varieties in the original cooking process since they will contain less amylose and will not be texturally, as hard. The same medium or short grain rice is recommended for use in menu items such as sushi, where the food *should* remain soft and "stick" together.

Table 6.3 Primary nutrients for the enrichment of rice

Nutrient	mg/lb
Thiamin	2–4
Riboflavin	1.2–2.4
Niacin	16–32
Vitamin D	250–1,000
Iron	13–26
Calcium	500–1,000

Amylose content of rice	
Size variety	% Amylose
Short grain	15–20 % (less amylase, more sticky)
Medium grain	18–26 %
Long grain	23–26 % (high amylase, less sticky)

CULINARY ALERT! Short grain rice is *low* in amylose. It is sticky and holds ingredients together. Therefore, in a product such as sushi, short grain, sticky varieties of rice are preferable over long grain rice.

Rice may be modified to allow flavor and aroma variety, very detectable by some palates. "Rice" may even be made from *pasta* such as when macaroni is shaped to resemble rice in products such as RiceARoni®. It may be processed into flours, starches, cereals, cooking wine, or the Japanese wine, sake. Rice "milk´ is commonly available and used. Rice flour is successfully made into items such as low-fat tortillas or noodles. Wild "rice" is actually *not* rice and, however, is derived from seeds of another reed-like water plant.

Numerous research studies have focused on shelf-stable cooked rice, ready-to-eat cereal, confectionery applications, rice oils, and flavored rice. Defatted rice bran extracts, aromatic rice, pregelatinized rice flours, starches, and rice syrups are chosen as food ingredients, depending upon the application. Rice use in a wide variety of foods continues to be common (Pszczola 2001).

Fig. 6.6 Corn taco shells (*Courtesy of* SYSCO® Incorporated)

Corn

Corn is a staple cereal food of many people and nations, although the majority of corn is used for animal feed. It is lacking in the two essential amino acids, tryptophan and lysine, yet research continues to explore the addition of a protein trait to corn DNA

Sweet corn is actually a cereal; however, it is commonly eaten as a vegetable. *Field corn* has non-vegetable uses, including starch that is of value to growers and consumers alike. The whole kernels of special breeds of corn containing 11–16 % moisture are desirable for popcorn where the kernel increases in volume as the water escapes as steam.

- The *whole or partial kernels* may be coarsely ground (perhaps stone-ground) and used to create cornmeal or masa. Cornmeal is popular in cornbread and tamales, corn tortillas, snack foods, and items such as taco shells (Fig. 6.6). It may be soaked in alkali, such as lime (calcium hydroxide) for 20–30 min, for a better amino acid balance and greater protein availability. This soaking process may sacrifice some niacin (vitamin B_3), however it adds calcium.
- The *endosperm* of corn may be made into hominy, ground into grits, or used in r-t-e breakfast cereals or cornstarch. It may be hydrolyzed in hydrochloric acid or treated with enzymes, to produce corn syrup, or high-fructose corn syrup (HFCS) (Chap. 14).
- The *germ* yields corn oil
- Corn and its finished products (corn syrup, etc.) may be allergens to some individuals

Fig. 6.7 Breads may be prepared using a variety of grains (*Source*: Wheat Foods Council)

CULINARY ALERT! For use in bread making, corn needs to be combined with other flour, such as wheat flour, since corn alone yields dense bread. As well, corn does not contain the proteins gliadin and glutenin that form gluten structures.

Other Grains

Other grains, exclusive of the wheat, rice, and corn previously discussed, are *not* abundantly consumed, yet they offer taste variety (Fig. 6.7) and often grow in more adverse environmental conditions where the more common grains will not grow. For some readers, the following grains may be very familiar and frequently utilized. For

other readers, these same grains are *not* used at all or may be relatively unheard of! The seeds are used both as forage crops and as food cereals in different parts of the world.

Barley

Barley is "winter-hardy" and is able to survive in the frost of cold climates. It is used for human and animal consumption. Barley is served as a cooked cereal, or the hull of the kernel is removed by abrasion to create pearled barley, i.e., commonly used in soups. Additionally, although barley may not be eaten as a whole grain, it is incorporated into many foods including breads, pilafs or stuffing, or it may be used for ***malt*** production. Barley is the most common malt as it has sufficient enzyme content to hydrolyze the starch efficiently to sugar.

Malt

- In order to create malt, the barley grain is first soaked in water. This soaking causes the germ to sprout and produces an enzyme that hydrolyzes *starch* to a shorter carbon chain, maltose *sugar*. Maltose is a fermentable carbohydrate that is then used to feed yeast and produce CO_2 and ethyl alcohol. (The alcohol and CO_2 are important for brewing alcoholic beverages and for baking.) Dried malt is used in a variety of products including brewed beverages, baked products, breakfast cereal, candies, or malted milks.
- Consumers following a gluten-free diet (no wheat, oats, rye, or barley) must avoid malt. They should read ingredients labels to determine (1) *if* malt is an ingredient in the food, and (2) the *source* of the malt.

Millet

Millet is the general name for *small* seed grass crops. The crops are harvested for food or animal feed (fodder). It is a major crop in some countries and is used as cereal, to make breads or soups. Millet includes proso (the most common) finger, foxtail, and pearl millet. Less common millets include barnyard, browntop, guinea, kodo, and little varieties of millet. Some millet is utilized in birdfeed, for cattle, hogs, poultry, and sheep.

Sorghum is a special type of millet with *large* seeds, typically used for animal feed, so far, yet it is the primary food grain in many parts of the world, where it is ground and made into porridge and cakes. It is also used to yield oil, sugars, and alcoholic beverages. A common variety of sorghum grown in the United States is milo; there are also waxy varieties. Overall, sorghums are resistant to heat and drought, and therefore, are of special value in arid, and hot regions of the world.

Sorghum is useful as a gluten-free way to produce malt. Sorghum and millet seeds are important cereals in semiarid, tropical regions of Asia and Africa.

A *very tiny* millet grain that has been used for centuries in the Ethiopian diet is *teff* or t'ef (*Eragrotis tef,* signifying "love" and "grass"). The seeds are approximately 1/32 of an inch in diameter, with 150 weighing as much as a kernel of wheat! Considering its size, it has a small endosperm in proportion to bran, and therefore is primarily bran, and germ. It is ground for use in flatbread. It grows in tropical climates in Africa, India, and South America. Commercial production of teff as a forage and food crop is also in the United States (Arrowhead Mills, Hereford, TX). It is cultivated in US states including Idaho and South Dakota.

Oats

Oat (referred to singularly when spoken of as a crop) is a significant cereal crop fed to animals such as horses and sheep, and also used by man. It is valued for its high protein content. In milling, the hull is removed and the oats are steamed and "rolled" or flattened for use in food. Oats are incorporated into many ready-to-eat breakfast

cereals and snack foods. Oat bran is a soluble fiber that has been shown to be effective in reducing serum cholesterol.

Due to the fact that oats have a fairly high fat content, as far as grains go, rancidity may develop. Lipase activity in the grain is destroyed by the administration of a few minutes of steam treatment.

Quinoa

Quinoa (keen-wa) is the grain highest in protein, although it is *not* an abundantly consumed grain. The small, round, light brown kernels are most often used as a cooked cereal.

Rye

Rye is richer than wheat in lysine, yet it has a relatively low gluten-forming potential.

Therefore, rye does not contribute as good of a structure to dough as is the case with wheat. It is frequently used in combination with wheat flour in breads and quick breads and is made into crackers. There are three types of rye—dark, medium, and light, which may be selected for baking into bread. Rye may be sprouted, producing malt or malt flour.

Triticale

Triticale is a *wheat* and *rye* hybrid, first produced in the United States in the late 1800s. As a crop, it offers the disease resistance of wheat and the hardiness of rye. It has more protein than either grain alone, although the overall crop yield is not high, so its use is not widespread. Triticale was developed to have the baking property of wheat (good gluten-forming potential) and the nutritional quality of rye (high lysine).

With regard to gluten intolerance or celiac disease, many grains are less subject to rigorous testing than wheat, rye, barley, oats, and triticale. Considered to be "safe" on a gluten-restricted diet are grasses such as sorghum, millet, and teff.

Non-cereal "Flours"

Non-cereals, including various *legumes* and *vegetables,* may be processed into "*flour,*" although they do *not* have the composition of grains. For example, soy and garbanzo beans (chick peas) are legumes (from the Leguminosae family) that may be ground and added to baked products. These foods may be found on the list of common food allergens.

Soy "flour" may be incorporated into formulations due to its protein value, or because it aids in maintaining a soft crumb. Cottonseeds (Malvaceae family), and potatoes (tubers), may also be processed into "flour." Buckwheat (fruit of *Fagopyrum esculentum* crop) contains approximately 60 % carbohydrate and may be used in the porridge kasha or as animal feed. Cassava (tuber) is the starch-yielding plant that yields tapioca and is a staple crop in parts of the world.

Cooking Cereals

In cooking, cereal products expand due to retention of the cooking water. *Finely* milled grains such as cornmeal, corn grits, or wheat farina should be *gently* boiled and only *occasionally* be stirred in order to prevent mushy and lumpy textures. *Whole or coarsely* milled grains such as barley, bulgur, rice, and oats (and buckwheat) may be added to *boiling* water and stirred occasionally during cooking.

To control heat while cooking, cereal products may be cooked in the top of a double boiler over boiling water. A disadvantage of this cooking method is that heating time is lengthened compared to direct heating without use of a double boiler.

More later, yet a bit regarding pasta: cooking pasta involves adding it to boiling water and

boiling it uncovered until the desired tenderness (typically al dente) is achieved. The addition of a small amount (1/2 teaspoon (2.5 mL) household use) of oil prevents boil-over from occurring.

CULINARY ALERT! Excessive stirring of any milled grain (especially finely milled grains) results in rupturing of the grain contents and is unpalatable, as the cereal forms a gummy, sticky consistency.

Breakfast Cereals

Breakfast cereals may perhaps be eaten hot or cold. An American religious group not wanting to consume animal products started the production of ready-to-eat breakfast cereals. The *Western Health Reform Institute* in Battle Creek, Michigan, produced, baked, and then ground a whole meal product to benefit the healthfulness of its institute's patients. A local townsperson, J. H. Kellogg, and his brother W.K. Kellogg started a business with this idea, applying it to breakfast food. A patient, C.W. Post did the same. (Both the Kellogg and Post names are still popular cereal manufacturers today.)

Breakfast cereals (Fig. 6.8) in many forms quickly became popular. Flaking, shredding, puffing, etc. and the production of various forms soon expanded although convenient, some criticize the levels of ingredients, including sugar and fiber, in r-t-e breakfast cereals. *Enrichment* and *fortification* also became a common practice for breakfast cereals that are now in the ranking of one of the most fortified foods available for consumption.

Fig. 6.8 Ready-to-eat breakfast cereal (*Source*: Wheat Foods Council)

Pasta

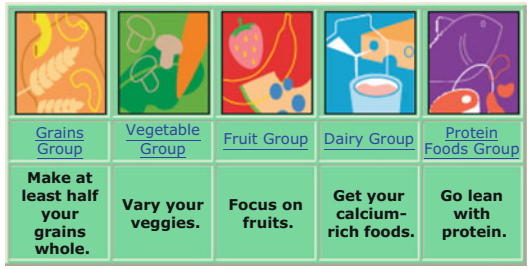
Pasta is the paste of milled grains (alimentary paste), extruded through a die or put through a roller. The crushed (not finely ground) endosperm of milled durum spring wheat, known as ***semolina***, is used in the preparation of high-quality pasta products. *Lower-quality* pastas that do *not* use semolina are also available to the consumer. These typically taste "starchy" and are pasty in texture. Although taste may not be affected, rinsing cooked pasta products prior to service may result in the loss of nutrient enrichment.

Pasta frequently appears on restaurant menus and home tables in the form of salads, side dishes, and main dishes. If pasta is processed to include legumes, as part of the formulation, a *complete protein* may be formed in a single food. For instance, pasta may now be commercially formulated to include pureed vegetables, herbs, and spices as well as cheeses. Pasta may also be cholesterol-free or gluten-free, made of non-wheat

flour, such as rice. "Technological breakthroughs now make it possible to enjoy rice pasta that tastes, looks, and cooks like regular pasta."

A variety of products including macaroni, noodles, and spaghetti are created by extrusion. In order to distinguish between macaroni and noodles, *macaroni* does *not* include eggs in its formulation *and noodles must* contain not less than 5.5 % (by weight) of egg solids or yolk (National Pasta Association, Arlington, VA).

Nutritive Value of Grains



What Foods Are in the Grains Group?

Any food made from wheat, rice, oats, cornmeal, barley, or another cereal grain is a grain product. Bread, pasta, oatmeal, breakfast cereals, tortillas, and grits are examples of grain products.

Grains are divided into two subgroups, Whole Grains and Refined Grains.

Whole grains contain the entire grain kernel—the bran, germ, and endosperm.

Refined grains have been milled, a process that removes the bran and germ. This is done to give grains a finer texture and improve their shelf-life, but it also removes dietary fiber, iron, and many B vitamins.

Most refined grains are *enriched*. This means certain B vitamins (thiamin, riboflavin, niacin, folic acid) and iron are added back after processing. Fiber is not added back to enriched grains. Check the ingredient list on refined grain products to make sure that the word "enriched" is included in the grain name. Some food products are made from mixtures of whole grains and refined grains.

Most of these products are made from refined grains. Some are made from whole grains. Check the ingredient list for the words "whole grain" or "whole wheat" to decide if they are made from a whole grain. Some foods are made from a mixture of whole and refined grains.

Some grain products contain significant amounts of bran. Bran provides fiber, which is important for health.

10 tips
Nutrition Education Series

make half your grains whole

10 tips to help you eat whole grains

Any food made from wheat, rice, oats, cornmeal, barley, or another cereal grain is a grain product. Bread, pasta, oatmeal, breakfast cereals, tortillas, and grits are examples. Grains are divided into two subgroups, **whole grains** and **refined grains.** Whole grains contain the entire grain kernel—the bran, germ, and endosperm. People who eat whole grains as part of a healthy diet have a reduced risk of some chronic diseases.

1 make simple switches

To make half your grains whole grains, substitute a whole-grain product for a refined-grain product. For example, eat 100% whole-wheat bread or bagels instead of white bread or bagels, or brown rice instead of white rice.

2 whole grains can be healthy snacks

Popcorn, a whole grain, can be a healthy snack. Make it with little or no added salt or butter. Also, try 100% whole-wheat or rye crackers.

3 save some time

Cook extra bulgur or barley when you have time. Freeze half to heat and serve later as a quick side dish.

4 mix it up with whole grains

Use whole grains in mixed dishes, such as barley in vegetable soups or stews and bulgur wheat in casseroles or stir-fries. Try a quinoa salad or pilaf.

5 try whole-wheat versions

For a change, try brown rice or whole-wheat pasta. Try brown rice stuffing in baked green peppers or tomatoes, and whole-wheat macaroni in macaroni and cheese.

6 bake up some whole-grain goodness

Experiment by substituting buckwheat, millet, or oat flour for up to half of the flour in pancake, waffle, muffin, or other flour-based recipes. They may need a bit more leavening in order to rise.

7 be a good role model for children

Set a good example for children by serving and eating whole grains every day with meals or as snacks.

8 check the label for fiber

Use the Nutrition Facts label to check the fiber content of whole-grain foods. Good sources of fiber contain 10% to 19% of the Daily Value; excellent sources contain 20% or more.

9 know what to look for on the ingredients list

Read the ingredients list and choose products that name a whole-grain ingredient ***first*** on the list. Look for "whole wheat," "brown rice," "bulgur," "buckwheat," "oatmeal," "whole-grain cornmeal," "whole oats," "whole rye," or "wild rice."

10 be a smart shopper

The color of a food is not an indication that it is a whole-grain food. Foods labeled as "multi-grain," "stone-ground," "100% wheat," "cracked wheat," "seven-grain," or "bran" are usually not 100% whole-grain products, and may not contain **any** whole grain.

USDA United States Department of Agriculture
Center for Nutrition Policy and Promotion

Go to www.ChooseMyPlate.gov for more information.

DG TipSheet No. 4
June 2011
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10 tips
Nutrition Education Series

choosing whole-grain foods

10 tips for purchasing and storing whole-grain foods

Whole grains are important sources of nutrients like zinc, magnesium, B vitamins, and fiber. There are many choices available to make half your grains whole grains. But whole-grain foods should be handled with care. Over time and if not properly stored, oils in whole grains can cause spoilage. Consider these tips to select whole-grain products and keep them fresh and safe to eat.

1 search the label

Whole grains can be an easy choice when preparing meals. Choose whole-grain breads, breakfast cereals, and other prepared foods. Look at the Nutrition Facts labels to find choices lower in sodium, saturated (solid) fat, and sugars.

2 look for the word "whole" at the beginning of the ingredients list

Some whole-grain ingredients include whole oats, whole-wheat flour, whole-grain corn, whole-grain brown rice, wild rice, and whole rye. Foods that say "multi-grain," "100% wheat," "high fiber," or are brown in color may not be a whole-grain product.

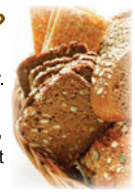
3 kids can choose whole grains

The new school meal standards make it easier for your kids to choose whole grains at school. You can help your child adapt to the changes by slowly adding whole grains into their favorite recipes, meals, and snacks at home.

4 find the fiber on label

If the product provides at least 3 grams of fiber per serving, it is a good source of fiber. If it contains 5 or more grams of fiber per serving, it is an excellent source of fiber.

5 is gluten in whole grains?



People who can't eat wheat gluten can eat whole grains if they choose carefully. There are many whole-grain products, such as buckwheat, certified gluten-free oats or oatmeal, popcorn, brown rice, wild rice, and quinoa that fit gluten-free diet needs.

6 check for freshness

Buy whole-grain products that are tightly packaged and well sealed. Grains should always look and smell fresh. Also, check the expiration date and storage guidelines on the package.

7 keep a lid on it

When storing whole grains from bulk bins, use containers with tight-fitting lids and keep in a cool, dry location. A sealed container is important for maintaining freshness and reducing the possibility of bug infestations or moisture.

8 buy what you need

Purchase smaller quantities of whole-grain products to reduce spoilage. Most grains in sealed packaging can be kept in the freezer.

9 wrap it up

Whole-grain bread is best stored at room temperature in its original packaging, tightly closed with a quick-lock or twist tie. The refrigerator will cause bread to lose moisture quickly and become stale. Properly wrapped bread will store well in the freezer.

10 what's the shelf life?

Since the oil in various whole-grain flours differs, the shelf life varies too. Most whole-grain flours keep well in the refrigerator for 2 to 3 months and in the freezer for 6 to 8 months. Cooked brown rice can be refrigerated 3 to 5 days and can be frozen up to 6 months.

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DG TipSheet No. 22
September 2012

Key Consumer Message: Make at least half of your grains whole grains.
View Grains Food Gallery

Grains make a significant nutritive contribution to the diet (Sebrell 1992). Whole grain products and processed cereal products contribute carbohydrates, vitamins such as B vitamins, minerals such as iron, and fiber to the diet in creative ways. Fortification with vitamin D and calcium are presently under consideration. Ready-to-eat varieties of breakfast cereals are frequently consumed in the more developed countries and many are highly fortified with essential vitamins and minerals, including folate.

Grains are low in fat, high in fiber, and contain no cholesterol, *although* cooked foods, breads, cereals, rice, and pasta dishes may be prepared with added fats, sugars, eggs, and refined flours, which changes the nutritive value profile. Unfortunately, with these additions, many commonly selected r-t-e breakfast cereals lose their original nutritional benefit, as they are manufactured to be high in sugar and/or low in fiber in developed countries.

Safety of Grains

Safety of cereal grains is better assured by proper storage including first-in-first-out (FIFO) rotation. Since whole grains are subjective to rancidity, storage should be kept cold, and not lengthy. All products should be stored off of the floor and a slight distance away from walls due to possible pipe flooding or insect infestation.

Conclusion

Cereals are the edible seeds of cultivated grasses and many cereal foods are prepared from grain. A kernel contains bran, endosperm, and germ, however, if "refined," the refined cereals contain *only* endosperm and are no longer whole grain. For example, *wheat flour* is not the same as *whole wheat flour*. Common cereal grains include wheat, rice, and corn, although other grains such as barley, millet, oats, quinoa, rye, and triticale may be used as a component in meals. Dried grains have a very long storage life, and much of the world depends on them for food.

Over 30,000 varieties of wheat exist, classified according to season, texture, and color. *Hard* wheat is used for bread making, and *soft* wheat for cakes and pastries.

Semolina flour from hard durum wheat is used for pasta production. Pasta is the paste of milled grains, primarily wheat, and increasingly appears in the American diet. It is a complex carbohydrate and low-fat food.

Rice is a staple food of much of the world. It grows as (extra long), long, medium, and short grain rice and grows in a variety of flavors that are used in many entrees, side dishes, even desserts. Corn is also common.

Cereals are included as the base of numerous food guides throughout the world, indicating that they are major foods of a nutritious diet. The USDA recommends that persons avail themselves of the great variety of products that are available in the marketplace.

Notes

CULINARY ALERT!

Glossary

All-purpose wheat flour White flour, not containing the bran or germ. Combining the properties of hard and soft wheat.

Bleached flour Bleaching the pigment to a whiter color, naturally by exposing pigment to air, or by chemical agents.

Bran The layered outer coating of the kernel, offering protection for the seed.

Bread flour Made from a hard wheat kernel, with a high protein–starch ratio; high gluten potential.

Cereal Any edible grain that comes from cultivated grasses.

Endosperm The starch-storing portion of the seed that produces white flour and gluten.

Enrichment Adding back nutrients lost in milling.

Fortification Adding nutrients at levels beyond that present in the original grain.

Germ The embryo; the inner portion of the kernel.

Gluten Protein substances (gliadins, glutenins) left in the flour after the starch have been removed, which when hydrated and manipulated produce the elastic, cohesive structure of dough.

Malt Produced from a sprouting barley germ. Long glucose chains are hydrolyzed by an enzyme to maltose, i.e., involved in both feeding yeast and producing CO_2. May be dried and added to numerous products.

Matured flour Wheat flour, i.e., aged naturally or by chemical agents to improve gluten elasticity and baking properties of dough.

Organic flour Flour from crops grown without the use of chemicals such as herbicides and insecticides.

Patent flour Highest grade of flour from mill streams at the beginning of the reduction rolls. High starch, less protein than mill streams at the end of reduction rolls.

Pasta The paste of milled grains, usually the semolina from durum wheat, extruded through a die to produce a diversity of shaped products. They are dried and then cooked in large amounts of water. Included are macaroni, noodles, spaghetti, ravioli, and the like.

Semolina Flour milled from durum wheat.

Other/Additional Glossary for Cereals, Flour, and Flour Mixtures

Oregon State University Select definitions for a better understanding of cereals, flour, and flour mixtures.

Amylopectin A fraction of starch with a highly branched and bushy type of molecular structure.

Amylose The long-chain or linear fraction of starch.

Baking powder Is a mixture consisting generally of an acid salt and sodium bicarbonate which, when water is added, and possibly heat, will produce carbon dioxide for leavening.

Batter Systems with their relative high water: flour: water is continuous. Structure depends much less on gluten development than on gelatinization of starch.

Bleaching Of flour is the oxidization of the yellow carotenoid pigments in wheat flour. This may be done with either chemicals or during "aging" over a length of time.

Carmelization The development of brown color and caramel flavor as dry sugar is heated to a high temperature; chemical decomposition occurs in the sugar.

Carotenoid pigment Yellow-orange compounds produced by plan cells and found in various fruit, vegetable, and cereal grain tissues; for example, beta-carotene.

Coagulation Change in protein, after it has been denatured, that results in hardening or precipitation and is often accomplished by heating.

Fermentation The transformation of organic substances into smaller molecules by the action of microorganisms; yeast ferments glucose to yield carbon dioxide and alcohol.

Gliadin Is the water-insoluble protein that contributes stickiness and tackiness to gluten structure.

Gluten Is an elastic cohesive mass made up of gliadin, glutenin, water, and a lipoprotein compound.

Glutenin Is the water-insoluble protein that contributes toughness and rubberiness to gluten structure.

Graham flour Is flour essentially from the entire wheat kernel. It may be ground to varying degrees.

Green flour Is flour which has not been aged or matured.

Maturing Of flour is the aging process that affects the flour structural proteins through oxidation of the gliadin and glutenin. Maturing may occur naturally or with chemical additions.

Milling Is the process which generally involves the separation of the bran and germ from the endosperm which is subsequently subdivided.

Oxidation A chemical reaction in which oxygen is added or electrons are lost.

Proofing The last rising of bread dough after it is molded into a loaf and placed in the baking pan.

Reducing substance A molecule that has an effect opposite that of an oxidizing agent: hydrogen or electrons are gained in a reaction involving reducing substances.

Rope Is a bacterial contamination that can originate in the flour bin or in the various constituents used to make bread. It will make a loaf of bread sticky and "ropy" in the interior.

Staling Refers to those changes in quality that occur in baked products after baking. Generally, there is a loss of flavor, softening of the crust or development of a leathery crust, and increased firmness of the crumb.

Starch gelatinization The swelling of starch granules when heated with water, often resulting in thickening.

Straight grade white flour Theoretically should contain all the flour streams resulting from the milling process, but actually 2–3 % of the poorest streams are withheld.

White wheat Flour is a food made by the grinding and sifting of cleaned wheat (definition, FDA).

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